Food and Agriculture Organization of the United Nations

CIHEAM ZARAGOZA


# Book of Abstracts

Università di Catania

Università degli Studi di Palermo

CoRFiLaC Consorzio Ricerca Filiera Lattiero Casearia •Ragusa•

MANGIMI LEONE

ADM

# Joint Seminar of the FAO CIHEAM Networks on Pasture and Forage Crops and on Sheep and Goat Nutrition

## Alternative feed resources and their management for transiting towards a sustainable ruminant production

### Catania, 27-29 September 2022

## Boosting the contribution of livestock and forage productions to sustainable agri food systems

The Mediterranean basin is highly affected by climate change, while certain countries still need to increase livestock production in order to achieve food self-sufficiency. Producing «better» is an urgent issue.

In this respect, ruminants have an asset: they can be fed on plants, plant parts and agro-industrial by products which are not directly recoverable for humans.

The Mediterranean landscapes are composed of an agro-silvo-pastoral mosaic, which offers opportunities for interactions between livestock production, agriculture and natural areas. Mediterranean grasslands are an important source of forage; cultivated forage, possibly associated to perennial or annual crops, provides high-quality feed for periods of high nutrient requirements; agro-industry produces a variety of typical by-products which may be included in ruminant diets.

This joint seminar of the «Ruminant nutrition» and «Mediterranean pastures and forage crops» sub-networks aims at exploring the various opportunities in terms of novel or underexploited local feed resources, which could be valued better in the future and used to secure small ruminant feeding systems and boost animal production. Joining these two sub-networks gives the opportunity to consider the question from two complementary points of view, thus encouraging system approaches

# Committees

## INTERNATIONAL SCIENTIFIC COMMITTEE

A. Araba, *IAV Hassan II, Morocco*
S. Ates, *Oregon State University, USA*
M. Avondo, *University of Catania, Italy*
H. Ben Salem, *INRAT, Tunisia*
M. Bengoumi, *FAO-SNE, Tunisia*
L. Biondi, *University of Catania, Italy*
A. Bonanno, *University of Palermo, Italy*
A. Cabiddu, *Agris, Italy*
M. Caccamo, *CoRFiLaC, Ragusa, Italy*
I. Casasús, *CITA- Aragón, Spain*
M. Chentouf, *INRA, Morocco*
P. de Frutos, *CSIC, Spain*
A. de Vega, *University of Zaragoza, Spain*
D. Giambalvo, *University of Palermo, Italy*
S. Giger-Reverdin, *AgroParisTech, France*
M. Jouven, *SupAgro, France*
A. Keli, *ENA-Meknés, Morocco*
A. Kyriazopoulos, *Democritus U. Thrace, Greece*
M. Lanza, *University of Catania, Italy*
A. López-Francos, *IAMZ-CIHEAM, Spain*
G. Luciano, *University of Catania, Italy*
G. Moreno, *University of Extremadura, Spain*
A. Natalello, *University of Catania, Italy*
A. Nudda, *University of Sassari, Italy*
C. Porqueddu, *CNR-ISPAAM, Italy*
A. Priolo, *Univerity of Catania, Italy*
M. Rekik, *ICARDA, Tunisia*
M. Scerra, *Università Mediterranea of Reggio Calabria, Italy*
P. Swanepoel, *Stellenbosch University, South Africa*
M. Todaro, *University of Palermo, Italy*
D. Yáñez-Ruiz, *CSIC, Spain*
B. Valenti, *University of Perugia, Italy*
A. Zoghlami, *INRAT, Tunisia*

## LOCAL ORGANISING COMMITTEE

M. Avondo, *University of Catania*
L. Biondi, *University of Catania*
A. Bonanno, *University of Palermo*
M. Caccamo, *CoRFiLaC*
R. Ingraffia, *University of Palermo*
M. Lanza, *University of Catania*
G. Licitra, *University of Catania, CoRFiLaC*
G. Luciano, *University of Catania*
R. Menci, *University of Catania*
A. Natalello, *University of Catania*
A. Priolo, *University of Catania*
M. Todaro, *University of Palermo*

Food and Agriculture Organization of the United Nations

CIHEAM ZARAGOZA


JOINT SEMINAR OF NETWORKS
ON PASTURE AND FORAGE CROPS
AND ON SHEEP AND GOAT NUTRITION

CATANIA / SICILY 27-29 SEPTEMBER

# Scientific Programme

Università di Catania

Università degli Studi di Palermo

CoRFiLaC Consorzio Ricerca Filiera Lattiero Casearia •Ragusa•

MANGINI LEONE

ADM

# DAY 1
## 27 SEPTEMBER

## MORNING

**08:00 REGISTRATION (30 min)**

**08:40 OPENING OF THE SEMINAR**
*Alessandro Priolo (Convener of the Seminar)*
*Raúl Compés López (Director CIHEAM Zaragoza)*
*Aimable Uwizeye (Officer, FAO Rome)*

**09:00 Opening lecture:** Small ruminants in Sicily
*Antonio Natalello (University of Catania, IT)*

**09:15 Opening lecture:** Forage resources in Sicily: current status and strategies for the future
*Dario Giambalvo (University of Palermo, IT)*

**SESSION 1: ALTERNATIVE FEED RESOURCES AND SUSTAINABILITY**
**Chairs:** *Pilar de Frutos (IGM, ES), Abdelilah Araba (IAV, MA)*

**09:30 Keynote:** Using local feed resources for livestock farming: Illusion or real promise?
*Guillaume Martin, Myriam Grillot, Clémentine Meunier, Marc Moraine, Julie Ryschawy, Fabien Stark (INRAE, FR)*

**10:00 Keynote:** Alternative feed resources and sustainability
*Cletos Mapiye, Obert C. Chikwanha (Stellenbosch University, ZA)*

**10:30** Coffee break and Posters at the Cloister

**11:15 Effect of peeling method, mode of production and variety of chestnut skins on in vitro rumen fermentation characteristics**
*Vincent Niderkorn, Angélique Torrent, Hervé Hoste*

**Potential of fenugreek (Trigonella foenum-graecum L.) fodder and seeds for sheep feeding under Tunisian conditions**
*Salah Benyoussef, Hichem Ben Salem*

**Impact of dried agro-industrial strawberry by-product as an alternative feed resource on rumen fermentation, milk production and quality, and blood parameters of lactating ewes**
*Amr S. Morsy, Yosra A. Soltan, Adel M. Saber, Elsad A.*

**Acorn use as alternative feed resource: evaluation and impact on sustainability in southern Mediterranean cork oak forests**
*Boutheina Stiti, Maryem Khalfaoui, Salima Bahri, Nizar Moujahed, Abdelhamid Khaldi*

**Evaluation of forage quality of Vicia sativa and Pisum sativum genotypes cultivated in different environments**
*Apostolos P. Kyriazopoulos, Maria Irakli, Zoi M. Parissi, Theodoros Manousidis, Eleni M. Abraham*

**Effects of cocoa bean shell on goat milk yield and composition**
*Manuela Renna, Carola Lussiana, Letizia Colonna, Vanda Maria Malfatto, Antonio Mimosi, Paolo Cornale*

**Potential risks associated with pesticides and heavy metals in agro-industrial by-products as feeds for livestock**
*Mahmoud HA. Hassan, Alejandro Belanche, Ignacio Martín-García, Manuel Romero-Huelva, Eva Ramos-Morales, David R. Yáñez-Ruiz*

**12:30** GENERAL DISCUSSION

**13:15** Lunch

## AFTERNOON

**SESSION 2: ALTERNATIVE FEED RESOURCES AND SUSTAINABILITY**
**Chairs:** *Pieter Swanepoel (Stellenbosch University, ZA), Manuela Renna (University of Turin, IT)*

**15:00 Keynote:** Modern domestication of Mediterranean pasture and fodder crop legumes
*Phillip G.H. Nichols (University of Western Australia, AU)*

**15:30 Keynote:** Emerging and sustainable feed source: insects
*Laura Gasco (University of Turin, IT)*

**16:00** Coffee break and Posters at the Cloister

**16:30 Characterization of lipids of Hermetia illucens and Tenebrio molitor meals as feed ingredients**
*Giuseppe Conte, Monica Tognocchi, Andrea Serra, Marcello Mele*

**Developing synergies between the exploitation of the Mediterranean forests and their contribution to the food systems of small ruminants, a challenge for public policies: The case of Corsica**
*Jean-Paul Dubeuf, Regis Lorton*

**Vetch forage: a promising alternative to cereal stubbles under conservation agriculture (CA) in Tunisia**
*Sourour Abidi, Salah Benyoussef, Hichem Ben Salem*

**Environmental impacts of seasonal sheep corrals in a dry Mediterranean ecosystem**
*Zaady Eli, Vinograd Arie, Kigel Jaime, Goldshleger Naftali, Shamir Omer, Basson Uri, Nejidat Ali, Diaz-Recka Damiana*

**Grape pomace: From waste to small ruminant feed and meat preservative**
*Obert C. Chikwanha, Cletos Mapiye*

**Effect of the use of argan bark (Argania spinosa L.) in fattening lamb on growth performances, carcass characteristics and meat quality**
*Mohammed Benbati, Brahim Yassin, Kaoutar Elfazazi, Fatima El Yaakoubi, Mohammed Diouri, Abdelhafid Keli*

**Incorporating pomegranate peels and pistachio hulls in concentrate feeds: effects on lambs' meat quality**
*Hadhami Hajji, Semia Kdidi, Salma Bessalah, Mohamed Dbara, Mabrouk M. Seddik, Touhami Khorchani, Mohamed Hammadi*

**Root nodule formation in Trifolium subterraneum ssp. yanninicum under fluctuating soil moisture conditions**
*Gereltsetseg Enkhbat, Phillip G.H. Nichols, Megan H. Ryan, Yoshiaki Inukai, Kevin J. Foster, William Erskine*

**18:00** GENERAL DISCUSSION (about 45 minutes)

**20:00** Welcome cocktail (Palazzo Biscari, Catania)

# DAY 2

28 SEPTEMBER

## MORNING

**SESSION 3: RESEARCH FUNDING: CONTEXT, DIRECTIONS, OPPORTUNITIES, AND SUCCESSFUL EXAMPLES**

**Chairs:** *David Yañez-Ruiz (EEZ-CSIC, ES), Antonio López-Francos (CIHEAM Zaragoza, ES)*

**08:30 Keynote:** Future research priorities for sustainable livestock systems to achieve the sustainable development goals

*Aimable Uwizeye (FAO, IT)*

**08:50 Keynote:** Continued CORE Organic Network Support for European Organic Food and Framing Research under the Horizon Europe Framework Programme (2022-2027)

*Ivana Trkulja (CORE ORGANIC – ICROFS, DK)*

**09:10 Keynote:** PRIMA's contribution to the funding of Research and Innovation in the field of agropastoralism and livestock systems

*Fabrice Dentressangle (PRIMA, ES)*

**09:30** Coffee break and Posters at the Cloister

**10:30 Green Sheep LIFE project for common estimates of carbon footprint at European level: comparison of different tools for sheep farms**

*Alberto Stanislao Atzori, Oscar del Hierro, Catalin Dragomir, Mauro Decandia, Cathal Buckley, Roberto Ruiz, Tim W.J. Keady, Jean Baptiste Dolle, S. Moreau*

**PASTINNOVA – Innovative models for sustainable future of Mediterranean pastoral systems**

*Athanasios Ragkos, Antonello Franca, Marta Guadalupe Rivera-Ferre, Paride D'Ottavio, Jean-Paul Dubeuf, Antonio Lopez-Francos*

**Mediterranean cross-border cooperation project for the sheep supply chain: JESMED**

*Taha Najar, Imen Belhadj Slimen, Ines Essid*

**LIVINGAGRO project – Cross border living labs for agroforestry**

*Pasquale Arca, Antonello Franca, Claudio Porqueddu, Panagiotis Kalaitzis, Konstantinos Blazakis, Lisa Radinovsky, Milad El Riachy, Peter Moubarak, Salam Ayoub, Sara Maltoni, Maurizio Mallocci, Roberto Lai, Mauro Forteschi, Federica Romano, Dina Porazzini, Alessandro Mancosu, Luciana Baldoni, Daniele Chiappini, Claudia Consalvo, Andrea Pisanelli*

**LIPOMEC: towards a better understanding of ruminant milk lipolysis through an integrative biology approach in milk and mammary gland**

*Catherine Hurtaud, Laurence Bernard, Philippe Trossat, Marine Gelé, Sofia Meurisse, Anne Barbat, Didier Boichard, Hélène Larroque, Aurore Oudotte, Jean-Louis Poulet, Anne Thierry, Marion Boutinaud, Mylène Delosière, Andrea Rau, Muriel Bonnet, Christelle Cebo*

**An inclusive and integrated development strategy for small ruminants in Morocco**

*Fatima-Zahra Najjar, Malek Hayder, Said Chatibi, Said Tazi, Nadia Naimi, Mohsen Daoudi, Lina Ramony, Jean-Claude Guesdon, Mohammed Bengoumi*

**11:45** GENERAL DISCUSSION

**12:30** Lunch

## AFTERNOON

**SESSION 4: A STAGE FOR YOUNG RESEARCHERS**

**Chairs:** *María del Mar Campo (University of Zaragoza, ES), Sourour Abidi (INRAT, TN)*

**14:00 Introduction**

*María del Mar Campo (University of Zaragoza, ES)*

**Keynote:** Circularity and emerging feeding solutions for sustainable small ruminant production systems

*Saheed Salami (Alltech, UK)*

**Dual-purpose management of perennial forbs sown with or without self-regenerating annual legumes for forage and nectar sources in a low-input dryland production system**

*Elizabeth Seeno, Serkan Ates, Shelby Filley, Jennifer MacAdam, Andony Melathopoulos*

**Goat farming in the Majella National Park: grazing behavior and milk quality**

*Martina Ercolani, Leonardo Angelucci, Bernardo Valenti, Daniela Gigante, Luciano Morbidini, Simone Angelucci, Luciano Di Martino, Viviana Bolletta, Mariano Pauselli*

**Responses of Mediterranean rangelands to increased summer droughts**

*Gerónimo A. Cardozo Cabanelas, Florence Volaire, Charlotte Barotin, Karim Barkaoui*

**Cultivated fodders in the sheep feeding systems in the Algerian steppe; status and possibility to improve their resilience**

*Hadbaoui Ilyes, Senoussi Abdelhakim, Huguenin Johann*

**Ecological characterization of the natural habitat of sulla flexuosa (Hedysarum flexuosum) in north-western Morocco**

*Soumaya Boukrouh, Jean-Luc Hornick, Ali Noutfia, Claire Avril, Mouad Chentouf, Jean-François Cabaraux*

**Use of cocoa byproduct in animal nutrition: the right way to improve livestock sustainability and human activity**

*Silvia Carta, Fabio Correddu, Eleni Tsiplakou, Anna Nudda*

**Feeding chicory silage and supplementing Se-yeast to peripartum ewes may improve efficiency through subtle changes to metabolism and antioxidant health**

*Hunter Ford, Massimo Bionaz, Serkan Ates, Erminio Trevisi*

**Could Hemp (Cannabis sativa L.) flower co-products be used in ruminant nutrition?**

*Alessandro Vastolo, Serena Calabrò, Dieudonné Kiatti, Monica I. Cutrignelli*

**Effects of replacing soybean meal with hempseed cake in goat finishing diets on growth, carcass and meat quality attributes**

*Farouk Semwogerere, Obert C. Chikwanha, Chenaimoyo L.F. Katiyatiya, Munyaradzi C. Marufu, Cletos Mapiye*

**Effect of different assumption ways of limonene on physicochemical properties of goat kid meat**

*Maria F. Sgarro, Pasquale De Palo, Vincenzo Landi, Francesco Giannico, Aristide Maggiolino*

**Black wattle (Acacia mearnsii) leaf-meal as an alternative fibre source in sheep finisher diets**

*Tulimo Uushona, Obert C. Chikwanha, Chenaimoyo L.F. Katiyatiya, Phillip E. Strydom, Cletos Mapiye*

**May differences in ruminal antilipogenic fatty acids explain the individual variation of milk fat depression in goats and ewes?**

*Antonella Della Badia, Pablo G. Toral, Juan J. Loor, Pilar Frutos, Gonzalo Hervás*

**16:30** Coffee break and Posters at the Cloister

**17:00** GENERAL DISCUSSION

**19:00** Social dinner

# DAY 3

29 SEPTEMBER

## MORNING

**Technical tour:** CORFILAC will welcome the participants and organize the technical visit

**08:00** Departure from Catania (Monastero dei Benedettini, Catania)

**10:00** Coffee break

**10:30** Introduction (*Giuseppe Licitra, President of CORFILAC, IT*)

**11:00** Technical tour

**12:30** Lunch

## AFTERNOON

**SPECIAL SESSION: IMPORTANCE OF RIGHT DIFFUSION AND TRANSFER OF SCIENTIFIC RESEARCH**

**Round table at CORFILAC (Ragusa, IT)**

**Animator:** *Hichem Ben Salem (INRAT, TN)*

**15:00 Keynote: Small Ruminant Research in a world of scavenging press**

*Serge Landau (Small Ruminant Research, Editor-in-chief)*

**Keynote:** Ethical issues in the animal science publishing

*Marcello Mele (Italian Journal of Animal Science, Editor-in-chief)*

**Keynote:** Scientific and technological transfer as the bridge from research to stakeholders

*Margherita Caccamo (CORFILAC, IT)*

**17:00 END OF WORKS & CONCLUDING REMARKS**

*Giuseppe Luciano (University of Catania, IT)*

*Magali Jouven (Coordinator Network Pasture and Forage Crops)*

*Hichem Ben Salem (Coordinator Network Sheep and Goat Nutrition)*

**17:30** Departure to Catania

# TABLE OF ABSTRACTS

Food and Agriculture Organization of the United Nations

CIHEAM ZARAGOZA


JOINT SEMINAR OF NETWORKS
ON PASTURE AND FORAGE CROPS
AND ON SHEEP AND GOAT NUTRITION

CATANIA / SICILY 27-29 SEPTEMBER

# Alternative feed resources and sustainability

Università di Catania

Università degli Studi di Palermo

CoRFiLaC

LEONE

ADM

# Using local feed resources for livestock farming: Illusion or real promise?

Guillaume Martin[1], Myriam Grillot[1], Clémentine Meunier[1], Marc Moraine[1], Julie Ryschawy[2], Fabien Stark[1]

[1] *INRAE, France*
[2] *INPT-ENSAT, France*

E-mail: guillaume.martin@inrae.fr

**Take home Message** Turning back to using local feed resources is possible but further interdisciplinary analytical and systems research is needed.

**Introduction** The livestock sector needs an overhaul. First, it has a high land footprint leading to severe competition between animal feed and human food production. Second, the livestock sector is responsible for massive nitrogen flows at the global level. Third, the livestock sector has well-established impacts on climate change, water pollution, soil acidification, and biodiversity loss are also well documented. Transition to more sustainable livestock production models are increasingly considered by the sector and demanded by governments and consumers. Among available options, one is turning back to using local feed resources with low opportunity costs (such as crop residues, herbage or food waste) for livestock farming. It amounts to designing and implementing more circular farm and food systems in which livestock's function extends to converting waste from the food system and various plant-based feed resources into valuable food and manure and delivering directly or indirectly multiple services to crop production. We explain how this can be implemented, discuss the multiple sociotechnical lock-ins that are to be addressed to allow for implementation and present promising research avenues.

**Using local feed resources: principles and practices** As a starting point, livestock farming should avoid feed-food competition. All along the chain from food production to food consumption, by-products are generated. Some are sources of feed that deserve further attention as they display high potential to be incorporated in livestock diets to reduce the feed-food competition and recycle nutrients locally. Avoiding feed-food competition also implies making full use of available agricultural land from highly productive pastures to poorly productive rangelands and forestland. Further using these feed sources implies reconsidering the sequencing of livestock diets across the year taking into account the seasonal and year-to-year variability of forage production on pastures and rangelands but also that of availability of co-products. This requires designing more flexible feeding plans to take advantage of more diverse feed sources and cope with unexpected events. Using local feed resources for livestock farming also involves reconnecting crop, pastures and livestock either at the level of individual farms but also among farms within a territory. This involves valuing the diversity of crops, pastures and livestock found on a farm or a territory by taking advantage of their complementarities and even by creating new synergies.

**Socio-technical innovations to using local feed resources** Implementation of more circular food systems relying on local feed resources for livestock farming is challenged by multiple socio-technical lock-ins (e.g. lack of professional networks, insufficient knowledge of the benefits). These lock-ins are problematic in that they increase the costs for information gathering, collective decision-making and/or implementation of such circular systems. Sociotechnical innovations are required to develop locally adapted systems reconnecting crops, pastures and livestock and guarantee their feasibility, legitimacy and acceptability. In the South of France (Minervois region), to address the above-mentioned lock-ins, a cooperative of organic crop farmers has been created to organize the logistics of this reconnection and ensure interesting commercial outlets for cereals and pulses. Organic arable cropping systems rely on long crop rotations, including fodder legumes (alfalfa, sainfoin) mowed by livestock farmers who thereby ensure the hay made matches their quality expectations. Shepherds have their flocks grazing crop residues, alfalfa and other pastures on arable crop farms. Successful implementation requires communication among farmers throughout the year.

**Conclusion** Using local feed resources for livestock farming offers real promises to improve the sustainability of livestock farming, but also that of crop farming by allowing the necessary diversification of cropping systems. It can even promote essential services to society at the level of territories. To allow for implementation, interdisciplinary research is needed on several topics to disentangle the complexity of the interplay between biophysical, economic, legal, and organizational issues: (i) developing knowledge on more diverse feed resources in terms of quality and availability in space and time; (ii) identifying and breeding animal types suited to valuing local feed resources; (iii) documenting novel practices and systems reconnecting crops, pastures and livestock in the context of given socio-technical systems and assessing their sustainability; (iv) developing participatory tools allowing multi-stakeholder dialogue and design of coupled innovations and systems reconnecting crops, pastures and livestock at field, farm and territory levels; (v) designing formal contracts and governance rules suited to these new forms of collaborations among stakeholders and (vi) developing policy measures creating the ground for these more circular systems.

**Acknowledgements** This study was supported by the SagiTerres project (2123-039) funded through Labex AGRO 2011-LABX-002 (under I-Site Muse framework) and through Daniel & Nina Carasso Foundation under the CO3 program.

# Alternative feed resources and sustainability

Cletos Mapiye, Obert C. Chikwanha

*Stellenbosch University, Stellenbosch, South Africa*

E-mail: cmapiye@sun.ac.za

**Take home Message** The Mediterranean region is endowed with a plethora of potential alternative and novel feed resources including plant products and by-products, food leftovers, insects, aquatic biomass and single-cell proteins, which contain a diversity of nutrients and bioactive compounds that have potential to promote sustainable small ruminant production and enhance meat quality.

**Introduction** Sheep and goats in the Mediterranean region account for 16% of the global small ruminant population of about 2.1 billion head (FAOSTAT 2016). In spite of small ruminants' significant contribution to greenhouse gas emissions and climate change (Marino et al. 2016), they play a key role in ensuring food, nutrition, and income security, especially for the native people residing in rural, mountainous, and marginal areas (Durmus et al. 2019). Small ruminant production in the Mediterranean as in the other regions is, however, being confronted with several challenges including environmental deterioration, climate change and food-feed-fuel competition (Durmus et al. 2019). This has increased scarcity and costs of conventional feed resources (i.e., cereals and grain legumes), thereby negatively influencing small ruminant meat production and quality. Nevertheless, the global demand for meat and consumer sophistication is rising due to increasing human population, per capita income, and urbanisation (OECD 2022). A search for human-inedible alternative feed resources (AFR) coupled with novel feed ingredients that promote sustainable production of sheep and goats is key towards satisfying current and future demand for meat. The current review, therefore, seeks to identify and unmask the effects of alternative and novel feeds on small ruminant meat production and quality, and highlight sustainability challenges and opportunities for their use.

**Prospective alternative and novel feeds in the Mediterranean region:** There is huge potential to use plant products (i.e., leaves and seeds from shrubs and woody species; Salem et al. 2020) and plant by-products from processing of fruits, vegetables, oilseeds, trees, shrubs, roots, tubers, herbs and spices, and production of sugar, alcohol, and biofuel (Salami et al. 2019; Sahoo 2021) as AFR for small ruminants in the Mediterranean region. These plant-based feed resources are abundantly available, have moderate to high contents of crude protein, and are rich sources of energy (i.e., starch or cellulose) and bioactive compounds (e.g., unsaturated fatty acids, polyphenols, carotenoids, essential oils, tocopherols, and phytosterols). Food leftovers (e.g., former food products and bakery by-products) also represent promising AFR for small ruminants in the Mediterranean region owing to their abundant availability and significant nutritional profile (Pinotti et al. 2021). Novel feed sources including insects (e.g., black soldier fly and housefly larva; Shah 2022), single-cell proteins (e.g., bacteria, yeast, fungi, and microalgae; Madeira et al. 2019; Halmemies-Beauchet-Filleau et al. 2018) and aquatic biomass (e.g., seaweed and duckweed; Min, 2021) hold potential to replace or supplement conventional feed ingredients in small ruminant diets. These novel feed ingredients contain a diversity of compounds ranging from proteins, lipids and carbohydrates to minerals and bioactive compounds (e.g., omega-3 fatty acids, chitin, and peptides). In semi-arid and saline areas, xerophytes (e.g., cactus) and halophytes (e.g., Atriplex) fodder species could be considered as AFR (Oliveira et al. 2020). Literature indicates that most of these alternative and novel feeds have potential to reduce enteric methane and nitrogen emissions, nutritional stress caused by bloat or acidosis, suppress gastrointestinal nematodes, improve nitrogen metabolism, animal growth, welfare, and health, and enhance shelf life, health value and eating quality of meat (Salami et al. 2019; Uushona et al. 2022). They also offer an array of additional sustainability benefits including reducing use of inorganic fertilisers, beneficiation of waste streams, increasing use of fibrous feeds and sparing arable land and fresh water (Halmemies-Beauchet-Filleau et al. 2018). Adoption of these alternative and novel feeds is, however, limited by the gap of knowledge regarding variability and bioavailability of nutrients and bioactive compounds, their effects on animal production and meat quality, safety, feasibility, scaling-up of production, harvesting and conservation practices, sustainability implications and acceptance by stakeholders.

**Future recommendations** The small ruminant industry in the Mediterranean region is recommended to valorise alternative and novel feeds to produce functional meat products with extended shelf life and low environmental footprint, which can be marketed at a premium in niche markets.

**References**

Durmus *et al*. 2019. J Env Sci Eng B 8, 241-248; FAOSTAT. 2016. http://faostat.fao.org; Halmemies-Beauchet-Filleau *et al*. 2018. Animal 12, s295-s309; Madeira *et al*. 2017. Liv Sci 205, 111-121; Marino *et al.* 2016. Small Rumin Res 135, 50-59; Min. 2021. Anim Nutr 7(4), 1371-1387; Oliveira *et al*. 2020. J Ethnopharmacol 267, 113464; OECD. 2022. doi: 10.1787/fa290fd0-en; Pinotti *et al*. 2021. J Cleaner Prod 294, 126290; Sahoo. 2021. Waste Manag 128, 232-242; Salami *et al*. 2019. Anim Feed Sci Technol 251, 37-55; Salem *et al*. 2020. Agroforestry Syst 94, 1133-1138; Shah *et al*. 2022. Anim Biosci 35(2), 317-331; Uushona *et al*. 2022. Anim Feed Sci Technol 284, 115187.

# Effect of peeling method, mode of production and variety of chestnut skins on *in vitro* rumen fermentation characteristics

Vincent Niderkorn[1], Angélique Torrent[1], Hervé Hoste[2]

[1]*INRAE, Université Clermont Auvergne, VetAgro Sup, UMRH, 63122, Saint-Genès-Champanelle, France*
[2]*UMR 1225 IHAP INRAE/ENVT Toulouse, France*

E-mail: vincent.niderkorn@inrae.fr

**Take home Message** Including chestnut skins in a basal diet decreases fermentability but without negative impact on VFA production whichever the chestnut variety, mode of production or peeling method.

**Introduction** Turning agro-industrial waste into a resource is a key-driver of circular bio-economy, and incorporating them in small ruminant diet is a promising way to add value to by-products. The objective of this study is to determine the *in vitro* rumen fermentation characteristics of chestnut skins (i.e., pericarp, endocarp and mesocarp) produced in contrasted conditions.

**Materials and methods** Eight samples of crude chestnut (*Castanea sativa*) skins were tested according to a 2×2×2 factorial design: two varieties of chestnut (Sylvestre *vs* M15), two modes of production (organic *vs* conventional) and two peeling methods (oven-drying at 85°C for 2 h *vs* microwave oven at 700 W for 8 min). The chestnut skins (200 g/kg DM) were incorporated into a basal diet consisting of 800 g/kg DM of hay and 200 g/kg of concentrate (composition of basal diet, in g/kg DM, NDF = 484; ADF = 252; ADL = 27; CP = 106). The basal diet without chestnut skins was used as control. The *in vitro* rumen fermentation assay was conducted by incubating anaerobically 600 mg of plant substrate in 40ml-batch fermenters containing a mixture of artificial saliva and rumen fluid from sheep (1:2 v/v) at 39°C for 24h as described by Niderkorn et al. (2012). At the end of fermentation, *in vitro* dry matter degradability (IVDMD), production of total gas and methane ($CH_4$), volatile fatty acids (VFA) and ammonia ($NH_3$) were determined. Statistical analyses were performed using a linear mixed-effects model (R software, version 3.6.2). The type of chestnut skins, the variety, the mode of production and the peeling method of chestnut were used as fixed effects, and the repetition in time (n=3) was used as random factor.

**Results and discussion** Overall, adding chestnut skins into the basal diet decreased IVDMD by 16%, total gas and $CH_4$ production by 14% and increased $NH_3$ by 15% (averaged values, $P < 0.001$, Table 1), while VFA production was not significantly different among treatments. The type of chestnut skins impacted IVDMD, gas, $CH_4$ and $NH_3$ ($P < 0.001$), but there was no effect of peeling method, variety and mode of production on all the parameters, except for IVDMD which was higher with the variety M15 than for the variety Sylvestre ($P = 0.001$). Reduced fermentability when chestnut skins are incorporated in basal diet could be explained by their high ADL content (in average, 220 g/kg DM). Surprisingly, lower IVDMD and gas production were not associated with lower VFA, which is important in terms of energy supply to the animal.

**Table 1** *In vitro* rumen fermentation characteristics of basal diet alone or containing 200 g/kg of two varieties of chestnut skins produced under two mode of production and two peeling methods

| Peeling method | | Oven-drying, 85°C, 2 h | | | | Microwave, 700W, 8 min | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mode of production | | Organic | | Conventional | | Organic | | Conventional | | | |
| Variety | Basal diet | Sylv. | M15 | Sylv. | M15 | Sylv. | M15 | Sylv. | M15 | SEM | *p*-value |
| IVDMD (%) | $54.2^{e}$ | $44.3^{a}$ | $45.0^{abc}$ | $44.7^{ab}$ | $47.0^{d}$ | $44.9^{abc}$ | $46.4^{bcd}$ | $45.5^{abcd}$ | $46.5^{cd}$ | 0.54 | < 0.001 |
| End products (mmol/g DM) | | | | | | | | | | | |
| Total VFA | 4.12 | 3.67 | 3.81 | 3.94 | 4.17 | 4.05 | 3.87 | 4.20 | 4.05 | 0.259 | 0.563 |
| $NH_3$ | $0.43^{ab}$ | $0.54^{b}$ | $0.56^{b}$ | $0.49^{ab}$ | $0.40^{a}$ | $0.45^{ab}$ | $0.55^{b}$ | $0.48^{ab}$ | $0.50^{ab}$ | 0.046 | < 0.001 |
| Total gas | $7.16^{c}$ | $6.15^{ab}$ | $6.01^{a}$ | $6.00^{a}$ | $6.26^{ab}$ | $6.30^{b}$ | $6.19^{ab}$ | $6.16^{ab}$ | $6.18^{ab}$ | 0.068 | < 0.001 |
| $CH_4$ | $1.54^{d}$ | $1.33^{abc}$ | $1.29^{a}$ | $1.28^{ab}$ | $1.35^{bc}$ | $1.37^{c}$ | $1.34^{abc}$ | $1.33^{abc}$ | $1.34^{abc}$ | 0.024 | < 0.001 |

SEM, standard error of the mean; IVDMD, *in vitro* dry matter degradability; VFA, volatile fatty acids
$^{a,b,c,d,e}$ Means within a row with different subscripts differ ($P < 0.05$).

**Conclusion** Although incorporation of chestnut skins decreases fermentability, the absence of negative impact on VFA production may maintain the energy supply to the animal, regardless the way the chestnut skins are produced.

**Acknowledgements** This study was supported by the Institut carnot F2E (COMBITAN research project).

**References**

Niderkorn V., Mueller-Harvey, I., Le Morvan, A., Aufrère, J. 2012. Animal Feed Science and Technology, 178, 48-56.

# Potential of fenugreek (*Trigonella foenum-graecum* L.) fodder and seeds for sheep feeding under Tunisian conditions

Salah Benyoussef, Hichem Ben Salem

*Institut National de la Recherche Agronomique de Tunisie (INRAT), Université de Carthage, Rue Hédi Karray, 1004, ELManzah, Tunis, Tunisia*

E-mail: benyoussef.salah@gmail.com

**Take home Message** As grain, a pure stand or in a hay mixture, fenugreek is a valuable source of protein for fattening sheep.

**Introduction** Fenugreek (*Trigonella foenum-graecum* L.) is an ancient annual legume that is native to the Mediterranean region and widely cultivated worldwide (Petroupoulous, 2002). This legume species is characterized by its low water requirement and wide adaptation to rainfed farming. It is a multi-purpose legume species and a commercially important spice crop grown for seeds and for quality forage for ruminants (Acharya, 2006). In Tunisia, fenugreek (FG) is still under-utilized in livestock feeding, although it could alleviate protein deficit and improve soil fertility through an appropriate rotation plan. The fodder potential of Fenugreek biomass and seeds under Mediterranean (particularly Tunisian) conditions is poorly investigated. A research program focusing on this topic was recently launched in our laboratory. We report herein some of our findings on the response of sheep to FG-containing diets.

**Material and methods** Three trials on fattening lambs were conducted. **Trial 1** compared growth responses to FG hay-based and oaten hay-based diets, while **Trial 2** compared responses to FG hay-based and FG-triticale mixture hay based-diets. The two hays came from two neighbouring 1 ha-fields, on which some agronomic prameters were measured on 6 randomly distributed square meters. In **Trial 3**, FG grains were incorporated as a protein source and compared to soyabean meal-based concentrate for lambs receiving oaten hay. In each trial, diets were allocated to a group of 8 to 10 Barbarine sheep. Daily intake and average daily gain (ADG) were determined during 90 days after 10 day-adaptation period. Appearent diet digestibilities were measured during 5 consecutive days on lambs housed in metabolic cages. Data generated from this study were submitted to statistical analysis using ANOVA procedures and means were compared using LSD (5%) for zootechnical data and T test for agrononic parameter means.

**Table 1** Results of Trial 1: Intake, diet digestibility and average daily gain of lambs receiving fenugreek hay or oaten hay-based diets

| | Fenugreek hay + 300 g concentrate | Oaten hay + 300 g concentrate | SEM | Prob. |
|---|---|---|---|---|
| ADG (g day$^{-1}$) | 69.8 | 40.9 | 4.70 | 0.001 |
| DMi (g DM day$^{-1}$) | 805 | 616 | 18.2 | <0.001 |
| DMiw (g DM day-1 kg-1 Metabolic weight) | 66.2 | 70.7 | 2.75 | 0.31 |
| Feed conversion ratio (kg diet DM kg$^{-1}$ BW gain) | 10.2 | 14.2 | 1.73 | 0.04 |
| Diet dry matter digestibility (%) | 66.6 | 65.9 | 0.83 | 0.81 |
| Diet organic matter digestibility (%) | 67.3 | 37.2 | 0.89 | 0.91 |
| Diet crude protein digestibility (%) | 69.6 | 55.3 | 2.01 | <0.001 |

**Results and discussion** In Trial 1, the dry matter intake (DMi) averaged 616 g day$^{-1}$ for lambs receiving an oaten hay-based diet compared to 805 g day$^{-1}$ for the FG hay-group. Lambs receiving FG hay grew faster than those on the oaten hay-based diet (P = 0.0015). The feed conversion ratio was greater for oaten hay compared to FG hay-fed lambs. In Trial 2, lambs assigned to FG hay exhibited greater DM intake (1221 against 1132 g day$^{-1}$) and ADG (165.5 vs 153.2 g) but had a lower feed conversion ratio (3.1 vs 3.5 kg dry matter (DM) kg$^{-1}$ body weight). However, monitoring agronomic parameters indicated that the crop mixture significantly surpassed the pure FG crop in terms of forage yield (7.46 T DM ha$^{-1}$ vs 5.63 T DM ha$^{-1,}$ P = 0.034), harvest height (66 cm over 58 cm, P= 0.049), and reduced weed infestation (data not shown). In Trial 3, lambs receiving FG grain or soya bean meal-containing concentrate grew similarly (120.3 g day$^{-1}$), as both lamb groups exhibited the same intake and digestion patterns. This result shows that FG grains could be a valuable alternative source of protein for fattening sheep.

**Conclusion** Based on the results obtained in the three trials we conclude that sheep fed fenugreek in the form of grain, pure stand hay or as a fenugreek-triticale mixture enhanced their feed intake and growth performance, when compared to conventional diets.

**Acknowledgements** This study was funded by the Ministry of Higher Education and Scientific Research as part of the research contract of the Laboratory of Animal and Forage Productions of INRAT.

**References**

Acharya S.N., Thomas J.E. Basu, S.K. 2006. Biodiversity 7 (3&4), 27–30.
Georgios A. Petropoulos. 2002. Fenugreek. The genus *Trigonella.* Taylor & Francis Inc,

# Impact of dried agro-industrial strawberry by-product as an alternative feed resource on rumen fermentation, milk production and quality , and blood parameters of lactating ewes

Amr S. Morsy[1], Yosra A. Soltan[2], Adel M. Saber[3], Elsad A. El-Wakeel[3]

[1]*Livestock Research Department, Arid Lands Cultivation Research Institute, SRTA-City, Alexandria, Egypt*
[2]*Animal Production Department, Faculty of Agriculture, Alexandria University, Alexandria, Egypt*
[3]*Agriculture Research Centre, Animal Production Research Institute, Sheep and Goats Research Department, Giza, Egypt*

E-mail: amrsalah277@hotmail.com

**Take home Message** Strawberry by-products (SBP) can be used as untraditional feed ingredients.

**Introduction:** The demand for livestock products quickly rises in most developing countries. However, many developing countries have feed deficits. Local alternative feed resources could play an important role in meeting this deficit. Strawberry by-products (SBP) processing, packing, distribution, and consumption generate a considerable amount of waste. According to The United Nations World Trade Center, Egypt ranks first in the world in the export of frozen strawberries in terms of amounts exported (140,000 tons), representing 20% of the quantities of global exports, with a value of 165 million dollars, representing 14.3% of the total world exports for 2019. Sánchez et al. (2010) reported that SBP is rich in phenolic compounds with high antioxidant activity. Thus, our hypothesis was, using these SBP in livestock feeding would add value to strawberry production and would reduce feed deficits in Egypt. The present study aimed to investigate the replacement value of SBP for berseem hay in terms of effect on milk production and quality, rumen fermentation, and blood parameters of lactating ewes.

**Material and methods** Thirty late pregnant Barki ewes were randomly assigned to one of 3 dietary treatments for 4 weeks before the expected lambing date until 8 weeks of lactation. The ewes were grouped (10 ewes/group). Control group (CON) received a basal diet, and berseem hay (50-50%), SBP1 and SBP2 groups received the same diet as the control, but after partial replacement of berseem hay with 25 and 50% SBP, respectively. Ewes were kept in semi-open sheds and fed the corresponding diets as a TMR while having free access to fresh water. After lambing, all samples were collected bi-weekly. The ruminal fluid was collected via the stomach tube after 3 h feeding to analyze ruminal VFA, $NH_3$ N, and protozoa. Milk samples were collected to determine milk composition. Blood samples were collected via a jugular vein to determine some biochemical characteristics. Data were analyzed using a linear mixed model (PROC MIXED from SAS version 9.1) (SAS, 2002)

**Results and discussion** The significant increases of VFA by SBP supply could be related to the increase of some individual VFA including butyrate concentration as mentioned by Donohoe et al. (2011). Dried strawberries are rich in essential amino acids especially from the point of view of animal feeding as mentioned by Pieszka et al (2015). This could partially explain the significant increase of $NH_3N$ by SBP. Dietary fiber derived from fruit pomace is a natural buffer, stabilizing rumen pH, which prevents the proper metabolism in the rumen (Abdollahzadeh and Abdulkarimi, 2012). This phenomenon can explain the stability of protozoa number of in SBP-ewes when compared with CON-ewes. Such increase of VFA can be considered a reason for a significant increase of milk yield. The increase of milk fat percentage could be due to raising individual VFA which is the main source of energy used for the synthesis of milk fat (Khiaosa-ard and Zebeli, 2014). Strawberry by-products are high in total polyphenols, making it a therapeutic feed source to animals (Djilas et al., 2011) and for that reason, no adverse effects were observed in blood metabolites.

**Table 1** Effect of strawberry by-products (SBP) on ruminal fermentation, milk production, and blood constituents of lactating Barki ewes.

| Parameters | Treatments | | | SEM | P-value |
|---|---|---|---|---|---|
| | CON | SBP1 | SBP2 | | |
| Total VFA, mmol/l | 49.81$^{b}$ | 77.10$^{a}$ | 67.05$^{a}$ | 1.01 | 0.024 |
| $NH_3$-N, mg/100 ml | 135.97$^{c}$ | 156.20$^{a}$ | 147.71$^{ab}$ | 2.84 | 0.009 |
| Protozoa, x $10^5$/ml | 29.84$^{ab}$ | 31.78$^{a}$ | 28.03$^{b}$ | 0.56 | 0.058 |
| Milk yield, kg/day | 1.06$^{b}$ | 1.22$^{a}$ | 1.23$^{a}$ | 0.03 | 0.074 |
| Milk fat% | 7.02$^{b}$ | 7.45$^{a}$ | 6.48$^{a}$ | 0.19 | 0.037 |
| Milk protein% | 3.44 | 3.59 | 3.61 | 0.07 | 0.507 |
| Milk lactose% | 5.05 | 5.41 | 5.50 | 0.11 | 0.189 |
| Blood total protein, g/dl | 56.76 | 57.47 | 55.11 | 0.49 | 0.112 |
| Blood albumin, g/dl | 26.47 | 27.22 | 25.63 | 0.38 | 0.293 |
| Blood glucose, mg/dl | 81.80 | 82.15 | 50.45 | 1.03 | 0.758 |
| Blood cholesterol, mg/dl | 208.77 | 205.16 | 211.45 | 1.43 | 0.222 |

**Conclusion** SBP can be used as a good feed ingredient to replace berseem hay in lactating ewes diets without any adverse effect on their production performance.

**Acknowledgments** This study was supported by the "Animal Production Research Institute".

**References**

Abdollahzadeh F., Abdulkarimi R. 2012. Life Science Journal 9, 81–85.
Djilas S.M., Tepic A.N., Savatovic S.M., Šumic Z.M., Čanadanovic-Brunet J.M., Ćetkovic G.S.,Vulic J.J. 2011. Acta Periodica Technologica 42, 33-44.
Donohoe D.R., Garge N., Zhang X., Sun W., O'Connell T.M., Bunger M.K., Bultman S.J. 2011. Cell Metabolism 13, 517-526.
Khiaosa-ard R., Zebeli Q. 2014. Livestock Science 162, 66–75.
Pieszka M., Gogol P., Pietras M., Pieszka M. 2015. Annals of Animal Science 15, 475-491.
Sánchez W., Murillo E., Méndez J. 2010. Scientia et. Technica 46, 138-143.
Statistical Analysis System. 2002. SAS PC Windows Version 9.2.0. SAS Institute Inc. Cary, NC, USA

# Acorn use as alternative feed resource: evaluation and impact on sustainability in southern Mediterranean cork oak forests

Boutheina Stiti[1], Maryem Khalfaoui[1], Salima Bahri[1], Nizar Moujahed[2], Abdelhamid Khaldi[2]

[1]*National Researches Institute of Rural engineering, Water ad Forests (INRGREF), University of Carthage, Ariana. Tunisia.*
[2]*National Agronomic Institute of Tunisia, University of Carthage. Ecosystems and Aquatic Resource Unit,* Tunis, Tunisia.

E-mail: stitibou@gmail.com

**Take home Message** The sustainable use of acorns in animal feed has no impact on the early stages of oak regeneration.

**Introduction** Interest in acorns is increasing as an alternative feed resource, especially, in the Southern Mediteranean oak forests where local populations are often poor and depended on livestock farming. In addition, the prices of roughage used in animal feed are raising more and more. Acorns can be used for up to 20% of the diet of chickens and ruminants and are nutritionally comparable to many cereal grains (Zarroug *et al.*, 2020). This study aims to assess acorn potential and valuate its economic value and to check the influence of their post-dispersal on natural regeneration.

**Material and methods** Acorns were collected directly from trees in November (harvest optimal period) then from the ground in the end of February. Indeed, two lots of 50 healthy trees each were used to quantity the seeds in 17 circular selected plots of 400 $m^2$ installed within a cork oak forest located in north-western Tunisia. Directly harvested on the trees of the first lot, all acorns were collected on two traps placed beneath the crown to avoid seed contact with the soil. To estimate the actual yield, acorns mass was determined per tree and then extrapolated per hectare using the density of the plots. To form the second lot, trees were selected to be close as possible to the trees of the first lot and belong to the same diameter and height classes. The second lot was used to assess (in number and mass) the acorns remaining on the forest ground in the end of February and to estimate the seedlings number derived from them in the spring in order to check the impact of acorn lost on the early stages of natural regeneration. The approach was to count the number of cork oak seedlings before the season harvest in autumn 2014 (November) and then in spring 2015 (April), period of the pick seedling emergence, in four orthogonal quadrats ($1m^2$) placed under each tree canopy. Moreover, a model was fit to correlate the mass of acorns produced per tree with dendrometric variables using the data of seeds gathered in November on the first lot of the 50 sampled trees. Economic value was assessed using market price of 2016 considered as farm gate price.

**Results and discussion** The results show a significant decrease in acorn quantity from 5.28 ± 4.61 t/ha in November to 0.684 ± 0.1 t/ha in February which indicate an important acorn loss. Moreover, the number of acorns recorded in February was estimated at 27 ± 41 acorns/$m^2$. Then in April, we recorded 4 ± 6 seedlings per $m^2$ (min=0 and max=34). Previously in November, we recorded 1 ± 2 seedlings/$m^2$ as a result of regeneration of the preceding year (2013) ranging between 0 and 16 seedlings/$m^2$. Furthermore, the average number of new seedlings was estimated in April at 40,000 seedlings/ha so there is not impact of acorn loss on the early stages of natural cork oak regeneration and on seedlings recruitment. A model was fitted to predict tree acorn production and to establish the best agroforestry system to optimize acorn use. It's a linear model, without constant, and with two variables (circumference at 0.30 m: C0.30 and circumference at 1.30 m: C1.30) was selected (table 1).

**Table 1** Parameters of the linear model adjusted to the weight of the acorns: Estimated value, Standard error (ES), value of the t statistic, approximate value of Pr > | t |. C1.3 (m): circumference at 1.30 m, C0.3 (m): circumference at 0.3 m.

| Parameter | Estimated value | ES | Value of t | Approximate value Pr > \|t\| |
|---|---|---|---|---|
| C1.30 | 36.202 | 7.964 | 4.523 | 0.000 |
| C0.30 | –0.235 | 0.073 | –3.233 | 0.002 |

Besides the economic value of acorns consumption as a part of grazing, at least 20% of the total production is picked by self-employment families to be stocked for livestock as supplementary feed and to be sold for other zones. As a result, 1.06 ± 0.92 t/ha is estimated to be available for the market. Considering the farm gate price at 0.042 €/kg in 2016, the value of acorns is estimated at 44.35 ± 38.72 €/ha. This showed a relatively high average value per hectare compared to other provisioning services valued in the same area, naming cork with 31 €/ha and grazing (including acorn consumption) with 89 €/ha (Khalfaoui *et al.*, 2020)

**Conclusion** From an economic point of view, the use of acorns is profitable. A sustainable sharing of acorn stock involving both forest administration and farmers can be a considerable step to use this resource without significant impact on the regeneration of oak forests. This research is ongoing to refine the findings.

**References**

Khalfaoui M., Daly-Hassen H., Stiti B., Jebari S., 2020. Forests 11 (2), 197.
Zarroug Y., Boulares M., Mejri J., Slimi B., Hamdaoui G., Djebi S., *et al*., 2020. International Journal of Analytical Chemistry, Article ID 8868673, 1-9.

# Evaluation of forage quality of *Vicia sativa* and *Pisum sativum* genotypes cultivated in different environments

Apostolos P. Kyriazopoulos[1], Maria Irakli[2], Zoi M. Parissi[3], Theodoros Manousidis[1], Eleni M. Abraham[3]

[1]*Department of Forestry and Management of the Environment and Natural Resources, DUTh, 193 Pantazidou str., 68200 Orestiada, Greece*
[2]*IPB&GR Central Unit, Thermi, Thessaloniki, Greece*
[3]*Laboratory of Range Science (236), Faculty of Forestry and the Natural Environment, AUTh, 54124 Thessaloniki, Greece*

E-mail: apkyriaz@fmenr.duth.gr

**Take home Message** Both common vetch and forage pea are promising sustainable alternative feeding resources for livestock when cultivated in the appropriate environmental conditions

**Introduction** Common vetch (*Vicia sativa*) and forage pea (*Pisum sativum*) are characterized as particularly promising and realistic sustainable alternative source of protein for livestock feeding. However, the presence of antinutritional factors, mainly conducted condensed tannins and total phenols may limit their feeding value. Thus, the cultivation of varieties best adapted in field conditions with low concentration of antinutritional factors is among the main goals of forage breeding programs. The aim of the present study was to evaluate various genotypes of these two species cultivated under different field conditions in terms of forage quality and antinutritional parameters.

**Material and methods** *Vicia sativa* (genotypes BK27, BK29, BK45, Evinos) and *Pisum sativum* (genotypes MP9, MP15, MP29, Arvica) were seeded and cultivated during 2018–2020 period. Field experiments were carried out at three locations: (a) the farm of the Agricultural University of Athens (AUA) (southern Greece), (b) the central farm of IIFC (Central Greece) and (c) the farm of the Aristotle University of Thessaloniki (AUTH) (northern Greece). Forage samples were analyzed for N and then calculated the crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL) and *in vitro* true digestibility (IVTD). For each genetic material, a seed bulk was obtained, and three biological replicates were used to determine total phenolic content (TP) based on Folin-Ciocalteu method, total tannins content (TT) subtracting non-tannin phenolics from TP and condensed tannins (CT) according to butanol-acid assay.

**Results and discussion** Forage of *Vicia sativa* cultivated in northern Greece (AUTH) had the highest CP and IVDT and the lowest NDF and ADF concentration. However, it had also the highest concentrations of all the measured antinutritional parameters. On the contrary, the forage which cultivated in southern Greece (AUA) had low concentrations of antinutritional parameters, while it had relatively high CP and IVTD concentrations, low ADL content and intermediate values of NDF and ADF. According to those findings, seems to be a promising alternative legume for livestock feeding when cultivated in warmer and drier conditions.

Forage of *Pisum sativum* cultivated in northern Greece (AUTH) had the highest CP and IVDT and the lowest NDF and ADF concentrations. However, it had also higher concentrations of all the measured antinutritional parameters than its cultivation in northern Greece, but lower than those in the central part of the country (IIFC). The antinutritional parameters were significantly lower in southern Greece but had very low IVTD and high NDF and ADF content, while the CP content was moderate. According to the results, forage pea can be suggested for cultivation in less warm conditions with higher participation.

**Table 1.** Chemical composition (g kg$^{-1}$ DM), IVTD (g kg$^{-1}$ DM), total phenols (TP) (mg GAE g$^{-1}$), total tannins (TT) (mg GAE g$^{-1}$) and condensed tannins (CT) (mg PCNE g$^{-1}$). of *V. sativa* and *P. sativum* in three different environments

| | NDF | ADF | ADL | CP | IVTD | TF | TT | CT |
|---|---|---|---|---|---|---|---|---|
| *Vicia sativa* | | | | | | | | |
| AUA | 360$^{b}$ | 232$^{a}$ | 51$^{a}$ | 169$^{b}$ | 77$^{b}$ | 7$^{a}$ | 4$^{a}$ | 0.18$^{a}$ |
| IIFC | 398$^{c}$ | 271$^{b}$ | 56$^{a}$ | 126$^{c}$ | 77$^{b}$ | 9$^{a}$ | 3$^{a}$ | 0.23$^{a}$ |
| AUTH | 334$^{a}$ | 226$^{a}$ | 66$^{b}$ | 188$^{a}$ | 82$^{a}$ | 11$^{b}$ | 5$^{b}$ | 0.33$^{b}$ |
| *Pisum sativum* | | | | | | | | |
| AUA | 410$^{b}$ | 282$^{b}$ | 35$^{a}$ | 135$^{b}$ | 64$^{c}$ | 8$^{a}$ | 3$^{a}$ | 0.19$^{a}$ |
| IIFC | 412$^{b}$ | 305$^{b}$ | 48$^{a}$ | 74$^{c}$ | 77$^{b}$ | 16$^{c}$ | 8$^{c}$ | 0.26$^{ab}$ |
| AUTH | 297$^{a}$ | 186$^{a}$ | 49$^{a}$ | 175$^{a}$ | 90$^{a}$ | 13$^{b}$ | 6$^{b}$ | 0.30$^{b}$ |

**Conclusion** Field conditions affected forage quality and antinutritional parameters for both species. It seems that *Vicia sativa* produced forage of better quality in southern Greece, while *Pisum sativum* performed better when cultivated in the north.

**Acknowledgements** Co-financed by the European Regional Development Fund of the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH–CREATE–INNOVATE (project code: T1EDK-04448)".

# Effects of cocoa bean shell on goat milk yield and composition

Manuela Renna, Carola Lussiana, Letizia Colonna, Vanda Maria Malfatto, Antonio Mimosi, Paolo Cornale

*Department of Agricultural, Forest and Food Sciences, University of Torino, Grugliasco (TO), Italy*

E-mail: manuela.renna@unito.it

**Take home Message** Cocoa bean shell can be used as a novel and sustainable feed ingredient in dairy goat diets.

**Introduction** Vegetable agro-industrial by-products can be used in animal nutrition to lessen human-animal competition for food supply, feeding costs on farm and environmental impact of livestock production (Yang *et al*., 2021). Cocoa (*Theobroma cacao* L.) bean shell (CBS), a discarded waste of the cocoa industry, is a rich source of protein, fiber and phenolic compounds (Rojo-Poveda *et al*., 2020). Studies are available on the potential use of CBS as feed ingredient for pigs, rabbits, layers, fish, cattle, and sheep, while no information is currently available for goats. The aim of this study was to assess the effects of the inclusion of CBS in the diet of dairy goats on their feed intake, milk yield, milk main constituents and feed efficiency.

**Material and methods** Twenty-two mid-lactating multiparous Camosciata delle Alpi goats were divided into two balanced groups and fed isonitrogenous and isoenergetic diets. Both groups were fed mixed hay *ad libitum*. The first group (control, CON) also received 1.2 kg/head × day of a commercial concentrate, while the second group (cocoa bean shell, CBS) daily received 1.0 kg/head of the same commercial concentrate and 0.2 kg/head of pelleted cocoa bean shell [per kg dry matter (DM): 173 g crude protein; 61 g ether extract; 495 g neutral detergent fibre; 177 g lignin; net energy for lactation: 4.27 MJ]. After ten days of adaptation to the diets, feed intake was recorded daily. Milk yield and milk samples collection occurred four times during the trial. Milk samples were analysed for fat, protein, lactose, casein, somatic cell count and urea. Data were statistically analysed with a mixed model for repeated measures. Significance was declared at $P<0.05$.

**Results and discussion** No palatability issues regarding the investigated by-product arose, as both CON and CBS-containing concentrates were always fully eaten by the goats. The inclusion of CBS in the goat diet decreased the voluntary intake of hay. As the tannin content in the tested CBS was relatively low (total tannins = 8.76 g/kg DM), we hypothesize that such effect would be the consequence of the presence of theobromine (4.3 g/kg DM), a toxic alkaloid, or of high amount of lignin in cocoa by-products (Aregheore, 2002). Neither milk yield nor milk fat, protein and casein contents were significantly affected by the dietary inclusion of CBS.

**Table 1** Milk production performance of dairy goats fed the CON and CBS diets.

| | Dietary treatment | | P-value | |
|---|---|---|---|---|
| | CON | CBS | DT | SD |
| Hay intake (dry matter basis) | 1.22 | 1.11 | *** | *** |
| Total dry matter intake (DMI) | 2.28 | 2.16 | ** | *** |
| Milk yield (kg/head × day) | 1.81 | 1.70 | ns | ns |
| Energy corrected milk (ECM, kg/head × day) | 1.84 | 1.75 | ns | ns |
| Fat (g/kg) | 37.37 | 37.05 | ns | ns |
| Protein (g/kg) | 32.04 | 33.44 | ns | ns |
| Casein (g/kg) | 24.76 | 26.01 | ns | ns |
| Lactose (g/kg) | 41.39 | 39.76 | *** | * |
| Urea (mg/dL) | 48.01 | 38.09 | *** | *** |
| Somatic cell count (×1,000 cells/mL) | 942.49 | 1096.37 | ns | ns |
| Feed efficiency (ECM / DMI) | 0.81 | 0.81 | ns | ns |

DT, dietary treatment; SD, sampling date. Significance: ***, P<0.001; **, P<0.01; *, P<0.05.

The lactose and urea contents were significantly lower in the milk secreted by the CBS-fed goats when compared to the CON group ($P<0.001$). These parameters have been positively correlated each other in goat milk (Čobanović *et al*., 2019). Urea results could be imputable to the high proportion of rumen undegradable protein (59% of total protein), particularly unavailable nitrogen, in CBS, which lowers the ratio between available protein and available energy in the rumen, confirming previous results obtained in the ovine species (Campione *et al*., 2021). Feed efficiency, calculated as the ratio between energy corrected milk and DM intake, remained unaffected by the treatment, as seen to occur for other by-products that have been tested in goat nutrition (Marcos *et al*., 2020).

**Conclusion** Cocoa bean shell can be used as feed ingredient when formulating diets for lactating dairy goats. Nutritionists should be aware of the limits imposed by the EU legislation concerning the theobromine content in animal feed. Technological treatments (i.e., detheobromination) are available to prevent theobromine-related toxic phenomena.

**Acknowledgements** This study was funded by the University of Turin (Project CORP_RILO_17_01).

**References**

Aregheore E.M. 2002. Tropical Animal Health and Production 34, 339-348.
Campione A., Pauselli M., Natalello A., Valenti B., Pomente C., Avondo M., Luciano G., Caccamo M., Morbidini L. 2021. Animal 15, 100243.
Čobanović K., Krstović S., Štrbac L., Šaran M., Kasalica A., Popović M. 2019. Contemporary Agriculture 68(3-4), 88-91.
Marcos C.N., Carro M.D., Fernández Yepes J.E., Haro A., Romero-Huelva M., Molina- Alcaide E. 2020. Journal of Dairy Science 103, 1472-1483.
Rojo-Poveda O., Barbosa-Pereira L., Zeppa G., Stévigny C. 2020. Nutrients 12, 1123.
Yang K., Qing Y., Yu Q., Tang X., Chen G., Fang R., Liu H. 2021. Agriculture 11, 207.

# Potential risks associated with pesticides and heavy metals in agro-industrial by-products as feeds for livestock

Mahmoud HA. Hassan[1], Alejandro Belanche[2], Ignacio Martín-García[1], Manuel Romero-Huelva[1], Eva Ramos-Morales[1], David R. Yáñez-Ruiz[1]

[1]*Estacion Experimental del Zaidin, CSIC, Granada, Spain*
[2]*Universidad de Zaragoza, Zaragoza, Spain*

E-mail: david.yanez@eez.csic.es

**Take home Message** Despite the high variability across by-products, pesticides and heavy metals have been detected in certain agro-industrial by-products. This should be carefully considered when they are fed to ruminants during prolonged periods of time in order to prevent animal health and food security risks.

**Introduction** The steady increase in fruits and vegetables production across the Mediterranean basin in the last decade generates vast amounts of agro-industrial by-products that can potentially lessen the current deficit in conventional feeds. Fruits and vegetables, plus roots and tubers have the highest wastage rates of any food (Parfitt et al., 2010). We have recently shown that the inclusion of different agro-industrial by-products in the diet of dairy goats results in a substantial reduction of the carbon footprint of goat milk (Pardo et al., 2016). Although the nutritional value of most by-products is widely known, their utilization is hindered by several factors, one of them being the poor control and knowledge of potential undesirable residues in the by-products from the chemical treatment applied to the crops or through processing such as pesticides or heavy metals (Choudhary et al., 2018). The objective of this work was to evaluate the potential risks associated with including a range of agro-industrial by-products from South Spain as ruminant feeds by determining the content in pesticides and minerals.

**Material and methods**. The following by-products were analyzed: apple pomace, citrus pulp, avocado seed, broccoli, watermelon silage, olive cake, avocado cake, and six types of silages made with straw and a combination of different by-products (80/20) from the intensive greenhouse horticulture: cucumber, tomato, pepper-cucumber, eggplant-tomato silage, tomato-pepper-watermelon silage, and watermelon-melon-tomato. The content in heavy metals and other minerals was quantified by atomic spectroscopy inductively coupled plasma-optical emission spectrometry analysis. The presence of pesticides residues was determined by Gas chromatography with mass spectrometer detector and Ultra-resolution liquid chromatography with mass spectrometer detector.

**Results and discussion** The mineral profile analysis showed a great variation in the content of minerals especially heavy metals among the different by-products. Watermelon silage had the highest content of aluminum (3885 ppm), titanium (65 ppm), strontium (270 ppm), and cucumber silage presented the highest content of silicon (3317 ppm), while apple pomace varieties recorded the lowest content of those minerals. The difference in the mineral profiles among the by-products could be due to the availability of minerals in the different soils and the fertilization schedule. The use of aluminum lignosulfonate as a complexing agent in mixtures of trace minerals and silica treatment in greenhouse intensive horticulture cultivations to enhance plant growth and resistance to environmental stresses and fungal diseases may explain the abundance of aluminum and silica in some by-products (Sahebi et al., 2015). It was also noticeable the high content of some metals (Fe, Cr, Si) which also may be related to the industrial manipulation process (Arco et al., 2016). With regards to pesticides, 45 types of compounds commonly used in agriculture were analyzed. A review of the EU database on maximum residue level for pesticides, confirms that all by-products used in this study were within the safe levels except for cucumber silage and watermelon-melon-tomato silage, that contained Tiabendazole (0.04 ppm), (EU, 2021) and the presence of Imazalil 0.09 ppm in lemon pulp. Thiabendazole is a synthetic preservative, that if ingested in low doses it may cause health problems. Imazalil is used for the prevention of mold in citrus fruits and has been described as a human carcinogen.

**Conclusion** The mineral content is very variable among by-products and their incorporation in the diets requires balancing well the overall mineral supply. Some by-products may contain large amounts of metals, which should be carefully evaluated if they were supplied during prolonged periods of time. The by-products studied are generally safe in terms of pesticide residues but the presence of some (Chlorpyrifos, Imazalil and Tiabendazole) above permitted legal levels should be carefully monitored and considered for future in vivo trials.

**Acknowledgements** EU Horizon 2020 research and innovation program under grant agreement Nº 818368 (MASTER).

**References**

Arco A., Yáñez-Ruiz D.R., Martín-García A.I. 2016. Options Méditerranéennes. Série A, Séminaires Méditerranéens 115, 275-279.
Choudhary S., Yamini N.R., Kamboj M., Sharma, A. 2018. Journal of Entomology and Zoology Studies 6(3), 330-333.
European Union (2021), https://ec.europa.eu/food/plant/pesticides/max_residue_levels_en
Hejna M., Gottardo D., Baldi A., Dell'Orto V., Cheli F., Zaninelli M., Rossi L. 2018. Animal 12(10), 2156-2170.
Pardo G., Martin-Garcia I., Arco A., Yañez-Ruiz D.R., Del Prado A. 2016. Animal Production Science 56(3), 646-654.
Parfitt J., Barthel M., Macnaughton S. 2010. Philosophical transactions of the royal society B: biological sciences 365(1554), 3065-3081.
Sahebi M., Hanafi M.M., Siti Nor Akmar A., Rafii M.Y., Azizi P., Tengoua F.F., Azwa J.N.M., Shabanimofrad M. 2015. BioMed research international, 2015.

# Modern domestication of Mediterranean pasture and fodder crop legumes

Phillip G.H. Nichols

*School of Agriculture and Environment and Institute of Agriculture - The University of Western Australia, Crawley, Australia*

E-mail: phillip.nichols@uwa.edu.au

**Take home Message** The Mediterranean region has been a rich source of pasture and fodder crop legume species for development of new cultivars to increase agricultural productivity in a range of Mediterranean-type climates.

**Introduction** Pasture and fodder legumes are highly valued by farmers for their high nutritive value for livestock and their ability to fix atmospheric nitrogen and increase soil fertility. The grasslands of the Mediterranean basin have immense floristic diversity, particularly of legumes. For example, Davis (1970) lists 925 legume species in Turkey alone, with most being herbaceous. Much of southern Australia also has a Mediterranean-type climate, but very few Australian native legumes are herbaceous and palatable to ruminant livestock and many are toxic (Nichols *et al.* 2012). This has led to selected native Mediterranean legumes becoming domesticated, whereby seeds are harvested and traded, leading to the development of a pasture seeds industry. Nichols *et al.* (2012) list 47 species or taxa from the Mediterranean region that have been developed for use as pastures and fodder crops in Australia. Some of these cultivars have subsequently been sown in the Mediterranean basin and other countries with Mediterranean-type climates (Porqueddu *et al.* 2016). Subterranean clover (*Trifolium subterraneum*) and annual medics (*Medicago* spp.) were first domesticated in the early 20th century, but a concerted plant breeding and selection effort has broadened the range of legumes since the early 1990s. This paper focuses on the domestication of Mediterranean legumes for use as pastures and fodder crops in the past 30 years. It examines their traits and common features, the process of domesticating new species and the prospects for future legumes.

**Traits and common features** Individual legume species and cultivars have been selected for specific reasons and local adaptation, but common features include: (i) high biomass and nutrition for livestock; (ii) no anti-nutritional or animal health issues; (iii) compatability with desirable grasses or herbs; (iv) competitiveness with weeds; (v) resistance to important pests and diseases; (vi) tolerance of key abiotic stresses; and (vii) grazing tolerance (pasture legumes). For permanent or semi-permanent pastures, persistence over seasons is important. Perennial species need traits for maintaining high plant density over seasons, while annuals need traits for seed production and reliable regeneration, including seed dormancy mechanisms to prevent out of season germination and harseededness for regeneration after seasons of little or no seed set. This latter aspect is crucial for annual legumes in ley farming systems. Fodder crops also need good cutting and curing traits. Importantly for all legumes are traits for high seed production and ease of harvesting and processing, to enable availability of low-cost, quality seed for farmers.

**Key steps in domestication** Domestication of a new species commences with the recognition of an agronomic need or potential opportunity (new agro-ecological niches or farming systems) not satisfied by current species. The key steps, outlined by Nichols *et al.* (2010), are: (i) germplasm acquisition from Genetic Resource Centres or targeted collection trips; (ii) identification of plants with desirable traits; (iii) evaluation of elite genotypes under farming conditions; (iv) 'duty of care' trials to confirm safety to grazing animals and weed risk assessment studies (Revell and Revell 2007); and (v) cultivar release (production and release of seed to industry). Further cultivars can then be developed for different agro-ecological niches or farming systems.

**New species and prospects for future pasture and fodder crop legumes** The perennial legumes, tedera (*Bituminaria bitumonosa* var. *albomarginata*), lebeckia (*Lebeckia ambigua*) and alsike clover (*T. hybridum*), and the annual legume, messina (*Melilotus siculus*), have been commercialised in Australia since the Nichols *et al.* (2012) review. Development of new species in Australia is less likely in the near future, due to reduced public funding for plant development and the unattractiveness of this high-risk activity to private industry. Instead, cultivar development is likely to be confined to current species, particularly the most profitable. However, the effects of climate change may lead to domestication of new species in the future, particularly those with traits for greater resilience under water and heat stresses.

**Acknowledgements** This study was supported by the Annual Legume Breeding Australia (ALBA) Joint Venture between the University of Western Australia and DLF Seeds.

**References**

Davis P. 1972. 'Flora of Turkey and the East Aegean Islands' (Edinburgh University Press: Edinburgh)

Nichols P.G.H., Loi A., Nutt B., Snowball R., Revell C. 2010. In 'Sustainable use of genetic diversity in forage and turf breeding' pp 137-141 (Springer: Dordrecht)

Nichols P.G.H., Revell C.K., Humphries A.W., Howie J.H., Hall E.J., Sandral G.A., Ghamkhar K., Harris C.A. 2012. Crop and Pasture Science 63, 691-725.

Porqueddu C., Ates S., Louhaichi M., Kyriazopoulos A.P., Moreno G., del Pozo A., Ovalle C., Ewing M.A., Nichols P.G.H. 2016. Grass and Forage Science 71, 1-35.

Revell C., Revell D. 2007. Field Crops Research 104, 95-102.

# Emerging and sustainable feed source: insects

Laura Gasco

*Department of Agricultural, Forest and Food Sciences - University of Turin, Turin, Italy*

E-mail: laura.gasco@unito.it

**Take home Message** Insect-derived products seem to be a good alternative to conventional feed sources and can make an important contribution to the sustainable development of the livestock industry.

As results of changes in food patterns and rising income, an increase in products of animal origin consumption is forecast, especially in emerging countries, which will led, in turn, to an increase in livestock and feed production. In 2022, the global compound feed production recorded an increase of 2.3% compared to 2021, reaching 1.235 billion metric tons. Major producers (65% of the total) are China (261.424 milion metric ton, mmt), U.S. (231.538 mmt), Brazil (80.094 mmt), India (44.059 mmt), Mexico (38.857 mmt), Spain (35.580 mmt), Russia (33.000 mmt), Turkey (25.300 mmt), Japan (24.797 mmt) and Germany (24.506 mmt) (Alltech, 2022). The use of conventional ingredients in animal feeds rises sustainability questions and the livestock sector needs new alternative ingredients to face them. In particular, the production of soybean meal, the most used protein source for farmed livestock, requests large amounts of land, water and energy, and a further increase, to meet future requirements, is no longer affordable.
Moreover, if the proteins shortage for feed is a global issue, it affects in particular the rural areas of developing countries where access to raw materials is less and less sustainable. The volatility of commodity prices and their continuous rise have a huge impact on small businesses. Feed is the main constrain for low-income farms, and the current challenge is to contain it to ensure their economic sustainability.

The last decades have seen a growing interest for the use of insects-derived nutrients in animal feeds. Insects contain high quality protein (with an amino acid profile better than soybean meal), lipids, minerals and vitamins and, for a decade, they have been seen as one of the most promising alternatives to conventional protein sources. Due to the different bioactive compounds they contain (chitin, specific fatty acids, and anti-microbial peptides), insect meals modulate the animal microbiota or stimulate the immune system with possible positive effects on animal health and welfare (Gasco et al., 2021).
In addition to their particular interesting nutritional profile, insects in animal nutrition could also lead to environmental advantages as their rearing requires low amount of soil and water and produce low greenhouse gases and ammonia emissions leading to an overall low environmental impact (Smetana et al., 2021). Some species are also very efficient in converting organic wastes, giving further answers to environmental issues and exalting the principles of Circular Economy.
For feed production, some species resulted most promising: black soldier fly (*Hermetia illucens*), common housefly (*Musca domestica*), and yellow mealworm (*Tenebrio molitor*). When formulating diets containing insects, factors such as the insect species, the process applied to insect larvae to produce insect-derived meals, and the level of inclusion are the main factors to take into consideration as they have a dramatic impact on performances and digestibility.

Legislation on the rearing and use of insect-derived products as feed is different from country to country. Under European Union (EU) rules, insects kept for the production of food, feed or other purposes are classified as "farmed animals" (Regulation (EC) No 1069/2009) and can therefore only be fed authorised (feed graded) substrates, listed in the Regulation (EU) 2017/1017. Nevertheless, outside EU, regulations on feeds for insects are less stringent and substrates such as waste, manure or other materials of animal origin are allowed.
According to EU legislation, only seven insect species can be processed to produce proteins for aquaculture (Regulation (EU) 2017/893) and poultry and swine (Regulation (EU) 2021/1372) feeds. The use of processed proteins from insect in ruminant feeds is forbidden. However, outside EU, regulation differs and the restriction for ruminants does not apply.

Research performed so far indicates that partial or total substitution of conventional protein sources with insect meals in fish, poultry and pigs is possible with no major negative effects (Hua, 2021; Liland et al., 2021; Moula and Detilleux, 2019; Veldkamp and Vernooij, 2021). Information on insect-fed ruminants is limited and investigation mainly addressed *in vitro* digestibility assessments (Toral et al., 2022).
As far as the quality of products derived from animals fed insect meals is concerned, a strong influence on the fatty acid profile is reported, with a decrease in valuable n-3 fatty acids, while sensory analyses have reported no or slight differences.
Insect-derived products seem to be a good alternative to conventional feed sources and can make an important contribution to the sustainable development of the livestock industry.

**References**

AllTech, 2022. 2022 Alltech Global Agri-Food Outlook. What does global feed production reveal about the future of agri-food? Available at https://www.alltech.com/agri-food-outlook
Gasco L., Józéfiak A., Henry M. 2021. Journal of Insect as Food and Feed, 7, 715-741.
Hua K. 2021. Aquaculture, 530, 735732.
Liland N.L., Araujo P., Xu X.X., Lock E.-J., Radhakrishnan G., Prabhu A.J.P., Belghit I. 2021. Journal of Insects as Food and Feed, 7, 743-759.
Moula N., Detilleux J. 20119. Animals 9, 201.
Smetana S., Spykman R., Heinz V. 2021. Journal of Insects as Food and Feed, 7, 553-571.
Toral P.G., Hervás G., González-Rosales M.G. Mendoza A.G., Robles-Jiménez L.E., Frutos P. 2022. Journal of Animal Sciences and Biotechnol 13, 21.
Veldkamp T., Vernooij A.G. 2021. Journal of Insects as Food and Feed. 7, 781 – 793.

# Characterization of lipids of *Hermetia illucens* and *Tenebrio molitor* meals as feed ingredients

Giuseppe Conte, Monica Tognocchi, Andrea Serra, Marcello Mele

*Department of Agriculture, Food and Environment - University of Pisa, Pisa, Italy*

E-mail: giuseppe.conte@unipi.it

**Take home Message** Enrich knowledge about the quality of insect lipids that could be used in animal nutrition.

**Introduction** World population is expected to reach over 9 billion people in 2050. This trend indicates that market demand for food will continue to grow. Consequently, the demand for cereal and protein sources for both human food and animal feed is expected to increase exponentially by 2050 (ISPI, 2015). Hence, humans and livestock will compete for the world source of some conventional feedstuffs. Therefore, efforts must be devoted to the identification of alternative sources of protein, energy and other nutrients for livestock, in order to avoid such competition (FAO, 2013). Although increasingly considered in animal feeding, the lipids of black soldier fly (*Hermetia illucens* – HI) and mealworm (*Tenebrio molitor* – TM) larvae and pupae are not yet fully characterized. In this study, we provide a comprehensive characterization of lipids: total lipid, triglycerides, phospholipids and sterol contents and fatty acid profile.

**Material and methods** Twenty-four batches (12 batches per species divided into 6 batches of larvae and 6 batches of pupae), each consisting of 70 subjects, were used for the analysis. Each batch was considered as one biological replicate. A first characterization of the lipids was performed by determining the saponifiable (containing fatty acids) and unsaponifiable (containing sterols) fractions by gas chromatography. Furthermore, for a more in-depth analysis, the saponifiable fraction of lipids were separated into the two components, neutral (triglycerides) and polar (phospholipids) to evaluate the organization of the FA in the lipid structure. Finally, for a more detailed characterization of the nutritional properties, we obtained the profile of the esterified FA in sn-2 position of the triglycerides, which represent the most adsorbed fraction by animals during digestion. The data were statistically analysed (JMP Pro 16.1.0 2021, SAS) with a linear model that took into account the fixed effect of the species and the stage of development, as well as their interaction and the random effect of the batch.

**Results and discussion** The composition of the lipids is presented in Table 1. The lipid content was significantly higher in TM than in HI. Saturated fatty acids (SFA) were most abundant in HI than TM, which conversely showed a greater level of unsaturated fatty acid. The major FAs in HI were C12:0, C18:1c9 and C16:0, while the more abundant FAs in TM were C18:2n6, C18:1c9 and C16:0. In both species, the FA that showed greater affinity for the sn-2 position of the triglyceride were: C10:0, C17:0, C18:0, C18:1c11, C18:2c9t11, C20:2n6, C20:4n6, C20:5n3. On the contrary, we revealed a higher affinity for sn-1,3 position for C18:2n6, C18:3n3. The level of phospholipids was higher in HI than TM. Phosphatidylethanolamine and Phosphatidylcholine were the most abundant phospholipids, while Sphingomyelin was only revealed in larvae. In both species, cholesterol, campesterol, brassicasterol, d-avenasterol, and β-sitosterol were identified. HI samples contained more sterols than TM, especially in larvae. The characterization of polar and non-polar lipids may contribute to better define the lipid nutrients provided when these insect meals are included as feed ingredient. The different lipid profile of the two insect meals considered suggests potential different uses in the formulation of animal diets. TM showed a FA composition very similar to that of vegetable lipid sources, in particular soybean, corn or sunflower. On the other hands, HI is characterized by a higher content of SFA and, very interestingly, CLA isomers. These characteristics might be of interest for feeding monogastrics and fish. Furthermore, the higher content of phospholipids makes this species an excellent ingredient for the formulation of the feed concentrate, because it allows a better homogenization of lipids.

**Table 1** Lipid profile of *H. illucens* and *T. molitor* (g/100g of total lipids)

| | Item | | | | SEM | P-value |
|---|---|---|---|---|---|---|
| | TM larvae | TM pupae | HI larvae | HI pupae | | |
| Total lipids (TL) | 10.71$^{a}$ | 9.07$^{b}$ | 3.88$^{c}$ | 8.04$^{b}$ | 0.45 | <0.001 |
| Triglycerides (%TL) | 80.12$^{a}$ | 80.05$^{a}$ | 61.33$^{b}$ | 61.35$^{b}$ | 2.40 | <0.001 |
| Phospholipids (%TL) | 6.90$^{c}$ | 7.90$^{c}$ | 17.90$^{b}$ | 30.20$^{a}$ | 2.10 | <0.001 |
| SFA (%TL) | 18.73$^{c}$ | 18.83$^{c}$ | 40.68$^{b}$ | 52.40$^{a}$ | 0.98 | <0.001 |
| MUFA (%TL) | 34.21$^{a}$ | 32.09$^{a}$ | 26.34$^{b}$ | 27.22$^{b}$ | 0.91 | <0.001 |
| PUFA (%TL) | 34.08$^{b}$ | 37.03$^{a}$ | 12.21$^{c}$ | 11.93$^{c}$ | 0.69 | <0.001 |
| Sterols | 0.64$^{b}$ | 0.65$^{b}$ | 3.98$^{a}$ | 1.11$^{b}$ | 1.01 | <0.001 |

**Conclusion** These results provide new nutritional information for the use of TM and HI in animal feeding.

**Acknowledgements** The authors thank the GO FEEDS project for providing larvae and pupae.

**References**

FAO (2013). Edible insects- future prospects for food and feed security. FAO Forestry Paper 171, IX.
ISPI (2015). Annual report, (Ed. Epoké, Novi Ligure, Italia), ISBN 978-88-98014-52-1.

