Net energy in soybean meal and other ingredients

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The net energy (**NE**) of soybean meal (**SBM**) and other ingredients is usually calculated using prediction equations based on digestible nutrients in the ingredient or based on the concentration digestible energy (**DE**) corrected for nutrient concentrations. In these prediction equations it is assumed that the NE of crude protein is much lower than the NE of starch and ingredients high in crude protein, therefore, have lower calculated NE than ingredients high in starch. As a consequence, the NE of SBM is assumed to be much lower than the NE of corn, but results of recent research have failed to verify this assumption. There is, therefore, a need for reviewing these assumptions and recent work at the University of Illinois aimed at testing the hypothesis that the NE of high protein ingredients such as SBM is much less than the NE of high starch ingredients such as corn.

In initial experiments, growth performance and carcass quality of pigs fed diets with different levels of crude protein and crystalline AA were determined. Three dietary sequences were fed to pigs from around 10 kg to market weight at around 138 kg and there were five dietary phases. Within each phase, all diets were formulated as high-, medium-, or low-protein diets, but all diets within the same phase met the same minimum requirements for standardized ileal digestible amino acids (**AA**). Within each phase, diets were formulated either without crystalline AA, with 3 crystalline AA (i.e., Lys, Met, and Thr), or with 5 crystalline AA (i.e., Lys, Met, Thr, Trp, and Val). As the concentration of crystalline AA was increased, the concentration of SBM in the diets was reduced. Results demonstrated that there were no differences among treatments in overall growth performance from 10 to 138 kg. Likewise, there were no differences in loin quality traits, belly quality, or backfat color. There was, however, a tendency ($P < 0.10$) for a reduction in loin eye area and there was also a tendency ($P < 0.10$) for an increase in back fat thickness as dietary crude protein was reduced. The tendency for a reduced loin eye area indicates that pigs fed the low-protein sequence of diets, while being able to maintain growth performance, were not able to maintain the same protein synthesis as pigs fed the diet sequence

with greater protein concentration. A follow-up experiment was, therefore, conducted to test the hypothesis that pigs fed low protein diets have reduced nitrogen retention compared with pigs fed diets with greater protein intake even if diets are balanced for digestible AA. The same diets as used in phase 1 of the growth performance experiment were used and pigs had an initial body weight of 17.75 kg when they were placed in metabolism crates and fed experimental diets for 12 days with urine and feces being collected for 4 days after a 7-day adaptation period. Results indicated that total daily nitrogen retention calculated as gram per day was reduced (linear, $P < 0.001$) as the protein level was reduced, which may be the reason for the reduced loin eye area that was observed in the growth performance experiment.

To further investigate the impact of reducing dietary crude protein and SBM on growth performance, carcass composition, and nitrogen balance, two additional experiments were conducted. The same diets were used in both experiments. A control diet that met all nutrient requirements was formulated based on corn and SBM without crystalline AA. Three additional diets were formulated by reducing the inclusion rate of SBM and adding 3 crystalline AA (i.e., Lys, Met, Thr); 4 crystalline AA (i.e., Lys, Met, Thr, Trp); or 5 crystalline AA (i.e., Lys, Met, Thr, Trp, Val) to the diet. Concentrations of standardized ileal digestible indispensable AA were at or above requirements in all diets, but the concentration of crude protein was reduced from 20.0% to 16.4, 15.4, and 13.4%, respectively, by including 3, 4, or 5 crystalline AA in the diets. There were 4 pigs per pen (2 gilts and 2 barrows) and 10 replicate pens per diet. Diets were provided to pigs on an *ad libitum* basis for 28 d. Results indicated that average daily gain and average daily feed intake were not affected by dietary treatments, which resulted in no differences in gain to feed ratio. Retained protein, lipid, and energy were also not significantly affected by dietary treatment, but energy efficiency tended to decrease (quadratic, $P < 0.10$) as dietary protein was reduced. In the nitrogen balance experiment using the same four diets 40 growing pigs (initial body weight: 20.5 ± 2.4 kg) were used. Pigs were housed individually in metabolism crates and fecal and urine samples were collected quantitatively for 5 days after 7 days of adaptation. Results indicated that although nitrogen retention calculated as percentage of intake increased (linear, $P < 0.001$), absorbed nitrogen and retained nitrogen calculated as gram per day were reduced (linear, $P < 0.001$) as dietary protein decreased.

Combined, results of the above experiments indicate that although growth performance can be maintained in diets based on corn, crystalline AA, and reduced levels of SBM, nitrogen

retention, and therefore protein synthesis, appears to be compromised, which will result in reduced carcass leanness. These observations are in agreement with results of some previous experiments that also indicated that nitrogen retention of pigs fed diets with reduced concentrations of SBM was reduced compared with pigs fed diets with greater protein concentration.

According to current book values, the NE of soybean meal is much less than that of corn. As an example, on a dry matter basis, the NE of corn is 3,026 kcal/kg and the NE of soybean meal is 2,319 kcal/kg. As a consequence of the assumed difference in NE between corn and SBM, the theoretical NE of a diet will increase if SBM is reduced, and the inclusion of corn and crystalline AA is increased. However, in several recent experiments, the NE of SBM was greater than estimated values and ranging from 82 to 125% of the NE of corn have been reported. If those values are correct, it would be assumed that the theoretical increase in NE obtained by increasing corn and reducing SBM in a diet because of inclusion of crystalline AA may not be realized in practical diets. An experiment was, therefore, conducted to test the hypothesis that the negative effect on diet NE of using SBM in diets is less than calculated. A diet based on corn, SBM, and L-Lysine was formulated and 5 additional diets in which the concentration of SBM was gradually reduced and inclusion of crystalline AA was increased were also formulated. All diets were formulated to meet the AA requirement for pigs from 30 to 115 kg. The concentration of corn increased from 69.3 to 85.4% and the concentration of SBM was reduced from 27.0 to 9.4% as the inclusion of crystalline AA increased. Diets were fed to group housed and ad libitum fed pigs housed in calorimeter chambers and the concentration of NE was determined for each diet. Results indicated that there were no differences among diets in NE and the hypothesis that the NE of SBM is greater than previously thought was, therefore, confirmed. Indeed, because NE did not change as dietary corn increased and SBM was reduced, results indicated that the NE of SBM may be close to the NE of corn. It was also noted that the observed NE of all diets, regardless of the level of SBM in the diet, was greater than the calculated values, further indicating that SBM may contribute more NE to diets than calculated from current book values. This last observation is also in agreement with results of other recent experiments.

There are two main reasons why SBM likely contains more NE than calculated from previously developed prediction equations. The first reason is that the digestible energy in SBM is greater than estimated in current book values. As an example, in an average of 22 sources of

SBM, the DE was 239 kcal greater than expected. A greater DE in SBM also results in a greater NE value and an increase in DE of 239 kcal per kg corresponds to an increase in calculated NE of approximately 170 kcal per kg. The second reason for increased NE in SBM is that modern genotypes of pigs are more efficient in retaining nitrogen in the body than older genotypes. Indeed, one of the reasons for the assumed negative impact of diet crude protein on NE is that it has been assumed that growing pigs only retain between 45 and 50% of absorbed nitrogen in the body. This estimate corresponds to a retention of 40 to 45% of consumed nitrogen and is in agreement with data published in the 1970's and 1980's. However, as pig genetic companies have placed more emphasis on selection based on lean deposition, pigs have become more efficient in retaining nitrogen in the body, and later data indicated that pigs were able to retain between 50 and 60% of consumed nitrogen. Recently, data from nitrogen balance experiments in which modern genotypes of pigs fed a corn-soybean meal-based diet without crystalline AA were used, pigs retained between 60 and 70% of consumed nitrogen. Thus, the genetics of pigs have become much more efficient in utilizing dietary nitrogen for protein synthesis and the quantities of AA that need to be deaminated with a subsequent excretion of nitrogen via the urea cycle is, therefore, less in modern genotypes of pigs than in older genotypes. Because deamination of AA and excretion of nitrogen are energy requiring processes, the theoretical energy contribution from dietary protein increases as nitrogen retention increases. As an example, if nitrogen retention increases from 45 to 70% of nitrogen intake, the NE of soybean meal will increase by approximately 165 kcal per kg. It is, therefore, likely that the increased nitrogen retention that is observed in modern genotypes of pigs contributes to the increased NE of SBM that has been consistently observed in experiments conducted in recent years.

In conclusion, results of numerous experiments conducted in recent years have demonstrated that the NE of SBM is greater than current book values. It is likely that this is a result of a greater concentration of DE in SBM than previously thought as well as a greater energy value of the protein fraction in SBM due to the greater nitrogen retention in modern genotypes of pigs compared with older genotypes. In experiments conducted to determine NE in SBM or in corn-SBM diets using indirect calorimetry or the comparative slaughter procedure, NE values for SBM between 90 and 100% of corn have been obtained, which is reasonably close to theoretical calculations of NE in SBM fed to modern genotypes of pigs.

K1-2

Future directions of animal feed technology research to meet the challenges of a changing world

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This abstract highlights the critical advancements and future directions in animal feed technology, emphasizing the importance of sustainability, innovation, and collaboration in driving the industry forward.

Animal feed technology encompasses scientific and technological processes to create nutritionally balanced feed that meets the needs of various livestock species. This is essential for optimizing animal growth, reproduction, and overall health, thereby contributing to food security and agricultural sustainability.

Tomorrow's feed mills will integrate technology, sustainability, quality assurance, and customer focus. Key features will likely include:

1. Robotics for ingredient handling, mixing, and packaging.
2. Real-time monitoring and predictive maintenance for enhanced efficiency.
3. IoT devices to track parameters like temperature and moisture.
4. Prioritization of renewable energy and waste reduction.
5. Robust tracking systems for safety and compliance.
6. Personalized nutrition for different species.
7. Integration of feed production with other stages for efficiency.
8. A culture of continuous improvement.

Nutrition, precision feeding and innovation

The primary goal is to adopt scientific principles for balanced nutrition and use novel feed raw materials and additives to produce cost-effective feed while enhancing performance and animal health. Sustainable practices are at the forefront, including sourcing ingredients locally to reduce transportation emissions and integrating by-products from the food industry to minimize waste. Also, innovations in feed formulations aim to reduce methane emissions from ruminants, a significant contributor to agricultural greenhouse gases by developing more digestible and nutritionally optimized feeds.

The adoption of digital technologies has revolutionized the feed industry. Precision feeding systems use data analytics and real-time monitoring to tailor feed supply to the exact nutritional needs of individual animals, improving efficiency and reducing waste. However, end users need to be more informed about the benefits of precision feeding.

Innovations aimed at improving feed conversion ratios are crucial for better productivity. Enhanced feed formulations and additives ensure that animals convert feed into body mass more efficiently, reducing the amount of feed required for growth, lowering costs for farmers,

and conserving resources. Feed technology plays a significant role in promoting animal health. Incorporating functional additives such as probiotics, prebiotics, essential oils, and enzymes enhances feed production and the nutritional quality of feed pellets.

Resource efficiency and collaboration

Advances in nutritional science underpin many innovations in animal feed. Detailed research into the specific dietary needs of different species and life stages has led to more targeted and effective feed formulations, ensuring optimal health and growth outcomes. Innovations in feed technology aim to optimize the use of available resources, including water and energy, and reduce dependency on non-renewable resources. Improved resource efficiency contributes to the overall sustainability of agriculture.

Ongoing collaboration between academic institutions, industry players, and policymakers drives continuous improvement and innovation in animal feed. These partnerships facilitate the development and implementation of cutting-edge technologies and sustainable practices. Key drivers of innovation in animal feed include sustainability, digitalization, efficiency, animal health, and regulatory compliance. These factors collectively push the industry towards more sustainable, efficient, and health-focused practices, ensuring the feed sector can meet modern agriculture's demands while minimizing its environmental impact.

Novel ingredients and precision nutrition

The use of novel ingredients in animal feed, such as insect protein, algae-based feeds, fermented ingredients, and by-products, is increasingly significant in Europe. These innovations reflect the European focus on sustainability, efficiency, and improved animal health, driving the evolution of the animal feed industry towards more environmentally friendly practices. Precision nutrition in animal feeding has revolutionized diet customization for livestock, ensuring optimal health and productivity. Nutritional modelling with advanced software tools enables precise prediction of nutrient requirements and feed intake, allowing for more accurate diet formulations. Feed formulation using least-cost software ensures that diets meet nutritional needs while minimizing costs by selecting the most cost-effective ingredients. These innovations not only improve feed efficiency and animal performance but also contribute to sustainability by reducing waste and resource use.

Feed additives and supplements

Feed additives and supplements play a crucial role in enhancing animal nutrition, improving feed quality, and ultimately contributing to the quality of food derived from animals. Key points include probiotics, prebiotics, enzymes, antioxidants, mycotoxin binders for the emerging mycotoxins, etc…

Probiotics: Live beneficial microorganisms that promote gut health by balancing the intestinal microbiota. Prebiotics: Non-digestible compounds that selectively stimulate the growth of beneficial gut bacteria. Enzymes improve nutrient utilization by breaking down complex molecules (e.g., starch, protein, and fiber) into simpler forms. Enzymes also enhance digestibility, reduce feed costs, and improve animal performance.

The innovative approach of novel antioxidants protects feed ingredients and animal tissues from oxidative damage caused by free radicals. Except for the standard antioxidants such as vitamins E and C, selenium, natural plant extracts are also showing potency.

Mycotoxin binders for emerging mycotoxins adsorb and neutralize mycotoxins in the digestive tract, preventing their absorption into the bloodstream. Feed additives in the EU contribute to sustainable and innovative animal nutrition, supporting both livestock health and food safety.

Integration of blockchain technology in feed production

The purpose of integrating blockchain technology may ensure transparency, immutability, and trust in traceability systems within agri-food supply chains. The benefits of such integration enable decentralized, real-time data monitoring and decision-making, reducing loss and recall incidents.

Automation in feed manufacturing has a role in streamlining feed manufacturing processes, from ingredient handling to packaging. The impact of such manufacturing is enhancing the efficiency, consistency, and quality control in feed production. Various sensors are already integrated in the feed production to sens the manufacturing processes and outputs. However, they also can collect real-time data on conditions (e.g., water activity, density, temperature, moisture, etc…) during feed manufacturing. This is all to optimize production parameters and ensure feed safety. Artificial intelligence (AI) even nowadays analyses sensor data, and predicts equipment failures, however, in the future it may optimize the feed formulations. Such an approach can improve accuracy, reduce waste, and better resource utilization.

The Internet of things, as a part of integrated blockchain technology, will connect all the sensors, machinery, and data networks. In such a way real-time monitoring, predictive maintenance, and data-driven decision-making will be possible..

This kind of approach will further bring a smart farming revolution where the blockchain combined with sensors and artificial intelligence will create a smart ecosystem for feed production. Thus sustainable, efficient, and traceable feed supply chains. Technology integration will empower more feed producers to enhance quality, reduce waste, and meet sustainability goals.

Innovative technology for a sustainable future:

There is still a space for innovations in the rather easy tasks such as improved feed mixing technology. IsDeCa® mixing technology is a good example of a patented technology that improves ingredient integration, especially semi-moist and moist feed raw materials like hydrolyzed proteins from fish trimmings. IsDeCa® mixing allows the incorporation of at least twice as many sustainable liquid-based marine ingredients compared to other mixing technologies. This innovative technology addresses issues with commercial mixing machinery, such as controlled dynamics, hygiene, and the ability to mix wet materials without forming large lumps over 25% added liquid, as it happens during the twin-shaft paddle mixing.

Successful case studies

Implementation of insect protein in a large-scale poultry farm in the Netherlands improved growth rates and reduced environmental impact. Also, the use of precision nutrition in dairy cattle enhanced milk production, improved health markers, and lower feed costs. Adoption of microalgal and insect based feeds in Norwegian salmon improved fish health and omega-3 content, and partially reduced dependency on fishmeal.

Challenges, opportunities and trends

High costs of novel ingredients and technologies, regulatory hurdles, market acceptance, and consumer perception are a challenge. Advances in feed technology offer the potential for improved animal health and welfare, reduced environmental impact, and economic benefits for farmers and the feed industry. Future trends in animal feed technology bring together artificial intelligence with predictive analytics for feed formulation and management with optimized feed efficiency and animal health outcomes.

Conclusion

Advancements in animal feed technology are driven by sustainability and efficiency. Continuous innovation is crucial for feed and food security, animal welfare, and environmental sustainability. Future trends point towards more sustainable, efficient, and health-promoting feed technologies.

K1-3

Impact of processing ingredients and diets on nutritional value

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The most commonly used methods for processing feed ingredients and diets include grinding, pelleting, and extrusion/expansion. The main objective of using these technologies is to increase digestibility of energy and nutrients, and therefore, improve feed conversion rate of pigs fed the diets that have been processed. Although these technologies are not new, there is considerable confusion about the practical implications. Therefore, the objective of this contribution is to review recent developments about the use of processing to increase the nutritional value of feed ingredients and diets.

The most commonly used feed technology is grinding, which is applied to all cereal grains and pulse crops used in diets for pigs. Grinding is done using either a hammer mill or a roller mill or a combination of the two mills. If only roller mills are used, it is usually necessary to stack two or three mills on top of each other to ensure sufficient grinding of the material and the particle size of the ground material is decided by the distance between the rollers in each mill. If a hammer mill is used, screen openings and speed of the hammer determine the particle size of the material. If ingredients are ground to the same particle size, there does not seem to be a difference between using a hammer mill or stacked roller mills. Reducing the particle size of corn, wheat, or sorghum usually results in increased digestibility of energy, which is mainly caused by an increase in small intestinal starch digestibility. Energy digestibility, and therefore, net energy also is increased in field peas if the particle size is reduced, and this also is a result of increased starch digestibility, but the total tract digestibility of total dietary fiber in field peas is also increased as the particle size is reduced. However, the digestibility of amino acids and phosphorus is not increased by reducing the particle size of cereal grains or pulses. The increase in energy digestibility is usually linear until the particle size is close to 300 microns.

There is no impact of diet particle size on average daily gain of pigs, but because of the increased energy digestibility in diets where a lower particle size is used, feed efficiency of both

weanling and growing-finishing pigs is improved as particle size is increased and a maximum for feed efficiency is usually obtained at a particle size between 400 and 500 microns, which is therefore, the recommended particle size for grains and pulse crops used in diets for pigs. Because a smaller particle size increases the risk of stomach keratinization and ulcers, it is not recommended to grind to a particle size that is less than 400 microns.

Pelleting of diets is commonly done to reduce dust and increase flowability. However, pelleting also increases the small intestinal digestibility of starch and amino acids, and as a result, energy digestibility and net energy of diets are also increased by pelleting. In some experiments, the total tract digestibility of dietary fiber was also increased by pelleting, which may also contribute to the increased energy digestibility. The increased net energy in pelleted diets results in improved feed efficiency of pigs fed pelleted diets compared with pigs fed diets in a mash form, whereas average daily gain is not improved by pelleting. These effects are observed in both weanling and growing-finishing pigs and the improvement in feed efficiency is usually between 4 and 8 %. Whereas the increased feed efficiency of pigs fed pelleted diets compared with mash diets primarily is a result of the increased net energy in pelleted diets, it is also possible that feed wastage is reduced if pelleted diets are used due to reduced rooting behavior in the feeders. Because the pelleting process causes friction in the material, the particle size is further reduced by pelleting. Therefore, the optimum particle size of cereal grains and pulses used in pelleted diets is between 500 and 700 microns and it is, therefore, not necessary to grind the grains as fine if pelleting is used as if diets are fed in meal form.

Extrusion and expansion are technologies that also may be used to improve nutrient digestibility. During this process, ground feed material is pressed through a small opening in a dye, and the friction generated during this process increases the temperature of the material. As is the case for pelleting, extrusion usually increases the digestibility of starch and amino acids, and sometimes also the digestibility of total dietary fiber. The reason for the increased digestibility of starch is primarily that starch gelatinization is increased and in cereal grains, it is possible to get close to 100% gelatinization of the starch if extrusion conditions are correct. In contrast, the digestibility of phosphorus is not improved by extrusion, but due to the increased starch and amino acid digestibility, the digestibility of energy is also increased by extrusion. However, because extrusion can result in very high temperatures, there is also a risk of over-heating the

material during extrusion, which may result in Maillard reactions, and therefore, reduced amino acid digestibility. It is therefore important that the temperature is increased only for a short period of time, usually 15 to 20 seconds, and the material is then cooled again. Although extrusion conditions may vary, the best results are usually obtained at temperatures between 110 and 120 ^{o}C and with the material reaching this temperature for less than 25 seconds. Extrusion may be combined with pelleting and extruded products are usually easy to pellet and improve pellet quality.

In conclusion, use of feed processing to increase the nutritional value of ingredients and diets are common in the global swine feed industry. Grinding cereal grains and pulse crops to a particle size of 400 to 500 microns usually results in the best feed efficiency of pigs due to an increase in net energy. Diets may also be pelleted or extruded and then pelleted and in both cases, the heat that is generated during extrusion or pelleting increases starch gelatinization, which results in increased starch digestibility. The small intestinal digestibility of amino acids is also improved by extrusion and(or) pelleting, and sometimes fiber digestibility may also be improved by extrusion. These effects results in increased energy digestibility and therefore improved feed efficiency of pigs fed diets that are pelleted or contain extruded ingredients.

O1-1

Modular approach for the R&D of novel feed supplements for improved sustainability of pig production: case study of humic-rich prebiotic fiber product development

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Introduction

Sustainability of pork production can be improved by increasing pig performance and supporting their resilience towards pathogens, mycotoxins, heat, or other stressors. By using a 5-step modular approach in product discovery, and by working within a network of industry partners and research provider companies, we have brought to market several performance-enhancing feed supplements which improve intestinal homeostasis and reduce susceptibility to diseases. The research modules include 1) recognizing target molecular functions with potential to aid in specific challenges, 2) *in vitro* -testing of several sustainably produced, non-food materials for their efficacy on the selected molecular functions, 3) *in vivo* trials with and without intentional challenge factors for the most promising product candidates, 4) benefit validation in commercial settings for the first application, 5) widening the product portfolio with other applications of the novel product. This approach we recently utilized to innovate a humic-rich prebiotic fiber product from selected, sustainably-produced peat from Neova Oy (Jyväskylä, Finland). Throughout the project, this industry partner had an active role in material selection, processing and analyses, as well as in planning of the individual studies.

Materials and methods

Module 1: Starting point for the project was knowledge on the benefits of a stable, fiber-fermenting gut microbiota on piglet performance. Searches into scientific literature, a market survey and discussions with research partners identified prebiotic carbohydrates and humic acids as potential molecules to improve the quality and function of gut microbiota. *Module 2:* Several peat types were compared in an *ex vivo* fermentation model. This step aimed to identify most promising product varieties regarding their ability to modulate of intestinal microbiota and its functions. The model used authentic intestinal contents as a source of substrate and microbial inoculum for the fermentation. The test also compared peat fiber types against lignocellulose which is commonly used in pig feed as a fiber source. *Module 3:* Two most promising product varieties were selected for a piglet trial which studied the effects of peat pellets as enrichment material on the performance and intestinal fermentation of weaned piglets. The setting, which did not include any intentional challenge factors, included 3 treatments (control, Peat 1, Peat 2), 10 pens/tr. and 19 piglets/pen. Faecal samples were collect to assess treatment effects on gut microbiota. *Module 4:* The chosen product variety was tested in commercial piglet farms as pelletized enrichment material, in order to collect opinions from the end-users. *Module 5:* In order to utilize the prebiotic, humic-rich product in more applications, its potential to bind mycotoxins was studied by *in vitro* and *in vivo* models. Moreover, the product was tested as a source of fiber in pig and poultry feeds, with the aim of finding all those applications in which the product improves animal performance in challenging environments.

