



Produits animaux de bonne qualité et nouvelles technologies en élevage

Production de produits animaux de haute qualité et mise en œuvre de nouvelles technologies en élevage en relation avec le projet GREENANIMO

Mots clés : qualité de la viande, alimentation animale, bien-être animal, systèmes d'élevage

Auteurs : Svetlana Georgieva¹, Moïse Kombolo², Todor Stoyanchev³, Aubert Nicolazo De Barmon⁴, Ivan Penchev⁵, Nicola Lambe⁶, Gonzalo Cantalapiedra-Hijar², Nadia Bozakova³, Mehmed Halil³, Alice De Boyer Des Roches⁷, Marie Haskell⁸, Ivelina Nedeva¹, Sophie Prache², Ivaylo Marinov⁵, Carol-Anne Duthie⁹, Dimitar Panayotov⁵, Jean-François Hocquette²

¹ Trakia University, Faculty of Agriculture, Department of Fundamental Sciences in Animal Husbandry, Students campus, 6000 Stara Zagora, Bulgaria; svetlana.georgieva8888@abv.bg ivalina.nedeva@trakia-uni.bg

² INRAE, VetAgro Sup, UMR1213, Recherches sur les Herbivores, Theix, 63122 Saint-Genès-Champanelle, France, moise.kombolo@inrae.fr gonzalo.cantalapiedra@inrae.fr sophie.prache@inrae.fr jean-francois.hocquette@inrae.fr

³ Trakia University, Faculty of Veterinary Medicine, Students campus, 6000 Stara Zagora, Bulgaria; todor.stoyanchev@trakia-uni.bg nadiab@abv.bg mehmed.halil@trakia-uni.bg

⁴ Institut de l'Élevage, Service qualité des carcasses et des viandes, 149, rue de Bercy, 75012 PARIS, France, aubert.nicolazodebarmon@idele.fr

⁵ Trakia University, Faculty of Agriculture, Department of Animal husbandry – Ruminant animals and animal products technologies, Students campus, 6000, Stara Zagora, Bulgaria, ivan.penchev@trakia-uni.bg, ivaylo.marinov@trakia-uni.bg, dpanayotov@uni-sz.bg

⁶ SRUC, SRUC Hill and Mountain Research Centre, FK20 8RU, United Kingdom; nicola.lambe@sruc.ac.uk

⁷ VetAgro Sup, UMR Herbivores INRAE-VetAgro Sup, 1 avenue Bourgelat, 69280 Marcy l'Etoile, France; alice.deboydesroches@vetagro-sup.fr

⁸ SRUC, West Mains Road, EH9 3JG Edinburgh, United Kingdom; marie.haskell@sruc.ac.uk

⁹ SRUC, Easter Bush, Roslin Institute Building, EH25 9RG Midlothian, United Kingdom, carol-anne.duthie@sruc.ac.uk

E-mail de l'auteur correspondant : svetlana.georgieva8888@abv.bg

Cet article est une compilation des présentations de la session 6 du 74^{ème} congrès européen des sciences animales (European Federation of Animal Science (EAAP)) qui s'est tenu à Lyon du 28 août au 1er septembre 2023.

Résumé

Le projet "GREENANIMO" est un projet de collaboration entre l'Université de Trakia en Bulgarie, INRAE en France et le SRUC en Ecosse. Il porte sur l'élevage des herbivores selon les principes de l'agroécologie et sur la qualité de la viande. Le projet est structuré selon quatre thèmes : « Amélioration de la qualité de la viande » ; « Augmentation de l'efficacité alimentaire » ; « Amélioration du bien-être animal » ; « Conception de systèmes d'élevage de ruminants durables ». Cette session était ouverte à tous les chercheurs du projet GREENANIMO mais aussi à tout chercheur en dehors de ce projet ayant une activité scientifique liée à un de ces quatre thèmes.

Abstract: Production of high-quality animal products and implementation of new technologies in animal husbandry

The "GREENANIMO" project is a collaborative project between the University of Trakia in Bulgaria, INRAE in France and SRUC in Scotland. It concerns the breeding of herbivores according to the principles of agroecology and the quality of the meat. The project is structured according to four themes: "Improving meat quality"; "Increasing feed efficiency"; "Improving animal welfare"; "Design of sustainable ruminant breeding systems". This session was open to all researchers from the GREENANIMO project but also to any researcher outside this project with scientific activity linked to one of these four themes.

INTRODUCTION

This session covered research related to production of high-quality animal products and implementation of new technologies in animal husbandry which are the topics of the GREENANIMO project. Any research activity related to these topics conducted in different countries were welcomed in this session to enrich the project with similar research carried out elsewhere.