# Developing synergies between the exploitation of the Mediterranean forests and their contribution to the food systems of small ruminants, a challenge for public policies: The case of Corsica

Jean-Paul Dubeuf[1], Regis Lorton[2]

[1]*INRAE SELMET-LRDE, Corte, France*
[2]*DRAAF CORSICA -Ministry of Agriculture, Ajaccio, France*

E-mail: jean-paul.dubeuf@inrae.com

**Take home message**: The development of silvopastoralism in the Mediterranean will depend on the capacity of public authorities to build relevant transverse incentives and governance.

**Introduction** In Corsica, as in many other Mediterranean hinterlands, forests occupy a large part of the territory (44%). Forestry production is struggling to structure itself due to the dispersion of forest ownership and the general poor condition of the forests. We explore to what extent the bio-mass of these forests, which constitutes an important potential resource, could be valued within the framework of the development of a silvopastoral strategy. We consider silvopastoralism as a mode of sustainable agriculture combining production of wood and pastoral objectives. It involves loggers and breeders, whether they are individual or collective, working together for their reciprocal benefit by creating synergies between the presence of animals grazing and the development of the woods. Forests are defined as composed in a more or less loose tree layer, a shrub layer and/or a herbaceous layer. This type of cover includes private (80% of the surface) and public (20%) forests, whether territorial or communal.

**Material and methods** A technical group from several organisms involved in forest and pastoralism identified several pilot sites discuss how to manage the synergy between forest and pastoralism. We analyze the activity and observations of this group and confront it with the general difficulties and opportunities of both the pastoral and wood sectors. The organization of grazing and the interventions on the woods are described as well as the methods of their formalization and the regulations to finalize the agreements

**Results and discussion** For the Regional Center for Forest Property (CRPF) in Corsica, silvopastoralism is the most effective practice for managing forest plots with pastoral potentialities. The implementation of pastoral management plans is necessary to formalize this complementarity. Several mechanisms exist: multi-year grazing agreements, pastoral groups, farm leases or grazing concessions in the case of public forests under the French Forestry Regime. These plans must specify both the organization of grazing (period of protection without grazing, areas to be grazed, types of animals) and silvicultural interventions (silvicultural thinning, types of high forest cutting, areas to be cleared) to keep open forest environments while providing fodder resources to herds, mainly sheep and goats, but also cattle and running pigs. Despite the efforts made to promote sylvopastoralism and the public aid offered by the Rural Development Plan for Corsica, the number of projects remains very limited and are often experimental. Besides, the technical complexity of silvopastoral management has reinforced the difficulties for articulating the expectations of breeders and foresters. Beyond this observation, we can identify the main obstacles to the implementation of a sylvopastoral strategy in Corsica and probably in many Mediterranean regions:
- A lack of skills on the part of both livestock breeders and foresters and a lack of governance to offer effective support services
- The often too cumbersome administrative procedures due to a too much sectorial approach which makes it difficult to match the intentions of the several actors
- Difficulties in establishing dividing lines between forests and woody shrub lands and in terms of policies to clear the forests
- The eligibility criteria for forest areas under the first pillar of the CAP.

**Conclusion**
For many Mediterranean territories, sylvo-pastoralism whose principles fully meet the current challenges of the agro-ecological transition could contribute to the preservation of their forest areas and landscapes and could limit forest fires. The Corsican example, however, shows that silvopastoralism is still an experimental framework and remains largely an utopia. This study participates in the questioning of still very sectorial public policies so that public action take better in account the expectations of the actors of the territories and local initiatives and change their mental models.

**References**
Amandier L., Dureau R., Joffre L.M., Joffre R., Laurent J.L. 1982. Forêt méditerranéenne 4(1), 13-24.
Dubeuf J.P. Sándor Kukovics. Goat Science - Environment, Health and Economy, IntechOpen, 2021, Goat Science - Environment, Health and Economy, INRAE UMR Selmet -LRDE, 96.

# Vetch forage: a promising alternative to cereal stubbles under conservation agriculture (CA) in Tunisia

Sourour Abidi, Salah Benyoussef, Hichem Ben Salem

*National Institute of Agricultural Research of Tunisia (INRAT), Ariana, Tunisia*

E-mail: sourour.abidi@yahoo.fr

**Take home Message** Summer vetch grazing and mixture hays are a promising alternative to cereal stubbles and an option allowing better adopting of CA.

**Introduction** In Tunisia, conservation agriculture (CA) is not a recent approach. It was introduced in 1999 and today covers approximately 12,000 ha. All these efforts are made with the aim of having an agriculture that conserves natural resources and sustainable production. However, the adoption of CA comes up against a major constraint: the use of cereal stubble to feed ruminants.It is therefore necessary to define a compromise between a sufficient residues required by the CA system and the need to feed small ruminants in arid areas through fodder alternatives to stubble, adapted to the edapho-climatic conditions of semi-arid, nutritious, and economically profitable. Thus, mixture hays and summer grazing of whole dried vetch which is a new practice could be a promising and economical alternative.

**Material and methods**: Two tri-specific cereal-legume mixture compared to the classic Vetch-Oat control were implemented at farm level in four regions characterized by sub-humid climatic. Mixtures are **M1** ans **M2** (Vetch70%-Oat15%-Triticale15%) installed Zhir and Safasaf, respectively, **M3** (Vetch60%-Oat7%-Triticale33%) installed in ksar Cheikh and **M4** (Vetch70%-Oat30%) installed in Fernana. Biomasse and chemical composition of these hays were assessed. In the second study, a series of experiments were carried out to compare the grazing of dried vetch alone or alternately with cereal stubble with the grazing of cereal stubble and the fattening diet. The vetch was grazed by lambs from the end of June at the stage of physiological maturity of the seeds. A stocking rate of 20 lambs $ha^{-1}$ was used. Lambs on cereal stubble were supplemented with barley grain. The commercial diet was based on oat hay ad libitum and fattening concentrate. Animal behavior, biomass and nutritional evolution, daily gain and the benefit cost ratio were assessed.

**Results and discussion:** Results revealed a significant variation between the different mixtures. M2 recorded higher forage yield (12 t DM ha-1 $ha^{-1}$) than M3 and M4. These yields are quite similar to those observed by Yucel and Avci (2009). The CP contents vary significantly between the mixtures ($P<0.001$). M2 and M4 present the highest CP contents (14.4 and 13.7% DM). These contents are explained by the high proportion of vetch and by the low proportion of weeds in in these mixtures. In all cases, hay produced from these mixtures is significantly higher in protein than that of oat in pure culture (Abdelraheem et al., 2019). The positive correlation between CP content and vetch proportion explains this higher quality.
Fiber contents were similar for all mixtures and similar to those reported in the literature (Abidi and Benyoussef, 2019; Haj-Ayed and al., 2000). However, the lignin was significantly affected by the kind of mixture. The high proportion of cereals in M2 explains the highest ADL content. In general, the Land Equivalent Ratio (LER) was significantly greater than 1 for all mixtures, confirming that they are more productive in intercropping than in pure culture.
Results of the second study revealed that over four years, the vetch presented an initial biomass yield ranging from 6.5 to 7 T $DMh^{-1}$a containing on average of 2 $Tha^{-1}$ of pods allowing a stocking rate of 20 $headsha^{-1}$ for at least 70 days. Residual biomass of vetch and cereal stubble at the end of the grazing period was higher with combined grazing (>2.5 $TDMha^{-1}$).
Along the grazing period, vetch conserved its pods indehiscent explaining the high crud protein content and metabolisable energy. Biomass and nutritive value of vetch and wheat stubbles gradually decreased throughout the grazing period. The decrease of CP content goes hand in hand with the progressive disappearance of the seeds. This finding corroborates those reported by Rebolé et al. (2004) and Biondi et al (2008). The summer grazing of the vetch alone or alternated with stubble affected the animal behavior by allocating more time on biomass uptake compared to those on cereal stubble. At the end of the grazing period, animals on vetch spend less time-consuming biomass. This behavior highlights the preference of the lambs to the vetch and denotes the high palatability of vetch. Dumont et al. (2001) came up with the same conclusion. DM intake was similar in lambs fed vetch and the commercial diet and significantly higher than in lambs on cereal stubble.
The nutritive value and DM intake of the common vetch are likely the key factors that significantly enhanced lambs' growth. These advantages of vetch grazing explain the 300% difference in the growth rate of lambs on vetch and those on wheat stubbles. These results corroborate with those obtained by Rihaoui et al. (2010). Economic analysis shows that with the grazing of vetch alone or combined with cereal stubble, the Benefit-Cost ratio is 7 times higher than that obtained with the fattening diet and 10 times higher than that obtained with stubble grazing.

**Conclusion** It can Our results show that mixtures hays and the summer vetch grazing alone or with cereal stubble could be recommended as promising options to improve sheep performance under the context of CA in the dry areas, like Tunisia.

**Acknowledgements** This study was supported by the CLCA (I, II) project "Integrated Crop-Livestock CA for Sustainable Intensification of Cereal-based Systems in North Africa and Central Asia", financed by the FIDA

**References**

Abdelraheem N., Li F., Guo P., Sun Y., Liu Y., Cheng Y., Hou F. 2019. Livestock Science (230), 103854.
Abidi S., Benyoussef S. 2019. 6th Int. Conf. on Sustainable Agriculture and Environment. 472-476.
Biondi, F., Kozubowski, T. J., Panorska, A. K., and Saito, L. 2008. Ecological Modelling. 211, 383–395.
Dumont B., Meuret M., Boissy A., Petit1 M. 2001. Fourrages. 166, 213-238.
Haj-Ayed M., González J., Caballero R., Alvir M. 2000. Annales de Zootechnie 49, 391–398.
Rihawi S., Iñiguez L., W.F. Knaus, Zaklouta M., (…), Bomfim M.A.D. 2010. Small Ruminant Reaserch 94(1-3), 38–44.
Yucel C., Avci. M. 2009. Bulgarian Journal of Agricultural Science. 323-332.

# Environmental impacts of seasonal sheep corrals in a dry Mediterranean ecosystem

Zaady Eli[1], Vinograd Arie[1,2], Kigel Jaime[2], Goldshleger Naftali[3], Shamir Omer[3], Basson Uri[4], Nejidat Ali[5], Diaz-Recka Damiana[5]

[1]*Agricultural Research Organization-Volcani Institute, Gilat Research Center, 8531100, Israel*
[2]*Hebrew University of Jerusalem, Rehovot, 76100, Israel*
[3]*Ariel University, Ariel 4077625, Israel*
[4]*GeoSence LTD, Eeven Yehuda 40500, Israel*
[5]*Ben-Gurion University of the Negev, Jacob Blaustein Institutes for Desert Research, Sede Boqer Campus, 8499000, Israel*

E-mail: zaadye@volcani.agri.gov.il

**Take home Message** Night corrals have a strong negative impact on vegetation, redistribution of soil nutrients, salinity leakage to the sub-soil layers, and environmental reservoir for tetracycline resistance genes.

**Introduction** Managing silvopastoral systems in planted and natural forests in semi-arid Mediterranean regions often requires seasonal night corrals for animal protection. The herds are held overnight in corrals for 4 to 6 months and locally increase the content of organic matter and nutrients that are stockpiled in the corrals. These long-lasting activities affect the soil parameters, leading to nutrient leakage and contamination of the upper and sub-soil surface. Furthermore, the landscape and grazing value of the forests is negatively affected by night seasonal corrals, as it changes the spatial distribution of animal excreta, resulting in a net transfer of soil mineral resources and their accumulation in the corrals. We aimed to implement rational management of active and abandoned seasonal sheep corrals based on a better understanding: (A) the vegetation processes occurring, (B) studying the dynamics of soil nutrients, (C) the influence of sheep corrals on the changes within the sub-soils of corrals and (D) the effect of soil enrichments on soil bacterial community structure and the abundance of tetracycline resistance genes.

**Material and methods** Relationships between temporal changes in the vegetation were studied in active and abandoned sheep corrals and compared with nearby reference plots in planted forests grazed by sheep herds in the semi-arid North-Western Negev, Israel. The region has a seasonal Mediterranean climate, with high dominance of annual species. Vegetation cover was assessed at flowering time in two consecutive years. Species cover (% of total plant cover) was assessed by the point transect method. Total vegetation biomass was assessed by clipping at soil level in 0.5 $m^2$ quadrats in corrals and in the control plots and determined after drying at 70°C for 48 h in the oven. Standard soil chemical analyses were used for soil P, ammonium N, nitrate N, K, electrical conductivity (EC), and pH. To estimate sub-soil contamination in corrals, we used the frequency domain electromagnetic method (FDEM) to measure salinity in the sub-surface. The soil bacterial community structure and the abundance of tetracycline resistance genes were based on 16S rRNA gene sequences. DNA was extracted from 0.5 g of soils and was screened with different PCR primers that amplify fragments of different genes encoding for abundance of tetracycline resistance genes.

**Results and discussion** Subsequent successional changes in the vegetation occurred slowly, driven by the depletion of soil resources in the abandoned corrals, and were still in progress 20 years after abandonment. Dung decomposition was a slow process lasting 5–10 years. Soluble-N, P, and K in the soil beneath the dung layer decreased gradually. Yet, 15–20 years after corral abandonment K and P were still 2 to 3 times higher than in the surrounding range, while soluble-N decreased within 10–15 years. Biomass production in the abandoned corrals was 2–3 times higher than in the grazed range up to 20 years after abandonment. Ruderals were replaced, first by taller grasses and followed by short grasses, but most forbs and particularly geophytes did not recover during this period. The EC was high in the corral center, low at the edge and outside the corral, and decreased with depth. Based on 16S rRNA gene sequences, a principal component analysis showed that the soil bacterial community structure in the active and the 1-year-old abandoned corrals was significantly different from that in the older corrals and the control. Genes conferring resistance to tetracycline were detected in high numbers.

**Conclusion** Grazing systems based on night corrals have a strong negative impact on the productivity of the vegetation due to depletion and redistribution of soil nutrients in the grazing range and the creation of focal sites for the reproduction and spreading of undesirable plant species. Recovery of the original herbaceous vegetation in the corrals was through seed dispersal from the surrounding vegetation, not from the original soil seed-bank remaining in the corrals after abandonment. Sheep corrals have shown similar patterns of salinity obtained in the sub-soil layers between active and abandoned corrals. The results prove that abandoned and active corrals are an environmental reservoir for tetracycline resistance genes.

**Acknowledgements** The research was supported by grants provided by the Israel Ministry of Science and Technology and the Jewish National Fund –KKL. The authors wish to thank Daniel Barkai and Rafi Yonatan for their dedication in helping with the field work during the study.

**References**

Goldshleger N., Shamir O., Basson U., Zaady E. 2019. Geoscience 9, 382.
Nejidat A., Diaz-Recka D., Gelfand I., Zaady E. 2021. FEMS Microbiology Ecology 97, fiab106.
Vinograd A., Zaady E., Kigel J. 2019. Journal of Arid Environments 164, 38-45.
Vinograd A., Zaady E., Kigel J. 2020. Journal of Plant Ecology 13, 722-731.

# Grape pomace: From waste to small ruminant feed and meat preservative

Obert C. Chikwanha, Cletos Mapiye

*Stellenbosch University, Stellenbosch, South Africa*

E-mail: occhikwanha@sun.ac.za

**Take home Message** Grape pomace can be used as an alternative feed supplement and meat preservative by the small ruminant meat industry.

**Introduction** Globally, inadequate nutrition and meat losses caused by oxidative and microbial deterioration are arguably the most important pre- and post-mortem challenges confronting the meat industry. In this context, the sustainability of the meat industry could be addressed by the valorisation of less food-competing feedstuffs and/or ecological leftovers that can simultaneously improve animal production and reduce meat losses (Salami et al., 2019). For example, winery wastes whose disposal and poor management have been associated with several environmental, social and economic problems have potential as livestock feed and meat preservative owing to their rich nutritional and diverse phytochemical profiles. However, their usage in livestock diets is currently limited by variation in nutrient and phytochemical composition and technical requirements for long-term preservation. Beneficiation of winery wastes can contribute to reduction of the ecological and water footprint associated with crop cultivation and improve meat production and shelf life. The current study evaluated the dieatry and meat preservative potential of sun-dried red grape pomace (RGP; *Vitis vinifera*) in feedlot lamb production.

**Material and methods** Forty Dohne Merino lambs (32 ± 1.7 kg; n = 8) were fed isonitrogenous and isoenergetic diets containing 0, 5, 10, 15 and 20% RGP for 42 days. Dry matter intake (DMI), average daily gain (ADG) and income-over-feed-costs (IOFC) were determined. The left *longissimus thoracis* was used for evaluating meat physicochemical parameters, the *longissimus lumborum* for shelf-life attributes and the right loin for sensory analyses. All data were analysed using PROC MIXED (SAS, 2012) with diet as a fixed factor. For shelf life and DMI, day was added in the model as a repeated measure while week was used for ADG. Optimum inclusion levels of GP on DMI, ADG and IOFC were determined using PROC RSREG.

**Results and discussion**Dry matter intake, ADG and IOFC increased quadratically with an optimum inclusion level of RGP at 11.3, 9.6 and 12.2%, respectively. This may be related to improved palatability, increased rate of passage and/ or reduced gut fill (Makkar, 2003). The reduction beyond optimum points was partially attributed to the increasing phenolic and lignin contents of RGP and lower available energy in lambs due to the associative effects of polyphenols (Calderón-Cortés et al., 2018). Increasing levels of GP in the diet had no effect on the moisture, ash and intramuscular fat contents of lamb meat except for protein which showed quadratic tendencies with increasing levels of GP. Diet had no effect on meat colour parameters which agrees with other findings that evaluated winery by-products (Jerónimo et al., 2012; Zhao et al., 2018). Cooking loss exhibited a negative quadratic response with the lowest loses at 11.1% GP inclusion. Grape pomace supplementation did not affect shear force. Diet × day interactions were observed for meat antioxidant activity, lipid and protein oxidation. The greatest antioxidant activity was observed for d 1 and 3 of retail display, corresponding to the lowest lipid and protein oxidation. The higher antioxidant activity during the initial days of retail display, especially for the 15 and 20% RGP might be due to high levels of α-tocopherol and proanthocyanidins in RGP. However, declining lipid and protein oxidation in the 15 and 20% GP during retail display could be linked to degradation of antioxidants overtime and the imbalance between the antioxidant and pro-oxidants (Carocho et al., 2018). Retail display period affected the total viable bacterial counts (TVC), coliforms and *Enterobacteriaceae* with day 9 having the highest counts followed by day 7 and day 1, respectively. Overall, there was a decline in TVC with increasing RGP in lamb diets, possibly linked to the antimicrobial properties of polyphenols (Apak et al., 2016). Overall, diet had no negative effect on the sensory quality of the lamb.

**Conclusions** Inclusion of RGP improved meat production and shelf life without compromising its sensory quality.

**Acknowledgements** The South African Research Chairs Initiative, partly funded by the South African Department of Science and Technology (UID number: 84633), RTF-NRF South Africa (Grant 98700) and Cape Wools SA (Grant S005139) funded the study.

**References**

Apak R., Özyürek M., Güçlü K., Çapanoğlu E. 2016. Journal of Agricultural and Food Chemistry 64(5), 997-1027.
Carocho M., Morales P., Ferreira I. C. 2018. Trends in Food Science & Technology 71, 107-120.
Jerónimo E., Alfaia C.M., Alves S.P., Dentinho M.T., Prates J.A., Vasta V., Santos-Silva J., Bessa R.J. 2012. Meat Science 92(4), 841-847.
Khliji S., Van de Ven R., Lamb T.A., Lanza M., Hopkins D.L. 2010. Meat Science 85(2), 224-229.
Makkar H.P.S. 2003. Small Ruminant Research 49, 241-256;
Salami S.A., Luciano G., O'Grady M.N., Biondi L., Newbold C.J., Kerry J.P., Priolo A. 2019. Animal Feed Science and Technology 251, 37-55.
Zhao J.X., Li Q., Zhang R.X., Liu W.Z., Ren Y.S., Zhang C.X., Zhang J.X. 2018. Animal Feed Science and Technology 236, 76-85.

# Effect of the use of argan bark (*Argania spinosa* L.) in fattening lamb on growth performances, carcass characteristics and meat quality

Mohammed Benbati[1], Brahim Yassin[1,3,4], Kaoutar Elfazazi[2], Fatima El Yaakoubi[3], Mohammed Diouri[4], Abdelhafid Keli[3]

[1]*Laboratory of Animal Nutrition, Regional Center for Agricultural Research in Tadla, National Institute for Agricultural Research, INRA, Beni Mellal, Morocco*
[2]*Laboratory of Food Science and Technology, Regional Center for Agricultural Research in Tadla, National Institute for Agricultural Research, INRA, Beni Mellal, Morocco*
[3]*Departement of Animal Production and Pastoralism, Ecole Nationale d'Agriculture de Meknes, Morocco*
[4]*Biology Department, Moulay Ismail University, BP 11201 Zitoune, 50070, Meknès, Morocco*

E-mail: benbati74@gmail.com

**Take home Message** The use of argan fruit epicarp as an alternative feed resource improved fattening lamb performance and reduced feed cost without negative effects on carcass characteristics and meat quality.

**Introduction** In Morocco, livestock represents an important socio-economic activity. This sector achieves a turnover of 26.5 billion dirhams and an added value of approximately 14.9 billion dirhams and 150 million working days (MAPMDREF, 2019). However, it is faced with numerous constraints, in particular its dependence on weather conditions and rising food prices. To remedy these constraints, several studies have shown that the use of agribusiness by-products is an essential solution to ensure the profitability and viability of this sector (Benbati et al., 2021). This work consists to evaluate the use of the argan bark in lamb fattening on growth performances, carcass characteristics and meat quality.

**Material and methods** The trial was conducted over a period of 95 days including 5 days of adaptation and on 18 lambs of the synthetic breed "Deroua" (age: 3 months, weight: 21kg) randomly divided into three lots. Three diets, according to the level of incorporation (%) of argan bark were tested: T0%, T17% and T34%. The body weight of the lambs was checked every 15 days and the intake was monitored daily. At the end of the trial the lambs were slaughtered, skinned and eviscerated and the carcasses were kept in a cold room at 4 °C for 24 hours. Average daily gain (ADG), feed conversion ratio (FCR) and feed cost are the main parameters measured to evaluate fattening performance. Fat deposition (mesenteric and pelvic-renal fat), fattening and conformation state, carcass yield, $pH_{24}$ and water holding capacity are the main parameters used to evaluate carcass characteristics and meat quality.

**Results and discussion** The results of this work showed no significant effect of diet on ADG (P = 0.1338); the recorded values are 228.3, 255.9 and 262.1 g/d for T0%, T17% and T34% respectively. The conversion index was 6.81, 6.35 and 5.96 kg DM/Kg of weight gain and the feed cost recorded was 17.57, 17.01 and 15.15 MAD/Kg of live weight for T0%, T17% and T34%, respectively. The results of this work are consistent with those recorded by Moutik et al. (2021) who reported that the use of argan bark at a level of 18% for the fattening of lambs has improved the ADG and FCR.

**Table 1** Parameters measured to evaluate fattening performance, carcass characteristics and meat quality.

| | Item | | | SEM | P-value |
|---|---|---|---|---|---|
| | T0% | T17% | T34% | | |
| ADG 0-90 d (g/d) | 228.3 | 255.9 | 262.1 | 11.85 | 0.1338 |
| FCR (kg DM/kg gain) | 6.81 | 6.35 | 5.96 | - | - |
| Feed cost (MAD/kg weight gain) | 17.50 | 17.01 | 15.15 | - | - |
| Carcass yield | 46.77$^{b}$ | 50.16$^{a}$ | 51.64$^{a}$ | 0.94 | 0.0096 |
| Mesenteric fat | 0.47$^{c}$ | 0.73$^{b}$ | 1.05$^{a}$ | 0.062 | <0.0001 |
| Pelvic-renal fat | 0.27$^{b}$ | 0.36$^{b}$ | 0.69$^{a}$ | 0.042 | <0.0001 |
| Fattening state | 2.00$^{b}$ | 2.20$^{b}$ | 2.85$^{a}$ | 0.12 | 0.0008 |
| Conformation | 2.85$^{b}$ | 3.20$^{a}$ | 3.40$^{a}$ | 0.098 | 0.006 |
| pH24 | 5.39 | 5.42 | 5.32 | 0.09 | 0.7 |
| Water loss (%) | 28.98 | 25.49 | 26.3 | 2.55 | 0.621 |

DM: dry matter, MAD: Moroccan dirham (10 MAD ≈ 1 USD)

The effect of diet was significant on cold carcass yield (P = 0.0096), fattening (P = 0.0008), conformation (P = 0.006), and mesenteric and pelvic-renal fat deposition (P < 0.0001). Meat $pH_{24}$ of all carcasses was almost similar (5.38). Diet had no significant effect on meat water holding capacity measured at the *Longissimus dorsi* muscle. However, meat from lambs on the T17% diet expressed a water loss that tended to be lower 25.49 compared to 28.98 and 26.3 for the T0% and T34% diets respectively.

**Conclusion** The results of this trial showed that the use of argan bark (epicarp) can be used up to a level of 34% for fattening of lambs can improve growth performance and reduce feed cost.

**References**

Benbati M., Keli A., Haddioui A., Boufarik W., El Fazazi K., Azzouzi H., Hansali E. M. 2021. Biosciences, Biotechnology Research Asia 18(2).
MAPMDREF. 2019. Agriculture En Chiffres 2018. PP: 27-29.
Moutik S., Benali A., Bendaou M., Maadoudi EH., Kabbour MR., El Housni A., Es-Safi NE. 2021. Heliyon. 1;7(2).

# Incorporating pomegranate peels and pistachio hulls in concentrate feeds: effects on lambs' meat quality

Hadhami Hajji, Semia Kdidi, Salma Bessalah, Mohamed Dbara, Mabrouk M. Seddik, Touhami Khorchani, Mohamed Hammadi

*Arid Regions Institute, Medenine, Tunisia*

E-mail: hajj.hadhami@gmail.com

**Take home Message** The agro-industrial by-products are rich in nutraceuticals and may be incorporated in feeds composition in order to cover animals supply and improve productivity and product quality

**Introduction** The Tunisian arid regions are the headquarters of production and accumulation of several agro-industrial by-products (ABP) resulting from many noble fruits harvesting, sort and transformation such as olive by-products, pomegranate waste and pistachio by-products available in large quantities varying from 30 to 45 % of the total harvested biomass. These ABP are rich in nutraceuticals and may be incorporated in feeds composition in order to cover animals supply and improve productivity and product quality. The present study was conducted to investigate the effects of integrating pomegranate peels and pistachio hulls at the level of 20% in two concentrate feeds' composition, on meat quality of D'Man lambs.

**Material and methods** The experiment involved 21 lambs of the breed D'Man aged 5 months with an average body weight of 24.3 kg. Lambs were divided into 3 batches (7 lambs each on each). The three batches received the same amount of oat hay, which increased from 800g/d to 900g/d and the same amount of concentrated feed, which increased from 600g/d to 700g/d. The first batch (CC) received commercial concentrate feed, the second (GRD) received a concentrate feed containing 20% of the pomegranate peel and the third batch (PST) received a concentrated feed containing 20% of pistachio hulls. The animals were fattened for 98 days after which they were slaughtered and then the meat physiochemical proprieties were studied on *longissimus dorsi* muscle.

**Results and discussion** The study of physio-chemical parameters of the meat from the different diets showed a significant difference between the three groups in pH meat (P = 0.02); in fact, the highest pH values were recorded for the PST group and the lowest values for the CC group underlining a higher glycogen mobilization during the first 24H (Hajji et al., 2016). The meat the GRD group loses more water during cooking than other groups this may be related to the polyunsaturated fatty acids (PUFA) melting during cooking (Hajji et al., 2016). Besides the meat of all groups had similar values for color parameters a*, b* and L. The water content in meat was lower for meat from CC group in comparison to both other groups (P= 0.02). The difference in lipid per oxidation indices was highly significant between groups (P=0.0001) with continued lower values for GRD meat during storage (P=0.0001). The resistance of GRD meat to lipid oxidation is associated to the higher content of polyphenols in pomegranate peels (Natalello et al., 2020). Regarding meat fatty acid composition the sum of PUFA and total conjugated linoleic fatty acid (CLA) were highly affected by the diet and the highest values were registered for the GRD group (P= 0.078; P= 0.009).

**Table 1**. Effect of concentrate feed on meat chemical composition, physiochemical parameters and fatty acids indexes

| | CC | GRD | PST | *P* |
|---|---|---|---|---|
| pH24 | 5.37$^{b}$ | 5.39$^{ab}$ | 5.52$^{a}$ | 0.05 |
| WCL | 16.32$^{a}$ | 23.24$^{a}$ | 16.07$^{a}$ | 0.10 |
| L | 45.19$^{a}$ | 42.46$^{a}$ | 43.58$^{a}$ | 0.47 |
| a | 16.52$^{a}$ | 15.88$^{a}$ | 16.32$^{a}$ | 0.79 |
| b | 2.60$^{a}$ | 1.85$^{a}$ | 3.01$^{a}$ | 0.73 |
| DM | 32.02$^{a}$ | 28.00$^{b}$ | 27.4$^{b}$ | 0.02 |
| Ash | 3.37$^{a}$ | 3.56$^{a}$ | 4.13$^{a}$ | 0.40 |
| OM | 96.63$^{a}$ | 96.44$^{a}$ | 95.87$^{a}$ | 0.40 |
| Lipids (%) | 24.07$^{a}$ | 18.87$^{a}$ | 23.17$^{a}$ | 0.78 |
| Proteins (%) | 73.46$^{a}$ | 76.01$^{a}$ | 74.86$^{a}$ | 0.55 |
| SFA | 50.00 | 48.86 | 50.09 | 0.61 |
| MUFA | 41.44 | 41.39 | 41.35 | 0.99 |
| PUFA | 5.25$^{b}$ | 7.75$^{a}$ | 6.00$^{ab}$ | 0.08 |
| C18 :1 | 38.90 | 39.10 | 38.84 | 0.99 |
| n6 | 4.02 | 6.19 | 4.67 | 0.09 |
| n3 | 0.46 | 0.74 | 0.57 | 0.09 |
| n6/ n3 | 8.68 | 8.58 | 8.37 | 0.92 |
| PUFA/SFA | 0.10 | 0.16 | 0.12 | 0.01 |
| TOTAL CLA | 0.36$^{b}$ | 0.51$^{a}$ | 0.35$^{b}$ | 0.01 |

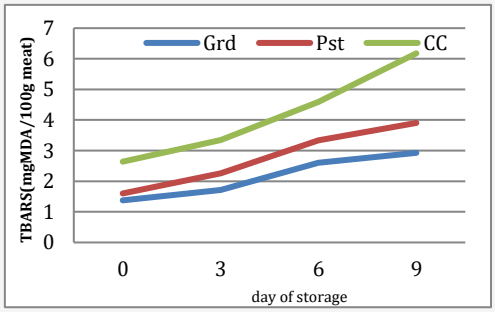



**Figure 1**. Evolution of the lipid oxidation index of meat during storage at 4°C.

**Conclusion** the pomegranate peels incorporation in concentrate feed at the level of 20 % has improved lamb meat micro and macro-chemical composition and limited its lipid oxidation during storage.

**Acknowledgements** This study was supported by the International Foundation for Science (IFS).

**References**

Hajji H., Joy M., Ripoll G., Smeti S., Mekki I., Molino Gahete F., Mahouachi M., Atti N. 2016. Journal of Food Composition and Analysis, 48, 102-110.

Natalello A., Priolo A., Valenti B., Codini M., Mattioli S., Pauselli M., Puccio M., Lanza M., Stergiadis S., Luciano G. 2020. Meat Science, 162. 0309-1740

# Root nodule formation in *Trifolium subterraneum* ssp. *yanninicum* under fluctuating soil moisture conditions

Gereltsetseg Enkhbat[1], Phillip G. H. Nichols[1], Megan H. Ryan[1], Yoshiaki Inukai[2], Kevin J. Foster[1], William Erskine[1]

[1]*The University of Western Australia, Crawley, Australia*
[2]*Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Japan*

E-mail: gereltsetseg.enkhbat@research.uwa.edu.au

**Take home message** A transition from waterlogged to water-stressed conditions severely reduces root nodule formation of ssp. *yanninicum* ecotypes, irrespective of ecotype nodulation rate under waterlogging.

**Introduction** Plants in Mediterranean regions can experience a number of wetting and drying cycles during their growth period. *Trifolium subterraneum* L. ssp. *yanninicum* is a pasture legume that is widely grown in medium and high rainfall areas of southern Australia and exhibits superior waterlogging tolerance (Enkhbat *et al.* 2021), but is shallow-rooted and susceptible to water stress. Its ability to form root nodules under soil moisture fluctuations (SMF) has not yet been determined. This study investigated nodule formation under SMF at three soil depths in three ssp. *yanninicum* ecotypes.

**Material and methods** Three ssp. *yanninicum* ecotypes, collected from the Mediterranean region: Ecotype A (Greece), Ecotype B (Turkey) and Ecotype C (Italy) were grown in free-draining plastic pots (350 mm length × 90 mm diameter) in a controlled-environment glasshouse. *Rhizobium leguminosarum* bv. *trifolii* strain WSM1325 was applied at sowing. Two treatments were imposed at 21 days of growth: (i) well-watered (WW-WW, maintained 80% of field capacity, FC) and (ii) waterlogged-to-water-stressed (WL-WS). In the WL-WS treatment, pots were first subjected to waterlogging (water kept 10 mm above the soil surface) for 28 days until Harvest I: remaining pots then had water stress imposed by draining until 40% FC, which was then maintained for 10 days (Harvest II). Root nodules were collected from roots at depths of 0-10 cm, 10-20 cm and 20-35 cm. Those in the top 10 cm were separated into tap and lateral roots. Nodules were oven-dried (60 °C for 72h) and dry weights (DW) recorded. Data were analy

**Results** At Harvest I, nodule DW was impacted by treatment ($P$<0.01) and ecotype ($P$<0.05), with no interaction (Fig. 1a). Notably, Ecotype B had higher nodule DW (90% of WW) under WL than Ecotype A (60%) and C (65%). Nodule DW distribution in the top 10 cm under WL was 53-63% on tap and 38-47% on lateral roots. At Harvest II, there was a treatment effect only ($P$<0.001), ranging from 24-26% of WW-WW (Fig. 1b). In the WL-WS treatment, the top 10 cm had 42-63% of nodule DW on tap and 25-45% on lateral roots, with a further 10-13% and 0-0.4% on the 10-20 cm and 20-35 cm root sections, respectively.

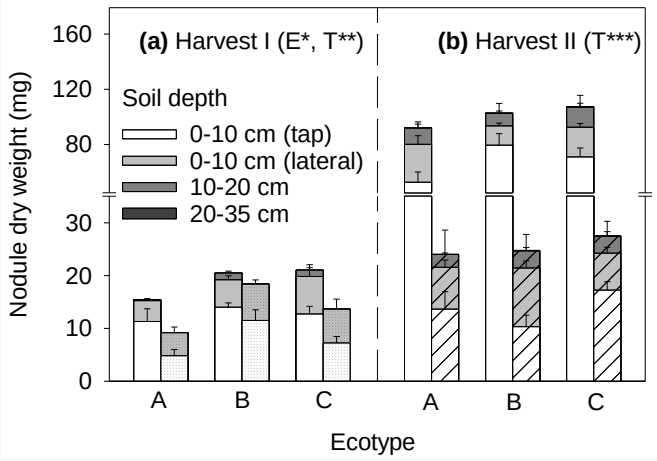



**Fig. 1** Total nodule dry weight at soil depths 0-10 cm, 10-20 cm and 20-35 cm for three ecotypes of *Trifolium subterraneum* ssp. *yanninicum* at two harvests (mean ± SE n=4). Treatments were imposed 21 days after sowing: well-watered (WW-WW, plain bars) and waterlogged-to-water-stressed (WL-WS). In the WW-WW, pots were maintained at 80% of field capacity (FC). In the WL-WS, pots were first subjected to waterlogging (dotted bars) with a water level 10 mm above the soil surface for 28 days (Harvest I): remaining pots then had water-stress (dashed bars) imposed by draining until 40% FC, which was then maintained for 10 days (Harvest II). At Harvest I and II, the results of a two-way ANOVA are presented with significant effects for ecotype (E) and treatment (T): *$P$≤0.05; **$P$≤0.01; ***$P$≤0.001.

**Conclusions** Nodule DWs for each ecotype were little affected by WL alone but their distribution was restricted to upper root sections. By contrast, WL-WS had a severe negative effect on nodule DWs, regardless of ecotype nodulation under WL, but nodules were formed at deeper soil depths. This nodule distribution response under soil moisture fluctuations could be associated with a root plasticity response, where new adventitious roots are restricted to upper soil layers under WL, while elongating roots adapt to WS by constructing a finer root network.

**Acknowledgements** This research was conducted as part of the Annual Legume Breeding Australia Joint Venture between UWA and DLF Seeds. G.E. is supported by an Australian Government Research Training Program scholarship and a Science Industry PhD Fellowship from the Government of Western Australia.

**References**

Enkhbat G., Ryan M.H., Foster K.J., Nichols P.G.H., Kotula L., Hamblin A., Inukai Y., Erskine W. 2021. Plant and Soil 464, 467-487.

# Nutritive value and utilization of alternative feed resources in ruminant feeding in Morocco

Abdelilah Araba

*Institut Agronomique et Vétérinaire Hassan II, Rabat, Morocco*

E-mail: a.araba@iav.ac.ma

**Take home Message** There is a potential to integrate alternative feed resources in ruminant diets in Morocco.

**Introduction** Livestock sector is of paramount importance for the economy and food security in North Africa as it provides jobs and essential nutrients for the population. The insufficiency of feed resources for livestock is the major constraint affecting livestock productivity in North African countries like Morocco (Boughalmi et al., 2015). The shortage is acute during droughts when pastoral resources are highly affected. This study was done to explore the nutritive value and utilization of alternative feed resources (AFR) that do not compete with human food.

**Material and methods** This study was done through 3 shutters:
- investigations with 50 farmers and industrial units in two regions of Morocco. The information collected concerns the availability of the AFR at the farm level (quantity, period, …), their utilization by the livestock (animal species, quantity, period, constraints, advantages, etc.);
- chemical analyses of a dozen of AFR. The feed samples were subjected to proximate analysis as per the standard procedures of AOAC (2005) in duplicate. The neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), were estimated by the methods of Goering and Van Soest (1970).
- trial to better storage and valorization of some of these resources i.e., discarded cacti fruits.

**Results and Discussion** The survey showed that some crop residues are much more used by the stockbreeders (sugar beet tops and groundnut tops) and are even subject of transactions in the studied areas. Other AFR are used only during drought, by some farmers (i.e. sugar cane tops, threshed sunflower heads, bean straw, peanut hulls). Whereas a third group of feeds are used only over one restricted period of the year (green residues and leguminous plant straw).
Three groups of AFR were identified:
1) group of feeds of low nutritional value and rich in fiber (olive cake, groundnut hulls and rice bran);
2) group of feeds rich in fiber and having a relatively average feed value (dried tomato pulp, groundnut tops, threshed sunflower heads residue, straws of leguminous plants and sugar cane tops);
3) group of feeds low in fiber presenting a high nutritive value, made up of the remaining studied feeds.
The cactus has significant potential on a national scale. The valorization in animal feed of discarded cactus fruits suggest that this AFR has a good aptitude for conservation in the form of silage.

**Table 1** Chemical composition of selected alternative feeds studied.

| | % as fed | % DM | | | | |
|---|---|---|---|---|---|---|
| | DM | Ash | CP | NDF | ADF | ADL |
| White tips of green sugar cane | 24.4 | 7.7 | 5.7 | 73.2 | 38.8 | 4.5 |
| Sugar beet leaves and tops | 75.9 | 24.4 | 12.3 | 37.5 | 20.1 | 3.7 |
| Peanut tops | 82.0 | 12.9 | 8.9 | 50.4 | 38.7 | 7.5 |
| Peanut shells | 77.8 | 11.7 | 8.3 | 88.4 | 69.9 | 25.0 |
| Threshed sunflower heads | 77.9 | 18.5 | 6.0 | 29.4 | 29.1 | 4.3 |
| sunflower threshing residues | 80.8 | 12.1 | 11.0 | 47.2 | 41.8 | 13.1 |
| Chickpea straws | 832 | 13.4 | 7.7 | 56.4 | 45.3 | 9.8 |
| Vetch Straws | 81.1 | 12.9 | 5.4 | 66.4 | 47.6 | 6.0 |
| bean straws | 85.9 | 7.81 | 6.7 | 62.8 | 55.2 | 8.6 |
| Dried pea residues | 77.3 | 25.6 | 15.6 | 43.5 | 32.1 | 5.7 |
| Bean green residue | 21.4 | 10.3 | 16.3 | 39.3 | 28.4 | 6.1 |
| Peas green residue | 21.5 | 15.6 | 16.5 | 39.3 | 30.4 | 5.5 |
| Green bean waste | 18.4 | 15.6 | 14.5 | 39.7 | 26.1 | 5.7 |
| Berseem threshing residues | 78.7 | 12.8 | 6.2 | 64.3 | 54.2 | 10.4 |

**Conclusion** These sets of data will allow enriching the animal feed tables, and will help in putting in place implementing strategic interventions to meet the feed demand at periods of scarcity. Additional chemical constituents and other AFR should be analyzed to update and to complete the tables of the nutritive value of AFR.

**Acknowledgements** This study was supported by the "SURFOLY/Prima" and MoFeed/IAV research projects.

**References**
AOAC. 2005. Official Methods of Analysis. 18th ed. Virginia, USA
Boughalmi A., Araba A., Yessef M. 2015. Livestock Research for Rural Development 27 (11)
Goering H.K, Van Soest P.J. Washington, DC: ARS-USDA; 1970. USDA Agriculturasl Handbook 379, 1–20.

# Reduction of enteric methane emissions in sheep with premix supplementation of natural bioactive compounds (Anavrin) tested in vivo with ventilated hoods

Alberto Stanislao Atzori[1], Maria Angela Porcu[1], Fabio Fulghesu[1], Antonello Ledda[1], Riccardo Losa[2], Pietro Landoni[2], Fabio Correddu[1]

[1] *Section of Animal Science, Department of Agriculture, University of Sassari, Sassari Italy*
[2] *Vetos Europe s.r.l., via delle Industrie 18, Cadenazzo, Switzerland*

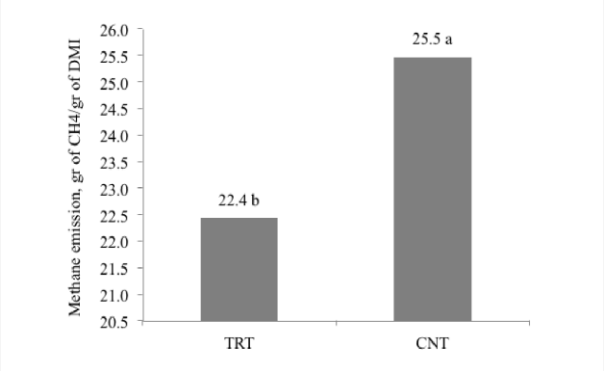
E-mail: asatzori@uniss.it

**Take home Message** Anavrin reduced methane emitted per gr of dry matter intake (-13%) without affecting digestibility.

**Introduction** The reduction of enteric emissions from ruminants represents a crucial challenge to face global warming. Bioactive substances act as rumen modifier such as dietary polyphenols (Vasta et al., 2019) and essential oils (Belanche et al., 2020). These studies showed that the reduction of $CH_4$ production in *in vivo* experiments ranged from 11-30%, with more frequent values around 15-20%. Using *in vivo* experiments for quantification of potential methane emission of ruminant diets, and for testing efficacy of feed additives or premixes, is extremely important to effectively transfer results to commercial farms. Dairy sheep can be considered as a valuable animal model in feeding trials, especially to test productive and metabolic animal response to animal diets. Objective of this work was to test the capacity of a small amount of dietary premix of natural bioactive compounds (blend of essential oils, bioflavonoids and chestnut tannins, Vetos Europe, Switzerland) to reduce methane emissions from sheep.

**Material and methods** The experiment was carried out at the experimental farm of the University of Sassari in Italy. Twenty-four dry Sarda ewes were allocated to two homogenous groups. Both were fed with a TMR and one of them (Treatment group, TRT) was supplemented with 1 g/day per head of premix Anavrin (Vetos Europe). It consisted in a bioactive compound premix, that is a blend of essential oils, bio-flavonoids and chestnut tannins. Each animal followed a 20-day adaptation period before methane emission measurements. Methane emissions were measured using metabolic cages and ventilated hood system (Lind et al., 2021; Lai, 2020), equipped with a digital gas analyzer (GMS810 SICK S.p.A., Vimodrone, MI, Italy), for 24 hours measurment period. Dry matter (DM) digestibility was measured during 4 consecutive days.

**Results and discussion** Intake, digestibility of DM and of NDF were not significantly affected by the treatment thus assuring an efficient use of the diet either with or without the Anavrin premix use. Anavrin inclusion in the sheep diet significantly reduced methane emission from sheep (in terms of gr of CH4 emitted per kg of DMI) of 13% in respect to Control diet (respectively 22.4 vs. 25.5 gr of CH4/kg of DMI; $p < 0.05$; Figure 1).




**Figur 1** Methane emission from sheep in Treatment (TRT) and Control (CNT) groups. Letters a, b, indicate a difference for $p < 0.05$ between groups.

The effect was also similarly evident per kg of digested dry matter, since emissions tended to be lower for TRT than in CNT (33.03 vs. 38.34 gr of CH4/kg of digested, respectively). The emissions were not significantly different per unit of NDF digested, which can be explained with the fact that it includes less than 40% of the nutrient intake even if those generally associated with methane emissions.
The observed values of daily methane emission were on average equal to 21.6 g/d (ranging from 17 to 32 g/d), similar to previous studies (24.11 ± 7.6 g/d, mean ± SD; Bhatt, 2019). It also corresponds to about 9 kg of methane emitted per ewe per year, in line with IPCC (2019) and Vermorel (2008; 9.3 for dry ewes).

**Conclusion** Anavrin supply allowed a significant reduction of 13% of methane per gram of DM intake, in comparison to control without affecting DM and fiber digestibility of the diet. We expect a similar response at commercial scale.

**Acknowledgements** This study was supported by Vetos Europe s.r.l. Via delle Industrie 18, 6953 Cadenazzo – Svizzera

**References**

Belanche A., Newbold C.J., Morgavi D.P., Bach A., Zweifel B., Yáñez-Ruiz D.R. 2020. Animals 10 (4), 620.
Bhatt R.S., Soni L., Sahoo A. 2019. Carbon Management 10 (3), 241-253.
Lai F., 2020. PhD Thesis Dissertation, XXXII Cycle University of Sassari.
Lind V., Schwarm A., Mele A., Cappucci A., Foggi G. Sizmaz O., Tsiplakou E., Atzori A.S., Van Mullen J., Peiren N. 2021. Chapter 7. In Bartzanas T. and Calvet S. Technology for Environmental Friendly Livestock Productions. In press.
Vasta V., Daghio M., Cappucci A., Buccioni A., Serra A., Viti C., Mele M. 2019. Journal of Dairy Science 102, 3781–804.
Vermorel M., Jouany J.P., Eugène M., Sauvant D., Noblet J., Dourmad J.Y. 2008. INRA Productions Animales 21, 403–418.

# Small ruminant pastoral systems in Cyprus: characteristics and challenges

Sokratis Sokratous[1], Alexandros Theodoridis[2], Athanasios Ragkos[3]

[1]*Cyprus Institute for Rural and Regional Development, Nicosia, Cyprus*
[2]*School of Veterinary Medicine, Aristotle University of Thessaloniki, Thessaloniki, Greece*
[3]*Agricultural Economics Research Institute, Hellenic Agriculture Organization "Demeter", Athens, Greece*

E-mail: alextheod@vet.auth.gr

**Take home Message** The production model of small ruminant animals in Cyprus is becoming more commercialized. The number of flocks is reduced but their size is increased. Traditional breeds are replaced by crossbreeds. Despite the gained dynamics of the sector due to the gigantic exports of the local cheese, halloumi, the sector has to maintain the overall diversity of small ruminant production systems that rear local breeds within the framework of the Farm to Fork Policy.

**Introduction** In the Mediterranean region, sheep and goat farming is an important and well-established activity, a traditional way of farming, a significant provider of income, employment, environmental protection, and social cohesion (De Rancourt et al., 2006). This study examines the importance of small ruminant sector for Cyprus and analyses its future challenges.

**Material and methods** A Narrative literature review of the studies related to small ruminant farming in Cyprus, but also in the EU was conducted. Information from all available papers, studies, reports and official documents (of the Ministry of Agriculture, the National Statistical Service, various Institutions, etc) were gathered and analysed. Moreover, a multi-stakeholder approach with stakeholders involved in the small ruminant sector/value chain (face-to-face interviews with farmers, representatives of breeding organizations, researchers and people that work in the sheep and goat industry using a semi-structured questionnaire) was implemented to collect information concerning the challenges faced by the sector. Through this approach, the current situation in sheep and goat production in Cyprus (structure of farms and geographical dispersion, economic contribution, the production model, the main products and marketing practices, biodiversity issues etc) was described and the basic strategic priorities for the development and the future prospects of sheep and goat farming in the country were pinpointed.

**Results and discussion** Sheep and goat farming constitutes an important sector for the agricultural economy of Cyprus. In 2020 the sector accounted for 17.5% of the total value of animal production, with the overall sector production to be valued at €72 mil. The lowest share of the sheep and goat sector to the total animal production value was in 2010 (€53 mil, 5.6%) and the highest in 2018 (€81.3 mil, 20.9%). In 2018, sheep and goats reached the prior to the financial crisis period population and, since then, have been expanding reaching approximately 430.000 sheep and goats in 2020. The majority of sheep are crossbreeds (Cyprus Chios and Assaf) (74%), while only 22.5% of the population are purebred Cyprus-Chios, which used to be the dominant breed on the island. The Damascus goat population is also declining (22%), and crossbreeds are expanding (73%). The production system depends heavily on the consumption of imported concentrated feed (90%). Milk production increased in 2020 reaching 74 million litres, of which more than 90% is used for halloumi cheese, recently certified as a PDO product. The exports of halloumi have been increasing by 20% per year during the last decade, reaching 40 million tonnes valued approximately €266 million. Regarding the milk marketing model, farmers mainly prefer the milk industry (Hadjipavlou, Tzouramani and Ligda, 2021). In general, the change in the structure of the sector is linked to the reduction of the number of flocks and the increase in flock size. Through the years the productivity has also increased mainly as a result of crossbreeding. The area of the permanent grassland as a percentage of the total Utilized Agricultural Area (UAA) for arable land, permanent grassland and land under permanent crops is declining.

**Conclusion** The increasing exports of halloumi cheese by 20% each year the last decade, is the driving force for the development of the sheep and goat sector on the island. After the financial crisis and in 2013, the number of animals and the size of flocks are increasing, oriented towards a model of intensive production with confined animals that depend on purchased feed. The local breeds of sheep and goats are replaced by more productive crossbreeds with higher nutrition requirements based on imported feed while on the other hand the size of the permanent grassland area as a percentage of the total UAA is declining. Therefore, the challenge the sector faces today is to follow the gained dynamics and ensure an adequate level of farm incomes, but also maintain the overall diversity of small ruminant production systems with the traditional breeds within the frame work of the new Green Deal and the Farm to Fork Policy.

**Acknowledgement** The paper is funded through PASTINNOVA project, funded by PRIMA Foundation under the PRIMA – Section 1 – Farming Systems – 2021 Call.

**References**

De Rancourt, M., Fois, N., Lavin, M.P., Tchakerian, E., Vallerand, F. 2006. Small Ruminant Research, 62, 167-179
Hadjipavlou, G., Tzouramani I., Ligda, C. 2021. Journal of Innovation Economics & Management 34, 57-58
Yearly review of the sheep and goat sector, 2013 - 2020 ISSN 1986-0706 available at http://www.moa.gov.cy/moa/da/da.nsf/page57_gr/page57_gr?OpenDocument

# Nutritional value and environmental impact of vegetable wastes as a local source of livestock feed in Tunisia

Ammar Hajer[1], Hlel Nawel[2], Selmi Houcine[2], Toumi Lamjed[2], Frija Ayman, Lopez Secundino[3]

[1]*Ecole Supérieure d'Agriculture de Mograne, 1121 Mograne Zaghouan, Tunisia*
[2]*Institut Sylvopastoral de Tabrka 8110 Tabarka, Tunisia*
[3]*Dept. Produccion Animal. Facultad de Veterinaria Campus Universitario de Vegazana Universidad de Leon 24007, Leon, Spain*

E-mail: hjr.mmr@gmail.com

**Take home Message** Vegetable wastes could be considered in animal nutrition for reducing animal production cost, environmental pollution and the emission of greenhouse gases.

**Introduction** Vegetable wastes have shown their importance in meeting the needs of animals. Literature studies have shown that the incorporation of vegetable wastes into the animal feed chain could generate enormous benefits both for the farmer due to the reduction in feed and animal production costs and for the environment by reducing the degree of pollution. Our main objective in this current research is to study the chemical composition, digestibility and kinetics of gas production in vitro of the waste of four vegetables (lettuce leaf, carrot leaves, artichoke and tomato pulp), supposedly often used in the Sidi Bouzid region for sheep feed.

**Material and methods** Vegetable wastes (lettuce leaves, artichoke stem/leaf, tomato pulp and carrot leaves) are commonly used in small ruminant diets, particularly sheep in the region of Sidi Bouzid. The samples were air dried, grounded and analyzed for chemical composition (mineral content (MM), crude protein (CP), cell wall (NDF, ADF, ADL)) secondary metabolites (flavonoid, polyphenols and condensed tannins) and their antioxidant activities. Kinetics of gas production were also assessed. All analysis were done on triplicates. Statistical analysis was performed using ANOVA test at P value 0.1%

**Results and discussion** Tomato pulps revealed the highest organic matter (OM) content (94% DM), while lettuce leaves (Table 1) recorded the lowest levels (73% DM). The crude protein (CP) varies (P<0.001) from 7.5% (artichoke stem) to 18% (tomato pulp and carrot leaves). Similar results were reported earlier by Rodriguez et al. (2019) on other different vegetable wastes The NDF and ADF contents were the lowest in lettuce (22.4% and 15.8%; respectively) and the highest in tomato pulp being 56% and 43%, respectively. It is pertinent to mention that cell wall lignification reported herein varied widely between vegetable wastes ranging from 17% (carrot leaves) to 32% (lettuce leaves). Similarly reported a large variability in cell wall lignification of some industrial by-products. The differences in chemical composition compared to results reported in the literature might be due to the stage of growth, season, species and variety, soil types, and growth environmental conditions.

Total phenol contents (TP) reached the highest levels (P <0.001) in artichoke stems (139 mg EAG / g DM) while the lowest were detected with lettuce and carrot leaves (57 mg EAG / g DM). The other sub-products contained (artichoke leaves and tomato pulp) recorded intermediate levels (93 mg / g DM). Base on the positive relationship found between secondary metabolites and antioxidant activity (AA) (Bastos et al., 2007), it would be believed that lettuce and carrot leaves should have the lowest AA.

**Table 1**. Chemical composition (g/kg DM), polyphenol (PP, EAG/g DM), flavonoid FC, mg EQ/g DM) and condensed tannin (CT, mg EC/g DM) contents in different vegetable wastes

| | Item | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | DM | OM | CP | NDF | ADF | ADL | TP | TF | CT |
| Lettuce | 26$^{c}$ | 73$^{e}$ | 16.5$^{b}$ | 22.4$^{e}$ | 15.8$^{d}$ | 6.6$^{d}$ | 57.3$^{c}$ | 62.5$^{a}$ | 1.7$^{c}$ |
| artichoke stems | 30$^{ab}$ | 88$^{b}$ | 7.5$^{d}$ | 43.1$^{b}$ | 30.1$^{b}$ | 13.0$^{b}$ | 139.1$^{a}$ | 24.0$^{b}$ | 0.9$^{e}$ |
| artichoke leaves | 31$^{a}$ | 84$^{c}$ | 13.1$^{c}$ | 43.0$^{c}$ | 30.1$^{b}$ | 12.9$^{c}$ | 93.1$^{b}$ | 35.7$^{b}$ | 1.2$^{d}$ |
| Tomato pulp | 23$^{d}$ | 93$^{a}$ | 18.4$^{a}$ | 55.7$^{a}$ | 42.7$^{a}$ | 13.1$^{a}$ | 92.6$^{b}$ | 55.9$^{a}$ | 3.2$^{a}$ |
| Carrot leaves | 28$^{bc}$ | 79$^{d}$ | 18.4$^{a}$ | 24.0$^{d}$ | 20.0$^{c}$ | 4.0$^{d}$ | 57.2$^{c}$ | 61.2$^{a}$ | 2.6$^{b}$ |

**Table 2** Kinetics of in vitro gas production of vegetable waste samples

| | Item | | | | | | |
|---|---|---|---|---|---|---|---|
| | a | b | c | VG24 | ME | VFA | OMD |
| Lettuce | 40.7$^{bc}$ | 2.5$^{b}$ | 0.07$^{c}$ | 31.3$^{c}$ | 7.8$^{b}$ | 0.69$^{c}$ | 54.8$^{b}$ |
| artichoke stems | 75.5$^{a}$ | 1.6$^{c}$ | 0.03$^{d}$ | 36.8$^{b}$ | 7.6$^{b}$ | 0.82$^{b}$ | 51.7$^{b}$ |
| artichoke leaves | 42.5$^{bc}$ | 3.9$^{a}$ | 0.03$^{e}$ | 18.8$^{d}$ | 5.5$^{c}$ | 0.39$^{d}$ | 38.5$^{c}$ |
| Tomato pulp | 46.9$^{b}$ | 0.3$^{d}$ | 0.13$^{b}$ | 44.0$^{a}$ | 9.2$^{a}$ | 0.99$^{a}$ | 62.8$^{a}$ |
| Carrot leaves | 44.7$^{bc}$ | 1.3$^{c}$ | 0.18$^{a}$ | 43.7$^{a}$ | 9.2$^{a}$ | 0.98$^{a}$ | 63.3$^{a}$ |
| ESM | 2.26 | 0.18 | 0.006 | 2.12 | 1.1 | 0.052 | 2.2 |

Likewise, in vitro assays using gas production technique pointed out significant variations (P <0.001) between the studied vegetable by-products for all kinetics of gas production (Table 2). The highest values (P<0.001) of gas production at 24h (VG24), metabolizable energy (ME), organic matter digestibility (OMD) and total volatile fatty acid (VFA) were recorded in tomato pulps and carrot leaves. These results are in agreement with the differences observed in the chemical composition of the vegetable wastes (Table 1).

**Conclusion** Vegetable wastes could be potentially used as source of nutrients in sheep feed. Some could be considered a protein source, others as energy source. The good management of these wastes could lead to reducing animal production cost and emission of greenhouse gases.

**References**

Bastos D.H., Saldanha L.A., Catharino R.R., Sawaya A.C., Cunha I.B.,..., Eberlin M.N. 2007. Molecules 12, 423–432.

# Nutritional characteristics of *Moringa oleifera* and *Leucaena leucocephala* as a forage source for small ruminants in arid areas

Ammar Hajer[1], Hlel Nawel[2], Selmi Houcine[2], Toumi Lamjed[2], Frija Ayman, Lopez Secundino[3]

[1] *Ecole Supérieure d'Agriculture de Mograne, 1121 Mograne Zaghouan, Tunisia*
[2] *Institut Sylvopastoral de Tabrka 8110 Tabarka, Tunisia*
[3] *Dept. Produccion Animal. Facultad de Veterinaria Campus Universitario de Vegazana Universidad de Leon , Leon, Spain*

E-mail: hjr.mmr@gmail.com

**Take home Message** Shrub/tree species could be an alternative source for ruminant nutrition raised under harsh conditions.

**Introduction** In Tunisia, over the last five decades, the pastoral areas decreased from 6.1 to 5.5 million hectares, corresponding approximately a 10% reduction in land area. This in turn inevitably caused a substantial feed gap for livestock, and also prompted the need for the search of alternative feed sources. From a nutritional point of view, native trees and shrubs, in particular leguminous species have proven to be effective sources of feed in meeting the needs of ruminants (Kholif et al., 2015) at different times of the year. However, there is a scarcity of studies in Tunisia on the nutritional value of cultivated trees of exotic origin, including *Moringa oleifera* and *Leucaena leucoephala*.

**Material and methods** Leaves, stems and residue (mixture of leaves, stems, grains and blak) materials of *M. oleifera* and leaves and pods of *L. leucocephala* were collected in spring 2020. Samples of both species were assayed for their proximate and secondary metabolite analyses. Ash, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) contents were determined according to AOAC (1995). Secondary metabolites in terms of flavonoid (Yi et al 2007), polyphenols (Singleton et al., 1999) and condensed tannins (Makkar,2003) were evaluated. In vitro dry matter digestibility through the kinetics of gas production were estimated using a sheep rumen liquid. The volume of gas produced was assessed at different incubation times (0-72h) in order to estimate pattern of fermentation (a, b, c) and estimate metabolizable energy (ME), organic matter digestibility (OMD) and total volatile fatty acid (VFA) production. Statistical analysis was performed using Tukey test at P value 0.1%.

**Results and discussion** Chemical analysis of *M. oleifera* and *L. leucocephala* samples revealed that the leaves of *M. oleifera* are characterized by high CP content (23 % DM), while the pods of *L. leucocephala* are characterized by high cell wall contents (Table 1). Similar results have been reported earlier on *M. oleifera* by Kholif et al., (2015). Based on their CP (>10%, the minimum required levels for ruminant nutrition, NRC, 2001), it can be assumed that, by the exception of pods of *L. leucocephala*, forages of the studied species can be used as protein complement for ruminant nutrition. Leaves of *M. oleifera* had the highest (P<0.001) total polyphenols (TP), total flavonoids (TF) and condensed tannins (CT). In parallel to proximate analysis, results in vitro gas production analysis indicated that the highest values (P<0.001) in ME, OMD and VFA were obtained from the leaves of *M. oleifera* (Table 2). Based on these data, *M. oleifera* is more fermentable than leaves and pods of *L. leucocephala*. Such results would be related to the lower cell wall contents found in *M. oileifera* as compared with *L. leucocephala*. A negative relationship between chemical composition and kinetics of fermentation was reported earlier on different other forages (Kholif et al., 2015).

**Table 1** Chemical composition (g/kg DM), polyphenol (PP, EAG/g DM), flavonoid (FC, mg EQ/g DM) and condensed tannin (CT, mg EC/g DM) contents in different parts of *M. oleifera* and *L. leucocephala*

| Parts | Parameters | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | DM | CP | NDF | ADF | ADL | PP | FC | TC |
| | | | | ***M. oleifera*** | | | | |
| Leaves | 26$^{c}$ | 22.9$^{a}$ | 29.4$^{d}$ | 17.6$^{d}$ | 15.6$^{d}$ | 335.6$^{a}$ | 158.0$^{a}$ | 2.3$^{a}$ |
| Stems | 30$^{ab}$ | 15.1$^{d}$ | 49.4$^{b}$ | 30.2$^{c}$ | 24.0$^{c}$ | 154.9$^{c}$ | 103.7$^{b}$ | 1.5$^{b}$ |
| Waste | 31$^{a}$ | 19.3$^{b}$ | 40.5$^{c}$ | 29.6$^{c}$ | 25.4$^{c}$ | 128.9$^{d}$ | 13.0$^{d}$ | 1.2$^{c}$ |
| | | | | ***L. leucocephala*** | | | | |
| Leaves | 23$^{d}$ | 17.5$^{c}$ | 64.6$^{a}$ | 45.0$^{b}$ | 32.4$^{b}$ | 228.0$^{b}$ | 39.3$^{c}$ | 1.0$^{d}$ |
| Pods | 28$^{bc}$ | 7.3$^{e}$ | 63.1$^{a}$ | 48.5$^{a}$ | 44.0$^{a}$ | 239.9$^{b}$ | 34.6$^{c}$ | 1.3$^{c}$ |
| SEM | 0.93 | 039 | 1.10 | 1.24 | 0.94 | 4.70 | 3.74 | 0.07 |
| P value | <0.001 | | | | | | | |

**Table 2** Kinetics of *in vitro* gas production of *M. oleifera* and *L. leucocephala* plant parts

| | Parameters | | | | | | |
|---|---|---|---|---|---|---|---|
| | a | b | c | VG24 | ME | VFA | OMD |
| | | | ***M. oleifera*** | | | | |
| Leaves | 0.17$^{d}$ | 45.5$^{b}$ | 0.16$^{a}$ | 44.5$^{a}$ | 9.6$^{a}$ | 1.00$^{a}$ | 65.5$^{a}$ |
| Stems | -2.87$^{e}$ | 46.9$^{a}$ | 0.14$^{b}$ | 41.8$^{a}$ | 8.7$^{b}$ | 0.94$^{a}$ | 59.7$^{b}$ |
| Waste | 1.5$^{c}$ | 23.5$^{c}$ | 0.08$^{c}$ | 22.3$^{b}$ | 6.3$^{c}$ | 0.47$^{b}$ | 44.2$^{c}$ |
| | | | ***L. leucocephala*** | | | | |
| Leaves | 3.43$^{b}$ | 16.4$^{e}$ | 0.06$^{d}$ | 16.0$^{c}$ | 5.4$^{d}$ | 0.32$^{c}$ | 37.4$^{d}$ |
| Pods | 5.11$^{a}$ | 19.7$^{d}$ | 0.04$^{e}$ | 17.0$^{c}$ | 4.9$^{d}$ | 0.35$^{c}$ | 33.6$^{d}$ |
| SEM | 0.001 | 0.001 | 0.0001 | 1.88 | 0.26 | 0.044 | 1.67 |
| P value | <0.001 | | | | | | |

**Conclusion** In light of their high digestible nutrients and moderate levels of secondary metabolites contents our results suggest that forage of *M. oleifera*, could potentially be included in livestock feeding programs in the region and may also hold a potential for improved protein metabolism and reduced methane emissions.

**References**

Ammar H., Lopez S. Gonzales J.S. 2005. Animal Feed Science and Technology 119, 323–331.
AOAC. 1995. AOAC International. Arlington, USA.
Kholif AE., Goudaa GA., Morsya TA., Salem AZM., Lopez S., Kholif AM. 2015. Small Ruminant Research 129, 129-137.
Makkar H.P.S 2003. Kluwer Academic, Dordrecht, the Netherlands.
National Research Council. Nutrient requirements of dairy cattle. 7th ed. National Academies Press, 2001. Washington DC.
Singleton V.L., Orthofer R., Lamuela-Raventos R.M., 1999. Methods in Enzymology 299, 152–178.

# Grazing dairy sheep on permanent grassland: effect of botanical composition and plant phenological stage on milk phenols profile

Andrea Cabiddu[1], Sebastian Carrillo[1], Salvatore Contini[1], Mauro Decandia[1], Marco Acciaro[1], Valeria Giovanetti[1], Gianpietro Carboni[3], Roberto Rubino[4], Giovanni Molle[1]

[1]*Agris Agenzia Regionale per la Ricerca in Agricoltura, Loc. Bonassai 07040 Olmedo, Sassari*
[2]*Universidad Nacional Autónoma de México, Cuautitlán, México*
[3]*Laore Sardegna, Cagliari Italy*
[4]*ANFOSC Potenza Italy*

E-mail: acabiddu@agrisricerca.it

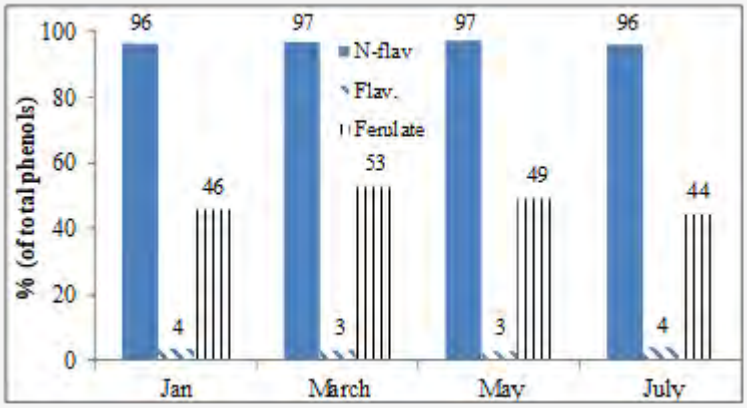
**Take home Message** Pasture based diet from permanent grassland increased milk sheep phenols content.

**Introduction** Pastures with high biodiversity rate are characterized by a wide range of plant bioactive compounds compared to monoculture grasslands (Claps et al., 2020); in addition supplementation with rich-bioactive compound forages increases total polyphenol, hydroxycinnamic acids, and flavonoid concentrations in goat milk and cheese (Delgadillo et al., 2021). In dairy sheep farming systems, data on the influence of permanent pasture on milk quality traits are scanty in both controlled conditions and at farm level. The aim of this study is to point out, in extensive dairy sheep farms, the main relationships between sheep diet characteristics (managerial factors, pasture botanical composition, plant phenological stage, days in milk and milk phenols content during the lactation period.

**Material and methods** Sarda sheep milk samples from 11 commercial flocks (bulk samples) grazing permanent grassland were investigated in terms of phenols profile. In each farm, structural and managerial data and milk samples were collected during 4 periods, January, March, May and July (at 50, 90, 130 and 170 days in milk (DIM respectivelly) of sheep . Phenolic compounds were determined using UHPLC (Agilent 1290 series) coupled to a quadrupole-time-of-flight mass spectrometer (G6550 iFunnel). Data from structural and managerial factors, feeding management and phenols profile were analysed by a GLM approach.

**Results and discussion** We observe that the proportion of legumes and forbs in pasture increased from January to May whereas grasses species decreased. Similarly, an increase of herbage daily diet contribution were observed from January to May. The main phenols detected in milk sheep were sesamin tyrosol and ferulic acid; they belong to non-flavonoids phenols (N-flav.) group which represent about 96% of total phenols found in milk. Others minor phenols detected were cyanidin and luteolin which belong to flavonoids phenols (**Flav.**) group, representing less than 4% of total milk phenols. Sampling period did not affect the milk profile in terms of N-flav and Flav, whereas considering sesamin and tyrosol individually, an effect of sampling period was detected. In particular, sesamin showed the lowest value in March and the highest in July (expressed as total phenols proportion), whereas tyrosol contribution had an opposite trend (highest in March and lowest in July). Moreover, total phenols, and **ferulate** (tyrosol+ferulic acid) contents were positively related to the estimated pasture intake ($P<0.05$), with higher levels in the growing than the flowering stage of plants. In addition, the increase of legumes and forbs in grassland appeared positively related to both total phenols and ferulate.

**Figure 1** Evolution of milk phenol profile in milk sheep




**Conclusion** These results confirm the positive effect of pasture contribution to diet intake on the total phenols content of sheep milk.

**Acknowledgements** This study was supported by Kent'Erbas project at University of Cagliari and Agris. Agreement n. 06_112 del 19/04/2019

**References**

Claps S., Mecca M., Di Trana A., Sepe L. 2020. Frontiers in Veterinary Science 7, 951.
Delgadillo-Puga C., Cuchillo-Hilario M. 2021. Animals 11(10), 2942.

# The effect of hazelnut skin feed supplementation on color stability and changes of sarcoplasmic proteins of lamb meat during storage

Antonella della Malva[1], Martina di Corcia[1], Antonella Santillo[1], Antonio Natalello[2], Mariangela Caroprese[1], Giuseppe Luciano[2], Maria Giovanna Ciliberti[1], Rosaria Marino[1], Marzia Albenzio[1], Agostino Sevi[1]

[1] *Department of Agriculture, Food, Natural Resources and Engineering (DAFNE) - University of Foggia, Foggia, Italy*
[2] *Department Di3A - University of Catania, Catania, Italy*

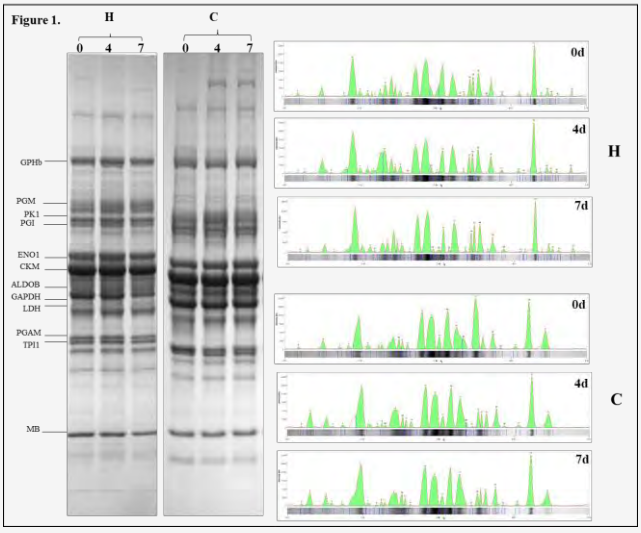
E-mail: antonella.dellamalva@unifg.it

**Take home Message** Among unconventional feed ingredients employed in small ruminants rearing system, the supplementation of hazelnut skins in the lamb diet has an impact on post-mortem metabolism and related meat quality traits.

**Introduction** The use of agro industrial by-products in animal feeding systems can be a potential sustainable strategy for improving animal welfare and product quality. It is well known that by-products, due to the high concentration of bioactive compounds, represent an effective resource in enhancing nutritional and organoleptic meat quality (Salami et al., 2019). Among meat quality traits, color represents the predominant criterion that determines meat marketability and consumer attractiveness (Gagaoua et al., 2020). Previous studies (Luciano et al., 2009; Soldado et al., 2021) demonstrated that tannin supplementation in lamb diet can affect meat oxidative stability, but little is known about the impact of these supplements on postmortem metabolisms, and related changes in sarcoplasmic protein profile. Therefore, this study aimed to investigate the effect of hazelnut skin (HS) supplementation in lambs' diet on color stability and changes of sarcoplasmic proteins during storage.

**Material and methods** The experiment was performed on 22 lambs (2 months of age) equally distributed in 2 homogeneous groups for a duration of 8 weeks. The control group (C) received a basal diet, while the hazelnut group (H) were fed with the same diet, but 150 g/kg dry matter of maize was replaced with HS. At the end of the experimental period, animals were slaughtered and, after 24 h, carcasses were longitudinally dissected and *longissimus thoracis lumborum* muscle (LTL) was removed for each side. The left LTL was then cut into 3 slices, placed in trays covered with PVC film and stored at 4°C to evaluate changes of meat color attributes and haem pigment concentrations immediately (0 d) and after 4 and 7 days of ageing. SDS-PAGE was then employed to investigate the changes in sarcoplasmic protein profiles during storage.

**Results and discussion** A significant effect of diet was found for lightness (L*; $P < 0.001$), redness (a*; $P < 0.01$), yellowness (b*; $P < 0.01$), and Chroma (C*; $P < 0.01$), with the highest values in meat from lambs fed with HS.
During aging time an increase of L*, b*, H*, and ΔE* parameters ($P < 0.001$) was found, whereas a* and C* decreased ($P < 0.001$) in both groups.
As shown in Figure 1, sarcoplasmic protein profiles were affected by the dietary treatment. In the H group, pyruvate kinase (PK), phosphoglucose isomerase (PGI) ($P<0.001$), and glyceraldehyde phosphate dehydrogenase (GAPDH) ($P<0.01$) showed higher band percentage values compared to the control. Whereas glycogen phosphorylase b kinase (GPHb), enolase (ENO1) and creatine kinase (CK) ($P<0.001$) values were found higher in meat from C group.
During the storage time, a decrease in the relative quantity of several protein bands involved in different metabolic pathways was detected in both C and H groups. Glyceraldehyde phosphate dehydrogenase (GAPDH) gradually decreases only in H group, on the contrary an increase of phosphoglucose isomerase (PGI) proteins, a glycolytic metabolism biomarker, was observed.




**Conclusion** The experiment confirmed the influence of the feeding regime on different post-mortem metabolic pathways in lamb's muscle. In particular, the supplementation of hazelnut skin influenced the profile of glycolytic enzymes suggesting a possible shift in muscle fibre type from slow to fast-twitch with high glycolytic activity.

**References**

Gagaoua M., Hughes J., Terlouw E. C., Warner R. D., Purslow P. P., Lorenzo J. M., Picard B. 2020. Trends in Food Science & Technology 101, 234-252.
Luciano G., Monahan F. J., Vasta V., Biondi L., Lanza M., Priolo, A. 2009. Meat science 81(1), 120-125.
Salami S. A., Luciano G., O'Grady M. N., Biondi L., Newbold C. J., Kerry J. P., Priolo, A. 2019. Animal Feed Science and Technology 251, 37-55.
Soldado D., Bessa R.J., Jerónimo E. 2021. Animals 11(11), 3243.

# Patterns of chemical composition of forage production in mountainous grasslands in northern western Greece

Zoi M. Parissi, Maria D. Karatassiou, Eleni M. Abraham

*Laboratory of Range Science (236), Faculty of Forestry and the Natural Environment, AUTh, 54124 Thessaloniki (Greece)*

E-mail: pz@for.auth.gr

**Take home Message** Nutritional quality of forages is affected by the topographical gradients of grasslands

**Introduction** Mountain grasslands are the main source of feed during summer for transhumant livestock farming. However, the high stocking rate applied during summer grazing reduces the abundance of palatable species, and enhances the less palatable ones (Briske, 2017). Moreover, the floristic composition is related with the slope inclination, and species' position in the slope indicates differences in the nutritional quality of the functional plant groups (Corona et al. 1995). Consequently, the alteration in floristic composition modifies forage quality and interferes with the quality of animal products as milk or cheese. The objective of this study was to examine the variability in chemical composition of functional plant groups in mountainous grasslands of Northern West Greece, as a result of the combined effects of slope inclination and grazing.

**Material and methods** The research was conducted in three mountainous grasslands with different topography (G1: flat, G2: moderate slope in NW exposure, G3: moderate slope in SE exposure) in the Regional Unit of Grevena. Transhumant flocks (mainly sheep in all grasslands and with a few cattle in G3) grazed continuously from April to October. In June the above-ground biomass was harvested and separated, for each grassland, into three functional plant groups: grasses, legumes, other forbs. The bulked samples of each group were oven-dried, ground through a 1 mm screen, analyzed for N using a Kjeldahl procedure, which enabled to calculated Crude protein (CP) content. Additionally, Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF), and Acid Detergent Lignin (ADL) were determined according to the methods of Van Soest et al. (1991) using an ANKOM 220 fiber analyzer. Statistical analysis of the data was performed using ANOVA with the use of the SPSS® statistical software v. 25.0 (SPSS Inc., Chicago, IL, USA). The Tukey criterion at the 0.05 probability level was used to detect the differences among means.

**Results and discussion** Overall, legumes had the highest CP content, as expected (Table 1). However, the CP content of grasses and forbs was high especially in G2. Probably, the topographic gradient of this grassland (lower part of the hill) leads to higher water supply that contributes to the growth of the plant species. On the other hand, NDF content have different pattern in each functional group. Grasses had significantly higher NDF content in G3 (grassland in the upper part of the hill), compared to G1 (flat) and G2. Concerning the legumes, the lower NDF content was observed in G3, while there was no significant difference in NDF content for the other forbs.

**Table 1.** Chemical composition (g/kgDM) of the three functional plant groups in the study grasslands (G1, G2, G3)

| | | CP (g/kgDM) | NDF (g/kgDM) | ADF (g/kgDM) | ADL (g/kgDM) |
|---|---|---|---|---|---|
| Legumes | G1 | 160.83$^{b}$ | 365.93$^{a}$ | 251.69$^{a}$ | 4.94$^{a}$ |
| | G2 | 190.35$^{ab}$ | 376.5$^{a}$ | 26716$^{a}$ | 5.13$^{a}$ |
| | G3 | 208.82$^{a}$ | 297.97$^{b}$ | 201.14$^{a}$ | 3.8$^{a}$ |
| Grasses | G1 | 125.07$^{b}$ | 466.96$^{c}$ | 241.76$^{c}$ | 2.42$^{b}$ |
| | G2 | 205.20$^{a}$ | 489.65$^{b}$ | 256.15$^{b}$ | 2.37$^{b}$ |
| | G3 | 129.68$^{b}$ | 525.22$^{a}$ | 279.36$^{a}$ | 3.10$^{a}$ |
| Other forbs | G1 | 152.05$^{a}$ | 281.76$^{a}$ | 197.53$^{a}$ | 4.49$^{a}$ |
| | G2 | 188.02$^{a}$ | 252.92$^{a}$ | 179.07$^{a}$ | 4.57$^{a}$ |
| | G3 | 141.4$^{a}$ | 322.00$^{a}$ | 236.44$^{a}$ | 5.28$^{a}$ |

**Conclusion** It seems that the nutritional quality of the functional plant groups had been affected both from the topographical gradients of the grasslands.