Results and discussion

Module 1: Literature search indicated that prebiotic fiber and humic acids have potential to benefit the microbiota and homeostasis of piglet gut. Specific peat types high in humic acids and prebiotic carbohydrates were identified as potential raw material candidates. *Module 2:* According to the laboratory test, peat types differ in their ability to modulate fermentation of piglet colonic microbiota. The most promising peat types reduced the production of branched-chain fatty acids, indicating less fermentation of proteins. The lignocellulose control treatment had no effects on colonic fermentation. The trial suggested that specific peat types as a fiber source may promote beneficial colonic fermentation in pigs, and offer advantages over lignocellulose. *Module 3:* Experiment evaluating peat pellets as enrichment material to weaned piglets showed that when peat pellets were freely available for 28 days, the mean peat intake was 580 g/piglet for Peat 1 and 480 g/piglet for Peat 2. Mean daily weight gain/piglet was 303 g, 370 g, and 353 g for control, Peat 1 and Peat 2, respectively, with 21% higher daily weight gain for Peat 1 in comparison to control ($p<0.05$). Microbial and chemical analysis of faecal samples indicated beneficial effects on microbiota, including higher colonic production of butyric acid, increased density of bifidobacteria, and reduced density of *E. coli* and *Bacteroides* spp. On the basis of Module 3, Peat 1 was selected as the most promising product candidate. *Module 4:* Practical experiences on using peat pellets as enrichment material were positive. In their answers to questionnaire, the farmers reported good palatability, less tail biting, and lower diarrhoea frequency in piglets with access to the product. *Module 5: In vitro* experiment suggested that the selected high-humic acid fiber product was able to remove part of zearalenone, deoxynivalenol, ochratoxin A and aflatoxin B from water solution at neutral pH. Validation on the *in vivo* capacity of the product to inhibit intestinal mycotoxin uptake has been scheduled. Moreover, the value of the product as performance enhancer in piglet feeds is studied in an experimental farm with known microbiological challenge factors.

Conclusion and implications: The 5-module product development pathway has again produced a new feed innovation with ability to improve piglet performance and reduce common problems in pig production. First starting with the application of enrichment material for pigs, the humic-acid rich prebiotic fiber will likely later be used in multiple applications for pigs, poultry, and other farm animals. A committed and skilled industry and research partner network has proven to be invaluable in the process.

Key words: prebiotic, fiber, peat, microbiota, enrichment material, performance, weight gain, tail biting, mycotoxins

O1-2

Interactive effects of dietary protein and fiber concentration on nutrient digestibility and fermentation products in pigs fed a blend of branched-chain volatile fatty acids

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Keywords: feed additives, insoluble fiber, intestinal microbiota, isoacids, swine.

Introduction
The branched-chain volatile fatty acids (**BCVFA**) isobutyrate (**IB**), 2-methylbutyrate (**2-MB**) and isovalerate (**IV**) serve as a substrate for the cellulolytic bacteria in ruminants(1). We recently reported that BCVFA supplementation in a normal protein, low fiber diet improved essential (9%) and non-essential (8%) amino acid (**AA**) and hemicellulose (38%) digestibility in growing pigs(2). The objective was to determine the effects of dietary protein and fiber concentration on apparent ileal (**AID**) and total tract digestibility (**ATTD**) of nutrients and fermentation products in growing pigs fed a BCVFA blend (IB, 2-MB, and IV at 1:1:1).

Material and methods
Fourteen cannulated pigs (20.4±1.4 kg) were used in a 5-period crossover design and assigned to one of six experimental diets, which provided at least 11 observations per dietary treatment. Experimental dietary treatments, organized in a 2 × 2 + 2 arrangement, consisted of BCVFA-supplemented diets with varying protein [low (**LP**; 15%) or normal (**NP**; 19%) protein] and fiber content [low (**LF**; 2.5% crude fiber (**CF**)) or high (**HF**; 5.0% CF) fiber]. A positive control (**PC**) with LP-LF and a negative control (**NC**) with NP-HF, both not supplemented with BCVFA, were included. An indigestible marker (TiO2) was included in the diets. Each experimental period lasted 14 d: 10 d for acclimatization to the diets, 2 d for fecal collection, and 2 d for digesta collection. Diets, fecal, and ileal digesta samples were analyzed for crude protein (**CP**), fiber, AA, and titanium concentration. The concentration of short-chain fatty acids and ammonia were also analyzed in digesta and fecal samples. Data were analyzed as a 2 x 2 factorial design using the PROC MIXED procedure in SAS and considering pigs as the experimental unit and period the random effect. Contrasts were used to determine the effects of BCVFA-supplemented diets vs unsupplemented diets. Tukey's adjusted means test was used to detect differences where $P \leq 0.05$ was considered significant.

Results and discussion
Pigs fed BCVFA-supplemented NP-HF diets had the greatest AID for CF, acid detergent fiber (**ADF**), acid detergent lignin (**ADL**), cellulose, and hemicellulose, and the greatest ATTD for ADF ($P<0.05$). Because pigs have limited ability to digest fiber at the proximal small intestine(3), it can be speculated that the above-mentioned findings are microbially mediated. It has been shown in ruminants that the inclusion of a blend of BCVFA increased fiber digestibility and altered the ruminal bacterial diversity(4). Of note, BCVFA supplementation to NP-LF diets increased CP ATTD ($P<0.05$), which may also be mediated by microbiome modulation. The AID of indispensable and dispensable AA was increased ($P<0.05$) in pigs fed PC diets compared to BCVFA-supplemented diet. Moreover, ileal ammonia concentration was reduced ($P<0.05$) in BCVFA-supplemented LP diets compared to NP diets. These results suggest that, while microbial metabolism may be the reason BCVFA-supplemented pigs had improved ileal insoluble fiber ileal digestibility, nitrogen availability/supply may modulate this response. Consistent with this hypothesis, when rumen-degraded protein (**RDP**) was limited in dairy cattle, cellulolytic bacteria abundance was decreased(5). Ileal concentrations of lactate, acetate, and butyrate were greatest in PC and isobutyrate concentration was greatest in BCVFA-supplemented LP-HF diets ($P<0.05$), which could not be clearly associated with the digestibility responses observed and merit further investigation.

Conclusion and implications
Supplementation of BCVFA enhanced insoluble dietary fiber digestibility, particularly at the ileal level, in growing pigs, which may represent an interesting strategy for feeding high fiber, simpler diets to pigs. The absence of BCVFA effect in LP diets could be attributed to a lack of nitrogen availability for cellulolytic bacteria. To the best of our knowledge, this is the first in a series of studies investigating BCVFA supplementation in growing pigs. Future research should focus on the role of intestinal microbiota to validate the digestibility, ammonia and fermentation product responses observed in the current experiment.

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References
(1)Andries, J. I., et al. "Isoacids in ruminant nutrition: Their role in ruminal and intermediary metabolism and possible influences on performances—A review." *Animal Feed Science and Technology* 18.3 (1987): 169-180. (2)Benavides-Infante, A. P. et al. "Dietary isoacids modulate nutrient digestibility and fermentation products in ileal digesta and feces of growing pigs fed corn-soybean meal diets." *Journal of Animal Science,* 102. 2 (2024): 279–280. (3)Lindberg, J. E. "Fiber effects in nutrition and gut health in pigs." *Journal of animal science and biotechnology* 5 (2014): 1-7. (4)Jiang, Fei, et al. "Isoacids supplementation improves growth performance and feed fiber digestibility associated with ruminal bacterial community in yaks." *Frontiers in Microbiology* 14 (2023): 1175880. (5)Firkins, J. L. "Viewing a Role for Isoacids in Dairy Nutrition Through a New Lens." *Cornell Nutrition Conference Proceedings*, 85th Meeting (2023).

O1-3

Continuous monitoring of particle size in pig feed to deliver feed that optimizes stomach health and feed utilization

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Introduction

Controlling feed particle size (FPS) is important due to the impact on feed utilization in pigs. When decreasing FPS gradually the feed utilization will improve (Vukmirović et al. 2017), and thus the climate impact of producing one kg pig meat will decrease. However, when reducing FPS the incidence and severity of stomach ulcers increases (Kiare and Mills 2019), which poses a threat towards pig welfare. The aim of this study is to describe how FPS can be monitored and how data from an automated sieve system developed by Vestjyllands Andel can be used to stabilize FPS in pig diets during feed production.

Material and methods

Determination of feed particle size is typically performed by either dry or wet sieving feed samples in a Retsch sieve shaker (Wolf et al. 2010) which is both time consuming and dependent on correct feed sampling. Vestjyllands Andel have developed a European patented (patent no. 4070049) system "VA Size Matters" for automated feed sampling according to the "Theory of Sampling" principles (Petersen et al. 2005) where samples afterwards are automatically sieved using 3-, 2- and 1-mm screens, respectively. The entire process is performed during feed production and enables control of FPS for each 2,000 kg batch of feed produced at the feed mill and receiving an alarm the corrections of mill settings are applicable with a delay of 3×2,000 kg batches of feed produced. The developed system also includes software for real-time monitoring which includes alarm system and documentation of batch-to-batch variation in feed particle size.

Results and discussion

An example of results from the VA Size Matters is shown in Figure 1. The results are used for adjusting the feed processing to achieve a stable particle size over time, and changes occur mostly due to attrition of the factory mills and changes in dry matter content of grains and dietary protein sources. As each feed delivery is composed of several batches of 2,000 kg, which are all sieved, this allows for rapid adaptation of mills to deliver the planned feed structure in all feed deliveries, and if a 2,000 kg batch is having either too fine or too rough particle size this will be counterbalanced by adjustments in the subsequent batches of feed within the same feed production.

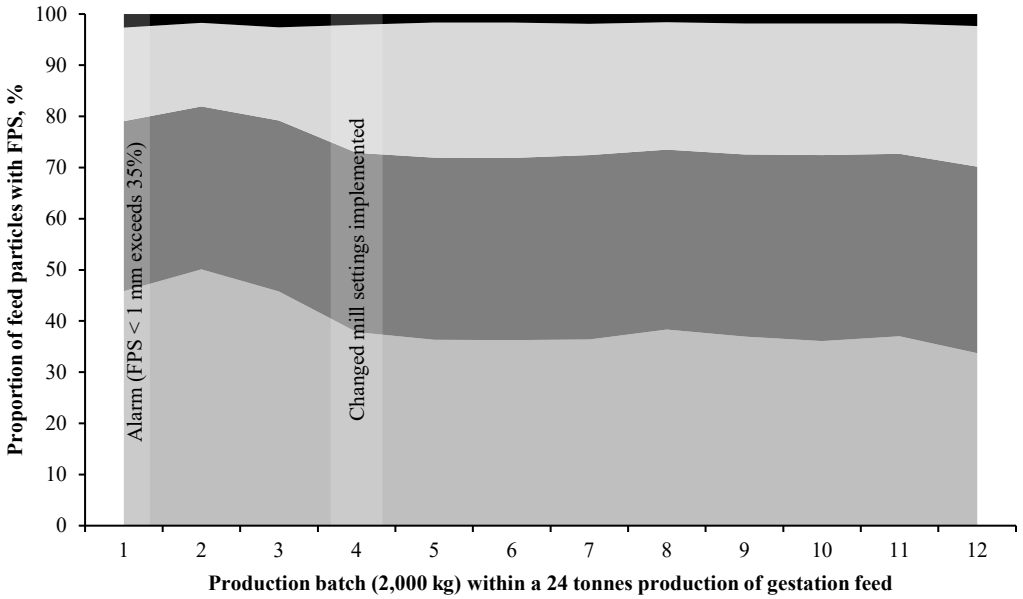

Figure 1. Example of results from continuous sampling of 12 consecutive 2,000 kg batches of gestation feed in a 24 tonnes feed delivery with a planned 35.0% content of feed particles below <1 mm produced at Vestjyllands Andel. The first batch provided an alarm which affected batch 2 and 3 as well, whereas changed mill settings affected from fourth batch and onwards. Overall FPS very close to the target and averaged >3 mm (1.98%; ■), 3-2 mm (23.86; ■), 2-1 mm (35.03; ■) and <1 mm (39.13; ■).

Conclusions and implications

The development of Size Matters for controlling and changing FPS while producing pig feed provides an opportunity for continuously optimizing the pig feed utilization but at the same time to avoid delivery of feed with too fine FPS to the farmers, which could cause an increase the prevalence of stomach ulcers, and thus, negatively affect welfare.

References

Kiarie, E.G.; Mills, A. (2019): Role of Feed Processing on Gut Health and Function in Pigs and Poultry: Conundrum of Optimal Particle Size and Hydrothermal Regimens. *Front. Vet. Sci*., 6:19.
Petersen, L.; Minkkinen, P.; Esbensen, K.H. (2005): Representative sampling for reliable data analysis: Theory of Sampling. *Chemometrics and Intelligent Laboratory Systems*, 77:261-277.
Vukmirović, D.; Čolović, R.; Rakita, S.; Brlek, T.; Đuragić, O.; Solà-Oriol, D. (2017): Importance of feed structure (particle size) and feed form (mash vs. pellets) in pig nutrition – A review. *Anim. Feed Sci. Tech*., 233: 133-144.
Wolf, P; Rust, P; Kamphues, J. (2010): How to assess particle size distribution in diets for pigs? *Livest. Sci*., 133: 78-80.

O1-4

Full title -The use of fast protein from vegetable plasma in low crude protein diets of weaned pigs improves total gain and reduces nitrogen excretion.

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Introduction -The faster a protein can enter the bloodstream, the more opportunity of the protein to be used for growth performance (1). The current study aimed to evaluate whether differences in in-vitro protein digestion speed, protein kinetics, were indicative for growth performance of weaned pigs and if this resulted in a higher nitrogen retention.

Materials & Methods - For this study, in-vitro protein kinetics were measured for 3 protein sources: soybean meal (SBM), a commercial soy protein concentrate (SPC) and enzyme treated soybean meal (ESBM) using the pH-stat method (2). The pH-stat method quantifies progress of protein hydrolysis by the indirect measurement of acid released during hydrolysis. In-vitro digestion speed was highest for ESBM followed by SBM and then SPC (160, 50, and 40 uL/moles, respectively, Figure 1A). Subsequently 4 antibiotic free diets were formulated containing either LOW (17%) or HIGH (20%) levels of CP using SBM and SPC (SLOW) or SBM and ESBM (FAST) combination. The complete diets were also analyzed using the pH-stat method and revealed 45% faster protein hydrolysis for FAST LOW compared to SLOW LOW and 63% faster protein hydrolysis for FAST HIGH compared to SLOW HIGH (Figure 1B). All diets were supplemented with synthetic amino acids to meet the requirements. A total of 256 weaned intact male piglets (YxL; age 28d at 7.3 kg) were allocated based on weight with 16 replicates per treatments in a 28 d 2x2 factorial design study. Data were analyzed by Two-way ANOVA.

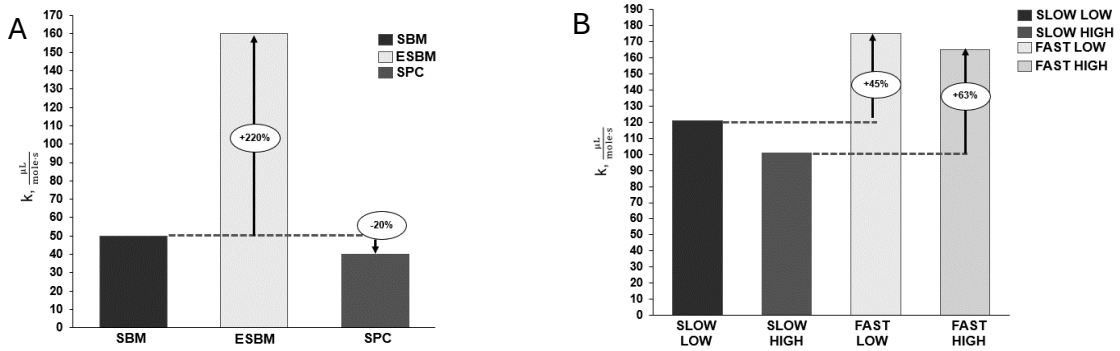

Figure 1: in vitro protein hydrolyzation speed of (A) SBM, ESBM and SPC and (B) of the 4 different diets containing either SLOW (SPC or FAST (ESBM) protein and LOW (16%) or high (19%) CP.

Results and Discussion - There were no interactions found for growth performance so only protein kinetics results will be presented. Feed intake did not differ for FAST or SLOW for D0-14(*P>0.05)*. There was a numerical difference in FCR between FAST and SLOW (1.26 vs 1.30, D0-D14 and 1.31 vs 1.32 for D0-28, respectively; *P>0.05*). Total weight gain (D0-28) was positively influenced by digestion speed with higher gains for FAST 11.1 ± 2.0 kg compared to SLOW 9.8 ± 2.1 kg, respectively *(P<0.05*). D28 BW was higher for pigs fed FAST diets compared to SLOW (18.5 ± 3.0 vs. 17.0 ± 2.6 kg; *P<0.05*).

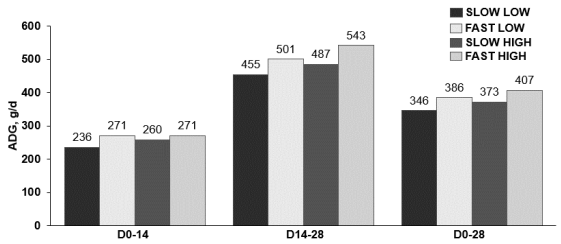

Figure 2. ADG for weaned pigs (D0 = weaning) fed with 1 of the 4 different diets containing either SLOW (SPC or FAST (ESBM) protein and LOW (16%) or high (19%) CP

The results of this study indicate differences in in-vitro protein kinetics are reflected in in-vivo performance of weaned pigs resulting in improved growth in pigs on FAST protein diets. This indicates that faster protein is better utilized than slow protein. Even though no interactions were found on growth performance, it is interesting to point out that numerically FAST LOW outperformed SLOW HIGH with 13 g per day higher ADG over the entire period resulting in more than 300 grams higher BW on day 28 while being on a lower CP diet (Figure 2). This indicates that protein is used more efficiently when coming from a fast protein source like ESBM. This was confirmed by lower nitrogen excretion (in feces) for pigs fed FAST protein. Average nitrogen levels from D14-28 tended to be lower for FAST compared to SLOW (326 vs 343 mg/g DM feces/CP intake, respectively; *P≤0.1*). On D28, FAST-LOW had less mg of nitrogen /g DM feces/CP intake than SLOW-LOW (303 mg vs 390 mg, *P<0.05*, respectively).

Conclusion and implications - The use of protein kinetics in piglet diet allows nutritionists to optimize the protein utilization and reduce (environmental) waste of nitrogen.

References: 1 van den Borne et al., 2007. Animal 1:666-674, 2 Bible, et al. (2023). ASAS CSAS WASAS,

O1-5

Effect of phosphorus and calcium precision feeding on their metabolic status across two gestation cycles in sows

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Introduction
Precision feeding is a way to improve nutrient utilization in swine, and applied to phosphorus (P), it is also a feeding strategy to reduce P excretion. With automatic feeders now used in sows barn, precision feeding can be applied. Research on precision nutrition in gestation sows have been carried out on lysine but, to our knowledge, models for predicting daily P and calcium (Ca) requirements in sows and applied with precision feeding technics have not been tested. The aim of the study was therefore to evaluate the effects of a precision feeding strategy during gestation on the P-Ca status and performance of sows compared with fixed feedings over two gestation cycles.

Material and methods
A total of 120 Yorkshire Landrace sows were followed through two gestation cycles (P1 and P2). Two diets were formulated: one rich in P and Ca (H; 3.2 g digestible P; 8.3 g Ca/kg) and one poor (L; 1.5 g digestible P; 4.6 g Ca/kg) while the other nutrients were similar and at requirement. From these two diets, three dietary treatments were obtained: Canadian (CAN; 100% H feed), European (EU; 59% H feed and 41% L feed), and a precision feeding treatment (PR). For the PR, maintenance and growth conceptus requirements were calculated according to Bikker and Blok (2017), and growth requirements according to Dourmad et al. (2021). In the lactation phase, a single feed was distributed (4.0 g digestible P; 8.1 g Ca/kg). Urinary excretions were collected for 24 h, for a minimum of 6 sows per treatment, at 30 and 90 days after insemination using Foley urinary catheters (size 18; 30 ml balloon; DYND11778, Illinois, USA) according to the method described by Grez-Capdeville and Crenshaw (2021). At 90 days of gestation, urine samples were only taken from CAN and PR sows as the dietary P intakes of the PR and EU treatments were deemed similar at this stage. Urinary Ca and P excretion were calculated. Blood samples were taken from the jugular vein of sows at 30 and 110 days after insemination to determine serum P and Ca. Serum and urine P and Ca concentrations were measured by ICP (soluble ICP, IRDA, Quebec, Canada). Urinary P and Ca excretion and serum P and Ca concentrations were analyzed by a linear model (lm, R, 4.1.2) with treatment, gestation stage and cycle as fixed effects. Tukey test were considered significant when $P < 0.05$ and a tendency was noted when the P was between 0.05 and 0.10.

Results and discussion
Urinary excretion of P was similar between treatments in P1, but varied in P2 ($P < 0.05$). On day 30 of P2, EU excreted more P than CAN and PR (+82%; $P < 0.05$), which could be explained by a lack of Ca in the feed that could have limited bone P deposition. On day 90 of P2, PR excreted more P than CAN ($P < 0.05$), and excretion was higher the lower the sow's weight at mating, leading us to assume that precision feeding is better calibrated for larger sows than smaller ones. Dietary treatments, stage of gestation or cycle did not influence urinary Ca excretion. This result is consistent with a trial by Lee et al. (2020) which concluded that, at a dietary Ca level of between 1.8 g/kg and 7.1 g/kg in late gestation sows, only Ca retention increased with dietary Ca intake, and the amount of urinary Ca was unaffected by dietary Ca intake This indicates that sows retained almost all the Ca they absorbed. Serum Ca and P were not influenced by dietary treatment and gestation cycle. However, serum Ca and P were higher on day 110 of gestation ($P < 0.05$), which could be due to bump feeding at the end of gestation apply in this experiment.

Conclusion and implications
Using precision feeding allowed to reduce P excretion by 13% in comparison to CAN. This study however highlights that Ca:digestible P ratios during the first two-thirds of gestation seems to be too low to maximize P utilization and retention and should be reviewed. Larger-scale monitoring over several cycles seems also necessary to confirm this strategy and promote it on commercial farms.

Acknowledgements
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References
Bikker P., Blok M.C., 2017. Phosphorus and calcium requirements of growing pigs and sows. CVB documentation report n°59., Wageningen Livestock Research, Wageningen, Pays-Bas, 72 p.
Dourmad J. Y., Etienne M., Noblet J., Boudon A., 2021. Contenu corporel en minéraux des truies reproductrices. Journées Rech. Porcine, 53, 203-204.
Grez-Capdeville M., Crenshaw T.D., 2021. Estimation of phosphorus requirements of sows based on 24-h urinary phosphorus excretion during gestation and lactation. Br. J. Nut., 128, 377-388.
Lee, S. A., Lagos, L. V., Bedford, M. R., Stein, H. H., 2020. Increasing calcium from deficient to adequate concentration in diets for gestating sows decreases digestibility of phosphorus and reduces serum concentration of a bone resorption biomarker. Journal of animal science, 98(3), skaa076.

