ETH publication series on animal nutrition

46th Swiss Animal Nutrition Conference

Systems Thinking for Sustainable Animal Nutrition: Focus on Nitrogen Use Efficiency and Excretions

Photo: M. Heuel

Conference proceedings

May 20th, 2026

ETH-Zurich

Institute of Agricultural Sciences

46th Swiss Animal Nutrition Conference 2026

Conference proceedings
May 20th, 2026

Publisher:
M. Niu, E. Broxham, M. Terranova, M. Heuel, J. Bérard, A. Liesegang, J. Gross ETH
publication series on animal nutrition

Band 46
ETH publication series on animal nutrition
ISBN 978-3-906466-46-9

Address:
Institute of Agricultural Sciences Animal Nutrition
Eschikon 27
8315 Lindau
May 2026

46th Swiss Animal Nutrition Conference 2026

M. Niu, E. Broxham, M. Terranova, M. Heuel, J. Bérard, A. Liesegang, J. Gross (Publ.)

Table of Contents

Keynote Presentations

Pathways for Sustainable Livestock Production Systems

Nadja El Benni

Research Unit Sustainability Assessment and Agricultural Management, Agroscope
Contact: nadja.el-benni@agroscope.admin.ch

Agriculture and food systems face increasing challenges from climate change and ecosystem degradation, leading to volatile yields and reduced resilience against shocks and long-term stresses. At the same time, geopolitical risks and pandemics lead to disrupted supply chains, volatile input and output prices and intensify pressures on the sector. Agricultural production is suffering from these changes but also contributes to it. Further measures must be taken to reduce nutrient surpluses and greenhouse gas emissions, both of which are disrupting the balance of our ecosystems, particularly in the context of livestock farming. Effective action is needed to strike a balance between food production and consumption and ensure food security.

Farmers have various options to adapt livestock production systems to changing conditions. For instance, GHG emissions can be reduced through technical and management measures such as improved feeding, breeding, animal health, manure management, and grassland management. Increasing productivity and resource efficiency is considered one of the most effective short-term approaches to mitigate climate change (GRA and SAI, 2014). However, in addition to improving efficiency by using new technologies, we must adapt and transform our production systems to reduce nutrient surpluses and greenhouse gas emissions in the long term. This requires cooperation between various stakeholders. Both private-sector initiatives and government measures are needed to support farmers improving efficiency and adapt and transform their production systems.

IP-SUISSE, the Swiss producer association of integrated production, implemented the so-called climate-point system. The goal of the resource project, co-financed by the Swiss Federal Office for Agriculture, was to reduce greenhouse gas emissions from their production by 10% between 2016 and 2025. In collaboration with Agroscope researchers, IP-Suisse developed a catalogue of greenhouse gas emission reduction measures for their farmers to choose from. The goal was achieved. Experiences from IP-SUISSE farms show that climate change mitigation measures such as increasing the number of lactations, heating with wood, and phase feeding in pigs contributed most to reducing environmental impacts (Bystricky, 2026).

However, the effectiveness of climate mitigation measures depends not only on their technical potential, but also on farmers' adoption behaviour. For example, while nitrogen management measures such as slurry tank covers and multi-phase pig feeding are already widely implemented, measures like agroforestry still offer substantial untapped potential to further reduce GHG emissions. However, such measures require transformational changes at farm-level and beyond, including supportive policies (Diogo, 2026).

Economic feasibility strongly influences farmers' adoption of mitigation measures. While agroforestry offers high GHG reduction potential, its implementation costs are also high and vary substantially between farms. In contrast, measures such as nitrogen-optimized feeding, increasing lactation numbers and using feed additives are low-cost options with broad applicability in Swiss agriculture, even leading to negative mitigation costs, i.e. these measures reduce greenhouse gas emissions while also saving money (Hao et al., 2025).

To support farmers in reducing greenhouse gas emissions and due to large differences in abatement costs between farms, aggregated rather than farm-level climate targets are more cost-effective. Aggregated targets, i.e. targets for a group of farmers rather than single farms, allow farmers to choose the cheapest mitigation options for their farm, thereby reducing overall abatement costs of the sector. Furthermore,

to make the reduction of greenhouse gas emissions efficient, targets should focus on the total amount of emissions avoided, allowing farmers to choose a combination of measures that works best for them, rather than supporting specific technologies (Tarruella et al., 2023).

In addition to private-sector initiatives, policy support is also needed to reduce the negative environmental impact of food production and make it more resilient to shocks and long-term stresses. Swiss agricultural policy supports farmers to overcome economic constraints in adapting their production systems. For instance, direct payments are provided to farmers if they extend the lifespan of their dairy cows, adopt pig phase feeding or subscribe to the grassland-based milk and meat production programme. Using herd-specific data from almost 10'000 cows, breed-specific culling statistics and accounting data from 189 Swiss farms, Gazzarin et al. (2025) show that extending the productive lifespan of dairy cows can increase herd profitability by around 10–15%. One prerequisite is that early culling, which is often due to fertility and health issues, can be avoided. In general, optimal lifespan is farm-level specific but typically between 4–6 years, dependent on the production intensity. The higher the intensity, the earlier the economic optimal culling year is. Farm-level advice is needed, as heifer costs and slaughter prices determine the optimal productive lifespan. A long-term strategy should focus on setting realistic milk-yield targets that reflect natural production conditions, while prioritizing breeding for longevity and reliable performance rather than maximizing milk yield alone. As a rule of thumb, cows with good performance reliability should not be culled, even if the replacement cow promises higher milk yields. To evaluate greenhouse gas emission reductions of extending lifespan of dairy cows, also calf fattening must be considered (Winter et al., 2024).

It should also be noted that farmers cannot achieve the shift towards a longer lifespan of cows on their own, as current framework conditions tend to predispose farmers to earlier culling. Interviews with various stakeholders, including farmers, breeder associations, veterinarians, retailers, extension services, advisory services and government agencies, reveal that they all feel unable to meaningfully influence the extension of dairy cows' productive lives. Therefore, joint action is needed (Rödiger and Home, 2023).

Regarding pig phase feeding, a modelling study using the agent-based sector-model SWISSland shows that minimal phase feeding can effectively reduce nutrient surpluses. Phosphorus can be reduced more than nitrogen, while CO_2 emissions remain largely unchanged and N_2O decreases only slightly. Differences between 2- and 3-phase systems are small, and emission reductions are higher on larger farms. Overall, implementation costs, assessed by the additional costs for silos, are low and farm income is hardly affected if stable feed prices are assumed (Dueri et al., 2025).

The grassland-based milk and meat production programme is a voluntary Swiss agri-environmental scheme aiming to reduce concentrate feed use and close nutrient cycles. An ex-post evaluation showed mixed results (Mack et al., 2017; Mack and Kohler, 2018): while it stabilised concentrate use and increased farm income, it had limited environmental impact and weak nutrient-cycle improvements. Ex-ante analyses (Bystricky et al., 2023; Mack et al., 2024) suggest that stricter feed protein and concentrate limits could modestly reduce nitrogen surpluses, but very strict rules would reduce participation. Overall, moderate constraints appear most effective, balancing environmental gains with farmer participation and income stability.

In summary, the risks and uncertainties facing livestock production are growing, rendering business as usual no longer viable. Addressing these challenges requires adaptive and transformational changes; technical measures alone can only achieve limited results. In addition to private-sector initiatives, policy measures are needed to support farmers in overcoming economic constraints. To identify effective and efficient measures, the trade-offs and synergies between different environmental, economic, and social impacts must be assessed both retrospectively and prospectively. Ultimately, change is required throughout the entire agri-food system, necessitating coordinated action from all stakeholders.

References

Bystricky, M., Bretscher, D., Schori, F., Mack, G. (2023). Reducing feed-food competition with direct payments? An ex-ante assessment of economic and environmental impacts, *Q Open* 3(3), qoad002, 1-25. https://doi.org/10.1093/qopen/qoad002

Bystricky, M. (2026). Klimaschutzleistungen von Landwirtschaftsbetrieben: Auswirkungen auf Produktebene, In: Ökobilanzplattform Landwirtschaft 5. Mai 2026, Hrsg. Agroscope, Zürich (CH), 2026. Ökobilanz-Plattform Landwirtschaft Agroscope

Diogo, V. (2026). Estimating the remaining climate mitigation potential of a portfolio of technical measures in Swiss agriculture, In: Ökobilanzplattform Landwirtschaft 5. Mai 2026, Hrsg. Agroscope, Zürich (CH), 2026. Ökobilanz-Plattform Landwirtschaft Agroscope

Dueri S., Winter E., Schlegel P., Schneuwly J., Mack G. (2025). Auswirkungen der Phasenfütterung von Schweinen auf N- und P-Emissionen und Wirtschaftlichkeit. In: 48. Agrarökonomie-Tagung. 18. November, Hrsg. Agroscope, Tänikon (CH). 2025.

Gazzarin, C., Schmid, D., Bieber, A. (2025). Economic drivers of the optimal productive lifespan on dairy cows in two different Swiss milk production systems, Journal of Dairy Science 180(11), 12352-12372. 10.3168/jds.2024-26086

GRA & SAI (2014). Reducing greenhouse gas emissions from livestock: Best practice and emerging options, https://saiplatform.org/wp-content/uploads/2014/12/news_release_livestock_resource-_16_dec_2014.pdf

Hao, Z., Bretscher, D., Kay, S., Mack, G., Winter, E., Keel, S. (2025). How measures for greenhouse gas mitigation in agriculture are implemented strongly determines cost-effectiveness. Available at SSRN: http://dx.doi.org/10.2139/ssrn.5930065

Mack, G., Kohler, A. (2018). Short- and Long-Run Policy Evaluation: Support for Grassland-Based Milk Production in Switzerland, Journal of Agricultural Economics 70, 215-240. https://doi.org/10.1111/1477-9552.12284

Mack, G., Schori, F., Huguenin-Elie, O., Bystricky, M. (2024). Ex-ante-Evaluation von Direktzahlungsbeiträgen zur Förderung der Proteinreduktion in der Rinderhaltung, Agroscope Science 181, 1-44. https://link.ira.agroscope.ch/de-CH/publication/55973

Prăvălie, R., Borrelli, P., Panagos, P. *et al.* (2024). A unifying modelling of multiple land degradation pathways in Europe. *Nature Communications* **15**, 3862 (2024). https://doi.org/10.1038/s41467-024-48252-x

Rödiger, M., Home, R. (2023). Systematic enablers and barriers to extending the productive life of dairy cows in Switzerland, Journal of Rural Studies 100, 103031, 1-10. 10.1016/j.jrurstud.2023.103031

Tarruella, M., Huber, R., Mack, G., El Benni, N., Finger, R. (2023). Cost-effectiveness of farm- vs. regional-level climate change mitigation policies, Q Open, 1-19. https://doi.org/10.1093/qopen/qoad022

Winter, E., Rödiger, M., Schneuwly, J., Gilgen, A., Mack, G: (2024). Modelling cow longevity policies: Impacts on GHG emissions of the Swiss agricultural sector, Agricultural Systems 221, 104107, 1-15. https://doi.org/10.1016/j.agsy.2024.104107

Nitrogen Use Efficiency in Nonruminants: Rethinking Priorities for Future Progress

Markus Rodehutscord

Institute of Animal Science, University of Hohenheim, Stuttgart, Germany
Contact: markus.rodehutscord@uni-hohenheim.de

Improving nitrogen use efficiency (NUE) in nonruminants is central to the sustainable production of high-quality animal protein amid increasing global demand, competition for production resources, and environmental and agroecological impacts of excreted nitrogen (N). In pigs and poultry, NUE is commonly defined as the proportion of nitrogen intake retained in body protein, including milk and eggs. Despite decades of research and advances in feeding concepts, a large fraction of dietary N is still excreted, and feeding appears to offer the greatest opportunity to reduce N waste in the sector (Shurson and Kerr, 2023). The question is: Are current approaches targeting the most relevant biological limitations?

Nutritional concepts to improve NUE have become increasingly sophisticated. The implementation of precaecal digestibility systems has improved the adequacy of amino acid supply. The use (if allowed) of free amino acids, reductions in dietary crude protein concentrations, and phase-feeding concepts have enabled a closer alignment between dietary supply and assumed requirements. As a result, N excretion has been reduced in both pigs and poultry without impairing health and performance, with regulatory constraints leading to differences in the magnitude of the reductions.

While the precision of feed protein evaluation has increased markedly, the primary bottlenecks of NUE improvement may not lie in feed protein characterisation. Livestock populations are not static targets. Continuous genetic progress alters growth potential, feed intake, and body composition, collectively changing nutrient requirements over time. A substantial proportion of absorbed amino acids is not retained by the animal but is irreversibly lost through post-absorptive metabolism, particularly via amino acid oxidation and body protein turnover. These processes represent major sources of inefficiency in N utilisation and are still poorly quantified. Whether body protein turnover in high-yielding animals can be manipulated using nutritional and genetic tools remains a major challenge for interdisciplinary animal science research (Berghaus et al. 2023; Kasper 2024; Schmid et al. 2024). In addition, emerging evidence on gastro-intestinal microbiota-mediated effects on NUE suggests further areas for worthwhile exploration (Sarpong et al. 2024; Schmid et al. 2025). This is particularly relevant when aiming to increase the use of fibre-rich non-human edible biomass in pig and poultry feeding.

Distinctly low-protein diets provide both promise and challenge for current feeding concepts. Although they are effective at reducing N excretion, their implementation often reveals limitations in the understanding of N metabolism. Performance responses, changes in body composition, and the need to consider nonessential amino acid supply show that N metabolism cannot be adequately described by essential amino acid supply alone. In growing poultry, the supply of glycine and other nonessential amino acids has been found decisive when approaching an NUE of approximately 75 % at high zootechnical performance under experimental conditions (Hofmann et al. 2019; Ibrahim et al. 2024; Siegert et al. 2025). These studies suggested a complex interplay among amino acid metabolism, energy supply, and metabolic priorities within the animal.
Future progress in NUE will therefore require a shift in perspective. While accurate evaluation of feed protein remains a standard, greater emphasis must be placed on understanding the animal as metabolically dynamic and variable. This includes developing more flexible and biologically grounded concepts of nutrient requirements, using machine learning tools, and exploiting variation in traits such as

protein turnover through breeding and nutrition.