**Acknowledgements** This paper is part of the project "True Cheese project (T1EDK-04475) which is co-funded by the European Union (European Social Fund) through the Action RESEARCH -CREAT-INNOVATE.

**References**

Briske D.D., 2017. In:Briske, D. (eds) Rangeland Systems. Springer Series on Environmental Management. Springer, Cham.

Corona M.P., Ciudad A.G., Criado B.G., de Aldana B.V. 1995. Communications in Soil Science and Plant Analysis 26(9-10), 1323-1341.

Van Soest, P.J., J.B., Robertson and B.A. Lewis. 1991. Journal of Dairy Science 74, 3583–3597.

# Feed restriction in ewes affects milk performances and milk lipolysis

Laurence Bernard[1], Catherine Hurtaud[2], Hélène Larroque[3], Charlotte Allain[4], Sara Parisot[4], David Portes[4], Valentin Coulon[4], Sylvain Emery[1], Aurore Oudotte[5], Philippe Trossat[5], Christelle Cebo[6]

[1]*INRAE, Université Clermont Auvergne, Vetagrosup, Herbivores, F-63122 Saint-Genès-Champanelle, France*
[2]*INRAE-Agrocampus Ouest, PEGASE, F-35590 Saint-Gilles, France*
[3]*INRAE, Université de Toulouse, ENVT, GenPhySE, F-31326, Castanet Tolosan, France*
[4]*INRAE, UEF Unité Expérimentale de La Fage, F-12250, Roquefort-sur-Soulzon, France*
[5]*Actalia-Cécalait, Rue de Versailles, F-39800 Poligny, France*
[6]*INRAE, AgroParisTech, GABI, Jouy-en-Josas, France*

E-mail: laurence.bernard@inrae.fr

**Take home Message** Feed restriction reduces not only milk yield but also milk lipolysis in ewes.

**Introduction** Milk lipolysis is defined as the hydrolysis of triglycerides, the main component of milk fat. As a consequence, the release of free fatty acids in milk is responsible for milk flavor defects together with alterations of foaming and creaming abilities of milk. Milk lipolysis represents an important criterion to assess the quality of milk. Feed restriction was used as a model for studying milk lipolysis and its mechanisms in 3 ruminant species within the frame of the LIPOMEC project (ANR-19-CE21-0010). Indeed, whereas feed restriction is known to increase and decrease milk lipolysis in dairy cows (Vanbergue et al., 2018) and goats (Chilliard et al., 2014) respectively, no data were available so far in dairy ewes. The aim of our experiment was to study the effect of feed restriction on milk performances in dairy ewes and to characterize its effects on milk spontaneous lipolysis in relation with the associated milk composition.

**Material and methods** At the INRAE experimental farm of La Fage located in Aveyron, two groups of 24 ewes (102 ± 2.0 days in milk) received either a control diet (100% of the dry matter intake (DMI) ad libitum: unrestricted; UR) or the experimental diet (65% of the DMI ad libitum: restricted; R) according to a 2 X 2 cross-over design. The diet consisted of 72% forage (half grass silage and half alfalfa hay) and 28% concentrate on a DM basis. The duration of the restriction was 5 days. Milk yield, fat and protein contents were measured. The last day of the treatment, lipolysis on morning and evening milkings was analyzed by both the copper-soap and by ISO/TS 22113 standard (BDI method). Milk fat globule and casein micelles size distributions were evaluated by laser light scattering. Analyses of variance including effects of group and diet were performed using the MIXED procedure of SAS.

**Results and discussion** For the first time, we showed that feeding restriction in ewes caused a decrease in milk spontaneous lipolysis measured by the copper-soap method (-0.25 and -0.46 Meq / 100 g of fat, P<0.001, respectively for morning and evening milking) or by the BDI method (-0.27 and – 0.45 Meq / 100 g of fat, P<0.01, respectively for the morning and evening milking). At the same time, milk yield, decreased (-0.41 l/d) whereas milk fat and protein contents increased (+ 5.2 and +1.0 g/l respectively, P<0.01) and no effect was observed on somatic cell count. Feed restriction was associated with an increase in the diameter of milk fat globules at evening milking (+0.2 µm, P<0.0001) and the diameter of casein micelles (+9 and +14 nm, P<0.001 respectively on morning and evening milkings). Dietary restriction induced decreases in live weight, indicating mobilization of body reserve.

**Table 1** Milk yield, composition and milk lipolysis according to feeding treatments, unrestricted (UR) or restricted ( R) in 48 dairy ewes (n=96)

| | Item | | | Diet effect |
|---|---|---|---|---|
| | UR | R | SEM | P-value |
| DMI, kg/d | 5.4 | 3.7 | 0.123 | <0.001 |
| Live -weight, kg | 74.8 | 69.3 | 0.63 | <0.001 |
| Milk, l/d | 1.92 | 1.51 | 0.056 | <0.001 |
| Fat content, g/l | 78.6 | 83.9 | 1.65 | <0.001 |
| Protein content, g/l | 58.7 | 59.7 | 078 | 0.0266 |
| **Lipolysis (mEq/100g fat)** | | | | |
| Copper salt Morning milking | 0.40 | 0.15 | 0.048 | 0.0001 |
| Copper salt Evening milking | 0.76 | 0.30 | 0.086 | 0.0001 |
| BDI Morning milking | 0.53 | 0.26 | 0.060 | 0.0018 |
| BDI Evening milking | 0.82 | 0.37 | 0.110 | 0.0001 |
| **Milk fat globule diameter, µm** | | | | |
| Morning milking | 5.30 | 5.34 | 0.068 | 0.459 |
| Evening milking | 5.10 | 5.30 | 0.071 | <0.0001 |
| **Casein micelles diameter, nm** | | | | |
| Morning milking | 140 | 149 | 2.8 | <0.0001 |
| Evening milking | 146 | 160 | 2.7 | <0.0001 |

**Conclusion** For the first time, the present study highlighted a decrease of more than 50 % in milk lipolysis in dairy ewes in response to feed restriction. This breeding factor may occur in periods of limited food resources due to climatic hazards in particular in the Mediterranean area. This first zootechnical approach will be enriched by lipidomics, proteomics and transcriptomics approaches applied to milk on a set of animals selected for being extreme in term of lipolysis.

**Acknowledgements** This study was supported by the French National Research Agency within the LipoMEC project.

**References**

Chilliard, Y., Toral P. G., Shingfield K. J., Rouel J., Leroux C., Bernard L. 2014. Small Ruminant Research 122, 31-37.
Vanbergue E., Peyraud J. L., Ferlay A., Miranda G., Martin P., Hurtaud C. 2018. Livestock Science 217, 116-125.

# Comparative assessment of advanced lines and cultivars of faba bean (*Vicia faba* L.) for anti-nutritional factors using molecular markers

Eleni Avramidou[1], Maria Irakli[2], Zoi Parissi[1], Eleni Abraham[1], Panagiotis Madesis[3]

[1]*Aristotle University Thessaloniki, Greece*
[2] *HELLENIC AGRICULTURAL ORGANIZATION –DIMITRA*
[3]*Department of Agriculture Crop Production and Rural Environment, University of Thessaly, Greece*

E-mail: eabraham@for.auth.gr

**Take home Message** Further research is needed in faba bean breeding programmes to diminish anti-nutritional factors.

**Introduction** Faba bean (*Vicia faba* L.) is an important grain legume with high protein content and nutritional value, which is broadly cultivated in temperate areas for human food, animal feed and green manure (Crépon et al. 2010). Faba beans are an alternative crop to cereals, maintaining soil fertility due to their ability to fix free nitrogen and to grow in different climatic zones (Gutierrez and Torres 2019). However, in many faba bean cultivars, anti-nutritional compounds hinder their nutritional quality, which limits their use for humans and animals (Skylas et al. 2019). In this respect, the genetic variation of faba bean germplasm needs to be explored to enable the release of high-yielding cultivars with high seed quality. The aim of the present study was to evaluate the genetic diversity by using ScoT molecular markers and the content of anti-nutritional traits of two commercial cultivars and three advanced lines of faba bean.

**Materials and methods** Three advanced lines from the company Agroland SA (KK18, KK10, KK14) and two cultivars (Polycarpe and Tanagra) were evaluated using 6 Start Codon Targeted (ScoT) molecular markers to determine their genetic diversity (Adawy 2014)**.** The procedure of Doyle and Doyle (1987) was used for the isolation of total genomic DNA. The Polymerase chain reaction (PCR) procedure for SCoT analysis was performed in a total volume of 20 μL. Amplification products were separated by electrophoresis on a 1.5% agarose gel and stained with ethidium bromide. For each genetic material, a seed bulk was obtained and three biological replicates were used to determine (a) total phenolic content (TP), based on the Folin-Ciocalteu method. (b) total tannin content (TT) by the difference in TP tested before and after the polyvinylpyrrolidone treatment and (c) condensed tannins (CT), according to a butanol-acid assay (Irakli et al. 2021).

**Results and discussion** A total of 103 loci were obtained from the SCoT markers, with 58.25% being polymorphic and 41.75% monomorphic. Among the populations, cv. Polycarpe had the highest polymorphism and genetic variation, according to Shannon's information index, and cv. Tanagra the lowest (Table 1). The advanced line KK18 had 5 private bands, following by cv. Polycarpe with 4.

**Table 1** Genetic diversity and concentration of total phenolic content, total tannin content and condensed tannins of five *V. faba* populations.

| Population | N[1] | NPB[2] | No private bands | P (%)[3] | Shannon's Index (I)[4] | GD[5] | TP (mg GAE/g)[6] | TT (mg GAE/g)[6] | CT (mg PCNE/g)[7] |
|---|---|---|---|---|---|---|---|---|---|
| cv. Tanagra | 5 | 78 | 0 | 50.49% | 0.300 | 0.205 | 3.71[a] | 2.07[a] | 4.70[b] |
| cv. Polycarpe | 5 | 81 | 4 | 66.02% | 0.392 | 0.269 | 3.93[a] | 2.19[a] | 4.08[a] |
| KK14 | 5 | 75 | 0 | 62.14% | 0.373 | 0.256 | 5.02[c] | 2.95[c] | 5.39[c] |
| KK10 | 5 | 83 | 1 | 61.17% | 0.370 | 0.255 | 4.81[c] | 2.73[b] | 5.73[c] |
| KK18 | 5 | 88 | 5 | 51.46% | 0.319 | 0.222 | 4.39[b] | 2.62[b] | 4.22[a] |
| Mean | 5 | 81 | | 58.25% | 0.351 | 0.241 | | | |
| Species level | 25 | | | | | | | | |

[1]N: number of individuals; [2]NPB: Number of polymorphic bands; [3]P (%): Percentage of polymorphic bands; [4]I: Shannon's information index; [5]GD: gene diversity; [6]TP: total phenolic content, TT: total tannins content, CT: condensed tannins; GAE: gallic acid equivalents, PCNE: procyanidins equivalents

Concerning anti-nutritional factors (Table 1), cultivars Tanagra & Polycarpe had the lowest TP and TT values, whereas lines KK10 and KK14 had the highest. For CT values, cv. Polycarpe and line KK18 had the lowest values. Overall, CT contents of the populations was quite high, particularly for KK14 and KK10, which may have detrimental effects on animal performance.

**Acknowledgments:** Co-financed by the European Regional Development Fund of the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH–CREATE–INNOVATE (project code: T1EDK-04448).

**References**

Adawy, S.S. 2014. Field Crops Res. 2010, 115, 329–339.
Doyle, J., Doyle, J.L. 1987. Phytochem. Bull. 19, 11–15.
Gutierrez, N. and Torres, A.M. 2019. Scientific reports 9, 16174.
Irakli *et al*. 2021. Antioxidants 11, 1154.
Skylas *et al*. 2019. Crop & Pasture Science, 70, 463–472.

# Agro-industrial by-products in animal feed industry: Sardinian livestock as a case study

Fabio Correddu, Maria Francesca Caratzu, Giuseppe Pulina

*Dipartimento di Agraria, University of Sassari, Sassari, Italy*

E-mail: fcorreddu@uniss.it

**Take home Message** Agro-industrial by-products may positively contribute to reduce feeding cost and the environmental impact of livestock.

**Introduction** The use of agro-industrial by-products in animals' nutrition has gaining renovate great attention, considering the recent increase of primary commodity prices, reflected on the feed price, and the urgent need to reduce the environmental impact of feed production. A part several coproducts originates from food chain production traditionally included in feeds, a large part of other by-products has not usually considered because of some problems related to their use (Correddu et al., 2020). These problems have been deeply investigated and are mainly related to the high humidity of these materials that compromises their stability and storage. Another complication is related to the lack of information about the quali-quantitative characteristics of these products. Indeed, the huge variability in chemical composition and in the availability across different years make difficult the inclusion of these feeds in livestock-diets. In this work, considering the livestock in Sardinia as a case study, an investigation on some main agro-industrial by-products was carried out to estimate the contribution of the inclusion of these by-products in animal nutrition, in the control of the prices of feeds and in the reduction of environmental impact of feed production.

**Material and methods** This study focused on by-products generated from winery, olive oil, tomatoes, artichoke, and beer industries: grape pomace, olive cake, tomato pomace and spent grains, respectively. Data of by-products production and chemical composition were retrieved by a literature revision and from official database (ISTAT, 2021). The amount of each by-product was calculated considering the total production of wine, olive oil, tomatoes, artichoke, and beer in Sardinia in the 2020 (ISTAT, 2021) and the mean percentage of each related by-product found in literature. For each by product the following chemical parameters were considered: moisture, dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), lipids, and ashes. Except for moisture, all the parameters referred to the dried by-products. The contribution of by-products in the reduction of feed cost and environmental impact was estimated considering the inclusion of the total amount of protein from all by-products in a typical ration of dairy sheep and a carbon footprint of concentrate (17% of CP) of 0.93 kg CO2 eq/kg of concentrate (Assalzoo, 2020).

**Results and discussion** the total amount of by-products was 89,636 tons. The calculated total amount of proteins was about 3000 tons. Considering a mean concentrate intake of 100 kg per year per head (CP 17%), the protein available from by-products could be included in the diet of about 450,000 dairy sheep, replacing 1/5 of the daily amount of dietary protein from concentrates. This calculation was carried out considering an average loss of material of about 50% from the industry to the fed-trough. In addition, the use of co-products in the ration of dairy sheep, could reduce the carbon footprint related to the concentrates for about 20%. The calculated reduction of the concentrate cost was of 15% (± 5%) varies with the specific dietary formulation.

**Conclusion** Results of the present study suggest that the inclusion of by-products (not yet considered by feed industries) in animal nutrition is a promising strategy to control the price of feeds and in reducing the environmental impact of their production.

**Acknowledgements** This research was funded by BSGreen2021, University of Sassari.

**References**

Assalzoo, Associazione Nazionale tra i Produttori di Alimenti Zootecnici. Report ambientale 2020.
Correddu F., Lunesu M.F., Buffa G., Atzori A.S., Nudda A., Battacone G., Pulina G. 2020. Animals, 10, p.131.
ISTAT 2021. Istituto nazionale di Statistica.

# Microbiological and Physical-Chemical Properties of Baled Silage after Long Term Conservation

Francesco Fancello[1], Mondina Francesca Lunesu[2], Francesca Ghilardelli[3], Lidia Nieddu[2], Severino Zara[1], Antonello Cannas[2], Antonio Gallo[3], Alberto Stanislao Atzori[2]

[1] *Unit of Microbiology, Department of Agriculture, University of Sassari, Sassari, Italy*
[2] *Section of Animal Science, Department of Agriculture, University of Sassari, Sassari, Italy*
[3] *Department of Animal Science, Food and Nutrition (DIANA) Università Cattolica del Sacro Cuore, Piacenza, Italy*

E-mail: asatzori@uniss.it

**Take home Message** Baled silages that are ensiled under desirable fermentation conditions can maintain their quality with minor Clostridia contaminations for up to 6 months of storage and provide high quality supplemental feed for dairy sheep.

**Introduction** Conservation of forages in baled silages can be a good alternative to haymaking, since high quality, vegetative and leafy biomass can be stored for supplemental feeding of dairy sheep (Borreani et al., 2019). This conservation method is a recent introduction to the Italian dairy sheep sector where concerns of Dairy plants, on potential negative effects of Clostridia contaminations in cheese maturation, have limited its use. In Sardinia, where 2.6 million sheep are reared, the supplemental feeding of high-quality baled silages to sheep during the times of limited pasture growth has recently gained a traction. The production of baled silages usually takes place from February to half May, but their storage and use can often be extended until summer and autumn for up to a period of 9 months following the ensiling. Thus, it is important to assess the effect of long-term storage on the silage characteristics. In this study, following 100 and 180 days of storage periods, the risk of undesired fermentation was investigated through quantifying the microbiological and physical-chemical characteristics of baled silages that were produced in four dairy sheep farms located in Sardinia island of Italy.

**Material and methods** A total of 50 samples of baled silages from pre-dried herbages were collected from four farms (10 bales in farm A, and five bales in each B, C and D farm; n= 25) at 100 and 180 days after baling. Physical-chemical (Gallo et al., 2021) and microbiological analyses were conducted. For microbiological analysis the count of lactic acid bacteria (LAB), total mesophilic aerobic bacteria (TMC), yeast, moulds and clostridia in different selective media were performed. The correlation matrix of microbiological and physical-chemical determinations was developed to find latent variable with the principal component analysis (PCA), and a varimax rotation criteria was used.

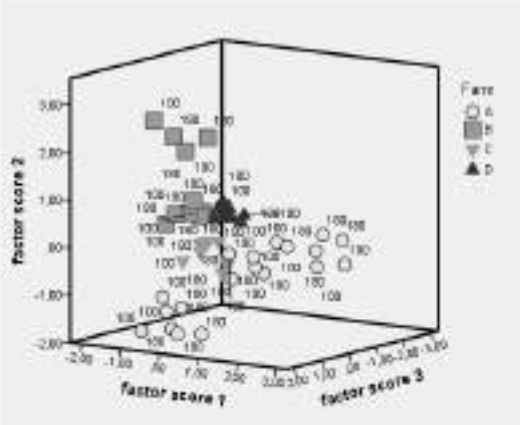



**Figure 1** Factor score plot from principal component analysis (PCA) of baled silage at 100 and 180 days.

**Results and discussion** Baled silages analysed in this study showed good physical-chemical and microbiological characteristics for sheep feeding. At 100 and 180 days, respectively, the following values were observed in the silage samples (mean±SD): dry matter (DM) content was 32.1±6.0 and 34.8±6.0% (ranging from 22.4 to 43.4%); pH was 3.97±0.16 and 3.98±0.20 (ranging from 3.6 to 4.3), CP was 13.0±28 and 12.8±2.8 (ranging from 8.2 and 19.8%) and NDF was 50.9±4.1 and 50.7±3.8% of DM (ranging from 44.2 to 57.5). Sporadic mould contamination, with only 7 out of 50 samples were observed (5 of them at 180 days), but never exceeding 103 CFU/g of silage. The 2.8% of samples had clostridia contamination, with an average of 330 spores/g of silage. Only in three samples, the spores exceed 103 spores/g of silage. LAB, TMC and yeast at 100 days were on average 6.23, 5.05 and 2.07 log10 CFU/g of silage, respectively. At 180 days, the LAB and TMC values decreased, whereas yeast slightly increased. The DM content of silages obtained in the current study were lower than those observed by Coblentz et al. (2018). The low content of ammonia nitrogen (on average, 4.85±1.9 % Total N) and butyric acid (on average, 0.002±0.006 % DM) of baled silage are in line with the low counts of clostridia. PCA aggregated the samples of baled silage in function of farm, while no differences were observed for time of sampling (Figure 1). The first three components explained 65% of the variance. The first component, “fermentative strength”, was positively correlated with number of LAB, lactic acid, ethanol, and 1,2 propanediol. The second component, “nitrogen metabolism”, was strongly correlated with CP and its fractions (NDIP, ADIP, soluble CP) or N-NH3, while negative correlation was observed with sugar and yeast count. The third component, “carbohydrate fractions”, was positively correlated with NDF, ADF and acetic acid, while it was negatively correlated with DM, ADL and starch.

**Conclusion** Baled silages produced in four Sardinian dairy sheep farms showed desirable chemical and fermentative quality, with low risks of clostridia contaminations up to a 180-day storage period. Broad surveys are needed to characterize the quality variability and the fermentative status of baled silages beyond 6 months of storage to investigate the effects of longer storage periods.

**References**

Borreani G., Ferrero F., Tabacco E. 2019. VI International Symposium on Forage Quality and Conservation, Brasil.
Coblentz W.K., Akins M.S. 2018. Journal of Dairy Science 101(5), 4075-4092.
Gallo A., Fancello F., Ghilardelli F., Zara S., Froldi F., Spanghero M. 2021. Animal Feed Science and Technology 277, 114962.

# Temporal patterns of variation in dairy performance suggest that sheep diverging in feed efficiency have similar resilience when exposed to a severe nutritional challenge

Gonzalo Hervás, Pablo G. Toral, Antonella Della Badia, Alejando G. Mendoza, Pilar Frutos

*Instituto de Ganadería de Montaña (IGM), CSIC-Universidad de León. Finca Marzanas s/n 24346 Grulleros, León, Spain.*

E-mail: g.hervas@csic.es

**Take home Message** In dairy ewes, a greater feed efficiency did not seem related to a lower resilience when exposed to a severe nutritional challenge (feeding only straw for 3 days).

**Introduction** In livestock production, resilience is defined as the ability of an animal to either maintain or revert quickly to high production and health status in response to a challenge. Due to the intrinsic resistance and resilience of small ruminants, sheep are usually reared in less-favored environments because they can adapt to harsh conditions, adding value to regions where other types of agricultural activities are difficult to impossible. Nevertheless, dairy ewes are being selected based on standard breeding goals, such as total milk yield, which is known to cause a loss of rusticity and a shorter productive life. Thus, the future productivity of dairy sheep flocks may be compromised by nutritional challenges, which are expected to increase their frequency and severity due to climate change and/or feed supply crises. Although a redirection in breeding programs from milk production level towards improved feed efficiency (FE) might take place in coming decades (Arthur et al., 2014), the extent to which FE may be increased without compromising resilience remains largely unknown, not only in sheep, but also in other dairy ruminants. Thus, this study was conducted as a first step to examine the relationship between FE and resilience in dairy ewes. To this aim, we compared the temporal pattern of variation in the dairy performance of lactating sheep phenotypically divergent for FE and subjected to a severe nutritional challenge.

**Material and methods** Forty primiparous Assaf ewes were housed in individual pens and milked twice per day. Sheep were offered ad libitum a total mixed ration (50:50 forage:concentrate ratio), and body weight and daily feed intake and milk yield were recorded over 3 weeks to estimate their FE (calculated as the difference between the actual and predicted intake estimated through net energy requirements for maintenance, production and body weight change; INRA, 2018). Then, ewes with the highest (n=10; H-FE) and the lowest (n=10; L-FE) efficiency were subjected to a severe nutritional challenge by restricting their feeding only to straw for 3 days. Sampling and controls were conducted i) on the last 3 days before the challenge (control period), ii) 1 day at the end of the challenge period, and iii) on days 9 and 10 after the challenge (recovery period). On those days, feed intake and milk yield were recorded and individual milk samples were collected for composition analysis and somatic cell count. Sheep were also weighed at the control and recovery periods. Data were subjected to ANOVA using the MIXED procedure of SAS 9.4, with a statistical model that included the fixed effects of the group (i.e., H-FE vs. L-FE), the period (i.e., control, challenge and recovery, which were included as repeated measurements) and their interaction. Means were adjusted for multiple comparisons with Bonferroni's method.

**Results and discussion** Differences in efficiency between L-FE and H-FE were mainly explained by a greater milk yield in the latter group (2.0 vs. 2.8 kg/d; $P<0.01$), while having a similar feed intake (on average, 2.8 kg DM/d; $P>0.10$). This FE phenotype is consistent with a recent study in dairy ewes (Toral et al., 2021), whereas improved FE in meat ruminants seems due to decreased intake level (Arthur et al., 2014). The undernourishment challenge caused a greater reduction in milk yield in H-FE (-72%) than in L-FE (-66%), but both groups fully recovered their initial production within 10 days from the end of the challenge ($P<0.01$). Similarly, an interaction between the effects of group and period ($P<0.01$) was observed for milk fat concentration, which increased by 84 and 50% in H-FE and L-FE in the challenge, recovering their respective control values afterwards. Milk fat yield was always greater in the most efficient ewes, regardless of the period (on average, +42%; $P<0.01$). Milk lactose and protein concentrations did not differ between groups at any period ($P>0.10$), and time-depending variations in their yield mirrored those of milk yield. Overall, the greater performance level of H-FE than L-FE before and after the challenge, and their full recovery afterwards might be indicative of similar resilience in sheep divergent for FE level. Nevertheless, H-FE ewes had lower initial body weight than L-FE (63.4 vs. 70.3 kg; $P<0.01$) and tended to lose more weight over the trial (-2.5 vs. -0.8 kg; $P=0.08$). Further research is required to examine how this greater tissue mobilization may affect the resilience of H-FE sheep subjected to a sustained nutritional challenge over time.

**Conclusion** The performance level of dairy ewes was fully recovered after a severe nutritional challenge regardless of their feed efficiency level, suggesting that divergences in efficiency would not be related with differences in resilience.

**Acknowledgements** Project PID2020-113441RB-I00 (MCIN/AEI) and grant PRE2018-086174 (MCIU/AEI/FSE, EU).

**References**

Arthur P.F., Pryce J.E., Herd R.M. 2014. Proceedings of the 10th WCGALP. 17-22 August 2014. Vancouver, Canada.
INRA. 2018. Alimentation des ruminants. Éditions Quae, Versailles, France.
Toral P.G., Hervás G., Fernández-Díez C., Belenguer A., Frutos P. 2021. Journal of Dairy Science 104, 5569-5582.

# *Bacillus subtilis* and *Phanerochaete chrysosporium* enhance the utilization of palm leaf hay replacing wheat hay in the diet of lambs under desert conditions

Hatem A. Hamdon[1], Ahmead E. Kholif[2], Gamal B. Mahmoud[3], Ali M.A. Khalifa[1], Mahmed N.Abdel Ati[3],

[1] *Department of Animal Production, Faculty of Agriculture, New Valley University, New Valley, Egypt*
[2] *Dairy Science Department, National Research Centre, 33 Bohouth St. Dokki, Giza, Egypt*
[3] *Department of Animal Production, Faculty of Agriculture, Assiut University, Assiut, Egypt*

E-mail: hamdon@agr.nvu.edu.eg

**Take home Message** Lambs fed date palm leaves without adverse effects on blood metabolites.

**Introduction** Semi-arid and arid regions experience low rainfall, resulting in low primary production and forage quality. Under these conditions, it seems only too convenient to use foliage from trees and shrubs as an adequate source of feed for small ruminants. Similar to many other countries, Egypt suffers from a lack of availability of feed ingredients, especially in tropical areas under desert conditions, leading to the utilization of unconventional feeds and secondary agricultural products. In Egypt, large amounts of agricultural by-products are available; however, most of these products are burned, causing environmental pollution. Date palm (*Phoenix dactilifera*) is a major crop in Egypt, with an estimated population of approximately 14 million trees producing approximately 650,000 tons of dry matter (DM) annually.

**Material and methods** Growth experiment trail, twenty-four Farafra lambs with an average body weight of 29.5 ± 1.25 kg and 5-6 months of age were randomly assigned to four experimental groups. Lambs were offered a basal diet containing a concentrate feed mixture and wheat hay at 60:40 (control treatment). In the other treatments, wheat hay was replaced with crushed palm leaf hay without supplementation (DPL treatment), supplemented with 2 g of B. subtilis and P. chrysosporium (DPL2 treatment) or supplemented with 4 g of B. subtilis and P. chrysosporium (DPL4 treatment). The concentrate feed mixture contained 550 g of yellow corn, 225 g of wheat bran, 200 g of soybean meal, 15 g of limestone, 5 g of premix and 5 g of sodium chloride per kg DM. Lamb requirements were adjusted biweekly according to changes in body weight. Daily allocations of B. *subtilis* and P. *chrysosporium* for each lamb were provided individually in 100 g of concentrate before morning feeding to assure intake. At the end of the experimental period, three random animals from each group were slaughtered. Digestibility experiment, twelve adult rams weighing 50±0.1 kg were randomly allocated into four treatment groups to determine the nutrient digestibility of the diets used in the performance experiment using the faecal bag technique. Statistical analysis was using GLM.

**Table 1** Performance, feed intake and feed efficiency of lambs fed date palm leaves supplemented with B. subtilis and P. chrysosporium at different levels.

| | Treatments[1] | | | | SEM | P value |
|---|---|---|---|---|---|---|
| | Control | DPL | DPL2 | DPL4 | | |
| *Performance (kg)* | | | | | | |
| Initial weight | 30.2 | 29.4 | 29.5 | 28.9 | 2.01 | 0.984 |
| Final weight | 45.0 | 44.7 | 45.4 | 45.5 | 2.23 | 0.995 |
| Daily gain (g/d) | 140$^{b}$ | 145$^{ab}$ | 152$^{ab}$ | 158$^{a}$ | 4.15 | 0.049 |
| Total gain | 14.7$^{b}$ | 15.3$^{ab}$ | 15.9$^{ab}$ | 16.6$^{a}$ | 0.32 | 0.045 |
| *Feed intake (g/d)* | | | | | | |
| Concentrate intake | 1116 | 1112 | 1112 | 1112 | 13.5 | 0.996 |
| Roughage intake | 527$^{a}$ | 331$^{b}$ | 323$^{b}$ | 304$^{b}$ | 10.6 | 0.001 |
| Total feed intake | 1643$^{a}$ | 1444$^{b}$ | 1435$^{b}$ | 1417$^{b}$ | 20.8 | 0.001 |
| Feed efficiency (g intake /g gain) | 11.72$^{a}$ | 9.93$^{b}$ | 9.46$^{c}$ | 8.95$^{d}$ | 0.13 | 0.001 |

[1]Lambs were fed a basal diet containing concentrate feed mixture and wheat straw (control treatment) or a basal diet containing date palm leaves (instead of wheat straw) without supplementation (DPL) or supplemented with Bacillus subtilis and Phanerochaete chrysosporium at 2 g (DPL2) or 4 g (DPL4) per lamb daily.

**Results and discussion** Supplementation with *B. subtilis* and *P. chrysosporium* at a high level enhanced the daily gain of lambs by approximately 12.8% compared with the control. Enhancement of nutrient digestibility and improvement of microbial protein synthesis result in increased amino acid supply at the post-ruminal level with supplementation and can be considered the main reasons for increasing daily gain. Additionally, increased release of different endogenous substances, including antibacterial substances, nutrients, antioxidants, growth factors and coagulating agents, enhances performance and reduces the incidence of diarrhoea by increasing the number of beneficial microorganisms in the rumen and enhancing animal health. The inclusion of palm leaf hay in the diets decreased roughage intake by approximately 37.2 to 42.3%, which is mainly due to the palatability and physical properties of palm leaves. Replacement of wheat hay with palm leaf hay enhanced feed efficiency by approximately 15.3 to 23.6%, which is a result of decreased feed intake and increased daily gain for lambs fed palm leaf hay. The DPL4 treatment increased the hot carcass weight and dressing percentage. The modes of action and positive effects of probiotics are generally considered to involve changes in rumen fermentation rates and patterns (Retta, 2016).

**Conclusion** Date palm leaves can be used as forage feed for lambs, replacing conventional forages such as wheat straw.

**Acknowledgements** The authors thank staff members, Faculty of Agriculture Farm, New Valley University.

**References**

NRC, 2007. National Academic of Science, Washington, D.C. USA, p. 45-50.
Retta K.S. 2016. International Journal of Livestock Production 7, 24–32.

# Substituting alfalfa hay with tomato wastes resulting from plants pruning to feed Barbarine lambs: effects on diet intake and growth performances

Hadhami Hajji, Mariem Ben Rjeb, Salma Bessalah, Mabrouk M. Seddik, Samira Arroum, Mohamed Dbara, Mohamed Hammadi, Touhami Khorchani

*Arid Regions Institute, Medenine, Tunisia*

E-mail: hajj.hadhami@gmail.com

**Take home Message** Greenhouse by-products could constitute an important inexpensive fodder resource whose exploitation makes it possible to avoid an environmental problem and feed livestock.

**Introduction** The geothermal waters of the oases in the south east of Tunisia are exploited in different ways, including warming and irrigation of greenhouses for the production of market garden crops. Greenhouses value chain generates the accumulation of a significant quantity of green plant biomass resulting from the pruning of plants during the production period and the uprooting of whole plants at the end of the season. These by-products could constitute an important inexpensive fodder resource whose exploitation could make it possible to reduce environmental problem and to feed livestock. The present work aims to valorize tomato by-products from the pruning of tomato plants as a substitute for alfalfa hay at different levels in fattening Barbarine lambs in order to reduce the meat production costs.

**Material and methods** The experiment involved 24 Barbarine male lambs (31.4 ± 2.1 kg of average body weight, 8 months age). The animals were divided into 3 groups; Al100, Al50-T50 and T75-Al25 receiving as basal diet 100% alfalfa hay, 50% tomato waste with 50% alfalfa hay and 75% tomato waste and 25% alfalfa hay, respectively. All lambs received the same amounts of forage (increasing from 1000 to 1400 g)and the same quantities of concentrated feed (increased from 500 to 700 g). The experiment lasted 88 days including 15 days of adaptation. During the experimental period feed intake was estimaded dayly by calculating the difference between the distributed and the refused quantities. Besides and animals growth was determined by weighing them every fortnight and average daily gain calculation. Feeds' chemical composition ( Dry matter, ash, protein, NDF, ADF,ADL) was determined.

**Results and discussion** The total nitrogen (TN) in Alfalfa hay was relatively low (18%) in comparison to known values and its Neutral detergent fiber (NDF) content was high (52%), this is due to the late cutting stage (4th cut). On the other hand, tomato waste has a satisfactory TN content (22%), which is close to the values known for alfalfa at the first and 2nd cut, and it has a lower content of parietal compounds (28%). The feed intake results revealed that the sum of both forages (alfalfa hay and tomato plants) was ingested with the same amount between Al100 and the Al50-T50 groups. However, the substitution of alfalfa hay by tomato wastes at the level of 75% has limited both forage and diet intake in comparison to both other groups (P=0.08; P=0.05). The intake results were clearly reflected on growth performances; in fact, Al100 and Al50-T50 groups had similar average daily gain (ADG) (135 and 136 g, respectively). The ADG values are lower than those found by Hajji et al, (2016) (164 g) when lambs were fed by diets composed of 1/3 of oat hay and 2/3 of concentrate feed. Besides, although the values were not statistically different, both Al100 and Al50-T50 groups reached higher total weight gains (TWG) for, (11.2 and 11.7 kg, respectively) in comparison to the T75-Al25 group which gained only 9.8 kg of biomass. These results confirm those of other authors who have shown that the fattening of lambs having reached the traditional marketing weight (25-30 kg) remains profitable and makes it possible to achieve better growth performance with mixed rations but rich in concentrated feed, 1/3 of the ration (Skouri et al 1969).

**Table 1** Feed chemical composition.

| | DM (%) | Ash (%) | TN (%) | NDF (%) | ADF (%) | ADL (%) |
|---|---|---|---|---|---|---|
| Alfalfa hay | 92 | 8.6 | 18 | 51.9 | 39.7 | 11 |
| Tomato plants | 91 | 9 | 22 | 28.3 | 15.8 | 7 |
| Tomato leaves | 93 | 8.3 | 23 | 21.5 | 14.2 | 7 |
| Tomato Stems | 92 | 7.4 | 18 | 38 | 30.6 | 5 |
| Concentrate feed | 94 | 8 | 18 | 25.1 | 11.7 | 1 |

**Table 2** Lambs growth performances and feed intake.

| | Groups | | | Statistics |
|---|---|---|---|---|
| | Al00 | Al50-T50 | T75-Al25 | P |
| IBW (kg) | 31.4 | 31.5 | 31.2 | 0.98 |
| FBW (kg) | 42.6 | 43.2 | 40.9 | 0.35 |
| ADG (g/d) | 135 | 136 | 125 | 0.42 |
| TWG (kg) | 11.2 | 11.7 | 9.8 | 0.37 |
| Forage intake (g) | 782[a] | 719[a] | 636[b] | 0.08 |
| Total diet intake (g) | 1227[a] | 1192[a] | 1133[b] | 0.05 |

IBW:initial body weight; FBW:finalBody weight; AdG: Avrage daily gain; TWG: Total weight gain

**Conclusion** Partial substitution of alfalfa hay by tomato waste is possible up to a rate of 50% without negative effect on lamb growth. Thus, the exploration of these local resources can improve the profitability of farms in regions close to greenhouse tomato growing areas.

**References**

Hajji H., Smeti S., Ben Hamouda M., Atti N. 2016. Animal Production Science 56, 2115-2121.
Skouri M., Sarson M., Tchamitchian L. 1969. Document Technique de l'INRA de Tunisie 42.

# What is the contribution of woody plants to horses' diet in Mediterranean rangelands?

Estelle Mikicik[1,2], Laura Etienne[2], Denis Bastianelli[1], Magali Jouven[1]

[1]*UMR SELMET (Université de Montpellier, Institut Agro-Montpellier, INRAe, CIRAD), 2 place Pierre Viala, 34060 Montpellier, France*
[2]*IDELE, 2 place Pierre Viala, 34060 Montpellier, France*

E-mail of corresponding author: magali.jouven@supagro.fr

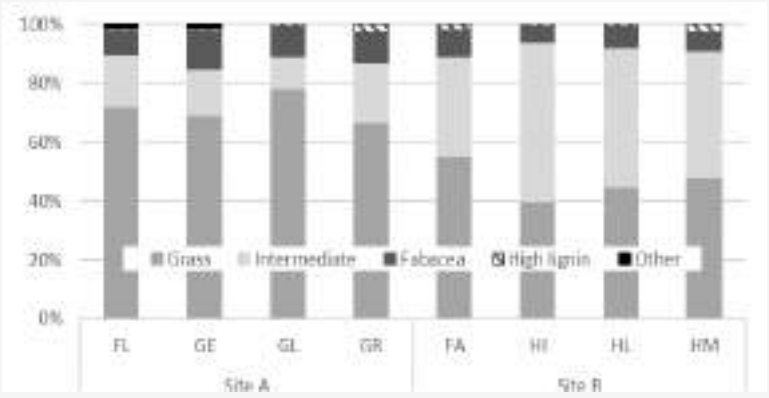
**Take home Message** Shrubs and trees contribute moderately but strategically to horses' diet: depending on the foraging context, horses ingest a variety of woody plants, which provide bites of similar quality than herbaceous forbs.

**Introduction** In Mediterranean countries, shrubby and wooded areas provide cheap forage to livestock and in return grazing conserves biodiversity-rich open areas and reduces fire risk. The development of the horse sector could be an opportunity to secure a pastoral utilization of areas of natural vegetation formerly used by ruminant farms and now abandoned. Such perspective is limited by two factors (Jouven et al., 2015): on the one hand, research studies suggest that horses are mainly graminoid feeders and avoid shrubs; on the other hand, most horse farmers are reluctant to use shrubby rangelands under the assumption of an associated low-quality diet. The objective of this work was to document the contributions of woody vegetation to the diet of horses grazing in Mediterranean rangeland, based on direct observations in two commercial farms.

**Material and methods** The work was carried out in 2019, in two 12ha-paddocks (1100m altitude) belonging to two equine farms located in the South-East of France. Each paddock was grazed by a group of young horses aged 2 to 4, associated with two older horses to calm them down. The animals did not receive any kind of supplementation besides salt blocks. Observations were carried out in May and June, which corresponds to the onset of grazing. On each site, the experiment lasted two weeks and involved two observers. The first week was devoted to calibrating data collection methods and accustoming the horses to human presence; data collection took place during the second week. Observations were carried out in two sessions per day. Each observer followed alternately 2 horses (changing horse every 2.5 min). If the horses were foraging, 20 consecutive bites were recorded. Bites were described using a coding grid referring to the botanical classification and the plant part taken. The last day, all bite categories were sampled and brought to the laboratory. Chemical composition was predicted on the basis of the NIRS spectrum using existing calibrations (Meuret et al., 1993; Cirad, unpublished). Besides, the full spectra were pre-treated and submitted to hierarchical ascendant classification.

**Results and discussion** The bites selected by horses were divided into four classes: (1) grasses, (2) intermediate (non-legume forbs + leaves from *Sorbus aria* and *Fagus sylvica);* (3) legumes (herbaceous + *Genista hispanica)*; (4) high-lignin bites (non-legume forbs + *Quercus alba, Rosa canina, Crataegus monogyna, Acer* sp.). The selected diets always associated these four classes, although the relative abundance of each class would depend on the site considered and, to a minor extend, on the horse (Figure 1). The contribution of woody plants to horse intake was low to moderate (1% or 18%, depending on the site). Our study confirms horses' preference for herbaceous plants (see for ex. Celaya et al., 2011). It also confirms a contribution of woody vegetation to horses' diet, as Van den Berg et al. (2015) suggested on the basis of a survey with Australian horse keepers.

**Figure 1.** Proportion of each bite class (% total number of bites) in the average diet of each horse, for the two sites. Initials : horses' names.




**Conclusion** The inclusion of woody plants in horses' diet and the interesting nutritional characteristics of the bites taken from woody plants suggest that Mediterranean shrubby rangelands can offer an interesting forage resource for horses. Moreover, shrubs and trees contribute to the horses' welfare by providing shade and a physical support for scratching.

**Acknowledgements** This study was supported by the PACA region (France) and the European Agricultural Fund for Rural Development. We are grateful to the two farmers who provided the horses and the rangeland paddocks.

**References**

Celaya, R., Ferreira, L. M. M., Garcia, U., Rosa Garcia, R., Osoro, K., 2011. Animal 5, 1467–1473.
Jouven, M., Vial, C., Fleurance, G., 2015. Grass and Forage Science 71(2), 178-194.
Meuret, M., Dardenne, P., Biston, R., Poty, O., 1993. Journal of NIRS 1, 45-54.
Van den Berg, M., Brown, W.Y., Lee, C., Hinch, G.N., 2015. Journal of Veterinary Behavior 10, 48-53.

# Automatic monitoring of feeding behaviour and intake in dairy sheep

Antonello Ledda, Alberto S. Atzori, Antonio Mazza, Antonello Cannas

*Dipartimento di Agraria, University of Sassari, Sassari, Italy*

E-mail: anledda@uniss.it

**Take home Message** Automatic feeding systems can enhance scientific knowledge on sheep feeding behaviour and intake

**Introduction** The utilization of automatic individual feed intake and feeding behaviour recording systems, together with the use of other precision feeding equipment, such as automatic precision scales and milking parlour with milk production measurements, can greatly improve our understanding of the factors affecting the efficiency of feed utilization and the productive performances of the animals. For this reason, with acquired a feed intake automatic recording equipment and tested its characteristics in our experimental farm.

**Material and methods** We tested the automatic feeders of Biocontrol AS (Rakkestad, Norway). They are made by individual feeding stations, each including an automatic identification system, a manger and high precision weighing load cells, to continuously measure the individual intake of the animals, dairy sheep in our case (Figure 1). The feeding stations are individually controlled by a software, in which is possible to define, for each animal, which manger(s) (and then which diet) is allowed to use, the maximum amount of diet allowed per day (or per four daily intervals), the time in which intake is not allowed or is restricted. As output, the software reports, for each animal and manger, the hour, the duration, and the amount of diet eaten at each single access. Each manger can feed various animals, with a number that varies depending on the eating rate of the diets used. The equipment was tested in adult lactating ewes (body weight range: 45-62 kg).

**Figure 1.** Details of the automatic feeders tested.

**Results and discussion** The ewes quickly adapted to the automatic feeder (1-2 weeks) and had many meals per day (e.g. Figure 2, left). The equipment accurately measured the intake even when it occurred in small amounts and for short times. The meal pattern and intake were affected by the hour of the day. It was also possible to calculate, for each ewe, the individual eating rate (g of feed eaten per second) for each meal, which markedly decreased as meal length increased with for the specific diet used (e.g., Figure 2, center). Even in diets fed ad libitum, the meal patterns were markedly affected by new feed supplies (e.g., Figure 2, right). Animals with problems were easily detected based on their meal pattern. About 6-8 ewes can be fed per manger, but when more than an ewe is fed per manger, the resulting orts cannot be attributed to a specific animal.

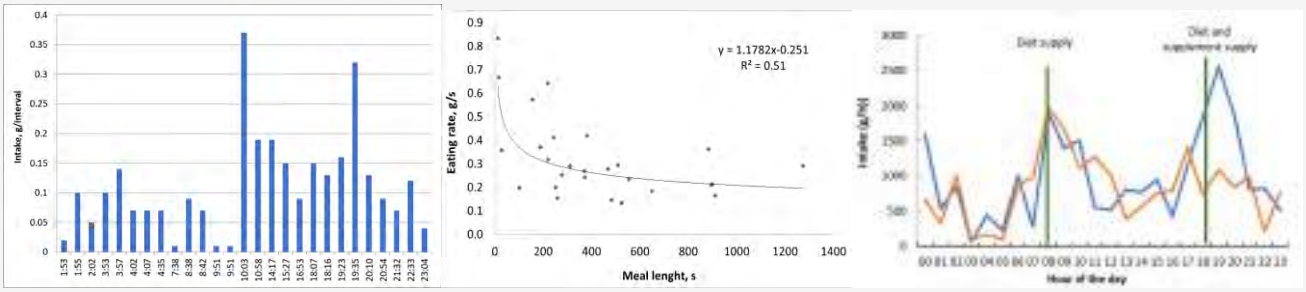



**Figure 2**. Daily meals (beginning time of the day) and intake per meal in a lactating ewe fed a total mixed ration (left); eating rate and meal length (center) for the same ewe. Hour of the meals and intake during the day for two groups of ewes diets fed ad libitum the same diet, with the orange group receiving a specific unpalatable additive in the evening meal.

**Conclusion** The automatic feeder tested provided detailed and accurate information on the feeding behaviour and intake of ewes. It represents a valuable tool to investigate the correlations among diet, feed intake and productive performances.

**Acknowledgements** This study was supported by research project COMETA PON 2017 AGRARIA.

# Adaptation of the AWIN Welfare Assessment Protocol for goats in semi-extensive farming systems

Monica Battini[1], Manuela Renna[2], Mauro Giammarino[3], Luca Battaglini[4], Silvana Mattiello[1]

[1]*Department of Agricultural and Environmental Sciences, University of Milan, Milan, Italy*
[2]*Department of Veterinary Sciences, University of Turin, Turin, Italy*
[3]*Department of Prevention, ASL TO3, Veterinary Service, Turin, Italy*
[4]*Department of Agricultural, Forest and Food Sciences, University of Turin, Turin, Italy*

E-mail: manuela.renna@unito.it

**Take home Message** A modified version of the AWIN protocol for goats can be used to assess the welfare of goats reared in semi-extensive farming conditions.

**Introduction** Welfare assessment in extensive farming systems has received less interest than in intensive systems (Temple and Manteca, 2020). Valid animal-based welfare indicators already used in intensive systems still need to be validated. Furthermore, new specific indicators need to be identified and tested for their validity, feasibility, and reliability under extensive and semi-extensive conditions, taking into account the extreme variability of environmental and management contexts characterizing pasture-based farming systems. This research aimed at testing the feasibility and reliability of a modified version of the AWIN welfare assessment protocol for goats in semi-extensive dairy goat farms.

**Material and methods** A modified version of the AWIN welfare assessment protocol was applied, simultaneously and individually, by three trained assessors in 13 dairy farms (Turin province, NW Italy) breeding Alpine and Valdostana dairy goats. From the original AWIN protocol (AWIN, 2015a), the indicators Queuing at feeding, Queuing at drinking, Kneeling at the feeding rack, Latency to first contact test and Bedding were removed because not meaningful for the considered context. The other 13 indicators of the original protocol were retained. In addition, four new indicators were included, namely Synchrony at grazing, Synchrony at resting, Use of shelter and Familiar Human Approach Test (FHAT). The order of data collection of the original AWIN protocol was modified to better adapt to the semi-extensive conditions: individual assessment of Body condition score, Hair coat condition, Abscesses, Overgrown claws, Udder asymmetry, Faecal soiling, Nasal discharge, Ocular discharge, and Improper disbudding was scheduled during the morning milking, followed by the assessment of Severe lameness on the way the goats walked from stable to pasture. In the pasture area, group-level indicators (Qualitative Behaviour Assessment - QBA, Synchrony at grazing, Oblivion, Thermal stress, FHAT, Synchrony at resting and Use of shelter) were finally recorded. The prevalence of animals without welfare problems was then calculated.

**Results and discussion** The prevalence of animals without welfare problems is reported in Table 1. Feasibility constraints were experienced by the assessors, mainly due to the need of using binoculars in unfenced pastures and grazable forestlands, to difficulties in counting animals during the group-level assessment in the pasture area, and to the presence of narrow and dark pens which in some cases made the individual-level assessment hard to conduct. These aspects, besides differences in the background of the assessors, affected data reliability, which was excellent or acceptable for almost all the indicators, but insufficient for Hair coat condition, Improper disbudding, Synchrony at grazing and QBA. Particularly for QBA, extensive training of the assessors seems to be required, as previously underlined (Battini et al., 2019). The FHAT, already included in the AWIN welfare assessment protocol for sheep to assess the Human-Animal Relationship in the ovine species (AWIN, 2015b), gave promising results and validation is currently ongoing.

**Table 1** Prevalence of animals without welfare problems (%, mean ± SE; min-max).

| | |
|---|---|
| Normal body condition | 67.9 ± 5.69 (25.0 – 100.0) |
| Good hair coat | 97.3 ± 1.99 (75.3 – 100.0) |
| Absence of abscesses | 88.1 ± 3.09 (65.0 – 100.0) |
| Regular claws | 100.0 ± 0.00 (100.0 – 100.0) |
| Symmetric udder | 96.2 ± 1.44 (87.0 – 100.0) |
| Absence of faecal soiling | 100.0 ± 0.00 (100.0 – 100.0) |
| Absence of nasal discharge | 100.0 ± 0.00 (100.0 – 100.0) |
| Absence of ocular discharge | 100.0 ± 0.00 (100.0 – 100.0) |
| Absence of severe lameness | 99.4 ± 0.50 (92.3 – 100.00) |
| Synchrony at grazing | 92.5 ± 3.63 (60.5 – 100.0) |
| Thermal comfort | 100.0 ± 0.00 (100.0 – 100.0) |
| Absence of oblivious goats | 99.3 ± 0.45 (94.9 – 100.0) |
| Synchrony at resting | 14.3 ± 7.22 (0.0 – 80.0) |
| Use of shelter | 95.1 ± 4.86 (56.3 – 100.0) |

**Conclusion** The results suggest the possibility to adapt the original AWIN protocol for goats when animals are reared under semi-extensive conditions.

**References**

AWIN 2015a. Welfare Assessment Protocol for Goats.
AWIN 2015b. Welfare Assessment Protocol for Sheep.
Battini M., Agostini A., Mattiello S. 2019. Animals 9, 477.
Temple D., Manteca X. 2020. Frontiers in Sustainable Food Systems 4, 545902.

# A qualitative approach to the agro-pastoral chain value: The case of Mount Ziria, Greece

Ragkos Athanasios[1], Maria Karatassiou[2], Zoi Parissi[2], Stavriani Koutsou[3]

[1]*Agricultural Economics Research Institute, Hellenic Agricultural Organization "DIMITRA", Athens, Greece*
[2]*School of Forestry and Natural Environment, Aristotle University of Thessaloniki, Greece*
[3]*School of Geotechnical Sciences, International University of Greece, Thessaloniki, Greece*

E-mail: karatass@for.auth.gr

**Take home Message** Pastoralism in Greece is dependent on EU subsidies. However, there are several options

**Introduction** It has been found that grazing provides greater flexibility to livestock farms and allows them to develop strategies to deal with adverse external conditions (Delsalle et al., 2012). However, agro-pastoral systems are characterized by low economic performance (Ragkos et al., 2014) and income losses due to the unfavorable competitive relationships they develop with intensive production systems. Transhumance is a livestock production system related to the climatic conditions and the topography of mountainous and less favoured areas in Greece. Despite the general trend of intensification of production, transhumance is still practiced throughout the country either co-existing with other sedentary systems or even with intensive ones (in their winter domiciles). Within PACTORES project (www.pactores.eu), the value chains of agro-pastoral production in several Mediterranean areas were analyzed, with the overall objective to understand the interactions of the actors throughout the supply chain of agro-pastoral products and how the organization of the value chain affects the provision of ecosystem services (ES). The Greek case study presented here mainly deals with transhumant sheep and goat farms that graze during summer in a typical mountain area, where also several transhumant bovine farms exist along with sedentary agro-pastoral farms.

**Material and methods** The research was conducted on Mount Ziria, in Peloponnese (Southern Greece). The inhabitants of the region are engaged mainly with agriculture and bean production following by other arable crops. Nevertheless, the oldest and most important economic activity is livestock farming, with a significant rate of transhumance flocks. An open-ended questionnaire was used in order to collect details about the structure and organization of the value chain of pastoral products in the area. The survey was conducted with personal interviews with actors throughout the supply chain of agro-pastoral system. A total of 14 in-depth interviews were conducted. In addition, informal discussions were held with other locals and visitors in order to enrich information about the dynamics of the area.

**Results and discussion** Based on the analysis of qualitative data of the field survey, sheep and goat farming in the region is mainly of dairy orientation, with meat production being a minor activity, complementary to milk production. According to farmers, this is mainly due to low and volatile meat prices. Isolation from the markets proved to be one of the main factors leading to low prices and, therefore, low economic performance, and this concerned both income from milk and meat. Specifically, for dairy products, three options were available to farmers: 1st Sales at a small local dairy, which produces high-quality cheese, sold mainly through local shops of a main supermarket chain at a price which is higher than average (based on a specific deal between the owner of the dairy and the supermarket). One of the disadvantages of this dairy is that it can only operate at certain periods during the year, due to the seasonality of production and low volumes of milk in winter, when transhumant flocks are in the lowlands. 2nd Sales to larger dairies. These industries collect milk from more farms and therefore achieve economies of scale to some extent. They can operate all year round and this provides them with greater financial flexibility. These industries are able to offer higher prices to large producers. 3rd Production of cheese on the farm. Usually, this strategy is complementary to the previous two and applies mainly to the summer season. According to the availability of labor, producers decide to process milk on the farm by producing cheeses and yogurt. These products are sold to local restaurants or directly to consumers at higher prices than the sale of milk to dairies, thus ensuring that producers benefit from high added value. It was noted with interest that most of the surveyed producers choose "hybrid" strategies, meaning they combine to some extent some of these three options. Transhumant farmers prefer to change industries between winters and their summer domiciles. Tourism provides an important opportunity for those who produce cheese on-farm, as there are many small shops in the area.

**Conclusion** The preliminary findings of the qualitative research presented in the current work define key directions for further research. These include - as an indication - (a) an in depth examination of the relationships among the different elements within the agro-pastoral food supply chains; (b) ways to boost and increase the involvement of residents from the study area through job creation; (c) establishing and achieving synergies and closer links with tourism and manufacturing; (d) generating more knowledge regarding the socio-environmental services (ES) of the agro-pastoral production systems. The combined examination of the above elements will lead to the proposal of comprehensive policies and targeted measures, which may contribute to increasing the sustainability of the agro-pastoral system in the region, reducing its vulnerability, and ensuring the provision of significant ES.

**Acknowledgements** This paper is part of the project PACTORES, "Pastoral Actors, Ecosystem services and Society as key elements of agro-pastoral systems in the Mediterranean" which is co-funded by the European Union (European Social Fund) through the Action "ERA-Net".

**References**

Delsalle L., Perez R., Dedieu B., Girard N., Hang G., Larranaga G., Magda D. 2012. 10th European IFSA Symposium.
Ragkos A., Siasiou A., Galanopoulos K., Lagka V. 2014. Options Mediterraneennes, 109, 575-579.

# Legume -Grass proportion in forage production of mountainous grazed grasslands, Northern Greece

Maria Karatassiou, Zoi Parissi, Eleni Abraham

*School of Forestry and Natural Environment, Aristotle University of Thessaloniki - Greece*

E-mail: karatass@for.auth.gr

**Take home Message** Forage production with high nutritive quality and consequently animal's products from mountainous grassland grazed by transhumance flocks.

**Introduction** Forage production depends on species composition and environmental factors such as precipitation, geomorphology, and grazing (Corona et al. 1995). Transhumance is an essential driver in the formation and maintenance of mountainous landscapes with unique floristic composition, which reflected in the production of high-quality milk and meat. The aim of this work was to investigate the contribution of different functional group in forage production of mountainous grasslands used by transhumance.

**Material and methods** The study was conducted in three neighbouring grasslands with different geo-morphological characteristics (Grassland 1: flat, Grassland 2: moderate slope in NW exposure, Grassland 3: moderate slope in SE exposure) in Northern Greece, with elevation ranged from 900 -1000m. The grasslands grazed by transhumant flocks of sheep and cattle from April to October. In each grassland, the above-ground herbage biomass was harvested by four square of 0.5 m size and put into polystyrene bags which transported to the laboratory. The samples were separated into three botanical functional groups: (1) grasses, (2) legumes, (3) forbs. The samples were oven dried at 60°C for 48 h. The proportion of functional group in each grassland was quantified as a percentage of its dry weight biomass in the total forage production of the grassland. After that, the ratio legumes/grasses were calculated. The data was statistically analysed using ANOVA (Steel and Torrie, 1980) with SPSS® statistical software v. 25.0.

**Results and discussion** The forage production was 360.8 g/m$^2$ in grassland 1, 397.2 g/m$^2$ and 338.5 g/m$^2$ in grassland 2 and 3 respectively. The percentage of contribution of the functional plant groups in the forage production of the three study mountainous grassland presented in Table 1. Overall legumes participated with the highest percentage in the forage production compared to the other two functional groups. The highest contribution of legumes in forage production was found in forage production of grassland 3 (47.45%.). On the other hand, forbs had the highest contribution in grassland 2, and grasses in grassland 1. In the three grasslands, forbs had the lower percentages in the forage production compared to other functional groups. Among the studied grassland, forbs had the lower percentage in grassland 3 (23.67%). The ratio legumes/grasses were higher than 1 in all studied grasslands indicating the higher proportion of legumes compared the grasses. The higher ratio presented in grassland 3 (1.46). These findings are in contrast with the general assumption that the proportion of grasses in forage production is higher in comparison to the other functional groups. This differentiation may be due to the climatic, the geomorphological conditions and/or in the effect of long term grazing by the transhumance flocks. However, further research is necessary to investigate the effect of this floristic composition on animal performance and animal products (milk, meat).

**Table 1** Contribution of functional plant groups in forage production of three mountainous grasslands

| | Percentage of functional group participation on forage production (%) | | | |
|---|---|---|---|---|
| | **Forbs** | **Legumes** | **Grasses** | **Legume/Grasses** |
| Grassland 1 | 27.83 ± 0.01$^b$ | 37.97± 0.87$^b$ | 34.2± 0.8$^a$ | 1.12 ± 0.05$^b$ |
| Grassland 2 | 35.66± 0.58$^a$ | 36.05± 0.57$^b$ | 28.29± 0.01$^a$ | 1.27 ±0.02$^b$ |
| Grassland 3 | 23.67± 0.42$^b$ | 47.45± 1.1$^a$ | 28.88 ± 0.57$^b$ | 1.46 ± 0.06$^a$ |
| P-value | 0.001 | 0.001 | 0.001 | 0.003 |

**Conclusion**. That preliminary results are indicative of high contribution of legumes on herbage production of these mountainous grasslands grazing by transhumance livestock for long time Further research is needed to investigate if the higher legumes contribution to biomass production leads to higher nutritive value.

**Acknowledgements** This paper is part of the project "True Cheese project (T1EDK-04475) Traditional cheese from milk produced by transhumant flocks in summer: Highlighting their special characteristics and quality" which is co-funded by the European Union (European Social Fund) through the Action RESEARCH -CREAT-INNOVATE.

**References**

Corona M.P., Ciudad A.G., Criado B.G., de Aldana B.V. 1995. Communications in soil science and plant analysis 26(9-10), 1323-1341.

Steel and Torrie, 1980. 2nd edn. New York: McGraw-Hill, 481p.

# Effect of feeding red grape pomace on nutrient intake, utilisation and nitrogen efficiency in lamb finisher diets

Obert C. Chikwanha, Cletos Mapiye

*Stellenbosch University, Stellenbosch, South Africa*

E-mail: occhikwanha@sun.ac.za

**Take home Message** Dried grape pomace improves volatile fatty acids with neutral effects on nitrogen utilisation in lambs.

**Introduction** The grape industry generates large quantities of ecological leftovers with huge economic costs associated with handling and transportation. Disposal of these ecological leftovers causes environmental stress due to the presence of phytotoxic compounds. However, winery wastes have moderate nutrient composition and are endowed with bioactive phytochemicals, thus, have potential as livestock feed. The use of by-products such as grape pomace (GP) in livestock nutrition is limited by its variable nutrient profile, high content phytochemicals and technical requirements for preservation essential for product stabilisation and attenuation of seasonal availability. The objectives of this study were to evaluate *in vitro* digestibility and assess the nutrient intake and digestibility, rumen fermentation and the efficiency of nitrogen (N) utilisation in lambs supplemented with red grape pomace.

**Material and methods** Grape (*Vitis vinifera* L. cv. Pinotage) pomace were obtained from Welgevallen Cellar (Stellenbosch, South Africa). A fresh sample (2 kg) of pressed grapes was collected over 6 days (n = 6). Each days pressing was sun-dried (DGP) until constant weight (temperature range; 25 - 33 °C) and then ground for chemical and phytochemical analyses. Five grams were used for the determination of *in vitro* NDF digestibility (ivNDFd at 24 h) following the Goering and Van Soest (1970) procedure. An *in vivo* digestibility trial was then conducted with 21 Dohne Merino wether lambs (6.0 ± 1.0 mo.; 51.6 ± 4.70 kg body weight). The animals were fed complete pelleted diets containing 0, 10 and 20% dried sun-dried Pinotage/ kg of diet (n = 7]. Animals were adapted for 14 d followed by 7 d of data collection (i.e., nutrient intake, total faecal and urine). At slaughter, rumen contents were collected for ruminal parameter determination (ammonia nitrogen and volatile fatty acids). The Chen and Gomes (1992) protocol was used for analysis of purine derivative and microbial protein analyses. All data were analysed using the PROC GLM SAS v. 9.4. The effect of feeding DGP on digestibility, microbial protein supply and rumen parameters was analysed using a completely randomised design with orthogonal polynomial contrasts performed to test for linear and quadratic responses to increasing level of GP.

**Results and discussion** Sun-dried GP had a low *iv*NDFd (24.4 ± 3.92%), which is due to high lignin and polyphenol contents. A linear decrease in the intake of NDF and starch was observed with the addition of DGP, while crude fat intake increased linearly ($P \leq 0.05$). Increasing fat content could have arisen from the increasing fat from the grape seed in GP, whist possibly contributing to the reduction in carbohydrate intake (Çoklar and Akbulut, 2017; Sabir et al., 2012). Apparent total tract NDF digestibility decreased linearly ($P \leq 0.05$) with increasing DGP due to the associative effects of proanthocyanidin, lignin and fat contents. Diet had no effect on ruminal pH ($P > 0.05$) but quadratically ($P \leq 0.05$) influenced total volatile fatty acids (VFA) production with addition of DGP. Allantoin declined linearly and total purine derivative excreted, and microbial nitrogen supply showed a negative linear response to the increasing level of DGP in the diet ($P \leq 0.05$). However, dietary DGP did not influence the N balance parameters (faecal and urinary N), N retention and the efficiency of N utilisation were not influenced by diet ($P > 0.05$).

**Table 1** Chemical composition of sun-dried grape pomace and experimental diets.

| | Item | | | | |
|---|---|---|---|---|---|
| | GP | GP 0 | GP 10 | GP 20 | SEM |
| Dry matter (DM) | 92.6 | 88.0 | 87.8 | 8.81 | 0.6 |
| Crude protein (CP) | 12.4 | 17.3 | 17.9 | 17.4 | 0.2 |
| Crude fat | 6.9 | 3.7 | 5.0 | 6.3 | 0.1 |
| NDF | 32.2 | 30.0 | 28.9 | 24.3 | 0.6 |
| Lignin | 19.8 | 2.4 | 4.7 | 6.0 | 0.2 |
| Total tannins | 8.9 | - | 3.5 | 5.9 | 0.2 |
| Proanthocyanidins | 6.0 | - | 1.2 | 2.6 | 0.01 |
| ME (MJ/ kg) | | 10.9 | 11.6 | 11.4 | 0.1 |

**Conclusions** Dried GP reduced carbohydrate intake, microbial N yield, total purine derivatives excreted in lamb finisher diets, it increased total VFA concentration and had neutral effect of DGP on N retention and the efficiency of N utilisation.

**Acknowledgements** This study was supported by the South African Research Chairs Initiative, partly funded by the South African Department of Science and Technology (UID number: 84633), RTF-NRF South Africa (Grant 98700) and Cape Wools SA (Grant S005139).

**References**

Çoklar H., Akbulut M. 2017. South African Journal of Enology and Viticulture 38(2), 264-272.
Sabir A., Unver A., Kara Z. 2012. Journal of the Science of Food and Agriculture 92(9), 1982-1987.

# Analysis of the feeding management of the dairy sheep flocks of the PDO Idiazabal in terms of the origin of the feedstuffs

Roberto Ruiz[1], Aitor Jauregui[2], Idoia Goiri[1], Josune Arranz[1], Aser García-Rodríguez[1], Miriam Molina[3], Nerea Mandaluniz[1]

[1]*NEIKER- Basque Institute for Agricultural Research and Development, Campus de Arkaute (Alava), Spain*
[2]*Abere S. Coop, Campus de Arkaute (Alava), Spain*
[3]*Protected Designation of Origin (PDO) Idiazabal, Campus de Arkaute (Alava), Spain*

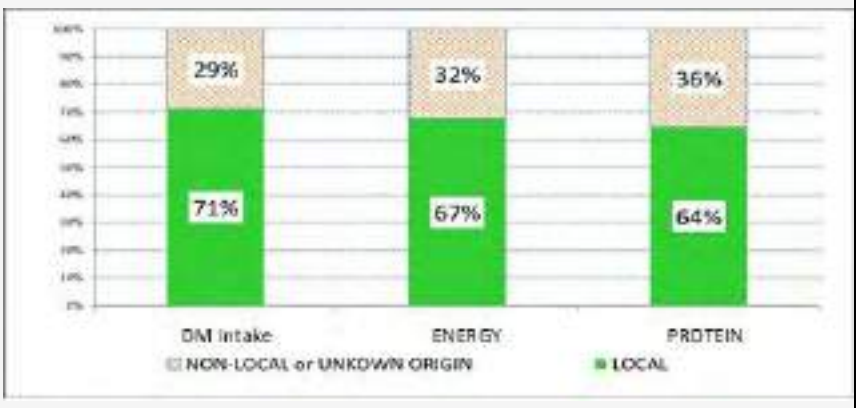
E-mail: rruiz@neiker.eus

**Take home Message** Latxa sheep flocks within the PDO Idiazabal are principally fed upon locally produced feedstuff.

**Introduction** The Delegated Regulation (UE) Nº 664/2014 by the European Commission requires that the feedstuffs for the animals used to produce foods under any Protected Designation of Origin (PDO) or PGI must be produced within the corresponding geographic zone. However, if for any reason it could not be completely possible, at least 50% of the total dry matter (DM) should have been produced within the geographic zone delimitated by the PDO or the PGI. Therefore, the PDO for Idiazabal cheese leaded a cooperation project to assess the situation of their flocks regarding the feeding management, in particular through the study of the use of the resources produced on-farm (pasture and forage mainly) or within the PDO geographical area (Basque Autonomous Community-BAC and Navarra).

**Material and methods** During the project, a sample of 74 flocks associated to the PDO Idiazabal (60 from BAC and 14 from Navarre, Spain), were surveyed during 2018 (data corresponding to 2017). Information was collected related to the main descriptive and productive features: flock size, lambing dates, housing/grazing management, evolution of the productive flock size, monthly yield and milk quality during the productive season, grazing resources available (natural pastures, improved pastures, crops, communal-mountain or forest pastures) and grazing management (dates and grazing time), total feedstuff used (type, origin, annual amount and quality - if laboratory analysis available) and average daily ration used for each type of animal and productive stage (before lambing, early lactation, etc.). With these data, the feeding requirements were assessed using the software INRAtion (4.07 Software), as well as the contribution of each feedstuff to meet the requirements. The following considerations were taken into account: i) concentrates or any feedstuff with unknown origin, were considered as non-locally produced (following a precautionary principle); ii) when grazing, the DM intake of grass allowed meeting the requirements left once the offer of indoors has been assessed; iii) no changes in the body condition score or body weight were taken into account. As a result, the percentage of the total annual energy and protein requirements that were met by local feedstuffs (grass, fodder, feed, etc.) in the Idiazabal PDO flocks, were assessed.

**Results and discussion** According to the results obtained, 86.5% of the surveyed PDO Idiazabal flocks did follow the Delegated Regulation (UE) Nº 664/2014, since at least 50% of the total DM was produced within the geographic zone delimitated by the PDO. On average, locally produced feedstuff represented 70% of the total annual DM intake and contributed to meet 66% of the total energy and 63% protein requirements. All the flocks analysed based an important part of their diet on grazing, since they do so for at least 7 months/year, mainly upon valley pastures, and 69% of them also graze on communal pastures during some time (around 3 months/year) during summer and autumn. However, there is an incipient trend towards farming systems with less connection to the territory, since in 13.5% of the flocks, locally produced feedstuff accounted for less than 50% of DMI.




**Conclusion** Latxa sheep flocks within the PDO Idiazabal are mostly fed upon locally produced feedstuff. These results will contribute further to the certification of the production system based on the use of local resources, through the maintenance and optimization of grazing practices and to avoid the evolution of the system towards highly intensified practices.

**Acknowledgements** Funded by the Rural development Funds 2014-2020 for Operational Groups (in the sense of Art 56 of Reg.1305/2013), and the Basque Government. Many thanks to farmers and technicians of the advisory services of ARTZAI GAZTA, ABELUR, ABERE, LORRA, LURGINTZA, LURSAIL and INTIA, who contributed to the achievement of the objectives of the project.

**References**

INRA. France; Paris: 2003. INRAtion 4.07 Software. http://www.inration.educagri.fr

# The use of locally produced oilseed-cakes in dairy sheep diet: effects on milk parameters and the fatty acid profile

Nerea Mandaluniz[1], Aitor Jauregui[2], Josune Arranz[1], Nora Unzeta[3], Roberto Ruiz[1]

[1]*NEIKER- Basque Institute for Agricultural Research and Development. Vitoria-Gasteiz (Spain).*
[2]*Abere S. Coop. Vitoria-Gasteiz (Spain).*
[3] *Department of Analytical Chemistry, University of the Basque Country (UPV/EHU). Vitoria-Gasteiz (Spain).*

E-mail: nmandaluniz@neiker.eus

**Take home Message** The inclusion of flax-cake in ewes' diet increase significantly PUFA and CLA content of milk.

**Introduction** These recent years chronic diseases are becoming a public health problem throughout the world. Some attribute this problem to the high consumption of meat and animal products, with high levels of saturated fatty acids. Under this context, the objective of the NUTFOOD project was to improve the nutritional quality of animal products (milk and meat) by feeding animals with locally produced oilseeds (rapeseed, sunflower and flax), rich in omega-3 and CLA content.

**Material and methods** A trial was carried out during 6 weeks with 4 homogeneous groups of ewes. Three groups were fed with concentrates formulated with cold-pressed cake oilseeds (rapeseed-RAP, sunflower-SUN and flax-FLA) and the fourth one was fed with a commercial concentrate (control-CTR). The four concentrates were formulated isoproteic (18.87±0.40% CP) and isoenergetic (0.97±0.06 UFL). Daily milk yield was monitored daily in the morning and afternoon milking and milk samples were taken twice during the two last weeks of the assay (n=4) to determine the composition in crude fat (CF) and protein (CP), lean dry stratum (LDS), lactose (LAC) y urea. Standardized milk yield (DMYs) was calculated according to Boquier *et al*. (1993).
Finally, the fatty acid profile of milk was determined (n=4) and data were grouped by saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA) and conjugated linoleic acid (CLA) contents.
Data were analysed with the MIXED procedure of the SAS statistical package (SAS Enterprise Guide 7.1), considering the initial data of each parameter as covariate, the animal as a random effect, and the concentrate, week and their interaction as fixed effects. In the results, only the effect of the concentrate is discussed since the interaction did not have a significant effect (P>0.05) on any of the parameters.

**Results and discussion** Average value of DMYs was 1.76±0.40 kg/day and milk had on average 6.15±0.71% CF, 4.32±0.38% CP, 10.21±0.63 % LDS, 5.13±0.27% 5.13±0.27% LAC and 334.47±80.60 mg urea/milk litre. According to the statistical analysis, milk from ewes' fed with SUN and RAP concentrates showed significantly (p<0.05) higher values of CF, CP, LDS and LAC. Moreover, DMYs was similar (p>0.05) in all the groups (Table 1) which could be to the dilution effect, as the groups with lower milk yield had a more concentrated milk.

**Table 1** The effect of different oilseed inclusion in dairy sheep diet on milk yield (DMYs), its composition (CF, CP, ESM, LAC, urea) and the fatty acid profile (SFA, MUFA, PUFA and CLA).

| | Concentrate | | | | | |
|---|---|---|---|---|---|---|
| | CTR | RAP | SUN | FLA | SEM | P-value |
| DMYs (L/d) | 1.78 | 1.83 | 1.73 | 1.54 | 0.085 | 0.087 |
| CF (%) | 5.72$^{b}$ | 6.21$^{ab}$ | 6.63$^{a}$ | 5.93$^{b}$ | 0.135 | <0.001 |
| CP (%) | 4.19$^{b}$ | 4.34$^{ab}$ | 4.53$^{a}$ | 4.23$^{b}$ | 0.067 | 0.003 |
| LDS (%) | 9.94$^{c}$ | 10.28$^{ab}$ | 10.56$^{a}$ | 9.98$^{bc}$ | 0.101 | <0.001 |
| LAC (%) | 5.09$^{ab}$ | 5.21$^{a}$ | 5.20$^{a}$ | 5.02$^{b}$ | 0.040 | 0.008 |
| Urea (mg/L) | 332$^{b}$ | 298$^{bc}$ | 387$^{a}$ | 273$^{c}$ | 13.43 | <0.001 |
| SFA (mg/g fat) | 710 | 638 | 666 | 691 | 28.79 | 0.371 |
| MUFA (mg/g fat) | 195$^{b}$ | 224$^{ab}$ | 245$^{a}$ | 205$^{b}$ | 9.920 | 0.017 |
| PUFA (mg/g fat) | 38.9$^{b}$ | 37.7$^{b}$ | 38.9$^{b}$ | 48.4$^{a}$ | 1.387 | <0.001 |
| CLA (mg/g fat) | 3.41$^{c}$ | 4.00$^{b}$ | 3.85$^{bc}$ | 5.09$^{a}$ | 0.109 | <0.001 |

In relation to the fatty acid profile of the milk, average values were 72.36±2.32% SFA, 23.25±2.49% MUFA, 4.39±0.50% PUFA and 0.44±0.08% CLA. According to the statistical analysis, the SFA content was similar in all the groups, while MUFA content was higher in SUN fed ewes' milk followed by RAP fed ones. Finally, PUFA and CLA contents were significantly higher in the FLA fed ewes' milk. These results coincide with the fatty acid profile of the raw oilseeds used in the assay.

**Conclusion** According to the results, milk from ewes fed with SUN and RAP showed higher values of CF, CP and LDS but DMYs was similar for all the groups. In relation to the composition of the fat, milk from the three oilseed diets showed higher unsaturated fatty acid content than CTR one and milk of sheep fed with FLA had higher values of PUFA and CLA. These results confirming that diet can broadly modify sheep milk quality towards a more desirable composition for human health.

**Acknowledgements** This study was supported by NUTFOOD research project (Funding: Elkartek 2020).

**References**
Bocquier F., Barillet F., Guillouet P., Jacquin M. 1993. In Annales de zootechnie 42, 57-66.

# Yield, nutrient content and digestibility changes of hydroponically sprouted two Moroccan barley varieties for ruminant

Sibaoueih Mounia

*Regional Center of Agricultural Research of Settat, National Institute of Agricultural Research, Avenue Annasr, BP 415 Rabat Principale, 10090 Rabat, Morocco*

E-mail: mouniasibaoueih@gmail.com

**Take home Message** Hydroponic culture is an alternative green fodder resource for ruminant production, feed value is improved and the optimum harvest time is the 8th day of germination.

**Introduction** Hydroponic barley culture under Moroccan conditions takes more attention over the last decade. Hydroponically sprouted barley production can fill the feed shortage in low rainfall areas. In fact, it ensures a continuous and constant resource of fodder mainly in countries where the climatic change is a big issue. During germination, chemical changes occur in the seed due to complex metabolic and physiological processes. The nutritive value of green hydroponically fodder is influenced by several factors including variety and harvest time. The present study was performed to evaluate the nutritional changes of hydroponically sprouted barley of two Moroccan varieties at 6 germination periods.

**Material and methods** Two Moroccan barley (*Hordeum vulgare L.*) varieties seeds (Beldi (B) and Rwiza (R)) were evaluated and six growth periods were considered (6, 7, 8, 9, 10 and 11 days of germination). Barley seeds were sprouted in hydroponic unit under controlled environment (23 °C, 75% relative humidity and two irrigations per day). Five trays per period and variety were removed from the chamber and the fresh green fodder was weighed to estimate the conversion ratio (CR) before being dried in an oven at 60°C. Three representative samples (about 150 g each) were collected from each dry tray, were ground and stored for chemical analysis. These analyses include ash, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) and in vitro dry matter digestibility (IVDMD).

**Results and discussion** The variety and growth periods showed a significant effect ($p<0.05$) for all studied parameters. During the 6 germination stages combined, the highest green fodder yield was obtained from Beldi variety (5.88 *vs* 3.01 Kg). Rwiza variety showed higher average DM content compared to Beldi (18.47% *vs* 14.47%).
For both varieties, the highest CP value was recorded at day 8 of growth while the highest significant IVDMD was observed at day 6 of growth. As the harvest period extended from day 6 to day 11, ash and fibres contents increased while DM and IVDMD decreased for both varieties. These results are in agreement with those of several authors (Fazeli et al., 2012 and Emam et al., 2018).