O1-6

Full title: Impact of fucosidase supplementation on gut microbiota composition to reduce enteric methane production and improve growth performance in pigs

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Introduction: Developing feed additives as climate mitigation tools for pigs, is a mean to address an urgent challenge for pig production, which is contributing to high atmospheric methane concentrations through enteric and storage emissions (Nielsen et al., 2023). The major components of the gut mucus of mammals are mucins, heavily O-glycosylated glycoproteins (Hesselager et al., 2016). These host glycans have a major role in determining which bacteria can successfully colonize the host (Høgsgaard et al., 2023). In-feed fucosidase has been suggested to support the growth of beneficial gut bacteria and inhibit methanogens by cleaving fucose from intestinal mucins or feed and releasing it into the gut lumen. This study aimed at investigating supplementation of fucosidase to pig feed as a tool to improve gut health and reduce enteric methane production in pigs by modifying their gut microbiota composition. Consequently, growth performance would be improved, and climate footprint reduced. The study included analysis of gut microbiota profile, quantification of gut methanogens, *in vitro* and *in vivo* production of enteric methane, and growth performance in pigs from weaning to slaughter weight.

Materials and Methods: Four treatment groups were included. A control group (**Control**) received standard starter, grower, and finisher diets. The other three treatment groups (**Fuc2, Fuc7, Fuc16**) were fed the same standard diets supplemented with 100 mg fucosidase per kg feed for 2, 7, and 16 weeks, respectively, starting at weaning; the remaining period, they received the control diets without fucosidase addition. A total of 240 crossbreed piglets (weaning age 22 days) from 80 sows were included. Three littermates per sow were housed in the same pen (20 pens per treatment group). On days 10, 43, and 114 post-weaning, one pig per pen from 12 pens per group was euthanized and samples were collected for analyzing *in vitro* methane production, gut methanogen numbers, microbial metabolite concentration, and microbiota composition. On days 43, 78, and 106, selected pig pairs (10 per treatment group) were placed in respiration chambers for 48h to determine *in vivo* methane emission. Data were analyzed by mixed effects models with increases expected from fucosidase supplementation, examined by one-sided tests. For microbiota profiling, the 16S rRNA gene was amplified targeting the V3-V4 regions. Microbial community composition was assessed using alpha diversity metrics such as Richness and the Shannon index, while microbial community structure was evaluated using the Bray Curtis dissimilarity metric as a measure of beta-diversity. Additionally, differential abundance analysis was conducted using statistical methods that account for the compositional nature of the microbiome data, like LINDA and ANCOM BC.

Results and discussion: When comparing all the groups fed with fucosidase together against the Control, a higher ($p=0.05$) ADFI during the first two weeks was observed in the fucosidase groups. On day 106, the *in vivo* enteric methane emission was lower in all three fucosidase groups compared to the Control ($p<0.05$) when corrected for dry matter intake and tended to be reduced when corrected for body weight ($0.1>p>0.08$). The *in vitro* methane production was similar in the Control and the fucosidase groups ($p> 0.05$). The number of methanogens was not different between the fucosidase groups and the Control ($p> 0.05$). Gut microbial metabolites concentration and microbiota composition will be shown and discussed.

Conclusions: The results suggest in-feed fucosidase provision as a potential strategy for mitigating enteric methane emission in pig production while increasing ADFI during the first two weeks post-weaning.

References:

Hesselager, M. O., Everest-Dass, A. V., Thaysen-Andersen, M., Bendixen, E., & Packer, N. H. (2016). FUT1 genetic variants impact protein glycosylation of porcine intestinal mucosa. *Glycobiology*, *26*(6), 607-622.

Høgsgaard, K., Vidal, N. P., Marietou, A., Fiehn, O. G., Li, Q., Bechtner, J., Catalano, J., Martinez, M. M., & Schwab, C. (2023). Fucose modifies short chain fatty acid and H2S formation through alterations of microbial cross-feeding activities. *FEMS Microbiology Ecology*, *99*(10). https://doi.org/10.1093/femsec/fiad107

Nielsen, O.-K., Plejdrup, M. S., Winther, M., Nielsen, M., Gyldenkærne, S., Mikkelsen, M. H., Albrektsen, R., Thomsen, M., Hjelgaard, K., Fauser, P., Bruun, H. G., Johannsen, V. K., Nord-Larsen, T., Vesterdal, L., Stupak, I., Scott-Bentsen, N., Rasmussen, E., Petersen, S. B., Baunbæk, L., & Hansen, M. G. (2023). *DENMARK'S NATIONAL INVENTORY-REPORT 2023*. https://dce2.au.dk/pub/SR541.pdf

P1-1

Biochar is counteracting negative impact of weaning.

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Introduction

Schmidt et al (2019)[1] reviewed biochar and concluded that "Our review demonstrates that the use of biochar as a feed additive has the potential to improve animal health, feed efficiency and livestock housing climate, to reduce nutrient losses and greenhouse gas emissions, and to increase the soil organic matter content and thus soil fertility when eventually applied to soil." They continued with stating that "A more systematic multi-disciplinary research is definitely needed to arrive at generalizable recommendations."

OBIO (OBIO.no) produce biochar by high temperature pyrolysis based on dead tall and fur harvested from Norwegian clean drift of forest. High pyrolysis temperature[1] (> 600 °C) and low ash-content seems to be important for the efficacy of biochar. The production of biochar from OBIO is based on a fixed raw material supply (dead tall and fur), high pyrolyse temperature (> 650 °C), a low ash-content (~2,7 %) and – additionally - a high carbon content (~92 %). The high carbon content leads to one ton of OBIO biochar will bind 3,1 ton of CO_2.

We decided to try using OBIO biochar mixed in feed at 10 kg/ton and 20 kg/ton for the newly weaned piglets to check the ability to counteract the negative impact of weaning.

Material and Methods

In a farm holding 2200 sows, 3 x 100 piglets was selected from one weaning batch. Piglets was treated metaphylactically with tilmicocin post weaning and with neomycin against E. coli diarrhea. Piglets was divided in 15 pens holding 20 piglets each. Each of 5 pens was treated with 1) biochar 0 kg/ton of feed, 2) biochar 10 kg/ton of feed and 3) biochar 20 kg/ton of feed in the first week of feeding and then followed by 1) biochar 0 kg/ton of feed, 2) biochar 2,5 kg/ton of feed and 3) biochar 2,5 kg/ton of feed for the next 10 days. Piglets was weighed individually at entrance and weighed again 5 weeks post treatment. Average weaning weight was: 1) 6,5 kg, 2) 6,6 kg and 3) 6,4 kg. Statistical analysis was done using a Linear mixed model and compensating for the difference in weaning weight.

Results and discussion

Average daily weight gain was significantly higher in the first 5 weeks post weaning for the 10 kg/ton group. In the group with 20 kg/ton the av. daily gain did not differ from negative control. Mortality was 4, 0 and 0 % respectively in group 1,2 and 3 and the reason for mortality was E. coli diarrhea.

Group	Av. daily gain	p-value	Mortality
1: 0 kg biochar/ton of feed (8 days p.w.) + 0 kg biochar/ton of feed (next 10 days)	**423 g/day [a]**	**-**	**4 %**
2. 10 kg biochar/ton of feed (8 days p.w.) + 2,5 kg biochar/ton of feed (next 10 days)	**466 g/day [b]**	**0,033**	**0 %**
3: 20 kg biochar/ton of feed (8 days p.w.) + 2,5 kg biochar/ton of feed (next 10 days)	**414 g/day [a]**	**NA**	**0 %**

Mortality was not the scope of this investigation and therefore no statistically calculation was done on this. It is however evident that the mortality in both treated groups was 0. Average daily gain was significantly 43 g higher for the first 35 days post weaning in the group that was treated with 10 kg/ton initially. The same was not seen in the group that was treated with 20 kg/ton of feed. The feed intake was marked lower in this group and this might be the reason for the lower growth.

Conclusion and implications

10 kg/ton of biochar in the first weaning diet followed by 2,5 kg/ton in the second diet gave an increased average daily gain of 43 g/piglet/day.

Biochar is produced in several ways and has different qualities. It is evident, that biochar produced with > 650 °C, based on a fixed raw material supply of dead tall and fur has the ability to influence the piglets in a manner where the negative implications of being weaned are counteracted, resulting in a higher average daily gain.

1) Schmidt H-P, Hagemann N, Draper K, Kammann C 2019. The use of biochar in animal feeding. PeerJ 7:e7373 DOI 10.7717/peerj.7373

P1-2

A combination of calcidiol (25-OH-D_3, Hy-D®) and triterpenoids improves grow-finish pig efficiency due to changes in muscle protein synthesis pathways

TOPIC 3: Improved nutrient utilisation in pig feed

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Introduction

Maximising feed efficiency in grow-finish pigs is critical to ensuring sustainable and production efficiency given the volume of feed consumed by grow-finish pigs. Known factors that contribute to grow-finish pig efficiency includes both pre-absorptive factors, such as gut function and digestion and absorption, and post-absorptive factors such as inflammation, oxidative stress, bone health, energy efficiency, and lean growth. The mechanisms behind lean growth have been demonstrated clearly using molecular research, particularly the study of gene expression. There has been a recent focus on pathways such as the mammalian target of rapamycin (mTOR), which is a key regulator of muscle mass (Yoon et al., 2017).

Material and methods

In the current work, gene expression analyses were used to study the mode of action of the combination of calcidiol (25-OH-D_3, Hy-D®) and triterpenoids, which has shown significant growth and efficiency improvements in grower-finisher pigs. Three experimental diets were evaluated for seven weeks; Positive control: 0.7% total Ca, 0.36% total P, vit D_3 at 1500IU/kg feed (PC), negative control: PC diet + 30% reduced Ca and 10% reduced P (NC), and NC diet with 1500IU D_3 in calcidiol form (25-OH-D3, Hy-D®) and triterpenoids (NC+). At 19 weeks of age, 16 animals per treatment were sacrificed and tissue samples were taken from the longissimus dorsi muscle and preserved in RNA later solution. The RNA was extracted, quality control checked, and mRNA sequenced using the Illumina platform with 150 base pair paired-end sequencing and 30M read depth. The sequenced data were aligned to the Sus scrofa reference genome (Sscrofa11.1) using Kallisto. Data were normalised and analysed for differentially expressed genes (DEGs) between treatments using DeSeq2. RNA integrity number and treatment were included in the statistical model. Genes were assigned to biological pathways using Biofractal's customisation of the Reactome pathway database. Changes in pathways due to treatment were related to FCR using Biofractal's machine learning algorithm (regularised regression) for phenotypic association.

Results and discussion

In the PC compared to the NC, there were 71 DEGs using a false discovery rate (FDR) of <0.10. Altered pathways included the inhibition of cellular stress pathways and increased cell turnover in the muscle of PC compared to NC pigs. In the NC+ compared to the NC, there were 155 DEGs (FDR <0.10). The most significantly upregulated gene in the NC+ treatment was adenylate cyclase (FDR <0.001), an upstream regulator of pathways related to energy metabolism and muscle protein synthesis. This mechanism was confirmed in pathway activation, which found that the NC+ treatment activated PKA-mediated phosphorylation of CREB, a pathway that promotes metabolic adaptation and inhibits muscle atrophy. The NC+ treatment also activated several pathways related to muscle growth, including the mammalian target of rapamycin complex 1 (mTORC1). Phenotypic association predicted that changes in energy metabolism and the activation of PKA-mediated phosphorylation of CREB due to the NC+ treatment were the key drivers of reduced FCR in finishing pigs.

Conclusion and implications

Activation of the PKA (protein kinase A)-mediated phosphorylation of CREB pathway in the muscle of pigs was a central effect of calcidiol (25-OH-D_3, HyD®) and triterpenoid (NC+) supplementation. This pathway is known to reduce muscle protein breakdown and promote muscle growth via metabolic adaptation (Berdeaux and Hutchins, 2019). It is possible that the changes in energy metabolism linked to reduced FCR in NC+ supplemented pigs are due to PKA/CREB activation, thereby improving energy efficiency and driving reduced FCR.

References

Berdeaux R, Hutchins C. Anabolic and Pro-metabolic Functions of CREB-CRTC in Skeletal Muscle: Advantages and Obstacles for Type 2 Diabetes and Cancer Cachexia. Front Endocrinol (Lausanne). 2019 Aug 2;10:535. doi: 10.3389/fendo.2019.00535. PMID: 31428057; PMCID: PMC6688074.

Yoon MS. mTOR as a Key Regulator in Maintaining Skeletal Muscle Mass. Front Physiol. 2017 Oct 17;8:788. doi: 10.3389/fphys.2017.00788. PMID: 29089899; PMCID: PMC5650960.

P1-3

TOPIC 3: IMPROVED NUTRIENT UTILISATION IN PIG FEED (Nutrient use efficiency)

A new precise and dynamic fiber and net energy evaluation of raw materials for optimum fattening swine sustainable efficiency

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Introduction

Dietary fibre (so called non-starch polysaccharides, NSP), usually defined as the indigestible fraction of feed derived from plants, forms a key component of many pig diets. Although not fully digested, dietary fibre can affect a wide range of physiological processes. A variety of fibrous feedstuffs are routinely added to pig diets, usually depending on local availability of low-cost fibre-rich ingredients which are often by-products. However, fibre content can also be variable both in the quality and quantity in more standard raw material like wheat, barley, and corn. A more precise and dynamic evaluation of fibre in pig diets will allow an optimal use of exogenous carbohydrase, a precise value of energy which can be extracted from each fibrous raw materials, and finally a more sustainable feed.

Material and methods

Around 400 samples of different raw materials including wheat, corn, barley, wheat bran, oats, rye, corn germ, and sorghum were collected to develop global near infrared reflectance (NIR) calibration curves for each raw materials. Chemical analysis was performed for NSP, including details on solubility and individual constituent sugars, as well as separate determinations for cellulose and lignin.
The same samples were scanned (400 to 2500 nm, every 0.5 nm) by two NIRS machines: a Foss model DS2500 and a Bruker Tango FT-NIR (Fourier transform near-infrared spectroscopy). The correlation between the NIRS and reference data for total and insoluble NSP and the main component sugars (arabinose, xylose, and glucose) were robust (R2 = >0.97) with a 1-VR > 0.96 and RPD values > 5.3. In order to evaluate the net energy value for each raw material, based on the fibre content and the digestibility of NSP, we applied the equation based on the Dutch CVB system (2015 - 2021): NE2015 (kJ/kg product or g/kg DM) = 11.70*DCP + 35.74*DCFATh + 14.14*(STAam-e + 0.90*SUG-e) + 9.74*FCH.

Results and discussion

We characterize each raw material for their fibre content and compared the actual fixed effect of exogenous carbohydrases (average level of net energy that is extracted from the average level of fibre in one raw material), with the recalculated dynamic value obtained with accurate evaluation of fibre content.
Depending on the amount of fibre, we were able to calculate different levels of net energy for each raw materials, and to apply a dynamic digestibility improvement factor (Dynamic D.I.F), instead of applying a fixed digestibility improvement value. Figure 1 shows the variability of wheat fibre content, and figure 2 shows the variability of net energy (kcal/kg) of wheat during years.

Figure 1: Content of arabinose and xylose (%) of

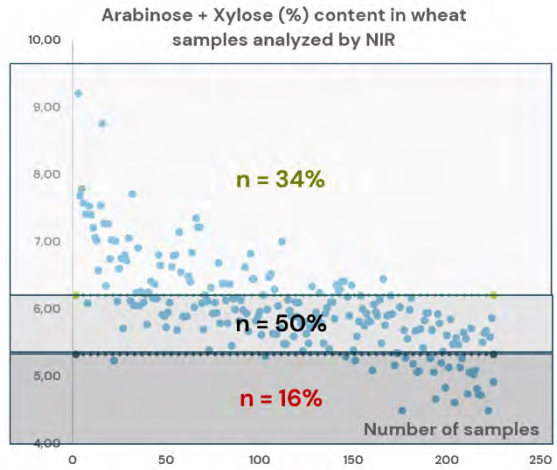
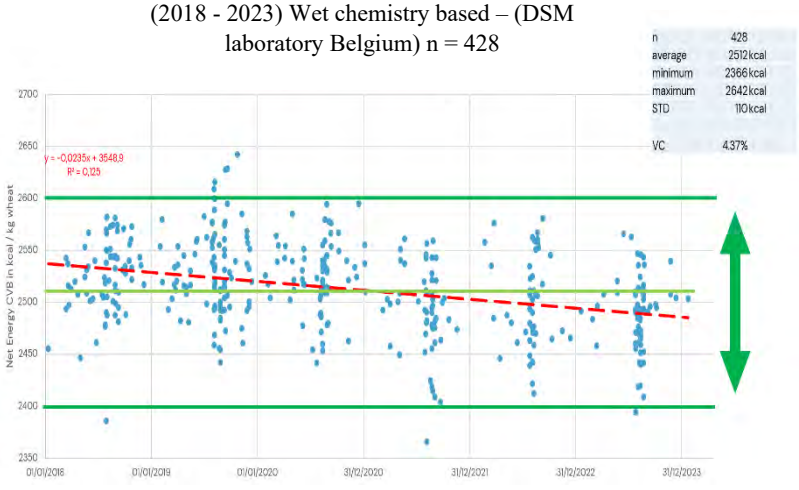


Figure 2: Wheat net energy calculation - wheat (2018 - 2023) Wet chemistry based – (DSM laboratory Belgium) n = 428



Conclusion and implications: The nutrient composition of cereals and byproducts is not as consistent as originally thought, and their fiber content in particular can be highly variable. This opens up the opportunity to extract a higher degree of energy through the use of an adapted strategy for exogenous carbohydrases. With rapid NIR evaluation, fibre quality and content can be easily evaluated in standard raw materials in a routine way. This evaluation allows for the application of a dynamic digestibility improvement factor for net energy when using a tailored carbohydrase enzymes strategy instead of assuming a standard fixed value for all raw materials regardless of their fibre composition and potentially underestimating the net energy uplift from your chosen carbohydrase strategy. This new precision feeding approach allows for better optimal use of fibre, exogenous carbohydrases and helps to optimize feed cost while decreasing wastage and animal performance variation.

Belen Nieto-Ortega *et al*., Animal Feed Science and Technology:285 (2022) 115214
Hao Li *et al*., Animal Nutrition:7 (2021) 259e267
Louis Paternostre *et al*., Animal Feed Science and Technology:281 (2021) 115091

P1-4

Combined approach of reduced NE content and supplementation of a β-mannanase enzyme to diets under field conditions retains post-weaning piglet performance

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Background and objectives - β-Mannans - strongly anti-nutritive polysaccharide fibers - are found in many vegetable feed ingredients. *In vitro* studies have demonstrated that as little as 0.05% of soluble β-mannan content in feed can elicit a strong innate immune response. In common commercial swine diets, the content of soluble β-mannans is much higher and estimated to range between 0.15 to 0.40%. Hemicell HT (Elanco Animal Health) is a β-mannanase enzyme to supplement animal feed which breaks down β-mannans. Hemicell HT minimizes production and economic losses caused by the wasteful feed-induced immune response (FIIR) elicited by β-mannans. This field study compared piglet performance on a control diet to a reformulated diet with lower energy content – 45 kcal/kg net energy (NE) reduction – including a β-mannanase enzyme under field conditions.

Materials and methods - A seven-week feeding trial was conducted on a commercial post-weaning facility with TN70 x Tempo piglets (n = 264; 9 pigs / pen; 15 replicates per group) weaned at 24 days of age. Standard three-phase control diets (phase 1, 0-10d; phase 2, 11-28d; and phase 3, 29-48d) were compared to reformulated diets with an energy reduction of 45 kcal NE/kg and inclusion of a β-mannanase enzyme (Hemicell HT™; Elanco) at 300 g/tonne. Standard production data (ADWG, FCR, mortality) were collected. The data were analyzed using JMP 15.0 statistical program.

Results - Overall, performance data did not differ significantly ($P > 0.05$) between treatment groups during the post-weaning period. Mortality was numerically higher in the Control group (3.79%) as compared to the Enzyme-treated group (0.76%). Piglets fed with the adapted feed formulation had a numerically lower overall feed cost (€ 17.51/piglets *vs.* € 17.04/piglets in the Control group). Hemicell HT had an overall benefit of € 0.47 per piglet and € 8.05 per tonne of feed due to the NE reduction.

Discussion and conclusions - The current trial demonstrated that the inclusion of Hemicell HT in reformulated diets with a lower energy content (45 kcal NE/kg of feed) was able to maintain production performance in post-weaned piglets with an economic benefit. The inclusion of Hemicell HT had an overall benefit of € 2.02 per piglet and € 8.05 per tonne of feed due to the 45 kcal/kg NE reduction.

P1-5

Development of a computer vision model to measure feces score on newly weaned pigs

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Keywords: Monitoring feces score, Artificial Intelligence, post weaning diarrhea,

Introduction

Sustainable pig production implies efficient feed utilization, low mortality, minimum use of antibiotics and animal welfare. An issue that compromises all these factors is the high prevalence of post weaning diarrhea. Consequently, it is highly desirable to develop feeding strategies or feed ingredients that reduces the incidence of post weaning diarrhea in pigs. At our test station Skjoldborg we make feeding trials aiming to study the effect of various feed ingredients on pig performance including feces score. Feces score was previously measured by a selected person among the staff at the test station, going through the test stables daily and performing a visual assessment of the slatted part of the floor in each pen. A method based on visual assessment is obviously very person-dependent, but a person will also assess differently from day to day depending on mood, time, etc. In addition, it is time-consuming and sensitive to staff turnover, weekends, and holiday periods, etc. The aim of this study was to develop a computer vision model designed to measure feces score from pictures of the slatted part of the floor in the weaner section.

Materials and Methods

Pictures were taken of the slatted part of the floor in the test rooms. All pictures were taken in the period from weaning (at day 26) until 14 days after weaning.

A pre-trained Yolo V8 model, that relies on a convolutional neural network, was trained to find, and classify feces based on 3 scores: 1,2 and 4, indicating the texture of the feces. Location and score of feces were annotated on 219 images. Of these, 24 images were used as test sets while 39 were used as a validation set.

To avoid problems with Small Object Detection, all images were split into 512x512 size sub-images, and the algorithm was trained on these sub-images. We used the Recall and Precision measures, which should be interpreted as follows: (1) Recall indicates what percentage of annotated boxes conform to at least one predicted box and (2) Precision specifies the percentage of predicted boxes that conform to at least one annotated box. Two boxes conform to one another if their overlap is at least 50% of both boxes.

Results and discussion

A computer vision model that translates pictures of feces at the slatted part of the floor was developed. The model is person-independent, quick, and precise and the only tools required are a camera and a computer. The images are run through the program written in Python and the data are automatically transferred to an Excel sheet. The developed model had a precision of 65% and a recall of 68%.

The average feces score of all the predicted feces in an image, had an average error of 0.24, when it was tested against the test kit. One can debate whether it is possible to develop a computer vision model that is many times better, since the image itself is only an estimate of reality. To improve the model, one can create an annotated training set with less variance by including multiple ratings, possibly by different experts. The model shows an acceptable performance in photos taken with another camera of lower resolution, but its performance should be improved by including images from a range of different cameras in the training set.

Conclusion and Implications

A computer vision model that can estimate the average feces score on a scale of 1, 2 and 4 was developed. Currently, the model is usable on the test farm where it was developed, however it is anticipated that it can be further developed to be usable in any weaner section. Consequently, the long-term perspectives are numerous and may include precision feeding aiming to reduce post weaning diarrhea in pigs without use of antibiotics. Being able to reduce post weaning diarrhea by precision feeding rather than use of antibiotics is a sustainable way to produce pigs, which would imply e.g. better feed utilization and improved animal welfare.