References

Berghaus, D., E. Haese, R. Weishaar, N. Sarpong, A. Kurz, J. Seifert, A. Camarinha-Silva, J. Bennewitz, T. Chillon, V. Stefanski, and M. Rodehutscord. 2023. Nitrogen and lysine utilization efficiencies, protein turnover, and blood urea concentrations in crossbred grower pigs at marginal dietary lysine concentration. J. Anim. Sci. 101: skad335. doi: 10.1093/jas/skad335

Hofmann, P., W. Siegert, Á. Kenéz, V. D. Naranjo, and M. Rodehutscord. 2019. Very low crude protein and varying glycine concentrations in the diet affect growth performance, characteristics of nitrogen excretion, and the blood metabolome of broiler chickens. The Journal of Nutrition 149: 1122-1132. doi: 10.1093/jn/nxz022

Ibrahim, A., Á. Kenéz, M. Rodehutscord, and W. Siegert. 2024. The influence of substituting dietary peptide-bound with free amino acids on nitrogen metabolism and acid–base balance of broiler chickens depends on asparagine and glutamine supply. Br. J. Nutr. 131: 41-53. doi: 10.1017/S0007114523001617

Kasper, C. 2024. Heritability of nitrogen use efficiency in fattening pigs: Current state and possible directions. Animal 18: 101225. doi: 10.1016/j.animal.2024.101225

Sarpong, N., J. Seifert, J. Bennewitz, M. Rodehutscord, and A. Camarinha-Silva. 2024. Microbial signatures and enterotype clusters in fattening pigs: implications for nitrogen utilization efficiency. Frontiers in Microbiology 15: 1354537. doi: 10.3389/fmicb.2024.1354537

Schmid, M., V. P. Haas, N. Sarpong, M. Rodehutscord, J. Seifert, A. Camarinha-Silva, and J. Bennewitz. 2025. Fecal microbiota-based investigations of nitrogen utilization efficiency and related traits in a Landrace × Piétrain crossbred population. J. Anim. Sci. 103: skaf028. doi: 10.1093/jas/skaf028

Schmid, M., R. Weishaar, J. Seifert, A. Camarinha-Silva, M. Rodehutscord, and J. Bennewitz. 2024. Genomic analyses of nitrogen utilization efficiency, its indicator trait blood urea nitrogen and the relationship to classical growth performance and feed efficiency traits in a Landrace × Piétrain crossbred population. Journal of Animal Breeding and Genetics 141: 559-570. doi: 10.1111/jbg.12864

Shurson, G. C., and B. J. Kerr. 2023. Challenges and opportunities for improving nitrogen utilization efficiency for more sustainable pork production. Frontiers in Animal Science 4: 1204863. doi: 10.3389/fanim.2023.1204863

Siegert, W., A. Omotoso, P. Hofmann, and M. Rodehutscord. 2025. Relevance of nonessential amino acids in low crude protein diets for broiler chickens – an updated review. Nutrition Research Reviews 38: 961-972. doi: 10.1017/S0954422425100176

Improving Nitrogen Utilization in Dairy Production: Animal and Farm-level Perspectives

Chanhee Lee

Department of Animal Sciences, The Ohio State University, Wooster, OH, USA 44691
Contact: Lee.7502@osu.edu

Efforts to improve nitrogen use efficiency (NUE) in dairy production have been made at animal and farm levels. Depending on the target level, the nutritional approaches for research and the strategies to be developed may differ. This distinction arises because improving NUE at the farm level involves consideration of manure N utilization. At both levels, improving NUE remains challenging, and effective strategies currently available are limited.

Improving NUE at the animal level has been a primary focus in dairy nutrition. NUE can be enhanced by increasing the proportion of dietary nitrogen directed toward milk protein synthesis while reducing urinary N excretion. One major area of focus has been maximizing ruminal microbial protein synthesis through optimization of ruminal fermentation (e.g., rumen-degradable protein, energy supply, synchronization between RDP and energy, or stabilizing ruminal pH). However, the effects of these strategies on increasing milk protein yield or decreasing urinary N excretion have generally been small. More recently, greater attention has been directed toward improving NUE at the postruminal level through the supply of balanced amino acids (AA). In particular, supplementation with rumen-protected amino acids (RP-AA), such as Met, Lys, and His, has been extensively studied. Although responses to RP-AA supplementation vary from positive to negligible, this approach is generally accepted as a strategy to improve NUE by enhancing milk protein yield. Future research should aim to identify the factors contributing to these inconsistent responses. In addition to supplying limiting AA, improving NUE may also be achieved by enhancing the overall quality of metabolizable AA. The AA profile of casein has often been considered “ideal” because casein is the primary protein component of milk. Similarly, microbial protein has been regarded as having a higher-quality AA profile compared with feed proteins (e.g., soybean meal). However, evaluating the quality of AA profiles based solely on similarity to milk casein AA is not theoretically sound, as the profile of AA changes substantially during digestion, absorption, and post-absorptive metabolism before being utilized for milk protein synthesis in the mammary gland. Therefore, future studies should focus on understanding the quality of metabolizable AA profiles and optimizing these profiles to enhance milk protein synthesis while reducing urinary nitrogen excretion.

Improving NUE at the farm level may be more straightforward in terms of approach. A key strategy is to reduce ammonia emissions from manure during storage and after land application. The goal is to produce manure with a balanced nutrient composition (e.g., N, P, and K) and to maintain this balance until nutrients are utilized by crops. While P and K are not subject to volatilization, a substantial portion of N can be lost as ammonia. Such losses result in nutrient imbalances in manure and less uptake of manure P by crops due to low N availability, followed by potential losses of P from the field. Therefore, mitigating ammonia volatilization is essential for minimizing nitrogen losses and enhancing nutrient cycling within the farm. Several effective strategies to reduce ammonia emissions during manure storage, such as acidification, urease inhibitors, and manure covering, are already available and can reduce emissions by up to 98%. However, the high costs associated with these technologies limit their practical adoption. An alternative approach is dietary manipulation to alter manure characteristics and reduce ammonia emissions, as it may be implemented with a minimal additional cost. For example, feeding diets high in distillers grains (replacing soybean meal) or lowering dietary cation–anion difference has been shown to reduce ammonia emissions by 20–40%. However, these strategies may negatively affect feed intake and lactation performance, limiting their practical application. Therefore, further research is needed to develop cost-effective direct manure treatment strategies or dietary manipulation approaches that do

not compromise animal performance. Successful implementation of such strategies would substantially improve NUE at the farm level.

In conclusion, efforts to improve NUE in dairy production have largely been pursued independently at the animal and farm levels. However, a more integrated approach that considers both levels simultaneously is needed to develop effective and sustainable strategies. Given the limited availability of practical and cost-effective methods to reduce ammonia emissions during manure storage, improving NUE at the animal level remains the most immediately applicable approach. Practically, NUE at the animal level can be enhanced by avoiding excessive dietary protein concentrations and by using a combination of protein sources or RP-AA to ensure that no essential AA are limiting. In addition, further studies are needed to understand the quality of the metabolizable AA profile to enhance AA utilization for milk protein synthesis, thereby reducing urinary N excretion.

Panel Discussion: Bridging Science and Practice in Nitrogen Efficiency

Moderator: Dr. Markus Rombach (AGRIDEA, Switzerland)

Panelists:

Prof. Dr. Markus Rodehutscord (University of Hohenheim, Germany)

Prof. Dr. Chanhee Lee (The Ohio State University, USA)

Dr. Patrick Schlegel (Agroscope, Switzerland)

Andrea Mantler (UFA AG, Switzerland)

Summary

The panel discussion at the Swiss Animal Nutrition Conference 2026 addressed key challenges and opportunities in improving nitrogen use efficiency in livestock production systems. Bringing together experts from academia, research, and industry, the discussion focused on biological limits, feeding strategies, modelling approaches, and the translation of scientific knowledge into practice.

A central theme was the extent to which current feeding strategies approach the biological limits of nitrogen utilisation. Prof. Rodehutscord emphasised that practical feeding systems remain well below these limits. At the same time, he highlighted the importance of maintaining safety margins to ensure that reductions in dietary protein do not compromise animal health or welfare. Current evidence suggests that moderate reductions in crude protein are possible without negative impacts, although continuous monitoring and research remain essential.

Building on this, Prof. Lee discussed the potential of targeted amino acid supplementation to improve nitrogen efficiency. He argued that existing requirement systems often overestimate protein needs due to built-in safety margins. Experimental studies indicate that slightly reduced protein diets, combined with rumen-protected amino acids, can maintain or even enhance performance. However, the extent of reduction depends on multiple factors, including diet composition, forage quality, and production level.

A major point of discussion was the gap between controlled experimental research and practical farm conditions. Panelists agreed that variability in commercial systems, such as differences in animal groups, management practices, and environmental conditions, makes it difficult to directly translate experimental findings into practice. Prof. Lee highlighted that while experiments often rely on uniform groups and individual feeding, commercial farms operate with heterogeneous groups, limiting the direct applicability of results.

From an industry perspective, Andrea Mantler emphasised the importance of reliability and risk mitigation. Farmers must balance innovation with economic security, and are often hesitant to adopt new feeding strategies without clear and consistent benefits under practical conditions. She stressed that scientific findings must be validated in real-world settings through applied trials to gain farmer acceptance.

Dr. Patrick Schlegel addressed the role of modelling in estimating nitrogen efficiency at farm level. While models provide valuable tools for simulating scenarios and supporting decision-making, their accuracy depends strongly on the quality of the underlying data. Uncertainties in feed intake, nutrient retention, and animal variability remain significant limitations. Nevertheless, modelling approaches can help identify potential improvements and guide policy and advisory frameworks.

Economic considerations were identified as a key constraint for implementation. Innovations such as amino acid supplementation must demonstrate clear benefits to farmers, particularly in ruminant systems

where compound feed represents only part of the total diet. Variability in forage quality and farm management further complicates the evaluation of such interventions. As a result, adoption depends not only on technical feasibility but also on economic viability and farmer confidence.
Looking ahead, the panel highlighted opportunities in precision feeding and new technologies. Automated feeding systems and sensors may enable more individualised nutrient supply, potentially improving nitrogen efficiency. However, practical implementation challenges, such as group-based management systems, remain significant.

Figure 1 l-r Moderator: Dr. Markus Rombach, Panelists: Andrea Mantler, Prof. Dr. Markus Rodehutscord, Prof. Dr. Chanhee Lee, Dr. Patrick Schlegel

Key Messages

The panel concluded with several key messages for research, policy, and practice:

- Current feeding systems remain below biological limits, but reductions must be implemented cautiously.
- Nitrogen efficiency can be improved through better targeting of protein supply, including amino acid supplementation.
- Bridging the gap between research and practice requires more applied, long-term, and on-farm studies.
- Modelling is a valuable tool but must be supported by robust and comprehensive datasets.
- Farmer adoption depends on economic viability, reliability, and demonstrated benefits under practical conditions.
- Reducing nitrogen losses across the entire system, including manure management, will be critical for future sustainability.

Overall, the discussion highlighted that improving nitrogen use efficiency requires coordinated efforts across disciplines and stakeholders. While no single solution exists, incremental improvements at multiple levels offer significant potential to enhance both environmental sustainability and production efficiency in livestock systems.

Research Talks

Adapting Pharmaceutical Virtual Screening to Rumen Biology: Alliin Emerges as a Natural MCR Inhibitor

R. Peng[1], Z. Song[2], G. Foggi[1], Z. Huang[2], M. Niu[1]

[1] *ETH Zurich, Department of Environmental Systems Science, Eschikon 27, 8315 Zurich, Switzerland,* [2] *Villanova University, Department of Chemical and Biological Engineering Directory, 800 E. Lancaster Avenue, 19085 Villanova, United States*

Corresponding author: mutian.niu@usys.ethz.ch

Enteric CH_4 from ruminants is a major short-lived climate forcer and energy loss. Methyl-coenzyme M reductase (MCR), the terminal enzyme of rumen methanogenesis, is an attractive inhibition target due to its unique cofactor (F430) absent in mammalian biochemistry. This study applied a pharmaceutical-inspired computational discovery pipeline, combining large-scale structure-based virtual screening, ADMET filtering, and *in vitro* rumen fermentation validation to systematically identify food-derived natural compounds as candidate MCR inhibitors. The X-ray structure of MCR from *Methanothermobacter marburgensis* (PDB 5A0Y) with coenzyme M (CoM) as a reference ligand, defined the catalytic F_{430} pocket. About 140,000 compounds from *FooDB* database were screened by molecular docking using the ICM platform, applying a weighted score threshold of −25 kcal/mol (CoM: −28 kcal/mol) to yield 56 primary hits. ADMET properties, commercial availability, and literature evidence reduced it to 20 candidates selected for *in vitro* validation, alongside an untreated control, 3-nitrooxypropanol (3-NOP) as positive control. Candidates were incubated at 1% of substrate organic matter (OM) in a 24-hour Hohenheim Gas Test with rumen fluid from three lactating dairy cows (duplicates per cow; n = 6 per treatment). Gas production and concentration (CH_4, H_2, and CO_2), pH, ammonia-N, VFA, *in vitro* OM digestibility (IVOMD), and dissolved gas concentration were measured. Data were analysed using mixed-effects models with donor cow as a random effect; planned contrasts assessed compound versus control differences. Positive control 3-NOP reduced both CH_4 yield (mL/g degraded OM) and dissolved CH_4 concentration by 99%, and IVOMD by 5% ($P < 0.01$). Alliin, a sulphur-containing amino acid derivative from garlic (*Allium sativum*), reduced both CH_4 yield and dissolved CH_4 by 50%, and IVOMD by 8%, with substantially increased H_2 accumulation ($P < 0.01$), indicating potential inhibition at the terminal step of methanogenesis. Tiglic acid, glutaric acid, and allantoic acid reduced dissolved CH_4 concentration by 42%, 38%, and 35%, respectively ($P < 0.05$), demonstrating that the pipeline identified multiple independent natural inhibitors. These findings demonstrate that adapting pharmaceutical computational discovery tools to food-derived chemical space provides an efficient and scalable strategy for identifying natural CH_4 inhibitors from dairy-relevant sources. Alliin warrants further evaluation *in vivo* in lactating dairy cows to assess dose-response, rumen ecosystem stability, and effects on milk composition and animal performance.