Project "GREENANIMO" aimed to significantly strengthen the competencies of Trakia University, an institution of excellence in Bulgaria, in agro-ecological ruminant production and meat quality, by creating a strong collaborative link with two scientific institutions INRAE, France, and SRUC, Scotland that are international leaders in this field. The target areas and fields of tasks of the project are as follows: "Enhancing meat quality"; "Increasing feed efficiency"; "Improving animal welfare"; "Designing sustainable ruminant farming systems". The challenge for the Bulgarian researchers is to bridge the gap between sciences, business and education-training, which will enable the livestock sector and rural areas to become more sustainable and competitive. By working with the researchers from the internationally/leading partners

INRAE and SRUC, knowledge transfer and successful integration into new networks is being achieved. The project clearly addresses all instruments as active measures in the project implementation: scientific exchanges; expert visits and medium and short-term on-site and virtual training; conference attendance, workshops; training courses for students and farmers, etc. Dissemination activities and promotion of newly-developed modules, knowledge, and experiences are oriented to the young and early career researchers and business through a multidimensional interdisciplinary system for scientific and popular media activity, and publications, as well as social demonstration and programmes. Addressing the problems of the primary production from ruminants and the needs for a thematic University centre interacting with the meat quality and productivity systems is a core challenge for the present project. Integration of the project in the University life and educational future is optimized by the students' activity and post graduate programs and individual courses with practical training set alongside presentation of fundamental concepts.

I. ENHANCING MEAT QUALITY

PLS-DA analysis on hand-held spectrometer for on-line prediction of beef marbling in slaughterhouses

Few studies have used Near Infrared (NIR) spectroscopy to assess meat quality traits directly in the chiller. This study aimed to predict marbling scores with a handheld NIR spectrometer operating in the 740-1070 nm region on intact meat muscles in the chiller in France and Italy. Marbling was assessed according to the 3G (Global Grading Guaranteed) protocol. The scores ranged from 100 to 1190 with a mean of 330. Five scans were performed at different points of the Longissimus thoracis muscle. Two PLS-DA models were used with or without sex and breed included. The first dataset was made of 677 samples (with sex and breed known), the second dataset was made of all of the 829 samples. The models were developed using an external validation set. Both models gave similar outcomes. The models were first evaluated using a confusion matrix which describes the classification performance. The overall accuracy for both confusion matrices was 61%. The model was also

assessed with receiver operating characteristic (ROC) curves where AUROC corresponds to the area under a ROC curve and a single value indicates the overall performance of a binary classifier. It ranges from 0.5 to 1 where the lowest value represents a random classifier and the maximum value represents a perfect classifier. AUROC values were higher for the low and high classes (ranging between 0.8 and 0.7). Finally, permutation plots were obtained for each class, using 100 permutations. Values of the permuted R^2 (the explained variance) and Q^2 (the predictive capability of the model) indicated that only the medium class prediction could be built randomly. In conclusion, results did provide a moderate prediction of the marbling scores which can be useful in the European industry context to predict low and high classes of MSA marbling (Kombolo *et al.*, 2023).

Application of computed tomography and hyperspectral images for enhanced meat quality evaluation.

Meat quality is difficult to determine because it is a combination of microbiological, nutritional, technological, and organoleptic components. Classical methods for measuring meat quality require the destruction of samples. Recently, X-ray computed tomography (CT) and hyperspectral imaging (HSI) have been investigated as tools for non-contact inspection and monitoring of meat and whole carcasses. This study aimed to evaluate the capabilities of CT and HSI to assess the quality of beef cuts. Different steaks (Ribeye steak; Denver steak; Rump steak; Top-sirloin steak) were

purchased from the city market in Stara Zagora. The meat samples were analysed by CT tomography Somatom Go (Siemens-Healthcare, Germany) and Hyperspectral camera AVT Goldeye CL-008, (Specim, Spectral Imaging Ltd. Oulu, Finland) in the spectral range 900-1700 nm. Spectronon software (Resonon Inc. Bozeman, MT, USA) was used for processing hyperspectral images. Fat; protein; dry matter and ash content of meat samples were determined by classical laboratory methods. PLS regression was used for the quantitative determination of the chemical content of meat. The

percentage of lean meat and fat was estimated on the base of CT and HSI images. A comparison of the determination accuracy of the two investigated methods was made. Equations for estimation of the chemical composition of meat samples based on spectral information in the near-infrared range provide good