Acknowledgements

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P1-6

Full title

DL- and OH-Met significantly reduce impact of climate change and increase the economic value of piglets in a European context, with a low climate change impact of its production compared to its benefits at farm gate

Key-words: methionine, climate change, sustainability, carbon, feed cost

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Introduction

According to the report of FAO (2023), pig accounts for 14% of climate change emissions due to livestock, with a production expected to increase leading to higher emissions over time. Therefore, it is important to increase sustainability of swine production, starting for instance at post-weaning stage. This stage is a critical period for the subsequent performance of the pigs (Collins et al., 2017), the latter being in relation to climate change emissions. One way to ensure the performance of piglets, is by providing them with all the required nutrients. Among these nutrients is the essential amino acid methionine. It is important that we provide methionine at the correct amount, for which we typically use supplemental free methionine. There are two main forms of methionine in the market, DL-methionine (**DL-Met**) and hydroxy-methionine (**OH-Met**). The objective was to calculate the environmental (climate change) and economic effects of DL-Met and OH-Met supplementation in piglets' diets and growth performance.

Material and methods

Ninety post-weaning piglets (28 days; 9.13 ± 0.65 kg) were distributed to 3 dietary treatments. One of the treatments was formulated as the negative control (**NC**) with no methionine supplementation and deficient (80%) in total sulfur amino acids (**TSAA**). For the other two treatments, methionine was supplemented as either DL-Met or OH-Met to provide TSAA at requirement (NRC, 2012). The experiment was run for 41 days. Treatments were replicated nine times, and blocking was done according to initial weight. Performance parameters were measured, economic gain, and climate change were calculated. Data were analysed using a mixed effect model with treatment as the fixed effect and block as a random effect. Climate change emissions were evaluated using Life Cycle Assessment (**LCA**) methodology according to Product Environmental Footprint Category Rules (**PEFCR**) with kg CO_2-eq/kg of body weight gain (**BWG**) of piglets (at farm gate) as functional unit. The database used for the climate change calculation of feed was GFLI Global database EF 3.1 Economics allocation 2.0 October 2022, including land use change. The perimeter of study is not including processing, transport of feed ingredients (from processing plant or storage to feedmill) and transport of complete feed, rearing conditions, breeders, manure, and gas emissions of animals. The LCA of OH-Met and DL-Met products at plant gate was performed following ISO 14040/14044 and PEFCR guidance v6.3, with FAO LEAP guidelines for feed additives and PEFCR for animal feed, Methodology EF 3.0 (adapted) V1.03 and SimaPro software for LCA modelling. Feed cost was calculated with an average French price list from April 2024.

Results and discussion

Comparing NC and DL- and OH-Met-supplemented diets, the climate change (kg CO_2-eq) per kg of BWG of piglets was decreased by -8% and -15% respectively (1.61 for DL-Met and 1.48 for OH-Met vs 1.75 kg CO_2-eq/kg BWG of piglets (NC), $P < 0.01$). The decrease in climate change impact is explained in this trial by significant improvement in the weight gain of piglets ($P < 0.01$). Moreover, climate change of all experimental diets was roughly similar, as there was only a marginal difference in the used raw materials and inclusion rates, except the inclusion of OH- and DL-Met (pre-starter: $1.4x10^3$, starter: $8.3x10^3$ kg CO_2-eq/t feed). Besides, the climate change of ingested DL- and OH-Met represents less than 0.5% of total ingested feed climate change. In addition, total ingested feed cost per kg of BWG (in €/kg BWG) was significantly decreased by -7% and -14% respectively for DL-Met and OH-Met (0.51€/kg BWG and 0.47€/kg BWG vs 0.55€/kg BWG for NC; $P < 0.01$).

Conclusion and implications

Proper dietary supplementation of Met allows a significant reduction in feed cost per kg of BWG of piglets in this European context. Furthermore, it permits a significant reduction in climate change per kg of BWG of live piglets compared to unsupplemented diets. It can also be noted that climate change benefits of DL- and OH-Met supplementation are much higher than their climate change impact at plant gate, corresponding to less than 0.5% of total climate change of ingested feed, for -8% and -15% climate change emissions, respectively. Other parameters not included in the study should be evaluated in future research, including manure emissions.

References

Collins, C. L., Pluske, J. R., Morrison, R. S., McDonald, T. N., Smits, R. J., Henman, D. J., Stensland, I., & Dunshea, F. R. 2017. Post-weaning and whole-of-life performance of pigs is determined by live weight at weaning and the complexity of the diet fed after weaning. Animal Nutrition, 3(4), 372-379.

FAO. 2023. Pathways towards lower emissions – A global assessment of the greenhouse gas emissions and mitigation options from livestock agrifood systems. Rome. https://doi.org/10.4060/cc9029en

NRC. 2012. Nutrient Requirements of Swine. National Academies Press, Washington, D.C.

P1-7

Effect of maternal pure organic selenium supplementation during pregnancy and lactation on sow reproductive performance and their progeny in hot climatic conditions

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Keywords: Sow, piglet, performance; hydroxy-selenomethionine; oxidative stress and

Introduction

Selenium (Se) supplements exists in inorganic forms, such as sodium selenite (SS), and in organic forms, such as seleno-yeasts (SY) or pure forms of selenomethionine (SeMet or OH-SeMet). The bio-efficacy of organic Se sources has been attributed to their SeMet proportion since it is the Se species that can increase the transfer of Se in tissues and milk and, therefore, maintain effective antioxidant defenses and enhance sows and their progeny performances, particularly under challenging conditions [1]. SY often shows a lower and variable bio-efficacy than pure SeMet, due to the variable content of SeMet in SY products [2]. The study aimed to demonstrate the benefit of maternal OH-SeMet compared to SY and SS supplementation on the performance, Se status and antioxidant capacity of sows and their offspring in hot climatic conditions.

Material and methods

A total of 60 at the same parity (Landrace ×Yorkshire) with similar body weight were randomly allocated to three groups (n=20 /group): basal diet (BD; with Se ≤ 0.1 mg/kg) + 0.3 mg Se/kg as SS, BD + 0.3 mg Se/kg as SY or BD + 0.3 mg Se/kg as OH-SeMet. The feeding trial was carried out from gestation to weaning on postpartum day 21. The experiment was performed in an experimental commercial farm during summer environmental conditions (THI > 75 throughout almost the entire experimental period). Blood samples were taken from all the sows at day 114 of gestation and day 14 of lactation and from 20 piglets from each group at 14 and 21 days for Se and redox biomarkers analysis. Colostrum was collected after 12 h of the birth and milk at day 14 of lactation for Se analysis. All data were analyzed using One-way ANOVA with a significant deference set at p-value <0.05 (version 17.0.0, JMP Statistical Discovery LLC).

Results and discussion

Sow performances, including gestation and lactation body weight and backfat thickness during gestation and lactation, were similar in both groups (P> 0.05). Compared to SS and (or) SY, OH-SeMet maintains more effectively (p <*0.05*) the offspring growth performance as shown by the increased of number of alive piglets at birth and at 21d and litter body weight gain during 1-21d (Table 1). OH-SeMet also decreased the diarrhea rate significantly in comparison to SY (p <*0.05*). Both SY and OH-SeMet (0.18 mg/L) significantly increased Se concentration in sow's serum at day 107 of gestation compared to SS (0.16 mg/L). However, only OH-SeMet significantly elevated Se levels in the milk of sows (0.12 mg/L) compared to SS (0.09 mg/L), as well as in the skeletal muscle of their offspring (0.144 mg/L for OH-SeMet, 0.110 mg/L for SS, with SY showing an intermediate level of 0.133 mg/L). Furthermore, OH-SeMet was more effective in supporting endogenous redox systems. This was evidenced by the increased levels of Thioredoxin reductase at day 107 of gestation (3.59 U/mL for OH-SeMet, compared to 2.14 U/mL for SS, with SY at an intermediate level 2.37 U/mL). Additionally, there was a decrease in protein carbonyl in the serum of sows and a reduction in MDA levels in the serum of piglets at day 21 (4.69 nmol/mL for OH-SeMet vs 5.99 nmol/mL for SS, with SY at an intermediate value 5.18 nmol/mL).

Table 1: Effect of maternal Se source on sow's reproduction performances and nursing piglets' (average ± SEM).

	SS	SY	OH-SeMet	P value
Piglets born alive, n	11.9 ± 0.7	11.1 ± 0.6	12.7 ± 0.5	0.1595
Diarrhea rate day 0–21,%	4.56**ab** ± 0.7	5.18**a** ± 0.7	3.34**b** ± 0.5	**0.0253**
Piglets weaned at day 21, n	10.5 ± 0.5	10.2 ± 0.4	11.5 ± 0.3	0.0849
Litter weight at day 21,kg	64.1**b** ± 3.3	62.2**b** ± 3.5	77.6**a** ± 3.4	**0.0035**
Body weight/piglet during day 1-21,kg	4.63 ± 0.2	4.65 ± 0.3	5.29 ± 0.2	0.0886
Litter Body weight gain during day 1-21,kg	46.1**b** ± 2.8	45.5**b** ± 3.4	59.5**a** ± 3	**0.0023**

Conclusion and implications

Maternal supplementation of OH-SeMet during pregnancy and lactation of sows raised under hot summer conditions improved sows' reproduction performance and the growth performance of their progenitors. This finding may highlight the important role of Se status in preventing negative consequences of oxidative stress during gestation and at birth.

References

1. F. Surai, P., I. Kochish, I., I. Fisinin, V., A.Velichko, O., 2018. Selenium in Poultry Nutrition: From Sodium Selenite to Organic Selenium Sources. The Journal of Poultry Science advpub. https://doi.org/10.2141/jpsa.0170132.

2. De-Marco, M., Conjat, A.-S., Briens, M., Hachemi, M.A., Geraert, P.-A., 2021. Bio-efficacy of organic selenium compounds in broiler chickens. Italian Journal of Animal Science 20, 514–525. https://doi.org/10.1080/1828051X.2021.1894994.

P1-8

Effects of pig allocation strategy and diet composition on growth performance of growing-finishing pigs

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Keywords: pigs, precision feeding, animal allocation strategy, N-efficiency

Introduction
To increase nutrient and N-efficiency in pigs, refined feeding strategies should be developed and implemented. The aim of the present experiment was to evaluate the effects of: 1. animal allocation strategy at pen level (birth weight (BW) and 2. breeding value (BV) for average daily gain (ADG)), and 3. application of a 3-phase feeding system or a precision feeding system for SID Lys on a weekly basis (dynamic) on the growth performance and N-efficiency in growing-finishing pigs (25-125 kg body weight).

Material and methods
The trial was conducted at the Swine Nutrition Center (SNC) De Elsenpas of De Heus with 384 growing-finishing (GF) gilts (PIC Duroc boar x TN 70 sow) in a 2 x 2 x 2 factorial experiment with 8 pens (with 6 animals each) per treatment. Pigs were fed a fixed diet per phase (4 weeks) or provided a different diet per week with an adjusted concentration of SID Lys by mixing a low and high SID Lys diet to match the assumed requirement for SID Lys using a factorial algorithm to predict the SID Lys requirement over a period of a week, based on the forecasted FI and ADG of animals per pen in a next week.

Results and discussion
The performance of the pigs from the start till delivery to the slaughterhouse is presented in Table 1. BW at the start ($P<0.01$) and at delivery ($P<0.001$), ADG ($P<0.001$) and ADFI ($P<0.01$) were higher in HBW than in LBW animals. Feed conversion ratio was not affected by BW. Pigs with a high BV for ADG were heavier upon delivery and had a higher ADG ($P<0.001$), and ADFI ($P<0.01$) than pigs with a low BV for ADG. Feed conversion ratio did not differ in animals with a low or high BV for ADG. Dynamic fed pigs tended ($P=0.09$) to have a higher BW at delivery compared to phase fed animals. However, ADG, ADFI and FCR did not differ between 3-phase or dynamic fed pigs. Nitrogen efficiency was improved by precision feeding compared to 3-phase feeding ($P<0.01$).

Table 1 Growth performance from the start till delivery to the slaughter house of growing-finishing pigs (gilts) with a low or high birth weight (BW) and a low or high breeding value (BV) for average daily gain, with a feeding regime based on a standard three phase feeding or on dynamic feeding for SID Lys on a weekly basis.

	Birth weight		Breeding value		Feeding regime		SEM[1]	P-value		
	Low	High	Low	High	Phase	Dynamic		BiW	BV	FeR
BW start (kg)	24.8^{a}	27.5^{b}	25.4	26.8	25.3	26.9	0.70	0.007	0.14	0.11
BW delivery (kg)	120.6^{a}	128.5^{b}	121.4^{a}	127.6^{b}	123.0^{x}	125.8^{y}	1.18	<0.001	<0.001	0.095
Age at delivery (d)	147.1	146.8	146.8^{a}	147.2^{b}	146.9	147.2	0.13	0.12	0.03	0.37
ADG (g/d)[2]	1127^{a}	1188^{b}	1129^{a}	1185^{b}	1150	1164	8.0	<0.001	<0.001	0.20
ADFI (kg/d)	2.66^{a}	2.78^{b}	2.65^{a}	2.79^{b}	2.69	2.75	0.033	0.01	0.005	0.20
FCR	2.36	2.34	2.35	2.35	2.34	2.36	0.017	0.30	0.95	0.37
N-efficiency (%)	50.3	50.6	50.4	50.5	49.9^{a}	51.0^{b}	0.29	0.58	0.96	0.007

[1] *S*EM = standard error of the mean; [2] There was a BV x FeR interaction: ADG was 1110 and 1189 g/d in LBV and HBV of phase fed pigs, respectively, and 1146 and 1182 g/d in LBV and HBV of dynamic fed pigs, respectively; Values with a different superscript within a treatment comparison differ at $P < 0.05$ (ab) or $P < 0.10$ (xy).

Conclusion and implications
Pigs with a high birth weight and high BV for ADG have a higher growth performance than pigs with a low BW and low BV for ADG. The former suggests that BW and the BV for growth performance (ADG) affect absolute body protein (N-) retention but is not related to changes in N-efficiency in pigs. Feeding pigs according to a 3-phase system or to a weekly precision feeding system based on supply of SID Lys at pen level, does not affect growth performance, but slightly increases the efficiency of utilization of nitrogen. Further refining the algorithms for forecasting feed intake and body weight gain of pigs at pen level could help to further improve precision feeding systems and increase N-efficiency.

Acknowledgements
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Expanding the incorporation of spray-dried porcine plasma in phase 2 nursery diets further improved the growth and nutrient use efficiency of weaned pigs

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Key words: spray dried plasma, nursery diets, performance, efficiency

Introduction

In the European Union, the prohibition of antibiotic growth promoters and the recent restriction on pharmaceutical levels of zinc oxide have led to diminished performance and nutrient use efficiency and increased incidence of diarrhea of pigs during the post-weaning (p-w) period (Eriksen et al., 2021). Introducing spray-dried porcine plasma (SDPP) into p-w diets has been identified as a potential strategy to modulate overall health and enhance performance and nutrient use efficiency in pigs (Balan et al., 2021). European swine producers have already adopted the inclusion of SDPP in phase 1 p-w diets to improve the performance and health of weaned piglets. However, pharmaceutical-grade zinc oxide was commonly employed in phase 1 and phase 2 post-weaning diets due to its extended protective effects on piglets. Consequently, this study aimed to investigate the effects of expanding the incorporation of SDPP into phase 2 p-w diets on the growth and nutrient use efficiency of pigs.

Materials and Methods

Ninety-six newly weaned piglets ([Large White x Landrace] x Pietrain; mixed sexes) of around 26 days of age (7.33 ± 0.02 kg BW), from IRTA's experimental sow herd at Mas Bové site (Spain) were allotted to 3 treatments (8 pens/treatment; 4 pigs/pen). Treatments represented the inclusion of different SDPP levels used in 2 nursery feed phases (pre-starter I , d0-14 p-w and starter I, d15-28 p-w). Treatments by respective nursery phases and level of SDPP in the diet were: T1) Control without SDPP; T2) 5, and 0% SDPP; T3) 5 and 2%. (Table 1). SDPP replace soy protein concentrate (SPC) in control diet. Performance data and diarrhea score was recorded per phase. Statistical analysis using the covariance of initial BW was done considering the effects of block.

Table 1. Composition of experimental diets

Ingredients (%)	**Phase 1 (0-14 d)**		**Phase 2 (14-28 d)**	
	T1	**T2, T3**	**T1, T2**	**T3**
Barley	30.71	33.64	37.79	38.94
Maize	20.00	20.00	20.00	20.00
Wheat				
SBM (48%)	22.58	22.24	25.95	25.84
Sweet milk whey	6.50	6.50	3.00	3.00
SPC	6.67		2.67	
SDPP (Appetein)		5.00		2.00
Dextrose	6.50	6.50	3.00	3.00
Animal fat	3.63	3.20	3.96	3.80
L-Lys-HCl	0.35	0.23	0.39	0.34
L-Thr	0.17	0.08	0.18	0.14
DL-Met	0.19	0.13	0.18	0.15
L-Tryp	0.04	0.01	0.04	0.03
L-Val			0.01	
Salt	0.52	0.25	0.58	0.47
Calcium carbonate	0.03		0.01	
Dicalcium phosphate	1.68	1.80	1.82	1.87
Noxyfeed	0.02	0.02	0.02	0.02
Vit-Min complex	0.40	0.40	0.40	0.40
Nutrient composition				
Crude Protein (%)	20.5	20.5	20.0	20.0
Energy (kcal ME/kg)	3300	3300	3280	3280
SID Lys (g/kg)	12.8	12.8	12.5	12.5
SID Thr (g/kg)	8.31	8.31	8.11	8.11
SID Met (g/kg)	4.61	3.83	4.44	4.11
SID Met+Cys (g/kg)	7.54	7.60	7.36	7.36
SID Trp (g/kg)	2.56	2.56	2.50	2.50
SID Ile (g/kg)	7.81	7.54	7.46	7.36
SID Val (g/kg)	8.69	9.47	8.48	8.68

Results and Discussion

Table 2. Performance of nursery pigs fed different amounts of SDPP.

	Control	SDPP Phase1	SDPP Phase 1+2	*P-value*
Phase 1 (0-14d)				
BW (kg)	7.33	7.33	7.34	0.671
ADG (g)	123	155	158	0.120
ADFI (g)	190	221	224	0.218
G:F	0.64	0.69	0.71	0.299
Phase 2 (14-28d)				
BW (kg)	9.05	9.50	9.55	0.113
ADG (g)	**369[a]**	**376[a]**	**417[b]**	**0.014**
ADFI (g)	**526[a]**	**521[a]**	**576[b]**	**0.044**
G:F	0.71	0.72	0.73	0.506
Global (0-28d)				
BW (kg)	**14.22[a]**	**14.77[ab]**	**15.39[b]**	**0.021**
ADG (g)	**246[a]**	**266[ab]**	**287[b]**	**0.024**
ADFI (g)	358	371	400	0.128
G:F	0.69	0.72	0.72	**0.085**

Pigs fed SDPP in phase 2 had increased ($P < 0.05$) ADG and ADFI during this period compared with control or feeding SDPP in just phase 1 (Table 2). For the whole period (0-28d) BW and ADG of pigs fed SDPP in phase 1+2 diets was improved compared to control treatment ($P = 0.024$) while pigs fed SDPP in phase 1 were intermediate. Gain to feed tended to improve when SDPP were included in both phase 1 diet alone and phase 1+2 diets. At the end of study, pigs fed SDPP were 0.55 kg and 1.17 heavier compared to control diet for phase 1 and 1+2 respectively. No differences in fecal scores due to treatment were observed.

Conclusion

The potential modulation of immunity and health from feeding SDPP during the nursery period may be associated with the better growth and nutrient use efficiency. Our results agree with others that reported pigs fed SDPP during the nursery phase had improved growth rate, nutrient utilization, and survival and can be an alternative to pharmaceutical levels of zinc oxide (Torrallardona, 2010).

References

P1-9

1. Eriksen et al., 2021. Porcine Health Manag. 9;7(1):54.
2. Balan et al., 2021. J. Anim. Phys. Anim. Nutr. 105, 699-714.
3. Torrallardona, 2010. Asian-Aust. J. Anim. Sci. 23(1), 131-148.

P1-10

Exploring higher doses of xylanase and β-glucanase as dietary strategy for enhancing nutrient digestibility in fattening pigs

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Key words. NSP-enzymes, carbohydrase, digestibility, swine

Introduction. Non-starch polysaccharides (NSP) can have a detrimental effect on digestibility in monogastric animals by increasing digesta viscosity and acting as a physical barrier in the plant cell wall, limiting the access of digestive enzymes to nutrients. However, NSP-degrading enzymes, such as xylanase and β-glucanase, offer a promising intervention that can help counteract the deleterious impact of NSP on nutrient utilization. Despite the importance of understanding dose effects of microbial xylanase and β-glucanase, there has been a lack of comprehensive research in this area. While some studies have hinted at the potential benefits of higher xylanase doses in enhancing arabinoxylans degradation, it is worth noting that dose response seems to depend on the specific type of xylanase employed (Bautil et al., 2021). This study aimed to evaluate the impact of two doses of a xylanase + β-glucanase preparation on digestibility in fattening pigs fed wheat-based diets.

Material and Methods. The study was conducted as a cross-over design in three separate and consecutive runs, each with six castrated pigs of 40 kg body weight (BW). Pigs were assigned to one of three treatments in each run according to their BW, resulting in two replicates per run and six replicates per treatment. Pigs were housed in single metabolic crates and given an adaptation period of three days, followed by a collection period of five days, during which feces and urine were collected (total collection). Animals were kept according to German animal welfare regulations. The study was conducted for 24 days (three runs of eight days each). The basal diet was formulated according to GfE to meet the maintenance requirements for pigs, pelleted at 70°C and contained phytase at 500 FTU/kg. Pigs were fed a wheat-corn-soy-based diet containing either 0, 100 or 200 ppm of an endo-1,4-β-xylanase (5600 TXU/g) + endo-1,4-β-glucanase (2500 TGU/g) preparation (BASF SE, Germany). Feed, fecal and urine samples were analyzed for gross energy and nitrogen content to calculate digestibility coefficients. Data were subjected to One-way ANOVA and statistical differences were considered significant at $P<0.05$. Mean separation was adjusted by Tukey's test. A linear regression analysis was performed to determine the linear effects of increasing enzyme dosage on nutrient digestibility. $P<0.10$ was presented if data suggested a trend.

Results and Discussion. The metabolizable energy (ME) of the diet increased linearly ($P<0.05$) with higher doses of the xylanase + β-glucanase preparation (Figure 1). Apparent total tract digestibility (ATTD) of gross energy was linearly increased ($P<0.05$) by the xylanase + β-glucanase preparation. The addition of the enzyme preparation tended to linearly increase the ATTD of nitrogen ($P=0.08$) and dry matter ($P=0.065$). The gross energy balance was increased by 2.9 percentage points ($P<0.05$) with the use of 200 ppm of the enzyme preparation compared to the control (0 ppm). Fecal excretion of nitrogen tended ($P=0.095$) to decrease linearly with increasing doses of the enzyme preparation, whereas the urinary nitrogen excretion was not affected by the dietary treatments ($P>0.05$). Data from this study demonstrate a linear relationship between the dosage of the NSP-enzyme, when added up to 200 ppm, and energy utilization, as indicated by improved ME and ATTD of gross energy with increasing enzyme dose. In this study, the addition of 100 ppm of the enzyme preparation resulted in an uplift of 0.1 MJ/kg in the diet's ME in pigs. Doubling the enzyme dose to 200 ppm further increased the ME by an even more substantial margin of 0.3 MJ/kg. This could be attributed to the abundance of substrates available for the NSP-enzymes in this diet. However, the understanding of dose response of NSP-enzymes is still limited and determining optimal dosage in relation to substrate concentration remains an area of investigation. In situations with high raw material costs, increasing the NSP-enzyme dosage has the potential to further reduce feed costs, provided that an appropriate energy credit is attributed to the enzyme within a feed formulation. Understanding the benefits and limitations associated with increased doses of NSP-enzyme is crucial for optimizing swine nutrition and achieving maximal nutrient utilization. It is important to note that different xylanases can vary in their ability to break down NSP (Choct et al., 2004), making dose optimization a characteristic specific to each enzyme product.