Impact of Colostrum Processing on Metabolic and Endocrine Parameters During Early Postnatal Life in Calves

I. Weber[1], M.A.E. von Riedheim[1], H. Erkinger[1], O. Calisici[2], J.J. Gross[1]

[1] *Veterinary Physiology, Vetsuisse Faculty, University of Bern, Bremgartenstrasse 109a, 3012 Bern, Switzerland*
[2] *Phytobiotics Futterzusatzstoffe GmbH, 65343 Eltville, Germany*
Corresponding author: josef.gross@unibe.ch

Colostrum feeding is essential for calf immunity and nutrition and is a key determinant of neonatal survival and health. Since timely feeding of colostrum is crucial, various storage and preservation methods have been implemented in dairy management practices to ensure a backup of colostrum in case maternal colostrum is insufficient. The objective of this study was to investigate the impact of different colostrum processing methods on metabolic and endocrine parameters in newborn calves. Eighteen calves (15 Holstein, 3 Holstein x Limousin crossbreds) were separated from their dams immediately after birth and randomly assigned to one of three groups. Calves were fed 2.5 L of either pooled native colostrum (**NC**), pooled pasteurized colostrum (**PC**), or vacuum-dried colostrum replacer (**CR**) produced from the same native colostrum batch at 4 h and 12 h postpartum (**p.p.**). On d 2 and 3 p.p., animals received transition milk (bulk tank milk mixed with 10% of the respective colostrum source), and from d 4 onwards bulk tank milk twice daily. Blood samples were collected at 4, 12, and 24 h p.p., and thereafter once daily until d 7 p.p. before morning feeding. Metabolic and endocrine parameters including total protein (**TP**), IgG, aspartate aminotransferase (**ASAT**), gamma-glutamyl transferase (**GGT**), glucose, insulin, cortisol, glucagon, non-esterified fatty acids (**NEFA**), triglycerides (**TG**), and total cholesterol (**TC**) were analyzed. Statistical analysis was conducted using SAS (version 9.4; SAS Institute Inc., Cary, NC). A mixed model was applied to assess the effects of colostrum processing, with group, time, and their interaction as fixed effects, followed by Tukey's post hoc test to adjust for multiple pairwise comparisons. Total protein and IgG concentrations were greater in PC and CR ($P < 0.01$) until d 2 compared to NC. Activity of GGT at 12 h p.p. was greater in PC and CR ($P < 0.01$) compared to NC. Insulin concentrations did not change in PC ($P = 0.31$) and CR ($P = 0.99$) until d 2, whereas a decline was observed in NC after 12 h p.p. ($P < 0.05$). Glucagon concentrations were greater in PC and CR ($P < 0.01$) up to d 2 compared with NC. Cortisol concentrations decreased in all groups until 24 h p.p. ($P < 0.01$). Colostrum processing did not affect lipid metabolism related parameters, including NEFA, TG, and TC, or ASAT activity. Our results demonstrate that pasteurization and freeze-drying of colostrum can improve IgG and nutrient absorption and enhance activation of glucagon-mediated metabolic pathways.

Distinct Microbial Hydrogen and Reductant Disposal Pathways Explain Interbreed Variations in Ruminant Methane Yield

Qiushuang Li, Jiabin Huo, Xiumin Zhang, Rong Wang, Shizhe Zhang, Zhiliang Tan, Min Wang*

State Key Laboratory of Forage Breeding-by-Design and Utilization, Institute of Subtropical Agriculture, Chinese Academy of Sciences, Changsha, Hunan, China

Corresponding author: mwang@isa.ac.cn

Ruminants are essential for global food security but are major sources of the greenhouse gas methane. Methane yield is controlled by the cycling of molecular hydrogen (H_2), which is produced during carbohydrate fermentation and consumed by methanogenic, acetogenic, and respiratory microorganisms. However, we lack a holistic understanding of the mediators and pathways of H_2 metabolism and how this varies between ruminants with different methane-emitting phenotypes. Here, we used metagenomic, metatranscriptomic, metabolomics, and biochemical approaches to compare H_2 cycling and reductant disposal pathways between low-methane-emitting Holstein and high-methane-emitting Jersey dairy cattle. The Holstein rumen microbiota had a greater capacity for reductant disposal *via* electron transfer for amino acid synthesis and propionate production, catalyzed by enzymes such as glutamate synthase and lactate dehydrogenase, and expressed uptake [NiFe]-hydrogenases to use H_2 to support sulfate and nitrate respiration, leading to enhanced coupling of H_2 cycling with less expelled methane. The Jersey rumen microbiome had a greater proportion of reductant disposal *via* H_2 production catalyzed by fermentative hydrogenases encoded by *Clostridia*, with H_2 mainly taken up through methanogenesis *via* methanogenic [NiFe]-hydrogenases and acetogenesis *via* [FeFe]-hydrogenases, resulting in enhanced methane and acetate production. Such enhancement of electron incorporation for metabolite synthesis with reduced methanogenesis was further supported by two *in vitro* measurements of microbiome activities, metabolites, and public global microbiome data of low- and high-methane-emitting beef cattle and sheep. Overall, this study highlights the importance of promoting alternative H_2 consumption and reductant disposal pathways for synthesizing host-beneficial metabolites and reducing methane production in ruminants.

How Accurately do Dog Owners Identify Overweight and its Associated Health Risks? Age and Confidence Effects in a Swiss Dog-Expo Survey

S.B. Harris[1], A. Popa[1], A. Liesegang[1]

[1] *Institute of Animal Nutrition and Dietetics, University of Zurich, Switzerland*
Corresponding author: aliese@nutrivet.uzh.ch

Background: Owner misperception of canine body condition (BC) has previously been reported in a Swiss dog exhibition survey, in which owners significantly underestimated their dogs' body condition score (BCS) compared with veterinarians (mean BCS 4.5/9 vs 5.2/9)[1]. The same study also reported uncertainty among owners regarding nutritional management and highlighting the need for targeted education by veterinary nutrition professionals.

Objective: To characterize owner perceptions of canine BC and overweight (OW), knowledge of associated health risks and management strategies, and to explore demographic gaps in knowledge and risk-threshold identification.

Methods: Cross-sectional anonymous survey of visitors to the university's veterinary nutrition stand at an annual Swiss dog exhibition (~199 respondents). Participants selected from five BCS images presented in a non-sequential order and mapped to the standardized 9-point BCS (5/9 = ideal)[2]. Respondents first selected the image they perceived as ideal and then selected the image representing the earliest point at which OW is associated with health risk (risk-onset "accuracy"). Respondents also completed multiple-response ("select all that apply") items on health consequences of OW and weight-management strategies, and rated agreement with statements regarding canine OW. Age-group differences in risk-onset accuracy were assessed using chi-square tests (six age categories: 18–24, 25–34, 35–44, 45–54, 55–64, ≥65 years). Age was selected *a priori* as the primary subgroup variable; other subgroup analyses were considered exploratory due to small subgroup sizes. Associations between self-reported confidence and risk-onset accuracy were assessed using Fisher's exact test and multivariable logistic regression adjusted for age group, first-time attendance, gender, and respondent role.

Results: Most respondents selected the BCS 5/9 image as ideal (93.8%). Overall, 79.4% selected the earliest available OW image (BCS 7/9) as the risk-onset threshold. Risk-onset accuracy differed by age group ($\chi^2(5)=16.08$, p=0.0066), with lower accuracy in 18–24 (53.3%) and ≥65 (63.0%) than in mid-age groups (≈80–92%). First-time visitors were directionally less accurate than repeat visitors (72.7% vs 83.3%). Self-reported confidence in assessing BC predicted risk-onset accuracy (83.6% vs 60.0%; Fisher p=0.0046); adjusted analysis confirmed higher odds of accuracy among confident respondents (OR 3.75, 95% CI 1.34–10.51; p=0.012). Descriptively, respondents frequently recognized orthopaedic, metabolic, and respiratory consequences, as well as shortened lifespan (>85% each), whereas cancer risk was recognized by only 48.2%. Selection of an "energy-reduced diet (if recommended)" as a weight-loss strategy varied by age ($\chi^2(5)=12.13$, p=0.033) and was lower in the youngest and oldest groups. Belief that weight loss could be achieved exclusively through supplements was uncommon but present; an exploratory signal suggested higher agreement among men than women (21.1% vs 6.1%; Fisher p=0.0419; small male *n*).

Conclusions: BC literacy was generally high, but identification of the OW-associated risk threshold varied by age and was positively associated with self-reported confidence, supporting the importance of targeted nutrition education delivered by veterinary professionals.

References

1. Gerstner K, Liesegang A. Survey: nutrition, body condition and activities of dogs in Switzerland. *J Anim Physiol Anim Nutr (Berl)*. 2017;101(Suppl 1):15-20. doi:10.1111/jpn.12615. PMID:28627058.
2. Laflamme DP. Development and validation of a body condition score system for dogs. *Canine Practice*. 1997;22:10-15.

Development, Digestive Anatomy, and Physiology of Calves Weaned on Hay or Concentrate Diets

Xinjie Zhao[1], Michał Jamrogiewicz[2], Marcin Przybyło[2], Jadwiga Flaga[2], Jarosław Kański[2], Dorota Wojtysiak[2], Renata Miltko[3], Sylvia Ortmann[4], Mutian Niu[5], Paweł Górka[2], Marcus Clauss[1*]

[1] University of Zurich [2] University of Agriculture in Kraków [3] Polish Academy of Sciences [4] Leibniz-Institute for Zoo and Wildlife Research [5] ETH Zürich

Corresponding author: mclauss@vetclinics.uzh.ch

Although ruminants are evolutionarily adapted to utilize forages, young animals are often fed high-starch diets to enhance growth and gastrointestinal tract (GIT) development. However, this likely reduces ruminal pH, potentially impairing rumen function. We hypothesized that a high-starch diet during early life would alter growth trajectories, rumen function, and GIT development.

We evaluated the effects of a high-starch concentrate versus a hay-only weaning diet on 48 newborn male calves from 3 batches, randomly allocated to two treatments and fed milk replacer with ad libitum access to either hay or high-starch concentrate. During the final week, feed intake, digestibility, and retention time were measured in 7 randomly selected animals per treatment, which were then slaughtered for gross measurements and sample collection. Rumen fluid pH was measured using a hand-held pH meter, and SCFA concentration was determined by gas chromatography. Groups were compared using mixed models. Body mass and solid feed intake increased significantly over time but did not differ between groups. STARCH showed, at similar dry matter intake, higher dry matter and protein digestibility ($P < 0.001$; $P = 0.002$) but lower NDF intake (in g/kg^0.75 and g/kg^0.85; $P < 0.001$) and lower NDF and ADF digestibility ($P = 0.001$; $P < 0.001$). STARCH had longer mean retention times for a fluid (in the lower GIT; $P = 0.039$), small particle (whole GIT and reticulorumen [RR]; $P = 0.002$ and $P = 0.014$) and large particle marker (whole GIT; $P = 0.003$), whereas the ratio of large to small particle retention in the GIT and RR was higher in HAY($P = 0.011$ and $P = 0.009$). At slaughter, there was no body mass difference between the groups, but a trend for heavier carcass mass in STARCH ($P = 0.063$). HAY had more digesta in the RR and the caecum ($P = 0.002$ and $P = 0.041$). GIT tissue mass was higher in STARCH for the caecum, jejunum tissue, and total small intestine tissue ($P = 0.002$; $P = 0.037$; $P = 0.024$), but not different for rumen. Although total SCFA concentration did not differ, the rumen propionate, butyrate and valerate proportions in STARCH were higher ($P < 0.001$, $P = 0.020$ and $P < 0.001$) at the expenses of acetate and isobutyrate, which were higher in HAY. The pH of rumen, abomasum and caecum contents were higher in HAY ($P < 0.00$; $P = 0.040$ and $P < 0.001$). The spleens of STARCH were larger ($P = 0.003$).

These results indicate that early-life concentrate feeding offers no growth or GIT development advantage when high-quality forage is available, but it does affect digestibility, digesta passage, SCFA profile, and pH. Whether the lower pH negatively impacts health, particularly later in life, will be assessed in older animals from this experiment. The larger spleens in STARCH may indicate a greater immunological challenge in this group.

A Comparison of Breath Acetone and Blood BHB Dynamics in Early Lactation Dairy Cows

Hendricks J.[1, 3], Ko J.[4], Reiche A. M.[1], Siegenthaler R.[2], Eggerschwiler L.[2], Güntner A.[4], Dohme-Meier F.[1]*

[1]*Ruminant Nutrition and Emissions, Agroscope, 1725 Posieux, Switzerland*
[2]*Research Contracts Animals, Agroscope, 1725 Posieux, Switzerland*
[3]*Department of Environmental System Sciences, Institute of Agricultural Sciences, ETH Zürich, 8092 Zürich, Switzerland.*
[4]*Department of Mechanical and Process Engineering, Human-centered Sensing Laboratory, ETH Zürich, 8092 Zürich, Switzerland*
Corresponding author: frigga.dohme-meier@agroscope.admin.ch

Early-lactation Holstein cows experience negative energy balance and elevated ketogenesis, increasing subclinical ketosis (SCK) risk. While SCK is diagnosed via invasive blood β-hydroxybutyrate (BHB) testing (≥1.2 mmol/L), breath acetone (BA) may offer a non-invasive alternative. This study compared longitudinal BA and BHB profiles, including an induced SCK challenge, to evaluate BA as a non-invasive SCK indicator. Thirty-one healthy multiparous Holstein dairy cows were assigned 42 d antepartum (ap) to one of two treatments (Schulz et al., 2014): either they (n = 20) received an SCK-inducing diet (high-energy diet (ap) and low-energy diet until 35 d postpartum (pp)), or a standard diet (CON, n = 11). Dry matter (DM) intake (ap + pp), milk yield (pp), blood BHB (ap + pp) and BA (ap + pp) were measured daily. Statistical analyses included linear mixed-effects models (fixed effects: treatment, day pp, interaction, baseline ap; random effect: animal), Spearman's rank correlation, principal component analysis (PCA), and receiver operating characteristic (ROC) analysis with area under the curve (AUC) and Youden's J to determine the optimal cut-off.
During the ap period, SCK cows had higher DM intake than CON cows ($p < 0.001$). In the pp period, DM intake was lower in SCK cows than in CON cows ($p < 0.001$), while milk yield was higher ($p < 0.001$), resulting in a more pronounced negative energy balance in the SCK group ($p < 0.001$). Correlation analysis revealed a moderate positive association between BA and BHB concentrations in SCK cows ($r = 0.63$, $p < 0.001$), and a weak positive association in CON cows ($r = 0.28$, $p < 0.001$). Cows with higher BHB concentrations (> 2.6 mmol/L) showed a strong positive association ($r = 0.74$, $p<0.001$). Inter-individual variability was high for BHB and BA, reflected by large coefficients of variation (BHB: 44.7–47.1%; BA: 56.4–90.4%). The PCA showed separation between SCK and CON cows (PC1: 37.4%, PC2: 10.9%). Mixed-effects models revealed an increase in both BHB and BA concentrations over time ($p < 0.001$). The ROC analysis demonstrated good discriminatory performance for BA, using BHB ≥ 1.2 mmol/L as the reference standard, with an optimal cut-off of 1.2 ppm (sensitivity = 0.81, specificity = 0.71, AUC = 0.84). The moderate correlation between BA and BHB indicates the suitability of BA as a biomarker. However, substantial inter-individual heterogeneity in longitudinal ketone dynamics highlights the need for individual animal–level analysis.

References

Schulz et al. (2014). Effects of prepartal body condition score and peripartal energy supply of dairy cows on postpartal lipolysis, energy balance and ketogenesis: an animal model to investigate subclinical ketosis. J. Dairy Res., 81(3), 257-266.