**Table 1** Chemical composition as % of DM and IVDMD at different growth periods ($P<0.05$)

| Parameters | Variety | Seed | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|
| CR (Kg/Kg) | Beldi | - | $4.5^{a}$ | $4.9^{a}$ | $5.9^{b}$ | $5.8^{b}$ | $7.1^{c}$ | $7.1^{c}$ |
| | Rwiza | - | $2.64^{a}$ | $2.41^{a}$ | $2.81^{a}$ | $3.63^{b}$ | $3.23^{b}$ | $3.36^{b}$ |
| DM (%) | Beldi | $93.14^{a}$ | $18.04^{b}$ | $15.32^{c}$ | $14.45^{c}$ | $14.83^{c}$ | $12.06^{de}$ | $12.11^{d}$ |
| | Rwiza | $90.45^{a}$ | $23.96^{b}$ | $19.59^{c}$ | $19.80^{c}$ | $16.73^{d}$ | $15.16^{f}$ | $15.56^{f}$ |
| Ash | Beldi | $1.97^{a}$ | $3.13^{b}$ | $3.65^{b}$ | $3.62^{b}$ | $3.76^{c}$ | $3.89^{d}$ | $4.19^{e}$ |
| | Rwiza | $2.91^{a}$ | $3.80^{b}$ | $4.25^{c}$ | $4.73^{d}$ | $6.11^{e}$ | $6.06^{f}$ | $6.52^{e}$ |
| CP | Beldi | $9.91^{a}$ | $11.24^{b}$ | $11.25^{b}$ | $15.01^{c}$ | $13.50^{d}$ | $13.25^{d}$ | $12.38^{e}$ |
| | Rwiza | $7.51^{a}$ | $8.58^{b}$ | $8.68^{b}$ | $10.65^{c}$ | $10.21^{d}$ | $9.73^{e}$ | $9.40^{f}$ |
| NDF | Beldi | $52.04^{a}$ | $52.38^{a}$ | $52.86^{a}$ | $55.04^{ab}$ | $55.02^{ab}$ | $57.94^{bc}$ | $59.17^{c}$ |
| | Rwiza | $35.44^{a}$ | $35.84^{a}$ | $39.22^{b}$ | $42.31^{bc}$ | $42.86^{bc}$ | $45.18^{c}$ | $45.79^{c}$ |
| ADF | Beldi | $6.09^{a}$ | 18.97b | 20.53c | 21.82d | 22.78e | $23.67^{f}$ | $24.75^{g}$ |
| | Rwiza | $7.95^{a}$ | $11.48^{b}$ | $15.60^{c}$ | $20.02^{d}$ | $22.01^{e}$ | $23.01^{f}$ | $23.93^{f}$ |
| ADL | Beldi | $5.39^{a}$ | $10.52^{b}$ | $11.98^{c}$ | $12.75^{d}$ | $13.07^{df}$ | $13.45^{df}$ | $13.78^{f}$ |
| | Rwiza | $4.39^{a}$ | $6.97^{b}$ | $10.19^{c}$ | $11.23^{d}$ | $12.64^{e}$ | $13.37^{e}$ | $13.17^{e}$ |
| IVDMD (%) | Beldi | $84.16^{a}$ | $74.12^{b}$ | $72.91^{c}$ | $71.90^{d}$ | $71.16^{d}$ | $70.46^{f}$ | $69.62^{g}$ |
| | Rwiza | $82.71^{a}$ | $79.96^{b}$ | $76.75^{b}$ | $73.30^{c}$ | $71.76^{d}$ | $70.98^{f}$ | $70.26^{f}$ |

**Conclusion** The optimum harvest time that can be recommended in terms of green fodder yield and nutritive value for both varieties is the 8th growth day. Ruminant feeding trials are needed to evaluate the technical and economic feasibility of hydroponic barley in low rainfall areas.

**Acknowledgements** This study was supported by the Medium-term research project, INRA Morocco.

**References**

Emam M.S.A, Badr A.M.M., Baker A.A., Ismail F.SH., Soliman A.M. 2018. Egyptien J. Nutrition and Feeds 21, 401-418.
Fazaeli H., Glmohammadi H.A., Tabatabayee S.N., Asghari-Tabrizi M. 2012. World Applied Sciences Journal 16, 531-539.

# Effects of substituting soybean with rapeseed meal on lambs' meat oxidative stability

Smeti Samir, Yagoubi Yathreb, Mekki Ilyes, Atti Naziha

*Laboratoire de Production Animale et Fourragère, INRAT, University of Carthage, Ariana, Tunisia*

E-mail: sam_fsb@live.fr

**Take home Message** The use of rapeseed meal in animal feeding could be a solution to food dependency by reducing imports of materials that remain at high prices.

**Introduction** To reduce dependency in terms of animal feed, the use of other local protein resources such as rapeseed meal to replace soybean meal may be a strategic alternative. In fact, rapeseed has various advantages; Its proteins have an interesting composition in amino acids. Its seeds contain a high proportion of unsaturated fatty acids and an interesting content of various minerals and B vitamins. In this context, our work was carried out to study the effects of the substitution of soybean meal by rapeseed meal at different rates on the quality of the meat quality of Barbarine lambs.

**Material and methods** The experiment focused on 28 male Barbarine lambs (10 months old) with an average body weight of 24.6±2.4 kg, divided into 4 homogeneous groups of 7 lambs each. All lambs received 600g of oat hay as roughage and 4 types of concentrate at different rates of substitution of soybean meal by rapeseed meal: 0 (C), 50 (R50), and 75% (R75). The trial lasted 77 days after which all the lambs were slaughtered, and samples of *Longissimus dorsi* were collected and then analysed for color and lipid oxidation (Botsoglou et al., 1994) evolutions.

**Table 1** Effects of rapeseed meal on meat color and lipid oxidation (mg MDA/kg of meat) evolution.

| | Diet (D) | | | Storage time (ST) | | | P-value | |
|---|---|---|---|---|---|---|---|---|
| | C | R50 | R75 | Day3 | Day6 | Day9 | D | ST |
| TBARS | 1.8 | 1.5 | 1.6 | 1.5 | 1.9 | 2.0 | 0.74 | 0.001 |
| L* | 43.1 | 41.8 | 41.1 | 42.2 | 42.5 | 40.1 | 0.39 | 0.003 |
| a* | 11.1 | 11.6 | 11.9 | 12.1 | 10.9 | 11.4 | 0.64 | 0.350 |
| b* | 6.9 | 4.3 | 5.3 | 4.0 | 7.1 | 4.2 | 0.014 | 0.001 |
| C* | 13.4 | 12.5 | 13.2 | 12.8 | 13.1 | 12.5 | 0.45 | 0.740 |
| h* | 32.1 | 20.5 | 25.1 | 20.0 | 33.2 | 19.8 | 0.025 | 0.001 |

**Results and discussion** The best oxidative stability of the meat studied was recorded for lambs receiving rapeseed when compared to soybean group (Table 1); but no significant difference was recorded (P>0.05). Otherwise, the TBARS values during the 9 days of storage did not exceed 2 mg of MDA/kg of meat, which is defined as the meat acceptability threshold (Ripoll et al., 2011).
Color is a major element of meat quality that influences consumers' purchase decisions. The color evolution during the storage period (Table 1) showed that the substitution of soybean with rapeseed meal affected significantly meat yellowness (b*) which was lower for rapeseed groups (4.8) and hue angle (h*) being higher for control group (32), but maintained meat lightness (L*) and redness (a*) in the same range as C group which concord with the finding of Sekali et al. (2020) who reported that the replacement of soybean with rapeseed meal did not alter lamb meat color.

**Conclusion** Findings from the current study showed that rapeseed meal can be included in lamb diets without compromising the oxidative stability of their meat. Hence, the substitution of soybean by rapeseed seems to be an effective strategy to reduce feeding costs.

**Acknowledgements** This study was financed by the Tunisian Ministry of Higher Education and Scientific Research.

**References**

Botsoglou N.A., Fletouris D.J., Papageorgiou G.E., Vassilopoulos V.N., Mantis A.J., Trakatellis A.G. 1994. Journal of Agricultural and Food Chemistry. 42, 1931–1937.
Ripoll G., Joy M., Muñoz F. 2011. Meat Science 87, 88-93.
Sekali M., Mlambo V., Marume U., Mathuthu M. 2020. Animals 10, 1735.

# Relationship between feed efficiency metrics and ruminal volatile fatty acids in dairy ewes

Pablo G. Toral, Gonzalo Hervás, Antonella Della Badia, Pilar Frutos

*Instituto de Ganadería de Montaña (IGM), CSIC-Universidad de León. Finca Marzanas s/n 24346 Grulleros, León, Spain*

E-mail: pablo.toral@csic.es

**Take home Message** More efficient dairy ewes (i.e., with lower residual feed intakes) showed a lower rumen acetate:propionate ratio. Nevertheless, this relationship was weak and could not be confirmed with other efficiency metrics.

**Introduction** Enhancing feed efficiency (FE) is required to improve the sustainability of dairy production, but the physiological basis of this trait has not been unraveled yet. Because the rumen plays a major role in the efficiency of digestion, it is presumed that differences in ruminal fermentation could help explaining individual variations in FE. However, most studies show no clear relationship between rumen volatile fatty acid (VFA) concentrations and FE estimated through residual feed intake (RFI; e.g., Lam et al., 2018; Durunna et al., 2019). In sheep, a recent report has suggested a greater relevance of propionic fermentation in dairy ewes with the highest FE estimated through a different metric (feed efficiency index; FEI), but this was not confirmed with ewes selected by RFI (Toral et al., 2021). It is unclear if this inconsistency is explained by the FE estimator or by the limited number of ewes in that trial (n=16). Therefore, this study aimed at gaining further insight into the role of rumen VFA as potential determinants of FE in dairy ewes, employing a dataset from 3 independent studies conducted by our team (n=106). The use of 3 efficiency metrics was also compared.

**Material and methods** Data from 3 trials using 40, 40 and 26 dairy Assaf ewes, and conducted under similar experimental conditions, were compiled. Sheep were fed a total mixed ration with the same formulation (forage:concentrate ratio 50:50). In each trial, body weight and data of daily feed intake and milk yield and composition were individually recorded (over 3 weeks) to calculate 3 efficiency metrics: RFI (residual term from the regression of intake on metabolic body weight, body weight change, energy-corrected milk yield and days in milk), FEI (difference between the actual and predicted intake estimated through net energy requirements for maintenance, production and body weight change; INRA, 2018) and feed conversion ratio (FCR, ratio between feed intake and energy-corrected milk yield). Concentrations of VFA were analyzed by gas chromatography in ruminal samples collected through stomach tube (Toral et al., 2021). The CORR procedure of SAS 9.4 was used to generate Pearson correlation coefficients ($r$) among FE metrics and rumen VFA, and a multiple linear regression with backward elimination was carried out with the REG procedure. To further explore the relationship between FE and VFA a principal component analysis (PCA) was conducted using R (http://www.r-project.org).

**Results and discussion** Significant although weak correlations were detected between RFI and the acetate:propionate ratio (A:P; $r$=-0.22; $P$=0.02), and between FEI and isobutyrate and isovalerate concentrations ($r$=-0.24 and -0.20, respectively; $P$<0.05), but none with FCR. These variables were identified as predictors in the stepwise regression, but prediction models had always marginal $R^2$ (<0.10; $P$<0.02). The PCA did not offer additional information about the role of VFA in determining FE, with the three FE metrics loading close to the origin of the plot. These results would downplay a clear relationship between VFA concentrations and FE in ewes, consistent with some previous studies in cattle (Lam et al., 2018; Durunna et al., 2018). However, variations in VFA production and epithelial absorption cannot be ruled out. In this context, ratios between VFA could still be of interest. Indeed, our previous report in dairy ewes (Toral et al., 2021) had showed an inverse numerical link between A:P and RFI, which was statistically significant in the present trial probably due to the larger sample size (n=16 *vs.* 106). A similar trend in ruminal fermentation pattern had been reported by Ellison et al. (2017) in growing wethers. Because propionic fermentation is associated with a lower energy loss through methane production, it is reasonable that more efficient sheep show decreased A:P. Regarding the comparison among efficiency metrics, FEI was moderately correlated ($P$<0.01) with FCR ($r$=0.60) and RFI ($r$=0.39), but only a slight trend between the two latter estimators was found ($r$=0.18; $P$=0.07). These results, together with the divergent relationship between each FE metric and VFA might contribute to explain paradoxical findings when studies using different FE metrics are compared.

**Conclusion** In dairy ewes, relationships between rumen VFA and FE seem weak, but more efficient sheep show a lower A:P ratio. Inconsistent results obtained using different metrics (RFI, FEI and FCR) preclude firm conclusions to be drawn.

**Acknowledgements** Project PID2020-113441RB-I00 (MCIN/AEI) and grant PRE2018-086174 (MCIU/AEI/FSE, EU).

**References**

Durunna O.N., Damiran D., Campbell J.R., Carroll J.A., Lardner B. 2019. Journal of Animal Science 97, 382-382.

Ellison M.J., Conant G.C., Lamberson W.R., Cockrum R.R., Austin K.J., Rule D.C., Cammack, K. M. 2017. Small Ruminant Research 156, 12-19.

INRA. 2018. Alimentation des ruminants. Éditions Quae, Versailles, France.

Lam S., Munro J.C., Zhou M., Guan L.L., Schenkel F.S., Steele M.A., Miller S.P., Montanholi Y. R. 2018. Animal 12, 1442-1450.

Toral P.G., Hervás G., Fernández-Díez C., Belenguer A., Frutos P. 2021. Journal of Dairy Science 104, 5569-5582.

# Metabolomics analysis of plasma reveal potential biomarkers of feed efficiency in dairy ewes

Pablo G. Toral[1], Gonzalo Hervás[1], Leticia Abecia[2], David R. Yáñez-Ruiz[3]

[1]*Instituto de Ganadería de Montaña (IGM), CSIC-Universidad de León. Finca Marzanas s/n 24346 Grulleros, León, Spain*
[2]*Department of Immunology, Microbiology and Parasitology, Faculty of Medicine and Nursing, University of the Basque Country (UPV/EHU), 48940 Leioa, Spain*
[3]*Estación Experimental del Zaidín (CSIC), Profesor Albareda 1, 18008, Granada, Spain*

E-mail: pablo.toral@csic.es

**Take home Message** A clear discrimination of high- and low-feed efficient dairy sheep can be achieved through metabolomics, which seems a valuable tool to identify potential biomarkers of this trait in plasma.

**Introduction** The current effort to redirect breeding programs from increased milk production towards improved feed efficiency (FE) faces the challenge of estimating this trait in commercial dairy sheep farms. All FE metrics rely on measuring individual feed intake, which is expensive and/or time-consuming. Thus, the use of biomarkers to discriminate the most efficient animals would be of great practical interest. In this regard, metabolomics may offer a valuable tool to identify potential biomarkers of FE, but available reports have mostly focused on cattle and lambs (Wang and Kadarmideen, 2019; Goldansaz et al., 2020), and we are not aware of published studies examining the relationship between metabolic profiles and FE in lactating sheep. On this basis, high throughput metabolomics was applied to an easily accessible animal fluid (plasma) with the aim of identifying candidate biomarkers to discriminate high- and low-FE dairy ewes.

**Material and methods** A trial was conducted using 40 Assaf sheep on day 61.6±0.10 post-partum and producing 2.6±0.01 kg milk/day (Toral et al., 2021). Ewes were housed in individual tie stalls, milked twice/day and fed ad libitum a total mixed ration. Intake and milk yield were recorded daily over 3 weeks. Milk samples were collected regularly for chemical analysis. Feed efficiency was calculated as the difference between actual and predicted intake estimated through metabolizable energy requirements for maintenance, production and body weight change (AFRC, 1993), and used to select 8 of the least efficient (L-FE) and 8 of the highest FE ewes (H-FE). At the end of the trial, blood samples were collected before feeding, and metabolomics analysis of plasma was performed using UHPLC-Q/TOF-MS (Ballesteros-Vivas et al., 2019). To detect differential metabolites between H-FE and L-FE, data were subjected to non-parametric Wilcoxon-Mann-Whitney test (fold change>1.2, P<0.05) using MetaboAnalyst (v5.0). Partial least squares-discriminant analysis (PLS-DA) was also conducted to identify the contribution of individual metabolites to H-FE and L-FE discrimination. Metabolites with variable importance in the projection (VIP) scores ≥1.5 and statistically different (P-value adjusted using false discovery rate <0.05) were submitted to tentative identification (Bos taurus metabolomics databases: Massbank, KEGG and Metlin).

**Results and discussion** A total of 793 metabolites were detected in plasma, and the volcano plot showed that the abundance of 100 compounds differed between H-FE and L-FE groups ($P$<0.05). Among the most significant metabolites, L-proline and nalidixic acid were upregulated in H-FE, whereas PC 20:4e, Leu-Ala-Pro-Leu-Glu, and L-carnitine were downregulated in high-efficient ewes. In addition, the PLS-DA clearly separated sheep by FE level, supporting the usefulness of metabolomics to discriminate high and low efficiency animals (Wang and Kadarmideen, 2019; Goldansaz et al., 2020). The associated VIP plot revealed 15 differential metabolites ($P$<0.05) that contributed the most for the division in H-FE and L-FE groups, such as L-proline, nalidixic acid, and Leu-Ala-Pro-Leu-Glu, which match the results of the volcano plot and represent candidate biomarkers of efficiency. Previous studies have shown that amino acid metabolism may be crucial in FE, with tryptophan metabolites being related to this trait in cows (Wang and Kadarmideen, 2019) and L-phenylalanine with carcass merit in lambs (Goldansaz et al., 2020). Our results would suggest the role of another amino acid, L-proline, as a more convenient biomarker of FE in lactating sheep. In addition, a possible connection between FE and lipid metabolism has also been highlighted in dairy ewes (Toral et al., 2021). In this regard, metabolomics revealed 2 potential biomarkers of FE within lipid metabolism pathways, specifically phosphatidylcholine PC 20:4e, a phospholipid, and L-carnitine, which is required for mitochondrial fatty acid oxidation (Carlson et al., 2006). A link between L-carnitine and reported variations in rumen ammonia concentration between H-FE and L-FE sheep (Toral et al., 2021) may also exist.

**Conclusion** Metabolomics profiles of plasma clearly discriminated high- and low-feed efficient dairy sheep and revealed potential biomarkers of this trait, such as L-proline, PC 20:4e and L-carnitine.

**Acknowledgements** Project CSI276P18 (Junta de Castilla y León, cofunded by ERDF/FEDER).

**References**

Agricultural and Food Research Council (AFRC) 1993. Energy and protein requirements of ruminants. CABI (UK).
Ballesteros-Vivas D., Alvarez-Rivera G., León C., Morantes S. J., Ibánez E., Parada-Alfonso F., Cifuentes A., Valdés A. 2019. Journal of Functional Foods 63, 103567.
Carlson D.B., Litherland N.B., Dann H.M., Woodworth J.C., Drackley J.K. 2006. Journal of Dairy Science 89, 4819-4834.
Goldansaz S.A., Markus S., Berjanskii M., Rout M., Guo A.C., Wang Z., Plastow G., Wishart D.S. 2020. Journal of Animal Science 98, skaa298.
Toral P.G., Hervás G., Fernández-Díez C., Belenguer A., Frutos P. 2021. Journal of Dairy Science 104, 5569-5582.
Wang X., Kadarmideen H.N. 2019. Metabolites 9, 151.

# Seasonal changes of milk phytanic acid content in Sarda sheep grazing on Mediterranean natural pasture

Andrea Cabiddu[1], Maurizio Satta[1], Lorenzo Salis[1], Maria Niolu[1], Mauro Decandia[1], Sebastian Carrillo[2], Salvatore Contini[1], Marco Acciaro[1], Valeria Giovanetti[1], Maddalena Cabizza[1]

[1]*Agris Agenzia Regionale per la Ricerca in Agricoltura, Loc. Bonassai 07040 Olmedo, Sassari*
[2]*Universidad Nacional Autónoma de México, México Cuautitlán, México*

E-mail: acabiddu@agrisricerca.it

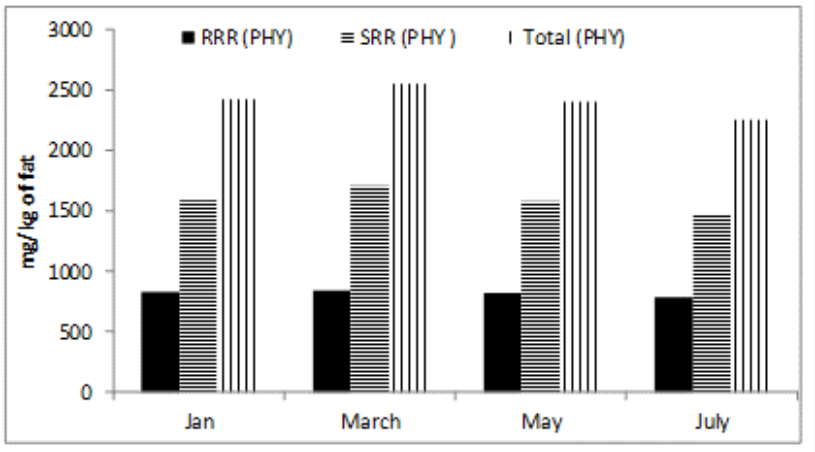
**Take home Message** The increase of daily pasture intake increase partially the content of PHY in milk sheep.

**Introduction** Branched-chain FA (BCFA) are an emerging class of bioactive FA that exerts several effects on human health (cytotoxic/anti-tumor effects, and improve pancreatic β-cell function). Because BCFA originate from the cell membranes of rumen bacteria, dairy products from ruminants are a unique source of these FA in humans's diet (Taormina et al. 2020). This allows for BCFA to be used as biomarkers of dairy intake in humans and also as biomarkers of rumen function. Phytanic acid (3,7,11,15- tetramethylhexadecanoic acid) is a multimethyl BCFAs synthesized in the rumen from the phytol component of chlorophyll found in forages. The aim of this study is to evaluate in extensive dairy sheep farms, the main relationships between sheep diet composition (supplementation, pasture intake and their botanical composition, plant phenological stage), with milk phytanic acid content during the whole lactation period.

**Material and methods** Sarda sheep milk samples (bulk samples) from 11 commercial flocks grazing permanent grassland were investigated in terms of phenols profile. In each farm, structural and managerial data and milk samples were collected during 4 periods, January, March, May and July (at 50, 90, 130 and 170 days in milk (DIM of sheep respectively) . Phytanic acid and its diastereomers SRR (3*S*,7*R*,11*R*,15-) and RRR (3*R*,7*R*,11*R*,15-) were determined in methylated fat and analyzed using GC MS triple quadrupole in SIM mode. Data from sheep diet composition and phytanic acid with their diastereomers stereomers were analysed by a GLM approach.

**Results and discussion** Overall, from January to May an increase of pasture herbage daily intake in sheep diet (+91%; P<0.01) was observed. The proportion of legumes and forbs in pasture increased from January to May whereas that of grasses decreased. During January and March, plants were characterized by a growing stage in agreement with their growing degree-days linked to the environmental drivers like temperature and rainfall. In May, most plants were in flowering stage whereas in July they were in maturity-senescence stage. Total milk PHY acid content was not affected by sampling period (figure 1) whereas taking into account the plant phenological stage we observed a tendency (+10%; P < 0.06) with highest level of total PHY when grassland plant are in growing/flowering stage compared to maturity/senescence stage. Similar results were found for both diastereomers RRR and SRR. A small correlation (r = 0.20; ns) was found between total PHY and % of herbage contribution of daily diet. No relationship was found between SRR/RRR ratio and herbage intake. Only considering the total daily production of PHY we found an effect of sampling day (P < 0.01) with the lowest value during July (50% lower) compared to January, March and May.

**Figure 1** Evolution of milk phytanic acid (PHY) content




**Conclusion** These preliminary results confirm only partially the results found on cows milk which shown that PHY increased with herbage intake, whereas when sheep eat pasture with plants in maturity-senescence stage daily PHY production was drastically reduced.

**Acknowledgements** This study was supported by Kent'Erbas project at University of Cagliari and Agris. Agreement n. 06_112 del 19/04/2019

**References**

Taormina V.M., Unger A.L., Schiksnis M.R., Torres-Gonzalez M., Kraft J. 2020. Nutrients 12(9), 2875.

# Chemical composition and nutritive value of five populations of *Hedysarum flexuosum* L. sampled at blooming stage in north-center Algeria

Nacima Zirmi-Zembri, Zahia Dorbane, Si Ammar Kadi

*Département des sciences agronomiques, Faculté des Sciences Biologiques et Sciences Agronomiques, Université Mouloud Mammeri de Tizi-Ouzou, 15000 Tizi-Ouzou, Algérie*

E-mail: zembrinacima@gmail.com

**Take home Message:** Nutritive value assessment of *Hedysarum flexuosum* L., an spontaneous fodder legume.

**Introduction** Spontaneous legumes have an important place in the Mediterranean flora, hence the need for their valorisation by their introduction into the land reserved for fodder crops or into fallow lands, rangelands and steppes (Abdelguerfi and Laouer, 1999). Algeria is characterized by a great diversity of microclimates, the region of Kabylie, located according to Véla and Benhouhou (2007) in the hotspot «Kabylie-Numidie-Kroumirie», contains several species of pastoral and forage interest, including *Hedysarum flexuosum*. The natural populations of *H. flexuosum*, with an erect habit (facilitating mowing), provide winter and spring pasture of good nutritional value (Abdelguerfi-Berrakia et al, 1991). The objective of this study was to assess the nutritive value of five population of *H. flexuosum* in Kabylie (Algeria) and is a continuation to the work of Zirmi-Zembri and Kadi (2020).

**Material and methods** The plant material comes from five populations of *H. flexuosum* from the Kabylie region, located in north central Algeria. The sites have been chosen following the gradient East (Souama), West (Sidi Naamane), North (Timizart), South (Ait Toudert) and Center (Bousmahel). For each population, 08 plants in blooming stage were harvested as a replication, making 40 samples. The samples were oven dried at 60°C for 48 hours and then crushed. We mixed the 08-shredded material from each site in order to constitute an "homogeneous sample". Each homogeneous sample was used for analyses of the chemical composition (using 3 replications and performed by the DA 7250 NIR, analyser): dry matter and organic matter (DM, OM), ash contents, crude fibre (CF), neutral and acid detergent fibre (NDF and ADF), crude protein (CP), fat content (FC), calcium (Ca) and phosphorus (P). In order to predict the energy and protein value, we used the equations developed by Vermorel (1988), Vérité and Pyraud (1988) and Baumont et al. (2010). All statistical analyses were performed using R software.3.6.1. For all measured parameters, differences between populations were calculated using analysis of variance (ANOVA) and means comparisons were made using Tukey pairwise test ($P \leq 0.05$).

**Results and discussion** The chemical composition of the five studied populations of Sulla flexuosa at blooming stage is reported in Table 1. Results revealed differences between the five populations for all parameters. The crude protein content was very high, ranging between 14.19% (Souamaa samples) to 21.83% (Ait Toudert samples). The Neutral detergent fiber (NDF), an important parameter, showed interesting values oscillating between 50.3 and 55.94%.

**Table 1** Chemical composition of ***Sulla flexuosa*** sampled from five zones in north-centre Algeria.

| Chemical parameters | Ait Toudert | Bousmahel | Sidi Naamane | Souamaa | Timizart | Pr |
|---|---|---|---|---|---|---|
| DM (%) | $10.56^{a} \pm 0.23$ | $13.47^{c} \pm 1.16$ | $11.37^{ab} \pm 0.49$ | $11.16^{ab} \pm 0.41$ | $12.84^{bc} \pm 0.88$ | <0.1 |
| OM (% DM) | $87.50^{a} \pm 0.02$ | $90.32^{b} \pm 0.05$ | $91.24^{e} \pm 0.02$ | $90.88^{d} \pm 0.02$ | $90.44^{c} \pm 0.02$ | <0.0001 |
| Ash (% DM) | $12.50^{e} \pm 0.02$ | $9.68^{d} \pm 0.05$ | $8.76^{a} \pm 0.02$ | $9.07^{b} \pm 0.03$ | $9.56^{c} \pm 0.01$ | <0.0001 |
| CP (% DM) | $21.83^{e} \pm 0.06$ | $16.22^{c} \pm 0.09$ | $15.34^{b} \pm 0.06$ | $14.19^{a} \pm 0.03$ | $16.67^{d} \pm 0.03$ | <0.0001 |
| NDF (% DM) | $54.45^{c} \pm 0.07$ | $54.68^{d} \pm 0.09$ | $55.94^{e} \pm 0.07$ | $51.26^{b} \pm 0.11$ | $50.30^{a} \pm 0.01$ | <0.0001 |
| ADF (% DM) | $31.98^{d} \pm 0.07$ | $31.78^{c} \pm 0.07$ | $33.64^{e} \pm 0.06$ | $30.21^{b} \pm 0.09$ | $28.70^{a} \pm 0.02$ | <0.0001 |
| CF (% DM) | $20.97^{a} \pm 0.04$ | $27.70^{d} \pm 0.09$ | $28.48^{e} \pm 0.05$ | $23.35^{b} \pm 0.06$ | $24.96^{c} \pm 0.31$ | <0.0001 |
| FC (% DM) | $2.01^{c} \pm 0.01$ | $1.98^{b} \pm 0.01$ | $1.92^{a} \pm 0.01$ | $1.97^{b} \pm 0.01$ | $2.01^{c} \pm 0.01$ | <0.0001 |
| P (g/kg DM) | $4.00^{d} \pm 0.00$ | $3.10^{c} \pm 0.00$ | $2.80^{a} \pm 0.00$ | $3.00^{b} \pm 0.00$ | $3.10^{c} \pm 0.00$ | <0.0001 |
| Ca (g/kg DM) | $5.00^{e} \pm 0.00$ | $4.30^{d} \pm 0.00$ | $4.10^{b} \pm 0.00$ | $4.00^{a} \pm 0.00$ | $4.20^{c} \pm 0.00$ | <0.0001 |

**Conclusion** Sulla flexuosa is hight crude protein content (21.82% DM) when harvested green at blooming stage particularly in Ait Toudert region. Its chemical composition and forage values are also interesting regardless of the harvest region. This legume is an excellent fodder and could contribute to the reduction of the fodder deficit which Algeria is currently suffering.

**References**

Abdelguerfi A., Laouar M. 1999. Pastagens e Forragens 20, 81-112.
Abdelguerfi-Berrakia. R., Abdelguerfi A., Bounaga N., Guittonneau G. 1991. Fourrages 126, 187-207.
Baumont R., DulphyJ. P., Sauvant D., Meschy F., Aufrère J., Peyraud JL. 2010. Ed. INRA. Paris. 153-183.
Véla E., Benhouhou S. 2007. Comptes rendus biologies 330 (8), 589-605.
Vérité R., Peyraud JL. 1988. Nutrition azotée In Jarrige R, (Eds). Ed. INRA. Paris. 75-93.
Vermorel M. 1988. Nutrition énergétique. In Jarrige R. (Eds). Ed. INRA. Paris. 55-74.
Zirmi-Zembri N., Kadi S.A. 2020. Journal of Rangeland Science, Vol. 10, No. 3, 341-356.

# Performance of sheep grazing either natural pastures or *Brachiaria brizantha* supplemented with by-products from *Acrocomia aculeata*, and rumen degradability of pastures and by-products

Winston E. Stanley[1], Óscar L. Valiente[1], Antonio de Vega[2]

[1] *Universidad de Asunción, San Lorenzo, Paraguay*
[2] *Universidad de Zaragoza, Zaragoza, Spain*

E-mail: avega@unizar.es

**Take home Message** Supplementation of sheep grazing either natural pastures or *Brachiaria brizantha* with by-products from grugru palm (*Acrocomia aculeata*) increases productive performance, mainly in ewes consuming natural pastures.

**Introduction** Sheep production on natural pastures presents serious limitations in terms of productivity hence the use of cultivated prairies, and/or supplementation of grazing animals has been proposed. In Paraguay there is no much information about botanical composition, yield, rumen degradability and productivity of natural pastures. Also, there is a lack of information regarding performance of sheep grazing cultivated *Brachiaria brizantha* or rumen degradability of the latter. Paraguay is abundant in grugru palm (*Acrocomia aculeata*) which oil is used for biodiesel manufacturing. Oil extraction generates by-products such as endosperm (ENE) or mesocarp (ME) expellers which could be efficiently used in animal feeding. Hence there is a high interest in generating useful information that will help to improve the use of those by-products in sheep grazing either natural pastures or cultivated prairies, in the specific conditions of Paraguay.

**Material and methods** Twenty-four non-pregnant, non-lactanting ewes (36 ± 3.8 kg) were assigned to four treatments (n = 6, two of them cannulated in the rumen) which were the type of pasture (natural mixed sward (NMS), and cultivated monophytic sward (CMS) of *Brachiaria brizantha* cv. Marandu), and the level of supplementation (without supplement (NS), and with a 1% supplement (dry matter (DM)/live weight (LW; S)). Two NMS and two CMS paddocks of 15,000 $m^2$ each were grazed. Within each type of pasture, sheep grazing in one of the paddocks were supplemented whereas they were not in the other. The supplement consisted in 2/3 of ME and 1/3 of ENE, and was offered at 17:00 in troughs installed in each paddock. Animals had access to the pasture between 7:30 and 19:30. During pasture consumption, NMS, CMS, ME and ENE were incubated in fistulated animals (NMS and CMS in animals grazing them (n=4), and ME and ENE in all animals (n=8)) for several hours (2, 4, 8, 16, 24, 48 and 72 h after accession to the pastures) in polyester bags. Non-fistulated animals were used to assess average daily gain (ADG) during a 7-week period. DM, organic matter, crude protein (CP), ether extract, neutral (NDF) and acid detergent fibre, insoluble nitrogen associated to these two latter, and acid detergent lignin were analysed following the recommended procedures in ME, ENE, supplement, NMS and CMS. DM, CP and NDF were also analysed in the bags' residues.

**Results and discussion** Both NMS and CMS had a low quality (5.1 *vs*. 4.7% CP, and 71.1 vs. 65.2% NDF, respectively) whereas the two expellers had a high content in fat (17.5 *vs*. 15.0% for ME and ENE, respectively); in addition, ENE was richer in protein (33.3% CP) than ME (6.1%). The supplement had a protein content (14.4%) close to that recommended for grazing sheep (14%). Degradability of pastures is shown in Table 1. Potential degradability (PD) of DM and CP of both ME and ENE expellers was not affected by the type of pasture consumed by the animals or the level of supplementation (P>0.05) with no differences between the two supplements. However, the fractional rate of degradation (c) of DM was faster (P<0.0001) for ME (0.129 $h^{-1}$) than for ENE (0.044 $h^{-1}$) probably due to the lower NDF and ADF content of the former. PD of NDF was higher (P<0.0001) for ENE (72.5%) than for ME (54.4%) with no differences in c (P>0.1). ADG was higher in supplemented animals (P = 0.007) which led to higher final LW, but only in animals grazing NMS (P value of the interaction between type of pasture and level of supplementation = 0.033), probably due to the lower fibre content of CMS. ADG was not affected by type of pasture (P=0.755).

**Table 1** Potential degradability (a+b) and fractional rate of degradation (c) of natural mixed sward (NMS) and cultivated monophytic sward of *Brachiaria brizantha* (CMS) in the rumen of sheep not supplemented (NS) or supplemented (S) with a mixture of 2/3 mesocarp expeller and 1/3 endosperm expeller of *Acrocomia aculeata*.

| Pasture (P) | | NMS | | CMS | | | P | | |
|---|---|---|---|---|---|---|---|---|---|
| Supplement (S) | | NS | S | NS | S | SEM | P | S | PxS |
| DM | a+b | $44.6_{bA}$ | $39.9_{aA}$ | $68.7_{B}$ | $70.7_{B}$ | 1.11 | <0.0001 | 0.1335 | 0.0026 |
| | c | 0.034 | 0.026 | 0.041 | 0.038 | 0.0019 | <0.0001 | 0.0030 | 0.0643 |
| CP | a+b | 32.7 | 37.07 | 54.8 | 62.3 | 4.60 | <0.0001 | 0.1048 | 0.6470 |
| | c | $0.070_{aA}$ | $0.168_{bB}$ | $0.102_{B}$ | $0.115_{A}$ | 0.0133 | 0.3163 | 0.0004 | 0.0021 |
| NDF | a+b | $42.9_{bA}$ | $33.9_{aA}$ | $63.8_{aB}$ | $68.1_{bB}$ | 1.43 | <0.0001 | 0.0493 | 0.0002 |
| | c | 0.026 | 0.024 | 0.041 | 0.038 | 0.0013 | <0.0001 | 0.0172 | 0.6011 |

a,b, Means with different lower case letters within a pasture differ significantly between supplementation levels (P < 0.05). A,B, Means with different lower case letters within a supplementation level differ significantly between pastures (P < 0.05)

**Conclusion** Supplementation with a mixture of 2/3 ME and 1/3 ENE at 1% LW increases ADG of sheep grazing either NMS or CMS, even though it decreased potential degradability of NMS DM but not that of CMS.

# Effect of fungal treatment by solid state fermentation on the nutritive value of date pedicels

Olfa Abid[1], Itaf Chebbi[2], Taha Najar[2], Atef Jaouani[1]

[1]*Higher Institute of Applied Biological Sciences of Tunisia (ISSBAT), University of Tunis El Manar, CP 1006, Tunis, Tunisia*
[2]*Department of Animal Science, National Agronomic Institute of Tunisia, Carthage University, 1082, Tunis, Tunisia*

E-mail: oulayfa@gmail.com

**Take home Message** Fungal biotreatement of date pedicels using Solid-state fermentation technology could potentially be introduced in ruminant nutrition to decrease the amount of lignocellulose and enhance the *in vitro* digestibility.

**Introduction** Date pedicels (DP) are the main date-palm by-products. They represent a fodder resource for livestock by oasis farmers. However, they are characterized by low organic nitrogen content and high levels of cell walls encrusted with lignin in complex ways. Strong chemical bonds which exist between lignin and polysaccharides and cell wall proteins make these compounds unavailable during digestion. In order to improve the nutritional value of DP, biological processes have attracted attention due to their low cost and their respect to the environment. The solid-state fermentation technique using white rot fungus, defined as growth of microorganisms on moist solid substrate in the absence of free-flowing water, has proven to be an effective means of degrading the ligno-cellulosic complex through lignocellulolytic enzymes produced.

**Material and methods** The fungal strain used in this study was *Fomes fomentarius* and was maintained at 4 °C on 2% malt extract agar. The inocula were prepared by growing fungi on a rotary shaker at 120 rpm at 28°C of following synthetic medium: 10 g/l malt extract, 5 g/l yeast extract,2g/l peptone and 1g/l glucose. Erlenmeyer flasks (1000 ml), each containing 20g of DP, were moistened with distilled water and autoclaved at 121°C for 20 min. Inoculation was performed with 5 ml of fungal suspension. Cultures were incubated at 28 °C for 22 days in an incubator. Protein contents of date DP were determined in accordance with the AOAC (1990) method. NDF, ADF and ADL were assessed according to the methods of Van Soest et al. (1991). In vitro gas production technique (Menke and Steingass, 1988) was used in this study for feed evaluation of SSF treated DP.

**Results and discussion** Solid-state fermentation of DP was compared with that of the properties of uninoculated DP. The fungi were examined for their potential to degrade the different plant cell wall components and to enhance the *in vitro* digestibility. As shown in table 1, a slight increase of protein content of treated DP can be explained by the low standard deviation. Contrariwise, the fungus caused significant loss in crude fiber fractions (NDF, ADF and ADL) during solid state fermentation. During fungal growth, part of the cell wall is converted into soluble sugars to provide energy, a phenomenon that could be responsible for decrease of NDF and ADF. White rot fungus attacked unaltered lignin polymers of DP causing cleavage of interlignol bonds and aromatic ring cleavage, which is expressed by ADL loss. Figure 1 shows the *in vitro* gas production kinetics. The highest increase in gas production for the treated substrate was occurred in the first 48 h and then began lower after 48 to 96 h. These results indicate that the carbohydrates fractions were readily available to the microbial population. The decrease in lignin content of the treated DP may facilitate the attack of polysaccharides by the rumen microflora which in turn increased gas production.

**Table 1** Cell wall component and protein content in untreated and treated DPL (%DM)

| Item | NDF | ADF | ADL | Protein |
|---|---|---|---|---|
| Untreated DP | $68.72^{a}$±0.45 | $44.69^{a}$±1.10 | $20.06^{a}$±1.11 | $3.65^{a}$±0.2 |
| Treated DP | $59.73^{d}$ ±0.98 | $33.19^{d}$±0.62 | $18.95^{ab}$±0.54 | $3.75^{ab}$±0.89 |

a,b,d means in the same column with different super scripts are significantly different (P < 0.05)

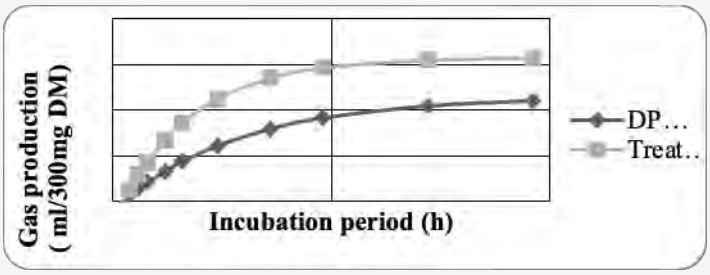



**Figure 1** Effect of DP bioprocessing by *fomes Fomentarius* on in vitro gas production

**Conclusion** This study opened useful applied access for the valorization of solid wastes to animal food of a better quality. Further work to quantify the in-vivo digestibility is necessary to confirm the efficiency of this technique on animal nutrition.

**Acknowledgements** This study was supported by the "Jesr Méditerranéen de la filière ovine *JESMED*/Réf n°IS 1.2" research project and "Valorisation de nouvelles ressources alimentaires pour l'alimentation animale : nouvelles variétés d'orge, sous-produits agro-alimentaires et matières premières de substitutions *VNRA*" research projects.

**References**

AOAC. 1990. Association of official analytical chemists. Arlington VA, USA.
Menke K.H., Steingass H. 1988. Animal Research and Development 28, 7-55
Van Soest P.J., Robertson J.B., Lewis B.A. 1991. Journal of Dairy Science 74, 3585-3597

# Olive cake as an alternative feed resource for lactating goat and its effects on milk production and composition

Samira El Otmani[1], Mouad Chentouf[1], Jean-Luc Hornick[2], Jean-François Cabaraux[2], Youssef Chebli[1]

[1]*Regional Center of Agricultural Research of Tangier, National Institute of Agricultural Research, Avenue Ennasr, BP 415 Rabat Principale, Rabat 10090, Morocco*
[2]*Department of Veterinary Management of Animal Resources, FARAH, IVT, Faculty of Veterinary Medicine, University of Liège, Belgium*

E-mail: samira.elotmani@inra.ma

**Take home Message** The incorporation of 20% olive cake in lactating goat diet had no effect on milk production and composition. This by-product could be considered as an alternative feed resource for lactating goat.

**Introduction** The Mediterranean basin is known by large surfaces of the olive tree (*Olea europea* L.). Olive oil extraction produces important amounts of by-products such as olive cake (OC). Disposing this by-product in nature affects negatively ecosystems (Dermeche et al., 2013). Many studies investigated the use of OC in cows and ewes, however few researches studied the OC effect in goat. Thus, the aim of this study is to evaluate the effects of OC supplementation on goat milk production performance and quality.

**Material and methods** Twenty-two lactating goats from the local population of northern Morocco "Beni Arous" were divided equitably into two groups based on milk production. The both of groups received a conventional diet (oat hay and with two concentrates). The control group (Co) received a concentrate composed of barley and faba bean, while the second one received a concentrate with 20% of OC. Milk production was recorded fortnightly to determine milk production and yield per lactation. 40 ml of milk was used to determine the chemical composition (fat, protein, lactose, fat-free solids and mineral matter). Mineral matter was analyzed according to AOAC (1997). While fat, protein, lactose and defatted dry matter were determined by the infrared method using the MilkoScan™Minor. The yield of these components was estimated by multiplying by the daily milk production and per lactation. The data were analyses by ANOVA II (ration and lactation period) and their interaction using SAS software.

**Results and discussion** Daily milk production was similar for all animal groups with 415 and 362 g/day for Co and OC, respectively (P>0.05). The milk composition was not affected by OC incorporation (P>0.05). The milk produced contained on average 2.3, 3.6, 4.5, 9.1 and 0.79% fat, protein, lactose, solid non-fat and mineral matter, respectively. Protein, lactose, solids non-fat, and ash contents were closely similar to the milk goat average with 3.52, 4.27, 8.75, and 0.86%, respectively (Kumar et al., 2012). The lactation period had a significant effect on all parameters of milk production and composition (P <0.01). The interaction between diet and lactation period was significant only for mineral content (P <0.05).
The yield per lactation of milk, fat, protein, lactose, solid non-fat and mineral matter were not affected by the diet distributed (P>0.05). The milk yield was in average 47 kg/lactation, which is in the Beni Arouss indigenous breed interval (40-54 kg/lactation; Hilal, 2018). The milk composition per lactation were similar in both of groups with an average of 1.14, 1.65, 2.11, 4,22 and 0.37 kg respectively for fat, protein, lactose, solid non-fat and mineral matter by lactation (P>0.05).

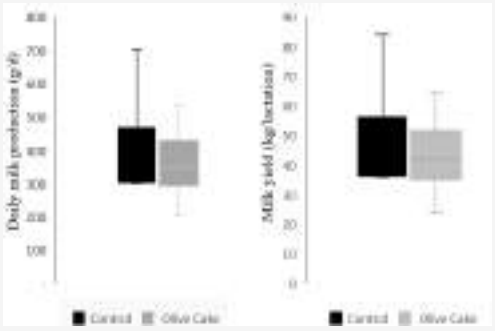


**Figure 1.** Daily milk production and yield of control and olive cake groups

**Conclusion** The introduction of OC in lactating goat diet had no effect on milk production and chemical composition. The OC could be introduced as alternative feed resource into goats' diet in order to recycling this by-product and to reduce feeding costs.

**Acknowledgements** The authors would like to thank the National Institute of Agricultural Research (INRA) and Research for Development Project (PRD) collaborators.

**References**

AOAC. 1997. Official Methods of Analysis of AOAC International. 16th edition. Washington, DC, USA. pp. 2000
Dermeche S., Nadour M., Larroche C., Moulti-Mati F., Michaud P. 2013. Process Biochemistry, 48, 1532–1552.
Hilal B. 2018. Caractérisation phénotypique, génétique moléculaire et zootechnique de la population caprine Hamra dans deux régions différentes (Béni Arouss et Rommani). PhD in Agricultural and Agri-food sciences, Agronomic and Veterinary Institute Hassan II, Rabat, Morocco. 19 April 2018.
Kumar S., Kumar B., Kumar R., Kumar S. 2012. Indian Journal of Dairy Science. 65(4), 266–273.

# Influence of dietary supplementation with mushroom Agaricua bisporus on health and meat quality of lambs

Goran Kiš[1], Luka Pajurin[2], Daniel Špoljarić[2], Branimira Šporaljić[2], Lidija Kozačinski[2], Tomislav Mikuš[2], Kristina Kljak[1], Maja Popović[2]

[1]*University of Zagreb Faculty of Agriculture, Zagreb, Croatia*
[2]*Faculty of Veterinary Medicine, University of Zagreb, Zagreb, Croatia*

E-mail: kis@agr.hr

**Take home Message.** Dietary supplementation of Agaricus bisporus mushroom into diet for lambs has a positive effect on animal health and productivity as well as quality and aroma profile of lamb meat.

**Introduction** The risks of using antibiotics as growth promoters in animal feed for human health have led to a ban on their use in the European Union. The consequences of the ban on the use of antibiotics as growth promoters are manifested in lower food utilization and reduced production, thus in increased morbidity and mortality of animals. It is, therefore, necessary to find alternative sustainable methods of controlling stressors on animal health inappropriate feeding systems. It is generally known that mushrooms contain active molecules of antifungal, anti-inflammatory, antiviral, antibacterial, hepatoprotective, antidiabetic, hypolipemic, antithrombotic, hypotensive, and symbiotic effects (indirect probiotic/direct prebiotic). Mushroom Agaricus bisporus is one of the most commonly grown mushroom species in the world. Good nutritional characteristics, low in fat and high in protein and carbohydrates, the most common of which are dietary fiber, make them a very acceptable food not only for humans but also for domestic animals intended for human consumption. Its extracts have significant antioxidant activity, which is largely attributed to polyphenolic compounds, but also the presence of α-tocopherol and β-tocopherol, carotenoids, ascorbic acid, and ergothioneine. It contains a favorable amount of minerals that are an important component of serum antioxidant enzymes and indicators of lipid peroxidation and therefore have an important function in the antioxidant defense mechanism. The favorable content of vitamins also significantly contributes to the antioxidant defense mechanism because these vitamins are effective fat-soluble antioxidants and thus protect fatty substances from oxidation or oxidative stress. On the model of monogastric animals, mushroom feed supplement showed: faster growth, lower food conversion, less disease, and better survival rate of animals. This work aims to determine whether we can get the same results in the ruminants feed supplementation, to determine the influence of Agaricus bisporus on the health and quality of lamb meat.

**Material and methods** This study was conducted on 45 lambs, autochthonous Croatian sheep breeds, Lika pramenka. Lambs were divided into three groups and fed voluminous and concentrate with the addition of 1,5% dried and fresh mushrooms. The lambs were clinically examined, their welfare was assessed, and their blood was withdrawn for further hematological analyses. After 35 days, the lambs were slaughtered and meat samples (m. longissimus dorsi) were sent for chemical analysis, fatty acid and cholesterol content, and thiobarbitut test (TBARS) as indicators of oxidative stability of meat.

**Results and discussion** Based on the results of several studies on lambs of the autochthonous Croatian sheep breed Lika pramenka feed with the supplementation of dried and fresh prepared Agaricus Bisporus in proportions of 1.5% additional feed mixture it is evident that mushroom added as dietary supplement improves animal health (decreased serum glucose and cholesterol levels and increased T-lymphocyte and B-lymphocyte counts) and productivity. The content of fat and cholesterol in lamb meat was reduced, more vaccenic acid, omega-7, conjugated linoleic acid precursors were found, which have multiple beneficial effects on the health of consumers of such animal products, and the oxidative stability of meat was improved. Adding fresh and dried button mushrooms to the diet increased ($p \leq 0.05$) the amount of fat in lamb meat (1.10 vs. 1.62 g/100g) but did not differ statistically from the control group. TBARS values were expected to increase from day 0 to day 6 (0.1 vs. 1.4) and differ significantly from day three between lamb meat fed a standard meal and a fresh mushroom meal (0.97 vs. 0.86), while the dry mushroom meal had no significant differences between the two lamb groups.

**Conclusion** Adding mushrooms to lamb's diet had a positive effect on animal health. It affected fat, cholesterol, and fatty acid composition of meat and increased the oxidative stability of meat.

**Acknowledgements** This study has been fully supported by the Croatian Science Foundation under the project "Innovative functional lamb meat products" (HRZZ-IP-06-2016-3685).

**References**

Kozačinski L., Cvrtila Ž., Mikuš T., Njari B., Pleadin J., Špoljarić D., Popović, M. 2021. MESO: Prvi hrvatski časopis o mesu, 23(6), 506-0.

Popović M., Pavić M., Vuković S., Mihelić D., Leiner D., Čurković S., Cvrtila Z., Kiš G., Kozačinski L., Mikuš T., Milinković Tur S. Mršić G., Njari B., Pajurin L., Poljičak Milas N., Shek Vugrovečki A., Šimpraga M., Špoljarić B., Vince S., Vlahović K., Žura Žaja I., Špoljarić D. 2022. Veterinarska stanica 53(2), 223-232.

# Effect on the *in vivo* digestibility, the N balance and the antioxidant status of avocado seed inclusion in the diet of goats.

A. Ignacio Martín-García[1], Alejandro Belanche[1], Pedro Romero-Márquez[1], Raquel del Pino-García[2], Manuel Romero-Huelva[1], Eva Ramos-Morales[1], David R. Yáñez-Ruiz,[1]

[1]*Estación Experimental del Zaidín (CSIC), Granada, Spain*
[2]*Centro Tecnológico de Investigación y Desarrollo del Alimento Funcional (CIDAF), Granada, Spain*

E-mail: ignacio.martin@eez.csic.es

**Take home Message** The avocado seed resulting from the guacamole manufacturing industry can be used in goats feeding as a replacer of traditional cereals like barley or corn.

**Introduction** Avocado production in the Spanish southern Mediterranean coast reached 96,000 tons in 2019/20, accounting for more than 90% of the production of the European shore of the Mediterranean basin. Taking into account the exponential growth of its consumption throughout the world, the high demand for the avocado/guacamole production sector in the coming years will entail a challenge in terms of the adequate industrial management of the by-products generated, while could potentially be used as a natural source of high-value bioactive compounds. In recent years, the agri-food industry has been implementing numerous circular bio-economy practices to better manage its waste and become more efficient and sustainable. The avocado seed (AS) accounts for 40% of the weight of the processed fruit, is of great interest for ruminant feeding (Martín-García et al., 2021a), since it has a starch content of between 35 and 60% of the DM, a slow ruminal degradation kinetics (Yáñez-Ruiz et al., 2021) and a high antioxidant potential (www.aguacavalue.es), without presenting any long-term health or metabolic risk for those species (Martín-García et al., 2021b).

**Material and methods** A trial was conducted using 12 Murciano-Granadina goats (40.5±7.40 kg), in their drying-off stage, divided into two groups (CTL and AVS) balanced by weight. Goats in CTL group were *ad libitum* fed during 21 d a commercial concentrate and oats hay, while AVS group where equivalently managed but 20% of corn and barley in the concentrate fraction was replaced by the avocado seed. Then, during 5 days, animals were individually installed in metabolic cages to perform a digestibility and N balance trial. Taking into account the voluntary intake showed in the 21-d adaptation period, a total weight of 800 g of the diets previously described (1:1 forage to concentrate proportion), were daily offered and refusals, faeces and urine were recovered. Finally, blood samples were obtained via the jugular vein for the analysis of β-hydroxybutyrate (βHB) or non-esterified fatty acids (NEFA) as indicators of the metabolic status, using an auto-analyzer (BA400, Bio-Systems, Barcelona, Spain), and Total Polyphenols (TP) and antioxidant activity (ABTS) as indicators of the antioxidant status of the animals, following the methodology described by de Renobales et al. (2012). The procedures and the analytical methodology used in this study were described by Arco-Pérez et al. (2017).

**Results and discussion** The introduction of AS in the diet did not induce any significant difference ($P \geq 0.462$) in the daily intake of any of the nutrients analysed with respect to the control diet, which contained conventional cereals. Regarding the apparent digestibility of nutrients (DM, OM, CP, Fat, NDF, ADF), no significant differences were observed ($P \geq 0.243$) between the CTL and AVS diets, as well as for the different parameters of N utilization. ($P \geq 0.352$). The figures found for all parameters were included in the average range of the data described for Murciano-Granadina goats in similar studies (Molina-Alcaide et al. 2010, Arco-Pérez et al 2017). Similarly, the absence of differences in the plasma concentration of βHB ($P=0.763$) or NEFA ($P=0.997$), showed, respectively, similar conditions of fermentation/absorption of VFA and mobilization of body reserves, indicating the absence of energy deficit for both experimental diets, being these figure within the physiological range for goats (0.1-0.7 and 0.1-0.9, respectively for βHB and NEFA). Despite the fact of the higher content of antioxidant in AS (ABTS: 22.0 g eq T/100g and Polyphenols: 4.17 g/100 g, www.aguacavalue), in terms of the antioxidant status of animals, the experimental diets did not promote differences in TP content ($P=0.462$), while the ABTS was significantly lower ($P=0.043$) for the AVS group.

**Conclusion** Despite not implying the improvement in the antioxidant status of goats in maintenance, the substitution of 20% of the cereals in the concentrate does not imply any variation in the digestibility of nutrients, the N balance or on certain indices of body reserves mobilization, indicating the suitability of the use of this by-product in goats feeding.

**Acknowledgements** Project AGUACAVALUE Operational Group (in the sense of Art 56 of Reg.1305/2013, www.aguacavalue).

**References**

Arco-Pérez A., Ramos-Morales E., Yáñez-Ruiz D.R., Abecia L., Martín-García A.I. 2017. Animal Feed Science and Tecnology 232, 57-70.
De Renobales M., Amores G., Arranz J., Virto M., Barrón L.J.R., […] Mandaluniz N. 2012. Food Chemistry 130, 90-96.
Martín-García A.I., Belanche A., […], Palma-Hidalgo J.M.,Yáñez-Ruiz D.R. 2021a. AIDA-ITEA 19, 63.
Martín-García A.I., Belanche A., […], Palma-Hidalgo J.M., Yáñez-Ruiz D.R. 2021b. AIDA-ITEA 19, 89.
Molina-Alcaide E., Morales-García E.Y., Martín-García A.I., Ben Salem H., Nefzaoui A., Sanz-Sampelayo M.R. 2010. Journal of Dairy Science 93(5), 2076-2087.
Yáñez-Ruiz D.R., Matas A., Belanche A., […], Romero P., Martín-García A.I. 2021. AIDA-ITEA 19, 78.

# Olive cake as an alternative feed resource for goat kids and its effects on rumen microbial community and meat quality

Samira El Otmani[1], Bernard Taminiau[2], Mouad Chentouf[1], Jean-Luc Hornick[3], Jean-François Cabaraux[3], Youssef Chebli[1]

[1]*Regional Center of Agricultural Research of Tangier, National Institute of Agricultural Research, Avenue Ennasr, BP 415 Rabat Principale, Rabat 10090, Morocco*
[2]*Department of Food Science, Food Microbiology, University of Liège, Avenue de Cureghem 6, B42, 4000 Liège, Belgium*
[3]*Department of Veterinary Management of Animal Resources, University of Liège, Avenue de Cureghem 6, B43, 4000 Liège, Belgium*

E-mail: samira.elotmani@inra.ma

**Take home Message** The incorporation of 35% olive cake to goat kids' diet did not strongly affect rumen microbial community and meat quality. This by-product could be used as an alternative feed resource for goat kids.

**Introduction** Domestic goats are the most dominant among ruminants due to their ability to thrive better in harsh environments, to their diseases' resistance, and low-quality forage enhancement (Chebli et al., 2020). This herd provides important quantities of meat that is a stable source of protein and essential nutrients. In harsh environments, their diets are based essentially on rangeland, which experiences degradation due to the over-use (Chebli et al., 2018). To reduce this degradation, breeders should adopt alternative feeding solutions like using by-products. The olive cake (OC) is an unconventional feed widely available in the Mediterranean area due to the large surfaces of the olive tree and olive oil manufactures. To our knowledge, there is no published study on OC effects on goat kids' meat quality and rumen microbial community. In this context, this work aims to evaluate the OC effects on ruminal bacteria diversity and meat quality of goat kids.

**Material and methods** Twenty-two goat kids from the local population of northern Morocco "Beni Arous", aged 3 months with an average weight of 10.5 kg, were divided equitably into two groups. Both of them received oat hay as a coarse feed. However, the control group received a conventional concentrate containing barley and faba bean, while the second one received a concentrate with 35% OC and faba bean. After 3 months of the experiment, the animals were slaughtered, and the rumen liquor was collected to determine pH and to extract DNA and identify the microbial community. After 24 h, meat pH at 0 hours and 24 hours after slaughter and color were determined at the longissimus dorsi, and samples were collected to determine humidity, ash, water retention capacity, proteins, and fat. The "diet" factor effect was tested by a generalized linear model (GLM) using SAS software.

**Results and discussion** Bacterial community composition was not affected by diet at the phylum and family levels. At the genera (Fig.1), control liquor contained *Aeriscardovia,* which produces lactic acid using the higher starch content in this diet (Wu et al., 2015), and is reflected in low ruminal pH (5.70 *vs* 6.09).
*Lachnospiraceae_NK4B4_group* was present in OC liquor, probably due to the high fibers of OC that are necessary to cellulolytic bacteria growth (Mannelli et al., 2018). For meat quality, there was no difference in pH0 and pH24, and meat color between control and OC groups. Except for protein that was lower in OC meat, humidity, ash, water retention capacity and fat were similar with an average of 82, 2, 23, and 2%, respectively.

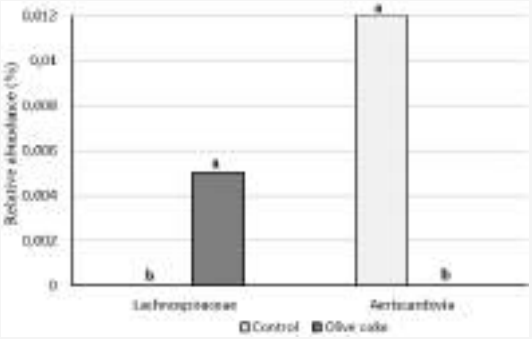



**Figure 1.** Relative abundance of genera in control and olive cake rumen liquor

**Conclusion** The introduction of OC in goat kids' diet did not strongly change the bacterial composition of rumen liquor and meat quality. The OC could be introduced as an alternative feed resource into goat kids' diet.

**Acknowledgements** The authors thank the National Institute of Agricultural Research (INRA) and Research for Development Project (PRD) collaborators.

**References**

Chebli Y., Chentouf M., Ozer P., Hornick J.L., Cabaraux J.F. 2018. Applied Geography 101, 23–35.
Chebli Y., El Otmani S., Chentouf M., Hornick J.L., Bindelle J., Cabaraux J.F. 2020. Animals 10(2), 196.
Mannelli F., Cappucci A., Pini F., Pastorelli R., Decorosi F., Giovannetti L., Mele M., Minieri S., Conte G., Pauselli, M., Rapaccini S., Viti C., Buccioni A. 2018. Scientific Reports 8, 1–11.
Wu Y., Ma H., Zheng M., Wang K. 2015. Bioresources Technology 191, 53–58.

# First evaluation of forage yield and agronomic parameters of *Eragrostis tef* cultivars cultivated in south Italy

Riccardo Primi[1], Bruno Ronchi[1], Pier Paolo Danieli[1], Roberto Ruggeri[1], Francesco Rossini[1], Vincenzo Natoli[2]

[1]*Università degli Studi della Tuscia, DAFNE, Viterbo, Italy*
[2]*Genetic Services s.r.l., Deliceto (FG) Italy*

E-mail: primi@unitus.it

**Take home Message** Teff offers potential as a drought-resistant forage crop.

**Introduction** Teff [*Eragrostis tef* (Zuccagni) Trotter] is a C4 warm-season annual grass presumably originated from Ethiopia, well-adapted to drought conditions. Traditionally, teff is used as a grain crop for human consumption, but some recent research focusing on nutritional profile has suggested its use as forage for livestock (Vinyard *et al*., 2018). Teff is a very adaptable species with over 5000 different genotypes available. Little is known on crop management, yield, and chemical composition of teff in the geographic regions differing from that of origin. The aim of the present study was to assess and compare the yield and some agronomic characteristics of 46 genotypes of teff, growing as warm-season fodder crops under the south Italy climatic conditions.

**Material and methods** A plot test was established in the open field at Foggia (Apulia, Italy), during the spring-summer 2017. Temperature at the experimental site ranged from 10°C to 35°C (average 25 °C), with a cumulative rainfall of 400 mm. Characteristics of soil were 29% clay, 48% silt and 23% sand, pH 8.09, organic matter 1.8% and total N 0.99‰. Preceding crop was durum wheat. A randomized complete block design experiment with two replicates was planned. Soil tillage consisted of descender and rotary harrow. The seeding was carried out with a Vignoli plot seeder. Individual plots consisted of 8 rows (1.2 × 4.8 m each) with a row spacing of 17 cm and a seeding depth of approximately 2 mm (equivalent to a seeding rate of 5 kg $ha^{-1}$). Fertilization with P was applied before sowing at the rate of 60 kg $ha^{-1}$; 80 kg $ha^{-1}$ of N was applied at the tillering stage. Weed control was achieved by using a pre-emergence herbicide (Stomp® Aqua, Basf) applied at 1.5 L $ha^{-1}$ rate. During the trial, drip irrigation was applied. Two manual mowings were carried out at the stage of flowering. The following parameters were recorded: plant density (PD, plant $m^{-2}$), stem strength index (SI, 0-9), sowing-first mowing interval (S-$M_1$, days), days between first and second mowing ($M_2$-$M_1$, days), total days elapsed from seeding to second cut (TDG, days), dry biomass at first mowing (DB-$M_1$ t $ha^{-1}$), dry biomass at second mowing (DB-$M_2$, t $ha^{-1}$) and total dry biomass produced (TDB, t $ha^{-1}$). A preliminary evaluation, through the Spearman's correlation procedure in R, was carried out to examine the relationship between the dry biomass yield and the agronomic parameters recorded. Variables with a Spearman's rank correlation coefficient (ρ) greater than ±0.5 were considered as significantly ($P < 0.05$) associated.

**Results and discussion** The descriptive statistics of the recorded data are as follows: PD 81.5±15.6 plant $m^{-2}$; SI 5.89±1.45; S-$M_1$ interval 106±7,4 days; first-second mowing interval 28.3±6.2 days; TDG 144.4±8.3 days; DB-$M_1$ 8.9±1.8 t $ha^{-1}$; dry biomass at second mowing 4.1±0.9 t $ha^{-1}$; total dry biomass 6.5±2.8 t $ha^{-1}$. As far as the correlation between agronomic traits, the stem strength index presented negative correlation with the DB-$M_1$ and the TDB ($P < 0.001$) (Table 1) and did not seem to affect the second cut. As also observed by Saylor *et al*. (2021), the TDB was positively correlated with days of growth before mowing ($P < 0.001$), including all the intervals evaluated. The second cut seemed not influenced by any of the variables considered. Plant density did not appear to be correlated with forage yield.

**Table 1** Spearman's rank correlation coefficients (ρ) between forage yield and agronomic parameters (n = 46). * $p < 0.05$; ** $p < 0.01$.

| Agronomic traits | Forage yield | | |
|---|---|---|---|
| | DB-$M_1$ | DB-$M_2$ | TDB |
| PD | 0.40 | -0.06 | 0.34 |
| SI | -0.66** | -0.05 | -0.63** |
| S-$M_1$ | 0.79** | 0.07 | 0.75** |
| $M_2$-$M_1$ | | 0.33 | 0.79** |
| TDG | | | 0.83** |

**Conclusion** The results from this study indicated that, under open field conditions, the cumulative forage yield differed among the teff genotypes according to the conditions that allowed the first cut. The robustness of the stem highly influenced the dry matter yield of the first cut, even though the density of the plants was not determinant for forage yield. These observations can be related to tillering: the greater sturdiness of the stem have induced less tillering and, consequently, a lower production of forage biomass. The plants density did not show a clear relationship with the biomass yield, probably because the tested densities were not adequate to represent the potential of the species and/or of the single genotype. Further analyses are in progress to determine the nutritive value and digestibility. Additional investigations should be addressed to select the best agronomic practices and the best genotypes for the Mediterranean environment.

**Refrences**

Saylor B.A., Min D., Bradford B.J., 2021. Journal of Animal Science and Technology 63(3), 510-19.
Vinyard J., Hall J.B., Sprinkle J.E., Chibisa E. 2018. Journal of Animal Science 96, 3420-3432.

# Efficient use of feeding resources of an experimental low-inputs goat flock to produce food for humans

Caillat Hugues[1], Kocken Tom[1], Ranger Benoit[1], Jost Jeremie[2]

[1]*INRAE, UE FERLUS, Les Verrines, 86600 Lusignan, France,*
[2]*French Livestock Institute, CS 45002, 86550 Mignaloux-Beauvoir, France*

E-mail: hugues.caillat@inrae.fr

**Take home Message** Dairy goat systems are net consumers of energy and net producers of proteins but it is necessary to supervise the characteristics of used concentrates.

**Introduction** The continuous increase in the world's population, associated with a growing tension in the use of land and resources (renewable or not), implies better use of these resources. In a context of significant tension on the resources use, particularly fodder resources, it is necessary to highlight the technical conditions facilitating the evolution of dairy goat systems towards greater efficiency to produce animal products. The GIS Elevages Demain has defined a methodology for calculating the total protein conversion ratio of vegetable proteins and energy into animal proteins and energy of livestock systems (Laisse *et al*., 2019). With the ERADAL project, the objective of which was to assess the efficiency of use of feed resources in dairy ruminant farms (Rouillé *et al*., 2019), has measured efficiency indicators for dairy goat farms.

**Material and methods** In this study, it was chosen to study one of the farmlets from the Patuchev experimentation-system (INRAE - UE FERLus) (Caillat *et al.*, 2016), with kidding in February and maximization of grazing. The study period was during 3 campaigns (2016-2018). The protein and energy efficiency indicators were calculated from the data recorded in the database of the French livestock institute (Diapason). The farmlet had 63 dairy goats of the Alpine breed with an annual mean milk production of 702 liters×goat$^{-1}$, 25 kids and 5 bucks. On average, 70 kids per year were sold at 8 days. Goats grazed mean of 179 days×year$^{-1}$. The feed intake of the flock was measured daily and feeding values regularly by a trolley equipped with a weighing system.

**Results and discussion** The annual mean forage intake was 846 kg dry matter×goat$^{-1}$×year$^{-1}$ and represented 71.3% of the total dry matter of the ration. The annual mean quantity of concentrates was 344 kg dry matter×goat$^{-1}$×year$^{-1}$ which 37% containing over 60% edible proteins by humans. The mean feed self-sufficiency was 80%, i.e. 19% more than in the farms of Inosys network (table 1). The mean gross energy efficiency was 0.10 and the mean gross protein efficiency was 0.18, which means that a goat has consumed 1 / 0.18 = 5.5 kg of vegetable protein to produce 1 kg of animal protein. 82% of the proteins and 81% of the energy consumed by the flock were not edible by humans, whereas the level was on mean 89% and 86% respectively for Inosys goat farms. The mean net protein efficiency was 1.02. A goat therefore has consumed on mean 1 / 1.02 = 980 g of vegetable protein in competition with human food to produce 1 kg of animal protein. This improved during the campaigns and became superior to the Inosys farms.

**Table 1** Evolution of protein and energy efficiency during 3 years

| | | | | | Inosys farms* | |
|---|---|---|---|---|---|---|
| | | 2016 | 2017 | 2018 | All | Grazing farms |
| Feed self-sufficiency (%) | | 83 | 78 | 78 | 61 | 76 |
| Proteins non-edible by humans in the ration (%) | | 79 | 82 | 84 | 89 | 85 |
| Energy non-edible by humans in the ration (%) | | 80 | 81 | 81 | 86 | 84 |
| Protein efficiency | *Gross* | 0.17 | 0.19 | 0.19 | 0.15 | 0.15 |
| | *Net* | 0.82 | 1.05 | 1.18 | 1.12 | 1.08 |
| Energy efficiency | *Gross* | 0.10 | 0.09 | 0.10 | 0.09 | 0.09 |
| | *Net* | 0.47 | 0.51 | 0.54 | 0.54 | 0.56 |

** Mean of dairy goat farms between 2012-2016 – 847 data*

**Conclusion** By choosing to improve feed self-sufficiency and limit the use of concentrates (344 kg×goat$^{-1}$×year$^{-1}$ *vs* 385 on mean Inosys farms), this grazing system improved its protein and energy efficiency. However, a higher milk production per goat during the campaigns demonstrated the importance of this indicator for a better level of efficiency. In addition, beyond the quantitative aspects, it is important to ensure the characteristics of feed intake. The choice of feed less in competition with human ration and the energy and protein values of the fodder (only 13% of crude protein on mean in 2017) are significant. In this study, the use of whole seeds of the cereal-legume mixtures distributed to goats could be more in competition than concentrates made up of co-products.

**Acknowledgements** This study was supported by the "ERADAL" research project of French Ministry of Agriculture. We thank the experimental staff of the FERLus experimental unit for daily measures of intake.

**References**

Caillat H., Bruneteau E., Ranger B., Furstoss V. 2016. Rencontres Recherches. Ruminants, 23, 247-250.
Laisse, S., Baumont, R., Dusart, L., Gaudré, D., Rouillé, B., Benoit, M. 2019. INRA Productions Animales 31, 269–288.
Rouillé B., Laurent M., Bluet B., Fança B., Morin E., Bienne F., Jost J. 2019. Fourrages 240, 305-309

# Solid-state fermentation with White-rot fungi: New technology to improve nutritional value of alternative fiber-feed for ruminants

Khalil Abid[1], Olfa Abid[1], Mohamed Neifar[2], Taha Najar[3], Atef Jaouani[1]

[1]*Higher Institute of Applied Biological Sciences of Tunisia (ISSBAT), University of Tunis El Manar, Tunis, Tunisia*
[2]*National School of Engineers of Sfax, University of Sfax, Sfax, Tunisia*
[3]*National Agronomic Institute of Tunisia, Carthage University, Tunis, Tunisia*

E-mail: atef.jaouani@issbat.utm.tn

**Take home Message** Solid-state fermentation with white-rot fungi improves nutritional value of alternative feeds and growth performance of lambs.

**Introduction** In southern Mediterranean countries, small ruminant farming remains an important socio-economic sector. The main challenge facing the sustainability of livestock farming in southern Mediterranean countries is the gap between feed requirements and low feed availability combined with the exponential increase in feed ingredient costs. The use of agricultural by-products as a feed alternative to solving this problem has received greater attention in recent decades due to the low cost of these by-products and has been often utilized by breeders. However, the majority of agricultural by-products in southern Mediterranean countries are characterized by low palatability, high lignin-fiber content and low protein content which limit their use as animal feed. Although ruminants have the ability to break down fibrous feed due to the cellulosic microorganisms, rumen digestion is not ideal and usually a large amount of fiber passes through the digestive tract unused. In most cases only 10 to 35% of gross energy is used as net energy. The presence of lignin is a major problem for the use of by-products by ruminant microorganisms which forms a complex matrix prohibiting celluloses and hemicelluloses from enzymatic degradation.

**Material and methods** In recent years, our research team has developed biological technologies namely solid-state fermentation with white-rot fungi to improve the nutritional value of these alternative feeds. White-rot fungi as lignocellulolytic microorganisms are able to decompose and metabolize all plant cell constituents by their enzymes. Solid state fermentation with white-rot fungi is often inexpensive and environmentally friendly option.
The chemical composition of agricultural by-products was determined before and after the solid-state fermentation with protocol of AOAC (1990), Dubois et al. (1956), Miller (1959) and Van Soest et al. (1991). *In vitro* fermentation technique with ruminal fluids of sheep proposed by Menke and Steingass, (1988) was used to evaluate the effect of the solid-state fermentation with White-rot fungi on gas kinetics, ruminal fermentation, *in vitro* digestibility, metabolizable energy and volatile fatty acids of alternative feed. *In vivo* experiment was carried out on lambs to determine the effect of the solid-state fermentation with white-rot fungi on the *in vivo* digestibility and growth performance of lambs.

**Results and discussion** The results showed that this technique allows significant growth of the mycelium in different substrates accompanied by an interesting enzymatic production. It induced significant ($P< 0.05$) changes in the chemical composition of low-quality agricultural by-products. Crude protein concentrations increased ($P< 0.05$) after solid state fermentation and fiber concentrations were reduced, especially the lignin level ($P< 0.05$). In addition, this treatment increases ($P< 0.05$) the reducing and total sugars. However, the effectiveness of this technology depends ($P< 0.05$) on the type of fungi, substrates and fermentation conditions. The *in vitro* study showed that the solid-state fermentation with White-rot fungi has ($P< 0.05$) improved gas kinetics, ruminal fermentation, *in vitro* digestibility, metabolizable energy and volatile fatty acids of alternative feed. This *in vivo* study confirmed that solid fermentation with White-rot fungi could be an approach to improve ($P< 0.05$) the nutritional value of agricultural by-products, increase nutrient digestibility and growth performance of ruminants.

**Conclusion** The solid-state fermentation with White-rot fungi offers is a promising technique that could increase the nutritional value of poor-quality feed and improve animal performance.

**Acknowledgements** This study was supported by the "Jesr Méditerranéen de la filière ovine *JESMED*/Réf n°IS 1.2" research project and "Valorisation de nouvelles ressources alimentaires pour l'alimentation animale : nouvelles variétés d'orge, sous-produits agro-alimentaires et matières premières de substitutions *VNRA*" research projects.

**References**
AOAC. 1990. Association of official analytical chemists. Arlington, VA, USA.
Dubois M., Gilles K.A., Hamilton J.K., Rebers P.T., Smith F. 1956. Analytical chemistry 28, 350-356.
Menke K.H., Steingass H., 1988. Animal Research and Development 28, 7-55.
Miller G.L. 1959. Analytical chemistry 31, 426-428.
Van Soest P.J., Robertson J.B. Lewis B.A. 1991. Journal of Dairy Science 74, 3585-3597.

# Effects of plowing on the floristic characteristics of the vegetation of fallow land

Hania Hamdi[1], Neila Khazri[2], Rania Neffati[2], Besma Merai[1], Saleh Ouhichi[1], Hichem Khemiri[3], Moncef Kthiri[3], Ezzine Messoudi[3], Chokri Hafsi[2]

[1]*Regional Field Crops Research Center of Béja, Béja, Tunisia*
[2]*Higher Institute of Biotechnology of Béja, Béja, Tunisia*
[3]*North West Development Sylvo-Pastoral Office, Béja, Tunisia*

E-mail: hania_hamdi@yahoo.fr

**Take home Message** Plowing is an important tool for making better use of fallow vegetation for animal feed.

**Introduction** In Tunisia, the diet of small ruminants is essentially based on natural resources (grazing land, fallow, stubble, etc.). However, these feed resources are not available all year round. In cereal-growing areas, fallowing is an integral part of cereal-livestock production systems. The fallow is used as pasture land. From a sustainable development perspective, the objective of improving productivity must be associated with strengthening the viability of the systems. Thus, fallow land could play a more effective role in managing climate risk, maintaining agronomic fertility, fighting erosion, and preserving the environment (Nielsen and Calderón, 2011). The quantity and quality of the pastoral biomass of fallow lands depends essentially on their botanical composition, which presents a great diversity. In this context, our objective is to determine the effect of tillage (Unploughed *vs*. Ploughed land) on the floristic characteristics of the fallow.

**Material and methods** The study was carried out at the research station "Lafareg" (36.69°N, 9.15°E) belonging to the Regional Field Crop Research Center of Beja (Tunisia). Two plots were set aside during the 2020-2021 campaign. The first plot was plowed, but the second was not. To study the vegetation characteristics of two fallow plots (unploughed vs plowed fallow), we used the intercept line and quadrat methods (Daget and Poissonet, 1971). The intercept line method consists of using a 20 m tape measure divided into 100 points spaced 20 cm apart. At each reading point, the object which is in contact with the stake is noted, which may be vegetation or the ground. The quadrat method was used to determine the weight contribution and the specific richness of species. It consists in throwing a quadrat of (1m2) on the ground at random then cutting all the quantity of vegetation located in the quadart. Also the weight contribution of each herbaceous species was determined. This involves determining the average weight of each species in relation to the average weight of the total biomass collected. The samples were dried for 72 hours in a ventilated oven set at 55°C, weighed in order to determine the dry weight.

**Results and discussion** In the Unploughed fallow (UPF), 20 species were identified (Table 1). *Bromus rigidus* is the most common species (14.1%) in the vegetation of this fallow, followed by *Marribium vulgare* (11%), *Ammi majus* (10.5%). The remaining species present low contributions (<10%). In the ploughed fallow (PF), 18 species grouped into 10 families were recorded. PF was composed mainly of *Chrysanthemum coronarium (34.2%), Avena sativa (28.3%), Silybum marianum (9.5%)* and other species. These results translate into a very low specific richness which was observed for the two fallows, 5.7 and 7.2 species /m2 respectively for UPF and PF. The herbaceous cover for both fallows was dominated by annual species (60%) whose presence remains dependent on climatic conditions, mainly rainfall. The *asteraceae* family is the most represented in the two fallows, indicating probably a disturbance in the plant flora. In contrast, the families of grasses and legumes, having a good pastoral value, present weak contributions to the vegetation of the fallows.

**Table 1** Floristic characteristics of herbaceous species of unploughed and plowed fallows

| | Unploughed fallow | Ploughed fallow |
|---|---|---|
| Number of species | 20 | 18 |
| Number of families | 12 | 10 |
| *Poaceae* (%) | 5 | 11.1 |
| *Fabaceae* (%) | 5 | 5.6 |
| *Asteraceae* (%) | 35 | 27.8 |
| % of annual species | 60 | 61.1 |
| Vegetation cover (%) | 94.6 | 67.6 |
| Specific richness (species /m2) | 5.7±1.2 | 7.2±1.5 |
| Biomass (kg DM/ha) | 801.4 | 624.4 |

Regarding the overall vegetation cover, UPF had a high recovery rate and it is classified as closed fallow (over 90%: Daget et *al*., 2010). Whereas, PF is considered half-open (vegetation cover between 50 and 75%). The biomass determined at UPF was greater (801 kg DM/ha) than that of the FP (624 kg DM/ha).

**Conclusion** Plowing of fallow land improved pastoral value by increasing the proportion of grass species and reducing species of low palatability (*Asteraceae* family). It is necessary to continue the study by determining the effect of the use of the vegetation of the fallow lands studied on animal performances.

**Acknowledgements** This study was financially supported by IRESA (Tunisia).

**References**

Daget Ph., Poissonet J. (1971) Annales Agronomiques 22, 5–41.
Daget Ph., Poissonet J., Huguenin J. (2010) Prairies & Pâturages. 955p.
Nielsen D.C., Calderón F.J. (2011) Soil Management: Building a Stable Base for Agriculture, 287-300.

# Characterization of the shrub community of the grazed forests in the region of Bizerte

Hania Hamdi[1], Gouider Tibaoui[2], Hana Ghribi[2], Maha Guizani[2], Mostapha Mansouri[3], Youssef Samet[4], Mekki Ferjani[3], Chokri Mejri[3]

[1]*Regional Field Crops Research Center of Béja, Béja, Tunisia*
[2]*High School of Agriculture Mateur, Bizerte, Tunisia*
[3]*North West Development Sylvo-Pastoral Office, ODESYPANO Sejnane, Tunisia*
[4]*Office of Livestock & Pasture, OEPMateur, Bizerte, Tunisia*

E-mail: hania_hamdi@yahoo.fr

**Take home Message** The current state of the grazed forests requires the implementation of a participatory and partnership strategy for the good management of the pastoral area.