Effect of husbandry factors on marbling deposition

Various studies confirm the positive impact of marbling on the overall palatability of meat. Thus, this criterion has been chosen by the French beef interbranch organization (INTERBEV) as a priority to better answer to consumers expectations. However, husbandry practices that enhance marbling deposition are partially known. The objective of the present study is to identify practices which allow to produce marbled meat from beef breeds females (Limousines and Charolaises). Measurements on carcasses were made in slaughterhouses with the new French marbling grid (from 1: no marbling, to 6: very high marbling). Then, two farm's groups were separated: a group producing carcasses with low marbling (LM - marbling score 2.2 ± 0.8) and another group with high marbling carcasses (HM - marbling score 3.7 ± 0.9). Interviews of breeders were conducted to collect husbandry practices to try to explain marbling levels. First, they had to define the major genetic type of their livestock between: "beefy type" selected on muscle deposition, "livestock type" chosen for maternal qualities and body size or "mixed

Effect of birth type on meat quality in Ile-de-France lamb

The aim of the present study was to investigate the influence of the factor "birth type" in lambs on the performance of the meat obtained from them. The studied lambs were of the Ile de France breed and were divided into two groups: the first group is Single and the second group - Multiple. The lambs were slaughtered at 120 days of age, with 4 lambs from each group slaughtered. Samples were taken at 24 hours post mortem from the following muscles: *m. Longissimus thoracis et lumborum* (LTL), *m. Iliopsoas* (IP) and *m. Semimembranosus* (SM). The research of the samples for the chemical composition and technological qualities of the meat was carried out 48 h post mortem, stored at 4°C. Regarding the total

In-abattoir 3D image parameters of beef carcasses for predicting carcass classification and weight

Imaging technology can extract measurements from beef carcasses, allowing for objective grading. Many abattoirs, however, still rely on manual grading due to the infrastructure and cost required, making the technology unsuitable. This study explores 3-Dimensional (3D) imaging technology, requiring limited infrastructure and its ability to extract automated measurements from beef carcasses to predict cold carcass weight (CCW), and EUROP conformation and fat class on the 15-point scale. Time-of-flight near-infrared cameras captured 3D images of beef carcasses in a commercial abattoir in Scotland over a 6-month period. Up to 35 frames were captured per carcass, with 74 measurements (lengths,

accuracy of the determination. In conclusion, results show the capabilities of the CT and HSI for fast and non-destructive estimation of meat quality, which can be useful in the meat industry (Liu *et al.*, 2022 ; Bangieva *et al.*, 2023).

type", which is intermediate. "Beefy type" is largely represented in LM group and "livestock type" in HM group. Results indicate two important nutrition periods that may affect marbling: between 5 and 12 months, a period embracing the "marbling windows" already identified for Anglo-Saxon breeds, and during finishing. Differences between the two extreme groups are important during these two periods. Between 5 and 12 months, the HM group distribute concentrate during a longer period (5.1 ± 2.4 months) than LM (2.6 ± 2.0 months). Moreover, HM distribute more concentrate than LM (around 30% of HM breeders give it ad libitum vs 0% for LM). Fattening periods are longer for HM group (5.7 ± 1.4 months) than for LM (2.9 ± 0.9 months). In addition, energetics levels during fattening are more important in the HM group ($+1.3$ UFV/d compared to LM group). The efficiency, technical and economical feasibility of the practices identified in this study must be confirmed in experimental farms to make them operational.

chemical composition of the meat, no significant difference was observed between the two study groups. There was also no significant difference between the groups in terms of technological qualities (pH value, colour, roasting losses, brittleness). Only a significant difference ($P < 0.05$) was found in the indicator of water-holding capacity between the groups in the studied LTL and IP muscles. Regarding the fatty acid composition of the meat, a significant difference was found in the n-6/n-3 ratio of LTL between the two studied groups (Panajotov, 2021 ; Achkakanova and Penchev, 2023)

widths, and volumes) extracted from each image using machine vision software. Values were averaged across frames giving one data row per carcass (9,577 steers, 8,323 heifers). The data were randomly split into training and validation datasets (70:30). The training dataset was used to build multiple linear regression and stepwise selection models, using either fixed effects₁ (sex, breed type, kill date (and CCW for conformation and fat class predictions)) or a combination of fixed effects and 3D measurements₂. Including 3D measurements substantially improved the fit of models for conformation (Rsq (adj) :1: 0.25, 2: 0.54, RMSE = 1: 1.18, 2: 0.93), fat class (Rsq (adj)=1: 0.20, 2: 0.30, RMSE = 1: 1.55, 2:1.38)

and CCW (Rs_q (adj) = 1:0.2, 2:0.74, RMSE = 1:31.14, 2:21.02). Validation of the best fitting models had low, moderate, and high accuracy, respectively, for fat (Rs_q =2: 0.3, RMSE = 2: 1.36), conformation (Rs_q =2:0.54, RMSE = 2:0.93), and CCW (Rs_q =2:0.74, RMSE = 2:21.28). Mapping predictions on to the traditional EUROP grid used in the UK showed that 95% of fat

classes and 81% of conformation classes were classified within the correct or one neighbouring grade. The 3D measurements were found to add value to the models, improving the accuracy, indicating the potential for technology requiring limited infrastructure to predict carcass traits. Accuracies may further be improved using machine learning models (Nisbet *et al.*, 2023),