The study was financially supported by the Swiss National Science Foundation and Innosuisse, Bern, Switzerland in the frame of a BRIDGE project (funding number: 40B2-0_218650).

Table of Posters

We would like to congratulate **Eleonora Pacifico** and **Tobias Heiri** and their co-authors for winning the awards for best posters, assigned respectively by the public jury and the scientific jury.

First Author	Title	Affliation
Antonacci, Alessandro	Low-protein diets improve nitrogen efficiency and mitigate ammonia production in growing-finishing pigs reared under contrasting hygienic conditions	Pig Research Unit, Agroscope, Switzerland
Avi, Rahul	Effects of Polyherbal Natural Choline on Nitrogen Utilization and Milk Production in Mid-Lactation Dairy Cows	Nuproxa Switzerland Ltd
Barrientos, Mario	Evaluating metabolic and fermentative heat loss in dairy cows under negative energy balance using exhalomics to differentiate breath from ruminal exhaled gases	ETH, Animal Nutrition Group, Switzerland
Canossa, M.	Advancing a causal loop diagram of ruminant feeding behavior: a step forward in modelling intake regulation	Department of Animal Science, Food and Nutrition (DiANA), Facoltà di Scienze Agrarie, Alimentari e Ambientali, Università Cattolica del Sacro Cuore, Piacenza, Italy
Chileshe, J.	Nutritional Evaluation of Rubber (*Hevea brasiliensis*) Seed Meal for Sustainable Poultry Nutrition	University of Naples Federico II, Italy
Frizzarin, Maria	Milk mid-infrared indicators of intake, nitrogen efficiency and methane across lactation	Animal GenoPhenomics, Agroscope, Posieux, Switzerland
Hämmerli, H.	Growth performance and body composition of *Tenebrio molitor* larvae reared on unconventional substrates – effects of substrate type and feeding duration	Institute of Animal Nutrition and Dietetics, Vetsuisse Faculty, University of Zurich, Switzerland
Heiri, Tobias	Cholesterol metabolism in early-lactation cows with different body condition scores	Veterinary Physiology, Vetsuisse Faculty, University of Bern, Switzerland
Heurtault, J.	Can sows maintain their bone mineral status when fed low-phosphorus lactation diets over successive parities?	Agroscope, Swine Research Group, Switzerland
Lampart, Mathias	Impact of different dietary Fe-supplementations on performance, blood parameters and *Campylobacter spp.* Contamination in broilers	UFA AG, Switzerland
Lin, P.	Growth, body composition and nutrient balance of pigs fed low protein diets with minimal soybean meal	Agroscope, Swine Research Group, Switzerland

Manzocchi, E.	*In vitro* digestibility and methane production of five fodder tree species harvested in late summer	Ruminant Nutrition and Emissions, Agroscope, Switzerland
Moscoso, F.F.	Developmental skeletal mineralization in *Carollia perspicillata*: implications for stage-specific mineral supply	Institute of Animal Nutrition and Dietetics, University of Zurich, Switzerland
Mueller, Andreas	A Phytogenic Blend (PHY) composed of Cinnamaldehyde, Thymol, Eugenol, Capsaicin and mixed saponins may help to reduce N-Excretion and NH_3-Emissions: Learnings from an *in vivo* study with growing broilers and an *in vitro* Urease Inhibition Assay	ERBO AG / TriPlant AG, Switzerland
Orquera-Arguero, K.G.	Comparison of two different approaches to measure methane emissions from dairy cows	Ruminant Nutrition and Emissions, Agroscope, Switzerland
Pacifico, Eleonora	In vitro evaluation of hydroponic barley fodder (HBF) as a dietary strategy to mitigate enteric methane emissions and maintain rumen digestibility	University of Milan, Department of Veterinary Medicine and Animal Science (DIVAS), Lodi 26900, Italy
Popa, A.	Neurological Signs in Icelandic Horses Following Ingestion of Poppy-Contaminated Hay	Institute of Animal Nutrition and Dietetics, Vetsuisse Faculty, University of Zurich, Switzerland
Schilde, Matthias	Combined effects of varying levels of Metabolizable Lysine and Rumen Protein Balance on N use efficiency in Holstein cows in mid lactation	Schothorst Feed Research (SFR), Netherlands
Schori, Fredy	Dairy cow performance, reproduction and health treatments under low-protein concentrate feeding in an organic herbage-based system	Ruminant Nutrition and Emissions, Agroscope, Switzerland
Schrade, Sabine	Measurements and model-based calculation of year-round NMVOC emission values from dairy housing at different diets	Ruminant Nutrition and Emissions, Agroscope, Switzerland
Wang, Kai	Effects of feed access restriction and 3-nitrooxypropanol on whole-body nutrient metabolism of cows using derivative-based differentiation of metabolic and fermentation CO_2	ETH, Animal Nutrition Group, Switzerland
Werner, Jessica	Validation of a noseband sensor for measuring grazing behaviour in veal calves	Research Institute of Organic Agriculture, FiBL, Switzerland

Poster Abstracts

Only posters that were presented at the conference are included in this publication

Low-Protein Diets Improve Nitrogen Efficiency and Mitigate Ammonia Production in Growing-Finishing Pigs Reared Under Contrasting Hygienic Conditions

Alessandro Antonacci[1], Paolo Silacci[2], Giuseppe Bee[1]

[1]*Pig Research Unit, Agroscope, Rte de la Tioleyre 4, 1725 Posieux, Switzerland*
[2]Animal Biology Group, Agroscope, Rte de la Tioleyre 4, 1725 Posieux, Switzerland Corresponding author: alessandro.antonacci@agroscope.admin.ch

The environmental footprint of pig production is increasingly scrutinised due to its contribution to nitrogen (**N**) losses and gaseous emissions. Excess dietary crude protein (**CP**) and amino acid supply exceeding pigs' requirements results in inefficient N utilisation and elevated N excretion, ultimately leading to increased ammonia (**NH_3**) emissions. Given the links between excess dietary CP, inefficient N utilisation, and NH_3 emissions, this study evaluated low-protein (**LP**) diets as a nutritional strategy to improve N efficiency and reduce NH_3 production potential of slurry in growing-finishing pigs reared under contrasting hygienic conditions. Forty-eight Swiss Large White female pigs (20 ± 2.2 kg BW) were assigned to either good hygiene or poor hygiene condition, the latter implemented via a less stringent pen-cleaning protocol. Under good hygiene conditions, manure was removed daily from the pen, whereas under poor hygiene conditions it was removed only twice per week, thereby increasing microbial pressure. Under both hygiene conditions, pigs were fed either a standard (**ST**) or LP diet. The ST grower and finisher diets were isocaloric and contained 16.4 and 12.5% CP, respectively, whereas LP diets were formulated by reducing CP and Lys, Met, Thr, Trp, and Val levels by about 20% compared to the corresponding ST diets. Feed intake was recorded individually using automatic feeders. Spot faecal and urine samples were collected to assess the N apparent total tract digestibility (**ATTD**), urinary N content, and *in vitro* NH_3 production potential of slurry, while N deposition efficiency in the carcass was estimated using dual-energy X-ray absorptiometry. Data were analysed using linear mixed models (R, v.4.4.1), with diet, hygiene, and the two-way interaction as fixed and litter as random effects. Hygiene conditions had no effect on total N intake, but LP pigs consumed 13.4% less N than ST pigs ($P < 0.001$). Although N ATTD was 3.1% lower in LP pigs, faecal and urinary N concentration decreased by 16.9% and 25.8%, respectively ($P < 0.001$). Urinary N concentration tended to be higher in pigs reared under good hygiene ($P \leq 0.071$). *In vitro* NH_3 production potential decreased by 24.9% in slurry from LP pigs but increased by 18.0% in slurry from pigs reared under good hygiene ($P \leq 0.043$). The N deposition efficiency was 10.4% higher in LP pigs and 5.1% higher in pigs reared under good hygiene ($P \leq 0.019$). These results suggest that reductions in N losses and NH_3 production potential of slurry are driven by improved post-absorptive N utilisation rather than N digestibility per se. LP diets and good hygiene conditions independently increased N deposition efficiency. LP diets also reduced urinary N losses and the *in vitro* NH_3 production potential of slurry, whereas hygiene management independently influenced urinary N concentration and slurry NH_3 production.

Effects of Polyherbal Natural Choline on Nitrogen Utilization and Milk Production in Mid-Lactation Dairy Cows

Rahul Avi[1*], Alanne T. Nunes[2], Francisco P. Renno[2]

[1]*Nuproxa Switzerland Ltd, La Romanèche 2C, 1163 Etoy VD, Switzerland*
[2]*Department of Animal Nutrition and Animal Production, University of SaoPaulo, Brazil*
Corresponding author: Rahul Avi, rahul.avi@nuproxa.com

Improving nitrogen use efficiency in dairy systems is important to reduce nitrogen losses while maintaining milk production. Choline plays a key role in methyl-group metabolism and lipid transport and influences nutrient utilization in dairy cows (Humer *et al.,* 2019; Huang *et al.,* 2023). The aim of this study was to evaluate the effects of increasing levels of polyherbal natural choline (rich in phosphatidylcholine >1.60%) on nitrogen intake, nitrogen excretion, milk nitrogen secretion, and milk performance in mid-lactation dairy cows.

Twenty-four Holstein cows (163 ± 98 days in milk; 27.6 ± 7.1 kg milk/d) were used in a replicated 4 × 4 Latin square design. Cows received either a control diet or the same diet supplemented with polyherbal natural choline (PNC; Natu-B4, Nuproxa Switzerland Ltd.) at 7, 14, or 21 g/d. Diets were isonitrogenous and offered as a total mixed ration. Data were analyzed using the PROC MIXED procedure of SAS, with treatment and period included as fixed effects and cow within square as a random effect. Dose-response effects of PNC were evaluated through linear and quadratic contrasts.

Results and Discussion

Milk yield showed a quadratic response (P = 0.042) to increasing levels of PNC, with values of 29.5, 30.5, 30.0, and 29.8 kg/d for the control, 7, 14, and 21 g/d PNC treatments, respectively. Milk protein percentage remained stable across treatments (3.41, 3.40, 3.41, and 3.40%; P = 0.931). Milk urea nitrogen was also unchanged (13.4, 13.7, 13.1, and 13.7 mg/dL; P = 0.650), indicating that ruminal nitrogen balance was maintained. Nitrogen intake was similar among treatments (675, 672, 680, and 675 g/d; P = 0.882). Nitrogen excretion through urine (174, 179, 167, and 171 g/d; P = 0.968) and feces (183, 190, 188, and 184 g/d; P = 0.288) was not affected by PNC supplementation. Milk nitrogen secretion showed a quadratic tendency (157, 162, 160, and 159 g/d; P = 0.078), indicating improved dietary nitrogen distribution towards milk production without increased nitrogen excretion.

Overall, PNC supplementation supports the potential role of nutritional strategies that improve nitrogen utilization efficiency as part of sustainable dairy production systems.

References

Humer, E., Bruggeman, G., & Zebeli, Q. (2019). A meta-analysis on the impact of the supplementation of rumen-protected choline on the metabolic health and performance of dairy cattle. *Animals*, *9*(8), 566.

Huang, B., Khan, M. Z., Kou, X., Chen, Y., Liang, H., Ullah, Q., ... & Wang, C. (2023). Enhancing metabolism and milk production performance in periparturient dairy cattle through rumen-protected methionine and choline supplementation. *Metabolites*, *13*(10), 1080.

Evaluating Metabolic and Fermentative Heat-Loss in Dairy Cows Under Negative Energy Balance Using Exhalomics to Differentiate Breath from Ruminal Exhaled Gases

M.A. Barrientos-Blanco*[1], U. Arshad[1], and M. Niu[1].

[1]*Animal Nutrition, Institute of Agricultural Sciences, ETH Zürich, Zürich, Switzerland*
Corresponding author email: mario.barrientosblanco@usys.ethz.ch

Physiological models of energy partitioning assumes that fermentation heat loss (**FHL**) equals urinary energy. Our study aimed to explore a method to quantify the FHL in dairy cows. Twelve multiparous Holstein cows (100 ± 20 days in milk; 43.4 ± 6.77 kg/d milk yield) were enrolled in a crossover design (2 week of adaptation and 1 week of caloric restriction) and randomly assigned to 2 treatments: 1) control (**CON)** or negative energy balance (**NEB**). The CON and NEB diets contained 19.8 vs. 16.7 MJ/kg of DM of gross energy (**GE**), 36.9 vs. 51.1% NDF, 17.0 vs. 11.3% CP, and 19.9 vs. 8.88% starch, respectively. Milk yield and quality, and DMI were monitored daily. The gases (CO_2, O_2, and CH_4) were measured using GreenFeed, paired with spot fecal and urine sampling. The sampling for gases, urine and fecal was conducted 8 times during the last 3 days of each period, to represent every 3 hours of the day. The GE and nitrogen content of diet, fecal, urine, and milk were determined through calorimetric bomb and Dumas method, respectively. Levels of non-esterified fatty acids (NEFA) were analyzed from blood collected at 0700 h on days 1 - 4 and 7 of caloric restriction period. Implementing an established method, we differentiated exhalome (**Ex**, ruminal eructation + breath) and breath (**Br**) using a threshold of 150 mV CH_4, to get CO_2 and CH_4 emissions, and O_2 consumption for Ex and Br. The adjusted values of gases representing FHL were determined as: FHL = Ex – Br g/second. Heat production (**HP**) for Br ($\mathbf{HP_{Br}}$) and FHL ($\mathbf{HP_{FHL}}$) were calculated according to Brouwer (1965). Energy retention (**ER**) was determined as: ER = Diet – Urine – Fecal – Milk – CH_4 – HP_{FHL} – HP_{Br}. Data were analyzed using mixed model with fixed effects of diet, period, time and their interactions, and random effect of cow. Inducing caloric restriction reduced ($P < 0.01$) the GE intake (368 vs. 545 ± 34.8 MJ/kg of DM) in NEB compared to CON. An interaction between diet and time was observed for NEFA ($P < 0.01$), as the concentrations increased from day 1 to 4 (0.38 from 0.23 vs. 0.11 from 0.09 ± 0.04 mmol/L) in NEB compared to CON, respectively. The caloric restriction also increased ($P < 0.01$) partitioning of energy towards urine (3.29 vs. 2.25%), feces (32.8 vs. 24.9%), CH_4 (4.33 vs. 5.76%), and HP_{Br} (34.1 vs. 27.2%) in NEB compared to CON. Nevertheless, the energy partitioned towards milk (31.6 vs. 25.4%) or HP_{FHL} (1.90 vs. 1.73%) did not differ across treatments. These findings demonstrate that the major heat energy loss likely originates from metabolic activity rather than fermentative energy production.