Conclusions and Implications. The inclusion of the xylanase + β-glucanase preparation linearly increased digestibility in fattening pigs fed a wheat-corn-soy-based diet in a linear manner up to 200 ppm of enzyme. Application of double the recommended dosage of the enzyme preparation (200 ppm) yielded even greater improvement in nutrient digestibility compared to the standard dosage (100 ppm). This study indicates that the use of an NSP-enzyme preparation could be an interesting strategy to enhance the nutritive value of diets for fattening pigs, which is particularly beneficial in times of high feed prices.

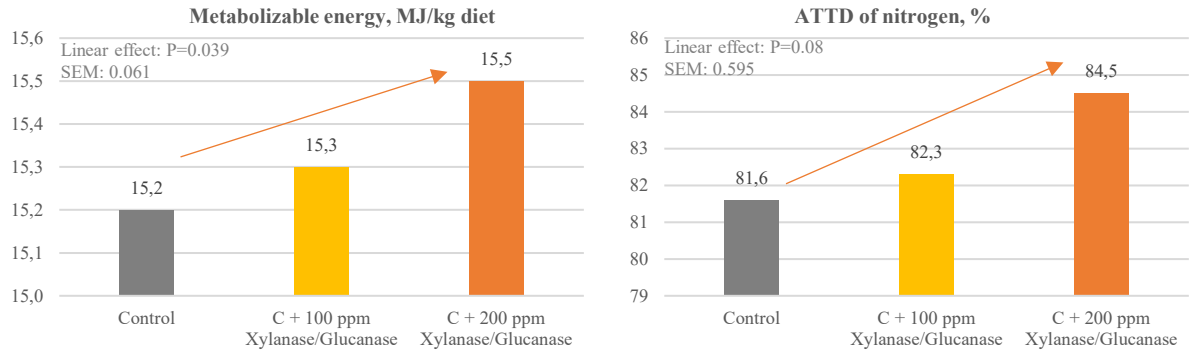

Figure 1. Effect of increasing doses of a xylanase/glucanase preparation on the metabolizable energy and on the apparent total tract digestibility of nitrogen of the diet in fattening pigs.

References

Bautil, A., Buyse, J., Goos, P., Bedford, M. R., & Courtin, C. M. (2021). Feed endoxylanase type and dose affect arabinoxylan hydrolysis and fermentation in ageing broilers. Animal Nutrition, 7, 787-800.

Choct, M., Kocher, A., Waters, D. L. E., Pettersson, D., & Ross, G. (2004). A comparison of three xylanases on the nutritive value of two wheats for broiler chickens. British Journal of Nutrition, 92, 53-61.

P1-11

Impact of adding methionine hydroxy analogue bis-chelated trace minerals, a protected benzoic acid, or their combination on growth performance of nursery pigs.

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Keywords: Mineral nutrition, survivability, weaned pigs, swine.

Introduction
Nursery pig feeding programs require careful selection of ingredients and functional components to maximize growth performance and health. Methionine hydroxy analogue bis-chelate of Zn, Cu, and Mn (MINTREX® Trace Minerals, NOVUS International, Chesterfield MO; MHAC) is a highly available trace mineral source that has been shown to enhance performance of nursery pigs (Peric et al., 2023). Further, MHAC has shown to decrease inflammation while improving gain in *E. coli* challenged weaned pigs (Acosta et al., 2023). Protected benzoic acid (PROVENIA® Feed Solution, NOVUS International Inc. Chesterfield, MO; PBA) has been shown to ameliorate the impact of an *E. coli* challenge in pigs by enhancing performance and decreasing inflammation (Acosta et al., 2022), improved growth performance of weaned pigs in research facilities (Peric et al., 2023) and in commercial nurseries (Correa et al., 2021). Combination of these two products have been shown to work positively together (Peric et al., 2023). The objective of this study was to determine the effect of MHAC and PBA alone or in combination on growth performance, removals, and mortality of nursery pigs in commercial conditions.

Materials and methods
A total of 728 weaned pigs [(Landrace ×Large white) × Duroc] were housed in a commercial nursery farm located in Murcia, Spain. Pigs were blocked by BW (initially 5.76kg) and randomly allotted in 56 pens to 1 of 4 treatments (n=14), including: 1) a control diet (Ctl) containing trace mineral in sulfate form at (100, 130 and 40 mg/kg of Zn, Cu and Mn); 2) a treatment containing MHAC at the same levels as the Ctl; 3) a treatment containing PBA (2.5kg/Ton); and 4) the combination of MHAC and PBA. The experiment lasted 40d. Data was analyzed in SAS V9.4 using pre-planned contrasts between the Ctl vs PBA, control vs. MHAC and control vs PBA+MHAC.

Results and discussion
Adding Zn, Cu and Mn in the MHAC form resulted in pigs with a final BW 0.410 kg heavier than Ctl (P=0.151; **Table 1**), PBA inclusion in the diet resulted in pigs which were 0.490 kg heavier at the end of the study (P=0.088). The combination of MHAC+PBA resulted in BW which was 0.760kg heavier than the Ctl (P=0.010). The final BW differences were supported by ADG analysis with MHAC pigs having 0.010 kg/d ADG (P=0.151), PBA 0.012 kg/d higher ADG (P=0.093) and the combination of MHAC+PBA having 0.019kg/d (P=0.010) higher ADG than the Ctl. There were no significant differences in ADFI among treatments compared to Ctl. MHAC resulted in 4.8 units lower feed conversion than Ctl containing inorganic trace minerals (P=0.068). PBA resulted in a FCR which was 5.8 points (P=0.029) lower than the Ctl without acidifier. The combination of MHAC+PBA resulted in the lowest FCR which was 8.4 points (P=0.002) lower than the Ctl indicative of an additive impact. Supplying Zn, Cu and Mn in the MHAC form resulted in less removals compared with the Ctl (-80%; P=0.032), PBA also resulted in numerically less removals (-40%; P=0.429). The combination of MHAC and PBA had numerically fewer removals compared to Ctl (-60% P=0.158). Mortality for the MHAC, PBA and MHAC+PBA treatments was 1.64%, 0.65 % and 1.10% compared with the Ctl of 2.20%. Supplying Zn, Cu and Mn in the MHAC resulted in less pigs either dead or removed (-64%; P=0.053) as did inclusion of PBA with a numerical decrease (-50%; P=0.168), and the combination of MHAC and PBA (-57%; P=0.099).

Table 1.
Overall growth performance, mortality, and removals of nursery pigs.

						P-value		
Item	Ctl	MHAC	PBA	MHAC+PBA	SEM	Ctl vs MHAC	Ctl vs. PBA	Ctl vs. PBA+MHAC
BW d 0, kg	5.75	5.77	5.77	5.76	0.36	0.967	0.976	0.984
BW d 40, kg	21.91	22.32	22.40	22.67	0.20	0.151	*0.088*	**0.010**
ADG, kg	0.404	0.414	0.416	0.423	0.005	0.159	*0.093*	**0.010**
ADFI, kg	0.611	0.590	0.588	0.587	0.011	0.167	0.116	0.128
FCR	1.475	1.427	1.417	1.391	0.017	*0.068*	**0.029**	**0.002**
Removals, %	5.49	1.10	3.30	2.20	-	**0.032**	0.429	0.158
Mortality, %	2.20	1.64	0.55	1.10	-	0.703	0.176	0.410
Mort+Removals, %	7.69	2.74	3.85	3.30	-	*0.053*	0.168	*0.099*

Conclusion and implications
The results of this experiment support the inclusion of a combination of PBA and MHAC in nursery feeding programs throughout the first 40-d post-weaning for supporting post-weaning performance and health. Furthermore, these results indicate the importance of substitution of inorganic trace minerals with minerals in the MHAC form, as well as inclusion of a protected benzoic acid as the sole dietary acidifier independently for improved post-weaning performance.

References
Acosta J. A., J. Chen, D. Hancock. 2023. 139 Trace mineral source matters for weaned pigs challenged with Escherichia Coli F18 in diets without pharmacological zinc oxide. J. Anim Sci. 101 (Suppl_2): 96-97. doi: 10.1093/jas/skad341.107.

Acosta J. A, D. Hancock, J. Chen, M. Vásquez-Añón. 2022. PSX-B-14 Effects of adding protected benzoic acid on growth performance, diarrhea, and inflammation in weaned pigs challenged with Escherichia Coli F18. J Anim Sci. 21;100(Suppl 3):218–9. doi: 10.1093/jas/skac247.397.

Correa F., D. Luise, M. Castillo, S. Peris, A. Palomo-Yague, P. Bosi, P. Trevisi. 2021. Effect of dietary supplementation with a blend of protected aromatic compounds, including benzoic acid, on growth performance and faecal microbial profile of weaned piglets as an alternative to zinc oxide. Livest. Sci. 246, 10445. doi: 10.1016/j.livsci.2021.104455.

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Perić D., R. Barea, S. Nešić, L. Makivić, J. Janjić, D. Šefer, R. Marković. 2023. Effects of dietary supplementation with benzoic acid and chelated copper, zinc and manganese sources on production performance in piglets. Acta Vet-Beograd. 73 (3): 355-373. doi: 10.2478/acve-2023-0027.

P1-12

Impact of Lawsonia intracellularis vaccination on sustainability parameters in fattening pigs (carbon footprint, N and P emissions)

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- Introduction

The pathogen *Lawsonia intracellularis* (L.I.) is widespread in pig herds (1). Beside the clinical control the vaccination improves performance parameters esp. feed conversion (FCR; 2, 3). Due to the optimal growth and performance in growing pigs it is necessary to feed an adequate quality and quantity of nutrients, eg nitrogen (N) and phosphorus (P). At the same time high faecal excretion of these nutrients have negative effects on the environment like subsequent eutrophication. As a result of the high excretion from pork production regulatory limitations were made and farms must fulfil individual management plans to limit levels of N-/P-excretion. As a further parameter of ecologic sustainability the carbon footprint as an indicator for greenhouse gas emissions (GHG) becomes more and more important. The aim of this report is to illustrate the effects of improved pig performance by L.I. vaccination together with defined feed compositions on N, P and CO_2 emissions.

- Material and methods

Performance data from field observations in 9 farms with a history of subclinical or clinical ileitis were recorded in non-vaccinated (NV) and vaccinated (L.I.) (intramuscularly/intradermally; 3-11 weeks of age) batches. NV batches, used as historical control, were compared to batches after implementing L.I. vaccination to control ileitis. N- and P-excretion were calculated using the official manual from the Lower Saxony Chamber of Agriculture (LWK NDS) using four crude protein (CP) levels (CP %/kg; 88% dry matter: "universal" 17.0, "N reduced" 16.4; "N greatly reduced" 15.4; "N very greatly reduced", 14.4) and four different P containing ratios (g P/kg 88% dry matter: "universal feed" 5.1; "P reduced" 4.6; "P greatly reduced" 4.3; "P very greatly reduced" 4.1). The carbon footprint (CO_2-e) was calculated using the agricultural GHG calculator "TEKLa" from the LWK NDS (base German-wide calculation standard in agriculture) assuming one standardized feed (12.6% imported soybean meal).

- Results and discussion

In L.I.-vaccinated groups ileitis-related signs were improved clinically and a mean improvement of -0,11 was recorded for the FCR. The average reduction of N excretion in L.I. vaccinated batches was calculated by 5.4-5.9% for all feeds when compared to non-vaccinated batches. The farm with the biggest improvement of FCR with L.I. vaccination (-0.27; -9.5%) showed 15.7% reduced N excretion. Between the non-vaccinated group with worst FCR and highest assumed CP content in feed a saving of 43%(25.3 g N/kg live weight, LW) was estimated. Calculation of the P excretion in L.I. vaccinated batches showed a mean reduction by 5.7-6.4% (P in feed 5.1-4.1 g) with a maximum of 17.1%, when compared to non-vaccinated batches. On the farm (non-vaccinated batch) with the most unfavorable FCR and assumed highest P content in feed (FCR 3.07; 5.1 g P/kg FM), P excretion reached 10.5 g/kg LW while the most favorable practical case it was 5.2 g P/kg LW (-50.5%).
Using the performance data for all groups (L.I. unvaccinated and vaccinated, 96 kg LWgain; FCR 2,79), TEKLa calculated a mean amount of 2891 g CO_2-e/kg LW. Of this 1594 g CO_2-e/kg LW (53-58%) belonged to feed. The average proportion of CO_2-e for produced piglets (29 kg LW), manure/digestion and energy consumption were 28.2%, 22.0%, and 2.7%, respectively, whereas 8.0% was credited due to the reuse of the organic fertilizer. The model showed that non-vaccinated groups emitted on average 2928 g, L.I.-vaccinated groups 2853 g CO_2-e/kg LW (Ø reduction 74 g CO_2-e/kg LW; 2.5%). In the farm with the highest improvement in feed conversion after introduction of the L.I. vaccination (FCR -0.27), a lowering of 182 g CO_2-e/kg LW was observed (6.23%). The maximum deviation in the carbon footprint between the worst and best fattening group was 12.1%.
Assuming a current average FCR of 1:2.80 in Germany (4) and a possible target range of the FCR of 1:2.50 (own estimation) would result in a theoretical potential range of 1:0.30. The improvement of 1:-0.11 would therefore correspond to a utilization of 37% of this potential. The model showed that after L.I. vaccination N and P-excretion on average of the farms could be reduced by 266 g/96 kg (CP 16.4%) and P excretion of 47 g/96 kg (P 5.1 g/kg). Transferred on 45 million fattening pigs (approx. number of pigs slaughtered in Germany without sows), the theoretical savings potential through such a measure applied to all German farms would be 11970 t N/year and 2115 t P/year.
If the former German GHG sector target for agriculture (GHG reduction 10% by 2030) were to be applied, the average CO_2 footprint reduction of 2.5% by. L.I.- vaccination would cover 25% of this requirement in pig farming. The potential for GHG reduction is even greater for the manure management and feed origin, especially the soy content. The advantage of the improved FCR with L.I. vaccination, however, is that L.I. can be diagnosed reliably, the measure can be implemented quickly as well as its success can be verified pragmatically. L.I. is widespread in almost all farms and its importance often massively underestimated due to their frequent subclinical occurrence. In addition, the L.I. vaccination leads in the vast majority of cases evaluated to a relevantly higher profitability (2; 3) and has also in organic production no restrictions (phytase use not allowed). This makes it extremely suitable as a simple and short-term solution that does not require any further, lengthy investments.

- Conclusion and implications

Under the conditions of this field observation and model calculation, it has been shown that N and P excretion in pig farming can be reduced markedly by improving performance data with *Lawsonia intracellularis* vaccination and by modulating N and P contents in the ration. Also, a reduction of GHG-emission associated with improved feed efficiency in pigs vaccinated against *Lawsonia intracellularis* was analyzed with the TEKLa model calculation. This data suggests that Lawsonia intracellularis vaccination together with the feed design has a high potential for improving sustainability.

- Acknowledgements

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- References

(1) Arnold M. et al. 2019. Porcine Health Management,5 (2) von und zur Mühlen et al. 2021 Tierärztl. Umschau 2; 28-37 (3) Nieberding et al. (2022) Tierärztl. Umschau 3; 16-24 (4) VzF-Auswertungen 2023

P1-13

Increase creep feed consumption in suckling piglets using free of animal-derived volatile compounds.

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Introduction

Creep feeding has become a key practice in the management of piglets due to the beneficial effects on post-weaning pig performance and health, especially familiarizing piglets to solid feed and improving maturation of digestive system (Heo et al., 2018). Consequently, increasing the percentage of suckling piglets consuming solid feed is essential to exploit the benefits of this practice. Weanex® NEO is an intake promoter containing free of animal-derived volatile compounds present in sow's placenta, colostrum and milk, and Neohesperidine Dihydrochalcone (NHDC), specifically designed to improve creep feeding in piglets. Therefore, this study was planned to investigate the effects of supplementing Weanex® NEO in the creep feed diets on feed intake in piglets during the lactation phase.

Material and methods

Five hundred thirteen 7±1.49 days-old suckling piglets from 40 litters ([Landrace x York Shire] x Pietrain) with an initial body weight of 2.21± 0.02 Kg were used to test the inclusion of Weanex® NEO in the creep feed diet. Litters were randomly assigned to a treatment, Control (Control) or Weanex® group (supplemented with 350 g/TM Weanex® NEO) during the whole experimental period. Furthermore, both treatments were supplemented with 0,5% of indigo carmine as a marker of feed intake. Creep feed diets were administered from day 7 to weaning (28±1.49 days old) and piglets were monitored for individual BW by ear tag identification. For every litter, total weight, ADFI, ADG, and homogeneity were also calculated. Additionally, the marker excretion in feces was checked to classify the piglets between eater or non-eater before weaning.

Results and discussion

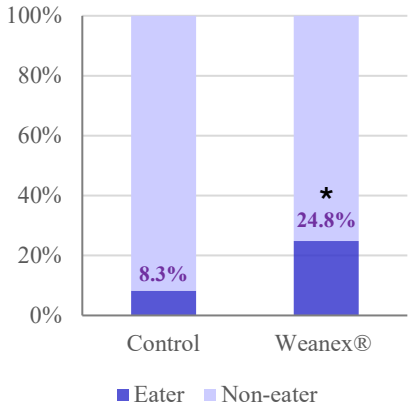
No statistical differences between treatments were observed for individual BW. Additionally, homogeneity, total litter weight, and litter ADG were also not affected by treatment (Table 1). However, litters of the Weanex® NEO treatment showed greater ($P < 0.05$) ADFI than the Control litters (20.0 ± 1.59 g and 15.3 ± 1.59 g, respectively) (Table 1). When the number of suckling piglets eating creep feed were analyzed by the screening of the marker in the feces, Weanex® NEO treatment evinced greater ($P < 0.001$) number of eaters compared with Control animals (59 and 19, respectively) (Figure 1), that might be explaining the higher ADFI observed in the litters of this treatment. Although creep feed is positively related to a better performance after weaning (Sulabo et al., 2010), during the suckling period it is very difficult to obtain statistical differences in performance, as observed in our study.

Table 1: Effect of the different experimental treatments during the lactation period (7d to 28d-weaning).

	Treatments		SEM	p-Value
	Control	Weanex®		
Day 7				
Sample size	12.85	12.80	0.229	0.8780
BW (g)	2205	2206	68.1	0.9920
CV (%)	14.6	13.9	0.86	0.5421
Litter Weight (g)	28396	28226	1032.5	0.9079
Day 28				
Sample size	11.55	11.70	0.315	0.7377
BW (g)	6117	6220	150.1	0.6297
CV (%)	19.1	17.5	1.08	0.3137
Litter Weight (g)	70696	72289	2233.8	0.6168
Day 7 to 28				
ADG litter (g)	186.3	191.2	6.11	0.5764
ADFI litter (g)	15.3[b]	20.0[a]	1.59	<0.05
Mortality (%)	9.89	8.77	1.944	0.6865

[abc]Values with different letters in the same row are significantly different ($P<0.05$)

Figure 1: Proportion of eater and non-eater piglets in each treatment.



*P<0.001

Conclusion and implications

The addition of Weanex® NEO to the creep feed diet improves the feed consumption of the suckling piglets increasing the percentage of eaters in the litters.

References

Sulabo, R. C., Jacela, J. Y., Tokach, M. D., Dritz, S. S., Goodband, R. D., Derouchey, J. M., & Nelssen, J. L. (2010). *Effects of lactation feed intake and creep feeding on sow and piglet performance.* JAS, 88(9), 3145–3153.

Heo, P.S., Kim, D.H., Jang, J.C., Hong, J.S., and Kim, Y.Y., (2018). *Effects of different creep feed types on pre-weaning and post-weaning performance and gut development.* AJAS, 31(12), 1956-1962.

P1-14

Increased number of daily meals did not affect ileal digestibility of calcium and phosphorus in sows

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Keywords

T-cannula, ileal digestibility, feed utilization, sow

Introduction

Utilization of calcium (Ca) and phosphorus (P) are low in gestating sows relative to growing pig and lactating sows (Lee et al., 2018). For practical reasons many gestating sows in Denmark are only fed one meal per day. However, it is not known if the digestibility of Ca and P are dependent on the number of daily meals. The aim of the study was, therefore, to test the effect of feeding sows 1, 2 or 3 meals per day on ileal digestibility of Ca and P.

Material and methods

Five empty sows (Yorkshire x Landrace) were fitted with T-cannulas in the distal ileum as outlined by Stein et al., 1998. Sows were allowed 7 days for postsurgical adaptation before the experimental feeding was initiated. All sows were fed the same daily amount of feed (2.15 kg/day, 25.4 MJ ME/day), given as either one daily ration (2.15 kg at 8.00am), or divided into two (1.075 kg at 8.00 am and 3.00 pm) or three meals (0.717 kg at 8.00 am, 3.00 pm and 8.00 pm) per day. The diet was based on barley, wheat, sugar beet pellets and soy bean meal, and yttrium oxide (0.1%) was added as indigestible marker. The effect of daily meals was examined in a cross-over design, where all sows were allotted to all dietary treatments. One treatment period lasted seven days, where the first five days were adaptation to the new treatment and on days 6 and 7, samples of ileal digesta were collected. Feed samples were collected weekly and pooled for analysis. Feed and ileal digesta were analyzed for nutrients and yttrium. The apparent ileal digestibility (AID) was calculated using the equation described by Fan et al. (1995). Data for AID of Ca and P were analyzed with ANOVA in R in a randomized block design. Sow was regarded as the experimental unit. The statistical model included the number of daily meals as a fixed effect and sow and period as random effects.

Results and Discussion

The number of daily meals did not affect AID of Ca and P in the sows (Table 1). The AID for Ca and P was in accordance with Lee et al. (2018), where they also found very low or negative apparent total tract digestibility (ATTD) for gestating sows. The negative values indicate that the endogenous loss of Ca is larger than the absorption of Ca. The very low AID found in the current study in empty sows, and in other studies on sows in mid gestation, are lower than for growing gilts, late gestating and lactating sows, which could be a result of a lower Ca and P requirement by these sows. The low AID for P leads to an increased proportion of dietary P being excreted into the environment.

Table 1. Daily intake and apparent ileal digestibility (AID) of calcium (Ca) and phosphorus (P).

Item	1 meal	2 meals	3 meals	SEM	*P*-value
n sows	5	5	5		
Ca intake, g/day	15.2	15.1	15.3		
P intake, g/day	8.0	8.0	8.1		
AID Ca, %	8.02	-9.32	11.67	7.72	0.1608
AID P, %	20.13	5.11	26.39	7.62	0.1802

Conclusion and implications

Increased number of daily meals did not affect the utilization of Ca and P in sows, indicating that at the present volume of feeding, the gut absorptive mechanisms for Ca and P are regulated independent of the frequency of feeding. Future research could, however, focus on optimizing utilization of Ca and P in gestating sows by exploring new sources with higher availability and optimizing dietary ratio of Ca to P.