II. INCREASING FEED EFFICIENCY

Relationships between lamb feed efficiency, rumen volume and carcass quality measured by CT scanning

There is mixed evidence in the literature about the relationships between feed intake or efficiency and body composition of sheep. In cattle there is some evidence that selection for feed efficiency may reduce fatness at a fixed age or weight. These relationships require further investigation before sustainable strategies to breed for improved efficiency and reduce methane can be proposed. Across two years, Texel x Scotch Mule lambs (n = 236 in total) from 10 sires were recorded through individual feed intake recording equipment, after weaning, for a total of six weeks (~14-20 weeks old), following a two week adaptation period. Lambs were CT scanned at the end of the feeding trial and a number of carcass quality traits were calculated from the resulting images, as well as reticulo-rumen volume (RRvol; known to be linked to methane emissions). Residual feed intake (RFI) was calculated for each lamb, by adjusting average daily dry matter intake for live weight, average daily liveweight gain and fixed effects (sex, litter size).

Residual values for the CT traits were calculated, after adjusting for fixed effects (sex, year, litter size in which the lamb was reared, age of dam) and live weight at CT scanning. Low to moderate negative correlations between residuals imply that reduced RFI is favourably associated with increased carcass muscle weight, eye muscle area and depth. No significant correlations with RFI were observed for fat traits (carcass fat weight or CT-predicted intramuscular fat), spine traits (length or vertebra number), or RRvol. Low to moderate negative correlations were observed between RRvol and most of the carcass traits, suggesting poorer carcass yield and quality (but reduced fatness) in lambs with higher RRvol, which has previously been associated with higher methane emissions. Larger data sets are being amassed to allow genetic relationships among these traits to be further investigated (Lambe *et al.*, 2022).

Do biomarkers of residual feed intake in beef cattle remain consistent regardless of feeding level?

The use of novel blood biomarkers to predict residual feed intake (RFI) has been proposed as a cost-effective technology to identify feed efficient cattle. However, it is unclear whether these biomarkers are linked to RFI because they reflect the metabolic efficiency of the animal or simply co-vary with the inherent differences in feeding level. This study aimed to determine if plasma biomarkers of RFI, identified under ad libitum feeding conditions, remain consistent when animals are feed-restricted on the same grass silage-based diet. Sixty Charolais crossbred young bulls divided into two groups of 30 animals were used in a cross-over design study with two 70-day test periods. Group 1 was fed ad libitum in period 1 (A1) and then restricted during period 2 (R2), while the opposite occurred for Group 2 (R1 and then A2). Animals in R1 and R2 were restricted at a level of 1.45% of their body weight. Blood samples were collected from the 12 most divergent RFI (6 Low-RFI, efficient; 6 High-RFI, inefficient) animals in both groups at the end of the first test period, and again on the same

animals after the second test period (n = 48). Plasma samples were analyzed by LC-tandem mass spectrometry and colorimetric methods for quantifying a total of 74 targeted metabolites. Repeated measurements analysis was conducted with the fixed effects of RFI, feeding level and their interaction and the random effect of animal; RFI was considered as either a categorical (Group 1; Low vs. High) or continuous (Group 2) variable. Fourteen plasma metabolites had a moderate-to-high repeatability ($0.55 \leq r \leq 0.91$) across both feeding levels. In Group 1, the plasma concentration of α -aminoacidic acid was lower in Low-RFI compared to High-RFI cattle for both feeding levels (FDR = 0.02). In Group 2, 5-aminovaleric acid concentration was positively correlated ($r = 0.72$) with RFI across both feeding levels (FDR = 0.01). These two metabolites belong to the lysine degradation pathway. Results suggest that metabolic regulations associated with RFI are not solely driven by differences in feeding levels (Nedelkov *et al.*, 2021).

III. IMPROVING ANIMAL WELFARE

Practical application of Observer XT software for behaviour and welfare research in sheep and cattle

In modern scientific research with animals, it is especially relevant to synchronize and combine various vital signs to obtain a complete picture of their welfare.