Keywords: fermentative energy loss, heat production, exhalome, breath

References

Brouwer, E. 1965. Report of sub-committee on constants and factors. in Proc. Energy Metabolism. Proc. 3rd Symp., 1965. Academic Press.

Advancing a Causal Loop Diagram of Ruminant Feeding BehavioUr: A Step Forward in Modelling Intake Regulation

M. Canossa[1], A.S. Atzori[2,3], and A. Gallo[2,3]

[1] *Department of Animal Science, Food and Nutrition (DiANA), Università Cattolica del Sacro Cuore, via Emilia Parmense, 84, 29122 Piacenza, Italy*

[2] *Department of Agricultural Sciences, Università di Sassari, Viale Italia 39, 07100 Sassari, Italy*

[3]*System Dynamics Italian Chapter, Viale Guglielmo Marconi, 19, 00146, Roma, Italy*

Corresponding author: Antonio Gallo. E-mail: antonio.gallo@unicatt.it

Daily feeding behavior (FB) in ruminants emerges from interacting physiological, dietary, managerial, and environmental drivers (Albright, 1993). Systems thinking (ST) provides a methodological base to conceptualize this complex biological phenomenon by identifying the interaction between variables (Tedeschi et al., 2025). A preliminary causal loop diagram (CLD) had previously identified the main feedback structures underlying FB, but several dynamic structures were not fully explicated, particularly those linking FB with nutrient inflow, nitrogen efficiency, and nitrogen dynamics as well as recycling (Canossa et al., 2025). This limitation is relevant to move toward a mathematical formulation of the conceptual model. A systems thinking approach was applied through problem articulation, system boundary definition, literature review, and extraction of variables and causal relationships from more than 90 publications. The previous CLD was refined by integrating short-term ingestive regulation with medium-term metabolic responses and external constraints. Where available, variables and causal links were specified using literature-derived quantitative evidence, so that the feedback structure is aligned with measurable relationships among key variables. The refined CLD highlights that FB is a determinant of nutrient inflow, because meal pattern and eating rate regulate the timing and quantity of substrates entering rumen fermentation. This is relevant for nitrogen dynamics, since dietary N intake, ruminal ammonia production, microbial N synthesis, urea-N recycling, and urinary and fecal N excretion depend on nutrient entry and absorption/transformation within the digestive system (Li et al., 2019). Thus, the expanded CLD provides a conceptual basis for linking feeding behavior to intake dynamics and for developing a quantitative model of nutrient inflow and nitrogen flows, supporting the evaluation of strategies to improve nitrogen use efficiency and reduce N excretion.

References

Albright, J. L. (1993). Feeding Behavior of Dairy Cattle. Journal of Dairy Science 76(2), 485–498. https:/doi.org/10.3168/jds.S0022-0302(93)77369-5.

Canossa, M., Atzori, A.S., Fiorbelli, E., Gallo, A. 2025. Applying the system thinking approach to examine complex issue of modelling feeding behaviour in ruminant. Animal- science proceedings. 16(3):433-434. https://doi.org/10.1016/j.anscip.2025.07.260.

Li, M.M., Titgemeyer, E.C. and Hanigan, M.D. 2019. A revised representation of urea and ammonia nitrogen recycling and use in the Molly cow model. Journal of Dairy Science. 102:5109–5129 https://doi.org/10.3168/jds.2018-15947

Tedeschi, L.O., D. Tulpan, H.M. Mendez III, and R.A. Mendoça Vieira. 2025.Modeling complex systems in animal science: A pedagogical framework for new researchers. R. Bras. Zootec. 54:e20240170. https://doi.org/10.37496/rbz5420240170.

Nutritional Evaluation of Rubber (Hevea brasiliensis) Seed Meal for Sustainable Poultry Nutrition

J. Chileshe[1], F. Masucci[2]

[1]*Master's in Sustainable Food Systems, University of Naples Federico II, Italy*
[2]*Department of Agriculture, University of Naples Federico II, Italy*
Corresponding author: j.chileshe@studenti.unina.it

Rubber (*Hevea brasiliensis*) seed meal is an underutilised agro-industrial byproduct with significant potential as a sustainable poultry feed. Although its nutritional value is well-documented (Nouke and Endeley, 1984), it remains largely underexploited. As rising global demand for conventional proteins like soybean meal strains livestock systems, valorising such non-conventional biomass is essential for enhancing agricultural resilience and resource efficiency. This study aims to assess the nutritional value and suitability of rubber seed meal as a potential feed ingredient for poultry nutrition through laboratory-based characterisation. Rubber seed meal obtained after oil extraction is being analysed to determine proximate composition, including dry matter, crude protein, ether extract, crude fibre, and ash content. Selected anti-nutritional factors are also evaluated to identify potential limitations affecting feed utilisation and safety, as rubber seed products may contain compounds requiring assessment before dietary inclusion (Abdullah et al., 2018). The findings of this research contribute to evaluating the feasibility of incorporating rubber seed meal into poultry feeding systems. By valorizing plantation-derived residues, this study promotes a circular bio-economy within the agricultural sector. Reducing the reliance on imported protein concentrates not only lowers production costs for smallholder and industrial farmers but also improves the overall resource efficiency and environmental footprint of livestock production systems.

References

Nouke, J., & Endeley, H. (1984). Chemical composition and nutritional value of para-rubber seed and its products for chickens. *Animal Feed Science and Technology*, 10, 257–267.

Abdullah, N., Sulaiman, F., & Taib, R.M. (2018). Effects of processing on nutrient composition and anti-nutritional factors of rubber seed meal. *Journal of the Saudi Society of Agricultural Sciences*, 17, 45–52.

Milk Mid-Infrared Indicators of Intake, Nitrogen Efficiency and Methane Across Lactation

Maria Frizzarin[1], Elisa Manzocchi[2], Anna-Maria Reiche[2], Patrick Schlegel[2], Giovanni Lazzari[2], Marco Tretola[3], Fredy Schori[2], Frigga Dohme-Meier[2], Claudia Kasper[1]

[1]Animal GenoPhenomics, Tioleyre 4, 1725 Posieux, Agroscope, Switzerland, [2]Ruminant Nutrition and Emissions, Agroscope, Switzerland, [3]Swine Research Group, Agroscope, Switzerland

Corresponding author: maria.frizzarin@agroscope.admin.ch

Dry matter intake (DMI), nitrogen use efficiency (NUE), and methane (CH_4) emissions are key sustainability traits in dairy production but remain difficult to measure. Milk mid-infrared (MIR) spectroscopy offers a low-cost phenotyping opportunity[1]; however, its biological validity still needs to be evaluated. Data were collected at the Agroscope experimental farm in Posieux between 2015 and 2024, including milk MIR spectra, feed intake, diet composition and automated head-chamber methane measurements. NUE was calculated by dividing milk nitrogen by nitrogen intake. To reduce the effects of daily variation, DMI and NUE were averaged across ±2 days and CH_4 across ±5 d of milk sampling. We tested prediction models including linear regression, partial least squares regression (PLSR), and neural networks (NN). These were implemented as simple regression models. Models were evaluated using 4-fold cross-validation, each including different sets of features. NN consistently outperformed PLSR models ($P < 0.05$). Including MIR information improved prediction of NUE and CH_4 compared with animal information alone ($P < 0.05$). The best model for each trait was applied to 9,975 historical milk MIR spectra to obtain estimated trait values for DMI, NUE and CH_4. Prediction accuracy was moderate (DMI: R^2=0.64; NUE: R^2=0.56; CH_4: R^2=0.52), with R^2 unadjusted coefficient of determination. To test the biological validity of the longitudinal patterns of predicted DMI, NUE and CH_4 along the lactation curve and across parities, the effects of lactation stage and parity were analysed using mixed-effects models. The predicted traits reproduced biologically expected patterns (Fig. 1). Correlations between residuals for predicted NUE and DMI as well as NUE and CH_4 were near zero, but moderate (0.44) between DMI and CH_4. These results demonstrate that MIR spectroscopy captures meaningful biological signals and can provide scalable longitudinal indicators of feed efficiency and environmental impact. Milk spectra therefore represent a promising scalable phenotyping tool for individual monitoring and genetic improvement[2] of sustainability traits.

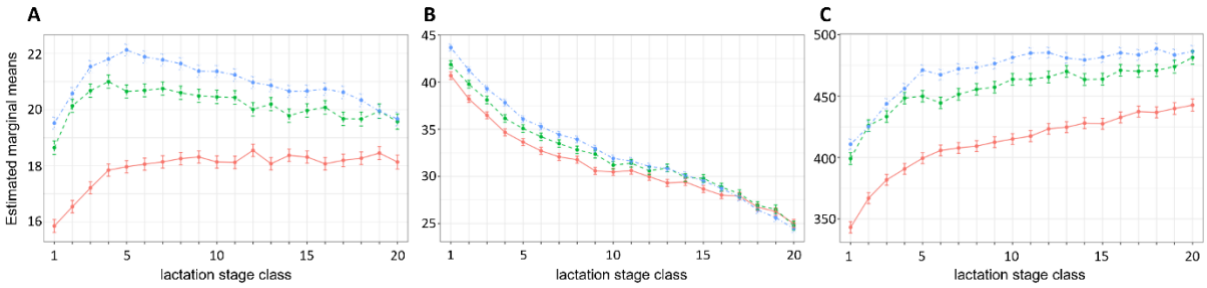

Fig. 1: Estimated marginal means and standard error of the means for mid-infrared predicted dry matter intake (kg/d; A), nitrogen use efficiency (g/100 g; B), and methane production (g/d; C) in first (red), second (green), and third or greater (blue) parity cows along lactation stage classes (spanning 15 days; x-axis) in dairy cows.

References

1. Tiplady KM, Lopdell TJ, Littlejohn MD & Garrick DJ. The evolving role of Fourier-transform mid-infrared spectroscopy in genetic improvement of dairy cattle. *J Anim Sci Biotechnol* **11**, 39 (2020).

2. Rojas de Oliveira H *et al.* Development of genomic evaluation for methane efficiency in Canadian Holsteins. *JDS Commun.* **5**, 756–760 (2024).

Growth Performance and Body Composition of *Tenebrio molitor* Larvae Reared on Unconventional Substrates – Effects of Substrate Type and Feeding Duration

Hämmerli H, Lucke A, Liesegang A

Institute of Animal Nutrition and Dietetics, Vetsuisse Faculty, University of Zurich, Switzerland
Corresponding author: Annette Liesegang aliese@nutrivet.uzh.ch

The aim of the study was to investigate the growth performance and body composition of *Tenebrio molitor* (yellow mealworm) larvae reared on unconventional substrates over two feeding durations. Larvae (early instars) were stored for five days at 12–14 °C prior to the experiment to maintain low activity. A total of 20 trays were prepared (7 g larvae per tray). Each tray received 3.5 g wheat bran and 3.5 g of one of four dried substrates: cat faeces (CF), goat faeces (GF), cauliflower (C), or wheat bran as control (W) (n = 5 per substrate). The total amount of the substrate was 7 g on each tray. Larvae were kept at 25 °C and 50–60% relative humidity. Carrots (1.5 g) were provided on days 1 and 4. Three replicates per substrate were harvested on day 9 (timepoint 1, T1), and the remaining two on day 23 (timepoint 2, T2). Larvae were separated from substrate, weighed, and analysed for dry matter (DM) and crude fat (EE). Individual body weight and length (20 larvae per tray).

At T1, larvae showed weight gains (per tray) in all groups compared to the initial weight, with the highest increase in the control (W: +0.659 g), followed by K (+0.168 g), C (+0.159 g), and Z (+0.121 g). At T2, weight differences were negative across all substrates (−1.09 to −1.64 g), indicating biomass reduction with prolonged feeding, potentially due to substrate depletion. Larval DM ranged from 31–35% at T1 and 29–32% at T2. At T1, fat content ranged from 19.0–23.7% on DM basis, whereas lower values (10.9–17.3%) were observed at T2. The highest levels of DM and EE were observed in mealworms fed wheat bran.

In conclusion, both substrate type and feeding duration significantly influenced larval growth and lipid deposition. Prolonged rearing resulted in reduced biomass and body fat, suggesting substrate depletion or altered nutrient availability over time.

Table 1. Growth parameters of *Tenebrio molitor* larvae fed different substrates.

		Substrate				P-value		
		Cat faeces	Goat faeces	Cauli-flower	Wheat bran	Timepoint	Substrate	Substrate x Timepoint
Total weight change (g)	T1	0.168	0.121	0.159	0.659	<0.001	0.010	0.061
	T2	-1.641	-1.450	-1.094	-1.264			
DM (g)	T1	32.7	31.1	32.3	35.0	0.024	<0.001	0.262
	T2	31.1	29.0	31.0	32.2			
Crude fat (% DM)	T1	19.0	19.2	19.4	23.7	<0.001	<0.001	0.439
	T2	10.9	13.1	12.1	17.3			
Length (mm)	T1	15.60	15.36	15.51	15.83	0.055	0.670	0.938
	T2	15.09	15.05	14.75	15.26			
Individual weight (g)	T1	0.047	0.044	0.044	0.048	0.346	0.786	0.770
	T2	0.040	0.045	0.044	0.045			

Cholesterol Metabolism in Early-Lactation Cows with Different Body Condition Scores

Tobias Heiri[1], Julia Eichinger [1], Jonas Hendricks [2], Anna-Maria Reiche [2], Frigga Dohme-Meier [2], Josef J. Gross [1]

[1] *Veterinary Physiology, Vetsuisse Faculty, University of Bern, Bremgartenstrasse 109a, 3012 Bern, Switzerland*
[2] *Ruminant Nutrition and Emissions, Agroscope, Rte de la Tioleyre 4, 1725 Posieux, Switzerland*
Corresponding author: josef.gross@unibe.ch

Dairy cows with a high body condition score (BCS) at calving are predisposed to postpartum (pp) metabolic disorders such as ketosis and fatty liver disease. While alterations in energy and fatty acid metabolism during early lactation are well documented, short-term dynamics of cholesterol and lipoprotein metabolism at the onset of lactation are poorly characterized. We therefore investigated cholesterol and lipoprotein metabolism during the first week pp in cows with differing BCS, hypothesizing that cows with higher BCS already exhibit alterations in cholesterol metabolism during the first week pp, prior to the manifestation of clinical disease. At d 42 antepartum (ap), 24 multiparous Holstein cows were assigned to either a high-energy feeding regimen (HC; n = 14; 6.9 MJ NEL from day −42 ap until calving, 6.6 MJ NEL pp) or a lower-energy feeding regimen (LC; n = 10; 5.3 MJ NEL until calving, 6.8 MJ NEL pp), resulting in groups with higher (HC; 3.69 ± 0.12) and lower (LC; 2.68 ± 0.11) BCS, respectively. Feed intake, BCS, body weight and milk yield were recorded continuously. Milk samples were taken daily and analyzed for fat, protein and lactose content to calculate energy corrected milk yield (ECM). Blood samples pp were collected daily and analyzed for glucose, non-esterified fatty acids (NEFA), β-hydroxybutyrate (BHB), triglycerides (TG), glutamate dehydrogenase (GLDH) activity, γ-glutamyltransferase (GGT) activity, total cholesterol and lipoprotein fractions (very-low-density lipoprotein (VLDL-C), low-density lipoprotein (LDL-C), and high-density lipoprotein (HDL-C)). Statistical analysis included linear mixed models (fixed effects: cow group, time, interaction; random factor: animal). Over the first week pp, HC cows exhibited greater ECM than LC cows ($P<0.05$). Plasma NEFA, BHB, and TG were greater in HC compared to LC cows, and NEFA and BHB increased over time (all $P<0.01$). While total cholesterol concentration showed no differences between groups, it increased over time ($P<0.01$). VLDL-C was greater ($P<0.01$) and HDL-C tended to be greater ($P<0.1$) in HC compared to LC cows. LDL-C and markers of hepatic activity (GLDH and GGT) did not differ between groups. Elevated BHB and NEFA concentrations in HC cows indicate increased hepatic metabolic load already during the first week pp, resulting in measurable alterations in TG and lipoprotein metabolism. Our results warrant further investigation of cholesterol metabolism in early lactation.