References

Fan, M. Z., W. C. Sauer, and M. I. McBurney. 1995. Estimation by regression analysis of endogenous amino acid levels in digesta collected from the distal ileum of pigs. Journal of Animal Science 73(8):2319-2328. doi: 10.2527/1995.7382319x %J
Lee, S. A., G. A. Casas, and H. H. Stein. 2018. The level of feed intake does not influence digestibility of calcium and phosphorus in diets fed to gestating sows, but gestating sows have reduced digestibility of calcium and phosphorus compared with growing gilts. 98(3):589-592. doi: 10.1139/cjas-2017-0144
Stein, H. H., C. F. Shipley, and R. A. Easter. 1998. Technical note: a technique for inserting a T-cannula into the distal ileum of pregnant sows. Journal of Animal Science 76(5):1433-1436. doi: 10.2527/1998.7651433x %J Journal of Animal Science

P1-15

Lanthanide citrate improves feed efficiency and enhances growth performance of weaned piglets

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Introduction

The immediate post-weaning period is a stressful period for the piglet, which can have a negative effect on feed intake and can increase the risk of colonization by pathogens like E.coli. Since the EU has banned the use of increased pharmaceutical dosages of zinc oxide in June 2022, there is an ongoing search for nutritional interventions to support to gut health of the piglet during and after weaning. One aspect of such a nutritional intervention could be the addition of lanthanide citrate (Terragut) to a weaner diet. Lanthanide citrate may stimulate the growth of beneficial bacteria and thereby inhibiting the growth of pathogenic bacteria. In a former trial, the addition of lanthanide citrate to a weaner diet improved faecal consistency and feed conversion ratio (FCR) post-weaning. However, the addition of lanthanide citrate to a rearing diet was not tested yet. Therefore the objective of this trial was to study the effect of prolonged addition of lanthanide citrate in a weaner- and rearing diet on growth performance of weaned piglets.

Materials and methods

In this 2x2 trial at the Denkavit Innovation Centre located in Voorthuizen (the Netherlands), 432 piglets (TN70 x Danbred Duroc) were weaned at 27 days of age and allocated into 1 of 4 dietary treatments. Piglets received per group either a control weaner diet or a weaner diet with lanthanide citrate on-top (250 mg/kg) the first 10 days after weaning. In addition, each group received either a control rearing diet or a rearing diet with lanthanide citrate on-top (250 mg/kg) from day 11 until day 36. Piglets were weighed individually at weaning and weighed per pen at day 11, 16, 23 and 36. Feed intake was registered per pen at day 11, 16, 23 and 36. Faecal colour and consistency were noted at day 5, 8, 11, 16, 19, 23, 29 and 36 using a 5-grade score system. Use of medication and mortality was registered per piglet during the trial. Data was analysed with an ANCOVA model with weaning weight as covariate.

Results and discussion

In the weaner phase, the addition of lanthanide citrate resulted in a higher weight gain (1.4 vs. 1.6 kg/piglet; P=0.04) and a better FCR (1.66 vs. 1.45; P=0.02). Both groups had a similar number of pens with loose faeces during the weaning phase. Also in the rearing phase an overall improved FCR was found for the group with lanthanide citrate (1.41 vs. 1.35; P=0.001). The weight gain between day 11-16 and day 23-36 was similar between treatment groups, but the weight gain between day 16-23 was significantly higher for the group received lanthanide citrate during the rearing phase (3.1 vs. 3.4 kg/piglet; P<0.001). Feed intake was statistically similar between the treatment groups. There was no difference in faecal colour and consistency between treatment groups.

Conclusion and implications

This study proved that the inclusion of lanthanide citrate to a weaner diet resulted in a significantly higher weight gain and improved FCR of the piglets. Next to that, lanthanide citrate supports the piglets to maintain a better growth rate in first half of the rearing phase, as a significantly higher weight gain and FCR were found. Thus a prolonged addition of lanthanide citrate supports the growth performance of piglets during both the weaner and rearing phase.

Preferred method of presentation: oral.

P1-16

Liquid iron supplementation during post-weaning improves growth performance, hemoglobin, and alleviates post-weaning diarrhea

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Key words growth performance, hemoglobin, iron, post-weaning, pigs

Introduction Iron (Fe) is an essential mineral and component of hemoglobin (Hb) (Linder, 1991). However, pigs' ability to utilize Fe from the diet is limited. Perri et al. (2009) observed a decrease in Hb levels after 3 weeks post-weaning. In addition, Fe from feed ingredients alone was not enough to maintain iron status above anemic levels (≤ 9 g/dL), but when post-weaning pigs were supplemented with 150mg Fe/kg growth, Hb, and hematocrit (Hct) levels increased, (Rincker et al., 2004). Moreover, Fe is a key mineral for pathogenic bacteria and *E. coli* proliferates with increasing iron supplementation (Kortman et al., 2012). Therefore, the objective of the trial was to evaluate the effects of liquid Fe supplementation (130mg/L) for 10 days during the post-weaning period on growth performance, diarrhea incidence, mortality, blood parameters and *E. coli* concentrations.

Material and methods A total of 548 pigs (5.46 ± 1.5 kg initial BW) were randomly distributed in 24 pens (22-23 pigs) and in two treatments (n=12). The control (CON) with no iron supplementation and the Fe treatment (FeT) with 130 mg Fe/L supplementation (Piglet Boozt®) through the drinking water for 10 days post-weaning. A 3-phase feeding program was used on a 41-d trial period with phase 1 lasting 10 days, phase 2 lasting 17 d, and phase 3 lasting 15 d. Body weight (BW) and total Feed Intake (FI) was recorded at pen level at the start and at the end of each phase to calculate the average daily gain (ADG), average daily feed intake (ADFI) and feed conversion (FCR). Diets contained 200 and 230 ppm of Fe for phase 1 and 2 respectively. Blood samples were collected from the same pigs on d 0, 10, 21 and 41 (n=10) and were analyzed using i-STAT (cartridge CG8+; Zoetis, USA) to evaluate pH, PCO2, PO2, HCO3, TCO2, sO2, Na, K, iCa, glucose, Hematocrit (Hct) and Hb, and base excess. A pool of fecal samples per pen were collected on d 0, 10, 21 and 41 (n =8) to analyze for *E. coli*. Faecal score was assessed daily during phase 1 and 2, and then 3 times per week in phase 3 using a subjective 4-point scale score (1 = normal faeces; 2 = moist faeces; 3 = diarrhoea; 4 = severe diarrhoea/watery diarrhoea). The frequency of diarrhoea in each pen was calculated by counting pens with a fecal score of 3 or greater. Data were analysed using the General Linear Model procedure of JMP (version 17.0) with the pen serving as the experimental unit for all analyses. Mean values were calculated using LSM statement. P values of < 0.05 were classed as significant and those between 0.05-0.1 were considered trends. Significantly different means were separated using the Tukey's HSD post-hoc test.

Results and discussion Pigs were PRRS positive and had lower performance than expected. Fe supplementation during phase 1 and 2 improved growth performance (Table 1), but no differences were observed on phase 3 and on final BW. FeT pigs compared with CON pigs had lower mortality and culling percentage in phase 2 (0% vs. 1.6%, respectively; $P<0.05$) and numerical lower mortality on the global period (8.2% vs. 11.0%, respectively). During Fe supplementation, FeT pig had higher levels of Hb (Table 2) and Htc, but no differences were observed after the supplementation. In addition, the Hb levels at the end of the study indicated that all pigs had anemia. For the rest of the blood parameters, no differences were observed. During phase 1, FeT pigs had lower fecal score compared with CON pigs (1.1 vs 1.5, respectively, $P<0.01$) and lower incidence of diarrhea (0.64% vs 4.49%, $P < 0.01$, respectively), no diarrhea incidence was observed on phase 2 and 3. No differences were observed between treatments on fecal *E. coli* levels through the study, but a reduction over time was observed (Table 2), which indicates that the current level of Fe supplementation did not promote *E. coli* growth in this study.

Table 1. Growth performance of weaned piglets (d 0 – 27)

	CON	FeT	SEM	*P-value*
BW0	5.7	5.7	0.29	0.920
Phase 1				
BW, kg	5.7[b]	6.2[a]	0.06	0.001
ADG, g/d	32.4[b]	62.5[a]	5,20	0.001
ADFI, g/d	65.8[b]	82.7[a]	4,42	0.010
FCR	2.33[b]	1.37[a]	0,195	0.002
Phase 2				
BW, kg	10.8[b]	11.4[a]	0.17	0.019
ADG, g/d	280.1[b]	311.7[a]	7.82	0.010
ADFI, g/d	352.7[b]	381.1[a]	7.62	0.001
FCR	1.27[y]	1.22[x]	0.022	0.082

Table 2. Hemoglobin levels (g/dL) and *E. coli* count (log UFC/g)

	Hb		*E. coli*	
	CON	FeT	CON	FeT
d 0	10.6	10.2	7.8	7.8
d 10	11.1[b]	12.0[a]	7.9	7.4
d 21	10.0	9.7	7.4	7.0
d 41	8.3	7.7	6.7	6.9
SEM	0.4	0.4	0.3	0.3
P-value				
Treat	0.252		0.428	
Day	0.035		0.001	
Treat*Day	0.020		0.643	

Conclusion and implications During the additional Fe supplementation (130mg/L) pigs showed improved growth performance, hematocrit and hemoglobin levels, and a reduced incidence of diarrhea, mortality, and culling percentage. However, the beneficial effect only lasted while Fe was being supplemented, which suggest that higher Fe levels might be necessary for longer periods. Supplementing 130mg Fe/L for 10 days did not promote *E. coli* growth. Taking altogether, Fe metabolism and dietary Fe levels on post-weaning should be reevaluated.

References

Linder, M.C., 1991. Nutrition and metabolism of the trace elements, in: Linder, M.C. (Ed.), Nutritional Biochemistry and Metabolism with Clinical Applications. Appleton & Lange, Connecticut, USA, pp. 215–276.

Perri, A.M., Friendship, R.M., D., Harding, J.C.S., D., Sullivan, T.L.O., 2016. An investigation of iron deficiency and anemia in piglets and the effect of iron status at weaning on post-weaning performance. J. swine Heal. Prod. 24, 10–20.

Rincker, M.J., Clarke, S.L., Eisenstein, R.S., Link, J.E., Hill, G.M., 2005. Effects of iron supplementation on binding activity of iron regulatory proteins and the subsequent effect on growth performance and indices of hematological and mineral status of young pigs. J. Anim. Sci. 83, 2137–2145.

Kortman, G.A.M., Boleij, A., Swinkels, D.W., Tjalsma, H., 2012. Iron availability increases the pathogenic potential of Salmonella typhimurium and other enteric pathogens at the intestinal epithelial interface. PLoS One 7, e29968. https://doi.org/10.1371/journal.pone.0029968

P1-17

MaxiFicient™ Boost GF based on calcidiol (25-OH-D_3, Hy-D®) and triterpenoids improves growth performance in grower-finisher pigs fed low Ca and P diets without compromising bone health

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Introduction

Designing novel nutritional strategies that would ensure realization of the full potential of the current genetic of fattening swine, while reducing environmental impact and without compromise on welfare is the challenge today's swine industry has to face. By harnessing the potential of calcidiol (25-OH-D_3) and specific triterpenoids, it is possible to fine-tune mineral utilization, thereby preventing the use of excessive calcium (Ca) and phosphorus (P) and promoting bone development and muscle growth in finisher pigs.

Material and methods

A study was conducted using sixty male pigs (29.9kg±0.5kg) to evaluate the effect of reducing dietary Ca and P and supplementing with 25-OH-D_3 and triterpenoids, on growth, bone and blood characteristics. Pigs entered the experimental room at 10 weeks of age and were randomly allocated to one of six pens in groups of 10. Pigs had a two-week adaptation where they were offered a grower diet (NE:12.3MJ, CP:17.5%) prior to receiving their respective treatments from 12 weeks (NE:11.5MJ, CP:16.19%). Three experimental diets were evaluated for seven weeks; 1.Positive control (PC): 0.7% total Ca, 0.29% available P, vit D_3 at 1500IU/kg feed; 2.Negative control (NC): 0.49% total Ca and 0.26% available P, vit D_3 at 1500IU/kg feed and 3.MaxiF group: NC with 1500IU of vit D in calcidiol form (25-OH-D3, Hy-D®) instead of vit D_3 and triterpenoids (NC+ MaxiF). Pigs had *ad-libitum* access to feed which was recorded individually via automated electronic feeders. At slaughter, blood was collected and whole-body and carcass composition scans were taken from pigs using dual-energy x-ray absorptiometry (DXA) and metacarpals were collected. Data were analyzed in JMP17.0 using one-way ANOVA, including treatment as a main effect and 10-week weight as a covariate, with pig as the experimental unit.

Results and discussion

Pigs offered NC+MaxiF had a heavier slaughter weight compared to NC and PC (P=0.007). Overall feed intake was higher in NC+MaxiF compared to NC and PC (P=0.03), and as a result NC+MaxiF had an increased average daily gain (P=0.007). The DXA-scan demonstrated that bone mineral density and content in NC+MaxiF pigs were comparable to PC and NC (P=0.03). Additionally, reducing Ca and P in NC resulted in numerically lower ash, Ca and P in the metacarpals. Interestingly, NC+MaxiF had similar bone P content to PC, indicating that NC+MaxiF allows for reduced Ca and P, without compromising bone composition. As expected, NC+MaxiF had higher 25-OH-D_3 and 24,25-OH2-D3 blood concentrations (P<0.001). Although there was no difference in circulating Ca, P concentrations were higher in NC+MaxiF compared to other groups (P=0.007), suggesting that NC+ MaxiF allowed for higher circulating P levels, despite being reduced in the diet.

Table 1. Effects of 25-OH-D_3 and triterpenoid solution on growth performance, blood and bone parameters in finisher pigs.

Parameter	PC	NC	NC + MaxiF	SEM	P-value
Final weight (kg)	102.9^{b}	100.5^{b}	108.3^{a}	2.368	0.007
Overall feed intake (kg/day)	2.50^{b}	2.40^{b}	2.60^{a}	0.075	0.027
Overall body weight gain (kg/day)	1.19^{b}	1.15^{b}	1.30^{a}	0.046	0.007
Overall feed conversion ratio (g/g)	2.05	2.11	2.00	0.050	0.130
Bone mineral density (g/cm^2)	1.03^{a}	0.98^{b}	1.01^{ab}	0.020	0.030
Bone mineral content (g)	2294^{a}	2214^{b}	2227^{ab}	31.3	0.030
Bone ash (% DM)	58.1	56.3	58.2	0.840	0.220
Bone Ca (% DM)	21.7	21.0	21.6	0.323	0.284
Bone P (% DM)	10.3	10.0	10.4	0.152	0.228
Blood 25-OH-D_3 (ng/mL)	19.1^{b}	20.2^{b}	50.2^{a}	2.08	<0.001
Blood 24, 25-$(OH)_2$-D_3 (ng/mL)	3.01^{b}	3.18^{b}	13.41^{a}	0.384	<0.001
Blood Ca (mg/dL)	11.25	11.07	10.94	0.108	0.144
Blood P (mg/dL)	9.14^{b}	9.25^{b}	9.80^{a}	0.144	0.007

^{a,b,c} values within a row that do not share a common superscript are significantly different from each other

Conclusion and implications

Supplementing a reduced Ca and P diet with MaxiFicient™ Boost GF enhances weight-gain and feed-conversion as well as improving blood 25-OH-D_3 without impacting negatively bone mineralization. This solution has the potential to be instrumental in allowing for more sustainable diet with beneficial effect on animal performance and no drawback on bone health.

P1-18

More eaters in 21 day weaned piglets by providing 24/7 piglet milk replacer during lactation

Key words: eaters, weaning, piglet milk replacer

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Introduction
The transition from sow milk and creep feed before weaning to only dry feed after weaning is a major change for young piglets. Often, weaning is accompanied by a lag and drop in feed intake, resulting in an impaired gut morphology and function, proliferation of pathogenic bacteria and post-weaning diarrhea. Piglets that consume dry feed during lactation are known to start eating faster after weaning (Bruininx et al., 2002). However, about half of the piglets do not consume prestarter at 21 days of age (DOA), which puts early-weaned piglets at greater risk of post-weaning health issues (Vodolazska et al., 2023). The aim of this study was to investigate the effect of supplementing sow-reared piglets 24/7 with a complex piglet milk replacer (PMR) on the number of eaters at weaning.

Material and methods
Piglets of 59 primi and multiparous TN 70 sows were used. Control piglets (n = 396) received only sow milk and dry feed before weaning, while milk piglets (n = 404) were supplemented with PMR from 4 DOA until 3 days before weaning (19 – 21 DOA) by an automatic cup system next to sow milk and dry feed. Dry feed was provided twice daily from 6 DOA until weaning and intake was recorded per litter. Piglets were weighed individually at 4 DOA and at weaning. Rectal swabs were taken at weaning day. Piglets were classified as eater when the swab was covered with light to dark brown manure and contained coarse textured particles, while non-eaters had yellow-coloured manure on the swabs without textured particles. When no clear distinction could be made, piglets were labelled as undefined.

Results and discussion
In the milk group significantly more piglets were classified as eaters compared to the control group, respectively 67.3% compared to 50.5% ($p < 0.0001$). Most importantly, supplementation of milk significantly reduced the number of non-eaters (20.5% compared to 6.4%, $p < 0.0001$). Milk piglets were found significantly heavier than control piglets (respectively 6.25 $\pm$ 0.09 kg and 5.37 $\pm$ 0.06 kg, $p < 0.0001$) at weaning and consumed more dry feed in the farrowing pen (resp. 152 $\pm$ 4 g and 119 $\pm$ 4 g per piglet, $p < 0.0001$). Next to the dry feed, milk piglets consumed 206 g PMR per piglet (on DM basis, single measurement on group level), resulting in a total DMI of about 358 g per piglet.
Kobek-Kjeldager et al. (2021) also showed that PMR was more attractive to piglets than liquid feed, which is known to be more attractive than dry feed (Byrgesen et al., 2021). However, the effect of supplementing PMR on the consumption of dry feed before weaning was not investigated before.

Conclusion and implications
Our results show that 24/7 supplementation of PMR during lactation increases the amount of eaters at weaning. Furthermore, PMR increases the DMI of dry feed as well as total DMI and body weight of piglets at weaning. Higher preweaning DMI ultimately leads to a better adaptation of the piglets to solid feed, which promotes gut development and therefore smoothens the stressful transition process around weaning. PMR provides nutrients before weaning that customize the digestive system in the change to solid feed, consequently preventing villous atrophy and improving gut barrier function after weaning. Reducing the number of non-eaters is thus key in the overall strategy of raising piglets without the need of antibiotics and zinc oxide.

References
Bruininx, E., Binnendijk, G., van der Peet-Schwering, C., Schrama, J., den Hartog, L., Everts, H. & Beynen, A. (2002). Effect of creep feed consumption on individual feed intake characteristics and performance of group-housed weanling pigs. *Journal of Animal Science, 80*(6): 1413-1418.

Vodolazka, D., Feyera, T., Foldager, L. & Lauridsen, C. (2023). The influence of supplementary feeding during suckling and later weaning on growth performance, incidences of post-weaning diarrhoea and immunity of piglets. *Livestock Science, 276*, 105321.

Kobek-Kjedager, C., Vodolazs'ka, D., Lauridsen, C., Canibe, N. & Pedersen, L.J. (2021). Impact of supplemental liquid feed pre-weaning and piglet weaning age on feed intake post-weaning. *Livestock Science, 252*: 104680.

Byrgesen, N., Madsen, J.G., Larsen, C., Kjeldsen, N.J., Cilieborg, M.S.c & Amdi, C. (2021). The Effect of Feeding Liquid or Dry Creep Feed on Growth Performance, Feed Disappearance, Enzyme Activity and Number of Eaters in Suckling Piglets. *Animals, 11,* 3144.

P1-19

Novel precision biotic interventions: Elevating pig resilience to social stress and advancing animal welfare

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Introduction

Stress-driven abnormal stereotypic behavior, such as tail biting and/or aggression, remains an economically relevant problem for the swine industry. In the light of stronger implementation of the existing ban on tail docking, rearing more entire male pigs and the growing social pressure around animal welfare in agriculture, it is possible problems associated with abnormal stereotypic behaviors become even more of a challenge. While some manipulation of macro nutrients such as amino acids and fiber may offer some benefits, this strategy alone may not be enough to address this issue. Recent progress in our understanding of the microbiome-gut-brain axis and its influence on stress resilience and behavior could offer another complementary approach to overcome this evolving challenge. To this effect, a novel precision biotic (PB) has been selected to modulate function of the microbiome in the direction of promoting stress resilient pigs. This novel solution was tested in a grower-finisher pig study under social stress challenge, and we investigated whether the nutritional supplementation of the PB could decrease lesion severity on the pig's body, tail and ear, and decrease overall stress level as measured by cortisol levels in hair and saliva.

Material and Methods

Seventy-two entire male pigs and seventy-two female pigs ([Large White x Landrace] x Pietrain) of c.a. 70 days of age and 25 kg body weight, with undocked tails were included in this study, and housed in 36 pens each accommodating 4 pigs/pen (male and female in separate pens). Pen was the experimental unit and there was 18 pens/treatment. Over the adaption period (week 10), all pigs received the control diet. Between week 11 and week 24, each pen was allocated either a control diet (NC) or NC + 250 ppm PB (PB). The social stress challenge was conducted at d 55 and d 56 by exchanging pigs between every two pens in the same treatment. The lesion scores on body, tail and ear were evaluated before, during and after each mixing challenge and at the end of the trial (d -7, d 52, d 55-57, d 89 and d 96). The methodology used a 3 points scale, with score standards (0=no lesion up to 2 in body score/3 in tail or ear score = severe lesions) that followed the Welfare Quality® Assessment (2009) and Hakansson et al. (2020). Saliva samples were collected from 1 pig per pen on d -7, 58 and 97, and hair from the same pigs were shaved at d -7 and 98 in the same region, and only hair samples at d 98 were collected for analysis. The concentration of cortisol in both saliva and hair was measured.

Results and discussion

The percentage of severe body lesions (score 2) increased from an average of 7.36% (before social stress challenge: d -7, d 52) to an average of 95.44% in the period of social stress challenge (d 56, d 57). The percentage of severe ear lesions (score 2) also increased from an average of 0% before social stress challenge to an average of 50.66% in the period of social stress challenge. These figures confirm the validity of the methodology employed to increase stress level. Although only a numerical reduction in lesions scores (6.2% for body lesions and 4.5% for ear lesions, respectively) could be observed in the pigs receiving the PB treatment, it was possible to demonstrate lower saliva cortisol level (141 *vs.* 174 pg/mg, upper end, $P<0.05$) in these animals, indicating that the experimental treatment was able to lower acute stress caused with a social challenge. Pigs in the PB treatment also showed lower hair cortisol level (224 *vs.* 263 pg/mg, upper end, $P<0.05$), indicating lower "accumulation" of stress over time. Moreover, within the whole trial period (d 0-98), dietary supplementation with PB improved growth performance of pigs when compared to NC, a result in line with our expectations for animal featuring high level of resilience to stress. The improvement in growth performance was even more pronounced during periods of social stress (d 51-59), which featured increased final body weight (71.86 *vs.* 69.60 kg, $P<0.05$), average daily gain (ADG: 671 *vs.* 499 g/d, $P<0.05$), and decreased on feed conversion ratio (FCR: 2.667 *vs.* 3.582, $P<0.05$). These results indicate PB can elevate pigs' resilience to social stress.

Conclusion and implications

The study provided evidence that nutritional supplementation of a novel precision biotic (PB) could be an effective strategy for promoting pig resilience to social stress, with implications for animal welfare, economic efficiency, and the development of more sustainable and humane livestock production systems.

References

Welfare Quality® (WQ®), 2009. Welfare Quality® Assessment Protocol for Swine. Welfare Quality® Consortium, Lelystad, Netherlands.

Hakansson, F., Lahrmann, H. P. and Forkman, B., 2020. A longitudinal study of pre- and post-weaning tail damage in non-docked pigs. Animal, 14(10), 2159-2166.