Observer XT software provides detailed and refined data on animal behaviour, but also provides the ability to visualize physiological data, as well as export and

synchronize ethological data with other physiological indicators. The aim of the present study is to review the practical use of Observer XT software for synchronizing and integrating ethological observations in sheep and cattle with different physiological parameters in relation to their welfare. To achieve the goal, we reviewed over 250 official documents, and scientific publications through electronic networks - PubMed, Research Gate, and Elsevier, related to the use of Observer XT software to integrate data from video recordings of various behavioural reactions of cattle, calves, sheep, lambs, and goats with their physiological, hormonal, biochemical, immunological and other indicators related to their welfare. As a result, we summarized and systematized the

scientific data from the practical use of Observer XT software to synchronize and integrate indicators from ethological observations in sheep and cattle with other multimodal data. This makes it possible to establish relationships and regularities between the various vital indicators and, as a result, to obtain a more complete picture of animal welfare, as well as to significantly improve the quality of scientific research. Based on established data, the Observer XT software is an optimal method for integrating and synchronizing ethological data in research with different physiological parameters in sheep and cattle in relation to their welfare (Bozakova, *et al.*, 2022 ; 2024).

Software tools and technologies used to study animal behavior-benefits and capabilities of Observer

Some behaviors can be used to gain insight into the emotional state and welfare of the animals. It is important to be able to recognize abnormal behaviors, equally important to understand which typical behaviors could be indicative of poor welfare when performed in excess, and which behaviors can indicate positive welfare. Using recording methods to quantitatively assess behaviors related to positive and negative welfare can be a powerful tool for professionals working with farm animals. Welfare assessment methods have evolved significantly in recent decades in terms of both behavioral and physiological indicators. Modern ethological studies require a good knowledge and precise measurements and synchronization of video data of behavior with the physiological parameters of the studied animals in this scientific field. Nowadays, applications are using that support these processes, such as software for studying

animal behavior - Observer XT. The aim of this research is to investigate the benefits and capabilities of Observer XT in analysing and study of farm animal behavior, as well as its practical application in teaching students. After numerous observations, trainings and specialized literature searches for the application of this unique software, in the present scientific study, we present that the Observer XT software offers a wide range of possibilities for simultaneous integration and synchronization of video - data from ethological observations, with physiological indicators such as heart rate, abdominal movements, respiratory rate in animals. Due to its flexibility, the application can be successfully used in various fields such as Ethology, Zoology, Veterinary Hygiene and Technology, both for scientific purposes and for training of future specialists.

Animal welfare: From research to practice

In the second half of the 20th century, research on animal welfare began. Initially, most research aimed at identifying and reducing suffering; e.g. research helped to define minimum space allowances per animal or to identify the need for social interactions. Then research focused on what would make animals comfortable; e.g. preferences between lying surfaces have been studied. More recently, the concept of positive welfare has been introduced, which goes beyond the mere satisfaction of needs by providing a rich environment and promoting positive emotions (expressed through play behaviour, positive interactions, exploration...). Much is now known about animal welfare, at least in theory. On the basis of this knowledge, legislation has been adapted in many countries, at least in the EU, to guarantee minimum standards of animal welfare, i.e. essentially to avoid poor welfare. Quality standards have also been developed by several production chains, some of which offer a higher level of welfare than the legislation. To bridge the gap between theory and practice, researchers need to work

with stakeholders to define best practices that can be applied on farms (or during transport and slaughter) to ensure a high level of animal welfare. These recommendations should not be seen as an addition to farming practices, but as an integral part of those practices. In other words, the latest knowledge on animal behaviour, sensory and cognitive abilities, health, physiology... should be considered when defining husbandry practices that meet the needs of animals and farmers. We believe that good practices should cover animal needs (basic needs, comfort) and best practices should promote positive welfare. We illustrate this approach with the CARE4DAIRY project, which is developing good and best practice guidelines for the dairy cattle sector. The scientific and technical knowledge will be used to define these practices which will be discussed with stakeholders (farmers, farm advisors, policy makers) before final guidelines are produced. The project covers dairy calves, heifers and cows, including cows at the end of their productive lives.

Effects of warm climatic periods on dairy cow behaviour and welfare in a maritime European climate.

Global warming is resulting in an overall increase in temperatures and in the frequency of extreme weather events. In dairy cattle, thresholds within the temperature-

humidity index (THI) have been used to indicate points at which cattle will likely experience thermal stress (e.g., a THI threshold of 75 predicts thermal stress). However,

high-yielding dairy cows that reside in temperate maritime climates may experience some degree of thermal discomfort below this threshold particularly when they are housed. Housing often results in high levels of humidity. The use of technology such as activity monitors and automated intake measures allow us to monitor responses. The aim of this study was to use technological solutions to assess behavioural changes in response to moderate increases in THI levels. Data from dairy cattle on an experimental unit were used. Data on daily lying times, lying bout frequency, step count, feed and water intake were extracted for 10 pairs of warmer (THI<65) and ten matching cooler (THI=43 to 60) periods. Each period was 3 or more days each, and warm and cooler periods were no more than 5 weeks apart to ensure that the data from the same animals were being compared. Results showed that total daily lying time was