Can Sows Maintain Their Bone Mineral Status When Fed Low-Phosphorus Lactation Diets Over Successive Parities?

J. Heurtault [a], M.P. Létourneau-Montminy [b], P. Schlegel [a]

[a] *Agroscope, Swine Research Group, 1725 Posieux, Switzerland*
[b] *Department of Animal Sciences, Laval University, Quebec G1V 1A6, Canada*
Corresponding author: Julien Heurtault. Email: julien.heurtault@agroscope.admin.ch

Previous studies have shown that sows are able to mobilize bone mineral reserves, depending on dietary calcium (Ca) and phosphorus (P) supply, to meet the high mineral demands of lactation and to subsequently restore these reserves during the following gestation, when mineral requirements are lower. Bone mobilization is enhanced under low dietary P supply. However, this resilience has only been reported for a single lactation cycle, this study aimed to assess resilience over consecutive lactations.
Twenty-eight primiparous Swiss Large White sows were selected from the Agroscope's herd. Throughout lactation, sows received ad libitum one of four diets designed to meet established nutrient requirements, except for digestible P and Ca: **100** (9.0 g Ca, 3.0 g digestible P/kg, and a 3:1 Ca/digestible P ratio; 8 sows); **50** (4.5 g Ca, 1.5 g digestible P/kg, and a 3:1 Ca/digestible P ratio; 8 sows); **100+FTU** (6 sows) and **50+FTU** (6 sows) corresponded to the **100** and **50** diets with an exogenous 6-phytase (750 FTU/kg, Quantum® Blue 5G, AB Vista, Marlborough, United Kingdom). During the first 80 days of gestation, sows were fed 2.8 kg of a single diet per day, and from day 81 onwards, they received 3.0 kg per day. The diet was formulated to contain 2.4 g/kg of digestible P and 7.8 g/kg of Ca. Bone mineral content (BMC) was assessed by dual x-ray absorptiometry scanner (DXA) during three consecutive lactations (Lact1, Lact2, Lact3) at 2 (d2) and 24 (d24) days postpartum, and during the second gestation (Gest2) at day 40 (d40). Litters were standardized to 13 piglets, and piglets were weighed at birth and at weaning. The BMC, BMC mobilized (BMC_{d24} – BMC_{d2}) during lactation, and litter average daily gain (ADG_litter) were analyzed using mixed-effects models including stage (time point of measurement) or lactation number, lactation diet, and their interaction as fixed effects, with sow as a random effect and a corsymm residual covariance structure.
On d24, BMC tended to be lower in 50 than in 100+FTU during Lact1 ($P = 0.054$), and was lower than in both 100 and 100+FTU during Lact2 and Lact3 ($P < 0.05$). BMC did not differ between treatments at the other stages. BMC mobilization during lactation and ADG_{litter} did not differ between treatments across lactations. ADG_{litter} was lower in Lact1 compared to Lact2 and Lact3 ($P < 0.05$).
These results confirm that sows fed a low-P diet during lactation mobilized more BMC without affecting litter performance, and showed that the mobilized BMC was restored over two consecutive gestations. The sow thus appears resilient to a low dietary P supply across several consecutive cycles. This supports the potential for strongly limiting mineral phosphate use in lactation diets without compromising sow skeleton longevity nor litter performance.

Impact of Different Dietary Fe-supplementations on Performance, Blood Parameters and Campylobacter spp. Contamination in Broilers

Mathias Lampart[1], Barbara Eichenberger[1], Mutian Niu[2]

[1]*Department Research and Development, UFA AG, Herzogenbuchsee BE 3360, Switzerland*
[2]*Department of Environmental Systems Science, Institute of Agricultural Sciences, ETH Zürich, Zürich 8092, Switzerland*
Corresponding author: mathias.lampart@ufa.ch

This study was conducted as part of Mathias Lampart's master's thesis, with Prof. Dr. Mutian Niu serving as supervisor and Dr. Barbara Eichenberger serving as co-supervisor.

Abstract
Iron (Fe) is an essential trace element that plays a role in various metabolic processes, and its precise supplementation is of great interest in modern poultry nutrition. This study investigated the influence of different levels of iron supplementation and the use of the technical additive Fluimas C on performance characteristics, blood parameters, litter quality and the prevalence of Campylobacter spp. in broilers under practical Swiss conditions.
At UFA Bühl, a total of 2'200 animals were housed in 16 identical pens, divided into four different treatments, with four replicates per treatment. The animals were fed with a basic diet of corn, wheat and soybean meal. The treatments were either the different iron supplementation (40, 20 or 0 mg/kg Fe), or the additional supplementation of the anticaking agent Fluimas C to the standard diet (240 mg/kg Fe).
The results showed that reducing iron supplementation to 20 or 0 mg/kg of feed had no effect on mortality, growth performance, or blood parameters and litter quality. The slaughter performance was also not affected, except the supplementation of 20 mg/kg Fe led to a better carcass classification.
The additional iron intake from Fluimas C did not affect all measured parameters, indicating a low bioavailability of the contained iron. The iron supply did not significantly influence the animals Campylobacter spp. load. To summarise the iron supplementation in broiler feed can be reduced to 20 milligrams per kilogram and the use of Fluimas C as a technical additive is safe in terms of its high iron content and does not require any adjustment of the iron calculation in feed formulation.

Growth, Body Composition and Nutrient Balance of Pigs Fed Low Protein Diets with Minimal Soybean Meal

P. Lin[1], M. Tretola[1], L. Pinotti[2], G. Bee[1], and P. Schlegel[1]

[1]Swine Research Unit, Agroscope, 1725 Posieux, Switzerland, [2]University of Milan, Department of Veterinary Medicine and Animal Sciences, 26900 Lodi, Italy;

Corresponding author: patrick.schlegel@agroscope.admin.ch

Surplus of nitrogen (N) in agricultural system and dependence on imported protein feed challenge the sustainability of the Swiss pig production. We aimed at feeding 48 pigs from 22 to 105 kg body weight (BW) grower and finisher diets with minimal imported protein source, soybean meal in particular, and simultaneously reducing dietary crude protein (CP) content compared to actual two-phase feeding practice. The pigs were blocked by litter, gender and BW. Each pig of a block was assigned to either a control (C) or a low protein (N-) grower (25-60 kg BW) and finisher (60-100 kg BW) diets, both being iso-energetic. In N-, soybean meal was replaced by local protein pea, rapeseed expeller and eight synthetic amino acids (AAs) to reach minimal CP, but equal digestible AA contents as in C. Compared to C, grower and finisher N- diets contained respectively 2.7% and 0% soybean meal and 140 and 115 g CP/kg, leading to 10% and 15% less CP content. Their costs increased, however, by 5 and 3%, respectively. Daily individual feed intake and BW at start (T0), diet change (T1, 60 kg BW) and end (T2, 100 kg BW) were recorded. Blood samples were collected at T1 and T2. Fecal and urine spot samples were collected between T0 and T1 as well as T1 and T2. Nutrient excretion was derived by subtracting body nutrient accretion measured by dual X-ray absorptiometry at T0, T1 and T2 from total nutrient intake. Neither apparent total tract digestibility of N, nor growth performance, nor pig's body composition (lean and fat tissue mass) was affected by diets ($P \geq 0.10$). Compared to C, the pigs fed N- had lower ($P < 0.01$) levels of blood (-30.6% and -21.8%) and urinary urea (-27.1% and -33.7%) and decreased ($P < 0.10$) fecal N concentration on a DM basis (-4.4% and -9.7%) during growing and finishing periods, respectively. The intake and excretion of N was reduced ($P < 0.01$) in grower, finisher and overall periods in N- pigs. These findings illustrate that it is technically feasible to replace imported protein sources with local ones. With an appropriate supplementation of the eight limiting AAs, the inclusion of protein rich feedstuffs could be minimized, thus resulting in very low CP contents to successfully reduce N excretion without compromising pig's growth of lean and fat tissue. The challenge of success in such feeding strategies consists in the market availability of sufficient local protein sources and in the increased feed costs, mainly attributed to four AAs being valine, leucine, iso-leucine and histidine.

In vitro Digestibility and Methane Production of Five Fodder Tree Species Harvested in Late Summer

E. Manzocchi[1] J. Botzas-Coluni[2], A. Manoukians[1], M. Probo[2], M. Terranova[3], P. Mariotte[2]

[1]*Ruminant Nutrition and Emissions, Agroscope, 1725 Posieux, Switzerland ;*
[2]*Grazing systems, Agroscope, 1725 Posieux, Switzerland*
[3]*AgroVet-Strickhof, ETH Zurich, 8315 Lindau, Switzerland*
Corresponding author: elisa.manzocchi@agroscope.admin.ch

In the context of climate change and increasingly dry summers, fodder trees offer a drought-resistant complementary forage source. This study evaluated the chemical composition, digestibility and *in vitro* methane (CH_4) production potential of the leaves of five tree species (*Alnus cordata*, *Fraxinus ornus*, *Morus alba*, *Salix caprea*, and *Tilia cordata*). Tree leaves were harvested in August 2024 from forage hedgerows established within the AgroForageTree project in Western Switzerland (Botzas-Coluni et al., 2025). The *in vitro* organic matter digestibility (IVOMD) and CH_4 production were determined using the Hohenheim Gas Test according to Menke and Steingass (1988). Five diets composed (in the DM) of 80% hay (grass-rich grassland, 1st cut, full-heading) and 20% freeze-dried leaves from each of the five tree species, and a 100% DM hay diet (as a control) were incubated in three experimental runs, using rumen fluid from two rumen-cannulated dry cows at AgroVet-Strickhof. Each run included three analytical replicates per diet. Condensed tannin content in the leaves and diet chemical composition were analyzed, and pH, ammonia, and volatile fatty acid (VFA) were measured in the liquid phase after 24 h incubation. Total gas production after 24 h was recorded, and CH_4 and CO_2 concentrations were quantified by gas chromatography. Replicates were averaged and analyzed in R using linear mixed-effects models with tree species as a fixed and run as a random effect. IVOMD of the mixed diets ranged from 57 to 66%, with the highest digestibility ($P < 0.01$) observed for *Morus alba* leaves, similar to the control hay (65%). The lowest IVOMD ($P < 0.01$) was obtained with *Alnus cordata*, while the other species yielded intermediate values. Consistently, total VFA concentration was highest for *Morus alba* (59 m*M*) and *Tilia cordata*, and lowest for *Alnus cordata* (52 m*M*). The diet including *Morus alba* also resulted in the highest concentration of ammonia (9.9 mmol/L; $P < 0.01$), reflecting the higher crude protein content the leaves (170 g/kg DM). The lowest CH_4/CO_2 ratio was observed with *Salix caprea*, which is consistent with its higher concentration ($P < 0.01$) of condensed tannins, known to inhibit methanogenesis. Conversely, *Fraxinus ornus*, *Morus alba*, and the control hay produced the highest CH_4/CO_2 ratios ($P < 0.01$). In conclusion, *Morus alba* showed the most promising nutritive value among the tested species, while *Salix caprea* exhibited the greatest potential for reducing CH_4 emissions. Further research, including *in vivo* studies at farm scale, is required to assess biomass yield, animal intake, and the practical integration of fodder trees into grazing systems.

References

Botzas-Coluni, J., E. Manzocchi, M. Rothacher, P. Ledermann, M. Probo, P. Mariotte. 2025. Assessing the palatability of five tree species in sheep. 45th Swiss Animal Nutrition Conference, 27th May, Lindau

Menke, K.H., and H. Steingass. 1988. Estimation of the energetic feed value obtained from chemical analysis and in vitro gas production using rumen fluid. Animal Research and Development 28, 7–55.

Developmental Skeletal Mineralization in *Carollia perspicillata*: Implications for Stage-Specific Mineral Supply

F.F Moscoso[1], D.R. Moscoso[2], Rüegg-van den Broek[3], A. Liesegang[1]

[1] Institute of Animal Nutrition and Dietetics, University of Zurich, Switzerland, [2] University of La Salle, Bogota, Colombia, [3] Papiliorama Foundation, Kerzers, Switzerland

Corresponding author: aliese@nutrivet.uzh.ch

Adequate dietary mineral supply is essential for normal skeletal development. Its effectiveness, however, depends on understanding the timing and regional dynamics of skeletal mineral deposition. In frugivorous bats, quantitative information on mineral requirements and developmental mineralization trajectories remains limited[1,2]. Captive diets frequently rely on cultivated fruits that may be comparatively low or imbalanced in essential minerals[3], making careful evaluation of mineral provision particularly relevant. Calcium (Ca) has been identified as a potentially limiting nutrient in bats, and inadequate supplementation can negatively affect bone mineral density (BMD)[4–5]. This study characterized developmental changes in skeletal mineralization and carcass composition in 177 captive *C. perspicillata* (92 females, 85 males) from a zoological population maintained under controlled husbandry conditions. Animals were euthanized as part of routine population management unrelated to this study and are considered broadly representative of this captive colony. Because chronological age was unknown, developmental stages were defined using segmented regression of body mass (BM) against head–body length and classified into three groups per sex (F1–F3; M1–M3). BM ranged from 4.7 to 23.3 g across groups. Bone mineral density (BMD) was assessed using peripheral quantitative computed tomography (pQCT) at selected axial and appendicular skeletal sites. Whole-body carcass homogenates were analyzed for proximate composition, mineral concentrations (Ca, P, Mg), and collagen content, with compositional variables expressed relative to fat-free dry matter (FFDM). Group comparisons were performed using one-way ANOVA followed by Tukey's HSD test, and two-way ANOVA models were used to evaluate effects of developmental stage and sex. Growth was characterized by marked increases in ash mass, mineral concentrations, and regional BMD. Cranial BMD increased from ~226 to ~419 mg/cm³, whereas cervical BMD remained consistently high (~393–426 mg/cm³), indicating early mineralization of the axial skeleton. In contrast, radial BMD increased from ~167 to ~421 mg/cm³, reflecting delayed appendicular mineralization. Ash mass increased significantly ($p < 0.0001$) from ~0.5 to ~0.8 g (11.5–16.3% FFDM). Collagen proportion declined from ~20% to ~16% of the protein fraction and was negatively associated with ash content ($R^2 = 0.05$, $p = 0.003$), indicating a shift toward increased mineralization. Mineral concentrations (Ca, P, Mg) increased significantly from early to intermediate stages and stabilized thereafter. These findings demonstrate asynchronous, stage-dependent, and region-specific skeletal mineralization dynamics in *C. perspicillata*. Mineral requirements appear to be highest during early and intermediate developmental stages, highlighting the importance of adequate mineral supplementation, particularly calcium, in captive frugivorous bats to support proper skeletal development.