P1-20

Title: Piglet response to L-leucine supply during the post-weaning phase depends on piglet birth weight

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Key words: Feed efficiency, Feed intake, Leucine, Nutrient requirements, Piglet

Introduction

Variation in piglet body weight has important implications for on-farm management, both before and after weaning. After weaning, body weight heterogeneity prevents all animals from receiving optimal feed. Previous studies have shown that branched chain amino acids (BCAA), especially leucine (Leu), are involved in the control of protein synthesis and can improve the performance of piglets with growth retardation and thus increase body weight homogeneity (Xu et al., 2016; Zhang et al., 2019). This trial aimed to investigate the piglet response to leucine during the post-weaning phase as a function of piglet birth weight. The hypothesis was that leucine improves piglet performance, especially for those with a low growth rate and light body weight.

Material and methods

This work was supported by the PIGWEB project, which has received funding from the European Union's Horizon 2020 programme under grant agreement No 101004770.

In this trial, 180 piglets weaned at 28d of age were allocated to six treatments for five weeks in a 2×3 factorial design: two body weight categories (BW) depending on the birth weight and three levels of digestible leucine/lysine in the diet (LEU) (deficient: 85%, at the requirement: 100% and in excess: 115%). The performance traits (growth rate, feed intake and feed conversion ratio (FCR)) were recorded and then statistically analysed with mixed models, using BW, LEU and their interaction as fixed factors (the experimental unit was the pen).

Results and Discussion

The BW×LEU interaction had a significant effect on final body weight, growth rate and feed intake ($P < 0.01$). The FCR was not influenced by the interaction, BW or LEU. In the group of light piglets, those fed 100% LEU had significantly higher feed intake, growth rate and final body weight than those fed 85% LEU ($P < 0.05$) and no significant difference in feed intake, growth rate or FCR compared to the heavy piglets fed the same level of LEU ($P > 0.05$; Figure 1). In the group of heavy piglets, those fed 115% LEU performed best, with a numerical or significant difference in feed intake, growth rate and final body weight compared to the two other LEU treatments.

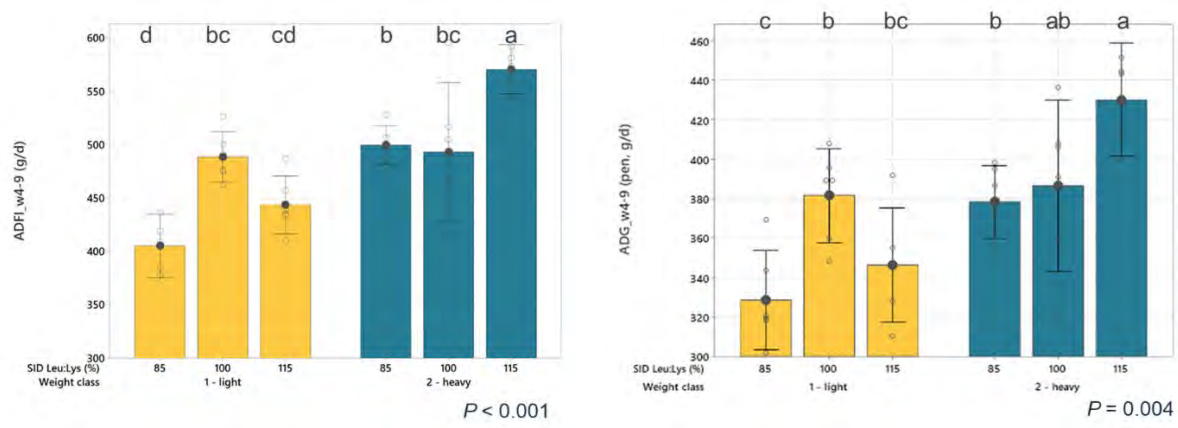

Figure 1. Average daily feed intake (ADFI) and average daily gain (ADG) of weaned piglets from 4 to 9 weeks of age, according to the leucine dietary level (SID Leu:Lys) and the piglet weight category

Conclusion and implications

In conclusion, the treatments with 85% LEU appeared deficient for all piglets. The heavy piglets responded positively beyond the level considered to be 100% of the requirement, while for the light piglets, this level seemed optimal. In both cases, the response to leucine seems to be driven by the feed intake, with no effect on the FCR. Moreover controlling the Leu level at 100% SID Leu:Lys allowed to homogenise the growth performance of all the piglets and, vs 85% SID Leu:Lys, reduced the difference in BW at the end of the PW phase between light and heavy piglets.

References

Xu W., Bai K., He J., Su W., Dong L., Zhang L., Wang T., 2016. Leucine improves growth performance of intrauterine growth retardation piglets by modifying gene and protein expression related to protein synthesis. Nutrition, 32, 114-121.
Zhang J., Xu W., Han H., Zhang L., Wang T., 2019. Dietary leucine supplementation restores serum glucose levels, and modifying hepatic gene expression related to the insulin signal pathway in IUGR piglets. Animals, 9, 1138-1153.

P1-21

Full title: Probiotic application to grower-finisher pigs facilitates substitution of soybean meal with rapeseed meal while maintaining performance and reducing emission

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Introduction: Scarcity in raw materials, increasing cost and variation in nutritional value adds to the complexity of formulating diets that perform consistently. Furthermore, selecting feed ingredients and formulating diets with low environmental impact is becoming increasingly important. We aimed at investigating whether probiotic application could give flexibility to use alternative feed ingredients in the diets without impairing pig performance. Therefore, the objective of this study was to investigate the impact of substituting 5% of soybean meal with rapeseed meal in diets for grower-finisher pigs, along with the effect of incorporating the *Bacillus*-based probiotic, BioPlus® YC, in these diets.

Material and methods: The study involved 384 fattening pigs, 85 days old, which were assigned to one of three treatments receiving: a positive control diet (PC), a negative control (NC) diet, and a NC diet with added probiotic (BioPlus® YC: 1.28E+09 CFU per kg/feed). Each treatment included 16 pen replicates with 8 pigs/pen. The PC diets were formulated to represent standard commercial G/F diets (FEDNA 2013). In the NC diets, 5% soybean meal was replaced with 5% rapeseed meal. The consequence of this replacement was a lower level of CP% (-4.21 in grower diet and -4.55% in finisher diet) and SID AA's (-3% in both diets). The diets were formulated to keep the ratio between AA's. An inert marker was included in the grower diets to assess the apparent total tract digestibility of protein at the end of the grower period. During the study, performance measurements were done and when the pigs reached about 110 kg, they were slaughtered and carcass quality was assessed. Data were analyzed with the General Linear Model (using SPSS v. 28.0) with treatment as fixed factor and room and sex as random factors.

Results and discussion: Results showed that replacing soybean meal with rapeseed meal had a negative impact on digestibility of crude protein and feed conversion ratio (Figure 1). Inclusion of the *Bacillus*-based product to the NC diet sustained the crude protein digestibility and FCR to the level of the PC group. Compared to the NC diet, the probiotic fed pigs had a significantly higher digestibility of crude protein and FCR tended to be lower during the grower period (-9.9%) and during the entire study (-2.9%). Carcass quality was not different between treatment groups. Emission of nitrogen can be calculated by considering growth, feed intake and crude protein content in the diets. When comparing the PC and NC + Probiotic groups, the latter group of pigs perform equally or better than the PC group and the protein content in feed was lower, ultimately leading to an 8% reduction of nitrogen emission.

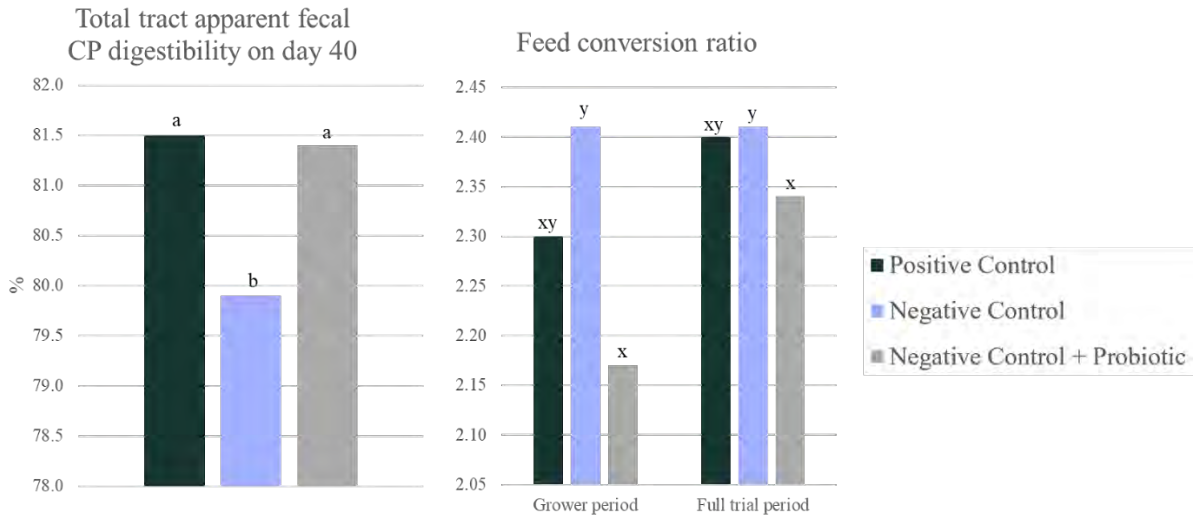

Figure 1. Total tract apparent fecal crude protein digestibility on day 40 of the study and feed conversion ratio during the grower period and full trial period in pigs fed a standard commercial diet (Positive Control), a diet with 5% soybeal meal substituted with 5% rapeseed meal (Negative Control) and a NC diet with BioPlus® included.

Conclusion and implications: These findings suggest that the *Bacillus*-based probiotic effectively mitigated the lower levels of crude protein and amino acids in the NC diet by enhancing protein digestibility. The greatest impact of ingredient substitution and BioPlus® YC administration was observed during the grower phase and no effect on carcass quality was identified. This implies that the use of probiotics could allow for greater flexibility in using alternative feed ingredients and enable the formulation of diets with a reduced environmental footprint.

P1-22

Supplementation of a β-mannanase enzyme to diets with low-cost alternative protein sources supports post-weaning piglet performance under field conditions

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Background and objectives - β-Mannans - strongly anti-nutritive polysaccharide fibers - are found in many vegetable feed ingredients. *In vitro* studies have demonstrated that as little as 0.05% of soluble β-mannan content in feed can elicit a strong innate immune response. In common commercial swine diets, the content of soluble β-mannans is much higher and estimated to range between 0.15 to 0.40%. Hemicell HT (Elanco Animal Health) is a β-mannanase enzyme to supplement animal feed which breaks down β-mannans. Hemicell HT minimizes production and economic losses caused by the wasteful feed-induced immune response (FIIR) elicited by β-mannans. This field study compared piglet performance on a control diet to a reformulated diet with low-cost alternative protein sources including a β-mannanase enzyme under field conditions.

Materials and methods - A seven-week feeding trial was conducted on a commercial post-weaning facility with TN70 x Tempo piglets (n = 264; 9 pigs / pen; 15 replicates per group) weaned at 24 days of age. Standard three-phase control diets (phase 1, 0-10d; phase 2, 11-28d; and phase 3, 29-48d) were compared to reformulated diets with low-cost alternative protein sources and inclusion of a β-mannanase enzyme (Hemicell HT™; Elanco) at 300 g/tonne. Standard production data (ADWG, FCR, mortality) were collected. The data were analyzed using JMP 15.0 statistical program.

Results - Overall, performance data did not differ significantly ($P > 0.05$) between treatment groups during the post-weaning period. Piglets fed with the adapted feed formulation including low-cost alternative protein sources had a numerically lower overall feed cost (€ 16.21/piglets *vs.* € 15.86/piglets in the Control group). Hemicell HT had an overall benefit of € 2.02 per piglet and € 8.05 per tonne of feed due to the use of alternative proteins.

Discussion and conclusions - The current trial demonstrated that the inclusion of Hemicell HT in reformulated diets with alternative protein sources was able to maintain production performance in post-weaned piglets with an economic benefit. The inclusion of Hemicell HT had an overall benefit of € 0.15 per piglet and € 8.80 per tonne of feed due to the alternative protein substitution.

P1-23

Supplementing a plant-derived phytogenic in late gestating and lactating sow diets improves immune status of sows and litter performance

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Recent research showed that the dietary addition of flavonoids, subgroup of plant polyphenols, can effectively enhance the anti-inflammatory and immune functions of sows. A study was conducted at a commercial research facility in Denmark to evaluate the effects of dietary supplementation with a plant-derived phytogenic feed additive during the last 14 days of gestation until end of lactation (41 days in total) on the immune status as well as performance of sows and suckling piglets. A total of 100 sows (Topigs TN-70 x DanAvl Duroc), consisting of 50 sow (parity 2 to 5) per treatment were allotted to two dietary treatments: i) Basal standard lactating sow diet based on barley, wheat, soybean meal in mash form (Control) and ii) Basal diet supplemented with a phytogenic (PhytriCare© IM; a synergistic blend of rosemary, hops, green tea and grapes which contains more than 10% flavonoid content) at 400 g/ton on-top (Phytogenic). Blood samples were collected (without fasting) from 10 sows per treatment on day 1 after farrowing to analyze for serum concentrations of tumor necrosis factor alpha (TNF-α) and superoxide dismutase (SOD). Sow body condition score, litter size (born alive and born dead), mortality of sows as well as piglet body weight, average daily gain (ADG), and pre-weaned mortality were recorded. On day 1 post-farrow, the litter size was standardized at 15 piglets per sow. Data were analyzed by ANOVA using Proc GLM of SAS and reported as least squares means. The model included t parity as covariate, and the sow was the experimental unit. Feed intake of sows as well as the number of piglets born alive, weaned pigs per sow, piglet mortality and piglet fecal consistency scores were not affected by the dietary treatments. Supplementation with Phytogenic tended to reduce ($P = 0.10$) body weight (BW) loss of sows (- 5.40 kg/sow) during lactation, however sow body weight and body condition scores were not affected. Phytogenic supplementation in sow diet increased litter weight at weaning ($P < 0.03$), litter weight gain (+ 4.40 kg/sow; $P < 0.02$) and ADG of piglets during lactation ($P < 0.03$). Serum TNF-α concentration was reduced by 31% (926 vs. 636 pg/ml; $P = 0.364$) but serum SOD concentration was significantly increased by 28% (16.4 vs. 22.8 U/ml; $P < 0.05$) by a phytogenic addition which indicates improved systemic inflammatory status of the sows. Overall, these results showed that supplementation with a plant-derived phytogenic reduces lactation BW loss of sows, increases immune status of sows and increases piglet and litter growth during lactation.

Keywords: Phytogenic, lactation, piglets, sows

P1-24

Supplementing weaned piglet diets with a combination of lysolecithins, synthetic emulsifier and monoglycerides improves growth performance and profitability

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Key words
Piglet, post-weaning, profitability, growth performance, biosurfactant.

Introduction
In the swine industry, the post-weaning period poses a critical challenge to piglet growth and health. One of the primary challenges during weaning is the physiological and digestive adaptations that piglets must undergo to effectively utilize nutrients from solid feed. Lysolecithins are known for their emulsifying properties, facilitating the digestion and absorption of lipids and other nutrients. Synthetic emulsifiers enhance nutrient utilization by promoting the dispersion of dietary fats in the digestive tract. Monoglycerides, being surface-active agents, further contribute to improved lipid digestion and absorption. The combination of these additives has shown to improve growth performance, feed efficiency and intestinal morphology in poultry. However, the published information in weaned piglets is scarce. Therefore, the present study aimed to evaluate the effect of a combination of lysolecithins, synthetic emulsifier and monoglycerides (LEX) on growth performance and profitability in weaned piglets.

Material and methods
The feeding trial was conducted at Tests and Trials piglet research farm (Huesca, Spain). The duration 42 days postweaning: 1-14 days (Pre-starter) and 14-42 days (Starter). The groups were balanced by sorting piglets into different blocks based on the initial weight and gender. A total of 336 weaned piglets ± 24 days of age, 50% DanBred Hybrid (Large white x Landrace) x 50% German Pietrain with a weight at start of 6.44 ± 1.59kg, were assigned to two experimental treatments: Control, receiving standard post-weaning diets; and LEX, receiving standard post-weaning diets supplemented with a combination lysolecithins, synthetic emulsifier and monoglycerides at 500 g/t of feed. Each treatment consisted of 28 replicates/pens (14 gilts-pens and 14-barrow-pens) with 6 piglets each. Feed was provided ad Libitum. Body weight (BW), average daily gain (ADG), average daily feed intake (ADFI), feed conversion ratio (FCR) and mortality/culls were determined as mean pen values. Individual BW and ADG were also analyzed along with their coefficient of variation (CV, %). To assess the economic impact and return on investment (ROI) of LEX supplementation, a calculation of the income over feed cost (IOFC) for each treatment was performed. Productive parameters were analyzed using a General Linear Model (GLM). Means were separated from Tukey's post-hoc comparison test. Significant differences were declared at $P<0.05$, while near-significant trends were considered for $0.05 \leq P \leq 0.10$.

Results and discussion
Piglets fed diets supplemented with LEX showed a higher BW at the end of the trial period compared to control (22.7 vs. 20.8 kg; p=0.0028). During the starter period (14-42 d) and overall (0-42 d), ADG was higher for piglets from the LEX treatment compared to control (0.456 vs. 0.393 kg; p<0.0001 from 14-42 d and 0.381 vs. 0.341 kg; p=0.001 from 0-42 d). These improvements in weight gain were also reflected into lower FCR for LEX piglets compared to control (1.38 vs. 1.51; p<0.0001 from 14-42 d and 1.36 vs. 1.43; p=0.0061 from 0-42 d). ADFI during the starter period (14-42 d) tended to be higher for LEX piglets compared to control (0.627 vs. 0.592 kg; p=0.0861), though this trend was not reflected in the whole experimental period (0-42 d). Though not significant, CV of individual BW at the end of the trial was reduced in piglets from LEX treatment compared to control (11.6 vs. 14.4 %; p=0.2149), which reflects BW homogeneity. LEX supplementation provided an IOFC of 1.824 €/piglet higher compared to Control, which resulted in a ROI of 33.8.

Conclusion and implications
The findings of the present study demonstrated that supplementing LEX to diets of weaned piglets increased BW at 42 days, improved ADG and FCR during the starter period (14-42 d) and overall (0-42 d) and resulted in improved profitability compared to control.

References
Brautigan, D.L., Li, R., Kubicka, E., Turner, S.D., Garcia, J.S., Weintraut, M.L., Wong, E.A. 2017. Lysophospholipids as feed additive enhances collagen expression and villus length in the jejunum of broiler chickens. Poultry Science 96, 2889–2898.
Jones, D.B., Hancock, J.D., Harmon, D.L., Walker, C.E. 1992. Effects of exogenous emulsifiers and fat sources on nutrient digestibility, serum lipids, and growth performance in weanling pigs. Journal of Animal Science 70, 3473–3482.
Pluske, J. R., Hampson, D. J., Williams, I. H. 1997. Factors influencing the structure and function of the small intestine in the weaned pig: a review. Livestock Production Science 51, 215-236.
Wealleans, A.L., Jansen, M., di Benedetto, M. 2020. The addition of lysolecithin to broiler diets improves growth performance across fat levels and sources: A meta-analysis of 33 trials. British Poultry Science 61, 51–56.
Wealleans, A.L., Bierinckx, K., di Benedetto, M. 2021. Fats and oils in pig nutrition: Factors affecting digestion and utilization. Animal Feed Science and Technology 277, 114950.
Zhao, P.Y., Li, H.L., Hossain, M.M., Kim, I.H. 2015. Effect of emulsifier (lysophospholipids) on growth performance, nutrient digestibility and blood profile in weanling pigs. Animal Feed Science and Technology 207, 190-195.

P1-25

Full title
The combination of an alternative zinc source and low ABC-4 diets can replace the high levels of ZnO in nursery piglet diets

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Keywords: nursery, swine, zinc oxide, ABC-4

Introduction
The inclusion of pharmacological levels of Zn in nursery pig diets is widely known to reduce post-weaning diarrhea and improve growth performance, gut health, and microbiota. Manipulating stomach acidity with low acid-binding dietary ingredients benefits nursery pig performance, crucial for weaned piglet feed formulation as pepsin activity peaks around pH 4 until 40-50 days of age, emphasizing the importance of Acid Binding Capacity at pH 4 (ABC-4). However, ZnO also has one of the highest ABC-4 values (21,863 meq/kg) among feed ingredients. Thus, the use of high levels of Zn through ZnO in weanling pigs has the potential to drastically increase the stomach pH, which might decrease the utilization of nutrients and increase the chance for pathogens to enter the intestinal tract. Recently, new diet formulation approaches have reduced ABC-4 values to 200 to 300 meq/kg as an alternative to high ZnO diets, without impairing pig performance (Stas et al., 2022). Currently, there are limited studies exploring the effects of different sources and levels of Zn in low ABC-4 diets on nursery pigs. Different physicochemical characteristics of Zn sources may permit feeding low Zn concentrations if used in conjunction with low ABC-4 diets. This study aimed to evaluate the effects of diets containing different levels of a novel Zn source (HiZox®, Animine, Annecy, France) in low ABC-4 diets on growth performance, fecal score and dry matter (DM).

Material and methods
The experiment took place at the Kansas State University Segregated Early Weaning Facility in Manhattan, KS. The trial included 240 piglets (DNA 200 × 400, male, initial BW of 5.90 ± 0.05 kg) that were weaned with 21 days of age. Piglets were randomly assigned to 4 feeding groups with 12 pens of 5 animals each (60/group). The experiment was divided into 2 feeding phases: phase 1 (d 0 to 10) and phase 2 (d 11 to 24). All diets were isocaloric and isonitrogenous and formulated using ingredients known to have low ABC-4 values. Feeding groups were consisted of: (1) negative control (NC, 150 ppm Zn (HiZox®), with ABC-4 values of 209 meq/kg and 253 meq/kg for phase 1 and phase 2, respectively); (2) positive control (PC, 3,000 ppm ZnO (phase 1) and 2,000 ppm ZnO (phase 2)); (3) Low HiZox contained 500 ppm (phase 1) and 300 ppm (phase 2) of Zn; and (4) High HiZox contained 800 ppm (phase 1) and 500 ppm (phase 2) of Zn. Feed and water were available for the animals ad libitum. Individual pig weights and feed disappearance were measured on days 0, 10, and 24 to calculate ADFI, ADG, and F/G. Feces were collected from the same three pigs in each pen at the end of phases 1 and 2. Fecal samples were dried (55°C for 48 h) to determine DM. The collected samples were scored in advance using a 5-point scoring system by a single observer. Scores were assigned on following appearance: 1 = watery feces; 2 = unformed feces; 3 = soft formed feces; 4 = firm formed feces; and 5 = hard feces. Data were analyzed using the GLIMMIX procedure of SAS. A p-value ≤ 0.05 was considered to indicate significant differences.

Results and discussion
In phase 1 (d 0 to 10), piglets fed with High HiZox had improved ADG (P=0.002) and were heavier (P=0.002) at d 10 and exhibited better F/G (P=0.02) compared to pigs fed the NC with pigs fed other treatments being intermediate. Additionally, High HiZox also had greater ADFI (P=0.016) than the NC. Increasing HiZox® increased ADG (quadratic, P<0.001), ADFI (quadratic, P=0.005), and improved F/G (quadratic, P=0.01). During phase 2 (d 11 to 24), there were no significant (P>0.10) differences on the growth parameters (ADG, F/G, and BW), whereas, increasing HiZox® had a tendency (quadratic, P=0.077) to increase ADFI. For the overall experimental period (d 0 to 24), piglets fed High HiZox tended to have higher (P=0.08) ADG than pigs fed the negative control, whereas, increasing HiZox® increased ADG (quadratic, P=0.007) and ADFI (quadratic, P=0.018). No significant differences (P>0.10) were observed among treatments for fecal DM (%) at d 10 and d 23. Additionally, piglets fed with either HiZox® or high ZnO both showed hard and firm fecal consistency, with fecal DM of 26.4% and 25.5%, respectively.