**Introduction** Rangelands play an important role in Tunisia. This spatial importance is of capital interest on the socio-economic and environmental levels. In mountainous areas, forest and maquis are the main sylvo-pastoral resources grazed by livestock. Forest rangelands area in Tunisia is between 750,000 and 850,000 ha. Humid, sub-humid and semi-arid zones represent only 2, 2 and 9% of natural pastures respectively (Hamdi et Lahmayer, 2016). These rangelands constitute the essential basis of the farming systems in these areas. They are grazed by small ruminants and especially goats. In a context of sustainable development, the viability of pastoral farming requires a good knowledge of the qualitative and quantitative characteristics of pastoral resources and their evolution over time. The study of the floristic composition of grazed forests is essential for a good management of the pastoral vegetation which should be undertaken especially in relation to the challenges of climate change and for the appropriate livestock feed management. Information on the state of grazed forests is limited and not yet very well defined. Thus, the objective of this work is to study the current state of the shrub community of different grazed forests in the region of Bizerte.

**Material and methods** This study was carried out in the region of Bizerte (Northern Tunisia). Four aeras (Sejnane, Kef Abed, Cap-Serrat and Ghezala) were chosen to determine the characteristics of the vegetation (composition, density and relative frequency) of the grazed forests. The quadrat method was used to determine the density of shrubby plants in grazed forests (the number of plants of every species per quadrat; Gamoun et *al*., 2019). The surface of the quadrat is 400 $m^2$ (20m x 20m). The frequency of species was calculated by the following formula:

Relative frequency of specie i = ((Total number of plants of specie i) / (Total number of plants of all inventoried species) ×100)

**Results and discussion** The floristic composition of the grazed forests studied is shown in Table 1. In total, 14 species belonging to 12 botanical families have been identified. The grazed forests of Sejnane, Kef Abed, Cap-Serrat and Ghezala were composed of 13, 10, 10 and 10 shrubs species, respectively. The most abundant species were *Erica arborea* (FR= 46.6% in Kef Abed and 45.2% in Cap-Serrat) and *Cistus ladanifer* (FR= 46, 2% in Sejnane, 29.7% in Ghezala and 25.3% in Cap-Serrat).

**Table 1** Plant density (plants/hectare) and relative frequency (%) of species inventoried in the grazed forests.

| | Sejnane | | Kef Abed | | Cap-Serrat | | Ghezala | |
|---|---|---|---|---|---|---|---|---|
| | D | FR | D | FR | D | FR | D | FR |
| *Erica arborea* | 75 | 1.0 | 6663 | 46.6 | 4358 | 45.2 | 1356 | 18.2 |
| *Calicotome spinosa* | 1588 | 20.7 | 194 | 1.4 | 225 | 2.3 | 319 | 4.3 |
| *Quercus coccifera* | 75 | 1.0 | 1906 | 13.3 | 200 | 2.1 | 619 | 8.3 |
| *Cistus ladanifer* | 3538 | 46.2 | 1825 | 12.8 | 2442 | 25.3 | 2213 | 29.7 |
| *Pistacia lentiscus* | 950 | 12.4 | 1250 | 8.7 | 1058 | 11.0 | 669 | 9.0 |
| *Myrtus communis* | 75 | 1.0 | 675 | 4.7 | 100 | 1.0 | 675 | 9.1 |
| *Phillyrea angustifolia* | 13 | 0.2 | 675 | 4.7 | 1025 | 10.6 | 813 | 10.9 |
| *Cistus salviifolius* | 158 | 2.1 | 381 | 2.7 | - | - | 56 | 0.8 |
| *Olea europaea* | 25 | 0.3 | - | - | 75 | 0.8 | 438 | 5.9 |
| *Lavandula stoechas* | 275 | 3.6 | - | - | 67 | 0.7 | - | - |
| *Daphne gnidium* | 163 | 2.1 | 419 | 2.9 | - | - | - | - |
| *Artemisia campestris* | 29 | 0.4 | 313 | 2.2 | - | - | - | - |
| *Chamaerops humilis* | - | - | - | - | 92 | 1.0 | 288 | 3.9 |
| *Asphodelus ramosus* | 696 | 9.1 | - | - | - | - | - | - |

With, D: density; FR: Relative Frequency

The grazed forests of Sejnane, Kef Abed, Cap-Serrat and Ghezala were composed by 13, 10, 10 and 10 shrubs species, respectively. The *Fagaceae* and *Oleaceae* families were the most represented (14.3%) with 2 species each. The other families each contribute 7.1% to the plant flora of the grazed forests.

**Conclusion** The pastoral flora of the grazed forests studied in the region of Bizerte is very rich. For this, inventories of much more sites are needed and it is necessary to define an appropriate management method for more robust and sustainable pastoral farming in these areas by controlling grazing pressure and season.

**Acknowledgements** This study was financially supported by IRESA (Tunisia). The authors are very grateful and thank the staff of ODESYPANO and OEP for their technical assistance.

**References**

Daget Ph., Poissonet J., Huguenin J. (2010). Prairies & Pâturages. 955p.
Hamdi M., Lahmayer I. (2016). UN-REDD Programme, 70 p.

# Effect of incorporation of *Aloe vera* gel on digestibility, intake and milk production of cow in center of Tunisia

Naziha Ayeb[1,2], Ines Aloui[1], Mohamed Dbara[2], Gamoudi Anis[3], Khouja Mohamed Larbi[4], Mohamed Hammadi[2] , Touhami Khorchani [2]

[1] *Regional Center for Agricultural Research (CRRA), Gafsa Road km 6, Sidi Bouzid, 9100, Tunisia.*
[2] *Laboratory of Livestock and Wildlife, Institute of Arid Lands (IRA), Elfje Road km 22, Medenine, 4119, University of Gabes, Tunisia.*
[3] *Regional Commissariat for Agricultural Development, Sidi Bouzid, 9100, Tunisia*
[4] *Forest Ecology Laboratory, National Institute for Research in Rural Engineering, Water and Forests (INRGREF), Tunisia*

E-mail: naziha.ayeb@yahoo.fr

**Take home message** The use of alternative resources in the diet of cows, such as Aloe vera can reduce animal feed costs by increasing milk production and improving the digestibility of ingested feed.

**Introduction** *Aloe vera* is a medicinal plant cultivated for various applications in medical, food and health products. The *Aloe vera* gel from the leaves of this plant is rich in various bioactive compounds, which could be valued as a feed ingredient for dairy cattle to improve animal health, intake and milk production. The present work was carried out to introduce *Aloe vera* (AV) gel into the feed of dairy cows and determine their effects on intake, digestibility *in vivo* and on milk production.

**Material and methods**. The experiment was carried out on 12 dairy cows (mean age = 4.4 years and mean weight = 669.68 kg) which were divided into 2 groups: control group (C), the cows received a basic ration and a concentrate and AV group, the cows received the same feed as the control group with the addition of the AV gel. The duration of the experiment was 8 weeks. The evolution of ingestion, digestibility and the milk yield were determined. Digestibility was determined by an internal marker method (Acid insoluble ash: AIA).

**Results and discussion**

***Digestibility and Intake evolution.*** Digestibility and average daily intake are presented in Table 1. The main results showed that the addition of *Aloe vera* gel did not affect (P> 0.05) the organic matter digestibility. It is slightly higher in ration of treated cows than that of the control group. Results in our study were within the range of values found by Banakar et al. (2021), whose organic matter digestibility was 67.14; 67.05 and 68.86% respectively with the addition of different concentrations (0; 20 and 40g/kg) of *Aloe vera* extract in three groups of lactating goats. Dry matter intake (DMI) was similar (P > 0.05) in two groups (Table 2). Unlike the study by Singh et al. (2020) who showed an increase in feed consumption between 0.5 kg/day to 4.63 kg/day in cows treated with *Aloe vera* waste.

**Table 1.** Effects of experimental diets on digestibility and average daily intake

| Ration | Control | Aloe vera | *P value* |
|---|---|---|---|
| Digestibility (%) | 65.77±2.75 | 66.07±2.7 | 0.939 |
| Dry matter Intake (kg/d) | 4233.10 ±10.13 | 4217.31 ±12.49 | 0.341 |
| Milk production (l/d) | 15.94 ±0.35$^{b}$ | 18.99 ±0.36$^{a}$ | <0.0001 |

***Milk production.*** The introduction of *Aloe vera* gel in the diet of dairy cows was highly affected (P<0.0001) the daily milk yield. The comparison of the means between the two groups of cows indicates an increase in the milk production of cows fed a diet rich in AV of almost 3 liters/day (15.94 ml / d vs. 18.99 ml / d respectively in the AV and C groups). Our results were similar to those reported by Singh et al. (2020) who showed that milk production increased significantly (P < 0.001) from 14.1 to 17.6 Kg/d by adding *Aloe vera* waste to the diet of dairy cows.

**Conclusion** the incorporation of *Aloe vera* gel in the diet of dairy cows did not affect the intake and the digestibility of the ration. On the other hand, it made it possible to improve the milk yield which increased by 2l/d by adding the gel. It is recommended to know the effect of the incorporation of gel on the nutritional quality of the milk and on the health of the cows.

**Acknowledgements** This study was supported by the regional center for agricultural research and Arid land institute of Medenine.

**References**

Banakar P.S., Kumar S., Vinay V.V., Dixit S., Tyagi N., Tyagi K. 2021.journal of Tropical Animal Health Production 53 (5), 517

Singh P., Singh H.J., Kumar P.A., Wadhwa M., Sharma A. 2020.Journal of Cleaner Production 288, 125118.

# Chemical characterization of some alternative feeds in animal production newly introduced in central Tunisia: hay of *Quiona* and *Panicum maximum*

Naziha Ayeb[1,2], Soumaya Raouadi[1], Azhar Hajlaoui[1], Mohamed Dbara[2], Hichem Hajlaoui[1], Mohamed Hammadi[2], Touhami Khorchani[2]

[1] *Regional Center for Agricultural Research (CRRA), Gafsa Road km 6, Sidi Bouzid, 9100, Tunisia.*
[2] *Laboratory of Livestock and Wildlife, Institute of Arid Lands (IRA), Elfje Road km 22, Medenine, 4119, University of Gabes, Tunisia.*

E-mail: naziha.ayeb@yahoo.fr

**Take home Message** The introduction of a new resource forage (Quinoa and Panicum) adapted to severe climatic conditions and which is characterized by high productivity and good protein value is a solution to fill the feed deficit for animals.

**Introduction** The livestock sector in the drylands is dominated by small herders. In addition, it suffers from the scarcity of conventional food resources. In these regions, livestock farming is highly dependent on imported raw materials, which leads to high production costs and jeopardizes its productivity and sustainability (Elloumi et al., 2001). On the other hand, the Tunisian center constitutes a reserve of little exploited plant genetic resources, it is the seat of production of several agro-industrial by-products resulting from the harvesting, sorting and processing of many crops, such as the by-products of vegetable crops, quinoa (produced at the level of work carried out in the CRRA center) and almond trees. It is in this context that the objective of this study is to characterize some alternative foods in animal feed in the region of Sidi Bouzid.

**Material and methods**. Quinoa and *Panicum maximum* were collected in the CRRA Sidi Bouzid experimental station. After harvesting the quinoa seeds and kernels, the by-products (quinoa waste, leaves stems) and forage plant *Panicum maximum* were collected.
Subsequently, the samples were divided into two parts, the first for the determination of dry matter (DM) in an oven at 105°C for 24 hours. The second part was dried at 60°C and ground through a 1 mm for to determine the chemical composition. Ash content was determined by incinerating samples in a furnace at 600°C for 6 h. Crude protein (CP) was determined by the Kjeldahl method (AOAC, 1190). The analysis of neutral (NDF) and acidic detergent fibers, (ADF) was carried out according to the method described by Van Soest (1970).

**Results and discussion**

*Chemical composition.* The results of chemical analyzes are presented in Tables 1 and 2. Analysis showed that Quinoa waste in the form of hay had recorded dry matter values of 80%. The average DM content in *Panicum maximum* was around 19%. This plant and the hay of Quinoa was relatively rich in crud protein (18.8 and 12.5% DM, respectively). The whole plant is used as green fodder and crop residues are also used as cattle feed. On the other hand, the almond tree by-products presented low levels of crude protein not exceeding 5%. we can say that quinoa waste and *Panicum maximum* has the advantage of providing a ration richer in MAT, it can therefore be associated with other fodder poor in nitrogen such as almond by-products to relatively improve the MAT rate of the ration of animals and to integrate them into new feed formulas for livestock.

**Table 1.** Chemical composition of some alternative feeds in central Tunisia

| | Quinoa waste (n=6) | Panicum maximum (n=18) |
|---|---|---|
| Dry matter % | 80.21± 3.14 | 19.82 ± 0.94 |
| Ash % | 5.26± 0.94 | 12.72 ± 0.36 |
| Crude protein% | 12.75± 1.23 | 18.82 ± 1.57 |

*Fiber content.* The fiber contents are shown in Table 2. The highest NDFmo and NDFms values were recorded in *Panicum maximum.* The fiber values (NDF, ADF and ADL) recorded in our study for *Panicum* were similar to those mentioned by Odedire and Babayemi (2008) which were 60; 38 and 7% respectively for NDF, ADF and ADL. The value of ADL *was* higher in Quinoa hay. The fiber content of quinoa is generally higher than that of most cereals.

**Table 2.** Fiber content of some alternative feeds in central Tunisia (%DM)

| | Quinoa waste (n=6) | Panicum maximum (n=18) |
|---|---|---|
| NDF ms | 51.80 ± 3.51 | 61.46± 2.52 |
| NDF mo | 51.47 ± 2.12 | 61.11± 2.51 |
| ADF ms | 31.65 ± 2.52 | 33.24± 2.29 |
| ADF mo | 29.08 ± 1.78 | 32.91± 2.29 |
| ADL ms | 29.01 ± 3.52 | 5.29 ± 0.41 |
| ADL mo | 26.65 ± 2.01 | 4.95±0.41 |

**Conclusion** The Sidi Bouzid region in center of Tunisian is an agricultural area, in particular livestock farming is an important component in the region. This area is very diverse in agricultural by-products. The chemical analyzes of this waste have shown their richness in some nutrients and can be alternative foods and used to reduce the use of unavailable and expensive market foods. It is recommended to complete studies on the digestibility of these foods and the secondary metabolites.

**Acknowledgements** This study was supported by the regional center for agricultural research.

**References**

Elloumi M., Nasr N., Selmi S., Chouki S., Chemak F., Raggad N., Ngaido T., Nafzaoui A. 2001. In « policy and institutional option for the management of rangelands in dry areas ». 2001, 34p
Odedire, J. A. ; Babayemi, O. J., 2008. Livestock Research for Rural Development (20) 2
Van Soest, P.J., Robertson, J.B., Lewis, B.A. 1970. Journal of Dairy Science 74, 3583- 3597.

# Eco-friendly active packaging based on goat gelatin and natural extract for promoting sustainable circular bioeconomy

Salma Bessalah, Hadhami Hajji, Touhami Khorchani, Mohamed Hammadi

*Arid Land Institute (IRA), Médenine,Tunisia*

E-mail: bessalahsalma@yahoo.fr

**Take home Message** Goat by-product can be used as promising alternative to develop smart food packaging.

**Introduction** Goat is one of economically important animals raised in Mediterranean countries since their meat and milk have become promising for consumption. In fact, goat populations increasing at a rate of approximately 1.29% annually. When goats are slaughtered, a large amount of skin has been produced as a by-product with a low market value. Several studies reported the feasibility of using goat skin for gelatin (Gn) extraction (Sulaiman et al., 2016). As such, the use of goat skin as raw material for producing Gn could pave the way for production of value-added products such as biodegradable films. Thus, this study aims to develop intelligent packaging film based on goat Gn supplemented by pomegranate by-product extract (PBP).

**Material and methods** For Gn extraction, goat skin was soaked in 0.5 M NaOH with ratio of skin/solution at 1:5 (w/v) for 3 days in order to remove non-collagenous proteins. After thorough washing, the pretreated skins were soaked in 0.1 M citric acid with ratio of 1:5 (w/v) for 1 hour. Samples were washed again with distilled water until the pH was neutral. The final step was carried out with distilled water at a ratio of 1:5 w/v at 50°C for 6 h. The supernatant was filtered through Whatman No. 4 filter paper, lyophilized and subjected to analyses. In order to prepare packaging film, a Gn solution of 4% W/V was prepared and magnetically stirred for 15 min at 60°C for complete dissolution. After cooling, different concentrations of pomegranate by-product powder were added to the mixture (1, 2, 3 and 4 wt %) and the final solution is stirred again for 10 min. The glycerol was included as a plasticizer for films. Then, the hot film-forming solution is poured into petri dishes (25 ml), and was left at room temperature for at least 3 days to obtain the films. The dry films were removed from the petri dishes and stored. Elaborated films were examined in terms of physical properties (thickness, water solubility, and biodegradebility).

**Results and discussion** The physico-chemical properties of goat Gn-film including water holding capacity (WHC), Film moisture (MC), and water solubility (WS) were listed in Table 1. These characteristics help in preventing the growth of microorganisms. Active Gn-PBP 4% tends to hold less water content. Water solubility is an important parameter for food storage. All films with PPP have reduced solubility in comparison to control film Goat gelatine-film.

**Table 1** water solubility (WS), Water holding capacity (WHC) and Moisture content (MC) of goat gelatine based film.

| | WS (%) | WHC (%) | MC (%) |
|---|---|---|---|
| Control | 68.12±0.4 | 407.5±2.8 | 1.3±0.8 |
| Gn-PBP (1%) | 53.14±0.05 | 355.03±1.2 | 1.2±0.4 |
| Gn-PBP (2%) | 45.01±0.2 | 357.11±0.8 | 1.15±0.5 |
| Gn-PBP (3%) | 42.22±0.5 | 377.23±1 | 1.1±0.9 |
| Gn-PBP (4%) | 36.19±0.2 | 382.3±0.5 | 1.1±1.5 |

The biodegradation of goat gelatin-based packaging food films was tested by burial in soil. The biodegradation results were shown in Fig 1. On the 5th day a few changes in the appearance of films were seen. During these days, the films were swollen remarkably and changed their colors to brown, after which they began to lose their outline shapes. On the 10th day, the biodegradability rate of composite biofilm was accelerated. On the 20th day, the biodegradation of film was complete. These finding indicate that the use of goat gelatin enhance biodegradability of the composite films through degradation of starch, leaving a porous framework in the synthetic polymer that then slowly degrades.

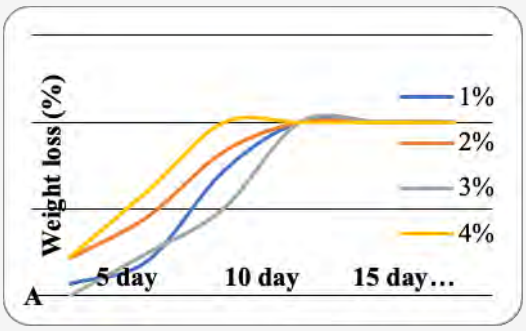



**Figure 1.** Weight losses of the Gn-PBP films after the specified days of soil biodegradation.

**Conclusion** The current study demonstrated the feasibility of conversion of goat skin biomass into a primary smart for active food packaging. Goat gelatine based-films enriched with natural extract are expected to be useful as a novel biodegradable food packaging to substitute synthetic packaging.

**References**

Sulaiman MA., Soottawat B., Thummanoon P., Sajid M.2016. Asian-Australasian journal of animal sciences 29,845-854

# Characterization of pastoral resources in rangelands of southern Tunisia

Mariem Benrejeb, Hathami Hajji, Naziha Ayeb, Mohamed Dbara, Touhami Khorchani

*Livestock and WildLife laboratory Arid Lands Institute- IRA, Medenine, Tunisia*

E-mail: mariem.benrjeb@yahoo.fr

**Take home Message** The role of pastoralists remains important, especially during critical periods, they have the possibility of providing adequate supplementation adapted to the season.

**Introduction** Forages are the most important feed resource for ruminants around the world; the rangelands of southern Tunisia are characterized by a great diversity of plant cover. Milk production and control of the physiological bases can only be ensured from a good balanced diet resulting from a great variability of pastoral species (Ould Ahmed, 2009). An evaluation of the nutritive value of the forage is necessary because it influences the grazing intake and ultimately the animal performance. Research on the future of rangelands in arid zones would make it possible to see whether there are new farming systems capable of enhancing and preserving vegetation. The primary objective would be to contribute to a better understanding of the dynamics of spontaneous pastoral vegetation and these adaptations to various climate changes. Our work consists in making a spatio-temporal evaluation of the fodder production of the courses of the Tunisian south on the qualitative level. The characterization of Tunisia's rangelands could allow management adapted to current changes and new constraints. Such research could constitute a step towards a detailed diagnosis of the state of arid rangelands and an understanding of the dynamics of the vegetation of these environments to assess the evolution of rangelands.

**Material and methods** The samples taken for the development of this work come from two rangelands in southern Tunisia. The plant species used are halophyte plants. Ten common species were sampled for the two sites (El Fjé and El Bhaier) which are: *Atriplex halimus; Retama raetam; Haloxylon schmittianum; Suaeda mollis; Zygophyllum album; Halocnemum strobilaceum; Frankinia thymifolia; Limoniastrum guyonianum; Salsola tetrandra* and *Nitraria retusa.* The quantity taken from each sample was divided into two parts: one for the determination of the dry matter content (DM) in an oven at 105°C and the second was dried in an oven at 60°C and ground to 1 mm with a flail mill and kept for the analyses: mineral matter (MM), organic matter (OM), crude protein (CP), fibers (NDF: Neutral detergent fiber, ADF: Detergent fiber acid and ADL: Sulfuric lignin and *in vitro* digestibility (DIVDM and DIVOM). All analyzes were performed according to the methods of the Association of Official Analytical Chemists (AOAC, 1990).

**Results and discussion** The dry matter contents vary between the species themselves. The strong variability between species can influence the amount of water in the plant. The pastoral species studied are generally halophytes: rich in salt; the highest value was recorded in *Salsola tetrandra* (33.3% DM). On the other hand, the lowest %MM content was recorded for *Retama raetam* (5.3 % DM). The majority of harvested species are rich in total NDF. Saharan plants form thick cuticles and sclerified cell layers on the stomata to reduce their evaporation rate but they are also poor in CP with an interval between (7.4 and 13.6%DM). The highest value of *in vitro* dry matter digestibility (54.4% DM) was recorded for *Zygophyllum album*.

**Table 1** Chemical composition and *in vitro* digestibility of pastoral species from southern Tunisia.

| Species | DM | MM | CP | NDF | ADL | IVDMD |
|---|---|---|---|---|---|---|
| *R. raetem* | 45.2±4.1 | 5.3±2.8 | 11.2±1.5 | 53.3±5.5 | 15.9±1.9 | 52.2±7.8 |
| *Z. album* | 22.1±6.4 | 24.8±4.8 | 8.99±2.1 | 34.3±6.1 | 6.9±2.2 | 54.4±6.8 |
| *S. mollis* | 26.1±8.7 | 27.3±4.9 | 13.6±3.8 | 43.8±6.1 | 10.3±3.2 | 50.7±7.5 |
| *A. halimus* | 29.3±3.3 | 25.9±7.7 | 11.2±4.7 | 45.7±7.7 | 9.5±4.2 | 52.4±9.7 |
| *H. strobilacum* | 26.3±4.9 | 31.0±3.1 | 8.5±3.2 | 38.7±3.3 | 7.6±1.1 | 52.4±8.3 |
| *N. retusa* | 31.4±6.3 | 14.9±3.4 | 11.1±4.3 | 54±6.1 | 15.1±3.1 | 40.7±11 |
| *L. guynianum* | 38.8±7.8 | 25.3±5.4 | 7.4±2.5 | 47.5±4.4 | 16.9±3 | 41.1±6.9 |
| *S. tetrandra* | 33.4±10 | 33.3±7.3 | 8.8±2.0 | 38.2±4.4 | 7.6±2.4 | 50.6±7.6 |

**Conclusion** The information provided by this work is intended to be used by breeders both when buying food for the maintenance of their herd and when guiding movements and transhumance. Forage quality information could help range managers choose an appropriate grazing method to achieve better animal performance and sustainable ruminant production.

**Acknowledgements** This study was supported by Livestock and Wildlife laboratory of the Arid Lands Institute IRA. Medenine. Tunisia.

**References**

AOAC. 1990. Association of Official Analytical Chemists. *Official Methods of Analysis*. 15th ed. Arlington. VA. ed.USA.

Ould Ahmed. M. 2009. Characterization of the dromedary population (Camelus dromedarius) in Tunisia (*Doctoral dissertation*.

# Types of weaning in Serra da Estrela ewes: lambs' growth *vs* milk production and quality, under different feeding strategies

Maria R. Marques, José. M. Ribeiro, Ana T. Belo, Carlos C. Belo

*INIAV, IP - Instituto Nacional de investigação Agrária e Veterinária, Fonte Boa, 2005-048 Vale de Santarém, Portugal*

E-mail: rosario.marques@iniav.pt

**Take home Message** Partial weaning of the lambs increases ewes' milk production with marginal effects on lambs' growth.

**Introduction** Serra da Estrela ovine breed (SE) is reared in the Centre of Portugal. Its milk is used to produce PDO Serra da Estrela cheese and IGP Serra da Estrela lambs. One of the most limiting aspects for the full expression of the ewes' milk potential is their ability to adapt to mechanical milking. Stress related to onset of machine milking, resulting from lamb separation, may lead to 40 to 50% loss in milk production (Ribeiro et al., 2000) due to retention of a considerable amount of milk in the alveoli, which through a negative feedback mechanism reduces the milk secretion rate by the mammary gland. Over the last decades, experimental work on the SE breed has been carried out to find indicators regarding their productive behaviour in relation to weaning type, adaptation to machine milking, and feeding management. Factors influencing lambs' growth and milk production, including type of weaning, number of suckled lambs and lambing season, have been considered as strategies to increase the ewes' production level and sustainability of the flocks.

**Material and methods** This work was conducted on SE sheep, from INIAV, during 22 lactations in which three types of weaning were considered: 1) Total suckling up to the 42$^{nd}$ day of lactation followed by abrupt weaning and milking twice a day; 2) Total suckling up to the 21$^{st}$ day, partial weaning from the 21$^{st}$ to the 42$^{nd}$ day of lactation, with milking once a day in the morning, and complete weaning at 42 days with milking twice a day, and; 3) similar to type 2, but ewes were milked twice a day and lambs suckled the residual milk after each milking between 21$^{st}$ and 42$^{nd}$ days of lactation. February and September lambing seasons were considered, and three feeding regimes (based on maize silage, oat hay, or pasture) with different levels of energy and/or protein supplementation. Lambs' weight was recorded weekly. During the suckling period, milk production was estimated by the method of double injection of oxytocin. After weaning, milk production was measured daily, and residual milk evaluated. Milk composition was determined by Milk-o-Scan. The results obtained for lambs' growth, milk production up to the 90$^{th}$ day of lactation, and milk composition were statistically analysed.

**Results and discussion** Lambing season, type of weaning (LT), and type of birth/number of suckled lambs significantly affected the lambs' body weight from birth to complete weaning, ewes' milk production and quality from lambing to the 90$^{th}$ day of lactation (P<0.05). February lambing season, due to the increased quality of available grass proved to be the most favourable season both for lambs' (LT 2 and 3) and for milk production. It can obviate in some extend typical seasonality of this production system. The LT 2 in February was the more favourable combination for lambs' growth: the ewes suckling singles (S), twins (T), or triplets (TR) weaned respectively 13.2 kg, 21.6 kg and 29.7 kg body weight. Between the 21$^{st}$ and the 42$^{nd}$ days of lactation 12.6 L and 16.3 L of milk, on average, was obtained in LT 2 and 3. Partial weaning was effective in reducing the ewes' stress related to weaning and onset of machine milking, with marginal effect in lambs' growth. The total milk production between 42 and 90 days of lactation, in February, averaged 35.8 L of milk in lambing type 1, while in lambing type 2 was 29.5 L and 36.4 L in ewes that suckled single and twin lambs, respectively.

**Table 1 –** Milk production (L/day) and milk fat (%) and protein content (%) during lactation.

| Lacta-tion phase | Number of lambs | February Weaning type 1 | February Weaning type 2 | September Weaning type 1 | September Weaning type 2 | September Weaning type 3 |
|---|---|---|---|---|---|---|
| | | Milk production | | | | |
| 0-21d* | S | 1.23 | 1.36 | 1.10 | 1.25 | 1.32 |
| | T | 1.63 | 2.02 | 1.75 | 1.86 | 1.92 |
| | TR | 2.00 | 0.63 | | 2.42 | 1.91 |
| 21-42 d | S | | 0.87 | | 0.73 | 0.68 |
| | T | | 0.96 | | 0.87 | 0.77 |
| | TR | | 1.4 | | 1.13 | 0.88 |
| 42-90 d | S | 0.65 | 0.59 | 0.54 | 0.52 | 0.65 |
| | T | 0.78 | 0.73 | 0.70 | 0.6 | 0.74 |
| | TR | 0.89 | 1.01 | - | 0.44 | 0.74 |
| | | Milk composition | | | | |
| 21-42 d | Fat | | 2.23 | | 3.05 | 5.06 |
| | Protein | | 4.68 | | 5.28 | 5.97 |
| 42-90 d | Fat | 7.23 | 6.34 | 7.17 | 7.86 | 6.53 |
| | Protein | 5.86 | 5.24 | 6.45 | 6.28 | 6.42 |

* Milk production estimated by average daily gain of the lambs from birth to partial weaning at 21 days of lactation (Degen et al., 2003).

**Conclusion** Partial weaning effect on lambs' growth was overcome by their increased intake of solid feed. On ewes, partial weaning reduces the effect of stress related to weaning and onset of machine milking thus improving milk persistency and total production. However, extra milk obtained by partial weaning is significantly lower in fat.

**References**

Ribeiro JM., Marques MR., Belo CC. 2000. Investigação Agrária 2(2):80–81.
Degen AA, Benjamin RW. 2003. Animal Science 76:455–460, 2003.

# Silage of prickly pear by-products: fermentation pattern, nutritive value and effect on growing lambs' performances

Imen Belhadj Slimen, Taha Najar, Mahmoud Boussen

*National Agronomic Institute of Tunisia, Tunis, Tunisia*

E-mail:belhadj_slimen_imen@yahoo.fr

**Take home Message** Prickly pear by-products were used as silages in growing lambs. Chemical analyses revealed interesting nutritive values and good fermentation pattern. Good growth performances were also recorded.

**Introduction** Opuntia ficus-indica L. (Mill.) is a dicotyledonous angiosperm plant that belongs to the Cactaceae family. Plantations of this plant species cover about 600 000 ha in Tunisia and produced fruits and cladodes are used for human consumption and livestock feeding, respectively. Since long time ago, *Opuntia ficus-indica* (*O. ficus-indica*) was recognized for its ability to thrive under arid and semi-arid environments, and was used as a fodder, food and beverage for humans and animals. O. ficus-indica was also reported for the good quality of its edible oil that is extracted from seeds. Various by-products are derived from oil seeds' extraction (fruit juice, peels and seed meal), and may be used in livestock feeding as a source of fermentable structural carbohydrates (Vastolo et al., 2020). However, the nutritional value of these prickly pear by-products (PPB) should be investigated. Moreover, the high fermentation rates of some of these by-products hinders their conservation. The aim of this study was to produce micro-silages of cactus cladodes and fruit by-products, to evaluate their chemical characteristics and fermentation kinetics, and to investigate their effect on the growth performance of lambs.

**Material and methods** PPB and cladodes were obtained from a private company (SODEVA), a prickly pear oil producing factory in the governorate of Kasserine (Thala), Tunisia. Barley straw, ground barley grains, palm dates cake, salt and urea were added to PPB and cladodes to formulate three different silages: F1, F2 and F3. Whereas F3 does not contain fruit juice, F2 is composed only of barley straw and fruit juice. The mixing procedure was carried out at SODEVA. A chamber vacuum-packing machine equipped with an automatic heat sealing was used to seal bags after air extracting (Johnson et al., 2005). Samples from each formula were transferred to the laboratory of the Department of Animal Sciences, National Institute of Agronomy of Tunisia, Tunisia, where 21 micro-silos were prepared for each formula. Dry matter (DM), ether extract (EE), crude protein (CP), ash and crude fibers (CF) were analyzed in raw materials, and F1, F2 and F3 silages. Net energy for lactation (UFL), Net energy for meat production (UFV), MAD, Truly digestible protein when degradable nitrogen limits microbial growth (PDIN), Truly digestible protein when available energy limits microbial growth (PDIE), Fill value for sheep (UEM) and Fill value for growing cattle and suckling cows (UEB) of the ensiled products were predicted using INRA equations (1979). pH was considered as a silage fermentation indicator, and was measured directly using a pH-meter. Regarding the 41-days feeding trial, thirty-two Thin Tailed West lambs (22.87 ± 3.97 Kg) were divided into four groups and received the experimental diets composed of the experimental silage offered ad libitum, oat hay and concentrate (Table 1). Dry matter intake (DMI), body weight gain (WG) and feed efficacy (FE) were recorded. The ANOVA II test was used to assess the statistical differences between groups.

**Table 1** Diet Composition of the control and experimental diets

| Ingredient | Diet composition (g) | | | |
|---|---|---|---|---|
| | Control | F1 | F2 | F3 |
| Oat hay | ad libitum | 500 | 500 | 500 |
| PPB F1 | - | ad libitum | - | - |
| PPB F2 | - | - | ad libitum | - |
| PPB F3 | - | - | - | ad libitum |
| Concentrate | 400 | 400 | 400 | 400 |

**Results and discussion** After three days of ensiling, the recorded pH of F1, F2 and F3 silages was 4.4, 4.76 and 4.63, respectively. At the end of the ensiling period (30 days), the final pH was 4.07, 4.52 and 4.03, for F1, F2 and F3, respectively. These pH values are lower than that of straw (6.86). These values show a good silage processing. The DM content of the three types of silages ranged between 36.8 and 40.7%. The lowest CP content was recorded for F2 (17.08 % DM), whereas the highest one was recorded for F3 (22.76 % DM). Indeed, F3 had the highest amount of CF (35.0 % DM). The predicted UFV values of F1, F2 and F3 silages were 0.79, 0.69 and 0.73 / Kg DM, respectively. The estimated PDIN values ranged between 99.58 and 132.69 g/Kg DM. Those of PDIE varied from 87.00 to 88.28 g/Kg DM. The calculated UEM was 1.63, 1.71 and 1.72, respectively for F1, F2 and F3 silages.
Regarding the feeding trial, the average of the intake of silages was 671.79, 571.24 and 663.88 g DM/d, respectively for F1, F2 and F3 groups. PPB silages allowed reducing hay intake from 859.37 g DM/d in control group, to an average of 401.29 g DM/d in experimental groups ($p > 0.0001$). The total body weight gain was 7.01, 6.94, 7.28 and 6.66 Kg, respectively for control, F1, F2 and F3 groups. The calculated daily weight gain was 170.97, 169.32, 177.56 and 162.42 g/d, respectively for the control, F1, F2 and F3 groups. These findings suggest that PPB silages could partially replace oat hay in lamb diets.

**Conclusion** Our findings suggest that ensiling is a suitable storage technique to preserve the nutritive value of PPB. The feeding trial showed that PPB silage consumption does not affect the growth performance of lambs, and are able to replace partially oat hay. This result denotes an economical advantage for the lower level of hay inclusion.

**Acknowledgments** The authors thank SODEVA for the financial support of this study.

**References**

Andrieu J., Demarquilly C., Wegat-Litre E. 1979. Prévision de la valeur nutritive des aliments des ruminants. INRA, Paris, France, 580 p.
Johnson H.E., Merry R.J., Davies D.R., Kell D.B., Theodorou M.K., Grith G.W., 2005. Journal of Applied Microbiology, 98, 106–113.
Vastolo A., Calabrò S., Cutrignelli M.I., Raso G., Massimo T. 2020. Animals, 10, 1716.

# Preliminary evaluation of the agronomic, utilization and nutritive value of four annual forage species of the genus *Vicia* under Mediterranean rainfed conditions

Teresa P. Carita[1], Miguel M. Martins[2], Noémia M. Farinha[2]

[1]*Instituto Nacional de Investigação Agrária e Veterinária, Elvas, Portugal*
[2]*Instituto Politécnico de Portalegre, Elvas, Portugal*

E-mail: teresa.carita@iniav.pt

**Take home Message** In order to be able to select productive and quality forage species varieties, it is essential, among other factors, to start with high genetic variability.

**Introduction** Mediterranean agroforestry systems are key to provide important ecosystem services (Balzan, 2020). One of the main attributes for a sustainable and effective management of these agrosystems is the productivity and quality of the forage, which is fundamental for animal performance in extensive rainfed systems. The genus *Vicia* brings together a large number of species, many of them very useful in agriculture in temperate climates, being used in animal feed and also as a ground cover crop. One of its main benefits comes from its ability to capture nitrogen and provide part of this nutrient to subsequent crops. The objective of this internship was to evaluate the agronomic and utilization value of 23 genotypes from the INIAV genetic improvement program of the genus *Vicia*.

**Material and methods** The experiments took place at the experimental station of National Institute for Agrarian and Veterinarian Research- Elvas, in the growing season 2020/2021. Elvas is located in Southern Portugal that is characterized by a semi-arid Mediterranean climate. This study was carried out within the scope of the Program for the conservation and improvement of grassland and forage species-PastForBreed. Twenty-two genotypes belonging to the genus *Vicia* (*V. bengalensis* (Vb): 8 genotypes; *V. ervília* (Ve): 12 genotypes; *V. sativa* (Vs): 2 genotypes and *V.villosa* (Vv): 1 genotype) and 2 controls were evaluated. Measured traits were: plant density, homogeneity between plants, start and end of flowering time, dry matter yield, crude protein content, neutral detergent fiber content and in vitro digestibility. Dry matter yield was evaluated by one cut at the beginning of flowering of each species. Data were analyzed using SPSS. The differences between means were separated by Tukey's multiple comparison test ($P \leq 0.05$).

**Results and discussion** Precipitation data recorded was above the average for the region (606 mm); The 30-year average is 535.4 mm (IPMA, 2020). However, it was poorly distributed. From the results, we infer that most genotypes showed good or high emergence and maximum uniformity. Genotypes Vs1840 and Ve8738 took more days to flower (182 and 158 days), whereas genotype Vb6359 only needed 145 days to start flowering; mean value was 154 days. These differences are highly significant ($p<0.001$). Genotypes were not different regarding dry matter production, its values ranged from 1270 kg $ha^{-1}$ (Vs140) to 3665 kg $ha^{-1}$ (Vb15735). In dry matter production, the most important characteristic under evaluation, 6 genotypes with production above 3000 kg $ha^{-1}$ were evidenced: Vb15735 (3665 kg $ha^{-1}$) Vb6360 (3327 kg $ha^{-1}$), Vb6359 (3312 kg $ha^{-1}$), Vb6361 (3304 kg $ha^{-1}$), Vv15736 (3145 kg $ha^{-1}$) and Ve8586 (3068 kg $ha^{-1}$). As for the average production of each species, *Vicia villosa* was the most productive, but with only 1 genotype under test (Vv15736, with 3145 kg $ha^{-1}$), followed by *Vicia benghalensis* (with 2828 kg $ha^{-1}$), *Vicia ervilia* (with 2438 kg $ha^{-1}$ kg $ha^{-1}$), the *Vicia sativa* (with 1738 kg $ha^{-1}$). It should be noted that the 2 witnesses, already registered with the National Catalog of Varieties of Agricultural and Horticultural Species had productions of 2032 kg $ha^{-1}$ and 1912 kg $ha^{-1}$, respectively Barril and Gil Vaz. The genotypes were very different ($p<0.001$) regarding protein, acid detergent fiber contente and in vitro digestibility and ranged from 13.3 (Ve82191) to 19.7 (Vs1840); 27.7 (Ve8334) to 40.4 (Vb15735) and 62.1 (Vs41A04) to 79.9% (Ve8219), respectively.

**Conclusion** We conclude that the genotypes under study are of great interest, in terms of biomass production, given that 17 of these genotypes produced more than the controls. The project team will continue to evaluate these genotypes and new ones, working to identify most promising genotypes for cultivation.

**Acknowledgements** This study was supported by PDR 2020 (7.8.4-Genetic Resources-Conservation and Improvement of Plant Genetic Resources, «Environment»)

**References**

Balzan M., Sadula R., Scalvenzi L. 2020. Land 9, 245.
IPMA 2020. www.ipma.pt

# The effect of the incorporation of date pits in the ration of pregnant and lactating ewes on milk production

Amira Salha Benatallah[1,2], Nedjoua Lakhdara[2], Kaouthar Lakhdari[1], Tarek Boussaada[1], Karima Bouali[2], Med El Hafed Kherraze[1], Amira Leila Dib[2]

[1]*Centre de Recherche Scientifique et Technique des Régions Arides CRSTRA, Touggourt et Biskra, Algérie.*
[2]*Université Frères Mentouri Constantine1 - Institut vétérinaire, Constantine, Algérie*

E-mail: benatallahamira@yahoo.fr

**Take home Message** The valorisation of natural plant resources at low cost and available locally for an economic and environmental profitability.

**Introduction** In Algeria, sheep farming is a strategic sector for food security. However, the needs of sheep in terms of food to maintain good health and develop their potential have increased because in the context of climate changes, a chronic or seasonal under-nutrition explains in large part a deficient productivity of this species. It is important to consider substituting sheep feed with the valorisation of locally accessible feed resources. Therefore, in order to show the benefit of using one of the agro-industry by-products in animal feeding,we will evaluate the effect of the incorporation of date pits in the ration of pregnant and lactating ewes on milk production (amount and quality).

**Material and methods** Twenty-four pregnant ewes, of the local Algerian breed "Ouled Djellal" were divided randomly into two groups. The first group (75 CON) received a ration, composed of 1.5 kg vetch-oat hay, in addition to 500g of concentrate. The second group (75MIX-CON) was fed with a ration composed of a mixture of 1.5 kg of vetch-oat hay and date pits at a ratio of 46.7 to 53.3% in addition to 500g of concentrate.
The concentrate is composed of barley grains and wheat bran at a ratio of 50%/50%.
The study focused on measuring the live weight of the lambs, physico-chemical analysis of the feed components of the ration:Dry matter (DM),Organic matter (OM), Mineral Matter (MM),Crude Protein (CP), Crude Fiber (CP), metabolic profile of lactating ewes, milk amount, and physico-chemical analysis of the milk (fat and protein levels).

**Results and discussion** The statistical analysis carried out (Minitab16) revealed that the analyzed feeds are very rich in dry matter and organic matter, contrary to the moisture and mineral contents where the rates are lower and that the values of the chemical analysis of date pits and concentrate are almost similar. The crude protein value of date pits is almost zero, so an adequate supplementation especially in crude protein and minerals is necessary. Results showed significant difference ($P \leq 0.05$) between the growth performance of lambs in the control and experimental groups (147.2 vs. 185.73 g/day). Milk production increased significantly in the experimental group with an average milk production of 0.59 l/d versus 0.47 l/d. Milk fat and proteins did not show any significant difference between the two groups in early lactation. Whereas milk fat showed significant difference between the two groups, the values during the 3rd week are higher than those observed during the 5th week of lactation.

**Conclusion** In conclusion, the supplementation of females at the end of gestation with date pits seems to have a positive effect both on the dairy performance of mothers and the growth performance of their lambs.

# Seasonal changes in the chemical composition and digestibility of forage species browsed by goats in a Southern Mediterranean Forest rangeland

Youssef Chebli[1], Jean-François Cabaraux[2], Mouad Chentouf[1], Samira El Otmani[1]

[1]*Regional Center of Agricultural Research of Tangier, National Institute of Agricultural Research, Rabat, Morocco)*
[2]*Department of Veterinary Management of Animal Resources, FARAH, Faculty of Veterinary Medicine, University of Liège, Liège, Belgium*

E-mail: youssef.chebli@inra.ma

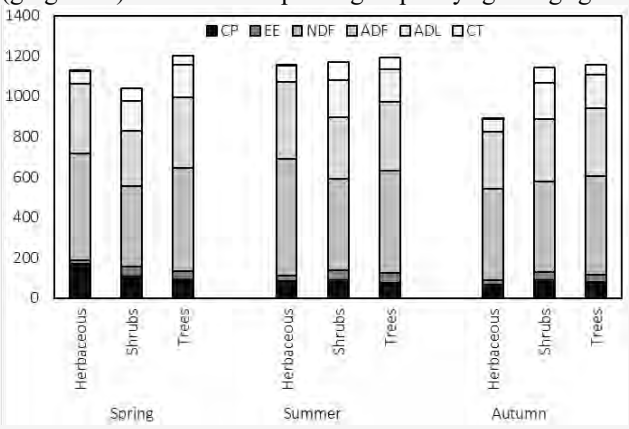
**Take home Message** The chemical composition and digestibility of forage species browsed by goats are known to assess the nutritional value of the goat diets in forest rangelands.

**Introduction** Forest rangeland is an important component of the Mediterranean silvopastoral system. In Morocco, these woodlands guarantee free feed resources for grazing goats. One of the main problems of rangelands in Morocco is the lack of data on pasture quality. The aim of this study was to evaluate the seasonal changes in the quality of forage species browsed by goats in a forest rangeland of Beni Arouss (Northern Morocco).

**Material and methods** Analyses were achieved on three different hand-plucked samples of each ingested part of the plant species like those consumed by goats (a mixture of leaves and green tender stems) during three grazing seasons (spring, summer, and autumn). Organic matter (OM), crude protein (CP), and ether extract (EE) analyses were performed according to the AOAC (1997). The crude protein (CP) content was calculated based on the Kjeldahl method. The EE were extracted by the Soxhlet method. All fibres in the studied samples were estimated using ANKOM 200 Fibre Analyzer (ANKOM Technology, New York, NY, USA) Condensed tannins (CT), *in vitro* organic matter (IVOMD) digestibility, and metabolizable energy (ME) of the studied plants were measured as described by Chebli et al. (2021). Forage quality was analysed using a general linear model (GLM) procedure of SAS in a factorial structure.

**Results and discussion** Three distinct groups of plant species dominated the forest vegetation and composed the goats' diet, namely: herbaceous plants, shrubs (*Arbutus unedo*, *Calicotome villosa*, *Cistus* spp., *Erica arborea*, *Lavandula stoechas*, *Myrtus communis*, *Phillyrea media*, *Pistacia lentiscus*, and *Rubus ulmifolius*), and trees (*Quercus* spp. and *Olea europaea*). The quality of shrubs and trees varies with seasons and species ($P<0.05$); depending on the season, the relative palatability of a given species change (Figure 1). The quality of shrub and tree foliage, although lower than that of herbaceous plants in spring, remains more stable. The CP level varied from 53 g/kg DM for *Erica arborea* in summer to 197 g/kg DM for *Calicotome villosa* in autumn, which also had the higher CP content (>187 g/kg DM) among all consumed shrub species in spring and summer. Shrubs and trees remain interesting forage resources in summer and autumn. The contents of CT and EE of shrubs and trees vary between species and seasons ($P<0.05$). The lowest and highest contents of EE were observed during spring in *Cistus crispus* (16 g/kg DM) and in *Erica arborea* (96 g/kg DM), respectively. The CT content ranged between 1.9 g/kg DM in *Lavandula stoechas* (autumn) and 206 g/kg DM in *Pistacia lentiscus* (summer). Concerning fibres, the highest NDF and ADF contents were recorded in *Calicotome villosa* during the three seasons and the highest ADL content in *Erica arborea* during the summer. Although, the lowest concentrations of ADF and ADL were noted in *Rubus ulmifolius* during autumn, while the lowest NDF content was in *Cistus crispus* during the three seasons.

**Figure 1** Seasonal variation in the chemical composition (g/kg DM) of selected plant groups by grazing goats.




**Conclusion** Shrubs and trees are interesting forage resources in summer and autumn. Their quality varies with seasons and species; depending on the season, the relative palatability of a given species suggests a season-dependent consumption. With a good grazing management strategy, the selected plant species by goats could guarantee high-quality feeding resources throughout the year.

**Acknowledgements** This study was supported by the Academy for Research and Higher Education-Development Cooperation Committee (ARES-CCD), Brussels, Belgium.

**References**

AOAC. 1997. Official Methods of Analysis, 16th ed.; Association of Analytical Chemists: Arlington, VA, USA.
Chebli Y., El Otmani S., Chentouf M., Hornick J.L., Cabaraux J.F. 2021. Animals 11, 1441.

# The effects of supplementary irrigation with treated wastewater on vegetation composition, productivity, and herbage quality

Renana Lavi, Avi Bar-Massada, Guy Dovrat

*Agricultural Research Organization - Newe-Ya'ar Research Center, University of Haifa, Haifa, Israel.*

E-mail: renanalavi@gmail.com

**Take home Message** Wastewater irrigation increased productivity but decreased forage quality. The significant increase in pasture productivity offset the decrease in quality and led to the addition of protein and herbage available to animals.

**Introduction** The proportion of wastewater reuse in Israel is the highest in the world. Irrigation with treated wastewater may impact the vegetation composition and herbage quality: the addition of water and nutrients to the soil may increase productivity and herbage quality. However, the addition of resources to the soil may change interplant interactions (competition level) in plant communities and gives an advantage to species with a high growth rate over small and drought-resistant species. This process can be accompanied by a decline in plant abundance and diversity. In addition, over time, irrigation with wastewater can damage soil quality.

**Material and methods** In order to test the effect of irrigation with treated wastewater on the vegetation and soil, ten grazing-prevention exclosures were established in the study site in Ramat-Hanadiv park, with half of them irrigated with treated wastewater. Irrigation was carried out for two years only in the winter and in limited quantities; in weeks when it rained less than 50mm, irrigation filled the missing gap to reach 50mm. Every spring (in March), the vegetation composition, species richness, productivity (by bioamass), and various indices that express herbage quality and leaf nitrogen content in the herbage, were sampled. The samples were taken during the two years of irrigation and one year after the cessation of irrigation.

**Results and discussion** Irrigation with wastewater increased productivity by an average of 38% and total pasture protein production (biomass * %protein) by 9% relative to the control plots. At the same time, irrigation decreased plant protein values, while increasing herbage fibre content and lowering its digestibility. Our results showed that over two years time species richness and total plant abundance were reduced in the irrigated plots, and the abundance of small annual cereals and legumes had declined. Most of the soil indices examined were not affected by irrigation, but in the vicinity of irrigation points, sodium values and SAR were higher than in areas without irrigation. Additional resources in winter enabled the plants to grow fast and high and increased interplant competition. The dominant plants in the irrigated plots were of fast-growing species; at the same time, small and drought-resistant species disappeared or declined in numbers due to competition for light. Changes in the vegetation composition were revealed in functional groups reshuffling and in species richness decline.

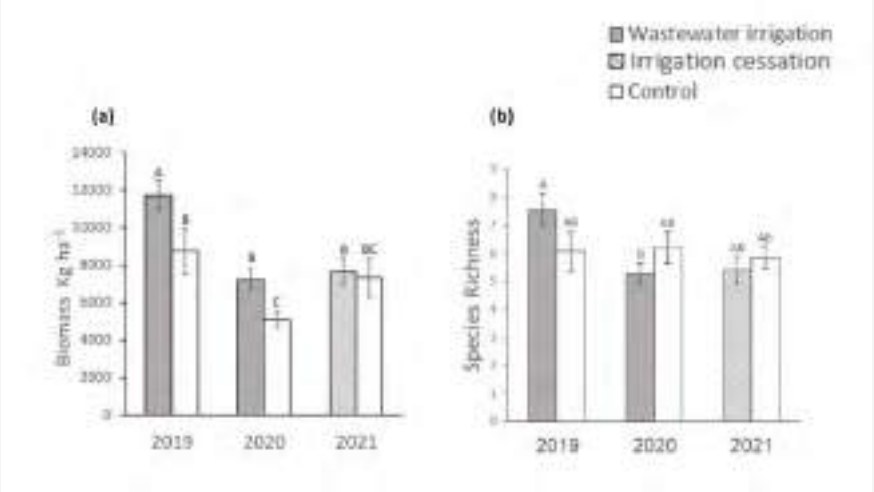



**Figure 1.** The effects of supplementary irrigation with treated wastewater at Ramat-Hanadiv park, Israel, during the years 2019-2020, and one year after irrigation cessation (2021); M ± SE of Plant productivity (a), and Species richness (b). Data were collected annually at flowering time (peak productivity). Different letters indicate significant differences between treatments and years (Post hoc Games–Howell).

**Conclusion** The results of our study show that wastewater irrigation caused an increase in productivity but a decrease in forage quality. At the pastoral system level, the significant increase in productivity offsets the decrease in quality and leads to the addition of protein and herbage available to animals. Soil salinization may cause further changes in the vegetation in the long term and requires caution use of this tool.

# Chemical composition of pastoral plants grazed by camels in extensive farming systems

Samira Arroum[1,2], Amel Sboui[1],Naziha Ayeb[4], Meriem Ben Rejeb[1], Mohamed Dbara[1], Hadhami Yahia[3], Meriem Fares[3], Mohammed Hammadi[1] , Touhami Khorchani[1]

[1] *Wildlife and livestock laboratory, Arid Land Institute, Médenine, Tunisia*
[2] *Higher Agronomic Institute Chott Meriem.University of Sousse. Tunisia*
[3] *Higher Institute of Applied Biology, Mahdia, Tunisia*
[4]*Regional Center for Agricultural Research (CRRA) Sidi Bouzid, Tunisia*

E-mail: arroumsamira2017@gmail.com

**Take home message** This work is an approach to know the chemical composition of pastoral plants grazed by camels in extensive livestock systems. The results showed that pastoral plants were rich in fiber and poor in crude protein.

**Introduction** Camel (*Camelus dromedarius*) breeding is an ancestral tradition in Tunisia. It plays an important economic, social and ecological role, particularly in the south of the country. Generally, camel breeding is best suited to the extensive breeding system. The dromedary forages at pasture on the vegetation rejected by other ruminants (Longo et al., 2007). The present work is part of a project about camel extensive breeding systems; our aim was to characterize the chemical composition of plants grazed by camels.

**Material and methods** The study was carried out in the Wildlife and Livestock Laboratory at arid Land Institute (IRA) Medenin. The whole plant was collected in south Tunisia "Halg ejmel,Chichma et Sidi Makhlouf" where the camel's herd grazed the totality of the plant over a period of (February to June). The species were divided into two fractions: the first was intended for the determination of dry matter (DM) by drying in an oven at 105°C for 24 hours and the second was dried in a ventilated oven at 60° C and ground using an electric grinder equipped with a sieve 1 mm in diameter. The powders from the grinding were used to determine the chemical composition of the sample through the infrared spectrophotometer (SPIR) whose database is the pastoral plants of southern Tunisia (Ben Rejeb, 2021). It is an analytical technique based on the absorption of radiation by organic matter with wavelengths between 800 and 2500 nm.

**Results and discussion**

**Table 1** Chemical composition of pastoral plants, as % of the dry matter

| *Plants* | DM | MM | CP | NDF | ADL |
|---|---|---|---|---|---|
| *Astragalus armatus* | 63.8±7.6 | 9.5±1.4 | 9.4±2.6 | 64.7±5.4 | 13.3±3 |
| *Stipa tenacissima* | 59,2±2,9 | 2.3±0.9 | 5,3±0,2 | 81,1 ±1,2 | 13.4±0.3 |
| *Suaeda mollis* | 53.2±5.3 | 18.6±2.1 | 7.9±0.03 | 60.5±0.6 | 15.2±1.3 |
| *Frankinia thymofolia* | 49.1±2.5 | 30.6±11.2 | 4.8±1.9 | 41.7±1.6 | 12.1±0.4 |
| *Atriplex halimus* | 45.1±7.3 | 17.4±8.9 | 9.3±2.6 | 57.7±8.7 | 12.5±2.9 |
| *Raumaria vermiculata* | 44.6± 0.6 | 17.9 | 9.9 | 40 | 11.2 |
| *Retama raetam* | 43.2±5.4 | 3.9±1.8 | 10,5±4,5 | 62,5±4,2 | 16.9±1.3 |
| *Straganum nudatum* | 38.7±8.6 | 24.6 | 9.07 | 49.1 | 6.6 |
| *Launaea glomerata* | 20.±8±4.4 | 17.1 | 8.6 | 56.9 | 9.2 |
| *Halocnemum strobilacum* | 18.8±5.1 | 30.1 | 6.9 | 48.1 | 10.3 |

The dry matter content varied widely from one plant to another, indeed, this value ranged from 18.8±5.1 to 63.8±7.6. *Retama raetam* and *Stipa tenacissima* are characterized by the lowest content of Mineral materials (MM; 3.9±1.89 and 2.3±0.9 respectively). While the highest mineral content was found for *Halocnemum strobilacum* (30.1) and *Frankinia thymofolia* (30.6±11.2). The mineral composition of a fodder results from the combined action of several factors: the vegetative phase of the plant, the environmental conditions and the methods of exploitation (Chehma & Youcef, 2009). For crude protein (CP), all the species displayed low values. It can be attributed to the adaptation strategy of Saharan plants to drought (Schultz et al, 1981). Assoumaya (2007) reported that variations in chemical composition are related to the climatic environment. The NDF and ADL content in the majority of plants were high (Table1). The NDF plays a decisive role in stimulating rumination. Therefore the camel diet needs a high rate of NDF to guarantee digestibility. In arid regions, forage plants contained more fibre and lignin, and less protein .They revealed an amount of fibre ranged by 23–90%, protein by 2–36%, lignin by 1–21% and minerals by 2–22% (Lee et al, 2018).

**Conclusion** A collection of different camel feeding samples was carried out through the (SPIR). The results showed that pastoral plants were poor in nitrogenous matter and rich in fiber > 40 % necessary to stimulate the camel's rumination.

**References**

Assoumaya C., Sauvant D., Archimède H. 2007. INRA Prod. Anim., 20, 383-392.
Ben Rejeb M. 2021. "Caractérisation et digestibilité des ressources pastorales dans le sud tunisien et estimation de l'ingestion sur parcours des espèces pastorales chez les dromadaires '' Thèse de Doctorat, p 128
Chehma A., Youcef F. 2009. Sécheresse 20, 373-381.
Longo H.F., Siboukeur O., Chehma A. 2007. Cahiers Agricultures 16, 477 – 483.
Lee M.A.2018. Journal of Plant Research, 131(4), 641-654.
Schultz J.C., Baldwin I.T., Nothnagle P.J. 1981. Journal of Agricultural and Food Chemistry 29, 823-826.

# Development of an application for the online sale of sheep and goats

Narjiss El Brihi[1], Said Chatibi[1], Fatima Zahra Najjar[2]

[1]*The National Sheep and Goat Association, Rabat, Morocco*
[2]*FAO, Rabat, Morocco*

E-mail: elbrihi.narjiss@gmail.com

**Take home Message** MyAnoc is a marketplace specialized in the sales of sheep and goats in Morocco developed by the National sheep and goat association for small ruminants to help sheep and goat breeders commercializing their products.

**Introduction** In the context of COVID-19 and in line with the digitalization strategy of the National Sheep and Goat Association (ANOC), the latter, in partnership with the National School of Applied Sciences of Oujda (ENSAO) has begun since march 2020 the development of an online sales platform for sheep and goats entitled "My ANOC". The objective of My ANOC is to establish a direct contact between the breeder and the consumer. With his smartphone, the consumer is able to visualize the animals, to consult the data on the animals and farming conditions provided by the breeder and to order selected animals without having to move to the livestock market.

**Material and methods** The development of the application was based on two panels: a panel of professionals consisting of technicians, farmers and ANOC executives for the development of the "seller" interface (supplier) and a panel of consumers for the development of the "buyer" interface (customer). Thus, several meetings took place every week between the IT development team and the ANOC representatives over a period of 9 months. These meetings were concluded by a workshop to present the project before its first online launch with the presence of all partners at ENSA in Oujda in June 2021, and with the support of FAO. The technicians of ANOC in charge of the sales management through My ANOC benefited from training on the different components of the platform. In parallel to the development of the application, a communication strategy related to the My ANOC Marketplace has been developed to accompany the launch of the application.

**Results and discussion** The outcomes of My ANOC project are the following:
1.MVP (Minimum Viable Product) Android mobile marketplace for customers published on the Play store under the name: My ANOC Marketplace
2.WEB MVP of the customer marketplace deployed on the ENSAO server
3.WEB MVP of the Backoffice for the ANOC staff deployed on the ENSAO server.

**Table 1** Results of communication and statics of the use of MyANOC

| Communication statistics | | | | | |
|---|---|---|---|---|---|
| | N° | Likes | Remarks | Shares | Target hit |
| Posters | 8 | 515 | 32 | 102 | 47457 |
| Videos | 3 | 281 | 19 | 48 | 15875 |
| Advertising media | 4 | | | | |
| Training workshop | 30 | | | | |
| **Statistics of the use of MyAnoc** | | | | | |
| | | | N° | | |
| Animals registered | | | 236 | | |
| Animals sold | | | 29 | | |
| Downloads | | | 680 | | |

The first version of the My ANOC martketplace was first launched in July 2021 during Eid al-Adha on the Google Play platform. The objective was to test this version as well as the related logistical organization, and draw recommendations for the next version in order to progressively reach an operational platform after 3 to 4 years. For this reason, communication was very limited during the first year to avoid saturation of the application and to avoid failures that could compromise the future of MY ANOC.

**Conclusion** This first version has allowed us to identify learned lessons for the next version, in the perspective of making the My ANOC Marketplace the first reference for buying and selling sheep and goats in Morocco.

**Acknowledgements** This project was supported by FAO.

# The management of herds and rangelands in the Algerian steppe is changing: example of the Hadj Mechri commune, Wilaya de Laghouat (Algeria)

Rachid F Hammouda[1], Lionel Julien[2], Brahim Bouchareb[3], Johann Huguenin[2]

[1]*Laboratoire d'Écologie Végétale et Environnement (LEVE), Faculté des Sciences Biologiques, Université des Sciences et de la Technologie Houari Boumediene (USTHB), Alger, Algérie.*
[2]*CIRAD,UMR SELMET, F-34398 Montpellier, France. SELMET, Univ Montpellier, CIRAD, INRA, Montpellier SupAgro, Montpellier, France.*
[3]*École nationale supérieure agronomique d'Alger (ENSA), El Harrach , Algérie.*

E-mail: hammouda.rachid@yahoo.fr

**Take home Message** To differentiate the strategies developed by the breeders to maintain their viable breeding activities in a context of rarefaction of the pastoral resource of the steppe rangelands.

**Introduction** The vegetation of the Algerian steppes is strongly altered. For a long time, this phenomenon was attributed to the succession of droughts. However, it is necessary to take into account the anthropological practices that appeared in the 1960s/1970s. They concern the strong increase in livestock, the division of land, restricted mobility, the provision of cereals to animals, the cultivation of steppes. They have led to decreases in the area of rangelands and their productivity. Steppe grazing only covers 30 to 40% of the animal's food needs (Hammouda & al., 2019; Hadbaoui & al., 2020). To cope with this situation, herders adopt different feeding strategies. Our objective was to identify the panel of alternative practices, adopted by the breeders to feed their herds in these steppe regions.

**Material and methods** This study in the commune of Hadj Mechri, (wilaya of Laghouat), 65 720 ha. The climate is arid. The average annual rainfall is 268 mm (CV: 31%, altitude: 1100m). 155 herders rearing small ruminants (random selection) were surveyed by direct interviews in 2013. The interview focused on rangeland management and feeding practices. The following issues were discussed: herd needs, surface area of rangelands and associated available resources, management methods of grazing, access rights to rangeland areas, herd mobility and distribution of concentrated feed. A simple descriptive statistical analysis revealed groups of herders who use their grazing lands in the same way, and established a calendar of rangelands use for each group of herders.

**Results and discussion** The classification of the calendars of rangelands use, for all the farmers surveyed, made it possible to retain four groups of farmers who use the rangelands in the same way (Table 1).

**Table 1.** Characteristics of rangeland user groups

| User groups | N° of herder/ group | N° of rangeland per group | N° of rangeland per herder | Maximum distance travelled by the flock/days/Km | Concentrate feed supply g/sheep/day |
|---|---|---|---|---|---|
| Gr1 : Continuous grazing all year long | 68 | 103 | 1 | <5 | 250 - 500 |
| Gr2 : Alternate grazing without transhumance | 32 | 47 | >2 | <5 5< >40 | 400 - 500 |
| Gr3 : Alternate grazing with transhumance | 31 | 76 | >2 | <5 >40 | 250 - 500 |
| Gr4 : Continuous grazing with occasional transhumance | 19 | 58 | >1 | < 5 >40 | 0-250 |

The first identified grazing practice is that of leaving the animals on a single grazing area, which is becoming more and more widespread. Locally, this grazing practice, where the herd does not change grazing area during the year, is called "stationary grazing". Not having any other choice, the breeders leave their herds all year long on the same pastures, exerting a strong pastoral pressure on these areas, which leads to a significant reduction in forage availability and overgrazing (Aidoud et al., 2011). Other herders try to use their grazing areas more efficiently. They favor pastures surrounding their homes with short distance (> 5 km < 40 km) trips during the long spring and summer days to graze stubble. Some mobile herders, on a seasonal basis, transhume mainly in winter to the south (Azâaba). Summer transhumance to the north (Achâaba) has become rare because of the high price of access to stubble (Bourbouze, 2010). The food deficit in the rangelands is compensated by the use of concentrates (barley, wheat bran) and with stubble and damaged barley.

**Conclusion** In the case of the latter, there are several mobility strategies: sedentary herders, small-scale mobility, and those who practice longer-distance transhumance. The modalities selected depend on five criteria: i) the amount of land available, ii) the mode of access to this land, iii) the ability to move, iv) the land tenure status of the grazing area, v) the ability to supplement the livestock.

**References**

Aidoud A., Slimani H., Roze F. 2011. Ecologia mediterranea – Vol. 37 (2), 17-32.
Bourbouze A. 2010. Agricultures et paysanneries du monde. Chapitre 3.pp. 63-81. Editions Quæ.
Hadbaoui I., Senoussi A., Huguenin J. 2020. Cahiers Agricultures 29, 28.
Hammouda R.F., Huguenin J., Julien L., Nedjraoui D. 2019. The Rangeland Journal. 2019, 41, 97 –107.

# Characterization of wastes from tomato cultivated under greenhouses heated by geothermal energy and its traditional use as basal diet for ruminants in southern Tunisia

Touhami Khorchani, Hadhami Hajji, Mariem Ben Rjeb, Ikram Tetouch, Mabrouk Mouldi Seddik, Mohamed Dbara, Mohamed Hammadi

*Arid Regions Institute of Medenine-Tunisia*

E-mail: touha2009@gmail.com

**Take home Message** The pruning of the tomato plants during the season extends and the uprooting of the whole plant at the end of the crop provides significant quantities of vegetal biomass that could be used in livestock feeding.

**Introduction** In southern Tunisia, geo-agriculture is one of the mainstays of agriculture. It occupied 215.8 ha in 2018, 52% of which is occupied by tomato cultivation (CTCPG, 2018).This mode of cultivation offers to existent companies an early production with a higher quality, giving them an advantaged position on the world market. The pruning of the tomato plants during the season extends during the year and the uprooting of the whole plant at the end of the crop provides significant quantities of vegetal biomass that could be used in livestock feeding. Forage deficiencies are accentuated in arid and desert regions with the increase in the frequency of dry seasons, the degradation of rangelands and the increase in feed raw material prices in international market. This work aimed to estimate the quantities of by-products of tomato cultivation in heated greenhouses, their characterizations (chemical composition and in vitro digestibility of dry matter (DMD) and organic matter (OMD) as well as the description of the mode the breeders use them in diets distributed to small ruminants.

**Material and methods** To obtain the necessary data a survey of 30 farmers in El-Hamma, Gabéswas conducted in order identify the various modes the greenhouse by products in general and the Tomato by- products in specific are valorised in livestock feeding. Then, to estimate the annual quantities of vegetal biomass produced in kilograms per hectare of area of tomato by-products, the head of two geothermal projects "Zina Fresh" and "Server" were interviewed. Different tomato by-products (leaves and stems) samples were collected. The chemical composition and the *in vitro* digestibility of dry matter (DM) and organic matter (OM) of tomato leaves and stems were determinedaccording to de Tilley and Terry method (1963) in order to estimate their nutritive values.

**Results and discussion** The annual produced quantity of tomato by products (pruning + uprooting) is estimated at 214.6 t/ha of dry matter (DM). The average DM was 27.8 ± 20.7%; this great variability of the DM content seems to be related to the variation of the leaf/stem ratio since the leaves contained approximately 3.5 times more water than the stems. The chemical analysis of tomato leaves and stems revealed that both components had different chemical composition. In fact, the ash content was higher in the leaves then in the stems (P= 0.04). Besides, the total nitrogen content of the leaves was twice of that in tomato stems (P= 0.03; 19.31 vs. 8.17%, respectively for leaves and stems), theses values are in accordance with the results found by Najar et al, (2018). The natural detergent fiber (NDF), the Acid detergent fiber (ADF) and the Acid detergent lignin (ADL) contents were more present in stems than in leaves. The different fiber content had a direct effect on the DMD and OMD; in fact the stems containing more fibers in general had lower values of DMD and OMD (Hammadi, 2003) ( P=0.04 and P= 0.01, for DMD and OMD, respectively). The survey of breeders using the by-products of tomato plants revealed 2 modes of distribution i)in addition to the pasture or ii) the ration, a controlled or *ad libitum* distribution. When used fresh, some breeders have observed cases of mortality, abortion, diarrhea and enterotoxemia as well as accumulations of plastic threads in the rumen. Other farmers have mentioned that the use of tomato by-products has reduced feeding costs, improved animal performance, induced an early return to heat for females and improved fertility.

**Table 1**Chemical Composition and *in vitro* digestibility of leaves and stems from tomato cultivated under greenhouses heated by geothermal water.

| | Leaves | Stems | P |
|---|---|---|---|
| **Ash** | 23.6 ± 7.27 | 14.4 ± 4.14 | 0.04 |
| **Crude protein** | 19.3 ± 3.94 | 8.17 ± 1.04 | 0.03 |
| **NDF** | 31.2 ± 16.12 | 44.8 ± 15.18 | 0.04 |
| **ADF** | 21.0 ± 14.10 | 32.7 ± 12.71 | 0.04 |
| **ADL** | 3.03 ± 1.99 | 5.34 ± 2.15 | 0.03 |
| **DMD** | 52.9 ± 6.94 | 44.73 ± 5.28 | 0.04 |
| **OMD** | 49.8 ± 8.54 | 36.3 ± 5.57 | 0.01 |

**Conclusion** Tomatoes' plants by-products produced under greenhouses in spring season could constitute a good forage source for small ruminants which use could resolve the problem of feed shortage in near arid regions.However, the results of the survey showed the need to deepen investigations to better understand the advantages and constraints of using this new feed resource.

**Acknowledgements** The authors of this work would thank all the implicated breeders and Pr M.M. Belkadhi DG of Centre Technique des Cultures Protégées et de Géothermie (CTPG) the heads of Zina Fresh" and "Server" companies for their collaboration.

**References**

CTCPG, 2018. Les cultures sous serres chauffées par les eaux géothermiques en Tunisie, document technique.

Hammadi M. 2003. Thèse annexe de vue de l'obtention du grade de docteur en sciences agronomiques et ingénieriebiologique, 15 p.

Taha I., Elkafafy M., El Mously H. 2018. Journal d'ingénierie Ain Shams.

Food and Agriculture Organization of the United Nations

CIHEAM ZARAGOZA


JOINT SEMINAR OF NETWORKS
ON PASTURE AND FORAGE CROPS
AND ON SHEEP AND GOAT NUTRITION

CATANIA / SICILY 27-29 SEPTEMBER

# Research funding: context, directions, opportunities, and successful examples

Università di Catania

Università degli Studi di Palermo

CoRFiLaC

LEONE

ADM

# Green Sheep LIFE project for common estimates of carbon footprint at European level: comparison of different tools for sheep farms

Alberto Stanislao Atzori[1], Oscar del Hierro[2], Catalin Dragomir[3], Mauro Decandia[4], Cathal Buckley[5], Roberto Ruiz, Tim WJ Keady[2], Jean Baptiste Dolle[6], S. Moreau[6]

[1] *Dipartimento di Agraria, University of Sassari, Sassari, Italy*
[2] *Neiker Derio, Spain*
[3] *Institutul National de Cercetare-Dezvoltare, Romania*
[4] *AGRIS Sardegna, Loc. Bonassai, Sassari, Italy*
[5] *Teagasc, Athenry, Co Galway, Ireland*
[6] *Institut de l'Elevage, France*

E-mail: asatzori@uniss.it

**Take home Message** Green Sheep Life is matching European tools to commonly estimate carbon footprint of sheep farms.

**Introduction** LIFE Green Sheep (LIFE19 CCM/FR/001245) has been targeting a common carbon footprint (CF) assessment methodology at European level. A broad assessment of sheep production farming from an environmental point of view requires aligned approaches and tools in order to have comparable estimates of environmental performances among countries and plan consistent inventories and mitigation practices at European level. This work aimed at comparing 3 tools available in Europe named CAP'2ER (C2E; France), ArdiCarbon (AC; Spain) and CarbonSheep (CS; Italy) to estimate the carbon footprint of sheep production systems relatively to the emissions for dairy farms.

**Material and methods** The three tools were previously developed at country level C2E in France, AC in Spain (Batalla et al. 2014) and CS in Italy (Atzori et al., 2021) and based on modified Tier 2 of IPCC, 2019. The comparison was performed collecting data from 3 sheep farms from each country (France, Spain, Romania and Italy; n=12). The most part of the farms were conducted in semi-extensive farming systems with animals having access to pasture. Life cycle inventory for each farm was performed with a basic list of inputs (82 for C2E, 83 for AC and 52 for CS) required to run each tool. The model runs allowed to obtain assessments of aggregated emissions from the following categories: total CF allocated to milk, enteric methane, manure management, crops and fertilizers, electricity, fuel and other purchased. In terms of functional units, emissions were expressed in kg of $CO_2$ equivalents per kg of fat and protein corrected milk (FPCM). A total of 36 estimates were obtained running each tool with the inputs of the 12 farms. The evaluation of estimates was performed considering the differences between C2E vs AC, C2E vs CS, and AC vs CS. The mean bias and the root mean square error of prediction (RMSPE) were then discussed as preliminary tool evaluation (Tedeschi, 2006).

**Results and discussion** The farms involved in the study had 499±123 ewes, 187±118 ha, and produced 87.2±87.8 ton of milk per year. They come from a broad range of farm sizes, farming systems, and production levels. The average farm CF observed for the 3 tools was equal to 3.57, 3.75, and 4.85 kg $CO_2$/kg FPCM for AC, CS, and C2E, respectively. High differences were observed in the percentage of allocation to milk (67% C2E, 86% AC and 94% CS). The differences in CF expressed as mean bias were slightly higher than 1.0 kg of FPCM between C2E-AC and C2E-CS, whereas resulted very small for AC-CS. When differences were evaluated as RMSPE, they were higher than the mean bias. It indicated that CF predicted by C2E was on average 1.7 kg of $CO_2$/of FPCM higher than AC and CS. AC predictions were on average 1.2 kg of $CO_2$/of FPCM higher than CS. Large differences were also observed for each hotspot. When the RMSPE of each hotspot were expressed as percentage of the RMSPE of CF, most of variation was due to enteric $CH_4$ (67% of RMSPE for AC-CS), and to manure management (62% of RMSPE for C2E –AC).

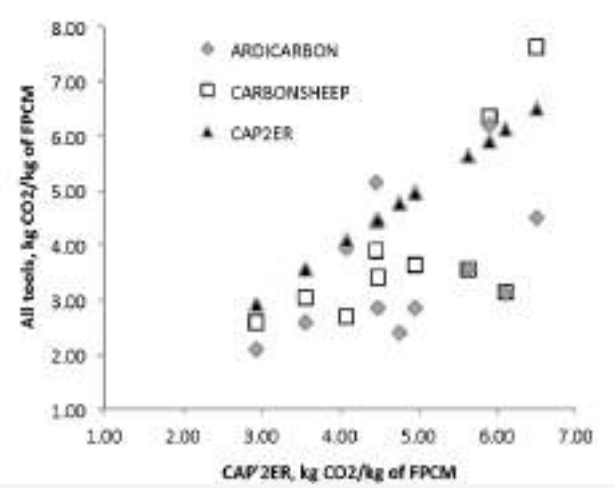



**Figure 1**. Comparison of carbon footprint estimates.

**Conclusion** The comparison indicated that tools developed for specific farming systems can give different estimates when applied at European level and algorithms and emission coefficients used in the 3 tools, especially for methane emissions and manure management, need a careful alignment before running common estimates at European level.

**Acknowledgements** Funded by European Community, LIFE PROGRAM for Climate Change mitigation. Green Sheep Life "Demonstration and dissemination actions to reduce the carbon footprint in sheep farming LIFE19 CCM/FR/001245

**References**

Atzori A.S., Lunesu M.F., Sau P., Pili D., Cannas A. Pacchioli M.T., 2021. Book of Abstracts n° 27 of the 72nd EAAP Meeting Davos, Switzerland: 430.
Batalla I., Knudsen M.T., Mogensen L., Del Hierro Ó., Pinto M., Hermansen J.E. 2015. J. of Clean. Prod. 104, 121–129.
IPCC. 2019. Published: IPCC, Switzerland.
Tedeschi L.O. 2006. Agricultural Systems 89, 225–247.

# PASTINNOVA - Innovative models for sustainable future of Mediterranean pastoral systems

Athanasios Ragkos[1], Antonello Franca[2], Marta Guadalupe Rivera-Ferre[3], Paride D'Ottavio[4], Jean-Paul Dubeuf[5], Antonio Lopez-Francos[6]

[1] *Agricultural Economics Research Institute, Hellenic Agricultural Organization - DIMITRA, Athens, Greece*
[2] *Institute for animal production system in Mediterranean environment - National Research Council, Sassari, Italy*
[3] *INGENIO (CSIC-UPV), Spanish National Research Council, Spain*
[4] *Marche Polytechnic University, Italy*
[5] *INRAE SELMET-LRDE, Corte, France*
[6] *CIHEAM Zaragoza, Spain*

E-mail: ragkos@agreri.gr

**Take home Message** PASTINNOVA is a 3-year project that focuses on the sustainability of Mediterranean pastoralism. The project aspires to deliver innovations and business models that pertain to the particularities of pastoral systems in the Mediterranean, accounting for a broad range of socio-cultural, economic, environmental and policy aspects in Mediterranean territories.

**Introduction** The key objective of PASTINNOVA is to re-enforce the sustainability, profitability and resilience of small pastoral farms, by setting up innovations, business and organizational models to valorize their full potential and promote their access to markets. In particular, the project examines pastoral systems which are able to provide a broad array of ecosystem services (ES) (from habitat services to cultural heritage or rural livelihoods) along with high-quality products (e.g. dairy, meat, wool and processed) in a variety of agro-ecological and socio-economic Mediterranean settings. Although PASTINNOVA encompasses this rich variety in the Mediterranean, it focuses on smallholders maintaining 'pastoral identities' by making sustainable use of local resources at risk of abandonment and providing examples of circular economy for centuries and an alternative to dominant intensive livestock production systems**.** Therefore, PASTINNOVA lies in the core of sustainable rural development.

**Material and methods** In order to address the weak positioning of pastoral smallholders in Value Chains of Pastoral products (VCP) (including short and circular ones)**,** PASTINNOVA proposes a holistic interdisciplinary approach. PASTINNOVA brings together a partnership of 20 of the most important pastoral Organizations – representing 12 countries - from various backgrounds (research, education, Cooperatives, policy, SMEs) and with different expertise (varying from socioeconomic analysis and Information and Communication Technologies to animal husbandry and rangeland science). In particular, based on the 'Living Laboratories' (LLs), a common network on "Pastoral actors and VCP" will be established to co-create innovative solutions for farmer organizations, farm management and VCP through the integration of needs, capacities and experiences of actors (e.g. farmers, entrepreneurs, manufacturers, retailers, policy makers, researchers, consumers). Selected solutions will be tested and implemented in small-scale real-life applications and assessed for their sustainability (economic, social, environmental). Particular focus will be set on the inclusion of vulnerable groups (e.g. women, young farmers and migrant workers) as well as on environmental performances of pastoral agro-ecosystems and chains, promoting sustainable and profitable use of farm waste. Furthermore, the project will propose a supportive policy framework and necessary value chain and market arrangements for efficient access to markets. Thus, the employed methodological framework will combine participatory approaches, assessments and real-life applications, where four elements interact (1) Diagnosis (listing of innovative project, practices and initiatives); (2) Testing of selected innovations under different contexts; (3) Small-scale pilot implementation, sustainability assessment; (4) Policy and market uptake.