References

[1] W. Hood, O. Oftedal, T. Kunz. (2006). J Comp Physiol B. doi:10.1007/s00360-006-0102-y. [2] Dempsey JL (2004) Fruit bats: nutrition and dietary husbandry. In: Fowler ME, Miller RE (eds.) *Zoo and Wild Animal Medicine: Current Therapy 4.* W.B. Saunders. [3] Barnard SM (ed.) (2011) *Bats in Captivity, Volume 3: Diet and Feeding — Environment and Housing.* Logos Press, Washington, DC. [4] A. Liesegang, U. Firzlaff, B. Kiefer, W.J. Streich, M. Clauss (2006). Zoo Anim. Nutr. III: 295-300 doi: 10.5167/uzh-3521 [5] M. Clauss, U. Firzlaff, J. Castell, B. Kiefer, W. Streich, A. Liesegang. (2007) J Anim Physiol Anim Nutr (Berl). doi:10.1111/j.1439-0396.2007.00691

Reduction of N-Excretion and NH_3-Emissions in Growing Broilers by a Phytogenic Additive Composed of Cinnamaldehyde, Thymol, Eugenol, Capsaicin and Saponins

Andreas S. Mueller, Rolf Tona, Kostas Syriopoulos, Robert Wandel and Raetus Boehlen

ERBO AG / TriPlant AG, Industriestraße 17, 4922 Buetzberg, Switzerland
Corresponding Author: mueller.andreas@erbo.ch

Emissions from the livestock industry are a growing global concern for the environment and human health. Monogastric animals substantially contribute to nitrogen (N)- and ammonia (NH_3)-emissions. Feeding specific combinations of phytogenic substances (PHY) may reduce N- and NH_3-emissions by improving N-digestibility and inhibiting urease activity. Based on literature information the current study therefore investigates the effects of a combination of encapsulated essential oils (cinnamaldehyde, thymol, eugenol, 20%), capsaicin (0.15%), and saponins from quillaja, yucca and fenugreek (3.5%) on growth performance, prececal N-digestibility, fecal N-excretion of growing broilers, and *in vitro* urease inhibition. For the *in vivo* study, thirty-six day-old Cobb500 broilers were randomly assigned to two groups: Control (Con) and phytogenic additive (PHY), housed in 12 pens with six replicates of three birds. Birds were fed a starter diet, based on Maize (31.6%), soybean meal 49 (33.2%) and wheat (25.2%) for 21 days, with or without addition of PHY (150 mg/kg). Titanium-IV-oxide served as an indigestible marker. On day 21, precaecal digesta were collected, pooled per pen, freeze-dried and analyzed for nutrients. Apparent prececal digestibility was calculated. *In vitro* urease inhibition, according to Chin and Kroontje (1962) was additionally tested at two PHY concentrations (c1 = 150 and c2 = 300 mg/L). Data were analyzed by one-way ANOVA. The PHY significantly improved final body weight and feed conversion ratio (Table). Apparent prececal digestibility of protein, ash and phosphorus increased by 2.5–7.5%, while starch and fat digestibility were unaffected. Fecal N-content was reduced by 16% (fresh matter) and 13% (dry matter). In vitro, PHY inhibited urease activity by more than 85%. Enhanced protein, ash and phosphorus digestibility may result from Nrf-2 pathway activation by essential oils and capsaicin, increasing intestinal amino acid transporter expression. Strong urease inhibition is attributed to saponins, particularly from yucca and quillaja. Overall, the tested PHY showed the potential to reduce environmental N-and NH_3-emissions.

Chin, W.T. and Kroontje, W. (1962). Urea hydrolysis, conductivity method for estimation of urease activity. J. Agric. Food Chem. 10, 347–348

Parameter	Con	Phy	Parameter	Con	Phy
Initial Body Weight (g)	43.9±1.40^a	43.9±1.35^a	App. XA-Digestibility (%)	44.2±1.42^a	47.7±1.57^b
Final Body Weight (g)	861.9±8.01^a	887.9±8.62^b	App. XPhos-Digestibility (%)	54.2±1.58^a	50.0±1.47^b
Daily Feed Intake (g)	49.32±0.99^a	50.0±0.51^a	Faecal N-content (%) on Wet Basis	12.0±1.88^a	10.1±1.04^b
Daily Weight Gain (g)	38.9±0.40^a	42.3±0.42^b	Feacal Dry Matter (%)	28.8±2.22^a	28.0±1.67^a
FCR (g/g)	1.267±0.025^a	1.244±0.022^b	Faecal N-content in Dry Matter (%)	41.6±5.68^a	36.3±4.89^b
App. XP-Digestibility (%)	79.9±0.71^a	81.8±1.14^b	In vitro Urease Inhibition PHY c1 (%)	0^a	85.5±2.53^b
App. XL-Digestibility (%)	86.2±2.33^a	85.4±0.68^a	In vitro Urease Inhibition PHY c2 (%)	0^a	91.4±1.44^b
App. XS-Digestibility (%)	94.1±0.38^a	94.4±0.31^a			

Significant differences (min. p<0.05) between groups are indicated by different supercripts (a,b; Tukey-Test)

Comparison of Two Different Approaches to Measure Methane Emissions from Dairy Cows

K.G. Orquera-Arguero, M. Zähner, F. Dohme-Meier, G. Lazzari, S. Schrade

Agroscope, Ruminant Nutrition and Emissions, 8356 Ettenhausen and 1725 Posieux, Switzerland
Corresponding author: karina.orqueraarguero@agroscope.admin.ch

In the context of accelerating climate change, it is imperative to reduce greenhouse gas emissions from ruminant systems, given that enteric fermentation is a major contributor to global agricultural methane (CH_4) emissions. To investigate CH_4 mitigation strategies, precise and reliable measurement methods are needed. The aim of this study was to compare two measurement approaches for quantifying CH_4 emissions from housed dairy cows: at individual-animal level and at housing level. Twenty lactating Brown Swiss and Holstein cows (33.8 kg milk/day; 698 kg body weight) were kept in a naturally ventilated cubicle housing with solid floors. The study lasted six weeks (May to July 2023), including weekly sampling periods (6–7 days) separated by three-day intervals. A total of 29 complete days were included in the analysis. Cows were fed a partial mixed ration ad libitum and were supplemented with concentrate at a feeding station to meet their energy and protein requirements. At the individual-animal level, CH_4 emissions were measured using the GreenFeed system (C-Lock Inc., Rapid City, SD, USA), an automated, portable chamber that quantifies CH_4 emissions. These emissions are calculated from repeated spot samples of exhaled air collected when animals voluntarily visit the unit at multiple time points throughout the day. At housing-level CH_4 emissions were quantified using the external tracer-ratio method with sulphur hexafluoride as a tracer gas (Mohn et al., 2018). From both approaches all collected raw data were consolidated into CH_4 emissions hourly averages (g/h per cow). A Pearson correlation revealed the two approaches to be moderately positively correlated ($r = 0.35$, $P < 0.001$). A T-test showed that the tracer ratio method resulted in higher CH_4 emissions per cow ($P < 0.001$) than the GreenFeed approach (555 ± 114.0 vs. 441 ± 49.5 g/d, respectively). This is logical, as the tracer ratio method detects additional of CH_4 sources beyond enteric emissions like those associated to the housing system (e.g., manure). The results indicate that both methods provide realistic CH_4 emission values, that reflect the respective system boundaries: the individual-animal level' and the housing level.

References:

- Mohn, J; Zeyer, K; Keck, M; Keller, M; Zähner, M; Poteko, J; Emmenegger, L; Schrade, S. (2018). A dual tracer ratio method for comparative emission measurements in an experimental dairy housing. Atmos. Environ., 179, 12-22. https://doi.org/10.1016/j.atmosenv.2018.01.057

In vitro Evaluation of Hydroponic Barley Fodder (HBF) as a Dietary Strategy to Mitigate Enteric Methane Emissions and Maintain Rumen Digestibility

Pacifico Eleonora[a,c*], Terranova Melissa[b], Amelchanka Sergej[b], Senese Marianna[a], Premarajan Prebin[a], Niu Mutian[c], Pinotti Luciano[a]

[a] *University of Milan, Department of Veterinary Medicine and Animal Science (DIVAS), Via dell'Universita 6, Lodi 26900, Italy*

[b] *ETH Zurich, AgroVet-Strickhof, Eschikon 27, Lindau 8315, Switzerland*

[c] *ETH Zurich, Department of Environmental Systems Science, Institute of Agricultural Science, Eschikon 27, Lindau 8315, Switzerland*

Corresponding author: eleonora.pacifico@unimi.it

Livestock agriculture has the challenge of reducing enteric methane (CH_4) emissions without compromising animal performance and feed efficiency. Hydroponic barley fodder (HBF) could offer a solution, due to its higher levels of readily fermentable carbohydrates and high enzymatic activity. This study evaluated the *in vitro* CH_4 mitigation potential and organic matter digestibility (IVOMD) of HBF when replacing standard dietary components at two physiological maturities: Day 4 (HBF1) and Day 6 (HBF2). The Hohenheim Gas Test was utilized to simulate rumen fermentation during a 24-hour incubation. Treatments included a standard control diet (CTR; 60% hay, 40% concentrate), pure HBF substrates, and mixed diets where HBF replaced either the hay fraction at graded levels or the concentrate fraction at 10% and 20% inclusion. The results show that several mixed diet formulations decreased CH_4 emissions and improved overall digestibility compared with CTR. Pure HBF substrates exhibited significantly higher digestibility compared to the CTR (60.08%). Further, HBF1 recorded an IVOMD of 73.56%, a finding that might reflect its high content of readily available starch. As the barley seedlings matured to Day 6 (HBF2), IVOMD decreased to 67.99%, potentially associated with the development of structural fibers. Correspondingly, both maturities lowered the CH_4/CO_2 ratio by 5.8% and 9.0% compared to the CTR. In the hay-substitution diets, higher inclusion levels of both HBF maturities consistently yielded a favorable balance of reduced CH_4 emissions without decreasing the digestibility compared to the control. Finally, a significant negative overall correlation was observed between the CH_4/CO_2 ratio and IVOMD ($r = -0.557$). This demonstrates that treatments improving digestibility are quantitatively associated with reduced methane output. The decrease in CH_4 emissions observed in high-HBF diets might be linked to the rapid fermentation of plant starches. *In vitro* findings suggest that substituting fibrous forage with hydroponic forages at certain maturity stages may help reduce CH_4 emissions; however, further *in vivo* studies are needed to evaluate these effects and determine potential optimal inclusion levels.

Neurological Signs in Icelandic Horses Following Ingestion of Poppy-Contaminated Hay

Popa A[1], Seghers T[1], Moscoso F[1], Liesegang A[1]

[1]*Institute of Animal Nutrition, Vetsuisse Faculty, University of Zurich, Switzerland.*
Corresponding author: aliese@nutrivet.uzh.ch

Introduction: Contamination of equine feed with toxic plants represents an increasing concern in veterinary medicine. Rhoeadine and morphine are opioid alkaloids derivatives found in plants of the genus *Papaver spp.*, which may cause clinical neurological manifestations in horses when ingested, especially in dried hay. This case report describes an outbreak of acute neurological symptoms in a group of Icelandic horses in Switzerland following suspected ingestion of hay contaminated with poppies.
Animals: A total of ten Icelandic horses were housed in an open stable at a boarding facility. They received 2–4 kg of hay three times daily, while concentrate feed was provided individually by their owners. A proportion of the hay originated from on-farm production, with the rest supplied by a long-established local provider. According to the stable owner, the suspected batch of hay was offered at midday and within 30 minutes, seven horses developed mild clinical signs, whereas three exhibited severe neurological manifestations., in the form of hyperreflexia, muscle tremors across the body (particularly involving the head), ataxia, circling, collapsing on the hindquarters, sitting down position and occasional falling over. Immediate treatment measures consisted of nasogastric tubing, administration of activated charcoal, non-steroidal anti-inflammatory drugs and corticosteroids. Clinical examination performed by the referring veterinarian revealed no significant abnormalities. Rectal temperature was within normal limits and cardiac and pulmonary auscultation findings were unremarkable. The severe clinical signs resolved within four hours, with residual muscle tremors persisting the following day. Inspection of the hay rack accessible to the horses revealed multiple poppy capsule fruits within the coarse feed. A representative sample of approximately 1 kg was submitted to the Institute of Animal Nutrition and Dietetics, where it underwent macroscopic examination, followed by microscopic analysis of the crumbled plant residues using a binocular microscope.
Results: The neurological signs were most likely attributable to the ingestion of contaminated hay. Macroscopic evaluation revealed a high proportion of dried poppy plants (*Papaver spp*.), representing 1.9% of the examined sample, in various stages of vegetation. The opioid alkaloid rhoeadine contained in poppy plant was considered the probable cause of the symptoms of poisoning. The possible presence of other toxic plants, including Delphinium spp. and Aconitum spp., was also suspected. Clinical signs resolved following symptomatic treatment, and no recurrence was observed after replacement of the hay batch.
Discussion: This report illustrates the considerable risk of equine toxicosis associated with the ingestion of hay contaminated by poppies, especially in extensively managed fields where these plants can proliferate. While fresh poppies are typically avoided by horses, drying alters palatability and raises the risk of consumption. The sudden appearance of neurological symptoms, combined with the documented toxicity of poppy alkaloids, highlights the need for routine sensory evaluation of forage.