shorter during warmer periods than cooler periods ($P<0.05$; means and SEMs (h): warm: 11.4 ± 0.04 ; cool: 12.0 ± 0.04) with a tendency for cows to have more daily lying bouts in warm periods ($P=0.08$; (counts): warm: 12.1 ± 0.1 ; cool: 11.9 ± 0.1). However, there was no effect of THI level on the no. of steps taken by cows ($P>0.05$ (counts): warm: 858 ± 6 ; cool: 856 ± 6). Water intake was higher during warm periods ($P<0.05$; (l) = warm: 79.4 ± 0.6 ; cool: 71.5 ± 0.5). Milk yield was lower during warm periods than cool periods ($P<0.05$; (l): warm: 30.3 ± 0.2 ; cool: 30.7 ± 0.2). This suggests that behaviour and milk yield are adversely affected even in conditions that are not traditionally regarded as exceeding cows' ability to cope with thermal challenge. Technological solutions aid in detection on cow thermal distress and may be used as a routine monitoring system. (Riley *et al.*, 2023).

Behavioral and hormonal effects of intensive sheep farming on milking behavior in a milking parlor

The aim of the present study was to evaluate how intensive dairy sheep farming influenced their behavior during milking in a milking parlor. The sheep ($n=633$) were divided into groups according to milk yield (high- and low-yielding) and stage of lactation (beginning, middle, end). Using video surveillance and data from morning and evening milking of the automated system installed in the milking parlor, an analysis of ethological parameters order of entry in the milking parlor (EMI) and milking parlor side preference (SMI) was made. The calculated EMI and SMI indices served for individual scoring of each animal for evaluation of studied factors. The blood concentrations of thyroid hormones (T3 and T4) and cortisol were assayed during three different seasons (summer, autumn, winter). The daily milk yield of studied sheep was 2.451 l, with a peak of 3.967 l in mid-lactation. The sheep built a stable hierarchical order

in the group throughout the entire lactation period, manifested with high values of the EMI index: 668.62. The milk yield had no effect on both the order of entry in the parlor and side preference. The established milking parlor side preference (SMI =69.38%) was not accompanied with preference to the milking place, which facilitate the technological process of milking. A statistically significant effect of the season ($P<0.001$ in the autumn) on blood cortisol, triiodothyronine and thyroxine concentrations was demonstrated with no relation with milk yields. Regardless of the established seasonal changes in adrenal and thyroid gland hormones, they had no effect on the health and welfare of sheep reared in intensive systems, but point out to a more difficult adaptation to this farming system (Nedeva, 2020 ; Nedeva *et al.*, 2022).

IV. DESIGNING SUSTAINABLE RUMINANT FARMING SYSTEMS

Combining cattle and sheep in a grassland-based system: which effects for system multiperformance?

The association of beef cattle and sheep shows benefits at the grazing season level, but a comprehensive assessment at system level is lacking. Three grassland-based organic systems were managed for 4 years as separate farmlets, with similar surface area and stocking rate: one mixed system combining beef cattle and sheep (MIX, 60:40 cattle:sheep livestock units (LU)) and two specialised systems, beef cattle (CAT) and sheep (SH). Calving and lambing were adjusted to grass growth to optimise grazing. Calves were pasture-fed from 3 months old until weaning in October, fattened indoors with haylage and slaughtered at 12-15 months. Lambs were pasture-fed from 1 month old until slaughter; if lambs were not ready for slaughter when the ewes mated, they were stall-finished with concentrates. The decision to supplement adult females with concentrate was based on the achievement of a target body condition score (BCS) at key periods. The decision to treat animals with anthelmintics was based on mean faecal egg excretion remaining below a certain threshold. A higher proportion of lambs were pasture-finished in MIX vs. SH due to a

higher growth rate which led to a lower age at slaughter. Ewe prolificacy and productivity were higher in MIX vs. SH. The level of concentrate consumption and number of anthelmintic treatments in sheep were lower in MIX vs. SH. Cow productivity, calf performance, carcass characteristics and the level of external inputs used did not differ between MIX and CAT. However, cow BW gain during the grazing season was higher in MIX vs. CAT. These outcomes validated our hypothesis that the association of beef cattle and sheep promoted the self-sufficient production of grass-fed meat in sheep (Prache *et al.*, 2023). It also promoted better female BCS and BW at key stages of the reproduction cycle and better development of the females used for replacement, which may enhance animal and system resilience (Prache *et al.*, 2023). It improved economic and environmental performance and feed-food competition in the sheep enterprise, due to better animal performance and reduced inputs use, but not in the beef cattle enterprise (Benoit *et al.*, 2023).