**Results and discussion** Among the key expected outputs of the project are (a) The establishment of four Regional LLs; (b) The delivery (co-design, testing, pilot implementation) of at least 12 innovations and business models for Mediterranean pastoralism (focusing on technology, organization/management, value chain/market and Cooperatives/Associations/Governance). The project will deliver demand-driven smart and sustainable pastoral farms, agro-ecosystems and VCP, adapted to the socio-cultural characteristics of farmers with 'pastoral identities' and their territories, profitable under actual conditions and resilient to future challenges In addition, it will upscale the role of pastoralism by pooling a rich variety of existing resources of project partners, their experience and networks, including the outputs of numerous pastoral-related projects. The combined capitalization of these projects, outputs and experience will be a decisive step forward towards more sustainable and resilient pastoralism.

**Conclusion** The key impact of PASTINNOVA will relate to the fulfilment of the true potential of pastoral systems with relevant benefits for smallholder pastoralists. Co-creation within LLs is a key measure demonstrating the effectiveness of the project approach to ensure maximum impact.

**Acknowledgements** PASTINNOVA project is funded by PRIMA Foundation under the PRIMA – Section 1 – Farming Systems – 2021 Call.

# Mediterranean cross-border cooperation project for the sheep supply chain: JESMED

Taha Najar, Imen Belhadj Slimen, Ines Essid

*National Institute of Agronomy of Tunisia, Tunis, Tunisia*

E-mail: najar.taha@inat.agrinet.tn

**Take home Message** JEMED project aims to create linkages between Italian and Tunisian professionals of the ovine sector, and to define the term of references required to obtain a meat label for the Black of Thibar, which is an ovine breed selected by Italians and reared in Tunisia.

**Introduction** The Black of Thibar (BT) is an ovine breed created in Tunisia since 1911 by The White Fathers, a Roman Catholic society of apostolic life, in order to face photosensitizing problems appearing after consumption of St. John's wort (*Hypericum perfoliatum*) growing in pastures. This breed originated from crosses between the Algerian Thin Tail breed and the Black Merino of Arles, and yielded a uniformly black animals recognized for their good conformation and meat quality. The prolificacy and fertility of this breed range between 130-134 and 68-88 %, respectively. Indeed, the meat has less fat and higher desirable fatty acids than other Tunisian rustic breeds. Since 2007, many efforts were joint to create a BT meat label. Unfortunately, this goal wasn't achieved. JESMED, or Mediterenean Jesr of ovine sector, aims to enhance the ovine enterpreunership in Tunisia and Italy, to define the terms of reference required for the obtention of a meat label for this breed, and to develop the cooperation between professionals from Tunisia and Italy in the sheep sector.

**Material and methods** Within the framework of the European Neighborhood Instrument - Cross-border cooperation 2014 – 2020, five Tunisian organisms and three Italian partners collaborated to contribute to the enhancement of the value chain of sheep production. Tunisian partners are the National Institute of Agronomy of Tunisia known as INAT, the General Direction of Agricultural Productions (DGPA), the Agricultural Development of the Breeders of Ewes of the North (GDAEBN), the Higher Institute of Applied Biological Sciences of Tunis (ISBAT), and the Interprofessional Group of Red Meats and Milk (GIVLait). The Italian collaborators are University of Catania (UniCT), Consorzio per la Ricerca sulla Filiera Lattiero-Casearia (CoRFiLaC), and Gruppo d'Azione Locale Eloro Società Consortile Mista a responsabilità limitata (GAL Eloro).
The program of the project provides studies dealing with sheep breeding systems of the black Thibar breed, the characterization of the meat of this breed, the development of guides of good management, the determination of the specifications for the labelling of the NT meat, the creation and development of economic entities and cooperation between the two cross-border regions. Surveys will be undertaken in order to understand the main production systems of BT, and if they affect the meat quality of this breed. Drawn conclusions will allow defining the terms of reference of the BT meat label and Halal certification. Breeders and technical agents will benefit from training about feed sources, traceability, slaughtering, and meat quality. A mutual services company will be created to enable practical knowledge exchange and facilitate BT commercialization.

**Results and discussion** The JESMED project started since 2019. INAT plays a leading coordinative, communicative and technical role in the different planned activities (Table 1). GDAEBN is the principal beneficiary from the project. The subscribed breeders will benefit from a mobile slaughterhouse, in order to ensure the safety and the traceability of the produced NT meat, as well as to meet the terms of the meat label and the Halal certificat. Two webinars were organized to raise awareness about the alternative feed sources allowing reducing feeding costs, the good hygiene practices of slaughtering, and the traceability system. A training session was held to promote the use of technical standards of cartography in BT mapping. Some practical guides dealing with breeding, slaughtering, and using alternative feed sources are being prepared. Eighty BT breeders were surveyed. The subsequent statistical analysis will allow identifying the properties of the main productive systems of the BT breed in Tunisia, and if they affect the meat quality. The gathered data is also useful to define the terms of reference of the planned labels. The mutual services company is in its final stage of creation. The legal status was delimited and the required administrative procedures were achieved.

**Table 1** Main activities of JESMED

| Group | Activities |
|---|---|
| 1 | Administrative and financial activities |
| 2 | Communication activities |
| 3 | Production systems definition<br>Practical guides elaboration |
| 4 | Webinars and info days organization<br>Meat quality studies |
| 5 | Commercial label elaboration<br>Halal certification |
| 6 | Mutual services company creation |

**Conclusion** Understanding the properties of the different production systems of the BT breed in Tunisia and elaborating a commercial label and a Halal certification will enhance the trade of ovine meet in Tunisia and Italy. The joint efforts of Tunisian and Italian partners will improve the breeding practices and the quality of the produced meat.

**References**

Chalh A., Djemeli M., Chalbi N. 2007. Journal of Biological Sciences 7, 1347-1353.
Hajji H., Joy M., Ripoll G., Smeti S., Mekki I., Molino Gahete F., Mahouachi M., Atti N. 2016. Journal of Food Composition and Analysis 48, 102-110.
Meyer C., ed. sc., 2022, Dictionnaire des Sciences Animales. [On line]. Montpellier, France, Cirad. [22/02/2022]. <URL : http://dico-sciences-animales.cirad.fr/ >.

# LIVINGAGRO project – Cross-border living labs for agroforestry

Pasquale Arca[1], Antonello Franca[1], Claudio Porqueddu[1], Panagiotis Kalaitzis[2], Konstantinos Blazakis[2], Lisa Radinovsky[2], Milad El Riachy[3], Peter Moubarak[3], Salam Ayoub[4], Sara Maltoni[5], Maurizio Mallocci[5], Roberto Lai[5], Mauro Forteschi[5], Federica Romano[5], Dina Porazzini[6], Alessandro Mancosu[6], Luciana Baldoni[7], Daniele Chiappini[8], Claudia Consalvo[9], Andrea Pisanelli[9]

[1] *Institute for animal production system in Mediterranean environment - National Research Council, Sassari, Italy*
[2] *Mediterranean Agronomic Institute, Chania, Greece*
[3] *Lebanese Agricultural Research Institute, Zahle, Lebanon*
[4] *National Agricultural Research Center, Baq'a, Jordan*
[5] *Agenzia Regionale Fo.Re.S.T.A.S., Cagliari, Italy*
[6] *A.T.M. Consulting S.a.s., Cagliari, Italy*
[7] *Institute of Biosciences and BioResources - National Research Council, Perugia, Italy*
[8] *Institute for Agricultural and Forest Systems in the Mediterranean - National Research Council, Perugia, Italy*
[9] *Research Institute on Terrestrial Ecosystems - National Research Council, Porano, Italy*

E-mail: pasquale.arca@ispaam.cnr.it

**Take home Message** Identifying a collection of innovations through the participatory approach in Living Labs to improve the sustainability of Mediterranean agroforestry systems

**Introduction** The combination of agriculture and forestry in the Mediterranean regions is deeply rooted in a culture of traditional practices and niche production, but fails nowadays to structure its knowledge for achieving an integrated system of good practices securing the sustainability of production, the protection of biodiversity, the transfer of innovation and the increase in profitability for the territories/stakeholders involved. The LIVINGAGRO project addresses the challenge of knowledge and technical transfer in Mediterranean agroforestry systems. It is funded by the EU under the ENI CBC Mediterranean Sea Basin Programme 2014-2020 and involves four countries: Italy, Greece, Jordan and Lebanon. The project gathers the main stakeholders for less favoured territories in these countries, and is aimed at sharing and disseminating innovations to improve the sustainability and profitability of production systems.

**Material and methods**. The methodology is based on the participatory approach, with a creation of two cross-border Living Labs (LL) to sustain education, R&D and technology transfer in agroforestry by reinforcing the co-operation between research institutions, small medium enterprises, farmers and other relevant stakeholders. The LLs deal with user-centered open innovation ecosystem, integrating research and innovation processes within a citizen-public-private partnership, in two specific fields: multifunctional olive system (LL 1) and grazed woodlands (LL 2). Olive cultivation is representative of many Mediterranean rural areas, and traditionally olive orchards were and are often still managed as agroforestry systems, in combination with cereals, fodder legumes and/or pasture. Grazed woodlands are major agroforestry systems in the Mediterranean that highly contribute to sustaining Mediterranean local economies supplying both plant and animal products. An Information and Communication Technology (ICT) platform, where the main activities and outcomes of the project are made available, supports the promotion of participatory activities, communication and dissemination of results. Field trials, on the other hand, are developed in all participating countries to test and characterize different technical options to reduce costs and increase environmental and production performance; the need for references in this area was expressed by farmers during the stakeholder analyses of the economic operators in both LLs.

**Results and discussion** This participatory approach led to the creation of a catalogue of innovations. After identifying potentially useful innovations, the LLs of LIVINGAGRO assessed the feasibility of each innovation, as well as the type of challenges it addresses. Taking into consideration the needs expressed by the stakeholders, the research teams and technical actors within the LLs reviewed the information provided by the stakeholders on each innovation. Following this review, LIVINGAGRO selected a common list of innovations. Among these, in response to the needs expressed by the economic actors in the sector, there is the selection and use of specific pasture seed mixtures for multifunctional olive and silvopastoral systems under Mediterranean rainfall conditions. This innovation responds to the need to improve forage quality and availability for LL2 and soil quality and protection for LL1. In order to achieve these results, experimental field trials were recently established in agroforestry systems in Sardinia and Lebanon. In the grazed woodland trials, three treatments are being compared: (1) improved pasture with commercial seed mixture, (2) improved pasture with innovative seed mixture and (3) natural pasture. In the olive grove system, traditional management (soil tillage) is also included as a fourth treatment. The innovative mixture consists in a mix of seeds selected in Sardinia, mainly based on annual self-reseeding species, which should provide a good adaptation to different marginal conditions and to prolonged drought periods. The innovativeness of the mixtures also lies in the careful combination of perennials and self-reseeding annual species, in order to maximise the adaptive synergies of the mixture through the balancing of different functional groups such as legumes-grasses-forbs and fast-slow establishing species. The current situation in the seed market forces the use of allochthonous seeds, selected abroad and often with limited adaptability. This represents a major problem, especially when operating in protected natural environments, such as Natura 2000 areas.

**Conclusion** The LIVINGAGRO project should provide appropriate solutions to improve the profitability and sustainability of Mediterranean agroforestry systems, thanks to a participatory approach involving the main stakeholders. The identification of specific seed mixtures to improve the production and environmental performance of these systems is a promising innovation for the whole Mediterranean agroforestry sector.

**Acknowledgements** This project was financed by the "ENI CBC Med".

# LIPOMEC: towards a better understanding of ruminant milk lipolysis through an integrative biology approach in milk and mammary gland

Catherine Hurtaud[1], Laurence Bernard[2], Philippe Trossat[3], Marine Gelé[4], Sofia Meurisse[4], Anne Barbat[5], Didier Boichard[5], Hélène Larroque[6], Aurore Oudotte[3], Jean-Louis Poulet[4], Anne Thierry[7], Marion Boutinaud[1], Mylène Delosière[2], Andrea Rau[5], Muriel Bonnet[2], Christelle Cebo[5]

[1]*INRAE, PEGASE, Institut Agro, 35590, Saint-Gilles, France*
[2]*INRAE, Université Clermont Auvergne, VetAgroSup, UMR Herbivores, F-63122, Saint-Genès-Champanelle, France*
[3]*Actalia-Cécalait, Rue de Versailles, 39800 Poligny, France*
[4]*Institut de l'Elevage, Maison Nationale des Eleveurs, 149 rue de Bercy, 75595, Paris cedex 12, France*
[5]*INRAE, GABI, AgroParisTech, Université Paris-Saclay, 78350 Jouy-en-Josas, France*
[6]*GenPhySE, Université de Toulouse, INRAE, ENVT, F-31326 Castanet-Tolosan, France*
[7]*INRAE, UMR1253 Science et Technologie du Lait et de l'Œuf, Agrocampus Ouest, 65 rue de Saint Brieuc, 35000 Rennes, France*

Email: christelle.cebo@inrae.fr

**Take home Message** LIPOMEC is the first large-scale integrative project to study lipolysis mechanisms in the milk and mammary gland in cow, goat and ewe.

**Introduction** Lipolysis is defined as fat-breakdown through the hydrolysis of triglycerides, the major component of milk fat. Short-chain fatty acids consequently released in milk are responsible for rancid flavor, unacceptable for consumers, in milk and dairy products. In addition, the presence of partial glycerides impairs milk functional properties such as foaming and creaming abilities. Thus, milk lipolysis represents an important criterion to assess milk quality. Spontaneous lipolysis results from a complex interplay between farming practices, animal physiology and animal genetics. However, changes in milk fat breakdown differ markedly between cow (Vanbergue et al., 2018) and goats (Chilliard et al., 2014), whereas ewe milk lipolysis is poorly understood. LIPOMEC, funded both by the French National Research Agency (ANR-19-CE21-0010) and dairy stakeholders (APIS-GENE), is the first large-scale integrative project to study the lipolytic system in the milk and mammary gland in the three dairy species.

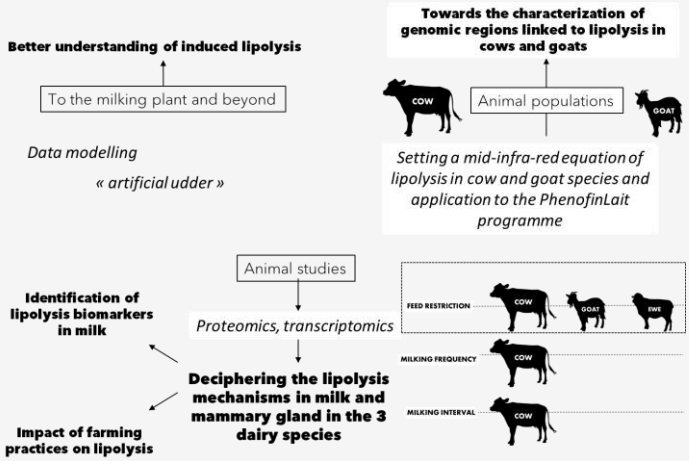


Figure 1: A schematic overview of the LIPOMEC project

**Material and methods** An overview of the LIPOMEC project is depicted in **Figure 1**. A feed restriction study was conducted in the 3 dairy species (cow, goat and ewe). For each experiment, two levels of feeding were applied: "non-restricted" with animals fed 100% of the dry matter intake (DMI) ad libitum and "restricted" with animals fed at 65% of the DMI ad libitum. The impact of the milking frequency and milking intervals on lipolysis were also studied on cow. Lipolysis values were measured by the reference methods in each species, i.e., the copper-soap method for cow, and the BDI method for goat and ewe. Samples generated (milk, blood, mammary gland biopsies) are currently being used to characterize mechanisms of lipolysis in milk and mammary gland through an integrative approach in the three dairy species. Our approaches include animal science, milk biochemistry and biophysics, proteomics, lipidomics, genetics, transcriptomics, cell biology techniques, data modelling, and statistics. Interactions between genetics, physiology, farming practices and technological factors related to the milking process will be considered.

**Results and discussion** Milk yield decreased in the three species in response to the nutritional challenge. For cows, feed restriction caused as expected an increase in spontaneous lipolysis of milk (+0.20 Meq/100 g of fat, $P<0.001$). Conversely, feed restriction induced a decrease in lipolysis in ewe milk (-0.27 Meq/100 g of fat, $P<0.01$), whereas no significant effect was observed for goats under feed restriction. This strongly suggests that lipolytic systems and their adaptations to physiological challenges sharply differ between species. Omics studies on the samples collected during animal experiments are currently in progress to decipher molecular mechanisms occurring in milk and mammary gland with regard to lipolysis in the three species. In addition, an equation based on mid-infra-red (MIR) spectra has been developed to explore the genetic determinism of spontaneous lipolysis in dairy cows. A similar approach is currently in progress in dairy goats within the frame of the LIPOMEC project.

**Conclusion** Taken together, these results will improve understanding of the lipolytic systems in the three dairy species and highlight inter-species peculiarities with regard to the regulation of lipolysis in milk.

**Acknowledgements** LIPOMEC receives financial support from Agence Nationale de la Recherche and APIS-GENE, which brings together professionals from the French ruminant industry (https://www.apis-gene.com/).

**References**

Chilliard, Y., Toral P. G., Shingfield K. J., Rouel J., Leroux C., Bernard L. 2014. Small Ruminant Research 122, 31-37.
Vanbergue E., Peyraud J. L., Ferlay A., Miranda G., Martin P., Hurtaud C. 2018. Livestock Science 217, 116-125.

Food and Agriculture Organization of the United Nations

CIHEAM ZARAGOZA


JOINT SEMINAR OF NETWORKS
ON PASTURE AND FORAGE CROPS
AND ON SHEEP AND GOAT NUTRITION

CATANIA / SICILY 27-29 SEPTEMBER

# A stage for young researchers

Università di Catania

Università degli Studi di Palermo

CoRFiLaC

LEONE

ADM

# Dual-purpose management of perennial forbs sown with or without self-regenerating annual legumes for forage and nectar sources in a low-input dryland production system

Elizabeth Seeno[1], Serkan Ates[1], Shelby Filley[1], Jennifer MacAdam[2], Andony Melathopoulos[3]

[1]*Oregon State University, Department of Animal and Rangeland Science, Corvallis, USA*
[2]*Utah State University, Department of Plants, Soil, and Climate, Logan, USA*
[3]*Oregon State University, Department of Horticulture, Corvallis, USA*

E-mail: seenoe@oregonstate.edu

**Take home Message** Dual-purpose management of forbs for forage and nectar production in a low input production system maximizes the utilization efficiency of marginal pastureland (e.g., waterlogged, acidic, summer-dry) in Pacific northwest.

**Introduction** Agricultural systems must make the most efficient use of farmland while reducing total inputs and carbon emissions for sustainable farming. Dual-purpose management of forbs can support this goal by providing high quality forage for livestock and valuable ecosystem services. This study compared forage yield, nutritive quality, as well as late summer floral density and nectar production of alfalfa (*Medicago sativa*), birdsfoot trefoil (*Lotus corniculatus*), red clover (*Trifolium pratense*), sainfoin (*Onobrychis viciifolia*), and chicory (*Cichorium intybus*) as monocultures and intercropped with either subterranean clover (*Trifolium subterraneum*) or balansa clover (*Trifolium michelianum*) in 2018-2020 in the Pacific Northwest. It was hypothesized that forbs will differ in their persistence and dual-purpose production potentials, and intercropping perennial forbs with self-regenerating annual legumes would increase the forage and nectar production by extending the growing season and improving floral abundance.

**Material and methods** Small plots (1.5m × 6m) were seeded using a plot seeder near Lebanon, OR on 7 September 2018. The treatments consisted of monocultures of alfalfa, birdsfoot trefoil, red clover, sainfoin, chicory, and binary mixtures of each perennial forage either with subterranean clover or balansa clover, arranged in a randomized complete block design with four blocks. Forage samples were collected beginning in April 2019 and ending November 2020. Harvest management was adjusted to allow plants to flower through late spring and summer to quantify their nectar production potentials. Forage samples were used to determine botanical composition, dry matter (DM) yield, nutritive value, and condensed tannin (CT) content. Plots were assessed for floral density by taking weekly counts of flowers in each plot in July-August of 2019 and 2020. Floral counts were used to determine peak flowering time and effect of intercropping with annual legumes of total flowers per $m^2$ in summer. Nectar volume was measured by sampling individual florets with a 0.5 microcapillary tube, counting florets per flower, then multiplying average nectar yield per flower by number of flowers per $m^2$.

**Results and discussion** Red clover out-performed other species in this trial in terms of herbage production when intercropped with balansa clover, producing 11 049 kg DM $ha^{-1}$ in the first year and 9 355 kg DM $ha^{-1}$ in the second. Though balansa clover failed to re-establish in the second year, red clover plots that had been intercropped with balansa the previous year still had higher DM yields and crude protein content relative to red clover monocultures. Perennial legumes showed a competitive interaction with subterranean clover, particularly birdsfoot trefoil and sainfoin. These species were dominated by subterranean clover, negatively affecting total forage yield and summer flower abundance. However, chicory intercropped with subterranean clover formed a more balanced mixture with improved DM yield and nutritive quality relative to chicory monocultures. The chicory (cv. Antler) used in this study showed high levels of condensed tannins (35.9 mg $g^{-1}$ DM) relative to the other forages (2.17–13.49 mg $g^{-1}$ DM), which is a valuable trait to consider when composing pasture mixtures for reducing enteric methane emissions from livestock (MacAdam & Villalba, 2015). Red clover and chicory had the highest floral density and nectar yields in 2018/2019, with peak blooms occurring in late July and early August. In 2019/2020, floral density was highest in birdsfoot trefoil monocultures at 402 flowers per $m^2$, but alfalfa produced the most nectar at 3.3 ml $m^{-2}$. Peak bloom for these species was mid-July whereas red clover and chicory continued blooming through August until the summer indicating their value as a nectar source in late season when the feed sources are the most limited (Timberlake *et al*., 2020).

**Conclusion** Perennial forbs produced high quality forage in a low input production system (e.g., rainfed, low fertilizer) and provided a rich pollinator habitat in late spring/summer season albeit with large variations in their nectar productions. Red clover was superior to other forbs in annual forage yield in heavy clay soils with acidic characteristics. Chicory benefited from intercropping with self-regenerating annual legumes the most, likely due to N fixed by companion legumes.

**Acknowledgements** This study was supported by Oregon Dairy Farmers Association and National Honey Board.

**References**

MacAdam J.W., Villalba J.J. 2015. Agriculture 5(3), 475-491.
Timberlake T.P., Vaughan I.P., Baude M., Memmott J. 2021. Journal of Applied Ecology 58(5), 1006-1016.

# Goat farming in the Majella National Park: grazing behavior and milk quality

Martina Ercolani[1], Leonardo Angelucci[2], Bernardo Valenti[1], Daniela Gigante[1], Luciano Morbidini[1], Simone Angelucci[3], Luciano Di Martino[3], Viviana Bolletta[1], Mariano Pauselli[1]

[1]*Dipartimento di Scienze Agrarie, Alimentari e Ambientali (DSA3), University of Perugia, Perugia, Italy*
[2]*Fattoria Casetta Bianca, Lettopalena, Italy*
[3]*Parco Nazionale della Majella, Pescara, Italy*

E-mail: bernardo.valenti@unipg.it

**Take home Message** Grazing goats vary the ingestion and select different portion of grasses, shrubs and trees to adapt at changeable grazing conditions and to optimize fiber and protein intake across the different seasons. The quality of milk changes depending on goat feeding behaviour.

**Introduction** Goat farming is ideally associated with unfavourable environments and local breeds due to the capability of these animals to adapt at difficult conditions and to exploit low quality feeding resources. Despite this, to date the intensive system represents the most widespread and profitable even for goats. Nevertheless, a renewed interest on the use of goats in marginal areas is emerging thanks to the contribution that this activity can give to in terms of ecosystem services, which are priority of EU, national and local institutions. In this context we investigated the feeding behaviour of goats grazing in area of Majella National Park and the relationship with milk quality from September 2020 to August 2021.

**Material and methods** The herd object of the study was composed by 108 multi-breed lactating goats, 25 kids and 2 adult male used for reproduction. Among the 108 lactating animals, 10 multiparous goats homogeneous for stage of lactation, live weight (40 ± 0.91 kg) and milk production (1190 ±154 g/d) were selected to monitor the milk yield and quality during spring and summer. Monthly, individual milk yield and samples were collected to determine the chemical composition and cheese-making properties. Moreover, from September 2020 to August 2021, six goats were monthly filmed on the same day by an action cam in order to investigate the feeding behaviour. Samples of the portion of the grazed essences (herbage, shrubs and trees) were also collected to estimate the composition of the diet. The observation was suspended during the winter because of the lack of pasture availability.

**Results and discussion** As expected, the characteristics of pasture greatly changed in terms of species and availability during the year, with greater herbage availability during spring and early summer and the goat adapted to these modifications (Manousidis et al., 2018). The observation of the feeding behaviour of the six grazing goats revealed that during spring the animals principally selected grasses (48%). Conversely, their diet was mainly composed of shrub and tree species in summer (74%) and autumn (85%), of which animals ingested leaves, fruits and barks. During summer, goats compensated a lower intake rate by increasing the time dedicated to graze at expense of rumination. Moreover, the selection operated on the different species of grasses, shrubs and trees allowed to favour the intake of fiber (NDF) than crude protein. On the contrary, in spring, the goats showed a greater voracity towards grasses (small and frequent bites), which could be explained by the greater availability and palatability of these essences. Milk yield progressively lowered during lactation and composition changed (Sabikhi, 2007). Interestingly, milk fat and protein did not differ between seasons, but during summer casein index increased and the time to curd firmness decreased. Regarding fatty acids (FA), saturated FA lowered during summer, probably because the phenological status of the plants. Conversely, monounsaturated FA and 18:1 *c*9 increased in summer, likely due to lipomobilization. Opposite trend was observed for linoleic (greater during summer) and linolenic acid (greater during spring). Despite this, PUFA n-6/n-3 ratio was comparable between seasons and notably showed values lower than 2.

**Table 1** Milk composition and technological properties in different seasons.

| | Season | | | |
|---|---|---|---|---|
| | Spring | Summer | SEM | P-value |
| Milk yield (g/d) | 1490 | 1185 | | |
| Casein index | 70.0 | 75.0 | 0.722 | <0.001 |
| Minutes to curd firmness | 6.36 | 4.16 | 1.50 | 0.037 |
| Saturated fatty acids % | 69.1 | 66.8 | 0.501 | 0.006 |
| Monounsaturated fatty acids % | 20.6 | 32.1 | 0.417 | 0.002 |
| 18:1 *c*9 % | 11.2 | 18.4 | 0.724 | <0.001 |
| 18:1 *t*11 % | 1.51 | 1.09 | 0.061 | <0.001 |
| 18:2 n-6 % | 1.93 | 2.12 | 0.038 | 0.008 |
| 18:3 n-3 % | 1.15 | 1.05 | 0.045 | 0.004 |

**Conclusion** The goats adapted feeding behaviour to the variable grazing conditions of a Mediterranean pasture over year. Their efficiency in digesting high-fiber-low-protein feeding is a valid "instrument" for the production of high quality milk.

**Acknowledgements** The authors thanks "Parco Nazionale della Majella" for collaboration.

**References**

Manousidis T., Kyriazopoulos A.P., Parissi Z.M., Abraham E.M., Korakis G., Abas Z. 2016. Small Ruminant Research 145, 142-53

Sabikhi L. 2007. Designer Milk. In advances in food and nutrition research 53, 161-198

# Responses of Mediterranean rangelands to increased summer droughts

Gerónimo A. Cardozo Cabanelas[1,2], Florence Volaire[1], Charlene Barotin[3], Karim Barkaoui[4,5]

[1]*University of Montpellier, Montpellier, France*
[2]*Instituto Nacional de Investigación Agropecuaria (INIA), Treinta y Tres, Uruguay*
[3]*INRAE, Lusignan, France*
*4Centre de coopération internationale en recherche agronomique pour le développement (CIRAD), Montpellier, France*
[5]*Unité Mixte de Recherche ABSys, Montpellier, France*

E-mail: gcardozo@inia.org.uy

**Take home Message** Successive drier summers alter more community structure than biomass productivity of rangelands.

**Introduction** Under climate change, temperatures and drought are expected to increase around the Mediterranean basin (IPCC, 2019) with an extended period of water stress in summer (Giannakopoulos et al., 2009). For Mediterranean rangelands, summer drought is a chronic stress factor that depends on soil types and water retention capacities. Water deficit was shown to be buffered by "adjusted" biomass production across a range of rangelands in contrasting soils (Barkaoui et al., 2017). However, we question to which extent increased drought can still be buffered to ensure the long-term resilience of this rangeland. We hypothesise that successive increased summer droughts could alter the community towards a new state with a loss of ecosystem functions especially for communities on shallow soils with low water reserve.

**Material and methods** The study was carried out on dry calcareous rangelands of southern France, at the INRAe-La Fage experimental (43°55′N, 3°05′E, 790 m asl). The vegetation is dominated by perennial grasses with different species communities according to soil depth and texture. Four sites with sub-areas of sandy shallow soil (18±5 cm) and deep silty soil (85±17 cm) were identified. Increased summer drought treatment was applied in comparison with ambient summer drought treatment. Since June 2016 and for 5 years, we simulated a drier summer by setting a temporary rainout shelter for ~ 75 days from mid-June to end of August to create a warmer and drier micro-climate. Climatic parameters and soil moisture were monitored. Spring and autumn Aboveground Net Primary Production (ANPP) were measured in June and December each year, respectively. Vegetation cover (% bare soil) and the community structure (% monocots) were regularly assessed.

**Results and discussion** Rainout shelters intercepted between 105 to 25 mm (44 to 99 %) of rainfall water, increased average temperature of 0.7 to 1.52°C and reduced relative humidity of 0.8 to 2.3 %, for shallow and deeper soil respectively, creating warmer and drier conditions (among the driest summers in 35 years). Soil moisture was reduced by ~15 % in the summer for both types of soil. Legacy effect of repeated drought was observed in soil moisture in autumn for deep soils all years, but all soils were re-filled entirely every winter. No difference was detected between treatments for cumulative ANPP across the first period (2016-2018, Years 1-2) and neither during the second period (2019-2021, Years 4-5) for deep soil communities, but cumulative ANPP was reduced in the second period for shallow soils communities (Fig. 1.A). Bare soil increased under drier condition for both periods and soils, mostly in shallow soils where it reached very critical levels, higher than 50% (Fig. 1.B). The proportion of monocots (mainly grasses) was stable across the first period in all communities (Fig. 1.C). Conversely, the proportion of monocots increased in deep soil and decreased in shallow soil communities towards the end of the experiment under drier summers (Fig. 1.C).

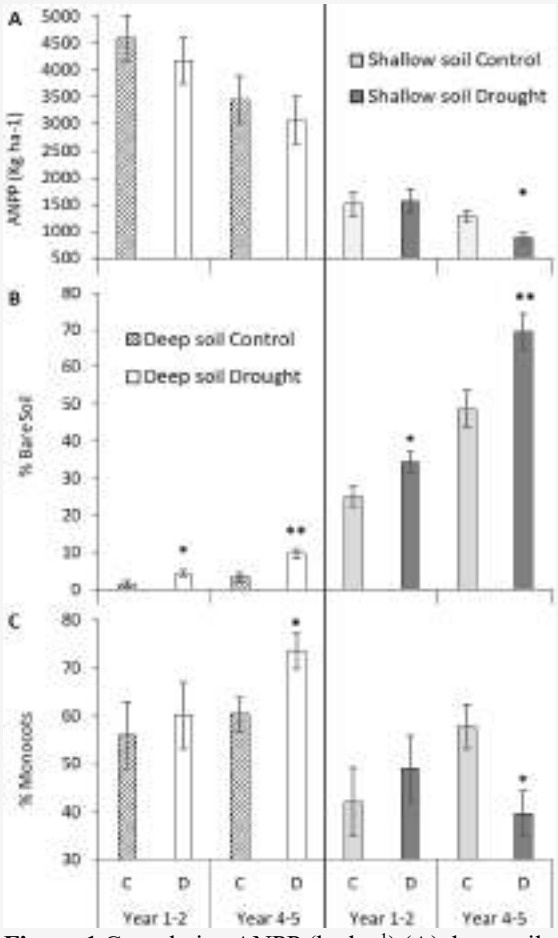



**Figure 1** Cumulative ANPP (kg ha$^{-1}$) (A), bare soil % (B) and Monocots % (C), for each treatment (C- control and D- increased summer drought) and period (2016-2018 and 2019-2021). Mean and EE; *p<0.05; **p<0.01.

**Conclusion** ANPP of herbaceous communities subjected to five successive increased summer droughts, was buffered more for rangelands on deep than on shallow soils. Drier summers contributed to a degradation of communities in shallow soils, with increased bare soil and significant species turnover.

**References**

Barkaoui K., Navas M. L., Roumet C., Cruz P., & Volaire F. 2017. Functional Ecology, 31(6), 1325–1335.
Giannakopoulos C., Le Sager P., Bindi M., Moriondo M., Kostopoulou E., & Goodess C.M. 2009. Glob. Planet. Change, 68(3), 209–224.
IPCC, 2019. Shukla P.R., (…), Malley J., (eds.).

# Cultivated fodders in the sheep feeding systems in the Algerian steppe; status and possibility to improve their resilience

Hadbaoui Ilyes[1], Senoussi Abdelhakim[2], Huguenin Johann[3]

[1]*Scientific and Technical Research Center on Arid Regions (CRSTRA) Biskra, Algeria*
[2]*Saharan Bioresources Laboratory: Conservation and Recovery. University kasdi Merbah-Ouargla, Algeria*
[3]*CIRAD, UMR SELMET, F-34398 Montpellier, France. SELMET, Univ Montpellier, CIRAD, INRA, Montpellier SupAgro, Montpellier, France*

E-mail: hadbaouiilyes@yahoo.fr

**Take home Message** The aim of this study is to analyze a new trend in steppe sheep systems which concerns the integration of cultivated fodders into the sheep feeding program and suggestions to improve food resilience.

**Introduction** In Algeria, the steppe territory is the cradle of sheep breeding. In the past, sheep used to utilize the natural fodder of steppe rangelands in a balanced operation. This balance is ensured through a breeding system based on the mobility of men and animals. However, since the last century, the steppe territory has experienced disturbances of biophysical and anthropic origin altering the surfaces, the bio-resources and the productivity of the rangelands. As a result, sheep breeders are forced to find alternative feeds for their animals. Currently, many of the breeders practice fodder farming and provide part of the livestock. These practices are among of resilience strategies adopted. This study is interested in the analysis of practices and modalities of integration of fodder crops in current sheep breeding systems, in order to identify their strong points and sources of weakness. The ultimate objective is to propose solutions for improving the resilience of breeding practices.

**Material and methods** The research methodology is based on interviews with breeders in one interview visit, which are selected to have a maximum diversity of existing sheep breeding systems in the M'Sila region in Algeria. This steppe region has a strong potential for sheep breeding; with one million hectares of rangelands and a sheep population of 1.65 million heads. A sample of 100 actors (breeders and agro-breeders) was selected from 20 potential breeding areas. The information collected concerns the management of flocks as well as that of fodder crops. Descriptive statistical analyses and estimations of the flock's feed diet were carried out in order to evaluate the contribution of each type of feed in the sheep diet.

**Results and discussion** Globally, the feeds used for sheep are: (i) Rangelands (ii) various concentrated feeds (iii) Green fodder (iv) Stubble and damaged cereals (v) Hay and straw (vi) Fallow land. The use of each of these feed resources is influenced by socio-economic considerations specific for each stockbreeder. The feed used can be totally or partially self-produced by the agro-breeders, or else acquired. The rate of self-production of feed varies from 0% to 95%, where: (i) 56% of the surveyed stockbreeders produce more than half of the feed themselves (ii) 32% produce less than half of the feed (iii) 12% purchase all the feed needed for their herds.
The fodder crops are limited only to three species: barley, oats and alfalfa, with barley being the major species (72% of the used farmland). They are cultivated in irrigated and non-irrigated systems. Their portions of cultivated area are: 37%, 19% and 5.2% in irrigated system for barley, oats and alfalfa, respectively and in the non-irrigated system are: 80% and 8% for barley and oats, respectively. Four utilization forms of barley crop for sheep are identified: (i) Green fodder (by topping) (ii) Grain fodder (concentrated feed) (iii) stubble (iv) Straw (by-product). The oat and alfalfa crops are used as green fodder and hay.
The estimation of the sheep feed composition shows that for 24% of the surveyed breeders, green fodders cover an average of 42% of the annual feed needs of the flocks, used especially during the winter period. These new trends appear as a solution adopted by the breeders themselves to deal with the scarcity of natural fodder in the steppe rangelands. Although the fodder crops provide a good part of the sheep flock's needs, they have technical defects that limit their resilience in the long-term. The extension of crops to the detriment of rangelands, the over-use of underground water resources, and the weak control of crop technology seem to be the elements of vulnerability of the current operation systems of natural resources, which present an additional degradation risk of the natural environment.

**Conclusion** In order to increase the resilience of current sheep breeding systems, improving the productivity of fodder crops is considered to be among the possible ways of development. In a reflection of sustainability, it allows to reduce the animal pressure on the rangelands. The improvement of fodder crops is possible, in particular through a good control of irrigation techniques and the use of fodder species more adapted to the drought.

**Acknowledgements** This study is part of a PhD research project at Kasdi Merbah University - Ouargla, Algeria.

# Ecological characterization of the natural habitat of sulla flexuosa (*Hedysarum flexuosum*) in north-western Morocco

Soumaya Boukrouh[1,2], Jean-Luc Hornick[1], Ali Noutfia[2], Claire Avril[3], Mouad Chentouf[2], Jean-François Cabaraux[1]

[1]*Department of veterinary management of animal resources, FARAH, IVT, Faculty of Veterinary Medicine, ULiège, Liège, Belgium*
[2]*INRA, Regional research of Tangier, Tangier, Morocco*
[3]*HEPH Condorcet, agronomy category, Mons, Belgium*

E-mail: soumaya.boukrouh@gmail.com

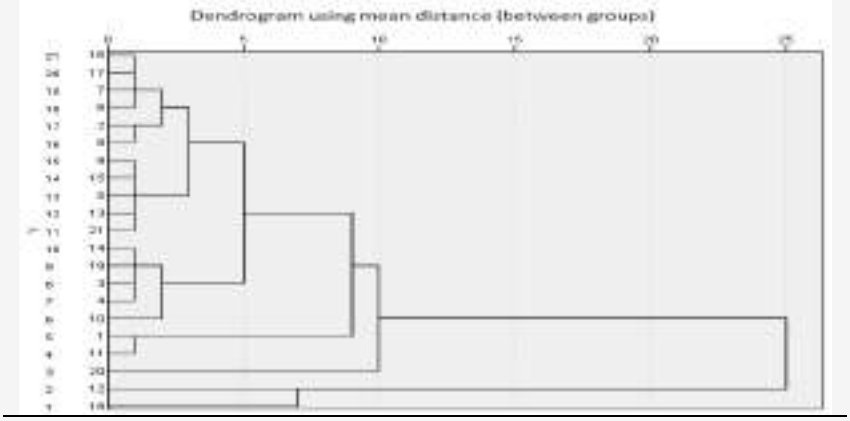
**Take home Message** The natural habitat of sulla flexuosa is characterized by considerable pedo-climatic variability, which makes it well adapted to the improvement of rangelands and the diversification of fodder production.

**Introduction** Sulla flexuosa (*Hedysarum flexuosum* L.) is a widely occurring species in north-western Morocco, where it is traditionally used by farmers and animal breeders as a spontaneous plant. These plants have many advantages that make their introduction justified in the improvement of rangelands and the diversification of fodder production. Knowledge of the natural agro-ecological environments of *Hedysarum* species is a key to their reintroduction into ecosystems from which they have apparently been lost, due to overgrazing and agricultural intensification (Annicchiarico et al., 2008). With this objective, the present work was carried out in order to characterize the soils of the collection sites of 21 sulla flexuosa ecotypes in the north-west of Morocco.

**Materials and methods** the collection was conducted in May-July 2018 in the natural environment of sulla flexuosa in north-western Morocco. Soil samples were taken from the 0 – 40 cm horizon of each sulla collection point. The soil parameters considered were: water pH, electrical conductivity (mmho/cm), total limestone (%), total nitrogen (%), phosphorus (%), potassium (%), carbon (%), organic matter (%), C/N ratio, particle size (%). Annual rainfall was also reported for all collection sites.

**Results and discussion** Sulla flexuosa was found to grow on loamy clay soils with more than 50% and 30% of silt and clay, respectively. The pH was higher than 8 for almost all parameters, which differs from previous results where *H. flexuosum* was collected on a soil with pH 6.4 (Abdelguerfi-Berrekia, 1991). The C/N ratio, greater than 10, indicated a preference for healthy soils where microbial life is active. The maximum level of total soil limestone was 21.01%, which is consistent with previous results in Algeria, where *H. flexuosum* was uncommon on soils with more than 25% total limestone (Abdelguerfi-Berrekia, 1991). Altitude varied between 26 and 358 m and annual rainfall was 600-873 mm for all sites. This result is consistent with the studies of Abdelguerfi-Berrekia et al., (1991) and Issolah et al., (2014), who claimed that *H. flexuosum* prefers regions with annual rainfall between 564 - 700 mm.

**Fig 1** Dendrogram of similarities between sulla collection sites in Morocco




These data have highlighted the adaptation of sulla flexuosa to quite different soil and climatic conditions. This result appears clearly on the dendrogram (Figure 1), which shows an increase in the number of homogenous groups at the bottom.

**Conclusion** This study highlighted the variability of pedo-climatic conditions in the natural habitat of sulla flexuosa. This broad adaptation is a great asset for the reintroduction of this species in the improvement of rangelands, soil protection and diversification of fodder production in the northern area of Morocco.

**Acknowledgements** This study was financed by the "Academy de researche et d'enseignement supérieur" of Belgium.

**References**

Abdelguerfi-Berrekia R., Abdelguerfi A., Bougana N., Guittonneau G. 1991. Fourrag 187–207.

Annicchiarico P., Abdelguerfi A., Ben Younes M., Bouzerzour H., Carroni A.M., Pecetti L., Tibaoui G. 2008. Australian Journal of Agricultural Research 59, 702–706.

Issolah R., Tahar A., Alane F., Sadi S., Adjabi M., Chellig-Siziani Y., Yahiatene S., Lebied M. 2014. Journal of Biological

# Use of cocoa byproduct in animal nutrition: the right way to improve livestock sustainability and human activity

Silvia Carta[1], Fabio Correddu[1], Eleni Tsiplakou[2], Anna Nudda[1]

[1] *Dipartimento di Agraria, Università di Sassari, Sassari, Italy*
[2] *Department of Animal Science, Aquaculture, Agricultural, University of Athens, Athens, Greece*

E-mail: scarta2@uniss.it

**Take home Message.** Cocoa husk fed on dairy sheep did not have negative effect on animal performance and animal health, could have positive effects on blood oxidative status and could reduce carbon footprint.

**Introduction.** The reduction of the environmental impact of human activity is one of the main goals of the global community. To achieve this result several ways could be put in place, and the recycle of raw material is one of these. The use of byproducts on animal nutrition is a good practice to improve the circular economy and to reduce the amount of waste arising from several food production chains. Cocoa husk (CH) is the principal byproduct derived from Theobroma cocoa. Every year 700 thousand tons of CH are generated and this represents a disposal problem for chocolate industry (Rojo-Poveda et al., 2020). However, CH is a good source of fiber, protein, and lipids. This byproduct has an interesting concentration of phenolic compounds (4.6-6.9% of gallic acid/100 g of DM), as catechin and epicatechin that make it an important source for animal health due to their antioxidant activity. CH contains also theobromine, a pure alkaloid that, if on the one hand could be toxic in certain amount for animal, on the other, could have a positive effect on oxidative stability. The aim of this study was to evaluate the effect of the inclusion of CH in the diet of sheep, on milk traits, animal health and blood and milk oxidative status.

**Material and methods.** Twenty-four Sarda ewes were allotted in three experimental groups. All animals received 2.580 kg/d of total mix ration as basal diet and a supplement of 100 g/d per head of soybean hulls (control group, CON), a supplement of 50 g/d per head of CH (CH50 group), a supplement of 100 g/d per head of CH (CH100). The trial lasted 8 weeks, 3 of which were the adaptation to the byproduct. Animals were kept in 12 pens (2 ewes in each pen). Individual milk samples were collected weekly in the morning and evening and analyzed separately for chemical composition. Samples of the diets and byproducts were also analyzed for chemical composition. Milk samples of morning milking were analyzed for fatty acid profile (FA) and for oxidative status. At the beginning and at the end of the experimental period blood samples were collected and analyzed for hematological parameters and oxidative status. All data were analyzed using a mixed model with diet, sampling and diet × sampling as fixed effects and pen as random effect. In addition, considering the annual amount of globally available CH (700,000 tons, CP 17%), the average number of dairy sheep whose diet that could be integrated (100 g/d of CH) with this byproduct and the reduction of carbon footprint related to the concentrates were estimated.

**Results and discussion.** Chemical analyses showed an interesting composition of CH that had a good content of NDF (45.99 % of DM), NFC (23.08 % of DM) and protein (16.77 % of DM). However, a high content of ADL was found. CH had a higher amount of polyphenols (3.36 g GAE/ 100 g of DM) then soybean hulls (0.22 g GAE/ 100 g of DM). The lipid content of CH was 5.57 % and the most abundant fatty acid found was C18:1 cis-9, followed by C18:0 and C16:0. As regard animal performance, CH did not influence dry matter intake (DMI), milk yield and milk composition compared to soybean hulls. A significant effect diet × sampling was found for fat, protein, casein and somatic cell count. Milk fat increased in all groups during the trial, as a consequence of milk concentration effect, with the CH100 group achieving on average the highest values. The significant interaction diet × sampling in SCC highlighted lower variation over time in CH groups compared with the CON. As regard FA, a decrease of C16:0 and an increase of C18:0 was found in CH50 ($P < 0.01$), while an increase of C18:1 cis-9 was found in both groups fed CH ($P = 0.02$). The values of hematological parameters were within physiological range in the two groups fed CH. Blood and milk antioxidant status was affected by the supplementation. In particular, protein carbonyl was lower in CH100 than other two groups, a demonstration of the protective role of cocoa against protein oxidation. Instead, a positive effect on milk. Lactoperoxidase was found in CH50. In addition, the global amount of CH could be used to integrate the diet of 16 million of sheep. Furthermore, the carbon footprint of concentrates could be reduced for about 20%.

**Conclusion.** The inclusion of CH in ewes diet did not show a negative effect on DMI, milk yield and composition. The incorporation of 100 g/d of CH did not negatively affect fatty acid profile and could be a good strategy to reduce oxidative status in blood plasma. In addition, using this amount of CH in sheep nutrition could be reduce the environmental impact as confirmed by the estimate of carbon footprint.

**References**

Rojo-Poveda O., Barbosa-Pereira L., Zeppa G., Stévigny C. 2020. Nutrients 12, 1123.

# Feeding chicory silage and supplementing Se-yeast to peripartum ewes may improve efficiency through subtle changes to metabolism and antioxidant health

Hunter Ford[1], Massimo Bionaz [1], Serkan Ates[1], Erminio Trevisi[2]

[1]*Oregon State University, Corvallis, Oregon, USA*
[2]*Università Cattolica del Sacro Cuore, Piacenza, Italy*

E-mail: hunter.ford@oregonstate.edu

**Take home Message** Chicory, although used primarily for *in situ* grazing, can be a valuable feed source in the form of silage by improving animal efficiency during the peripartum period.

**Introduction** The transition from pregnancy to lactation brings with it a host of metabolic, immune and inflammatory challenges that can increase an animal's susceptibility to disease and reduce animal productivity. Both grazing chicory, an alternative pasture forage with high bioactive compounds, as well as the supplementation of organic selenium (Se) have been proposed to improve ruminant performance and health (Ford et al., 2021; Jaaf et al., 2020); however, there is a lack of studies evaluating these factors during the peripartum period in sheep. Previous work regarding Se supplementation has shown that organic Se, like Se-yeast, has a higher bioavailability than inorganic Se, such as Na-selenite (Hall et al., 2012), leading us to use organic Se in this investigation. The objective of this study was to evaluate the effects of silage type (grass vs chicory) and organic-Se supplementation on ewe performance, milk quality and immune health during the peripartum period.

**Material and methods** Forty-five pregnant Polypay ewes were randomly allocated into four different groups and were moved into individual pens approximately one month prior to parturition. Ewes were fed either grass or chicory silage *ad libitum* and provided a standard sheep mineral mix or supplemented with 3.6 mg Se-yeast /ewe/day. Diets were formulated to be isonitrogenous and isocaloric. Milk production and lamb growth were measured on days 7, 14, and 21 postpartum via the weigh-suckle-weigh method and milk samples were analyzed for quality using a LactoScope for components and a SomaScope for somatic cell counts (SCC). Blood was collected at five different time points over the course of the peripartum period and profiled for a number of parameters associated with metabolism, inflammation, and immune function. Additional blood samples, collected on days 10, 20 and 30 postpartum and assessed for a complete blood count. Data were analyzed using the GLIMMIX procedure (SAS v9.4) with silage type, Se supplementation status and time as the fixed effects with ewe as the random effect. Significance was declared at $p \leq 0.05$.

**Results and discussion** Overall, most of the differences observed between groups in this study were driven by the type of silage that was offered, with few parameters affected by the presence Se-yeast. Dry matter intake was lower in the ewes fed chicory silage, mainly attributable to the large quantity of stems in the chicory silage that were unpalatable to the animals. Despite this reduced DMI, the chicory silage-fed animals had similar overall milk yields and a tendency ($p=0.093$) for higher dairy efficiency pointing towards a higher nutrient and energy density in the chicory silage compared to the grass silage. Among the secondary compounds (e.g., anthocyanin) measured in the forages, only resveratrol was found at higher levels in the chicory silage than the grass silage. Resveratrol has been shown to function as an antioxidant mediator, activating pathways involved in antioxidant protection. Overall milk fat % was found to be higher among the animals fed chicory silage. Both NPN and MUN were higher in the ewes fed grass silage and there was a tendency ($p=0.096$) for these ewes to have higher milk protein %. No differences in SCC were observed. Regarding the parameters profiled in the blood, both NEFA and BHBA were higher in animals fed chicory silage. Blood levels of glutamic oxaloacetic transaminase (GOT) and gamma-glutamyltransferase (GGT), biomarkers of liver damage, were also lower in the blood of ewes fed chicory silage, as were blood levels of urea. FRAP, an indicator of antioxidant health, was significantly affected by the interaction of silage type and Se-yeast supplementation. Among ewes fed chicory silage, those that were supplemented Se-yeast had higher FRAP. The opposite effect was observed among ewes fed grass silage, where the ewes that were supplemented had lower blood levels of FRAP. While no differences in white blood cell populations or total red blood cells were observed, hematocrit was higher in ewes fed chicory.

**Conclusion** Feeding chicory silage to ewes changed milk quality and metabolic activity, with minimal effects on immune function. Slight differences in the secondary compound composition between the silages were detected; however, these differences did not seem to affect the antioxidant response. Peripartum ewes fed chicory silage had higher milk fat %, and positive shifts in liver function. No parameters measured were affected by Se-yeast supplementation independently; however, its interaction with the two silage types had a strong effect on antioxidant activity in the blood.

**Acknowledgements** This investigation was supported with funding from the Agricultural Research Foundation.

**References**

Ford H.R., Busato S., Trevisi E., Muchiri R.N., van Breemen R.B., Bionaz M., Ates S. 2021. Frontiers in Animal Science 2, 729423.

Hall J.A., Van Saun R.J., Bobe G., Stewart W.C., Vorachek W.R., Mosher W.D., Nichols T., Forsberg N.E., Pirelli G.J. 2012. Journal of Animal Science 90, 568–576.

Jaaf S., Batty B., Krueger A., Estill C.T., Bionaz M. 2020. Journal of Dairy Research 87(2), 184-190.

# Could Hemp (*Cannabis sativa* L.) flower co-products be used in ruminant nutrition?

Alessandro Vastolo, Serena Calabrò, Dieudonné Kiatti, Monica I. Cutrignelli

*Department of Veterinary Medicine and Animal Production, University of Naples Federico II, Italy*

E-mail: alessandro.vastolo@unina.it

**Take home Message**. Hemp (*Cannabis sativa* L.) flowers co-products are useful in ruminant nutrition

**Introduction** the interest in hemp cultivation and the use of its products (flour and oil) were increased throughout the countries. Considering the agriculture areas, the use of land for the cultivation of hemp increased over 50% from 2008 to 2018 in Europe (from 12,232 to 24,939 ha) (FAOSTAT, 2020). Indeed, hemp could be considered a valid alternative to the conventional crops produced in excess due to its limited environmental impact, such as less use of water and land exploitation. In this regard, several authors studied the nutritional characteristics of hempseed cake co-products for ruminants nutrition (Serrapica et al., 2019; Mierliţă et al., 2018; Karlasson et al., 2010). Otherwise, a few data concerning co-products of hemp flowers is present in literature. The present study aimed to evaluate the chemical composition, fermentation characteristics, and methane production of hemp flower co-products.

**Material and methods** Two co-products obtained by flowers trimming characterised by different granulometry (RF: rough flower and TF: thin flower) were used. The samples were analysed for chemical composition (AOAC, 2015) and structural carbohydrates (Van Soest et al., 1991). The phytocannabinoid contents were detected by UHPLC-ESI-QqTOF-MS and MS/MS analyses. All samples were incubated in serum flasks with rumen fluid at 39°C under anaerobic condition for 120 h (Theodorou et al., 1994) in order to assess organic matter degradability (OMD), cumulative gas production (OMCV), and fermentation kinetics. For each substrate, four flasks were stopped at 24 h to measure the methane ($CH_4$) production (Guglielmelli et al., 2011).

**Results and discussion** According to Kleinhenz et al. (2020), the concentrations of CBDA were 19 and 16 mg/g, while Δ-9 THCA resulted in 1.85 and 1.25 mg/g for TF and RF, respectively. Regarding the chemical composition, both co-products showed high amount of protein (>20% DM) and lipids (>14% DM). Similarly, all samples resulted in high level of NDF (>31% DM), which were only partially lignified. Furthermore, considering the *in vitro* fermentation parameters, the OMD resulted in less than 30%. However significant differences were observed between substrates, RF produced slowly higher amount of gas compared to TF, which had a higher fermentation rate (OMCV: 155 vs. 137 ml/g: $p<0.05$; $R_{max}$: 3.22 vs. 4.99 ml/h; $p<0.01$; for RF and TF, respectively). Otherwise, RF showed the lowest values of methane production after 24h of incubation (dCH4: 1.78 vs. 11.73 ml/g $OMD_{24h}$). The results are probably related to the higher concentration of ether extract. The higher acetate and propionate production (< 80%) registered by flower co-products after 120h of incubation with rumen fermentation liquor could indicate that the structural carbohydrates of these substrates were highly fermented

**Conclusion** Considering the high protein, structural carbohydrate and lipid values, the by-products of hemp flower trimming could represent suitable feed for small ruminants, despite their rather limited fermentability. However, further studies are needed to evaluate their palatability and the effects on quantitative and qualitative productions.

**References**

AOAC. (2015). Official Methods of Analysis (20th ed.). Gaithersburg, MD, USA.

FAOSTAT (2020, Semptember 26). Retrieved from: http://www.fao.org/faostat/en/#data

Guglielmelli A., Calabrò S., Primi R., Carone F., Cutrignelli M. I., Tudisco R., Piccolo G., Ronchi B., Danieli P. P. 2011. Grass and Forage Science 66, 488–500

Karlsson L., Finell M., Martinsson K. 2010. Animal 4(11), 1854–1860.

Kleinhenz M.D., Magnin G., Ensley S.M., Griffin J.J., Goeser J., Lynch E., Coetzee J.F. 2020. Applied Animal Science 36, 489–494.

Mierliţă D. 2018. South Africa Journal of Animal Science 48(3), 504–515.

Serrapica F., Masucci F., Raffrenato E., Sannino M., Vastolo A., Barone C.M.A., Di Francia A. 2019. Animals 9, 918

Theodorou M.K., Williams B.A., Dhanoa M.S., McAllan, A.B., France, J.A. 1994. Animal Feed Science and Technology 48, 185–197.

Van Soest P.J., Robertson J.B., Lewis B.A. 1991. Journal of Dairy Science 74, 3583–3597.

# Effects of replacing soybean meal with hempseed cake in goat finishing diets on growth, carcass and meat quality attributes

Farouk Semwogerere[1], Obert C. Chikwanha[1], Chenaimoyo L. F. Katiyatiya[1], Munyaradzi C. Marufu[2], Cletos Mapiye[1]

[1]*Stellenbosch University, Stellenbosch, South Africa*
[2]*University of Pretoria, Pretoria, South Africa*

E-mail: 21515093@sun.ac.za

**Take home Message** Hempseed cake can completely substitute soybean meal in goat finishing diets

**Introduction** Research into alternative protein sources for livestock is paramount to extenuate the ever-increasing food-feed-fuel demand for soybean which has increased feed costs. An example of such potential alternative is hempseed cake (HSC), a by-product of the fast-growing hemp (*Cannabis sativa* L.) industry. It has an average crude protein (CP) content of 341 ± 50.4 (g/kg DM), ether extract (EE) of 116 ± 15.5 (g/ kg DM), neutral detergent fiber of 395 ± 40.7 (g/kg DM) and 65–80% polyunsaturated fatty acids with linoleic (18:2 n-6; 60–80%) as the dominant fatty acid. The superior fiber digestion ability of goats compared to sheep and cattle could be exploited to utilize the high fiber and plant secondary metabolites content for meat production. Hence, the objective of this study was to evaluate the growth, carcass and meat quality traits of goats fed varying levels of HSC in finisher diets.

**Material and methods** A 42-d study was conducted to evaluate the effects of replacing soybean meal (SBM) with increasing levels of HSC in goat finishing diets on growth performance, carcass and meat quality attributes. Thirty-five, 3-month-old Kalahari Red wethers (25 ± 1.5 kg initial body weight) were randomly allocated to one of five dietary treatments with seven animals per treatment. Wethers were fed maize-lucerne based finishing diets with inclusions of 0 (control), 25, 50, 75 and 100 g/kg DM of HSC replacing SBM as the main protein source. Feed intake, average daily gain, final body weight, dressing percentage, meat color and pH, drip and cooking loss, shear force as well as meat chemical composition were measured. All the data was analyzed using GLIMMIX procedure of SAS with orthogonal contrasts.

**Results and discussion** Diet had no effect ($P > 0.05$) on daily feed intake, average daily gain, final body weight and income-over-feed costs. Carcass and meat quality attributes were not influenced ($P > 0.05$) by HSC, except for the linear increase ($P \leq 0.05$) in intramuscular fat (IMF) and decrease ($P \leq 0.05$) in ash with HSC inclusion levels. The linear increase in goat meat IMF in this study might be attributed to a similar trend in the dietary EE with increasing HSC inclusion. The linear decrease in the ash content of goat meat was expected since there is a strong negative correlation between meat ash and IMF (Keeton, Llerbeck, & Núñez de González, 2014).

**Table 1** Effects of feeding hempseed cake on goat growth, carcass and meat quality attributes

| | Hempseed cake inclusion level (%) in the diet | | | | | | P-value | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 2.5 | 5 | 7.5 | 10 | SEM[1] | Linear | Quadratic |
| Average daily gain, kg | 0.25 | 0.24 | 0.25 | 0.24 | 0.25 | 0.017 | 0.897 | 0.693 |
| Dry matter intake, kg/d | 1.21 | 1.17 | 1.17 | 1.16 | 1.20 | 0.062 | 0.929 | 0.481 |
| Cold carcass weight, kg | 17.7 | 17.9 | 18.1 | 17.7 | 18.3 | 0.743 | 0.678 | 0.931 |
| Dressing % | 50.0 | 50.0 | 50.7 | 49.3 | 50.6 | 0.870 | 0.863 | 0.830 |
| Moisture, % | 74.5 | 74.9 | 73.9 | 73.5 | 74.2 | 0.479 | 0.204 | 0.537 |
| Ash, % | 2.07 | 1.81 | 1.57 | 1.14 | 0.79 | 0.074 | 0.001 | 0.186 |
| Crude protein, % | 20.0 | 20.6 | 20.0 | 20.4 | 20.2 | 0.397 | 0.094 | 0.404 |
| Intramuscular fat, % | 4.07 | 4.19 | 5.25 | 5.29 | 5.45 | 0.388 | 0.003 | 0.522 |
| L* | 36.8 | 37.4 | 37.5 | 37.9 | 37.9 | 0.655 | 0.202 | 0.781 |
| a* | 11.4 | 11.9 | 11.7 | 11.9 | 11.9 | 0.427 | 0.459 | 0.623 |
| b* | 9.54 | 9.84 | 9.03 | 9.52 | 9.23 | 0.377 | 0.432 | 0.924 |
| Drip loss, % | 1.23 | 1.54 | 1.56 | 1.66 | 2.19 | 0.479 | 0.065 | 0.361 |
| Cooking Loss, % | 36.2 | 37.1 | 36.2 | 35.8 | 34.4 | 1.614 | 0.335 | 0.482 |
| Shear force, N | 50.4 | 51.5 | 52.8 | 54.2 | 49.5 | 2.498 | 0.919 | 0.225 |

[1]SEM: Standard error of means.

**Conclusions** It was concluded that HSC could completely replace SBM in goat finishing diets without affecting goat meat production and quality.

**Acknowledgements** The South African Research Chairs Initiative in Meat Science: Genomics to Nutriomics (UID 84633) funded by the National Research Foundation and Department of Science and Technology of South Africa.

**References**

Keeton J.T., Llerbeck S.M., Núñez de González M.T. 2014. 2nd edition, 235-243

# Effect of different assumption ways of limonene on physicochemical properties of goat kid meat

Maria F. Sgarro, Pasquale De Palo, Vincenzo Landi, Francesco Giannico, Aristide Maggiolino

*Department of Veterinary Medicine, University of Bari, Valenzano, Italy*

E-mail: maria.sgarro@uniba.it

**Take home Message** Although this was a short-term exposure, oral administration of limonene in goat kids improved protective mechanism against oxidative stress.

**Introduction** D-limonene is one of the most abundant terpenes in nature, and is the major constituent in several citrus oils. The applications of limonene extract are different: it has been used for foods' packaging, foods' aroma, as well as it has been studied as biomarker of grazing and geographic typing of rearing system (Tornambé et al., 2006). Natural extracts in food packaging and animal feeding can improve the animal products' oxidative stability (Brewer, 2011). However, to our knowledge, there are rather few studies on the effects that assumption way of terpenes could have on its concentration and consequent effect in goat meat. The aim was to evaluate the effect of oral and respiratory intake ways of limonene on animal oxidative status and meat properties.

**Material and methods** A total of 12 three-month-old goat kids were involved in the trial. Animals were randomly divided in control group (CG; n=4), oral group (OG; n=4) and respiratory group (RG; n=4) and fed with the same diet until slaughtering. Only OG received, orally, 1 mL of limonene every 12 h, while RG had breathed a diluted mixture of essential oil through an electric diffuser. The trial lasted 7 days. After slaughtering, meat samples of each group were randomly assigned to three ageing periods (1, 4 and 7 days). Then, meat samples were processed for colorimetric, oxidative and enzymatic activity evaluation. All data were subjected to ANOVA and, when significant, Tukey test was applied to evaluate the differences among times.

**Results and discussion** Limonene tends to accumulate in fat due its lipophilic nature (Lu et al., 2014) and its concentration in intramuscular fat (IMF) depended by the route of administration: high levels of limonene were detected in IMF of kids who had received additive oral supplementation ($P<0.01$). Yellowness showed higher values in OG after 7 aging days ($P<0.01$), although both redness and yellowness decreased in all experimental groups ($P < 0.01$). Differently, lightness increased over time ($P<0.01$). It is possible that dietary limonene essential oil supplementation modifies indirectly meat colour, probably by decreasing haemoglobin oxidation and activating mechanisms that modify pigment distribution in animal tissues, improving oxidative stability (Simitzis et al., 2008). During aging, an increase in TBARS values over time was observed in all samples, with lower values in OG group compared to the other ones ($P<0.01$). Limonene, like oregano, grape seed and rosemary, could inhibit lipidic oxidations during ageing and limit the production of oxidation metabolites (Karre et al., 2013). Limonene dietary inclusion also improved the potential activity of SOD, Catalase and GPx in muscle; higher levels were observed in OG compared to RG and CG groups ($P<0.01$). This result could express a better responsiveness of the cell to oxidation mechanisms *in vivo* and during *post-mortem*.

**Conclusion** Oral intake of limonene reduced oxidation products and discoloration of the meat during ageing. A brief respiratory exposure probably has no effects on physicochemical characteristics of goat kid due to its poor accumulation in meat. Furthermore, an increase in enzyme activity such as SOD, Catalase and GPx was observed in muscle of animals that ingested limonene. Improving oxidation protection mechanisms could not only promote greater animal welfare in vivo, but also allow for more stable and conservable meat to be obtained.

**References**

Tornambé G., Cornu A., Pradel P., Kondjoyan N., Carnat A.P., Petit M., Martin B. 2006. Journal of Dairy Science 89, 2309-2319.

Brewer M.S. 2011. Comprehensive reviews in food science and food safety 10, 221-247.

Lu W.C., Chiang B.H., Huang D.W., Li P.H. 2014. Ultrasonics Sonochemistry 21, 826-832.

Simitzis P.E., Deligeorgis S.G., Bizelis J.A., Dardamani A., Theodosiou I., Fegeros K. 2008. Meat Science 79, 217-223.

Karre L., Lopez K., Getty K.J. 2013. Meat Science 94, 220-227.

# Black wattle *(Acacia mearnsii)* leaf-meal as an alternative fibre source in sheep finisher diets

Tulimo Uushona, Obert C. Chikwanha, Chenaimoyo L. F. Katiyatiya, Phillip E. Strydom, Cletos Mapiye

*Department of Animal Sciences, Faculty of AgriSciences, Stellenbosch University, Private Bag X1, Matieland 7602, South Africa*

E-mail: utulimo@yahoo.com

**Take home Message** *Acacia mearnsii* leaf-meal could be a suitable fibre source in sheep finishing diets.

**Introduction** Animal production faces conflicting demands to produce large quantities of high-quality meat at low price. This is challenging as the use of cereal and legume grains in animal diets creates a competitive conflict with human nutrition and fuel production. This has prompted the search for novel, non-convectional feed sources that can synchronously improve animal health and production and extend meat shelf-life (Jiang and Xiong, 2016). Among potential feed resources in South Africa is *Acacia mearnsii,* an invasive alien plant, which is rich in fibre, protein and phytochemicals that have nutritional, anthelmintic and biopreservative properties. However, the optimum inclusion level of *Acacia mearnsii* leaf-meal required to improve sheep meat production and quality has not been investigated. Thus, the study objective was to evaluate the effects of feeding increasing levels of *A. mearnsii* leaf-meals in sheep finisher diets on growth performance and carcass attributes.

**Material and methods** Forty, 3-month-old Dohne Merino wethers (25.7 ± 1.6 kg initial body weight) were housed in individual wooden slatted floor pens (2 × 1 m) with feeders and water troughs. Lambs were randomly allocated to five dietary treatments of 0 5, 10, 15 and 20% *A. mearnsii* leaf-meal inclusion levels (n = 8 sheep/treatment) in a completely randomised design. Animals were adapted to diets for 14 days followed by 42 days of sample collection. Sheep were provided clean fresh water and feed *ad libitum*. Feed offered and refused per animal were weighed and recorded daily for the determination of dry matter intake (DMI) and sampled on daily basis and stored at -20 °C for laboratory analysis. Carcass attributes were analysed using the GLIMMIX procedure of SAS with diet as a fixed factor and animals as random factor. For DMI and average daily gain (ADG), day was added in the model as a repeated measure and initial weight as a covariate.

**Results and discussion** Crude protein of the diets was low in the control compared to other diets, while condensed tannins (CT) increased with increasing inclusion levels of *A. mearnsii* leaf-meal. Overall, the control, 5 and 10% diets had greater ($P \leq 0.05$) final live weight (FLW), ADG and feed efficiency (FE) than the 15 and 20% diets (Table 1). This could be attributed to the high fibre and condensed tannin contents observed for the later diets. At high concentrations, CTs form of indigestible complexes with protein and carbohydrates (Naumann et al., 2017). These CT-nutrient complexes inhibit nutrient breakdown while free CTs may chelate metallic ions required for metabolism by rumen microorganisms. This consequently reduces nutrient digestibility (Patra and Saxena, 2011) and animal growth performance. These results could also explain the reduced cold carcass weight (CCW) and dressing percentage observed beyond 10% *A. mearnsii* dietary inclusion ($P < 0.05$).

**Table 1** Effects of feeding increasing dietary levels of *A. mearnsii* on the growth and carcass attributes of wether lambs

| Component | Diet | | | | | SEM | P-value |
|---|---|---|---|---|---|---|---|
| | 0 | 5 | 10 | 15 | 20 | | |
| Final live weight | 42.9$^{ab}$ | 43.3$^{ab}$ | 43.6$^{a}$ | 40.3$^{ab}$ | 38.6$^{b}$ | 1.28 | 0.021 |
| Average daily gain | 0.41$^{a}$ | 0.41$^{a}$ | 0.43$^{a}$ | 0.35$^{ab}$ | 0.31$^{b}$ | 0.02 | 0.001 |
| Dry matter intake | 1.56$^{c}$ | 1.56$^{c}$ | 1.70$^{a}$ | 1.60$^{bc}$ | 1.62$^{b}$ | 0.01 | 0.001 |
| Feed efficiency | 0.24$^{a}$ | 0.24$^{a}$ | 0.24$^{a}$ | 0.19$^{ab}$ | 0.16$^{b}$ | 0.01 | 0.001 |
| Cold carcass weight | 20.7$^{a}$ | 21.1$^{a}$ | 22.0$^{a}$ | 18.5$^{b}$ | 17.5$^{b}$ | 0.49 | 0.001 |
| Dressing percentage | 49.1$^{bc}$ | 50.0$^{ab}$ | 51.9$^{a}$ | 47.5$^{c}$ | 47.3$^{c}$ | 0.51 | 0.001 |

**Conclusion** Overall, inclusion of *A. mearnsii* up to 10% in sheep diets had comparable results to the control diet for FLW, ADG, DMI, FE, CCW and DP.

**Acknowledgements** This study was supported by the RUFORUM GTA funded by University of Namibia and Stellenbosch University; the SARChI partly funded by the South African Department of Science and Technology (UID: 84633); RUFORUM GTA doctoral research grant funded by Carnegie Corporation of New York.

**References**

Jiang J., Xiong Y.L. 2016. Meat Science 120, 107–117.
Naumann H.D., Tedeschi L.O., Zeller W.E., Huntley N.F. 2017. Revista Brasileira de Zootecnia 46, 929–949.
Patra A.K., Saxena J. 2011. Journal of the Science of Food and Agriculture 91, 24–37.

# May differences in ruminal antilipogenic fatty acids explain the individual variation of milk fat depression in goats and ewes?

Antonella Della Badia[1], Pablo G. Toral[1], Juan J. Loor[2], Pilar Frutos[1], Gonzalo Hervás[1]

[1]*Instituto de Ganadería de Montaña (CSIC-University of León), Finca Marzanas s/n, 24346 Grulleros, León, Spain*
[2]*Department of Animal Sciences, University of Illinois, Urbana, IL, USA*

E-mail: a.dellabadia@csic.es

**Take home Message** Individual susceptibility of goats and sheep to the milk fat depression syndrome cannot be explained by antilipogenic biohydrogenation metabolites. However, potential antilipogenic fatty acids provided with diet may play a role.

**Introduction** Both goats and sheep show different degrees of milk fat depression (MFD) when their diets are supplemented with marine lipids to improve their milk fatty acid (FA) composition towards a healthier profile for consumers (Frutos et al., 2017). This MFD syndrome has been attributed to alterations in the pathways of ruminal biohydrogenation (BH) leading to the production of various metabolites with potential antilipogenic activity. In a parallel study with these animals (Della Badia et al., 2021), we were not able to find a solid relationship between antilipogenic metabolites (e.g., *t*10 18:1, *t*10 *c*15 18:2, *t*9 *c*11 18:2, *t*10 *c*12 18:2 and 10-oxo-18:0) appearing in milk and individual degrees of MFD intensity, neither in sheep nor in goats. However, on that basis, we hypothesized that differences occurring in the rumen might be better detected in rumen fluid than in milk. Thus, this study aimed at examining whether differences in ruminal FA composition may explain the individual variation of goats and ewes to fish oil-induced MFD.

**Material and methods** This study was conducted with 25 Murciano-Granadina does and 23 Assaf ewes. All animals were fed a total mixed ration, first without lipid supplementation for 3 weeks (control), and then supplemented with 2% of fish oil to induce MFD. After 5 weeks on this supplemented diet, and on the basis of the extent of decreases in milk fat content, the 5 most responsive (RESPON+) and the 5 least responsive (RESPON−) animals were selected within each species (n=10/species). At the end of each period, samples of rumen fluid were collected to analyse the changes in FA composition between the control and MFD periods, with particular focus on antilipogenic metabolites, using gas chromatography. Statistical analyses to examine those differences were performed with the MIXED procedure of SAS 9.4, using ANOVA to test the fixed effects of species (caprine vs. ovine), responsiveness (RESPON− vs. RESPON+) and their interaction, with the animal as the random effect. Means were adjusted for multiple comparisons with Bonferroni's method.

**Results and discussion** Several ruminal BH intermediates containing a *trans*-10 double bound (i.e., *t*10 18:1, *t*10 *c*12 18:2 or *t*10 *c*15 18:2) have confirmed or presumed antilipogenic effect, in particular by inhibiting de novo FA synthesis in the mammary gland (Toral et al., 2020), but none of them showed significant variations between RESPON- and RESPON+ or its interaction with ruminant species ($P>0.10$). Neither could changes in 10-oxo-18:0 concentrations be related to individual variations in MFD severity ($P>0.10$), although the large increments in its milk concentration during fish oil-induced MFD have suggested a putative role in the syndrome (Frutos et al., 2017; Della Badia et al., 2021). In addition, a significant interaction between responsiveness and species was found for changes in potentially antilipogenic *t*9 *c*11 18:2 ($P=0.02$), but no differences were found in the pairwise analysis after adjustment for multiple comparisons using Bonferroni's method. These results would downplay a major role of BH metabolites in determining the individual susceptibility of goats and ewes to MFD. However, changes in some FA that derive directly from fish oil showed significant differences between RESPON+ and RESPON- in the pairwise analysis. Specifically, sheep and goats suffering a more severe MFD showed greater concentration of *c*9 16:1, 20:5n-3 and 22:6n-3 ($P<0.05$), with no interaction with ruminant species, which suggests a lower disappearance in the rumen of RESPON- in both goats and sheep. Because duodenal infusion of fish oil in cows has been reported to induce MFD by decreasing the yield of FA with 16 or more carbons (Loor et al., 2005; Dallaire et al., 2014), it could be speculated that a greater ruminal outflow of unsaturated FA from fish oil might also inhibit the yield of ≥C16 FA in small ruminants and play a role in their susceptibility to MFD. Further research is required to test this hypothesis and confirm the putative antilipogenic effect of *c*9 16:1, 20:5n-3 and 22:6n-3 in small ruminants.

**Conclusion** Changes in the ruminal concentration of antilipogenic BH metabolites cannot fully explain the individual variability of MFD in goats and ewes. However, a putative role of potentially antilipogenic FA from fish oil may exist.

**Acknowledgements** Authors acknowledge support by PID2020-113441RB-I00 (MCIN/AEI), AGL2017-87812-R (MINECO/AEI/FEDER, EU) and PRE2018-086174 (MCIU/AEI/FSE, EU).

**References**

Dallaire M.P., Taga H., Ma L., Corl B.A., Gervais R., Lebeuf Y., Richard F.J., Chouinard P.Y. 2014. Journal of Dairy Science 97, 6411-6425.
Della Badia A., Hervás G., Toral P. G., Frutos P. 2021. Journal of Dairy Science 104, 11509-11521.
Frutos P., Toral P. G., Hervás G. 2017. J. Dairy Sci. 100, 9611-9622.
Loor J.J., Doreau M., Chardigny J.M., Ollier A., Sebedio J.L., Chilliard Y. 2005. Animal Feed Science and Technology 119, 227-246.
Toral P.G., Gervais R., Hervás G., Létourneau-Montminy M.P., Frutos P. 2020. Animal Feed Science and Technology 261, 114389.

# Can traits related to rumen fermentation and biohydrogenation predispose sheep and goats to be more susceptible to the milk fat depression syndrome?

Antonella Della Badia, Gonzalo Hervás, Pablo G. Toral, Pilar Frutos

*Instituto de Ganadería de Montaña (CSIC-University of León), Finca Marzanas s/n, 24346 Grulleros, León, Spain*

E-mail: a.dellabadia@csic.es

**Take home Message** Traits related to rumen fermentation and lipid biohydrogenation do not seem to predetermine the individual tolerance or susceptibility of sheep and goats to diet-induced milk fat depression.

**Introduction** Unlike cows, dairy goats and sheep were long considered not to be prone to the milk fat depression syndrome (MFD). However, we now know that they can also suffer this disorder, although, within each species, individual animals may display very different degrees of sensitivity. Some studies have indicated that individual responsiveness to diets inducing MFD might be predetermined by certain pre-existing traits (e.g., the production level), but available results in the literature are inconsistent (Baldin et al., 2018; Dewanckele et al., 2019; Della Badia et al., 2021). Given the relationship between ruminal processes and MFD development, we conducted this study to analyze whether some pre-existing traits related to rumen function (namely, differences in rumen fermentation and biohydrogenation) may predetermine the individual tolerance or susceptibility of sheep and goats to MFD.

**Material and methods** We carried out this study with 25 Murciano-Granadina does and 23 Assaf ewes that were fed a control diet for 3 weeks. At the end of this period, samples of rumen fluid were collected through stomach tube for pH, ammonia and VFA concentrations, and for fatty acid (FA) biohydrogenation analysis. Then, all animals received the same basal diet supplemented with 2% of fish oil to induce MFD. After 5 weeks on this supplemented diet, and on the basis of the extent of induced decreases in milk fat content, the 5 most responsive (RESPON+) and the 5 least responsive (RESPON−) animals were selected within each species (n=10/species). Analyses were conducted only on samples from these selected ewes and does. Rumen ammonia was determined by colorimetry, and VFA and biohydrogenation intermediates by gas chromatography (Toral et al., 2017). Statistical analyses were performed with the MIXED procedure of SAS 9.4, using ANOVA to test the fixed effects of the species (caprine vs. ovine), the responsiveness (RESPON− vs. RESPON+) and their interaction, with the animal as the random effect. Means were adjusted for multiple comparisons with Bonferroni's method.