References:

[1] Hertzsch R. et al. (2015) *Tierärztliche Praxis Großtiere,* Vol 43: 35; [2] Starzonek J and Vervuert I. (2025), *Poppies in hay: A case report on intoxication in horses.*

Combined Effects of Varying Levels of Metabolizable Lysine and Rumen Protein Balance on N Use Efficiency in Holstein cows in Mid-Lactation

Matthias Schilde, Wilfried van Straalen

Schothorst Feed Research (SFR), Meerkoetenweg 26, 8218NA Lelystad
Corresponding author: mschilde@schothorst.nl

Feeding low crude protein (CP) diets while balancing for adequate supply of N to rumen microbes and metabolizable amino acids aims at improving N efficiency in dairy cows.
The objective of the present study was to investigate the effects of lowering CP content in diets by reducing the rumen protein balance (RPB) in combination with low and high levels of true metabolizable Lysine (TM-Lys) on feed intake and N use efficiency.
In a randomized block design with a 3-wks pre- and 6-wks main period, 60 cows in mid lactation (112 ± 21 DIM; 38 kg/d milk) were blocked based on parity and fat-protein-corrected milk yield (FPCM) in pre-period and randomly allocated within each block to one of the four treatments. Diets were formulated targeting two levels of CP (150, 130 g/kg DM) by lowering RPB (10, -10 g/kg DM) combined with high or low levels of TM-Lys (> 5.8%, < 5.3% TM-Lys of true metabolizable protein (TMP)) at similar TM-Met level (2.3% TM-Met of TMP). Basal diet contained 52.5% grass silage, 37% corn silage, 10.5% beet pulp. TM-Lys was varied by feedstuff selection. Cow-individual daily dry matter intake (DMI), milk yield/composition and body weight (BW) were measured at the experimental station of Schothorst Feed Research. An ANOVA (Genstat®) was carried out with the 3-wks pre-period as covariate, the main effects of RPB and TM-Lys level and their interaction and including cow and block as random effects.
The DMI, BW, and milk fat (%, g/d) were not affected by treatments and interactions. With lowering RPB and TM-Lys, milk and FPCM significantly decreased with the greatest reduction in the group with lowest RPB and TM-Lys ($P_{TM\text{-}Lys} < 0.05$). Milk urea (mg/dL) and protein (%, g/d) were significantly affected by RPB and TM-Lys level. High RPB and TM-Lys levels resulted in greater milk protein % and yield. Milk urea was lowest from diets with lowest RPB irrespective of TM-Lys level, whereas highest milk urea concentration was observed in the group with high RPB and high TM-Lys level. Interestingly, N use efficiency was only significantly affected by RPB level, but not TM-Lys or their interaction. Balancing for higher TM-Lys level improved feed efficiency ($P_{TM\text{-}Lys} < 0.05$) and numerically N efficiency. In general, N efficiency was on a high level ranging between 34.3 and 36.1% ± 0.55 meaning that its further improvement by a further decrease in CP levels below 150 g/kg DM is difficult to obtain. Thus, N efficiency was 34.5% and 35.8 in RPB+10 and RPB-10, respectively.
In conclusion, lowering CP levels below 155 g/kg DM in mid lactation is at a risk of a lower milk yield while achieving only marginal improvements in N efficiency. In diets with CP levels of 130 g/kg DM, the greater TM-Lys supply partly compensated for the lower milk yield showing that balancing rations for TM-Lys by feedstuff selection is a strategy to maintain milk performance at lowest N emissions.

Dairy Cow Performance, Reproduction and Health Treatments Under Low-Protein Concentrate Feeding in an Organic Herbage-Based System

Fredy Schori, Andreas Münger, Frigga Dohme-Meier

Ruminant Nutrition and Emissions, Agroscope, Tioleyre 4, 1725 Posieux, Switzerland
Corresponding author: fredy.schori@agroscope.admin.ch

A previously proposed alternative scenario for the Grassland-based Milk and Meat Production programme allowed only concentrates with ≤ 12% crude protein (CP), without fixed requirements for herbage or concentrate proportions. This study evaluated the effects of low-protein concentrate supplementation on performance, health treatments, and reproduction of dairy cows in a herbage-based system. The experiment was conducted on the organic farm Ferme-École de Sorens, located in Mountain Zone 1 in Switzerland, and included three grouped calving seasons in late winter. In total, 138 lactations from 94 Holstein and Swiss Fleckvieh cows were analysed. During winter, cows were fed hay (5.2 MJ net energy for lactation [NEL], 111 g CP per kg dry matter [DM]) ad libitum and were gradually transitioned to full grazing (6.1 MJ NEL, 178 g CP per kg DM) in spring. All cows received 3 kg concentrate (as fed) per day during the first 90 days in milk (DIM) and 1 kg per day from 100 to 150 DIM. Paired cows were randomly assigned to a low-CP concentrate (LOPRO; 137 g CP/kg DM) or a protein-rich concentrate blend (HIPRO; 221 g CP/kg DM). Performance, body weight (BW), and body condition score (BCS) data were allocated per cow to early, mid, and late lactation stages. With identical concentrate intake per standard lactation (333 kg as fed), milk yield tended to be lower in LOPRO than in HIPRO cows (6154 vs. 6358 kg, $P = 0.07$). Most treatment-related differences ($P < 0.05$) occurred in early lactation, when LOPRO cows showed lower milk yield (–1.4 kg/d), milk fat content (–1.4 g/kg), and energy-corrected milk yield (–1.7 kg/d), as well as lower milk urea concentrations (–4.5 mg/dL) compared with HIPRO cows. Milk protein, lactose, somatic cell counts, BW, and BCS did not differ between treatments. No treatment effects were detected in mid or late lactation. Lactation stage had an effect ($P < 0.001$) on all aforementioned traits, with treatment-by-stage interactions ($P < 0.05$) for actual and energy-corrected milk yield, BW, and milk fat, lactose, and milk urea concentrations. Despite similar calving-to-first-insemination intervals, LOPRO cows had a 12-d longer calving-to-conception interval ($P = 0.01$), a 12-d longer calving interval ($P = 0.03$), and a higher insemination index (+0.4, $P = 0.01$) than HIPRO cows. The experimental treatment had no effect on the number or the distribution of health disorder treatments. In conclusion, low-protein concentrate supplementation lowered milk urea concentrations, indicating reduced nitrogen losses, but was associated with reduced performance and longer calving intervals.

Measurements and Model-Based Calculation of Year-Round Non-Methane Volatile Organic Compound (NMVOC) Emission Values from Dairy Housing at Different Diets

Sabine Schrade[1] Kerstin Zeyer[2], Joachim Mohn[2], Giovanni Lazzari[1], Frigga Dohme-Meier[1], Michael Zähner[1]

[1]Ruminant Nutrition and Emissions, Agroscope, [2]Emissions and Isotopes, Empa
Corresponding author: sabine.schrade@agroscope.admin.ch

Beyond NH_3 and CH_4 emissions, cattle farming is also a relevant source of NMVOC emissions. According to previous studies, a large proportion of these emissions originate from feed, predominantly silage. Around one third of the milk marketed in Switzerland is produced without silage ('hay feeding'). To accurately determine NMVOC emission data for the inventory, different feeding strategies (silage vs. silage-free diets) must be considered.

To improve the data basis for NMVOC emissions from dairy farming, Agroscope and Empa conducted measurements in the experimental dairy housing for emission measurements (Tänikon). The naturally ventilated housing comprises two compartments (each for 20 lactating cows) which allow for simultaneous emission measurements. The effects of four different dietary treatments ('silage-free', 'mixed silage', 'grass silage' and 'sainfoin silage') were assessed at herd level over two years covering three seasons. A tracer ratio method using SF_6 and SF_5CF_3 was used to determine emissions under natural ventilation conditions. Approximately 30 different NMVOC compounds were analysed using GC-FID. To derive annual values of NMVOC emissions for the dietary treatments 'silage' and 'silage-free' across two altitude categories (plain and mountain region) and two seasonal periods (vegetation and non-vegetation period), a statistical model was developed to characterise emissions and simulate their variance components. Air temperature data from 42 MeteoSwiss weather stations representing both altitude categories over a five-year period (2017–2021) were used as input variables for the model-based calculations.

The measured NMVOC emissions from all silage treatments were higher than those from the silage-free treatment ($p<0.001$). Furthermore, temperature was found to have a significant effect on NMVOC emissions. Modelled annual NMVOC emission values for silage treatments were slightly higher in the plain region than in the mountain region. They were 26.5 kg per animal per year for the vegetation period and 20.6 kg per animal per year for the non-vegetation period in the plain region, compared to 24.5 and 19.3 kg per animal per year in vegetation and non-vegetation period respectively in the mountain region. Significantly lower year-round NMVOC emission values were determined for the silage-free treatment: 1.3 kg and 0.8 kg per animal per year for the plain region in vegetation and non-vegetation period, respectively; and 1.1 kg and 0.7 kg per animal per year for the mountain region in vegetation and non-vegetation period, respectively. This study provides updated annual NMVOC emission values specific to Swiss conditions, which improve reporting in the emissions inventory.

Effects of Feed Access Restriction and 3-nitrooxypropanol on Whole-Body Nutrient Metabolism of Cows Using Derivative-Based Differentiation of Metabolic and Fermentation CO_2

K. Wang, M.A. Barrientos-Blanco, U. Arshad, and M. Niu

Animal Nutrition, Institute of Agricultural Sciences, Department of Environmental Systems Science, ETH Zürich, Zürich 8092, Switzerland

Corresponding author: mutian.niu@usys.ethz.ch

Separating metabolic (**mCO_2**) from fermentation CO_2 (**fCO_2**) can improve indirect calorimetry for modeling nutrient partitioning in ruminants. Conventional approaches estimate fCO_2 from CH_4 using stoichiometric relationships may be invalid when CH_4 inhibitors are applied. We aimed to assess effects of feed restriction and 3-nitrooxypropanol (3-NOP) on nutrient metabolism of dairy cows using a dynamic method to separate breath and eructation based on second-to-second GreenFeed data. Sixteen cows fed 42% NDF TMR were used in a 2×2 factorial study of feed access [ad libitum (AL) vs. regulated (RE); RE cows were limited to 12% of daily intake per meal with a 1-h lockout] and 3-NOP supplementation [control vs. 3-NOP (70.5 mg/kg DM)]. Sensor outputs after background correction were converted to gas fluxes (L/s) by applying calibration factors, airflow and the ideal gas law. Breath and eructation were separated using the first derivative of rolling-median smoothed CH_4 flux; derivatives within ±1.25×median absolute deviation were classified as zero and breath events were defined as near-zero regions bounded by negative and positive slopes. Effect of feed access or feed access by 3-NOP interaction were not detected for fCO_2/CH_4. The fCO_2/CH_4 ratio was greater for 3-NOP vs. control (1.7 vs. 1.2; $P<0.05$), led by a joint effort of inhibited CH_4 and unbiased fCO_2. Metabolic CO_2 and O_2 fluxes were then used to calculate whole-body fat oxidation (FOX; $1.69\times O_2 - 1.69\times mCO_2 - 2.03\times$urinary N) and carbohydrate oxidation (COX; $4.57\times mCO_2 - 3.23\times O_2 - 2.60\times$urinary N). Cows in RE had higher COX than AL (4417 vs. 4095 g/d; $P<0.05$), but lower FOX (1363 vs. 1510 g/d; $P<0.05$). Feed access by time of day interactions were observed ($P<0.05$), with RE cows showing lower post-feeding COX than AL cows (0700–0900 h: -34.5 g/h; 1700–1900 h: -46.9 g/h) but higher COX during later in the afternoon and at night (1300–1700 h: 50.9 g/h; 2100–0100: 46.9 g/h), reflecting diurnal shifts in substrate use. Derivative-based separation of mCO_2 enabled high resolution of indirect calorimetry independent of stoichiometric relationships with CH_4.

Keywords: feed restriction, nutrient metabolism, indirect calorimetry

Validation of a Noseband Sensor for Measuring Grazing Behaviour in Veal Calves

J. Werner[1], A.Neujahr[1,2], F.Leiber[1], G.Mesbahi[1]

[1]*Research Institute of Organic Agriculture, FiBL, 5070, Frick, Switzerland;*
[2]*University of Hohenheim, 70599, Stuttgart, Germany*
Corresponding author: jessica.werner@fibl.org

Precision Livestock Farming (PLF) technologies are increasingly used in cattle production, with most applications focusing on adult dairy cows. In contrast, their use and validation in young stock remain limited, despite the importance of monitoring early-life behaviour. The RumiWatch noseband sensor is a well-established tool for detecting grazing and rumination behaviour in adult cattle (Rombach et al., 2018). This study aimed to validate its application in veal calves aged 3 to 6 months under pasture-based conditions. A total of 18 calves from three genotypes (Brown Swiss, Swiss Fleckvieh, Limousin × Brown Swiss) were observed across three pasture-based farms. All animals had a similar supplemental feeding plan and pasture access was ranging from 9 to 12 hours/day per farm and was adapted from day grazing to night grazing in summer. Behavioural data were collected through visual observation using 1-minute scan sampling. Observations took place on three measurement days per farm replicated either twice or three times over the vegetation period. On each measurement day, there were two 2-hour observation intervals: either from 9-11 am and 1-3 pm, or, in the case of night grazing, from 6-8 am and 6-8 pm. Sensor data (n=442 hours) were compared to visual observations across all behavioural categories, showing a high level of agreement, analysed by Bland-Altman statistics, as displayed in Table 1.

Table 1: Statistical agreement metrics between automated and visual observations for grazing, ruminating, and other activities (n=442 hourly summaries).

Metric	**Grazing**	**Ruminating**	**Other Activities**
Concordance Correlation Coefficient	0.93	0.92	0.87
Mean difference and standard deviation (min/h)	1.19 ± 6.29	-1.35 ± 3.49	-0.22 ± 6.75
Upper limit of agreement (min/h)	13.51	5.50	13.02
Lower limit of agreement (min/h)	-11.41	-8.19	-13.45

There was a high agreement, especially for grazing and rumination. Minor discrepancies, mainly due to algorithmic exclusion of short rumination bouts, were noted. The results confirm that the RumiWatch noseband sensor is a valid tool for monitoring grazing behaviour in veal calves on pasture. Its application offers new opportunities for studying and understanding grazing patterns in young cattle under extensive conditions.

References

Rombach, M., Münger, A., Niederhauser, J., Südekum, K. H., & Schori, F. (2018). Evaluation and validation of an automatic jaw movement recorder (RumiWatch) for ingestive and rumination behaviors of dairy cows during grazing and supplementation. *Journal of Dairy Science*, *101*(3), 2463–2475.

Figure 2 Speakers and organisers

Figure 3 Winners of the Poster Prizes

ETH zürich

Save the Date: 25th May 2027

ETH Zentrum, Zürich City

agridea

AgroVet Strickhof

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs, Education and Research EAER
Agroscope