Milking temperament and its relation with Test day milk yield in Bulgarian Murrah buffaloes

The aim of the study was to assess temperament during preparation for milking and the milking itself of Bulgarian Murrah buffaloes reared in Bulgaria. The study included 91 buffalo cows that were between 30 and 240 Days in milk (DIM). Cows were housed under the conditions of tie-stall housing system and milked with a milking pipeline. The average milk yield of cows for standard lactation was 2245.37 kg with 7.77% fat and 4.34% protein content in milk. The average score for temperament during attaching the milking cluster was 1.83, and for milking temperament - 1.93. The highest was the percentage of cows that reacted by leg lifting (18.9%), followed by animals that were moving on the stall bed during milking (10%), cows that definitely kick (9.9%), and 13.3% managed to remove the milking cluster during milking. A higher percentage of cows responded by leg lifting and kicking during the milking cluster attaching compared to milking itself, 27.8% and 13.3%, respectively. During milking, 72.2% of the buffaloes stood still or only have stepped from foot to foot (scores 1 and 2), and 14.5% have shown undesirable

behavior (scores 4 and 5). A significant difference between the first and second temperament scores during preparation for milking and during milking was not reported. With the highest LS-means for Test Day milk yield (TDMY) were cows with the most undesirable behavior during milking, scores 5 (8.18 kg) followed by those with a score of 4 (7.65 kg). The milk yields of cows with milking temperament scores from 1 to 3 were almost the same and lower than that of aggressive and nervous cows, respectively from 7.21 to 7.37 kg. In cows with scores 1, 2 and 3, the lactation curves were similar in both shape and variation. In all cows, the maximum milk yield was 7.5 to 8.0 kg and was maintained for several months with small variation. The lactation curve in cows with a score 5 had the most fluent shape and the highest maximum milk yield - over 8.5 kg. The lactation curve in cows with a temperament score 4 was with the most undesirable shape - steep reaching the peak and a sharp decrease in milk yield after the peak (Gergovska *et al.*, 2014).

SWOT analysis for supporting development of the grazing livestock meat production sector in Bulgaria through the GREENANIMO project activities.

The grazing livestock meat production sector in Bulgaria has shown considerable development in the last 7-8 years but is still far from European countries in terms of production efficiency, quantity and quality of production. The goal of this study is to develop the most appropriate strategies to support the development of the grazing livestock meat production sector in Bulgaria through the activities of the GREENANIMO project – knowledge transfer and implementation of innovative practices in order to achieve sustainable production of quality meat while increasing the benefits for farmers. Primary data for the SWOT analysis were obtained by use of a survey of a representative sample of farmers rearing beef cattle, meat sheep and meat goats. A comparative index was used to rank the strengths (S) and weaknesses (W), opportunities (O) and threats (T) for the development of the grazing livestock meat production sector in our country. To calculate the metric assessments of each of the factors, an additional ranking was performed based on the average assessment on the importance of the factor by the respondents in the survey,

weighted with an additional expert assessment of the possibility this factor to be influenced by GREENANIMO project activities. Matrices for estimation of the internal (IFE) and external factors (EFE) have been created. The determination of the strategy of the highest importance was made by compiling a SWOT matrix and analyzing the results of four alternative strategies SO, WO, ST and WT. The results of the study show that the (W) and the (T) for the business prevail at almost equal value to the (O). The analysis of the SWOT matrix points at WT and WO strategies, which are the implemented actions leading to minimization of W to limit the T for the sector, as well as to support the realization of O. The appropriate strategies and the activities for their implementation were found, which will be planned in the preparation of the “Action Plan for research and implementation of innovative practices in the grazing livestock meat production sector” within the GREENANIMO project with a view to support the development of the grazing livestock meat production sector in Bulgaria (Panayotova *et al.*, 2021).

CONCLUSION

The project “Greenanimo” extended the capacities of Trakia University and Bulgaria for collaborative work with farmers and meat business operators on R&D activities based on meat-producing ruminant breeds. The created scientific network with the partners from INRAE France and SRUC Scotland successfully introduced innovative practices and models in the training of students in agricultural sciences and veterinary medicine. New practical training courses have been created as programs for students, post-graduate development and training of specialists in grazing animals’ practice.

The EAAP conference was an ideal opportunity to showcase the collaboration between the partners and the new research generated throughout the project. Abstracts from each of the main project themes illustrate the use of new technology and methodology in key areas. The presentations from Trakia University illustrate the uptake of new knowledge building on the outcomes of scientific missions and scientific discussions across the partners. The participation of all partners in the conference clearly cements a sound foundation for collaboration in the future.