**Results and discussion** Reductions in milk fat concentration and yield averaged 6% in RESPON− and 26% in RESPON+, without significant interaction for species x responsiveness (P>0.10).
Regarding rumen fermentation parameters, we found neither differences between RESPON− and RESPON+ nor significant interactions, and even differences due to species were very scarce: only the content of isoacids (i.e., isobutiric + isovaleric) was significantly lower in goats than in sheep (1.56 vs. 2.52 mmol/L; P<0.05).
Concerning biohydrogenation metabolites, we detected many differences between sheep and goats, as expected. However, despite the comprehensive profile (with around 100 identified FA), significant divergences related to the individual susceptibility to MFD (i.e., between RESPON− vs. RESPON+) were also very few. In fact, only the *cis*-9 17:1, a minor intermediate, showed a tendency to a lower accumulation in animals displaying more severe MFD (0.035 g/100 g of total FA in RESPON− vs. 0.026 in RESPON+; P<0.10). In addition, the concentration of some 16:2 isomers appeared increased in RESPON+, but only in goats (0.70 vs. 0.11; P=0.01 for the interaction species x response). Something similar, a difference only in does was observed for the 18:3n-6, another minor intermediate (0.013 vs. 0.008 for RESPON− and RESPON+, respectively, P=0.01 for the interaction species x response).
In a parallel study with these animals (Della Badia et al., 2021), we found that sheep and goats with better energy balance before receiving the diet inducing MFD tended to be less susceptible to this syndrome. Ewes with a lower milk fat concentration were also less prone, but no significant differences were detected in does. In both parallel studies, statistical power limitations related to the low number of animals cannot be ruled out, so it might be hypothesized that a meta-analysis with more data would allow more conclusive results to be obtained.

**Conclusion** Pre-existing traits related to rumen fermentation and biohydrogenation do not seem to predetermine the individual susceptibility of sheep and goats to diet-induced MFD.

**Acknowledgements** Authors acknowledge support by PID2020-113441RB-I00 (MCIN/AEI), AGL2017-87812-R (MINECO/AEI/FEDER, EU) and PRE2018-086174 (MCIU/AEI/FSE, EU).

**References**

Baldin M., Zanton G.I., Harvatine K.J. 2018. Journal of Dairy Science 101, 376–385.
Dewanckele L., Jing L., Stefanska B., Vlaeminck B., Jeyanathan J., Van Straalen V.M., Koopmans A., Fievez V. 2019. Journal of Dairy Science 102, 4025–4040.
Della Badia A., Hervás G., Toral P.G., Frutos P. 2021. Journal of Dairy Science 104, 11509-11521.
Toral P.G., Hervás G., Carreño D., Leskinen H., Belenguer A., Shingfield K.J., Frutos P. 2017. Journal of Dairy Science 100, 6187–98.

# Effects of dietary carob pulp's levels on fatty acid profile and lipid oxidation of lamb meat

Diego N. Bottegal[1], Sandra Lobón[2], María A Latorre[3], Javier Álvarez Rodríguez[1],

[1]*Universitat de Lleida,25198 Lleida, Spain*
[2]*Centro de Investigación y Tecnología Agroalimentaria de Aragón, 50059 Zaragoza, Spain*
[3]*Universidad de Zaragoza-IA2, 50013 Zaragoza, Spain*

E-mail: diego.bottegal@udl.cat

**Take home Message** The inclusion of carob pulp (a natural by-product) in fattening light-lambs' diets may be a useful tool to improve the marbling without negatively affecting the meat fatty acid composition.

**Introduction** Carob pulp is a by-product obtained after processing the Mediterranean native tree's fruit (*Ceratonia siliqua L.*). It is commonly used in animal feeding, which contains high levels of condensed tannins (CT) and hence antioxidant capacity. In addition, condensed tannins can affect the ruminal biohydrogenation process. Therefore, it is likely that diets with carob can modify the lamb meat fatty acid composition by decreasing rumenic acid (RA) and PUFA n-3 (Vasta et al., 2007). The aim of this study was assessing the effect of the inclusion of carob pulp in fattening lambs' diet on lipid oxidation and intramuscular fatty acid (FA) profile of light-lamb meat.

**Material and methods.** The trial was carried out in Bonarea Group experimental farm in Lleida, Spain. Forty lambs were slaughtered after a 42-day (d) fattening period, with a concentrate-based diet plus barley straw ad libitum (83.2±9.3d old and 27.3±3.8 kg of live-weight). Diets were iso-energetic and iso-preotic, and 0, 15 or 30% of carob pulp was included. To achieve iso-energetics diets (1.76 Mcal NE for ruminants/kg of concentrate), palm oils levels were added (0.9, 3.0 and 5.4% in 0, 15 and 30%, respectively). The 0, 15 and 30 carob concentrates had 2.8, 5.0 and 7.2% of ether extract, respectively. Lamb carcasses were chilled at 4°C for 18h. From each right leg, four 1.5-cm chops (100 g approx. each) were obtained. Furthermore, each chop was randomly assigned to four display times (0, 7, 9 or 11d), and was immediately placed in a modified atmosphere package (70% $O_2$+30% $CO_2$). In every sample, lipid oxidation was determined by measuring the 2-thiobarbituric acid reactive substances (TBARS). Besides, the FA profile of feeds and FA from intramuscular fat (IMF) of Semimembranosus muscle were determined using gas chromatography (100m length column) with flame ionization detector as fatty acid methyl esters (FAMEs). ANOVA was carried out and means were separated by Tukey test when significant ($p<0.05$) dietary treatment effect was detected.

**Results and discussion** The higher the carob pulp level included, the higher the IMF reached (Table 1). Furthermore, carob increased lipid oxidation of meat ($p<0,01$), which was minimal in carob 0 compared to carob 15 and 30 (0.27, 0.49, 0.47 mg MDA/kg sample, respectively). The lipid oxidation increased until 9d of display, regardless of diet ($p<0.0001$). The IMF tended to increase linearly due to carob inclusion ($p<0.1$), but no SFA or MUFA levels differences were detected, whereas the sum of BCFA, SFA methyl-branched (Me), the sum of CLA and RA levels decreased by including carob in diets ($p<0.05$).

**Conclusion** The inclusion of carob pulp (rich in condensed tannins) and oils in the diet reduced biohydrogenation intermediates (as RA) and some fatty acids such as BCFA and SFA Me. Therefore, carob may improve the marbling and acceptance of meat from fattening light lambs.

**Table 1**. Effect of dietary carob pulp levels (0, 15 and 30%) on IMF fatty acid composition (g FA/100 g identified fatty acid methyl esters)

| | Carob 0 | Carob 15 | Carob 30 | SE | P-value |
|---|---|---|---|---|---|
| n | 13 | 14 | 15 | | |
| Σ SFA | 44.92 | 45.22 | 44.54 | 0.53 | NS |
| Σ BCFA | 2.37 a | 2.04 ab | 1.6 b | 0.15 | 0.0039 |
| Σ DMA | 3.37 | 3.40 | 3.99 | 0.27 | NS |
| Σ SFA Me | 0.64 a | 0.62 ab | 0.56 b | 0.02 | 0.0076 |
| Σ MUFA | 38.96 | 38.81 | 39.99 | 0.84 | NS |
| Σ cis MUFA | 35.86 | 35.45 | 37.16 | 0.85 | NS |
| Σ trans MUFA | 3.10 | 3.36 | 2.84 | 0.26 | NS |
| Σ PUFA | 16.12 | 15.97 | 15.47 | 0.66 | NS |
| Σ PUFA n-6 | 13.13 | 13.14 | 12.60 | 0.58 | NS |
| Σ PUFA n-3 | 1.55 | 1.57 | 1.51 | 0.10 | NS |
| n-6/n-3 | 8.76 | 8.71 | 8.66 | 0.55 | NS |
| Σ CLA | 0.42 a | 0.36 b | 0.35 b | 0.02 | 0.016 |
| CLA 9c.11t RA | 0.2 a | 0.16 ab | 0.15 b | 0.01 | 0.0268 |
| IMF (g FA/g meat) | 1.80 b | 2.14 ab | 2.29 a | 0.13 | 0.0516 |

Σ SFA= C10:0+C11:0+C12:0+C13:0+C14:0+C15:0+C16:0+C17:0+C18:0+C19:0+C20:0+C21:0+C22:0+C24:0. Σ MUFA= C12:1+C14:1+C15:1+C16:1+C17:1+C18:1+C20:1+C22:1+C24:11. Σ PUFA= C18:2+C18:3+C19:2+C20:2+C20:3+C20:4+C20:5+C22:4+C22:5+C22:6. Σ BCFA= sum of a- and i-fatty acids. Σ DMA=sum of dimethylacetals (DMA-C16:0+DMA-C18:0+DMA-C18:1). Σ SFA Me= Σ C14:0Me (C14:0-6Me+C14:0-8Me+C14:0-4Me+C14:0-10Me+C14:0-2.6DiMe) + Σ C15:0Me (C15:0-8Me+C15:0-4Me) + Σ C16:0Me (C16:0-2Me+C16:0-6Me+C16:0-8Me+C16:0-4Me+C16:0-12Me)+ Σ C17:0Me (C17:0-12Me+C17:0-cyclo)

**Acknowledgements** European Union H2020 research & innovation programme under Marie Sklodowska-Curie grant N° 801586. To Jonathan Pelegrin Valls for helping in the sample collection.

**References**

Vasta, V., Pennisi, P., Lanza, M., Barbagallo, D., Bella, M., Priolo, A. 2007. Meat Science 76(4), 739–745.

# Stakeholder opinions and perceptions of crop legume cultivation for livestock in Greece

Efstratios Michalis, Athanasios Ragkos

*Hellenic Agriculture Organization (ELGO-DIMITRA), Agricultural Economics Research Institute, Athens, Greece*

E-mail: efstratiosmichalis@gmail.com

**Take home Message** The study indicates orientations for strategy and policy design towards the inclusion of grain legumes in livestock production and their adoption by crop farmers in Greece based on experts' opinions and perceptions.

**Introduction** The potential of grain legumes to contribute to sustainable and low-cost livestock production has been an issue of high importance (Rochon et al., 2004). Legume crops, especially those used for livestock feed (referred here as "livestock legumes"), have low penetration in Greek crop production systems and their use is mostly dependent on their adoption by livestock farmers as feedstuff for ruminants. Their low adoption rate is associated with relatively low grain yields, which fluctuates between 800-1500 kg/ha (according to primary data collected from legume farms in Greece). Nevertheless, these crops have environmental benefits, being suitable for crop rotation schemes (Manousidis et al., 2016). In Greece, livestock legumes are supported through the Common Agricultural Policy by means of coupled payments, which increases their competitiveness against other crops. They constitute alternatives for arid areas and are characterized by low requirements for agrochemicals and fertilizers. The purpose of this study is to shed light on how experts perceive the prospects of livestock legume cultivation for inclusion in ruminant diets in Greece, by focusing on four crops (bean, lupin, pea and vetch).

**Material and methods** The study presents the results of an online survey of experts in Greece. In particular, a structured questionnaire was designed in order to highlight factors that would promote or hinder expansion of the cultivation of livestock legumes in Greece. The questionnaire included three sets of Likert-scale questions (on a scale from 1 = not at all, to 5 = very much), which involved: (1) factors and strategies to promote the cultivation of livestock legumes; (2) factors that hinder adoption and expansion of livestock legumes; and (3) the characteristics of livestock legume varieties that are of interest to farmers. The questionnaire was addressed to four categories of experts: (a) researchers and academics; (b) agriculturalists and advisors; (c) representatives of Cooperatives; as well as (d) farm input suppliers. The participants were also asked to specify which category of experts they belong to; their education level; and the number of years they have been involved in agricultural production or research. In total, 100 experts were approached. The data were analyzed using descriptive statistics methods and differences across groups were tested by the Kruskal-Wallis test, followed by post hoc tests to detect significant differences between groups.

**Results and discussion** A total of 66 experts responded to the survey, providing the study with interesting findings. Regarding the strategies promoting the cultivation of livestock legumes, factors such as the reduction of production costs, efficient training, environmental protection and development of livestock production are considered important in experts' mindset. In addition, their attitude towards the factors which limit the expansion of livestock legumes is a meaningful issue. The large-scale adoption of legumes would be easy, as no additional mechanical equipment is required and their labor requirements are low (also supported by Manousidis et al., 2016). However, the lack of seeds and well-adapted varieties, the low yields and the dependence of farms on soybean for animal feedstuff are identified as important barriers. In order to overcome constraints, the positive effects of legumes need to be communicated to stakeholders. (Reckling et. al., 2016). Farmers are interested in characteristics such as the selling price, the availability of legume products in markets and the achievement of higher yields, in order to decide to integrate legumes in their farming activities, therefore the proposed strategies should be oriented towards these domains.

**Conclusion** Livestock legumes are still not widespread in Greece, although the opportunities emerging from legume-based systems are important in socioeconomic terms and environmental perspective. The investigation of the opinions of experts regarding the prospects of legumes cultivation offers important considerations for future research and policy-making. Integrated strategies are required and need to focus on the development of regional supply chains involving all market stakeholders (crop farmers, livestock farmers, feedstuff industries and other actors involved).

**Acknowledgements** This research has been co-financed by the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH – CREATE – INNOVATE «(project 'Legumes4Protein', Code:T1EDK-04448)».

**References**

Manousidis T., Ragkos A., Abas Z. 2016. Options Méditerranéennes 115, 563-567.

Reckling M., Bergkvist G., Watson C.A., Stoddard F.L., Zander P.M., Walker R.L., Pristeri A., Toncea I., Bachinger J. 2016. Frontiers in Plant Science 7.

Rochon J.J., Doyle C.J., Greef J.M., Hopkins A., Molle G., Sitzia M., Scholefield D., Smith C.J. 2004. Grass and Forage Science 59, 197-214.

# Within day response to temperature humidity index of lactating and dry sheep housed indoor

Fabio Fulghesu, Antonello Ledda, David Edache, Mondina F. Lunesu, Antonello Cannas, Alberto S. Atzori

*Section of Animal Science, Department of Agricultural Science of University of Sassari, Sassari, Italy*

E-mail: ffulghesu@uniss.it

**Take home Message** Respiratory rate is a potential biomarker of thermoregulation in dairy sheep.

**Introduction** Sheep are considered one the most favoured species to adapt to climate change (Sejian et al., 2017). Mediterranean summer conditions are characterized by high variations of daily temperatures, which often cause heat stress in dairy sheep (Sevi and Caroprese, 2012; Peana et al., 2017). Heat stress refers to low capacity of the animal to maintain thermal homeostasis as consequence of high endogenous heat production due to nutrition level and of high environmental temperatures (Sejian et al., 2017). Several studies estimated the animal response to environmental condition change. They showed that the increase of respiratory rate, rectal temperature, hearth rate and skin temperature aims to enhance heat losses (conduction, convection, radiation; water diffusion from the skin) by increasing blood flow from the core to the surface and facilitate heat dissipation (Sejian et al., 2017). This response to heat stress increases energetic maintenance requirements thus the quantification of the metabolic efforts for thermoregulation are useful to adjust feeding requirements of sheep. In this sense physiological measures can be target as biomarkers of energy expenditure to predict changes in energy metabolism and improve feeding models. The study aimed to define the response to daily temperature variation in sheep at different production level and housed indoor without forced cooling systems.

**Material and methods** Fifteen Sarda dairy ewes were divided in three groups homogenous for Body Weight (48.2+-3.57 kg) and different for milk yield (MY): HighMY, LowMY and Dry with 1900, 1200, 0 g/d of milk per ewe (n=5), respectively. Ewes were housed in separate pens of 15 m2 and were monitored one day per week for 60 days between July and September 2020 for physiological response top environmental temperature and humidity index (Kliber, 1964). Data were recorded 5 times per day at 6.00, 9.00, 12.00, 15.00 and 18.00 hours. Respiratory rate was measured with manual counts within videos of 1 minute, pulse heart rate in beat per minute using digital pulse oximiter and mammary, ear, rectal and vagina temperature using digital thermometers. Statistical analyses were performed with the software SAS (9.0) testing a mixed model for repeated measurements considering fixed effects of air temperature and milk production and random effects of hours, day and animal.

**Table 1** Effect of daily temperature on physiological response of dairy sheep housed indoor in summer 2020.

| | | | | | P-value | | | | |
|---|---|---|---|---|---|---|---|---|---|
| THI class, °F | <66 | 66-70 | 70-74 | >74 | THI | Milk yield | Hour | Day | Animal |
| Resp. rate, act/min | 72.8$^{d}$ | 98.8$^{c}$ | 133.6$^{a}$ | 125.7$^{b}$ | <0.0001 | 0.14 | <0.01 | 0.04 | 0.02 |
| Heart rate, beat/min | 71.8$^{b}$ | 75.4$^{b}$ | 87.1$^{a}$ | 89.5$^{a}$ | <0.01 | 0.36 | 0.06 | 0.13 | 0.05 |
| Rectal temp., °C | 39.2$^{c}$ | 39.4$^{b}$ | 39.7$^{a}$ | 39.5$^{a}$ | <0.0001 | <0.001 | 0.16 | 0.04 | 0.02 |
| Vaginal temp., °C | 39.2$^{c}$ | 39.4$^{b}$ | 39.7$^{a}$ | 39.5$^{a}$ | 0.0001 | <0.01 | 0.45 | 0.04 | 0.02 |
| Ear temp., °C | 36.8$^{c}$ | 37.1$^{b}$ | 37.8$^{a}$ | 37.4$^{a}$ | <0.0001 | 0.02 | <0.01 | 0.06 | 0.05 |
| Udder temp., °C | 38.4$^{b}$ | 38.8$^{a}$ | 39.5$^{a}$ | 39$^{a}$ | <0.01 | 0.25 | 0.12 | 0.04 | 0.02 |

**Results and discussion** Results showed that the increase of barn THI caused an increase in respiratory rate, rectal temperature, vaginal temperature, ear temperature (P<0.001), heart temperature and mammary temperature (P<0.01) (Table 1). Milk production was positively associated with variation of rectal (P<0.001), vaginal temperature (P<0.01) and ear temperature (P<0.05). As the temperature increased, the frequency of these variables increased proportionally. The only air temperature explained 58% of the diurnal variability of the respiratory rate in the considered summer interval: respiratory rate, acts/min=8.047*temp., °C -105.23 ($R^2$=0.58; P<0.0001). The respiratory rate had a continuous increase (from 06:00 until 12:00-15:00) when it reaches the highest values, and then undergoes a slight decrease with the advance of the afternoon hours and the stabilization of temperatures. In the first hours of the day lactating and dry animals had similar respiratory rate, but with the increase of temperature the lactating sheep undergo a greater respiratory rate than the dry sheep, although the differences are not significant among groups.

**Conclusion** All of the physiological variables related with THI variation, in particular respiratory rate, should be targeted as relevant biomarkers of maintenance requirement variation for thermoregulation in dairy sheep.

**References**

Kliber H.H. 1964. LXVII. Research Bulletin (University of Missouri. Agricultural Experiment Station).
Peana I., Francesconi A.H.D., Dimauro C., Cannas A., Sitzia M. 2017. Small Ruminant Research 153, 194-208.
Sejian V., Bhatta R., Gaughan J., Malik P.K., Naqvi S.M.K, Lal R. 2017. Springer.
Sevi A., Caroprese M. 2012. Small Ruminant Research 107, 1-7.

# Limonene transfer in sheep milk: a pilot study to assess the impact of different assumption way on on milk concentration

Roberta Greco, Aristide Maggiolino, Vincenzo Landi, Giovanna Calzaretti, Pasquale De Palo

*Department of Veterinary Medicine, [1]University of Bari, Valenzano, Italy*

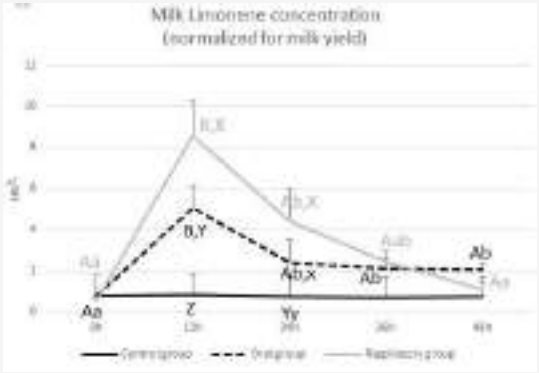
E-mail: roberta.greco@uniba.it

**Take home Message** The link between farms and production area, the key to understand how an ecosystem can affect products and their unicity.

**Introduction** Consumers have a growing interest for animal welfare and their rearing conditions: both are strongly linked to food quality. Animal feeding regimens affect milk composition by intestinal assimilation of substances but, in a wider point of view, we can also consider the environment effect on it. Volatile compounds, like terpenes, mark out grassland, and these may be transferred directly through inhaled air into different tissues, bypassing rumen metabolism. In this prospect we can trace back the milk and milk products from animals feeding on grassland (Prache et al., 2005). The aim of this trial was to evaluate the efficiency of alimentary and respiratory path in the transfer of limonene, used as molecular marker, to milk in daisy ewes.

**Material and methods** A total number of 12 dairy ewes were included in the trial. The experimental design (a 3×3 latin square), in which three treatment groups were created. Thus, limonene was administered orally (OG), through respiration route (RG) while the third was the control group (CG). Each group of ewes was initially assigned to one of the treatments, lasted seven days. The first 5 days were used for overall adaptation/wash out, and then were followed by 48 h of limonene administration. After the first 7 days-treatment, the groups were switched so that all groups were subjected each one to the three different treatment conditions. The whole experiment period lasted three weeks. Terpene administration was performed by using an essential oil containing 99.9% of limonene. The oral treatment was performed twice a day (0h, 12h, 24h and 36h of the trial), by administering one ml of limonene directly in the mouth. A diluted mixture of essential oil was prepared for respiratory treatment (10% concentration) performed by an electric diffuser. Air limonene concentration was monitored applying the NIOSH 1552 method (NIOSH, 1996). Animals were hand milked two times per day (0h, 12h, 24h, 36h, 48h). Milk limonene concentration was determined using solid phase micro-extraction, coupled with gas chromatography mass-spectrometry (SPME-GC/MS). The milk limonene concentration was analysed according to the General Linear Model (GLM) procedure with random blocks effect of SAS (SAS, 2011). A Tukey test was applied to evaluate the differences according to the time. The significance was set at $P < 0.05$

**Results and discussion** No differences were observed in the control group (CG) during the trial. Differently, milk limonene concentration increased in both oral group (OG) and respiratory group (RG) from 0 to 12h and then decreased ($P < 0.01$). Moreover, the RG showed higher limonene concentration than OG at 12h ($P < 0.01$) and 24h ($P < 0.05$). All milk samples contained limonene, even though at different concentrations. Hay-fed animals acquire terpenes from hay, and this explains why animals from the CG group produced milk with a kind of "baseline" of limonene concentration (Viallon et al., 2000). The limonene concentration after 12h of oral and respiratory treatments reached the highest level, then it sharply decreased. The decrease rate for the two treatments was different, with a higher drop rate in RG than OG. These observations support the idea that there is a rapid absorption and excretion of monoterpenes, including limonene, through the mammary gland. Moreover, the efficiency of absorption and secretion of the mammary gland after 12h of administration seems efficient in the case of respiratory route than the oral one




**Conclusion** There is a rapid transfer of limonene to milk in dairy sheep through both oral and respiratory pathways, and that the latter seems to be more efficient. A first practical implication of the study is that the quantification of terpenes in milk could be a useful tool to assess the environment in which animals are reared and this finding could be extended to any monoterpene.

**References**

Burt S. 2004. International Journal of Food Microbiology 94(3), 223–253.
Prache S., Cornu A., Berdagué J.L., Priolo A. 2005. Small Ruminant Research 59, 157–168.
Viallon C., Martin B., Verdier-Metz I., Pradel P., Garel J.P., Coulon J.B., Berdagué J.L. 2000. Lait 80, 635-641.

# The effect of replacing concentrate with a non-irrigated premature millet as hay on the performance of Jersey dairy cows

Doha M. Khalifeh, Kamal Khazaal

*Lebanese University, Dekwaneh, Lebanon*

E-mail: khalifehdoha33@gmail.com / khazaalk@hotmail.com

**Take home Message** Proso millet (*Panicum miliaceum*) can provide a good yield and high-quality forage biomass (hay) when harvested before maturation that can partially (up to 25 %) replace concentrate without affecting the performance of Jersey dairy cows negatively.

**Introduction** Forages are naturally the main source of feed for ruminants. They ensure a normal and active rumen ecosystem which is essential for maintaining the performance and health of animals. In addition, roughages promote rumination which is necessary for breaking up feed particles to be absorbed properly, and increase saliva production leading to better digestion (Mikuła *et al.*, 2022). As rumination increases the acetic acid production in the rumen increases which is responsible for the fat synthesis and healthy rumen environment (Kalač & Samková, 2010).
Rumination also improves the recycling of NH3 to the rumen where urea-N can be used as a source of N for microbial protein, which is the major contributor to the metabolizable protein supply to the small intestine (Getahun et al., 2019).
In Lebanon, the ruminant production sector faces many problems due to the lack of grasslands and the limited production of high-quality forages. The climate, the decreasing water resources and many other factors have aggravated this shortage in forages for ruminants and left farmers with low-quality chopped cereal straw used as forage. This shortage increases the dependence of farmers on concentrate feed to compensate for animals' needs for stable production.
The increase in the use of concentrate up to 70 % of the total diet coupled with the use of chopped cereal straw causes the rumen pH to decrease (pH <6), which reduces cellulolytic rumen microbes (Heinrichs, *et al.,* 1999). This practice is the main cause of acidosis and many related metabolic diseases which are the major diseases in most Lebanese farms.
All mentioned above create the need for a good quality forage that needs little to no water, is easy to cultivate, cost-effective, and is easily preserved (sun drying rather than silage). Thus, this study aims to assess the potential of producing non-irrigated premature millet as hay and its effect as a replacement up to 20-25% of the concentrate on the performance (intake, milk yield, milk fat, protein, SNF and BCS) of Jersey dairy cows.

**Material and methods** Proso millet was planted in a 1700 $m^2$ area. For DM yield estimation, 3 sub-plots (0.5$m^2$) were selected, weighed fresh, and followed by continuous sun drying until the weight became stable to check moisture content.
In a complete randomized design, 6 Jersey cows were selected from a local farm and divided into 2 groups with similar periods of lactation and number of gestations (4 cows were in their 1st gestation at late lactation, and the other 2 cows were in the 4th gestation at the mid-lactation stage) and divided accordingly. The control group was fed a typical diet composed of a 70:30 ratio of concentrate to forage throughout the study. Feeding was adjusted according to live body weight at 3%. At the 1$^{st}$ stage (5 days), 2$^{nd}$ stage (5 days), and 3$^{rd}$ stage (5 days), 5 %, 12.5 %, and 20 % of the concentrate was replaced by millet hay, respectively. During the 4$^{th}$ stage (15 days) 25 % of the concentrate was replaced by millet hay.
Milk yield was recorded twice a day (morning and evening, 3 times per week). Milk samples were taken from the collected milk of each cow and analyzed twice a week to test fat, protein, and SNF using an infrared machine.
All the data and graphics of the results were calculated using Microsoft Excel. For each stage averages of nutrients (CP and ME) and milk records were calculated. Data were statistically analyzed using SPSS by using a two-way ANOVA.

**Results and discussion** The Dry Matter (DM) yield of the crop as premature hay was 4744 kg DM/ha from millet hay. Milk yield was significantly higher ($p < 0.05$) in the control group in all stages, the milk yield in the control group was 10.47 kg (±5.79) and 6.62 kg (±0.61) for the millet hay group at 25% replacement. However, at 25% replacement, the millet fed group was slightly higher ($p > 0.05$) in milk fat content (3.71 % ±0.79); and Solid Non-Fat (SNF) (9.40% ±0.21) as compared to the control group (3.48% ±0.95 and 9.30% ±0.62, respectively), and protein content was close in both the control and millet groups (3.50% ±0.23 vs. 3.52 % ±0.08, respectively). Although feeding millet slightly reduced ME and CP supply, it had no adverse effect on DMI. On the contrary, a slight improvement in rumination (Mikuła *et al.*, 2022), milk quality (Kalač & Samková, 2010), as well as lower cost of production were observed.

**Conclusion** Millet hay can replace 25% of the concentrate without an adverse effect. Moreover, the process of producing and feeding millet hay is easy to apply by small farmers compared to silage and can improve the health status of animals and the profitability of the farmer.

**References**

Getahun D., Alemneh T., Akeberegn D., Getabale, M., Zewdie D. 2019. Biomedical Journal of Scientific & Technical Research 20(1), 2574 -1241.
Heinrichs A.J., Buckmaster D.R., Lammers B.P. 1999. Journal of Animal Science 77(1), 180-186.
Kalač P., Samková E. 2010. Czech Journal of Animal Science 55(12), 521-537.
Mikuła R., Pszczola M., Rzewuska K., Mucha S., Nowak W., Strabel T. 2022. Animals 12, 50.

# Growth performance of Sahelian x Djallonké crossbreed pre-weaning lambs in the sub-Saharan, West Africa

Dieu donné Kiatti[1,2], AlessandroVastolo[1], Monica I. Cutrignelli[1], Youssouf Toukourou[2], Serena Calabrò[1]

[1]*Department of Veterinary Medicine and Animal Production of University of Naples Federico II, Naples, Italy*
[2]*Department of Animal Production of Faculty of Agronomy, Parakou, Benin*

E-mail: alessandro.vastolo@unina.it

**Take home Message:** To improve growth performances in Djallonké lambs, Sahelian rams can be used, but age and sex needs to be taken into account.

**Introduction:** In the Republic of Bénin the majority of the population (90%) is involved in the breeding of small ruminants (Hounzangbé-Adote, 2011; MAEP, 2013). Livestock constitutes the second activity for the subsistence of rural farming households. The Djallonké (dwarf sheep) represents the main part of the small ruminant's population in Benin (Hounzangbé-Adote, 2011). The predominance of this breed is due to its great resistance to parasitic diseases (e.g., trypanosomiasis), and tolerance to hot and humid tropical conditions (Bosso, 2006). However, the Djallonké heads grow slowly, and their meat yield is limited. In this way the Sahelian breed was introduced in some farms to improve Djallonké performance. The aim of this study was to evaluate the effect of sex on growth performance of the lambs obtained by the crossbreed Sahelian x Djallonké.

**Material and methods:** The study was conducted in the municipality of Ouassa Péhunco, Republic of Bénin (10°13'42" Nord 2°0'7" Est) in a local sheep farm. The ewes were conducted to natural pasture and received a complementary feed. Totally 74 lambs (36 males and 38 females) of crossbreed Sahelian x Djallonké were recruited immediately after lambing. As usual, lambs were naturally weaned at 2 months only suckling. All the lambs were individually identified using the neck collar and weighed at birth and subsequently once per week using an electronic balance (0 to 50 ± 0.02 kg). The daily weight gain (DWG, kg) and infantile mortality rate (IMR, %) were calculated as proposed by Lhoste et al. (1993). Analysis of variance (ANOVA) has been applied to the data using R software version 4.0.3 to evaluate the effect of the gender. The means were reported using Student t test.

**Results and discussion:** During the first mouth of life totally 22 lambs (10 males and 12 females) died. The infantile mortality rate (IMR) in the first 10 days corresponded to 16.22 % of total born lambs (tbl) whereas during the full experimental period the weaning mortality rate (WMR) was 32.43 % tbl. These values are higher than those reported in literature for Djallonké breed (IMR 7.18 % tbl, Nianogo, 1992), but similar to that described by Missoko et al. (2020) on Djallonké sheep in Congo Brazzaville. Nevertheless, our data falls within the range described by Armbruster et al. (1991) (20-48 % tbl) in Djallonké lambs before weaning. These authors justified this range with the differences in breeding management, seasons, and environmental condition in different African area. Regarding live wight (LW) data, the gender significantly affected the LW both at birth (2.88±0.57 and 2.47±0.73 kg in males and females, respectively; $p<0.05$) and at the age of two months (7.28±1.33 and 6.19±1.21 kg in males and females, respectively; $p<0.05$). These results were similar to those reported by Missoko et al. (2018). Although, the mean LW at the birth was higher than those reported by Gbangboché et al. (2002) Missoko et al. (2018) on Djallonké breed in Bénin and in Congo Brazzaville, respectively. Moreover, the DWG during the trial (60 d) was affected by the gender (154±35 vs. 119±38 g/d, respectively for males and females; $p<0.05$), particularly higher was the DWG of male lambs during the second month of life (80.3±2.5 vs. 57.7±13.6, $p<0.001$). Nevertheless, these data were lower than that observed by Toukourou et al. (2016) where Djallonké lambs received a supplementation of 50 - 100 ml soy milk (1 kg in 8 litres) in addition to sucking.

**Conclusion:** This study has shown that sex and age have a significant effect on the lambs born of Sahelian x Djallonké. However, a crucial rule is played by the breeding management (i.e. supplementation of feed, sanitary control) of ewes and lambs to obtain better performance.

**Acknowledgments:** The authors thank the farm's owner for his collaboration.

**References**

Armbruster T., Peters K.J., Hadji-Thomas A. 1991. Journal of Animal Breed and Genetics 108, 220–26.
Bosso N.A. 2006. Ph.D. thesis, Department of Animal Sciences, Wageningen University.
Gbangboché A.B., Abiola F.A., Laporte J.P., Salifou S., Leroy P.L. 2002. Tropicultura 20(2), 70–75.
Hounzangbé-Adote M.S., Azando E., Awohouedji Y. 2011. Atlas de La Biodiversité de l'Afrique de l'Ouest, 506–18.
Lhoste P., Dollé V., Rousseau J., Doltner D. 1993. Collection Précis d'élevage, Ministère de La Coopération, France, 281.
MAEP. 2013. Annuaire Statistique.
Missoko R.M., Mopoundza P., Ekou D. C., Massamba S.N., Akouango P. 2018. Journal of Applied Biosciences 131(1), 13284.
Missoko R.M., Akouango P., Ognika A. 2020. Journal of Animal & Plant Sciences 46, 8141–48.
Nianogo A.J. 1992. International Livestock Centre for Africa (ILCA), 346–421.
Toukourou Y., Abdoulaye M., Attakpa Y.E., Alkoiret I.T. 2016. Tropicultura 34(2),150–57.

# Carbon sequestration and greenhouse gas emissions from different crop rotation systems in the Mediterranean-climate region in South Africa

Lisa Matthews[1], Pieter A. Swanepoel[1], Johann Strauss[2], Arne Poyda[3], Thorsen Reinsch[3], Friedhelm Taube[3]

[1]*Stellenbosch University Department of Agronomy, Stellenbosch, South Africa*
[2]*Western Cape Department of Agriculture, Stellenbosch, South Africa*
[3]*Christian-Albrecht University, Kiel, Germany*

E-mail: 20866852@sun.ac.za

**Take home Message** Nitrous oxide and methane soil fluxes are variable over the season and influenced by rotation system. Long-term carbon sequestration in different rotation systems does not differ.

**Introduction** The agricultural sector is a major producer of greenhouse gases (GHG), and responsible for majority share of nitrous oxide ($N_2O$) emissions. Nitrogen (N) fertiliser usage, due to its energy-intensive production, transport, and volatilisation into $N_2O$, is correlated to system GHG emissions (Snyder *et al.* 2009). Methane ($CH_4$) emissions are associated with anaerobic soil conditions and enteric fermentation in livestock. Emissions can occur directly from on-site activities and soil processes, or indirectly through manufacture of inputs and fuel usage. Having insight into GHG emissions produced in agricultural soils will aid in developing sustainable farming practices. The Swartland region in South Africa has a Mediterranean climate with an average annual rainfall of ca. 400 mm. Most farmers follow conservation agriculture practices and commonly rotate wheat (*Triticum aestivum*), canola (*Brassica napus*), barley (*Hordeum vulgare*), lupins (*Lupinus* spp.), and sheep on annual medic (*Medicago* spp.) pastures. Cereal cash crops generally receive N-fertiliser rates between 30 and 150 kg N $ha^{-1}$ and wheat yields around 3 to 5 t $ha^{-1}$. Livestock integration into crop systems has the potential to decrease system emissions by decreasing N-fertiliser requirement, and machine passes. The aim of this study was to investigate carbon sequestration and GHG emissions from the soil in different rotation systems each with different crop choices, levels of integration with livestock, and fertiliser applications.

**Material and methods** The experimental site was a long-term crop rotation trial at Langgewens Research Farm (33.276821552 S 18.703171288 E). The soils are shallow, sandy loam, shale-derived lixisols. Three rotation systems were evaluated: Wheat-Wheat-Wheat-Canola (WWWC); Wheat-Medic-Canola-Medic (WMCM); and Wheat-Canola-Wheat-Mixed hay crop (WCWH). Systems WMCM and WCWH contained N-fixing legumes, reducing the N-fertilisation rates. The average N-fertiliser application rates for WWWC, WCWH and WMCM were 85, 60, and 18 kg N $ha^{-1}$, respectively. Systems were replicated twice, with each phase of rotation represented every year, resulting in 24 experimental units. Weekly $N_2O$ and $CH_4$ fluxes were sampled via the closed chamber method, from 30 days after planting (week 1) until stem elongation (week 11 – 13). Carbon sequestration was estimated using soil organic carbon (SOC) values from 2002 – 2020. $N_2O$ flux, $CH_4$ flux, and SOC responses to rotation system were analysed with mixed model ANOVAs in R. Soil temperature and water content were logged hourly.

**Results and discussion**. No significant differences were found between rotations. All systems SOC values hovered around 1.3% and showed a slow gradual increase over time. $CH_4$ fluxes were negligible and negative, as expected in drier climates. $N_2O$ fluxes were highly variable, and rotations had different seasonal patterns, the cumulative emissions are shown in figure 1. WWWC showed negative fluxes (absorption of $N_2O$) in week 12. Maali & Agenbag (2003), documented that soil N on this site decreased as the season progressed, and fertilisers were quickly used by crops. Week 12 occurred just after a soil drying and wetting cycle and coincided with stem elongation phase. Wheat and canola residues have a higher C:N ratio than legumes, meaning decomposition by microbes would further immobilise N, but mineralise it in leguminous systems. It is speculated that these conditions of high plant and microbial activity coupled with an overdemand of N led to decreased emissions of $N_2O$.

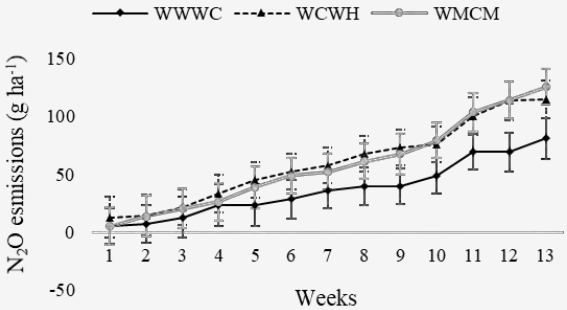



**Fig. 1:** Cumulative $N_2O$ emissions over period

**Conclusion** Rotations did not significantly differ in terms of soil GHG fluxes and carbon sequestration. Seasonal $N_2O$ fluxes were inconsistent but gave interesting insights into rotation dynamics. These results are preliminary, continuation of measurements, finalisation of calculations and life cycle analyses will bring further clarity.

**Acknowledgements** This study was supported by the Western Cape Department of Agriculture, Protein Research Foundation, Western Cape Agricultural Research Trust, Stellenbosch University and Christian-Albrecht University of Kiel.

**References**

Maali A., Agenbag G. 2003. South African Journal of Plant and Soil 20, 119-126
Snyder C., Bruulsema T., Jensen T., Fixen P. 2009. Agriculture, Ecosystems and Environment 133, 247-266.

# Effects of hay, dehydrated and fresh sulla forage on feed intake, milk production and oxidative status of ewes

Marialetizia Ponte[1], Antonino Di Grigoli[1], Adriana Di Trana[2], Giuseppe Maniaci[1], Riccardo Gannuscio[1], Marco Alabiso[1], Massimo Todaro[1], Adriana Bonanno[1]

[1]*Dipartimento Scienze Agrarie, Alimentari e Forestali, Università degli Studi di Palermo, Italy*
[2]*Scuola di Scienze Agrarie, Forestali, Alimentari ed Ambientali, Università degli Studi della Basilicata, Potenza, Italy*

E-mail: adriana.bonanno@unipa.it

**Take home Message** Dehydration is a valid opportunity to exploit the favorable responses of dairy ruminants to sulla forage-based diets also in periods when fresh forage is unavailable.

**Introduction** The choice of sulla (*Sulla coronarium* L.) was based on the widespread availability of this legume species in Mediterranean areas, where it is recognized for the excellent agronomic traits, and fresh sulla forage (FSF) is appreciated for the positive effects of its high protein content and moderate condensed tannins (CT) concentration on intake, milk yield and milk composition of small ruminants (Bonanno et al., 2016). At moderate level (<6% DM), CT bind dietary protein, protecting it from ruminal degradation and contributing to increase its intestinal absorption and utilization for milk casein synthesis. CT exert also an antioxidant activity which was able to improve the plasma oxidative status of goats (Giorgio et al., 2020). Dehydration of FSF could be a valid process to preserve these properties, as an alternative to hay-making which causes great losses of nutrients and bioactive components. The aim of this research was to evaluate the responses, in terms of feed intake, milk yield and oxidative status, of dairy ewes fed with diet based on sulla hay (SH), pelleted dehydrated sulla forage (DSF), and FSF.

**Material and methods** Ten primiparous (PRI) and ten pluriparous (PLU) Valle del Belice ewes at 60 days in milk were distributed into 5 homogeneous groups, fed 5 diets in a partial 5×2 Latin square design with 5 groups and 2 periods. The diets were different for the forage basis: SHL = SH ad libitum (al); DSF2 = 2 kg/d DSF + SH al; FSF2 = 2 kg/d FSF + SH al; FSF4 = 4 kg/d FSF + SH al; FSFL = FSF al. The diets were integrated with energetic concentrate at level of 800 g/d for PRI or 1,200 g/d for PLU. Ewes' feed intake and milk yield were recorded daily. Forages and concentrate were sampled to determine centesimal composition, polyphenols, CT and fatty acids. Faeces composition was used to estimate diets digestibility. Milk was analysed for its components and clotting ability, and plasma to determine oxidant (ROMs, reactive oxygen metabolites) and antioxidant substances (BAP, biological antioxidant potential), and the oxidative stress index (OSI = ROMs/BAP).

**Results and discussion** DSF, compared to FSF and contrary to SH, showed a slight reduction of protein, a moderate increase in the fibre content, no loss in terms of vitamin E and polyunsaturated fatty acids, and a decrease in CT and polyphenols due to dehydration treatment. There was higher DM intake with DSF2 diet than with other diets (table 1), indicating the good palatability of DSF. DSF2 diet implied also higher protein and vitamin E intakes than other diets, whereas compared to FSFL its intake was analogous for net energy and lower for CT and polyphenols. DM digestibility was analogous among diets. The antioxidant protection exerted by the higher vitamin E intake can be responsible of the greater oxidative status of ewes fed DSF2 diet, that exhibited lower values of ROM and OSI at plasma level (table 1). Milk yield and casein percentage (table 1) with DSF2 diet were comparable to those with FSF4 and FSFL diets, characterized by higher incidences of green forage, whereas curd firmness ($a_{2r}$) similarly improved with DSF2 and FSFL diets. This result confirms the positive impact of FSF on milk production, presumably due to the effect of CT on the efficiency of dietary protein utilization for the synthesis of milk casein, and shows that advantageous effects on milk production emerges also when FSF is replaced by DSF.

**Table 1** Ewes' DM intake, milk yeld, casein and oxidative status (a, b, c, d = p≤0.05)

| DIETS | SHL | DSF2 | FSF2 | FSF4 | FSFL | p< |
|---|---|---|---|---|---|---|
| DM intake, g/d | 2351 b | 2799 a | 2433 ab | 2301 b | 2061 b | 0.0002 |
| CT intake, g/d | 8.02 d | 8.78 d | 11.7 c | 23.8 b | 43.0 a | <0.0001 |
| Polyphenols intake, g/d | 22.6 c | 33.0 b | 28.8 b | 33.2 b | 50.2 a | <0.0001 |
| Vitamin E intake, mg/d | 23.53 d | 55.22 a | 30.05 c | 34.37 c | 44.67 b | <0.0001 |
| Milk yield, g/d | 1781 b | 1914 a | 1780 b | 1872 ab | 1925 a | 0.0029 |
| Milk casein, % | 3.79 b | 3.93 ab | 3.75 b | 3.87 ab | 4.03 a | 0.0384 |
| ROMs, unit Carr | 79.7 ab | 72.5 b | 83.0 a | 86.4 a | 84.2 a | 0.0462 |
| BAP, mmol/l | 2.13 | 2.51 | 2.21 | 2.19 | 2.31 | 0.1526 |
| OSI (ROMs/BAP) | 40.8 a | 30.4 b | 41.2 a | 42.1 a | 37.5 ab | 0.0003 |

**Conclusion** The inclusion of 2 kg of DSF in the diet gave better results than a diet exclusively based on sulla hay, and was comparable to diets with higher levels of FSF in terms of milk yield and casein. Since dehydration preserved the vitamin E content, the dehydrated sulla can have contributed to enhance the oxidative balance of ewes. On this basis, the storage and use of sulla forage as dehydrated pellets suggest interesting perspectives in terms of animal welfare and farm sustainability.

**Acknowledgements** This research was developed within the project DISOLASULLA (MIPAAF, 2020-1533).

**References**

Bonanno A., Di Grigoli A., Mazza F., De Pasquale C., Giosuè C., Vitale F., Alabiso, M. 2016. Animal 10(12), 2074-2082.
Giorgio D., Di Trana A., Di Gregorio P., Rando A., Avondo M., Bonanno A., Valenti B., Di Grigoli A. 2020. Antioxidants 9(3), 224.

# The potential of feeding ewes with fresh or dehydrated sulla forage to enrich sheep cheese in molecular biomarkers of health quality

Antonino Di Grigoli[1], Marialetizia Ponte[1], Riccardo Gannuscio[1], Margherita Addis[2], Giuseppe Maniaci[1], Marco Alabiso[1], Adriana Bonanno[1], Massimo Todaro[1]

[1]*Dipartimento Scienze Agrarie, Alimentari e Forestali, Università degli Sudi di Palermo, Italy*
[2]*Azienda AGRIS Sardegna, Olmedo, Sassari, Italy*

E-mail: adriana.bonanno@unipa.it

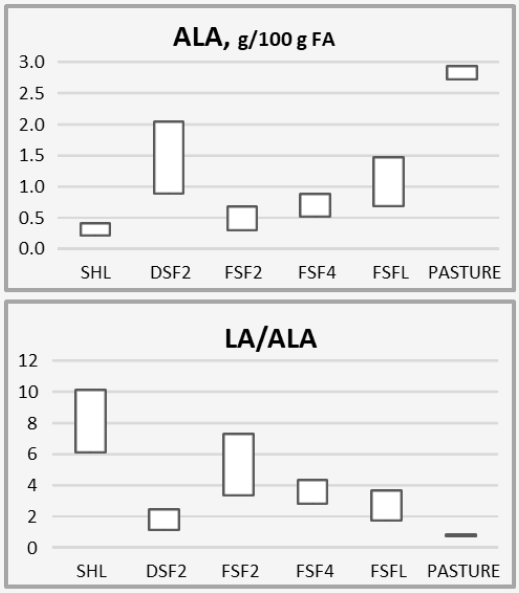
**Take home Message** The use of fresh or dehydrated sulla forage in dairy ewes feeding enhances the health properties of cheeses due to transfer of antioxidant molecules and polyunsaturated fatty acids (PUFA).

**Introduction** Sulla (*Sulla coronarium* L.) is a widespread legume species used as fresh or preserved forage. It is well known the positive impact of fresh sulla forage (FSF) on performance of ruminants and quality of their products, linked to the moderate content of phenolic compounds, mainly condensed tannins (CT) (Piluzza et al., 2014). Moderate levels of CT (<6% DM) inhibit the complete ruminal bio-hydrogenation of dietary unsaturated fatty acids (FA), enriching the animal products with PUFA beneficial for human health. Moreover, FSF contributed to increase the content of antioxidant compounds, thus improving the antioxidant capacity of goat milk (Di Trana et al., 2015). Dehydration of FSF could be suitable to preserve these properties, that are greatly lost during the hay-making process. This research has compared the cheeses produced from milk of ewes fed with diets based on sulla hay (SH), pelleted dehydrated sulla forage (DSF), or FSF, evaluating their FA profile and antioxidant activity, and verifying the presence of biomarkers of health properties useful for traceability of fresh forage-based diets.

**Material and methods** The individual daily milk from 10 primiparous (PRI) and 10 pluriparous (PLU) Valle del Belice ewes at 60 days in milk, divided into 5 homogeneous groups fed different diets in a partial 5×2 Latin square design with 5 groups and 2 periods, and the bulk milk of farming ewes fed only on natural pasture were used in 2 sessions of micro cheese-making to manufacture pressed-curd type cheeses. The experimental diets were: SHL = SH ad libitum (al); DSF2 = 2 kg/d of DSF + SH al; FSF2 = 2 kg/d of FSF + SH al; FSF4 = 4 kg/d of FSF + SH al; FSFL = FSF al. Concentrate was supplied at level of 800 g/d for PRI or 1,200 g/d for PLU. Cheeses were sampled at 48 h and analyzed for their physico-chemical traits, including contents of FA, vitamins A and E and polyphenols, and for their antioxidant capacity (TEAC) and oxidative stability (POV and TBARs). The ability of cheese components to discriminate the ewes' diets was also evaluated.

**Results and discussion** The diet FSFL with exclusive fresh forage ad libitum, as that of grazing animals, was confirmed to greatly improve the health properties of cheese. Indeed, FSFL diet was responsible of increased amounts of antioxidant substances, as vitamins A and E and polyphenols, that induced a better oxidative stability, and enhanced the level of PUFA such as rumenic (C18:2c9t11), the main CLA isomer, and α-linolenic (ALA, C18:3n-3). In cheeses from DSF2, the contents of vitamin A and PUFA were higher than in SHL cheeses and comparable to cheeses from the diet with 4 kg of FSF, whereas ALA was detected at the same level of FSFL cheeses. Evaluating the possibility of using these health cheese components as biomarkers of animals' diet, a promising role in differentiating cheese from animals fed fresh forage emerged for vitamin A and some FA such as C15:0iso, C18:1, C18:1t11, total PUFA, n-6/n-3 ratio, and especially for ALA and its ratio with linoleic acid (LA, C18:2n-6) (figure 1).

**Figure 1** Variation of ALA and LA/ALA ratio in cheese in relation to diet




**Conclusion** The results showed how dehydration was able to preserve the potential of fresh sulla forage also with regard to nutritional and health properties of dairy products. Thus, the use of dehydrated sulla pellets as alternative to hay in periods of limited pasture resources can contribute to enhance the antioxidant capacity and the FA profile of milk and cheese, with health benefits for consumers. Moreover, some PUFA, especially ALA and the LA/ALA ratio, exhibited an effective role as biomarker of health quality and could be used for traceability of feeding regime.

**Acknowledgements** This research was developed within the projects CANESTRUM CASEI (AGER2, 2017-1144).

**References**

Piluzza G., Sulas L., Bullitta S., 2014. Grass and Forage Science 69, 32–48.
Di Trana A., Bonanno A., Cecchini S., Giorgio D., Di Grigoli A., Claps S. 2015. Journal of Dairy Science 98, 37-46.

# Effect of grazing botanically-diverse pasture on the fatty acid profile and vitamin E content of beef

Michelle Kearns, Jean-Christophe Jacquier, Sabine M. Harrison, Raquel Cama-Moncunill, Tommy M. Boland, Helen Sheridan, Simona Grasso, Frank J. Monahan

*University College Dublin, Dublin, Ireland*

E-mail: michelle.kearns@ucdconnect.ie

**Take home Message** Grazing steers on low-input, botanically-diverse pasture improves the fatty acid profile of beef.

**Introduction** There is growing interest in biodiverse and sustainable pasture-based feeding systems for ruminants to improve the nutritional profile of beef (Leroy et al., 2018). Beef from pasture-fed animals is viewed as a healthier and more welfare-friendly alternative to feedlot-fed beef. Green forages are rich in desirable n-3 polyunsaturated fatty acids (PUFA) and natural antioxidants such as vitamin E resulting in increased levels for uptake into muscle. Therefore, the aim of this study was to determine the effect of grazing botanically-diverse pasture species on the fatty acid profile and vitamin E content of beef.

**Material and methods** Sixty Hereford x Holstein Friesian yearling steers were randomly allocated to one of three divergent pasture treatments (n = 20 per treatment); a monoculture (perennial ryegrass (PRG) (*Lolium perenne*)), a two-species pasture (perennial ryegrass and white clover (PRG+WC) (*Trifolium pratense*)) and a multi-species pasture ((MS) consisting of perennial ryegrass, timothy (*Phleum pratense*), white clover, red clover (*Trifolium repens*), chicory (*Cichorium intybus*) and plantain (*Plantago lanceolata*)). Following slaughter and postmortem ageing of muscle (*M. longissimus thoracis)*, α-tocopherol concentrations were determined by high performance liquid chromatography and fatty acid methyl esters (FAMEs) by gas chromatography. Statistical analysis involved a one-way analysis of variance (ANOVA) followed by Tukey's multiple-comparison test.

**Results** Total polyunsaturated fatty acid (PUFA) proportions were higher ($P < 0.01$) in the muscle of MS animals compared to PRG and PRG+WC, which did not differ (Table 1). C18:3n-3c and C18:2n-6c proportions were higher ($P < 0.01$) in the muscle of MS animals, compared to PRG+WC and PRG. The proportions of n-3 PUFA, highly-peroxidisable (HP) PUFA and the polyunsaturated : saturated fatty acid (PUFA:SFA) ratio were higher ($P < 0.01$) in muscle from MS animals compared to PRG animals, neither of which differed to PRG+WC animals. The proportion of n-6 PUFA and the n-6:n-3 ratio was higher ($P < 0.01$) in the muscle from MS compared to PRG and PRG+WC, which did not differ. a-Tocopherol concentrations were higher ($P < 0.05$) in muscle from PRG animals compared to muscle from MS animals, but neither were significantly different from the muscle of PRG+WC animals.

**Table 1** Fatty acid proportion and vitamin E content of M. longissimus thoracis muscle of steers grazing three different swards.

| | Pasture | | | | |
|---|---|---|---|---|---|
| FA % | PRG | PRG+WC | MS | SEM | P-value |
| C18:0 | 13.97$^{b}$ | 14.32$^{ab}$ | 15.07$^{a}$ | 0.318 | 0.05 |
| C18:1n9c | 38.70$^{a}$ | 36.35$^{b}$ | 35.17$^{b}$ | 0.589 | <0.01 |
| C18:2n-6c | 3.64$^{b}$ | 4.33$^{b}$ | 5.91$^{a}$ | 0.310 | <0.01 |
| C18:3n-3c | 0.82$^{c}$ | 1.12$^{b}$ | 1.56$^{a}$ | 0.058 | <0.01 |
| SFA | 45.79 | 47.01 | 46.43 | 0.628 | 0.40 |
| MUFA | 45.67$^{a}$ | 42.78$^{b}$ | 40.88$^{b}$ | 0.599 | <0.01 |
| PUFA | 8.56$^{b}$ | 10.22$^{b}$ | 12.72$^{a}$ | 0.721 | <0.01 |
| HP-PUFA | 4.47$^{b}$ | 5.34$^{ab}$ | 6.20$^{a}$ | 0.405 | <0.01 |
| n-6 | 5.58$^{b}$ | 6.54$^{b}$ | 8.47$^{a}$ | 0.499 | <0.01 |
| n-3 | 2.77$^{b}$ | 3.40$^{ab}$ | 3.93$^{a}$ | 0.209 | <0.01 |
| PUFA:SFA | 0.18$^{b}$ | 0.22$^{ab}$ | 0.27$^{a}$ | 0.019 | <0.01 |
| n-6:n-3 | 1.98$^{b}$ | 1.92$^{b}$ | 2.13$^{a}$ | 0.037 | <0.01 |
| a-Tocopherol (µg/g) | 3.20$^{a}$ | 2.70$^{ab}$ | 2.40$^{b}$ | 0.185 | <0.05 |

$^{a,b,c}$ different letters within a row indicate a significant difference ($P < 0.05$).
SEM = pooled standard error of the means.
PRG = perennial ryegrass; PRG+WC= perennial ryegrass + white clover; MS = multi-species.

**Conclusion** Grazing animals on botanically-diverse pasture affected the fatty acid profile and vitamin E content of the meat. Beef from animals grazing a botanically-diverse sward has a higher proportion of PUFAs and a lower concentration of α-tocopherol, and therefore may be more susceptible to oxidation, compared to beef from animals receiving perennial ryegrass or perennial ryegrass plus white clover.

**Acknowledgements** This study was supported by the "Smartsward" research project funded by the Irish Department of Agriculture, Food and the Marine (17S267).

**References**

Leroy G., Hoffmann I., From T., Hiemstra S.J., Gandini G. 2018. Animal 12**,** 2627-2638.

# Effect of cooling condition on milk performance in Saanen goats during the summer season

Mondina F. Lunesu, Maria F. Guiso, Paola Sau, Elisabetta Manca, Giuseppe Pulina, Anna Nudda

*University of Sassari, Sassari, Italy*

E-mail: mflunesu@uniss.it

**Take home Message** A short period of cooling did not modify milk production traits but slightly alleviated heat stress improving physiological response. However, a longer treatment period may be useful to observe an effect on milk production.

**Introduction** Heat stress is one of the most important stressors of small ruminant which can negatively influence productive and reproductive performance making animals more vulnerable to disease (Al Dawood, 2017). At farm level, heat stress causes long term effects inducing important economic losses. Among small ruminants, goats can tolerate better heat stress conditions than sheep (Silanikove, 2000). However, in Sardinia region this phenomenon occurs when Saanen goats are starting the mid lactation period or in a period in which milk production level is high. Since one of the most important strategies that can be better applied at farm level consists in the use of sheds, fans or evaporative cooling, the aim of this study was to evaluate the effect of the use of cooling on milk performance and physiological response in lactating Saanen goats.

**Material and methods** The study was conducted in a commercial dairy goat farm located in the northwest of Sardinia (Italy), during the summer season.A total of 20 Saanen dairy goats at 120 days in milk (DIM) were exposed to cooling (COO) or to heat stress (HS) conditions for 1 month. Animals were selected from a larger group to be homogeneous for milk production and body weight (BW). Data on environmental temperature and humidity were recorded throughout the experiment by two data loggers. Individual milk production and BW were recorded once a week. Individual milk samples were collected weekly and analysed for chemical components. Heart rate, rectal temperature and oxygen saturation (SpO2) were measured 4 times per week. Water and feed intake were also evaluated. Data were analysed by the PROC MIXED procedure for repeated measurements of SAS. The model included the effect of group, the effect of period and their interaction.

**Table 1** Animal performance and physiological response in lactating Saanen goats under cooling (COO) and heat stress (HS) conditions

| | Group | | | P-value[3] | | |
|---|---|---|---|---|---|---|
| Item[1] | COO | HS | SEM[2] | Group | Period | GxP |
| BW, kg | 64.17 | 6.15 | 3.52 | NS | ** | NS |
| Milk yield, kg/d | 3.41 | 3.30 | 0.33 | NS | NS | NS |
| Fat, % | 2.94 | 3.04 | 0.14 | NS | ** | NS |
| Protein, % | 3.23 | 3.33 | 0.15 | NS | ** | NS |
| Lactose, % | 4.44 | 4.41 | 0.07 | NS | NS | NS |
| SCC, log | 3.01 | 3.13 | 0.15 | NS | NS | NS |
| Rectal temperature, °C | 39.23 | 39.21 | 0.019 | NS | NS | NS |
| SpO2, % | 74.22 | 71.55 | 1.29 | * | NS | NS |
| Heart rate, beats/min | 74.73 | 74.25 | 3.06 | NS | NS | NS |

[1] BW = body weight; SCC = somatic cell count; SpO2 = oxygen saturation.
[2] SEM = standard error of the mean.
[3]GxP= group x period interaction.
*P < 0.05, **P < 0.01, ***P < 0.0001, NS = not significant.

**Results and discussion** The DMI did not differ between groups and, on average, was 2.86 kg/d. Water intake was numerically lowest in the COO group. Milk production and composition were not affected by the treatment.
Rectal temperature and hearth rate did not differ between groups. The COO group showed higher SpO2 evidencing a better response. The other blood haematological parameters did not differ between groups.

**Conclusion** Cooling treatment did not affect significantly milk yield in lactating Saanen goats. The lack of effect on milk performance was probably due to the short period of observation. For this motivation, future research is needed.

**Acknowledgments** The authors thank the Società Agricola Demontis E Scanu SS for making the farm and animals available.

**References**
Al-Dawood A. 2017. Annals of Animal Science 17, 59-88.
Silanikove N. 2000. Livestock Production Science 67, 1-18.

# Grass pea seeds as an alternative protein source for lambs in Mediterranean saline lands

Mouna Friha, Linda Majdoub-Mathlouthi

*Institut Supérieur Agronomique de Chott-Mariem, 4042, Université de Sousse, Tunisia*

E-mail: friha.mouna@gmail.com

**Take home Message** Grass pea seeds constitute a promising alternative protein source allowing the same growth and carcass performances for lambs, compared to soybean meal.

**Introduction** In arid and semi-arid Mediterranean regions, feed available from natural pastures becomes limited (Majdoub-Mathlouthi *et al*., 2021). For fattening lambs, the concentrate supplementation remains necessary. In Tunisia, the main concentrate constituents are frequently imported with continuous increase prices. Protein requirements are more difficult to cover because of higher prices of protein resources (Hajji *et al*., 2015). Soybean meal is the most used and expensive source of protein, thus the use of locally legumes constitutes a cost-effective. In the Mediterranean basin, especially in marginal areas, grass pea (*Lathyrus sativus* L.) is a promising legume since its tolerance to drought and high salinity (Hanbury *et al*., 2000). The objective of this study was to evaluate the effects of soybean meal substitution, by grass pea seeds on growth and carcass characteristics of lambs reared on natural saline rangeland.

**Table 1** Constituents of the experimental concentrates (%) and feed value (in raw material basis)

| Concentrate | Control | G30 |
|---|---|---|
| Maize | 15.9 | 9.3 |
| Barley | 30 | 25 |
| Wheat bran | 15 | 15 |
| Soybean meal | 11.6 | 3.2 |
| Alfalfa pellet | 23.5 | 13.5 |
| Grass pea | 0 | 30 |
| MVS | 4 | 4 |
| CP (%) | 15.14 | 15.14 |
| UFV (/kg) | 0.83 | 0.86 |

MVS: Mineral vitamin supplement; CP: Crude protein; UFV: Meat forage unit

**Material and methods** The experiment was conducted in a sheep farm in Kerkennah archipelago (semi-arid region of Tunisia). Thirty weaned female lambs from local breed Queue Fine de l'Ouest, aged 191±8 days were divided into two groups balanced for live weight (n=15). Animals were reared on 12 ha of natural saline pasture for 6 h daily and supplemented with concentrate (300 g/animal/day). The grass pea was dry cultivated next to the farm. The grass pea seeds inclusion level was 0 or 30% (on DM-basis) to obtain iso-proteic and iso-energetic concentrates which corresponds respectively to the Control and G30 group. Lambs were weighed every 21 days to determine average daily gain (ADG). After two months, eight lambs/treatment were slaughtered. Lambs were weighed (slaughter weights: SW) and then sacrificed. The red offals (heart, lungs, liver, kidneys and spleen) were weighed to determine their proportions relative to SW. Hot carcass weights (HCW) were taken and dressing percentages (DP) were determined. Carcasses were placed at 4°C for 24 h. Subcutaneous fat thickness was measured and perirenal fat was weighed. The right half carcasses were cut and proportions of high-priced cuts (leg+loin+shoulder) were calculated. The effect of the type of concentrate on performances was analyzed using STATISTICA (version 12, Stat Soft, USA). SEM was used as the error term. Differences between means were considered significant when $P < 0.05$.

**Results and discussion** No effect of the incorporation of grass pea on the live weight was noted (P>0.05). The mean final weight was of 31.87 kg. This result could be explained by a similar nutrient intake for the groups. Thus, a similar ADG was observed and averaged 189 g/d. HCW and DP were not affected by the incorporation of grass pea and averaged 13.44 kg and 52.29%, respectively. The percentage of red offals was similar (4,25% on average), indicating the absence of adverse effects of grass pea on animal health. The evaluation of carcass fatness demonstrated that source of nitrogen has no effect on subcutaneous (2.12 mm) and perirenal (128.31g) fats. High-priced joints percentages were also similar between treatments (61.04%; P>0.05).

**Table 2** Performances of lambs fed or not with grass pea seeds.

| | Control | G30 | SEM | P-value |
|---|---|---|---|---|
| | n=15 | | | |
| Initial weight (kg) | 22.13 | 21.40 | 0.324 | 0.357 |
| Final weight (kg) | 32.20 | 31.53 | 0.394 | 0.196 |
| Average daily gain (g) | 188 | 190 | 3.683 | 0.304 |
| | n=8 | | | |
| Slaughter weight (kg) | 29.44 | 29.81 | 0.354 | 0.665 |
| Hot carcass weight (kg) | 13.30 | 13.57 | 0.182 | 0.846 |
| Dressing percentage (%) | 52.00 | 52.57 | 0.639 | 0.693 |
| Red offals (%) | 4.12 | 4.37 | 0.071 | 0.244 |
| Subcutaneous fat thickness (mm) | 1.90 | 2.33 | 0.209 | 0.454 |
| Perirenal fat weight (g) | 128.98 | 127.64 | 10.369 | 0.415 |
| High-priced cuts (%) | 60.71 | 61.37 | 0.391 | 0.668 |

**Conclusion** Grass pea seeds can be used as a source of nitrogen at a level of 30% for partial substitution to soybean meal and to reduce the quantities of maize, barley and alfalfa pellet which are also imported, without negative effects on growth and carcass performances of grazing lambs.

**References**

Hajji H., Smeti S., Ben Hamouda M., Atti N. 2015. Animal Production Science 56, 2115-2121.
Hanbury C.D., White C.L., Mullan B.P., Siddique K.H.M. 2000. Animal Feed Science and Technology 87, 1-27.
Majdoub-Mathlouthi L., Hamdi H., Kraiem K. 2021. Springer Cham, 291-307.

# Technical solutions for better storage of Prickly pear fruit by-products

Riccardo Gannuscio[1], Alessandro Vastolo[2], Giuseppe Maniaci[1], Antonino Di Grigoli[1], Maria Luisa Scatassa[3], Massimo Todaro[1]

[1]*Department of Agricultural, Food and Forest Science (SAAF), University of Palermo*
[2]*Department of Veterinary Medicine and Animal Production, University of Federico II, Napoli*
[3]*Istituto Zooprofilattico Sperimentale della Sicilia, Palermo*

E-mail: riccardo.gannuscio@unipa.it

**Take home Message** Prickly pear fruit by-products hold promise as an alternative feed source for livestock.

**Introduction** The use of agro-industrial by-products as animal feed represents an important component of the global strategy to reduce the environmental impact of agro-industrial and to increase livestock production. The use of some by-products as animal feed has been explored and could represent a socio-economic advantage in order to reduce the competition for food directly consumable by humans. By-products are commonly used in the animal feed industry due to their high nutritional value, being rich in fiber or protein, and bioactive molecules. Prickly pear by-product (PPB), obtained from processing of juice extraction of *Opuntia ficus-indica* (L.) fruits, could be an interesting by-product for ruminant feeding. However, PPB, as several by-products, are subject to seasonality and some of these are difficult to store. This paper reports the results obtained from two preliminary investigations with the aim to enhance the PPB storage aptitude.

**Material and methods** The aim of the first study was to evaluate the nutritional characteristics of PPB and its stability during a 21-days of outdoor storage. The potassium metabisulfite (PMB), as natural stabilizer, was added to the PPB at different doses (0, 50, 100, and 150 g/kg). Samples of treated PPB were analysed at days 1, 3, 7, 14, and 21 for chemical composition and microbiological profile (Todaro et al., 2020). In the second study, PPB was ensiling with different levels of wheat straw (0, 5, and 10% as fed). After 35 days of storage, from 4 micro-silages for each thesis, samples were collected and analysed for composition and fermentation kinetics using the *in vitro* gas production technique (Vastolo et al., 2020).

**Results and discussion** The fractioning of PPB showed that it contained 28% of peel and pulp and 72% of seeds on a DM basis. This new by-product is low in moisture and protein when compared to other fresh by-product available in Sicily for ruminant feeding, such as fresh lemon pulp. Overall, PPB was low in crude protein (CP, 5.3% DM), high in fiber (51.4%, 41.2% and 14.6% DM for NDFom, ADFom and ADL, respectively), non-fiber carbohydrates (NFC, 29.7% DM), and soluble sugars (13.3% DM), with a moderate level of net energy for lactation (4.59 MJ/kg DM). In the first study, the storage time was responsible for the decline, during the first week, of NFC and soluble sugars, mainly due to fermentation activity, and then it stopped. The same trend was observed for the pH values during the first week, which subsequently showed a substantial increase at day 21, presumably due to a deacidification following the use of acid lactic for microbial growth. On this basis, the use of PMB at doses of 100 and 150 g/kg was able to slightly slow down the early phase of the acidification process and limit the presence of spoilage microorganisms, coliforms and *Enterobacteriaceae* after a three-weeks storage period. The second study showed that PPB silage with the addition of wheat straw guaranteed the preservation of NFC and CP, indicating a potential reduction in losses due to leachate. PPB silage showed good ensiling parameters (Table 1), especially when 5% of straw is added: significantly lower pH and ammonia nitrogen concentration. Furthermore, comparing the three PPB silages, the inclusion of 5% of straw seems to guarantee higher fermentability (organic matter disappearance, OMD, and cumulative volume of gas related to incubated organic matter, OMCV) and volatile fatty acids production.

**Table 1** Micro silos evaluation and chemical composition of prickly pears by-products (PPB) silages.

| Parameters | | PPB Silage: Straw Percentages | | |
|---|---|---|---|---|
| | | 0% | 5% | 10% |
| DM | % | 27.68±0.42 | 26.46±0.27 | 28.42±0.27 |
| pH | | 3.99 ± 0.01 $^{A}$ | 3.85 ± 0.01 $^{C}$ | 3.96 ± 0.01 $^{B}$ |
| N-$NH_3$ | % TN | 14.10±0.18 $^{B}$ | 13.29±0.12 $^{C}$ | 15.24±0.12 $^{A}$ |
| CP | % DM | 6.91 ± 0.14 $^{A}$ | 6.68 ± 0.09 $^{A}$ | 6.40 ± 0.09 $^{B}$ |
| Ether extract | “ | 6.13±0.39 $^{AB}$ | 6.97 ± 0.25 $^{A}$ | 5.30 ± 0.25 $^{B}$ |
| NDFom | “ | 61.12±0.38 $^{A}$ | 59.50±0.24 $^{B}$ | 60.69±0.24 $^{A}$ |
| ADFom | “ | 48.39±0.51 | 48.57±0.33 | 49.34±0.33 |
| ADL | “ | 14.68±0.21 $^{A}$ | 13.86±0.14 $^{B}$ | 12.98 ± 0.14 $^{C}$ |
| OMD | % | 45.09±1.00 $^{C}$ | 56.10±0.65 $^{A}$ | 50.36±0.65 $^{B}$ |
| OMCV | ml/g | 132.7±5.28 $^{B}$ | 206.5±3.41 $^{A}$ | 211.9±3.41 $^{A}$ |

**Conclusion** Prickly pear fruit by-product could be a very interesting diet ingredient for ruminants. PPB seems to be an important nutrients’ resource suitable to increase the economic value and the environmental sustainability of livestock farming as well as giving added value to dairy products. The results obtained with the use of PMB showed that this by-product is able to control the fermentation process and the presence of alterative microorganisms, but also the difficulty to obtain a homogeneous distribution in the by-product mass. Instead, ensiling PPB with wheat straw is an appropriate storage technique to preserve the nutritional characteristics of PPB. Further studies are necessary to evaluate alternative conservation methods.

**References:**

Todaro M., Alabiso M., Di Grigoli A., Scatassa M. L., Cardamone C., Mancuso I., Mazza F., Bonanno A. 2020. Animals, 10, 949.
Vastolo A., Calabrò S., Cutrignelli M. I., Raso G., Todaro M. 2020. Animals 10, 1716.

# Effects of bitter vetch and sorghum grain incorporation on goat kid carcass and meat quality

Soumaya Boukrouh[1,2], Jean-Luc Hornick[1], Ali Noutfia[2], Claire Avril[3], Mouad Chentouf[2], Jean-François Cabaraux[1]

[1]*Department of veterinary management of animal resources, FARAH, IVT, Faculty of Veterinary Medicine, ULiège. Liège, Belgium*
[2]*INRA, Regional research of Tangier. Tangier, Morocco*
[3]*HEPH Condorcet, agronomy category. Mons, Belgium*

E-mail: s.boukrouh@uliege.be

**Take home Message** bitter vetch and sorghum grains can substitute fava bean and barley, respectively in the diet of goat kids in Northern Morocco.

**Introduction** In Northern Morocco, goat production is an important economic activity for rural population providing more than 68 % of the income. Bitter vetch (*Vicia ervilia*) is an ancient grain legume crop of the Mediterranean region grown and harvested to utilize its grains and hay in ruminant feeding (Sadeghi et al., 2009). Its grains are potentially valuable feed for ruminants as a source of protein (Larbi et al., 2011). Sorghum (Sorghum bicolor L. Moench) is cultivated worldwide and is an important crop for food and feed. In Morocco, sorghum is considered a minor cereal (Ater and Hmimsa, 2006), but efforts are made nowadays to add value to underexploited feed resources.
This study aimed to evaluate the effects of incorporating sorghum or bitter vetch grains in the diet of goat kids as a substitute for a local diet based on barley and fava bean.

**Material and methods** Thirty-six goat kids were allocated into three homogeneous groups and received an isonitrogenous and isoenergetic diet containing 50% oat hay and, respectively, either 30 % bitter vetch and 19% barley, 30% fava bean and 19% sorghum, or 30% fava bean and 19% barley (control diet).
The experiment lasted 90 days and was preceded by an adaptation period of 15 days. Diet's ingredients were ground, mixed, and provided as a total mixed ration twice a day, at 8:00 AM and 4:00 PM. Water was provided ad libitum. The refusals were collected and weighed daily to determine daily dry matter intake (DMI, g/d) and to adjust the quantities distributed to allow 10 % refusals. The average daily gain was calculated by the difference between the initial and final live body weights divided by the number of days in the trial period. At the end of the trial, and after a 24-h fasting period, animals were weighed and slaughtered.
Fasted body weight, chilled body weight, hot carcass weight, and empty body weight were measured to characterize carcass quality. Longissimus Dorsi and Semimembranosus Muscles were used to determine meat quality. The factors were tested by generalized linear models (GLM). Growth performance, slaughter and carcass measurements were compared using one-way analysis of variance. Meat quality results were compared according to a mixed model.

**Results and discussion** Diet had no significant effect on average daily gain weight, final hot and chilled carcass weight even if daily dry matter intake was significantly lower for bitter vetch group. This result could be attributed to efficiency of use of diet components. Diet had significantly affected carcass colour. No significant effect was observed on Belly and tail outline. However, at back and saddle, lightness, redness and yellowness indices were significantly different.
The back of carcasses of animals that received bitter vetch were lighter than control and redder than sorghum. The group that received sorghum was less yellow than control, probably due to low accumulation of fat. At saddle, sorghum was lighter and less red than control. This could be due to the oxidation of myoglobin to metmyoglobin (Calnan et al., 2016). Regarding muscles (Longissimus Dorsi and semimembranosus) characteristics, no effect on moisture was recorded however pH, colour, water retention capacity and ash content were significantly affected.

**Conclusion** Bitter vetch and sorghum grains can be introduced into goat kid diets without any negative effect on carcass and meat quality. Investigations on meat fatty acids are needed to characterize the effects of diets on goat kid meat.

**Acknowledgements** This study was by financed by the "ARES" "Academy de recherche et d'enseignement supérieur" of Belgium.

**References**
Ater M., Hmimsa Y. 2006. In Proceedings of the MEDCORE International Conference Florence, 10-14.
Calnan H., Jacob R.H., Pethick D.W., Gardner G.E. 2016. Meat Science 119, 41-50.
Larbi A., El-moneim A.M.A., Nakkoul H., Jammal B., Hassan S., 2011. Animal Feed Science and Technology 165, 278–287.
Sadeghi G.H., Pourreza J., Samei A., Rahmani H., 2009. Tropical Animal Health and Production 41, 85–93.

# Evaluation of *Lupinus albus* L. cultivars and advanced lines as a feed in ruminants nutrition

Zoi M. Parissi[1], Maria Irakli[2], Apostolos P. Kyriazopoulos[3], Apostolia-Theodora Drakopoulou[1], Eleni M. Abraham[1]

[1]*Laboratory of Range Science (236), Faculty of Forestry and the Natural Environment, AUTh, 54124 Thessaloniki, Greece*
[2]*IPB&GR Central Unit Thermi, Thessaloniki, Greece*
[3]*Department of Forestry and Management of the Environment and Natural Resources, DUTh, 193 Pantazidou str., 68200 Orestiada, Greece*

E-mail: pz@for.auth.gr

**Take home Message** Further research in breeding programmes of *Lupinus albus* populations is needed in order to diminish anti- nutritional factors as alkaloids

**Introduction** Soybeans is the main source of protein in animal feeding in the European Union. This makes the livestock sector directly dependent on global soybean trade and therefore particularly vulnerable (Abraham et al 2019). *Lupinus albus* (white lupin) could be an alternative source of protein in animal feeding that can replace soybean meal without loss in production and quality of animal products (Sedláková et al 2016). The protein content of its seeds is high and comparable to that of soybean. Inversely, the presence of quinolizidine alkaloids is the main antinutritional factors that prevent their use in animal feeding. The aim of the present study was to evaluate the nutritive value and the content of total alkaloids of commercial cultivars and advanced lines of *Lupinus albus*.

**Material and methods** Seeds of nine commercial cultivars of white lupine (Orus, Sulimo, Ulysse, Figaro, Amiga, Multi Italia, Magnus, Fas Sweet, Estoril) and three advanced lines obtained by the company AGROLAND SA (LKAU, LKML,LKAP,) were analysed for their nutritive value, and the antinutrional actor like alkaloids. The ground samples of seeds were analyzed for N using the Kjeldahl procedure (AOAC, 2002). After that, Crude Protein (CP) was calculated by multiplying the N content by 6.25. The Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) contents were determined according to the methods of Van Soest et al. (1991) using an ANKOM 220 fiber analyzer. Moreover, Total alkaloids were determined using the method outlined by Fadhil et al. (2007).

**Results and discussion** Significant differences among the cultivars and the advanced lines were detected for the total alkaloids as well as for all the nutritional traits except the ADL content (Table 1). The total alkaloids were significantly lower in the commercial cultivars compared to advanced lines with only exception for Multi Italia, which is one of the most common used cultivars in Greece. On the other hand, the advanced line LKML showed higher CP content compared to the others. Generally, the CP and fiber content were relatively high and low respectively and within the ranges that referred in the literature for white lupin (Musco et al 2017).

**Table 1** Chemical composition (g/kg DM) and alkaloids content (%) in seeds of *L. albus* cultivars and advanced lines

| Species | Genotypes | Total alkaloids (%) | CP | NDF | ADF | ADL |
|---|---|---|---|---|---|---|
| Cultivars | Orus | 0,020 $^{ef*}$ | 340$^{de}$ | 209$^{cde}$ | 143$^{c}$ | 8 |
| | Sulimo | 0,054 $^{d}$ | 384$^{c}$ | 216$^{c}$ | 138$^{cd}$ | 9 |
| | Ulysse | 0,004 $^{f}$ | 334$^{de}$ | 233$^{b}$ | 167$^{b}$ | 9 |
| | Figaro | 0,009 $^{ef}$ | 460$^{b}$ | 209$^{c}$ | 134$^{d}$ | 9 |
| | Fas Sweet | 0,035 $^{de}$ | 387$^{c}$ | 193$^{g}$ | 125$^{cd}$ | 8 |
| | Estoril | 0,025 $^{ef}$ | 322$^{e}$ | 200$^{fg}$ | 134$^{cd}$ | 6 |
| | Magnus | 0,015 $^{ef}$ | 310$^{e}$ | 257$^{a}$ | 185$^{a}$ | 12 |
| | Amiga | 0,004 $^{f}$ | 376$^{cb}$ | 204$^{ef}$ | 135$^{e}$ | 9 |
| | Multi Italia | 0,286 $^{bc}$ | 365$^{cb}$ | 217$^{c}$ | 140$^{ed}$ | 10 |
| Advanced lines | LKAU | 0,267 $^{bc}$ | 373$^{cb}$ | 207$^{def}$ | 141$^{cd}$ | 9 |
| | LKML | 0,325 $^{a}$ | 528$^{a}$ | 209$^{cde}$ | 140$^{cd}$ | 9 |
| | LKAP | 0,261 $^{bc}$ | 309$^{e}$ | 213$^{cd}$ | 142$^{cd}$ | 10 |

**Conclusion** According to the results, the nutritive value of white lupin varied widely among the studied cultivars and the advanced lines, indicating potential for further improvement and further use in animal feeding. .

**Acknowlegments:** Co-financed by the European Regional Development Fund of the European Union and Greek national funds under the call RESEARCH–CREATE–INNOVATE (project code: T1EDK-04448)".

**References**

Abraham E.M., Ganopoulos I., Madesis P., Mavromatis A., Mylona P., Nianiou-Obeidat I., Parissi Z., Polidoros A., Tani E., Vlachostergios, D. 2019. International Journal of Molecular Sciences 20(4), 851.
AOAC. 2002. 17th ed. Association of Official Analytical Chemists. Washington DC.
Fadhil S., Reza M.H., Rouhollah G., Reza V.R.M. 2007. Research Journal of Phytochemistry 1, 79-82.
Musco N., Cutrignelli M.I., Calabrò S., Tudisco R., Infascelli F., Grazioli R., Lo Presti V., Gresta F., Chiofalo B. 2017. Journal of Animal Physiology and Animal Nutrition 101(6), 1227-1241.
Sedláková K., Straková E., Suchý P., Krejcarová J., Herzig I. 2016. Acta Veterinaria Brno 85, 165–175.
Van Soest, P.J., J.B., Robertson and B.A. Lewis. 1991. Journal of Dairy Science 74, 3583–3597.

# Effect of feed and grazing season on characteristics of Sicilo-Sarde ewes' milk and ripened cheese

Waâd Nasri[1, 2], Ilyes Mekki[1], Gerasimos Papakitsos[3], Theofilos Massouras[3], Samir Smeti[1], Naziha Atti[1]

[1]*University of Carthage, National Institute of Agronomic Research of Tunisia, Laboratory of Animal and Forage Productions, 2049 Ariana, Tunisia*
[2]*University of Carthage, National Agronomic Institute of Tunisia, 1082 Tunis, Tunisia*
[3]*Agricultural University of Athens, Department of Food Science & Human Nutrition, Laboratory of Dairy Research, 11855 Athens, Greece*

E-mail: waad.nasri@gmail.com

**Take home Message** A diet based on sulla, ryegrass and beet pulp improves the composition of ewes' milk and cheese. The late spring cheese has a healthier fatty acid profile than that of other seasons.

**Introduction** Feeding effects were shown on animal products' quality (Bonanno et al., 2016). Sheep farming, rooted in Mediterranean traditions, is mostly based on extensive grazing. Thereby, milk and cheese largely depend on climatic conditions influencing the pasture (Todaro et al., 2014). Interest in health effects of products from grazing ruminants has been increasing. This work aims to study the feeding impact through the effect of different dairies and seasons on fat and protein contents of milk and ripened pressed cheese of Sicilo-Sarde ewes in Tunisia with focus on cheese fatty acid (FA) profile.

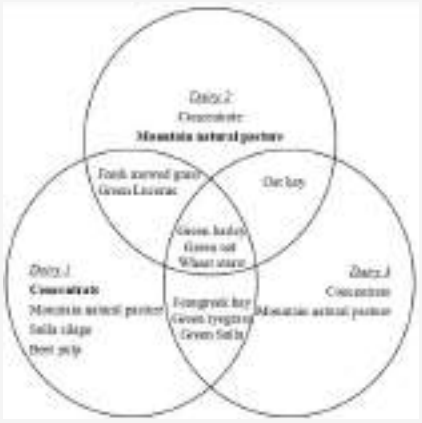


**Figure 1** Feeding of the ewes in the farms corresponding to the dairies

**Material and methods** Three dairies (D) processing Sicilo-Sarde milk were selected. Thirty-six, two months, ripened pressed cheese samples were collected: four from each dairy during three seasons: winter (ewes were mostly fed indoors and partially grazing: S1), early spring (more grazing than indoors feeding: S2) and late spring (grazing and reduced indoors feeding: S3). Three samples of bulk milk used to make each cheese trial were collected. Feeding details are in Figure 1. Milk and cheese were analyzed for fat and protein using MilkoScan 120 and FoodScan (Foss Electric), respectively. The cheese lipid extraction was carried out by a gravimetric method then FA methyl esters were analyzed according to Massouras et al. (2018). Data were analyzed using SAS 9.1 software. Analysis of variance using GLM procedure was carried out considering two factors: season, dairy and their interaction. Means were compared by Duncan test.

**Results and discussion** D1 milk was richer in fat and protein than D2 and D3; this is probably due to D1 diet (sulla, ryegrass, beet pulp). The increase of milk fat during S3 can be explained by consumption of fibrous forage and the late lactation stage. Milk composition was significantly affected by the interaction of dairies and season. D1 and S3 cheese had the highest contents in fat and the lowest in protein. Higher contents of milk fat leads to increase fat and lower protein in cheese (Bonanno et al., 2016). The high fat content in S3 cheese could also be linked to the fibrous feed in warm season (Todaro et al., 2014). FA profile improved from S1 to S3 (higher CLA and PUFA percentages, higher PUFA/SFA and UFA/SFA and lower n6/n3 ratios). Todaro et al. (2014) also reported a healthier FA profile for summer cheese comparing to spring cheese.

**Table 1** Effect of dairy and season on some properties of Sicilo-Sarde ewes' milk and cheese

| | Parameter | Dairy | | | Season | | | SEM | P-values | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | D1 | D2 | D3 | S1 | S2 | S3 | | D | S | D*S |
| Milk | Fat (g/kg) | 74.09$^{a}$ | 64.83$^{b}$ | 62.50$^{c}$ | 64.73$^{c}$ | 66.32$^{b}$ | 70.37$^{a}$ | 0.104 | <0.001 | <0.001 | <0.001 |
| | Protein (g/kg) | 58.01$^{a}$ | 51.67$^{c}$ | 56.63$^{b}$ | 55.06$^{b}$ | 56.64$^{a}$ | 54.61$^{c}$ | 0.112 | <0.001 | <0.001 | <0.001 |
| Cheese | Fat (g/kg) | 31.76$^{a}$ | 30.89$^{ba}$ | 30.30$^{b}$ | 30.48$^{b}$ | 29.15$^{c}$ | 33.32$^{a}$ | 0.397 | 0.040 | <0.001 | <0.001 |
| | Protein (g/kg) | 29.78$^{b}$ | 30.27$^{ba}$ | 31.33$^{a}$ | 31.94$^{a}$ | 31.14$^{a}$ | 28.30$^{b}$ | 0.387 | 0.019 | <0.001 | 0.003 |
| | CLA % | 0.73$^{b}$ | 0.83$^{a}$ | 0.79$^{ba}$ | 0.60$^{b}$ | 0.85$^{a}$ | 0.90$^{a}$ | 0.026 | 0.072 | <0.001 | 0.031 |
| | PUFA % | 5.27 | 5.30 | 5.60 | 4.91$^{b}$ | 5.29$^{b}$ | 5.96$^{a}$ | 0.121 | 0.162 | 0.001 | 0.221 |
| | PUFA/SFA | 0.08 | 0.08 | 0.08 | 0.07$^{b}$ | 0.08$^{b}$ | 0.09$^{a}$ | 0.002 | 0.683 | 0.001 | 0.646 |
| | UFA/SFA | 0.44 | 0.43 | 0.39 | 0.39$^{b}$ | 0.40$^{ba}$ | 0.47$^{a}$ | 0.020 | 0.326 | 0.054 | 0.741 |
| | n6/n3 | 6.08$^{b}$ | 6.18$^{b}$ | 8.27$^{a}$ | 8.15$^{a}$ | 6.63$^{ba}$ | 5.75$^{b}$ | 0.541 | 0.031 | 0.034 | 0.122 |

D: Dairy; S: Season; SFA: saturated FA; MUFA: monounsaturated FA; PUFA: polyunsaturated FA.

**Conclusion** Grazing sulla and ryegrass, sulla silage and beet pulp increase milk's fat and protein and cheese's fat. Production of late spring cheese ensures healthier FA profile comparing to other seasons.

**Acknowledgements** This study was financed by the Tunisian Ministry of Higher Education and Scientific Research.

**References**

Bonanno A., Di Grigoli A., Mazza F., De Pasquale C., Giosuè C., Vitale F., Alabiso M. 2016. Animal 10(12), 2074–2082.
Massouras T., Maragoudakis S., Hadjigeorgiou I. 2018. Archives of Dairy Research and Technology 2018(01), 1–12.
Todaro M., Bonanno A., Scatassa M. L. 2014. Dairy Science and Technology 94(3), 225–239.

# Effect of ewes' body weight and body condition score at mating on reproductive parameters of Tunisian sheep breeds

Yathreb Yagoubi[1], Samir Smeti[1], Mohamed Raguem[2], Mokhtar Mahouachi[3], Samia Ben Saïd[3], Aziza Mohamed[3], Naziha Atti[1]

[1]*National Institute of Agronomic Researches of Tunisia (INRAT)), Ariana, Tunisia*
[2]*Office de l'élevage et des Pâturages de Tunisie, Tunis, Tunisia*
[3]*Ecole Supérieure d\'Agriculture du Kef (ESAK), Kef, Tunisia*

E-mail: yagoubiyathreb@hotmail.fr

**Take home Message** Body weight and body condition score of ewes could affect the fertility and prolificacy of the Tunisian sheep flock.

**Introduction** Body condition score is an important indicator of animal's body reserves that helps to adjust the nutritional program of herds at different stages of production and especially to maximize reproductive efficiency as it reflects the body reserves available for growth, pregnancy and lactation mainly when it was established that the fertility is negatively affected by body condition loss (Nazhat et al., 2021). For that this study was conducted to evaluate the effect of ewes' body condition score on reproductive parameters for two Tunisian sheep breeds: The Queue Fine de l'Ouest and fat-tailed Barbarine which is characterized by an additional site of reserves in the caudal level to overcome food shortage during hard conditions.

**Material and methods** The present study, was carried out during 2 consecutive years and performed on 2 flocks reared under semi-intensive conditions in Sawef farm of the "Office de l'élevage et des pâturages of Tunisia". They were from the fat-tailed Barbarine (BB) and Queue Fine de l'Ouest (QFO) breeds with 170 and 140 ewes selected for each breed during year 1 and year 2, respectively. All ewes grazed rangeland and stubble hay and received concentrate as complementation. The production system was based on a once-a-year mating period, beginning, out of season, on late April- early May and lasting 3 months. The ewes began to lamb in October and suckled their lambs during 4 to 5 months. All ewes were weighed and scored on lumbar and caudal levels just before the mating. Both measurements are graded on a 5-step scale [1= thin, 5= fat] and were performed by 2 trained technicians and an average score was adopted. A correlation test between ewes' mating body weight and BCS and reproduction parameters was performed.

**Table 1.** Characteristics of ewes at early mating and reproduction parameters according to flock and year

| Flock | Year | Body weight (kg) | Body condition score | | Fertility (%) | Prolificacy (%) |
|---|---|---|---|---|---|---|
| | | | Lumbar score | Caudal score | | |
| Barbarine | 1 | 42.7 ± 4.62 | 1.66 ± 0.4 | 2.24 ± 0.69 | 76.8 | 114 |
| Barbarine | 2 | 45.7 ± 4.16 | 1.44 ± 0.34 | 2.18 ± 0.72 | 78.9 | 113 |
| QFO | 1 | 47.2 ± 5.71 | 1.96 ± 0.95 | . | 82.1 | 116 |
| QFO | 2 | 43.2 ± 5.49 | 1.66 ± 0.25 | . | 76.5 | 108 |

**Results and discussion** Average ewes' body weights (BW) and body condition scores (BCS) during two years and the corresponding reproduction parameters are reported in Table 1. Considering the range of BCS, 25 % of ewes had low BCS (<1.5), 50 % a middle BCS (1.5-2.25) and 25 % a high BCS (>2.25). For BB flock, body condition scores at lumbar and caudal levels decreased in the 2nd year, while the body weight increased, which probably enhanced the fertility (76.8% vs. 78.9%). The prolificacy was similar among both years. For the QFO flock, ewes showed losses in body weight and lumbar score in the 2nd year, which consequently affected the fertility and the prolificacy that decreased from 82.1 to 76.5 % and from 116% to 108%, respectively. For Barbarine ewes, the fertility rates are lower than those (85%) reported by Khaldi (1989) and Yagoubi and Atti (2018) for the same breed (85%). Similarly, for prolificacy, the rates recorded in the current study, were lower than those reported by Khaldi (1989) which are around 119%. This may be due to poor body condition at mating and not application of flushing, given ewes properly fed before and during the mating period will be relatively more prolific than those that are underfed (Atti et al., 2001). For Barbarine flock, the correlation test between ewes' mating body weight and BCS and reproduction parameters showed a positive but non-significant correlation among BW and BCS and fertility and prolificacy. However, for QFO flock, the correlation among these parameters was positive and significant.

**Conclusion** During both years, mating was conducted in similar climatic and nutritional conditions for both flocks, however a slight difference in fertility and prolificacy was noted between both breeds and within the same breed across the years of control according to body condition score changes.

**Acknowledgements** This study was supported by the "National Agency of Scientific Research promotion of Tunisia (ANPR)", as a part of PRIMA-H2020 Adapt Herd project.

**References**

Atti N., Thériez M., Abdennebi L., 2001. Animal Research 50, 135-144.
Khaldi G., 1989. FAO, Animal Production Heath Paper 74, 96–135.
Nazhat S.A., Aziz A., Zabuli J., Rahmati S. 2021. Open Journal of Veterinary Medicine 11(7), 272-288.
Yagoubi Y., Atti N. 2018. Journal of New Sciences, Agriculture and Biotechnology 59 (3), 3806-3815.

# Nutritional evaluation of natural pasture grazed by Bagnolese sheep in Campania Region

Alessandro Vastolo[1], Dieudonnè Kiatti[1,2], Ivan B. Koura[2], Emanuele D'Anza[1], Serena Calabrò[1]

[1]*Department of Veterinary Medicine and Animal Production, University of Napoli, Federico II, Napoli, Italy*
[2]*Ecole de Gestion et d'Exploitation des Systèmes d'Elevage, Université Nationale d'Agriculture, Ketou, Benin*

E-mail: serena.calabro@unina.it

**Take home Message** Natural pastures grazed by Bagnolese sheep are important to support the local economy, protect marginal land and improve cheese quality. Our findings revealed some interesting forage species; with a relatively high crude protein content (25.2 % DM) and energy level ($NE_l$: 1.44 Kcal/kg DM).

**Introduction** The Bagnolese sheep, bred in the Campania Region for milk/meat production, has officially registered 200,000 heads (https://www.agraria.org/ovini/bagnolese.htm), of which 34% in Avellino province. The milk (130-150 L in 210 days of lactation) is used for the production of Pecorino Bagnolese cheese, one of the local traditional agri-food products (PAT). The animals are reared in a semi-extensive system, grazing natural mountain and hill pastures in summer and lowland pastures in winter. In the event of severe adverse weather conditions or when necessary (e.g., lactation, fattening) the ration is supplemented with concentrate. To consolidate the 'breed-territory-product' link, improving pastures and evaluating the nutritional characteristics that can be transmitted to the cheese is very important. This study reports preliminary results relating to the botanical and nutritional characterization of the forages collected in areas grazed by the Bagnolese sheep.

**Material and methods** The sample collection was carried out two times from June to October in 2021, in hilly areas (about 1200 m above sea level) in Caposele (AV) where the pilot farm of the SAVEPEB project is located, and animals grazed in summer. The farm raises 130 heads of Bagnolese sheep (about 100 lactating females), with average milk production per sheep of 500 mL/d. The botanical evaluation was carried out on the forage samples, randomly collected in the identified grazing areas, before drying (in an oven at 65 ° C for 24 hours). The samples were then ground with a 1.0-mm screen and analysed for chemical composition (AOAC, 2015) and structural carbohydrates fraction (Van Soest et al., 1991). Net Energy for lactation was also estimated (INRA, 1988).

**Table 1** Nutritional evaluation of natural pasture (N = 11)

| | Average | Min | Max | SD |
|---|---|---|---|---|
| Dry matter, % | 32.6 | 23.1 | 54.4 | ± 12.2 |
| Crude protein, %DM | 15.7 | 5.59 | 25.2 | ± 5.95 |
| Ether extract, % DM | 2.50 | 1.72 | 3.08 | ± 0.49 |
| NDF, % DM | 50.6 | 35.5 | 68.5 | ± 10.5 |
| ADF, % DM | 34.3 | 21.9 | 42.5 | ± 6.38 |
| ADL, % DM | 7.86 | 2.49 | 11.5 | ± 2.54 |
| Ash, % DM | 9.91 | 8.27 | 11.2 | ± 1.04 |
| $NE_l$, Kcal/kg DM | 1.12 | 0.98 | 1.44 | ± 0.14 |

**Results and discussion** Most of the forage collected are from polyphite natural pasture, where Leguminosae (*Trifolium* spp., *Medicago sativa* L.) and Graminacea (*Pocacee* spp., *Eragrostis spectabilis*, *Dactilis glomerata*) families are the most represented and homogeneously distributed (40 and 36 %, respectively). However, other species were identified in variable amounts (from 7.8 to 38.8%). The chemical composition shows that the protein content can reach relatively high value (25.2 % DM), as well as energy level ($NE_l$: 1.44 Kcal/kg DM). As a whole, the structural carbohydrates' fractions (NDF: 68.5 % DM) appear on slightly higher compared to other investigation on natural pasture in Mediterranean area (Molle et al., 2007). Protein and ADL resulted the most variable parameters (coefficient of variation 0.38 and 0.32, respectively), maybe due to the penological stage of the plants at the sampling time or to the botanical families present.

**Conclusion** This previous results indicate some variability in pasture grazed by Bagnolese sheep. In order to improve the cheese quality more complete characterization need to carry out. The *in vitro* fermentation characteristics and degradability of the forages, including the nutraceutical aspects (i.e. fatty acids profile) that are still being processed, will contribute to this aim. The season variation will also be considered.

**Acknowledgements** The study was supported by research project PSR Campania 2014/2020 Misura 19: Salvaguardia dell'ambiente e valorizzazione economica della Pecora Bagnolese (SAVEPEB).

**References**

AOAC. 2015. Official Methods of Analysis, 20th ed. Gaithersburg, MD, USA.
INRA, 1988. Alimentation des bovins, ovins et caprins. Ed. R. Jarrige, INRA, Paris.
Molle G., Cabiddu A., Decandia M. 2007. Italian Journal of Animal Science 6:sup1, 235-243.Van Soest P.J., Robertson J.B., Lewis B.A. 1991. Journal of Dairy Science 74, 3583–3597.

# Effect of incorporating different levels of cactus *Opuntia Ficus-indica* L. seed cake on fattening performance, feed cost and meat quality of sheep

Brahim Yassine[1,2,4], Mohammed Benbati[2], Kaoutar Elfazazi[3], Kaoutar Elidrissi[4], Abdelhafid Keli[4], Mohammed Diouri[1]

[1]*Biology Department, Moulay Ismail University, BP 11201 Zitoune, 50070, Meknès, Morocco*
[2]*Laboratory of Animal Nutrition, Regional Center for Agricultural Research in Tadla, National Institute for Agricultural Research, INRA, Beni Mellal, Morocco*
[3]*Laboratory of Food Science and Technology, Regional Center for Agricultural Research in Tadla, National Institute for Agricultural Research, INRA, Beni Mellal, Morocco*
[4]*Departement of Animal Production and Pastoralism, Ecole Nationale d'Agriculture de Meknes, Morocco*

E-mail: yassinebra.onca@gmail.com / benbati74@gmail.com

**Take home Message** The cactus is considered a miracle food for the population of arid areas and even a means of social stability, it is used either for sale and consumption of fruits, cosmetics and food for small ruminants.

**Introduction** In Morocco, pasture is available only for short periods or is not available at all. In addition, the succession of drought years has made it increasingly difficult to feed and maintain ruminant livestock; and the use of cereals and compound feeds in diets has become very expensive. The use of prickly pear cake in the feed of small ruminants is not common in small ruminant farms, except in areas where the plant is locally available. whose women's cooperatives extract cactus seed oil for cosmetic use, after this operation the product that remains to be valued is cactus seed cake. The objectives of this study were to determine the optimum level of incorporation of cactus seed cake in the feed of small ruminants, and to evaluate its effect on the fattening parameters, the feed cost and the meat quality.

**Material and methods** The main objective of the present work is to study the effect of incorporating the cactus seeds cake in the diet of fattening lambs. The experiment lasted 90 days and it was conducted on 24 lambs of the synthetic breed "Deroua", randomly divided into four homogeneous groups. Four diets according to the level of incorporation of cactus seed cake (CSC) have been tested: T0% (0%CSC), T8% (8%CSC), T17% (17%CSC) and T34% (34%CSC). Lambs were weighed at the beginning and at the end of the trial and at 15-day intervals for the remainder of the trial. At the end of the trial, 20 lambs were slaughtered to study carcass characteristics (Hot carcass yield, Cold carcass yield and conformation) and meat quality (pH meat and color). On top of that, live weight, average daily gain (ADG), feed conversion index (FCI), diet cost, non-carcass components, fattening, mesenteric and perirenal fat, the compactness and conformity index, water holding capacity of meat. The effect of different cactus seed cake incorporations on these parameters was analysed using a one-way analysis of variance. The PROC GLM procedure of the SAS statistical package (version 8.01) was used for the analysis. Comparisons between mean values were tested using the LSD test.

**Results and discussion** The results obtained showed that the T0 diet recorded the highest live weight (LW) 40.5 kg, on the other hand the T34 recorded the low live weight 35.2 kg. The average daily gain of different groups was 261; 250; 223 and 197 g/d respectively for T0, T8, T17 and T34, ($P<0.0001$), which is in agreement with Figueiredo Monteiro et al. (2014) who noted that total body weight gain and average daily gain decreased linearly with the level of replacement of wheat bran with spineless cactus. And this does not contradict the results found by Felix et al., (2016). In their work, the ADG of sheep decreased beyond 58.7% replacement of spineless cactus. The conversion index was 6.48; 6.16; 7.85 and 8.79 kg DM/Kg of weight gain, and the recorded diet cost was 19.30; 17.41; 20.56 and 19.46 dhs/Kg of estimated live weight for T0; T8; T17 and T34, respectively. Carcass characteristics (fat cover, non-carcass components, pelvic fat and muscle index) of slaughtered animals were not diet depended. In contrast, mesenteric fat deposition, carcass yield and conformation were slightly superior for the T17 treatment. In addition, meat color of lambs on the T8; T17 and T34 diets tended to be lighter and less red than the T0. Meat pH of all carcasses 24 hours after slaughter was almost similar (pH=5.6). The diet had no significant effect on the water holding capacity of the meat measured in the *Longissimus dorsi* muscle. However, lambs on the T8 diet expressed a meat water loss that tends to be lower 22.03% compared to 23.84%, 23,54% and 23.35% for the T34; T17 and T0 diets respectively.

**Table 1** Effect of diet on live weight (LW) and Average Daily Gain (ADG)

| Item | Diet | | | | SEM | P |
|---|---|---|---|---|---|---|
| | T0 | T8 | T17 | T34 | | |
| Initial LW | 19.6 | 16.9 | 19.9 | 18.6 | - | - |
| Final LW | 40.5$^{a}$ | 39.6$^{a}$ | 37.3$^{b}$ | 35.2$^{c}$ | 0.58 | 0.0001 |
| ADG | 261,6$^{a}$ | 250,8$^{a}$ | 223,0$^{b}$ | 197,5$^{c}$ | 7,03 | 0,0001 |

**Conclusion** It is concluded that cactus seed cake could be used as an alternative feed resource for fattening lambs in vulnerable areas. The incorporation of this by-product at a level of 8% allows to improve the feed conversion index and reduce the feed cost.

**References**

Figueiredo Monteiro C.C., Silva de Melo A.A., Ferreira M.A. 2014. Tropical Animal Health and Production 46(7), 1149–1154.

Felix C.R.S., Pessoa R.A.C., Marcelo de Andrade F. 2016. Tropical Animal Health and Production 48(2), 465–468.

# Assessment and comparison of sustainability of small bovine dairy farms in two regions of the North of Tunisia

Khaoula Attia, Cyrine Darej, Naceur M'Hamdi, Nizar Moujahed.

*National Agronomic Institute of Tunisia, Research unit of ecosystems and aquatic resources, Tunis, Tunisia.*

E-mail: attiakhaoula@ymail.com

**Take home Message** Sustainable agriculture stands at the heart of a new social agreement between agriculture and society.

**Introduction** With the growing awareness of the sustainability of agricultural systems, several tools are created to measure the sustainability of farms. The main aim of this study is to assess and compare the sustainability of bovine dairy farms in two regions of Bizerte in the North of Tunisia.

**Material and methods** A survey derived from the IDEA method (Indicateurs de Durabilité des Exploitations Agricoles; "Farm Sustainability Indicators") is conducted into 23 small bovine dairy farms. A total of 122 questions inspired by the IDEA grid (version 3) are developed to collect general information about the farm, livestock management ways, biodiversity aspects, land management and agricultural practices, farmer's relationship with his entourage and quality of life, and economical aspects. This method is structured around 17 objectives that constitute the three scales of sustainability: (i) agro-ecological; (ii) socio-territorial; (iii) economic. Each of these three scales is subdivided into three or four components (i.e. 10 components in total), which in turn comprise 42 indicators.
The information obtained are used to calculate the indicators and scores. A general linear model is used to the compare the sustainability of the two regions. It is analysed with PROC GLM using SAS 9.0 (SAS Institute Inc., Cary, NC, USA, 2009). The following model was used: $Yij = \mu + Ri + eij$, where:
Yij: observation sustainability; μ: general average; Ri: regions (i = 1, 2); eij: random error.
The factor levels were compared two by two using the SNK test. Results were expressed as means. Results with an associated probability less than or equal to 0.05 were considered significant.

**Results and discussion** Results show that the socio-territorial scale is the limiting factor for the two regions. However, the region of Ras Jbal records significantly lower score than the region of Teskreya ($p<0.01$, 48.7 and 59.92 respectively). In contrast, the economic scale is the strong point of the region of Ras Jbal that records 10% higher points than the other region (67.40 and 60.23 respectively). Indeed, the agro-ecological and economic scales are relatively the best asset on all farms. The factor that most differentiate the two regions is the socio-territorial scale followed by the economic scale.

**Table 1** Socio-territorial sustainability indicators

| Socio-territorial scale | Teskreya | Ras Jbal | P-value | SEM |
|---|---|---|---|---|
| B1- Quality approach | 6.00 | 6.00 | NS | 0 |
| B2- Enhancement of built heritage and landscape | 4.69 [a] | 2.90 [b] | 0.01 | 0.381 |
| B3- Management of non-organic waste | 0.07 [b] | 1.40 [a] | <0.05 | 0.248 |
| B4- Accessibility of space | 2.30 [a] | 1.20 [b] | <0.05 | 0.278 |
| B5- Social implication | 3.07 | 2.6 | NS | 0.245 |
| B6- Short trade | 5.00 | 4.50 | NS | 0.217 |
| B7- Autonomy and valorization of local resources | 7.53 | 6.80 | NS | 0.382 |
| B8- Services, multi-activities | 0 | 0 | NS | 0 |
| B9- Employment contribution | 4.84 | 5.40 | NS | 0.439 |
| B10- Collective work | 2.84 | 2.60 | NS | 0.143 |
| B11- Probable sustainability | 2.92 | 3.00 | NS | 0.043 |
| B12- Contribution to the world food balance | 8.00 [a] | 1.00 [b] | <.0001 | 1.043 |
| B13- Animal welfare | 1.76 [a] | 0.4 [b] | <.0001 | 0.195 |
| B14- Training | 0.07 | 0 | NS | 0.043 |
| B15- Labor intensity | 4.30 | 4.70 | NS | 0.225 |
| B16- Quality of life | 3.38 | 3.70 | NS | 0.152 |
| B17- Isolation | 1.69 | 1.70 | NS | 0.159 |
| B18- Reception, hygiene and safety | 1.38 | 0.80 | NS | 0.211 |
| Total | 59.92 [a] | 48.70 [b] | <0.01 | 2.259 |

**Conclusion** Overall, the farms from the two regions are not significantly different in terms of sustainability performance. Nevertheless, improvements should be made simultaneously at all three scales.

# Feeding behaviours of lambs fed with lupins: detecting aversion through infrared thermography and video analysis

Mariana Almeida[1,2], Sofia Garcia-Santos[3], Ana Nunes[4], Sara Rito[5], Cristina Guedes[1,2], Luis Ferreira[3], George Stilwell[2,6], Severiano Silva[1,2]

[1]*Veterinary and Animal Research Centre (CECAV), Vila Real, Portugal*
[2] *Associate Laboratory for Animal and Veterinary Sciences (AL4AnimalS), Portugal*
[3]*Centre for the Research and Technology Agro-Environmental and Biological Sciences (CITAB), Vila Real, Portugal*
[4]*University of Trás-os-Montes e Alto Douro, Vila Real, Portugal*
[5]*Instituto Superior de Agronomia, School of AgricultureLisbon, Portugal*
[6]*Centre of Interdisciplinary Investigation in Animal Health (CIISA) Lisbon, Portugal*

Email: mdantas@utad.pt

**Take home Message** IRT and video analysis might be useful tools to determine aversion or palatability of different feeds.

**Introduction** Lupins are an important alternative source of protein even though they produce some bitter and anti-nutritional compounds which might affect their palatability (Cheek and Kelly, 1989). Food preference in sheep has been studied over the years (Villalba et al., 2010), however, there is little information about feeding behaviours being affected by lupins. Non-invasive technology such as infrared thermography (IRT), has been investigated to measure stress and/or pain (Stubsjøen et al., 2009), although no studies have used IRT to assess aversion to different feeds. The present study aimed to understand the differences in eating behaviour in *Churra da Terra Quente* lambs supplemented with different levels of lupins, using video analysis and IRT.

**Material and methods** Each group of 4 lambs was provided with different diets: a control (C) with 150 g/kg as fed of soybean meal, a diet supplemented with 50 g/kg as fed *Lupinus luteus* cv. Mister (LL5) and a diet supplemented with 50 g/kg as fed *Lupinus albus* cv. Nacional (LA5) on trial 1; a control diet (C) and three diets supplemented with *Lupinus luteus* cv. Mister (100 g/kg as fed, 150 g/kg as fed, 200 g/kg as fed; LL10, LL15, LL20, respectively). Each diet also had 20 g/kg as fed of wheat and meadow hay was provided *ad libitum*. DM intake (DMI) and hay DM intake (HDMI) were calculated. Eating behaviour was evaluated by registering the frequency of lambs seen eating hay (H) between 8 a.m. and 8 p.m., on days 1, 7, 14 and 28 of each trial, and the time spent eating concentrate feeds (T) was also calculated. Eating hay behaviour was obtained using a scan sampling every 10 minutes on each of the observation days and the number of animals eating hay in each group was then transformed into a percentage. Thermographic images were obtained during feeding time (EyeT).

**Results and discussion** In trial 1 EyeT was lower on lambs fed diets with lupin incorporation (37.59 vs 37.14 and 37.17 ˚C; $p<0.05$). No significant differences were observed on the other parameters. On trial 2 lupin inclusion affected ($p<0.05$) hay and dry matter intake (Table 1). Time spent eating the concentrate feeds was higher for lambs from LL20 ($p<0.05$) and the lowest in lambs from LL15. Incorporation of Lupinus luteus increased the percentage of lambs at the feeding station in comparison to those fed soybean meal ($p>0.05$). Due to the low sample size, it is possible that the scan sampling might not have been able to properly detect differences between groups, which is a common error in these type of studies (Mitlöhner et al., 2001). Diets also affected ($p<0.05$) eye temperature. Eye temperatures of lambs fed diets with yellow lupins were lower than in C group ($p<0.05$). Fluctuations in eye temperature have been related to stressful experiences (Travain et al., 2015), but also to expecting positive rewards (Travain et al., 2016).

**Table 1.** Dry matter intake, hay dry matter intake, time spent eating concentrate feeds and eye temperature of lambs on trial 2.

| | Diet | | | | SEM | p-value |
|---|---|---|---|---|---|---|
| | C | LL10 | LL15 | LL20 | | |
| DMI | 734.6$^{ab}$ | 705.3$^{ab}$ | 755.1$^{a}$ | 689.6$^{b}$ | 14.608 | 0.034 |
| HDMI | 555.5$^{a}$ | 525.6$^{ab}$ | 556.5$^{a}$ | 493.4$^{b}$ | 14.035 | 0.024 |
| T (minutes) | 11.63$^{b}$ | 10.44$^{c}$ | 9.5$^{c}$ | 12.5$^{a}$ | 0.584 | 0.003 |
| EyeTemp (˚C) | 36.76$^{a}$ | 36.18$^{b}$ | 36.05$^{b}$ | 35.84$^{b}$ | 0.166 | 0.001 |

**Conclusion** Higher concentrations of lupins caused some alterations in the time spent eating concentrate feeds and hay. Lower eye temperatures of lambs fed lupin seeds could indicate a mild reaction to lupins as alternative protein source, although the low sample size of the study dos not allow to draw any definitive conclusions.

**Acknowledgements** This work was supported by the project UIDB/CVT/00772/2020 funded by the Portuguese Foundation for Science and Technology (FCT).

**References**

Cheeke P.R., Kelly J.D. 1989. Wageningen (Netherlands) 189-201.
Mitlöhner F.M., Morrow-Tesch J.L., Wilson S.C., Dailey J.W., McGlone J.J. 2001. Journal of Animal Science 79(5), 1189-1193.
Stubsjøen S.M., Flø, A.S., Moe R.O., Janczak A.M., Skjerve E., Valle P.S., Zanella A.J. 2009. Physiology & Behaviour. 98(5) 640-648.
Travain T., Colombo E.S., Heinzl E., Bellucci D., Previde E.P., Valsecchi P. 2015. Journal of Veterinary Behavior 10(1), 17-23.
Travain T., Colombo E.S., Grandi L.C., Heinzl E., Pelosi A., Previde E.P., Valsecchi P. 2016. Physiology & Behaviour. 159, 80-87.
Villalba J.J., Provenza F.D., Manteca X. 2010. Animal 4(7), 1240.

# Feeding sainfoin pellets (vs alfalfa) modifies the sensory properties and the fatty acid profile of goat cheese

Ruggero Menci[1], Bruno Martin[2], Steffen Werne[3], Cécile Bord[4], Anne Ferlay[2], Amélie Lèbre[5], Florian Leiber[3], Matthias Klaiss[3], Mauro Coppa[6], Félix Heckendorn[3]

[1]*University of Catania, Catania, Italy*
[2]*INRAE, Université Clermont Auvergne, Saint-Genès-Champanelle, France*
[3]*FiBL, Research Institute of Organic Agriculture, Frick, Switzerland*
[4]*Université Clermont Auvergne, Lempdes, France*
[5]*FiBL, Eurre, France*
[6]*Independent researcher at INRAE, Université Clermont Auvergne, Saint-Genès-Champanelle, France*

E-mail: ruggero.menci@unict.it

**Take home Message** Sainfoin can replace alfalfa in goat diet. This could result in a more intense aroma of cheese and in a healthier fat composition. The effect may change according to the cheesemaking technique.

**Introduction** Sainfoin (*Onobrychis viciifolia* Scop.) is a legume fodder with interesting properties for ruminant nutrition and health: thanks to its tannin content, sainfoin can naturally control bloat and parasitism, and reduce urinary nitrogen and methane emissions. Moreover, dietary tannins are known to improve the fatty acid (FA) profile of ruminant products by modulating ruminal biohydrogenation. However, little is known about the effects of feeding sainfoin on the quality of cheese. This study aimed to test the effects of sainfoin feeding on the sensory properties and the FA profile of goat cheese. Two different cheese varieties were tested: Picodon, a 60-g soft-ripened French PDO cheese with bloomy rind, and Mutschli, a semi-hard pressed traditional Swiss cheese.

**Material and methods** Two experiments were carried out in two commercial goat farms: one producing Picodon cheese (PCD, Drôme department, France) and the other producing Mutschli cheese (MTS, Valais canton, Switzerland). The experiments followed the normal farming practices of the two farms. In both farms, two groups of lactating Alpine goats (balanced for milk protein and fat contents) were fed 700 g/d of alfalfa (*Medicago sativa* L.) pellets (ALF. $n$ = 14, PCD; 10, MTS) or sainfoin pellets (SNF. $n$ = 18, PCD; 10, MTS). The PCD goats also received 50 g/d of whole barley grain, while the MTS goats received 100 g/d of corn grit. All the goats, in their respective farms, had access to pasture for 5 h/d. The experimental feeding lasted 6 weeks, and in the last 2 weeks the bulk milk of the ALF and SNF goats were transformed into cheese in parallel. In total, 6 and 4 different cheesemaking trials were conducted on different days, for Picodon and Mutschli respectively. The FA profile of cheese was determined by gas-chromatography. The sensorial differences between the ALF and SNF Picodon and Mutschli were assessed through a triangle test, with 38 untrained persons. The sensory profiles of the ALF and SNF Picodon and Mutschli were evaluated by 10 trained panellists. The effect of the diet on the FA and sensory profiles was assessed with a mixed model ANOVA, using the random effect of the panellist or the cheesemaking day, respectively. The answers (correct or incorrect) obtained in the triangle test were tested statistically based on comparisons with values from the binomial law parameter P = 1/3 with $n$ replicates.

**Results and discussion** The participants in the triangle test successfully ($P$<0.001) discriminated between the two diets, with 79% correct answers for Picodon and 61% correct answers for Mutschli. The differences between the ALF and SNF cheeses were confirmed by the sensory profile. In particular, the inclusion of sainfoin in the diet modified the aroma, taste and mouthfeel of Picodon, and the mouthfeel of Mutschli (Table 1). According to panellists, sainfoin did not lend any off-flavour to both cheeses. Concerning FA profile, sainfoin increased ($P$<0.05) the concentration of *trans*11-18:1 and 18:3*n*-3 in both Picodon and Mutschli. In addition, the SNF Picodon had higher ($P$<0.05) 4:0, 6:0, and *cis*9*trans*11-18:2 concentrations compared to the ALF Picodon. The effects observed on FA profile were likely due to the modulation of rumen biohydrogenation by the tannins contained in sainfoin. The more intense "farm" and "goat" aroma of the SNF Picodon may have resulted from a greater lipolysis of some short FA such as 4:0 and 6:0, which produces compounds known to lend goat cheese its typical aroma.

**Table 1** Effect of sainfoin feeding on the sensory profile of Picodon and Mutschli cheese

| | Picodon | | SEM | P-value | Mutschli | | SEM | P-value |
|---|---|---|---|---|---|---|---|---|
| | ALF | SNF | | | ALF | SNF | | |
| "Farm" aroma | 2.1 | 2.6 | 0.11 | 0.009 | - | - | - | - |
| "Goat" aroma | 4.7 | 5.2 | 0.08 | 0.048 | 5.5 | 5.9 | 0.16 | 0.074 |
| Rancid aroma | 2.0 | 2.1 | 0.10 | 0.377 | 1.0 | 1.0 | 0.12 | 0.892 |
| Bitterness | 2.7 | 3.1 | 0.12 | 0.009 | 3.1 | 3.0 | 0.15 | 0.527 |
| Hardness | 5.8 | 4.9 | 0.13 | <0.001 | 5.3 | 5.5 | 0.16 | 0.314 |
| Dryness | 5.7 | 4.9 | 0.13 | <0.001 | 4.2 | 4.6 | 0.17 | 0.041 |
| Crumbliness | 4.6 | 3.7 | 0.20 | 0.008 | 2.6 | 2.6 | 0.16 | 0.716 |
| Stickiness | 3.1 | 3.1 | 0.11 | 0.982 | 2.0 | 1.5 | 0.16 | 0.022 |

**Conclusion** The sensory properties and the FA profile of Picodon and Mutschli have been modified by replacing alfalfa with sainfoin in the diet of goats. However, no off-flavour was detected. A different effect was observed according to the type of cheese, with more important modifications for Picodon than for Mutschli. Further research should investigate the interaction between dietary tannins and cheesemaking technique on cheese composition and sensory properties.

**Acknowledgements** Part of this study was funded by the Canton Valais and the Swiss Federal Office of Agriculture.

# *Satureja montana* essential oils improve the quality of Beni Arous buck semen during storage at 4°C

Amr Kchikich[1], Nathalie Kirschvink[2], Sara El Kadili[3], Marianne Raes[4], Samira El Otmani[5], Jean Loup Bister[4], Bouchra El Amiri[5], Said Barrijal[1], Mariam Serroukh[1], Mouad Chentouf[5]

[1]*Department of Biology, Faculté des Sciences et Techniques de Tanger, Tangier, Morocco*
[2]*Department of Medicine, Namur Research Institute for Life Sciences (NARILIS), University of Namur, Namur, Belgium*
[3]*Department of Animal Production, Ecole Nationale d'Agriculture de Meknès, Meknes, Morocco*
[4]*Department of Veterinary Medicine, Namur Research Institute for Life Sciences (NARILIS), University of Namur, Namur, Belgium*
[5]*National Institute of Agricultural Research, Regional Center of Agricultural Research of Tangier, Rabat, Morocco*

Email: kchikch.amr@gmail.com

**Take home Message** The addition of 0,01% of *Satureja montana* essential oil (SMEO) to skimmed milk diluent improves Beni Arous buck semen quality during storage at 4°C by reducing the production of malondialdehyde and oxidative stress.

**Introduction** Natural substances, such as EO or phyto-extracts, are used to improve mammalian semen liquid preservation, due to their biological antioxidant and antibacterial activities. SMEO could also be useful for sperm preservation due to its antioxidant effect protecting the polyunsaturated fatty acids of sperm membrane from oxidation (Kumar & Rawat, 2013). This study aims to investigate SMEO effects on Beni Arous buck semen quality during 48 h of liquid storage in skimmed milk at 4°C.

**Material and methods** SMEO was extracted from leaves by hydro-distillation, and chemical compounds was identified by gas chromatography coupled with mass spectrometry. Six Beni Arous bucks were used in this experiment. The ejaculates were collected from each buck once a week, for ten weeks, during three months (May–August). The pool was diluted to 400 x $10^6$ sperm/ml and supplemented with 0.01% and 0.05% of EO. Skimmed milk without supplementation was considered as control. Semen evaluation (total motility, progressive motility, viability and lipid peroxidation) was performed at 0, 4, 8, 24, 28, 32 and 48 h of storage at 4°C. Lipid peroxidation was performed as described by Allai et al. (2015), while the other parameters were determined according to El Kadili et al. (2019). Data analysis was performed using SAS 9.4 software, and all data were subjected to ANOVA2 (treatment and storage duration).

**Results and discussion** The most abundant compounds in SMEO were terpinene-4ol, γ-Terpinene, linalol and δ-3-Carene (Table 1) which are known by their antioxidant activities (Mezza et al., 2017). The addition of 0.01% SM was found to be useful for the preservation of spermatozoa throughout the storage period (48 h). Supplementation with 0.01% of EO led to higher viability and progressive and total motility rates compared to the control after 48 h of storage, while 0.05% negatively affected total and progressive motility at 0 h. The addition of 0.01% of the EO can decrease positively the oxidative stress effect by reducing the production malondialdehyde. However, a spermicidal effect is observed at 0.05%. High level of SMEO prevents the excessive formation of malondialdehyde induced by reactive oxygen species, while blocking normal sperm functions, resulting in spermicidal effects.

**Table 1** Composition of *Satureja montana* essential oil

| Compounds | Area % | Retention index |
|---|---|---|
| Terpinen-4ol | 30.90 | 1177.7 |
| γ-Terpinene | 15.76 | 1059.7 |
| Linalol | 12.93 | 1099.0 |
| δ-3-Carene | 11.04 | 1003.3 |
| γ-Terpineol | 4.48 | 1164.5 |
| Terpinolene | 3.85 | 1086.9 |
| Linalol acetate | 2.75 | 1255.2 |
| α-Terpinene | 2.33 | 1017.1 |
| α-Humulene | 1.83 | 1453.1 |

**Conclusion** The supplementation of skimmed milk with 0.01% essential oils of *Satureja montana* improves buck semen quality during refrigeration, while 0.05% appears to be toxic and spermicidal.

**Acknowledgements** This research was supported by the Belgian Academy of Research and Higher Education— Research Project for Development (ARES- PRD)

**References**

Allai L., Druart X., Contell J., Louanjli N., Ben Moula A., Badi A., Essamadi A., Nasser B., El Amiri B. 2015. Animal Reproduction Science 160, 57–67.

El Kadili S., Raes M., Bister J.L., Archa B., Chentouf M., Kirschvink N. 2019. Animal Reproduction Science 201, 41–54.

Kumar D.B, Rawat D.S. 2013. Bioorganic & Medicinal Chemistry Letters 23(3), 641–645.

Mezza G.N., Borgarello A.V., Grosso N.R., Fernandez H., Pramparo M.C., Gayol M.F. 2017. Food Chemistry 242, 9–15.

# Polyphenols Characterisation and Antioxidant Capacity of Multi-Species swards grown in Ireland – Environmental Impact and Nutraceutical Potential

Samuel Rapisarda, Nissreen Abu-Ghannam

*TU Dublin - Environmental Sustainability and Health Institute (ESHI) Grangegorman, D07 H6K8, Dublin, Ireland.*

Email: nissreen.abughannam@tudublin.ie

**Take home Message** Multi-Species sward is a sustainable feeding strategy which supplies ruminants with phytochemicals linked to animal health and productivity.

**Introduction** Ruminant production systems are major contributors of greenhouse gases emissions, with animal feeding practices being the main cause for methane and nitrous oxide's release. Although feeding forages has been proven to be more sustainable, traditional ryegrass monocultures still require a lot of input (e.g., fertiliser and pesticides). Multi-species swards consisting of different functional groups (e.g., grasses, forage legumes and herbs) need less management and fertiliser, produce more dry matter, while also adding a variety of phytochemicals into the animal diet. In particular, polyphenols have been associated with positive impact on animal health and productivity. For instance, chlorogenic acid has been linked to reduction in the risks of mastitis (Gong et al., 2018); formononetin and biochanin A have shown to increase the amount of equol in milk, an oestrogen which can lower the incidence of osteoporosis and cardiovascular diseases (Sathyapalan et al., 2018); kaempferol and luteolin have been shown to be important in the ruminal fermentation, as they can reduce methanogenic activity in the rumen (Oskoueian et al., 2013).
Nevertheless, information on the phenolic profile in forages is still very scarce, and even little is known about the change of phenolic composition and concentration over the grazing period.

**Material and methods** In this study, the phenolic composition and concentration of multi-species swards components (i.e., perennial ryegrass, timothy, white clover, red clover, chicory and plantain) was investigated over five months during a typical Irish grazing season. Polyphenolic concentrations of each species were assessed using colorimetric assays and Liquid Chromatography-Electrospray Ionisation-Mass Spectrometry/Mass Spectrometry (LC-ESI-MS/MS). Antioxidant capacity of the species was also studied over the investigated grazing period, using FRAP, DPPH and ORAC assays.

**Results and discussion** The Total Phenolic Content (TPC) value was significantly different among species ($p < 0.01$), while there was no significant difference within species over the grazing season ($p > 0.05$) (Table 1). High TPC was found in plantain, timothy and chicory, whereas low in red clover, perennial ryegrass and white clover.
Overall, chlorogenic acid was found to be the predominant polyphenol in perennial ryegrass, timothy, plantain and chicory, while formononetin and biochanin A were high in red clover, white clover and in chicory. Luteolin and kaempferol were only found in chicory.
Plantain showed the highest antioxidant capacity throughout the study period, almost one and a half more than timothy, and twice as much as chicory ($p<0.001$). Antioxidant capacity was not found to be significantly different over the grazing season ($p > 0.05$).

**Table 1** Total Phenolic Content (TPC), antioxidant capacity and quantification of selected polyphenols (Cga=Chlorogenic acid, Fmnt=Formononetin, Bca=Biochanin A, Lu= lutenin Kae=Kaempferol) of multi-species components.

| | | Perennial Ryegrass | Timothy | White Clover | Red Clover | Chicory | Plantain | P-Value |
|---|---|---|---|---|---|---|---|---|
| mg GAE/g | *TPC* | 19.95$^{a}$ | 95.45$^{c}$ | 20.16$^{a}$ | 38.60$^{b}$ | 74.94$^{c}$ | 138.69$^{d}$ | p<0.001 |
| mg/g DM | *CgA* | 6.62$^{b}$ | 20.69$^{c}$ | 1.05$^{a}$ | 0.11$^{a}$ | 1.16$^{a}$ | 9.58$^{b}$ | p<0.001 |
| | *Fmnt* | 0.03$^{a}$ | 0.25$^{a}$ | 1.71$^{a}$ | 8.23$^{c}$ | 5.68$^{b}$ | 0.86$^{a}$ | p<0.001 |
| | *BcA* | 0.01$^{a}$ | 0.06$^{a}$ | 4.04$^{b}$ | 3.03$^{b}$ | 3.25$^{b}$ | 0.45$^{a}$ | p<0.001 |
| | *Lu* | 0.03$^{a}$ | 0.04$^{a}$ | 0.06$^{a}$ | 0.03$^{a}$ | 1.29$^{b}$ | 0.02$^{a}$ | p<0.001 |
| | *Kae* | 0.05$^{a}$ | 0.07$^{a}$ | 0.06$^{a}$ | 0.05$^{a}$ | 1.23$^{b}$ | 0.02$^{a}$ | p<0.001 |
| µM TroloxE/g | *FRAP* | 102.7$^{a}$ | 352.0$^{b}$ | 97.9$^{a}$ | 136.0$^{a}$ | 286.7$^{b}$ | 482.4$^{c}$ | p<0.001 |
| % DPPH inhibition | *DPPH* | 23.0$^{a}$ | 68.0$^{b}$ | 27.2$^{a}$ | 37.5$^{a}$ | 58.9$^{b}$ | 80.9$^{c}$ | p<0.001 |
| µM TroloxE/g | *ORAC* | 960.1$^{a}$ | 1665.4$^{b}$ | 1185.2$^{a}$ | 1220.4$^{a}$ | 1594.2$^{b}$ | 2478.9$^{c}$ | p<0.001 |

**Conclusion** Multi-species swards include various phenolic compounds which are identified as precursors to nutraceutical compounds in milk and linked to improving animal health and emission reduction. This study suggests that implementing multi-species swards in ruminant production systems can provide micronutrients associated with animal health, in addition to positively impacting the environment.

**Acknowledgements** The research reported herein is funded by the Irish Department of Agriculture, Food and the Marine's competitive funding programmes, in conjunction with commercial industry. Project title: Future Proofing Irish livestock.

**References**

Gong X.X., Su X.S., Zhan K., Zhao G.Q. 2018. Journal of Dairy Science 101(11), 10089-10097.
Oskoueian E., Abdullah N., Oskoueian A. 2013 BioMed Research International 2013, 1-8.
Sathyapalan T., Aye M., Rigby A.S., Thatcher N.J., Dargham S.R., Kilpatrik E.S., Atkin S.L. 2018. Nutrition, Metabolism and Cardiovascular Diseases 28(7), 691-697.

# Effect of partial substitution of oat hay by olive cake on growth performance, carcass characteristics and meat quality of Noire de Thibar lambs

Khalil Abid [1], Ines Essid [2], Samia Ben Saïd [3], Hassen Jerbi [4], Taha Najar [2], Atef Jaouani [1]

[1] *Higher Institute of Applied Biological Sciences of Tunisia (ISSBAT), University of Tunis El Manar, Tunis, Tunisia*
[2] *National Agronomic Institute of Tunisia (INAT), University of Carthage, Tunis, Tunisia*
[3] *Higher School of Agriculture of Kef (ESAK), University of Jendouba, Le Kef, Tunisia*
[4] *National School of Veterinary Medicine Sidi Thabet (ENMV), University of Manouba, Manouba, Tunisia*

E-mail: mr.khalil.abid@gmail.com

**Take home Message** The reduction of the gap between feed needs and the feed resources is the challenge to ensure the sustainability of ruminal breeding. The use of agro-industrial by-products as an alternative feed is becoming a current trend that can be a solution for this challenge.

**Introduction** Olive cake is available in huge quantities in Mediterranean's countries. The majority of this waste is thrown out in the environment. It represents a potentially ecology problem. This by-product is characterized by its high fiber and fat content (Abid et al. 2022). The use of this substrate, containing appreciable oils, in ruminant feed, could be a practicable strategy to improve meat quality (Chiofalo et al. 2020). This study was conducted to assess the effect of replacing 30% of oat hay by olive cake on the growth performance, carcass traits, and meat quality of lambs.

**Material and methods** This study was conducted with 12 Noire de Thibar lambs. Animals were assigned into two groups and hosted in individual boxes for 73 days. The control group was fed with 50 % of concentrate and 50% of oat hay, while the test groups was fed with 50% of concentrate, 35% of oat hay and 15 % of olive cake. At the end of the trial, all lambs were slaughtered. The carcass traits and meat quality of lambs were analysed. Data of growth performance, carcass traits and meat quality were analysed by a mixed model analysis with the MIXED procedure of SAS 9.2, using ANOVA to test. Comparisons between means were performed using the dunam test. Differences were considered significant at $P < 0.05$.

**Results and discussion** The replacing oat hay with olive cake did not affect ($P > 0.05$) daily gain, final weight, slaughter carcass weight and dressing percentage of lambs. The dissection of the carcasses shows that replacing oat hay with olive cake has no affect ($P > 0.05$) on muscles and bone yields. Whereas a significant increase ($P < 0.05$) in carcass fatness quantity was recorded. Moreover, meat quality analysis showed no effect on pH value, lightness, redness, moisture, protein and ash contents ($P > 0.05$). However, meat juiciness increased significantly in lambs fed with olive cake ($P < 0.05$). The cooking loss of meat was higher in control lambs ($P < 0.05$).

**Conclusion** The use of olive cake as lambs' alternative feed can reduce the pollution caused by this waste without any significant negative effect on their growth performance and little modification on meat and carcass quality. Furthermore, the replacement of 30% of oat hay by these co-products is a good strategy to significantly decrease the cost of lambs feedt.

**Acknowledgements** This study was supported by the "Jesr Méditerranéen de la filière ovine JESMED/Réf n°IS 1.2" research project

**References**

Abid, K., Jabri, J., Yaich, H., Malek, A., Rekhis, J., Kamoun, M. 2022. Archives Animal Breeding, 65(1), 79-88.
Chiofalo, V., Liotta, L., Lo Presti, V., Gresta, F., Di Rosa, A. R., Chiofalo, B. 2020. Animals, 10(7), 1176.

# Meat production and quality of lambs fed sericea lespedeza substituted for lucerne

Leo N. Mahachi[1], Obert C. Chikwanha[1], Chenaimoyo L.F. Katiyatiya[1], Munyaradzi C. Marufu[2], Adeyemi O. Aremu[3], Cletos Mapiye[1]

[1]*Department of Animal Sciences, Stellenbosch University, Matieland, South Africa*
[2]*Department of Veterinary Tropical Diseases, University of Pretoria, Onderstepoort, South Africa*
[3]*Indigenous Knowledge Systems Centre, Faculty of Natural and Agricultural Sciences, North-West University, Mmabatho, South Africa*

E-mail: 23415177@sun.ac.za

**Take home Message** Sericea lespedeza can substitute lucerne in lamb finishing diets without compromising growth performance, carcass, and meat quality.

**Introduction** Sheep productivity in arid and semiarid regions is constrained by scarcity of nutritious feed more so in recent past with the advent of severe droughts. Feed supplements traditionally used to enhance performance and meat quality, respectively, are expensive and often linked with increased chemical residues in meat and ill-health in humans, prompting search for alternatives. Sericea lespedeza (SL), a drought-tolerant forage legume has potential to be utilised as an alternative source of nutrients and bioactive compounds necessary to enhance meat production and quality. However, the optimum dietary inclusion level required to modulate lamb meat production and quality is not known. The current study aimed to determine the effects of substituting different levels of sericea lespedeza for lucerne on growth performance, carcass attributes, and meat quality of feedlot lambs.

**Material and methods** Forty intact Dohne Merino lambs (29.89 ± 2.67 kg) were randomly assigned to five dietary treatments (0%, 25%, 50%, 75% and 100% inclusion of SL). Diets were formulated to meet the recommended energy and protein requirements for growing lambs. Lambs' dry matter intake (DMI) and average daily gain (ADG) were monitored for 42 days before humane slaughter. Total income, price margin and feed margin were calculated according to Esterhuizen et al. (2008). Meat quality attributes were determined on fresh *longissimus thoracis et lumborum* muscle. The PROC GLIMMIX of SAS (v. 9.4) was used for data analysis with diet and lamb fitted in the model as fixed and random effects, respectively.

**Results and discussion** Dietary inclusion of SL had no effect on lamb DMI, final weight, ADG and feed efficiency ($P > 0.05$, Table 1). Cold carcass weight and dressing percentage decreased as dietary SL increased ($P \leq 0.05$, Table 1). The ultimate pH and temperature of meat were not different ($P > 0.05$; Table 1) probably due to marginal differences in growth rates and carcass weights, which did not affect muscle fibre composition and carcass cooling rates. Whereas increasing SL reduced total feed cost ($P \leq 0.05$, Table 1), no dietary effects were observed for total income after selling carcasses ($P > 0.05$; Table 1). Dietary inclusion of SL did not influence price and feed margins ($P > 0.05$; Table 1). These findings may be related to the collective effects of DMI, feed efficiency, carcass weights and dressing percentages observed for the lambs. Overall, diet did not affect physicochemical parameters ($P < 0.05$; Table 1), and the values were within acceptable ranges for good quality lamb meat.

**Table 1** Effects of increasing dietary sericea lespedeza on lamb growth performance, carcass attributes and meat physicochemical quality.

| Item | Inclusion of sericea lespedeza (%) | | | | | SEM | P-values |
|---|---|---|---|---|---|---|---|
| | 0 | 25 | 50 | 75 | 100 | | |
| Initial weight, kg | 31.0 | 30.2 | 29.5 | 30.1 | 29.5 | 0.67 | 0.440 |
| Final weight, kg | 44.6 | 43.2 | 42.9 | 44.5 | 44.9 | 0.83 | 0.305 |
| Average daily gain, kg/d | 0.32 | 0.35 | 0.30 | 0.32 | 0.25 | 0.02 | 0.074 |
| Dry matter intake, kg/d | 1.80 | 1.69 | 1.62 | 1.78 | 1.81 | 0.05 | 0.082 |
| Feed efficiency | 0.20 | 0.21 | 0.21 | 0.21 | 0.21 | 0.01 | 0.969 |
| Cold carcass weight, kg | 21.1$^{a}$ | 20.9$^{a}$ | 20.2$^{ab}$ | 21.4$^{ab}$ | 19.6$^{b}$ | 0.53 | 0.024 |
| Dressing percentage, % | 48.4$^{ab}$ | 47.9$^{a}$ | 48.8$^{a}$ | 47.6$^{ab}$ | 46.8$^{b}$ | 0.40 | 0.009 |
| Total feed cost | 21.6$^{a}$ | 20.9$^{a}$ | 18.9$^{b}$ | 18.4$^{b}$ | 15.7$^{c}$ | 0.54 | <0.001 |
| Total income | 98.8 | 97.6 | 96.8 | 95.4 | 91.2 | 2.09 | 0.162 |
| Price margin | 38.0 | 37.8 | 38.6 | 38.3 | 38.3 | 0.83 | 0.961 |
| Feed margin | 49.8 | 48.9 | 43.6 | 47.3 | 45.2 | 2.13 | 0.204 |
| pH | 5.40 | 5.50 | 5.48 | 5.55 | 5.70 | 0.07 | 0.063 |
| Temperature | 3.65 | 3.58 | 3.65 | 3.66 | 3.48 | 0.09 | 0.278 |
| Moisture, % | 75.4 | 75.0 | 75.3 | 74.8 | 75.3 | 0.25 | 0.468 |
| Ash, % | 1.14 | 1.16 | 1.17 | 1.21 | 1.12 | 0.03 | 0.195 |
| Crude protein, % | 20.1 | 20.2 | 20.2 | 20.3 | 20.4 | 0.25 | 0.922 |
| Fat, % | 3.21 | 3.43 | 3.10 | 3.60 | 3.00 | 0.19 | 0.205 |
| Cooking loss, % | 32.0 | 33.5 | 31.2 | 34.2 | 34.2 | 0.94 | 0.083 |
| Drip loss, % | 1.72 | 1.68 | 1.60 | 1.86 | 1.72 | 0.10 | 0.443 |
| Shear force, N | 62.4 | 70.8 | 62.5 | 65.3 | 73.4 | 4.42 | 0.288 |
| Lightness, L* | 37.6 | 37.5 | 37.0 | 37.8 | 36.4 | 0.59 | 0.512 |
| Redness, a* | 12.2 | 12.3 | 12.2 | 12.3 | 11.7 | 0.26 | 0.669 |
| Yellowness, b* | 12.3 | 12.7 | 12.1 | 12.8 | 11.6 | 0.41 | 0.269 |

**Conclusion** Sericea lespedeza can be fed to growing lambs without compromising performance, carcass, and meat quality.

**Acknowledgements** Funding received from the South African National Research Foundation (UID: 118585) and South African Research Chairs Initiative (SARChI) in Meat Science: Genomics to Nutriomics (UID: 84633).

**References**

Esterhuizen et al., (2008). S. Afr. J. Anim. Sci., 38(4), 303–314.

# The effect of myrtle distillate leaves (*Myrtus communis* L.) incorporation in culled ewe diet on weight gain, meat's fatty acid profile and antioxidant activity

Souha Tibaoui[1], Samir Smeti[1], Ines Essid[2], Naziha Atti[1]

[1]*Department of Animal and Forage Productions, National Institute of Agronomic Research of Tunisia (INRAT), Tunis, Tunisia*.
[2]*Department of Animal Resources, Fisheries and Food Technologies (INAT), Tunis, Tunisia*.

E-mail: souhatibaoui@gmail.com

**Take home Message** This study revealed that Myrtle distillate leaves (MDL) could substitute, in ewes feeding, up to 87% of hay or up to 30% of concentrate without negative effects on body weight, carcass characteristics and meat quality.

**Introduction** Mediterranean populations have largely used aromatic and medicinal plants (AMP), widely spread in forests, for their aromatic and health virtues. These plants have a long history of application as food replacing spices for meat cooking or as food integrators because of their high content of bioactive compounds. Among the most abundant AMP in the Mediterranean forest are the rosemary, thyme and myrtle. The residues of AMP can be used in animal nutrition as component of the diet or as source of natural antioxidant to prevent lipid oxidation and preserve meat quality given their richness in phenolic compounds and other bioactive compounds. However, rosemary and thyme were largely studied while results on the myrtle residues use in animal nutrition are absent. Myrtle distillate leaves (MDL) may be considered as a natural antioxidant and used in animal diet to prevent lipid oxidation and preserve their meat quality. Hence, the objective of this study was the use myrtle distillate leaves (MDL) as an alternative feed as well as natural antioxidant for culled ewes, characterized by poor body condition and meat quality. The influence of MDL dietary supplementation on the body weight (BW) gain and meat quality was investigated

**Material and methods** For this study, 27 Barbarine ewes were assigned into 3 groups. Animals in the control group (C) received 500g of oat hay and 750g of concentrate while the diet of the other groups was modified by totally substituting oat hay by pellets containing 87% of MDL (MHay group) and partially substituting the concentrate by pellets containing 30% of MDL (MCon group). Feed was withheld twice a day (9 h and 15 h) with free access to water; the BW of ewes was recorded weekly in order to determine BW gain. At the end of fattening period (90 days), ewes were slaughtered and carcasses dissected. The Longissimus dorsi (LD) muscle from each carcass was extracted and used to determine meat quality, for fatty acid profile, lipid oxidation potential (TBARS method) and Vitamin E analysis, samples were frozen at -20°c until analysis. Total phenolic content (TPC) and antioxidant activity of MDL and in the feedstuff were determined

**Results and discussion** For both types of pellets containing MDL, TPC and antioxidant activity were higher than the conventional feeds. The dry matter intake was higher ($p<0.05$) for MConc and C group, while higher crude protein intake was recorded for both groups receiving MDL (MHay and Mconc). No significant difference was recorded, among groups, for the average daily gain (102 g) and final BW (41.8 kg). Ewes from MHay and MConc groups had better feed conversion rate than Control group (12.5 vs. 15.4). Carcass tissue composition was similar for all groups. Meat's saturated (SFA) and monounsaturated fatty acids (MUFA) content was not affected by the treatments, while polyunsaturated fatty acids (PUFA) content was significantly ($p<0.05$) higher in MConc group. The level of BCFA was similar among all groups. Similar results were found on meat from lambs supplied by linseed and quercetin (Smeti et al., 2018). Oleic acid (C18:1-9) followed by palmitic acid (C16:0) and stearic acid (C18:0) were the most abundant individual fatty acids. These results are in concordance with the literature (Andrés et al., 2014; Smeti et al., 2018). The concentration of total CLA isomers detected was low for all groups. Both MDL groups had the lowest values of 18:1-10t/C18:1-11t ratio. MDL dietary supplementation significantly ($p<0.05$) delayed meat's lipid oxidation where experimental groups (receiving MDL) presented lower TBARS values (1.06, 1.2 vs. 1.98 mg MDA/kg) and increase their Vitamin E and total phenolic content.

**Conclusion** A dietary supplementation of MDL in animal feeding may be a useful method to valorize this product, hence, from a nutritional point of view; it may replace conventional feed resources and permits to obtain higher meat quality with better antioxidant potential

**Acknowledgements** Authors are grateful to ZinaTaghouti, technician in Animal Production laboratory in INRAT and to the technicians of the "Centro de Investigacion on y Tecnologi Agroalimentaria de Aragon" (CITA), for their technical assistance and the staff of the experimental farm Bou-Rebiaa for the feeding experiment servicing.

**References**

Smeti S., Hajji H., Mekki I., Mahouachi M., Atti N. 2018. Small Ruminant Research 158, 62–68.
Andrés S., Morán L., Aldai N., Tejido, M.L., Prieto N., Bodas R., Giráldez F.J.E. 2014. Meat Science 97, 156–163.

# LIST OF PARTICIPANTS

| Last name, First Name | Affiliation | Email |
|---|---|---|
| Abidi, Sourour | INRAT | sourour.abidi[at]yahoo.fr |
| Abraham, Eleni | Aristotle University of Thessaloniki | eabraham[at]for.auth.gr |
| Almeida, Mariana | CECAV - UTAD | mdantas[at]utad.pt |
| Ammar, Hajer | ESA - Mograne | hjr.mmr[at]gmail.com |
| Araba, Abdelilah | IAV Hassan II | a.araba[at]iav.ac.ma |
| Arca, Pasquale | CNR - ISPAAM | pasquale.arca[at]ispaam.cnr.it |
| Attia, Khaoula | INAT | attiakhaoula[at]ymail.com |
| Atzori, Alberto Stanislao | University of Sassari | asatzori[at]uniss.it |
| Avondo, Marcella | University of Catania | marcella.avondo[at]unict.it |
| Ayeb, Naziha | CRRA - Sidi Bouzid | naziha.ayeb[at]yahoo.fr |
| Belhadji Slimen, Imen | INAT | belhadj_slimen_imen[at]yahoo.fr |
| Bella, Marco | University of Catania | marco.bella[at]unict.it |
| Ben Salem, Hichem | INRAT | bensalem64.hichem[at]gmail.com |
| Benatallah, Amira Salha | Mentouri Brothers University of Constantine | benatallahamira[at]yahoo.fr |
| Benbati, Mohammed | INRA | benbati74[at]gmail.com |
| Benrjeb, Mariem | | mariem.benrjeb[at]yahoo.fr |
| Benyoussef , Salah | INRAT | benyoussef.salah[at]gmail.com |
| Bernard, Laurence | INRAE | laurence.bernard[at]inrae.fr |
| Bertino, Antonio | University of Catania | |
| Bionaz, Massimo | Oregon State University | massimo.bionaz[at]oregonstate.edu |
| Biondi, Luisa | University of Catania | luisa.biondi[at]unict.it |
| Bolletta, Viviana | University of Perugia | viviana.bolletta[at]studenti.unipg.it |

| Last name, First Name | Affiliation | Email |
|---|---|---|
| Bonanno, Adriana | University of Palermo | adriana.bonanno[at]unipa.it |
| Bordonaro, Salvatore | University of Catania | salvatore.bordonaro[at]unict.it |
| Bottegal, Diego | University of Lleida | diego.bottegal[at]udl.cat |
| Bouali, Karima | Mentouri Brothers University of Constantine | |
| Boukrouh, Soumaya | University of Liège | s.boukrouh[at]uliege.be |
| Cabiddu, Andrea | Agris Sardegna | acabiddu[at]agrisricerca.it |
| Caccamo, Margherita | CoRFiLaC | amministrazione[at]corfilac.it |
| Cacciola, Giustina | University of Catania | |
| Caillat, Hugues | INRAE | Hugues.Caillat[at]inrae.fr |
| Calabrò, Serena | University of Napoli Federico II | serena.calabro[at]unina.it |
| Cardozo Cabanelas, Gerónimo Agustín | CEFE, CNRS | geronimo.cardozo[at]cefe.cnrs.fr |
| Carita, Teresa | INIAV | teresa.carita[at]iniav.pt |
| Carta, Silvia | University of Sassari | scarta2[at]uniss.it |
| Cebo, Christelle | INRAE | christelle.cebo[at]inrae.fr |
| Chessari, Giorgio | University of Catania | |
| Chikwanha, Obert | Stellenbosch University | occhikwanha[at]sun.ac.za |
| Compes, Raul | CIHEAM Zaragoza | raul.compes[at]iamz.ciheam.org |
| Conte, Giuseppe | University of Pisa | giuseppe.conte[at]unipi.it |
| Correddu, Fabio | University of Sassari | fcorreddu[at]uniss.it |
| Criscione, Andrea | University of Catania | a.criscione[at]unict.it |
| De Palo, Pasquale | University of Bari | pasquale.depalo[at]uniba.it |
| de Vega García, Antonio | University of Zaragoza | avega[at]unizar.es |
| del Mar Campo, María | University of Zaragoza | marimar[at]unizar.es |

| Last name, First Name | Affiliation | Email |
|---|---|---|
| Della Badia, Antonella | IGM (CSIC-ULE) | a.dellabadia[at]csic.es |
| della Malva, Antonella | University of Foggia | antonella.dellamalva[at]unifg.it |
| Detressangle, Fabrice | PRIMA | fabrice.dentressangle[at]prima-med.org |
| Drakopoulou, Apostolia Theodora | Aristotle University of Thessaloniki | lora.dr97[at]gmail.com |
| Dubeuf, Jean Paul | INRAE ACT SELMET LRDE | jean-paul.dubeuf[at]inrae.fr |
| El Otmani, Samira | INRA | samira.elotmani[at]inra.ma |
| Ford, Hunter | Oregon State University | hunter.ford[at]oregonstate.edu |
| Franca, Antonio | CNR - ISPAAM | antonio.franca[at]cnr.it |
| Friha, Mouna | Institut Supérieur Agronomique Chott Mériem | friha.mouna[at]gmail.com |
| Frutos, Pilar | IGM (CSIC-ULE) | p.frutos[at]csic.es |
| Fulghesu, Fabio | University of Sassari | ffulghesu[at]uniss.it |
| Gallo, Antonio | Università Cattolica del Sacro Cuore | antonio.gallo[at]unicatt.it |
| Gallo, Michele | Mangimi Leone S.p.a. | info[at]mangimileone.com |
| Gannuscio, Riccardo | University of Palermo | riccardo.gannuscio[at]unipa.it |
| Gasco, Laura | University of Torino | laura.gasco[at]unito.it |
| Gereltsetseg, Enkhbat | University of Western Australia | gereltsetseg.enkhbat[at]research.uwa.edu.au |
| Giambalvo, Dario | University of Palermo | dario.giambalvo[at]unipa.it |
| Giunta, Gioacchino | Mangimi Leone S.p.a. | info[at]mangimileone.com |
| Greco, Roberta | University of Bari | roberta.greco[at]uniba.it |
| Guillaume, Martin | INRAE | guillaume.martin[at]inrae.fr |
| Guiso, Maria Francesca | University of Sassari | mfguiso[at]uniss.it |
| Hajji, Hadhami | Arid Regions Institut of Medenine | hajji.hadhami[at]gmail.com |

| Last name, First Name | Affiliation | Email |
|---|---|---|
| Hamdi, Hania | Regional Field Crops Research Center of Béja (CRRGC) | hania_hamdi[at]yahoo.fr |
| Hamdon, Hatem | New Valley University | hamdon9[at]yahoo.com |
| Hassan, Mahmoud | EEZ - CSIC | mahmoud.hassan[at]eez.csic.es |
| Hervás, Gonzalo | IGM (CSIC-ULE) | g.hervas[at]csic.es |
| Ilyes, Hadbaoui | Scientific and Technical Research Center on Arid Regions (CRSTRA) | hadbaouiilyes[at]yahoo.fr |
| Iommelli, Piera | University of Napoli Federico II | piera.iommelli[at]unina.it |
| Jaouani, Atef | Institut Supérieur des Sciences Biologiques Appliquées de Tunis (ISSBAT) | ajaouani[at]yahoo.fr |
| Jouven, Magali | Institut Agro Montpellier | magali.jouven[at]supagro.fr |
| Julien, Lionel | CIRAD | lionel.julien[at]cirad.fr |
| Karatassiou, Maria | Aristotle University of Thessaloniki | karatass[at]for.auth.gr |
| Kearns, Michelle | University College Dublin | michelle.kearns[at]ucdconnect.ie |
| Khalifeh, Doha | Lebanese University | khalifehdoha33[at]gmail.com |
| Khorchani, Touhami | Arid Regions Institut of Medenine | touha2009[at]gmail.com |
| Kiatti, Dieudonne | University of Napoli Federico II | dieudonne.kiatti[at]unina.it |
| Kis, Goran | University of Zagreb | kis[at]agr.hr |
| Konate, Nene | University of Catania | |
| Landau, Serge | Agricultural Research Organization | vclandau[at]volcani.agri.gov.il |
| Landi, Vincenzo | University of Bari | vincenzo.landi[at]uniba.it |
| Lanza, Massimiliano | University of Catania | massimiliano.lanza[at]unict.it |
| Lavi, Renana | University of Haifa | renanalavi[at]gmail.com |
| Ledda, Antonello | University of Sassari | anledda[at]uniss.it |

| Last name, First Name | Affiliation | Email |
|---|---|---|
| Leone, Alessandro | Mangimi Leone S.p.a. | info[at]mangimileone.com |
| Leone, Kathrin | Mangimi Leone S.p.a. | info[at]mangimileone.com |
| Leone, Luana | Mangimi Leone S.p.a. | info[at]mangimileone.com |
| Leone, Massimiliano | Mangimi Leone S.p.a. | info[at]mangimileone.com |
| Licitra, Giuseppe | University of Catania | giuseppe.licitra[at]unict.it |
| López-Francos, Antonio | Mediterranean Agronomic Institute of Zaragoza (CIHEAM) | lopez-francos[at]iamz.ciheam.org |
| Luciano, Giuseppe | University of Catania | giuseppe.luciano[at]unict.it |
| Maggiolino, Aristide | University of Bari | aristide.maggiolino[at]uniba.it |
| Mangano, Fabrizio | University of Catania | fabrizio.mangano[at]unict.it |
| Mangione, Guido | University of Catania | guido.mangione[at]phd.unict.it |
| Mapiye, Cletos | Stellenbosch University | cmapiye[at]sun.ac.za |
| Marletta, Donata | University of Catania | donata.marletta[at]unict.it |
| Marques, Maria do Rosário | INIAV | rosario.marques[at]iniav.pt |
| Martín García, A. Ignacio | EEZ - CSIC | ignacio.martin[at]eez.csic.es |
| Matthews, Lisa | Stellenbosch University | 20866852[at]sun.ac.za |
| Mele, Marcello | University of Pisa | marcello.mele[at]unipi.it |
| Menci, Ruggero | University of Catania | ruggero.menci[at]unict.it |
| Michalis, Efstratios | Hellenic Agriculture Organization | efstratiosmichalis[at]gmail.com |
| Migliorisi, Linda | CoRFiLaC | migliorisi[at]corfilac.it |
| Morbidini, Luciano | University of Perugia | luciano.morbidini[at]unipg.it |
| Morsy, Amr S. | City of Scientific Research and Technological Applications (SRTA-City) | amrsalah277[at]hotmail.com |
| Musati, Martino | University of Catania | martino.musati[at]phd.unict.it |

| Last name, First Name | Affiliation | Email |
|---|---|---|
| Najar, Taha | INAT | najar.taha[at]inat.agrinet.tn |
| Natalello, Antonio | University of Catania | antonio.natalello[at]unict.it |
| Nichols, Phillip G.H. | University of Western Australia | phillip.nichols[at]uwa.edu.au |
| Niderkorn, Vincent | INRAE | vincent.niderkorn[at]inrae.fr |
| Nudda, Anna | University of Sassari | anudda[at]uniss.it |
| Pardo, Andrea | Mangimi Leone S.p.a. | info[at]mangimileone.com |
| Parissi, Zoi | Aristotle University of Thessaloniki | pz[at]for.auth.gr |
| Pasta, Catia | CoRFiLaC | pasta[at]corfilac.it |
| Pauselli, Mariano | University of Perugia | mariano.pauselli[at]unipg.it |
| Petriglieri, Rosario | CoRFiLaC | acquisti[at]corfilac.it |
| Pipi, Marianna | University of Palermo | marianna.pipi[at]unipa.it |
| Ponte, Marialetizia | University of Palermo | marialetizia.ponte[at]unipa.it |
| Porqueddu, Claudio | CNR - ISPAAM | claudioantonio.porqueddu[at]cnr.it |
| Primi, Riccardo | Tuscia University | primi[at]unitus.it |
| Priolo, Alessandro | University of Catania | alessandro.priolo[at]unict.it |
| Privitera, Salvatore | University of Catania | |
| Ragkos, Athanasios | Hellenic Agricultural Organization - DIMITRA | ragkos[at]agreri.gr |
| Raguem, Mohamed | Office de l'Elevage et des Pâturages | naziha.atti[at]gmail.com |
| Rapisarda, Samuel | Technological University Dublin | samuel.rapisarda[at]tudublin.ie |
| Renna, Manuela | University of Torino | manuela.renna[at]unito.it |
| Ruiz, Roberto | NEIKER | rruiz[at]neiker.eus |
| Salami, Saheed | Alltech | sayodeji14[at]yahoo.com |
| Scerra, Manuel | University of Reggio Calabria | manuel.scerra[at]unirc.it |

| Last name, First Name | Affiliation | Email |
|---|---|---|
| Seeno, Elizabeth | Oregon State University | seenoe[at]oregonstate.edu |
| Semwogerere, Farouk | Stellenbosch University | 21515093[at]sun.ac.za |
| Sgarro, Maria Federica | University of Bari | maria.sgarro[at]uniba.it |
| Smeti, Samir | INRAT | sam_fsb[at]live.fr |
| Stiti, Boutheina | INRGREF | stitibou[at]gmail.com |
| Swanepoel, Pieter | Stellenbosch University | pieterswanepoel[at]sun.ac.za |
| Theodoridis, Alexandros | Aristotle University of Thessaloniki | alextheod[at]vet.auth.gr |
| Todaro, Massimo | University of Palermo | massimo.todaro[at]unipa.it |
| Todaro, Stefania | Mangimi Leone S.p.a. | info[at]mangimileone.com |
| Toral, Pablo G. | IGM (CSIC-ULE) | pablo.toral[at]csic.es |
| Trkulja, Ivana | CORE ORGANIC - ICROFS | ivana.trkulja[at]icrofs.org |
| Tudisco, Raffaella | University of Napoli Federico II | tudisco[at]unina.it |
| Tumino, Serena | University of Catania | seren.tumino[at]unict.it |
| Uushona, Tulimo | Stellenbosch University | utulimo[at]yahoo.com |
| Uwizeye, Aimable | FAO | Aimable.Uwizeye[at]fao.org |
| Valenti, Bernardo | University of Perugia | bernardo.valenti[at]unipg.it |
| Vastolo, Alessandro | University of Napoli Federico II | alessandro.vastolo[at]unina.it |
| Yañez-Ruiz, David | EEZ - CSIC | david.yanez[at]eez.csic.es |
| Yassine, Brahim | University Moulay Ismail - Meknès | yassinebra.onca[at]gmail.com |
| Zaady, Eli | Agricultural Research Organization | zaadye[at]volcani.agri.gov.il |