Références :

- Achkakanova E., Penchev I.G. (2023). Effect of birth type on slaughter characteristics of Ile-de-France lambs. *Bulgarian Journal of Agricultural Science*, 29 (Issue 2), 359-364.
- Bangieva D., Stoyanchev T., Demirev D. (2023). Carcass traits and meat quality of cattle fed sunflower and soybean protein sources. In proceedings of the International scientific conference “One health”, Bulgaria, Stara Zagora, 12 May 2023.
- Benoit M., Vazeille K., Jury C., Troquier C., Veysset P., Prache S. (2023) Combining beef cattle and sheep in an organic system. II. Benefits for economic and environmental performance. *Animal*, 17, 100759.
- Bozakova N. & Ivanov, V. (2022). Opportunities for sheep welfare improvement by Silymarin additive – a review article. *Bulgarian Journal of Agricultural Science*, 28 (No 3) 2022, 502–509.
- Bozakova N., Halil M., Georgieva S. (2024). Practical application of Observer XT software for behaviour and welfare research in small and large ruminants. *Bulgarian Journal of Agricultural Science*, in press.
- Gergovska Zh., Marinov I., Penev T., & Angelova T. (2014). Effect of milking temperament on productive traits and SCC in Black-and-White cows. *International Journal of Current Microbiology and Applied Sciences*, 3(8), 1-11.
- Kombolo-Ngah M., Goi A., Santinello M., Rampado N., Atanassova S., Liu J., Faure P., Thoumy L., Neveu A., Andueza D., De Marchi M., & Hocquette J.-F. (2023). Across countries implementation of handheld near-infrared spectrometer for the on-line prediction of beef marbling in slaughterhouse. *Meat Science*, 200, 109169. <https://doi.org/10.1016/j.meatsci.2023.109169>
- Liu J., Ellies-Oury M. P., Stoyanchev T., & Hocquette J. F. (2022). Consumer Perception of Beef Quality and How to Control, Improve and Predict It? Focus on Eating Quality. *Foods*, 11(12), 1732-1759. <https://doi.org/10.3390/foods11121732>
- Nedelkov K., Slavov T., Cantalapiedra-Hijra G. (2021). Ruminal degradability and intestinal digestibility of dm and cp in high-protein fraction from sunflower meal - a cheap source of dietary protein for ruminants. *Advances in Animal Veterinary Science*, 9(7), 983-988. | <http://dx.doi.org/10.17582/journal.aavs/2021/9.7.983.988>.
- Nevada I. (2020). Primary factors influencing sheep welfare in intensive and extensive farming systems – a review article, , *Bulgarian Journal of Agricultural Science*, 26 (Suppl. 1), 97-106.
- Nevada I., Slavov T., Radev V., Panayotov D., Varlyakov Y. (2022). Blood biochemical profile as an objective measure of welfare in Lacaune sheep. *Bulgarian Journal of Agricultural Science*, 28 (Issue 2), 324-330. https://journal.agrojournal.org/page/en/details.php?article_id=3755
- Panayotov D. (2021). Study on chemical composition, fatty acid composition and technological quality of meat in Boer goat kids. *Bulgarian Journal of Agricultural Science* 27, (No 6), 1248–1257. https://journal.agrojournal.org/page/en/details.php?article_id=3669
- Panayotova M., Krastanov J., Varlyakov I., Stoyanchev T. Marinov I. (2021). SWOT analysis for supporting the development of the grazing livestock meat production sector in Bulgaria through the GREENANIMO project activities. *Bulgarian Journal of Agricultural Science*, 27(6), 1065–1073.
- Prache S., Vazeille K., Chaya W., Sepchat B., Note P., Sallé G., Veysset P., Benoit M. (2023). Combining beef cattle and sheep in an organic system. I. Co-benefits for promoting the production of grass-fed meat and strengthening self-sufficiency. *Animal*, 17, 100758.
- Lambe, N. R., McLaren, A., McLean, K., Gordon, J. & Conington, J., (2022), Variation in reticulo-rumen volumes between and within sheep breeds and genetic relationships with production traits. *Animal Production Science*. 62, 7, p. 610-621
- Nisbet, H., Lambe, NR., Miller, G. A., Doeschl-Wilson, A., Barclay, D., Wheaton, A. & Duthie, C-A., (2023), Using in-abattoir 3-dimensional measurements from images of beef carcasses for the prediction of EUROP classification grade and carcass weight. *Meat Science*. 109391.
- Riley, B. B., Duthie, C-A., Corbishley, A., Mason, C., Bowen, J. M., Bell, D. J. & Haskell, M. J., (2023). Intrinsic calf factors associated with the behavior of healthy pre-weaned group-housed dairy-bred calves. (abstract from previous Greenanimo conference).