Conclusion and implications
In summary, the use of novel Zn source as an alternative to high dietary ZnO levels demonstrates comparable feed intake, growth rate, and feed efficiency. Overall, the increasing inclusion of HiZox (from 150 to 800 ppm) tends to enhance both average daily feed intake (ADFI) and average daily gain (ADG). Moreover, HiZox mirrors the performance of high levels of zinc oxide in terms of fecal characteristics, including dry matter and consistency. The combination of HiZox and low ABC-4 concept is an effective way to replace the high dietary levels of zinc oxide used in nursery piglet diets.

References
Stas, E., Tokach, M., DeRouchey, J., Goodband, R., Woodworth, J., Gebhardt, J. Evaluation of the acid binding capacity of ingredients and complete diets commonly used for weanling pigs, Transl Ani Sci, 6, 3 (2022). https://doi.org/10.1093/tas/txac104

P1-26

Full title

The effect of weaning weight class on individual feed intake and diarrhoea incidence of group-housed weaned piglets

Authors and affiliations

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Introduction

After weaning, piglets often experience a low and fluctuating feed intake. Struggling to transition from sow milk to solid feed and stressed by transport and/or mixing with non-litter mates, piglets may consume minimal amounts shortly after weaning or even temporarily stop eating. These challenges lead to irregular intake patterns, adversely affecting gastrointestinal morphology and physiology, which in turn may cause growth checks and increased susceptibility to diseases such as diarrhoea. The aim of this study was to identify the effect of weaning weight class on individual feed intake characteristics and the incidence of diarrhoea of group-housed weaned piglets.

Materials and methods

Piglets (TN70 x Tempo) were born at De Heus' Swine Nutrition Center De Elsenpas. During the suckling period, piglets had *ad libitum* access to creep feed. At weaning, 100 female piglets, on average 26.7 days, were individually weighed and classified as either Light Weight (LW; 4.4-7.5 kg) or Heavy Weight (HW; 9.0-12 kg). The piglets were transported over four hours to the animal facilities of Laboratory of Animal Nutrition and Product Quality (LANUPRO, Ghent University, Ghent, Belgium) and allocated to pens equipped with an electronic feeding station (MLP 2 Ferkel Komplett, Schauer, Schauer Agrotronic GmbH, Prambachkirche, Austria). The feeding stations were activated immediately after the allocation was completed (t=0). Each of the ten pens contained ten piglets (five LW and five HW) that were fed a commercial weaning feed until d14 after weaning and a follow-up starter diet from d14-d42 after weaning. There was no natural light and artificial light was used from 07:00 to 19:00 with a night light operating in each feeding station outside these hours. For all traits, the piglet was considered as the experimental unit. Data on feed intake characteristics were evaluated by restricted maximum likelihood (REML) estimation using the mixed model repeated measurements procedure in Genstat (Genstat, 23rd Edition) with BW class and day post-weaning and their interaction as fixed effects and pen as random effect. To evaluate the effect of BW class on latency time to first feed intake, a Kaplan-Meier analysis was performed. Periodical diarrhoea incidence data were evaluated using a Kruskal Wallis test. Daily diarrhoea incidences data were subjected to a logistic regression with fixed effect of BW class and random effect of piglet nested within pen. Correlation analysis between the latency time to first feed intake and average diarrhoea incidence was performed using Spearman correlations.

Results and discussion

Both LW and HW piglets lost about 2.5-3.0% of BW during the 4-hour transport. Latency time to first feed intake was not affected by BW class ($P>0.05$). HW piglets had a higher daily feed intake than LW piglets, but the pattern over days was dependent on BW class (BW class x Day interaction: $P<0.001$). Average feed intake during day 0-42 amounted to 845 g/d and 670 g/d for HW and LW piglets, respectively. This difference was not associated with the number of successful visits per day, because this was on average 15% lower ($P=0.003$) for HW piglets (28 visits) compared to LW piglets (34 visits). The higher daily feed intake for HW piglets seemed associated with a higher feed intake per successful visit for HW piglets compared to LW piglets (BW class x Day interaction: $P<0.001$). Piglets consumed on average 4 grams per successful visit on d1, which gradually increased to 53 grams per visit for LW piglets and 79 grams per visit for HW piglets. There was a significant ($P=0.04$) BW class with Day interaction for day-to-day difference in feed intake (indicator of fluctuation in feed intake). On average, LW and HW piglets consumed 37.2% and 34.5% of their feed intake during dark hours, respectively ($P<0.001$). Mean diarrhoea incidence during d0-42 was not affected by BW class, and averaged 3.68% and 4.67% for LW and HW piglets, respectively ($P=0.418$). Logistic regression did not further reveal an effect of BW class ($P=0.485$). There were no significant correlations between the latency time to eat and the average diarrhoea incidence for periods d0-14, d14-42 and d0-42, where correlations amounted to 0.05, 0.09 and 0.07, respectively.

Conclusion and implications

The results of this study show that body weight at weaning significantly influences the feed intake patterns of group-housed weaned piglets, but this does not result in decreased diarrhoea incidence.

Acknowledgements

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References

P1-27

Tissue enrichment of Zn using Methionine hydroxy analogue chelate or Zn amino acid complex using stable isotopes.

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Keywords: Trace mineral nutrition, swine.

Introduction
Zinc (Zn) is vital for critical physiological functions. Therefore, supplementation with more stable chemically bound sources can be an effective avenue to greater Zn availability. However, not all chemically bounded sources are equivalent. Zn stable isotopes in ruminants have shown that methionine hydroxy analogue chelated Zn (MHAC) results in greater tissue Zn enrichment compared to Zn as Zn glycinate (Tucker and Provin, 2020). We hypothesize that MHAC Zn would result in greater Zn enrichment than Zn supplied from a non-specific amino acid complex (AAC). This experiment compared Zn enrichment in different tissues using stable isotopes, between Zn-MHAC and Zn-AAC in growing gilts.

Materials and methods
Twenty individually housed gilts (31.5 ± 2.8 kg of BW) were fed a common corn-soy-based diet (containing phytase) for a 28-d adaptation period. Total Zn in the diet was 41 mg/kg of Zn from ingredients and Zn sulfate. At d 28, gilts were moved to metabolism crates where 16 gilts were randomly selected to receive an oral Zn bolus containing 8 or 12 mg as a combination of Zn^{67} in the Zn-AAC form and Zn^{70} in the MHAC form. The remaining 4 pigs served as controls by receiving a placebo bolus used to determine naturally occurring abundance of Zn^{67} and Zn^{70}. Gilts were chosen as a proxy for reproductive and structural development. At 24-h after bolus administration, all pigs were euthanized, and tissues harvested. Zn isotope enrichment was calculated as the difference in isotope abundance resulting from mineral sources and naturally occurring abundance. Data were analyzed as a 2×2 factorial (mineral source×dose) using the PROC MIXED procedure of SAS.

Results and discussion
There were no interactions between mineral source and dose (P > 0.100). The results showed that gastrointestinal and central metabolic tissues, including stomach, duodenum, jejunum, ileum, pancreas, liver, and kidney, demonstrated greater enrichment from Zn-MHAC than Zn-AAC (P < 0.05; **Figure 1**). When tissues associated with reproductive function were evaluated, ovary showed no differences in Zn enrichment between Zn-MHAC and Zn-ACC (P = 0.836). However, greater enrichment from Zn-MHAC was observed in the uterus (P = 0.002). For structural musculoskeletal tissues Zn-MHAC tended to have a greater enrichment of the hoof matrix (P = 0.097) and a numerical difference of metacarpal bones (P = 0.257) compared to Zn-AAC. Immune tissues, including thymus (P < 0.001) and spleen (P = 0.017), demonstrated greater enrichment from Zn-MHAC than Zn-AAC. The average ratio across tissues showed that enrichment of Zn from MHAC was 1.5 times the enrichment of Zn from ACC.

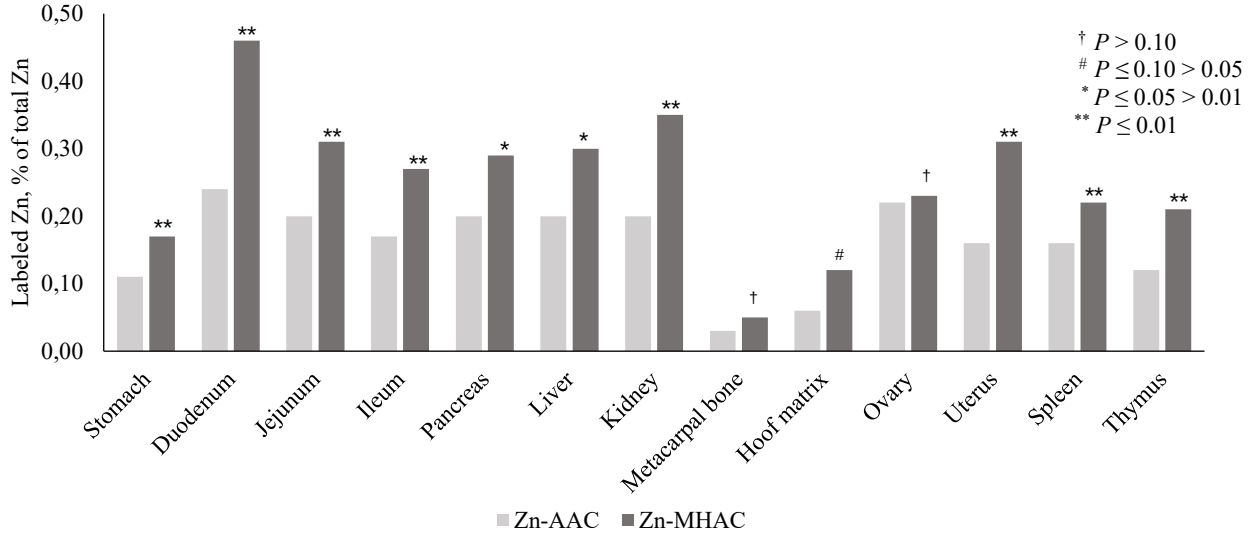

Figure 1. Relative tissue enrichment from an oral dose of Zn in organs and tissues between Zn-AAC and Zn-MHAC.

Conclusion and implications
Zinc from MHAC was more effective enriching tissues than Zn from AAC. The delivery of Zn to tissues might account as differential to the response to Zn source supplementation.

References
Tucker, H.A. and A. Provin. 2020. Benefit of Zn methionine hydroxy analogue chelate to increasing tissue enrichment with dietary antagonism in Holstein calves. J. Dairy Sci. 104 (Suppl. 1) W81.

P1-28

Zinc oxide impairs the phytase matrix for phosphorus and calcium in post-weaning pig: a meta-analytical approach

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Introduction
The use of microbial phytase has increase in commercial pig production since the first introduction in 1991 to degrade the phytic phosphorus (PP), the first form of phosphorus (P) storage in plant feedstuff (Sauvant et al., 2004) and has gain in interest in the last decade in post-weaning pig also for its extra-P effect. The P matrix values of a phytase provide the nutritionist with information about how much inorganic P can be replaced by a phytase in the feed. However, some factors are known to modulate the PP liberation by microbial phytase (Maenz et al., 1999), such as zinc (Zn) and can thus altering the matrix values. The objective of this study is thus to quantify the impact of Zn on the efficacy of phytase in releasing P and Ca.

Materials and Methods
From a systemic literature search conducting in July 2023 a database has been constructed with 16 publications reporting 47 treatments published between 1994 and 2021. The experimental treatment containing more than 5000 FTU/kg were excluded. The nutritional composition of the diet was recalculated from ingredient table (Sauvant et al., 2004) and the Acid Binding Capacity (ABC) based on available literature (Lawlor et al., 2005; Stas et al., 2020). The meta-design was examined carefully taken variables two by two. The dependent variables were the digestible P and Ca (g/kg diet), obtained with the apparent total tract digestibility of P and Ca (ATTD P, ATTD Ca) multiplied by total dietary P, and Ca and the independent variables PP, Non-Phytate P (NPP), microbial phytase (PHYTM), Zn, ABC, and dietary Ca. The meta-analysis was conducted using a mixed effect of the experiment in R software.

Results and discussion
Dietary P contributed 0.53 g/kg of digestible P to the feed ($P<0.001$; $R^2=0.92$; RMSE=0.280). The PHYTM increased the digestible P linearly ($P<0.001$) and quadratically ($P<0.001$). Without phytase, the Zn reduced the digestible P ($P<0.001$) and negative interaction between PHYTM and Zn was found ($P=0.001$) showing that in a feed containing 6.5 g/kg P and 1000 FTU/kg PHYTM, the amount of digestible P was 4.01 g/kg with 100mg/kg Zn and only 3.43 mg/kg with 3000 mg/kg Zn. In a second model ($R^2=0.95$; RMSE=0.245), the variable Zn was replaced by ABC value as they are colinear. Dietary P contributed to 0.64 g/kg of digestible P ($P<0.001$) and phytase improve the digestible P with a linear ($P<0.001$) and quadratic component ($P<0.001$). The ABC value decrease the P digestibility ($P<0.001$) and tend to decrease the phytase efficacy ($P=0.07$).
For Ca, PP reduced digestible Ca (g/kg) by 1.97 ($P<0.001$; $R^2=0.96$; RMSE=0.258). Dietary Ca provided 0.52 g/kg of digestible Ca in the feed ($P<0.001$). PHYTM also improved Ca digestibility linearly ($P<0.001$) and quadratically ($P<0.001$). Dietary Zn tended to increase Ca digestibility ($P = 0.08$), and a negative interaction was found between PHYTM and Zn ($P<0.001$); a feed containing 7.5 g/kg Ca and 1000 FTU/kg PHYTM, and 100mg/kg Zn provided 4.41 g/kg digestible Ca whereas it provided 4.15 mg/kg with 3000mg/kg Zn.
The results showed that high Zn inputs reduced the amount of digestible P and Ca both without and with phytase addition. In vitro, Zn reduces PP degradation by reducing phytase efficiency via the strong complexing power of Zn on PP (Champagne and Fisher, 1990). The high buffering capacity in the form of ZnO (Stas et al., 2022), the main source of Zn used in post-weaning, reduces both the solubilization of PP required for its degradation by phytase through its pH-dependent activity of the enzyme (Philippi et al., 2023). Without phytase, the reduce P digestibility can be explained by the formation of Zn-PP complexes in the small intestine preventing the brush border phytase action.

Conclusions and implications
In conclusion the presence of pharmacological of ZnO reduces the phytase efficacy but no effect was observed at European level of 150 mg of Zn /kg of diet. The inclusion of supra-nutritional levels of Zn in the diet change the phytase matrix and must be taken in account in countries where it is still use.

References
Champagne, E. T., and M. S. Fisher. 1990. Binding differences of Zn(II) and Cu(II) ions with phytate. J Inorg Biochem. 38:217–223. doi:10.1016/0162-0134(90)84014-G.
Maenz, D. D., C. M. Engele-Schaan, R. W. Newkirk, and H. L. Classen. 1999. The effect of minerals and mineral chelators on the formation of phytase-resistant and phytase-susceptible forms of phytic acid in solution and in a slurry of canola meal. Anim Feed Sci Technol. 81:177–192. doi:10.1016/S0377-8401(99)00085-1.
Philippi, H., V. Sommerfeld, W. Windisch, O. A. Olukosi, A. Monteiro, and M. Rodehutscord. 2023. Interactions of zinc with phytate and phytase in the digestive tract of poultry and pigs: a review. J Sci Food Agric. 103:7333–7342. doi:10.1002/jsfa.12879
Sauvant, D., J.-M. Perez, G. Tran, Institut national de la recherche agronomique (France), and Association française de zootechnie. 2004. Tables de composition et de valeur nutritive des matières premières destinées aux animaux d'élevage : porcs, volailles, bovins, ovins, caprins, lapins, chevaux, poissons. Hors Collection. (Inra, editor.).
Stas, E. B., M. D. Tokach, J. M. Derouchey, R. D. Goodband, J. C. Woodworth, and J. T. Gebhardt. 2022. Evaluation of the acid-binding capacity of ingredients and complete diets commonly used for weanling pigs. Translational Animal Science. 6:1–9. doi:10.1093/tas/txac104. Avai;lable from: https://doi.org/10.1093/tas/txac104

P1-29

Application of Tonisity Px improves pre-weaning mortality in a high-productive sow farm

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Background and objectives - Improving intestinal health in piglets is important to achieve optimal productivity in the farrowing house. During the suckling period, a substantial amount of good, but small piglets die in a runt condition. An isotonic protein-electrolyte solution (Tonisity Px; Tonisity International) has the characteristics of being highly palatable as well as providing key amino acids for support of intestinal function. It was hypothesized providing 500 mL of 3% Px solution to each litter from day 2 to 8 in the farrowing room could result in improved survival to weaning.

Materials and methods - The study was performed on a farrow-to-finish sow herd using 4-week batch-management system and weaning at 21 days of age. A total of 147 sows and their respective litters were enrolled in the study and randomized in two groups (Control, Px). The piglets in the Px group received 500 ml of a 3% Px solution daily from day 2 to 8 (7-day treatment). The number of piglets at d2 (start of Px treatment), at d9 (end of Px treatment) and at weaning was recorded. Mortality in period 1 (P1; 2-8 days), period 2 (P2; 9-19 days) and overall mortality (2-19 days) were calculated. Data was analyzed in JMP 15.0.

Results – At day 2 and 9, no significant difference in the number of piglets was observed between the Control and Px groups. However, at day 19, the number of piglets in the Px group was significantly higher as compared to the Control group. Mortality in P1 was slightly higher (P = 0.30) in the Control (4.5%) as compared to the Px group (3.9%), meaning a 12.7% reduction in mortality during the Px treatment. Mortality in P2 was significantly higher (P = 0.03) in the Control (2.9%) as compared to the Px group (1.8%), which resulted in a 37.9% reduction in mortality. Overall mortality reduced significantly by 22.9% in the Px group (5.7%) as compared to the Control group (7.4%) (P = 0.02).

Discussion and conclusions – Tonisity Px administered from day 2 to 8 in the farrowing room resulted in a reduced overall mortality of 22.9% in the Px group.

P1-30

By-product of fungal fermentation maintains growth performance and carcass characteristics of grower-finisher pigs fed a low crude protein diet

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***Keywords*:** amino acids, carcass quality, fungal fermentation, growth performance, pig

Introduction
Long-term sustainability strategies in swine production aim to reduce excess supply of amino acids (**AA**), reduce protein fermentation, and minimise nitrogen excretion and emissions. Therefore, feed ingredients that increase the feeding value of diets warrant study. By-products of fungal solid-state fermentation (**SSF**) with residual enzymatic activity can be used to increase nutrient digestibility and animal performance. The hypothesis of the present study was that grower-finisher pigs fed a low crude protein (**CP**) diet containing a by-product of fungal SSF would not differ in growth performance and carcass characteristics compared to pigs fed the same low CP diet supplemented with crystalline AA. The objective was to evaluate the effect of a by-product of fungal SSF in a low CP diet on growth performance and carcass characteristics in grower-finisher pigs.

Material and methods
200 pigs were fed rye-barley-wheat based diets containing variable amounts of crystalline AA (Lys, Met, Thr, Trp, Val, Ile) in three feeding phases for 89 days (Grower I, day 1-36; Grower II, d 37-61; Finisher, day 62-89). The two dietary treatments differed as follows: 1) control, precaecal (**pc**) digestible AA content meeting the requirements for 850 g, 1050 g, and 1000 g average daily gain (**ADG**) in the phases Grower I, Grower II, and Finisher according to the Gesellschaft für Ernährungsphysiologie (GfE, 2008); 2) MAXFERM/Pro, pc digestible AA content 8% (Lys) to 20% (Ile) below the requirements supplemented with 500 ppm by-product of fungal SSF (*Aspergillus niger*, *Aspergillus tubingensis*, *Neurospora intermedia*, *Neurospora tetrasperma*; Provita Supplements, Germany). Diets were formulated to provide 13.1, 12.9, and 12.7 MJ metabolizable energy/kg in the phases Grower I, Grower II, and Finisher. Data were analysed by one-way ANOVA and differences among least squares means with $P \leq 0.05$ were considered significant.

Results and discussion
Average daily feed intake (**ADFI**), ADG, and feed conversion ratio (**F:G**) of pigs did not differ ($P > 0.05$) between control and MAXFERM/Pro for each feeding phase and the entire trial (Table 1). There was also no difference ($P > 0.05$) in carcass weight and lean meat content between the two treatments. The SSF is the cultivation of a microorganism (e.g., fungus) on moist substrate. A broad spectrum of enzymes can be produced by SSF such as cellulase, xylanase, amylases, and phytases, depending on substrate and fungi used (overview in Graminha et al., 2008). The residual enzymatic activity of the by-product of fungal SSF might have increased dietary fibre digestion and fermentation by the gut microflora affecting changes in the physicochemical properties of fibre (Zjlstra et al., 2012). Thus, the by-product of fungal SSF might have improved diet nutrient digestibility, especially of AA, maintaining growth performance and carcass characteristics. Further studies are needed to assess the effect of the by-product of fungal SSF on diet nutrient digestibility and the gastrointestinal microbiota.

Table 1. Growth performance and carcass characteristics of fattening pigs fed low CP diets either supplemented with crystalline amino acids or by-product of fungal SSF.

	Initial body weight, kg	ADFI (g/d)	ADG (g/d)	F:G (g/g)	Final body weight, kg	Carcass weight (kg)	Lean meat content (%)
Control	30.2	2408	925	2.75	112.5	91.5	57.1
MAXFERM/Pro	30.2	2399	922	2.75	112.3	91.9	56.6
pooled SEM	0.49	13.53	19.10	0.05	1.82	1.29	0.45
P-value	0.972	0.543	0.850	0.950	0.900	0.759	0.289

Conclusion and implications
In conclusion, supplementing a low CP diet with a by-product of fungal SSF maintained the growth performance and carcass characteristics of grower-finisher pigs compared to the supplementation of crystalline AA. Grower-finisher pigs can be fed 500 ppm of a by-product of fungal SSF in diets formulated below the AA requirements without reducing growth performance.

References
GfE. 2008. Recommendations for the supply of energy and nutrients to pigs. Frankfurt am Main: DLG-Verlag.

Graminha, E. B. N., A. Z. L. Gonçalves, R. D. P. B. Pirota, M. A. A. Balsalobre, R. da Silva, and E. Gomes. 2008. Enzyme production by solid-state fermentation: Application to animal nutrition. Anim. Feed Sci. Technol. 144:1–22. doi:10.1016/j.anifeedsci.2007.09.029.

Zijlstra, R.T., R. Jha, A. D. Woodward, J. Fouhse, and T. A. T. G. van Kempen. 2012. Starch and fiber properties affect their kinetics of digestion and thereby digestive physiology in pigs. J. Anim. Sci. 90:49–58. doi:10.2527/jas.53718

P1-31

Energize for success: The vital role of butyric acid as energy source for the enterocyte on post weaning performance.

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Key Words:
Weaning performance, slow release encapsulated butyrate, intestinal health,

Introduction
Post-weaning in pigs prompts a temporary decrease in feed intake, causing undernutrition and growth stunting. This affects small intestinal structure and function, often leading to gut disorders like diarrhoea, marked by villus atrophy and reduced enzyme activity (Lallès et all. 2004). Rapid intestinal recovery is crucial for pig performance, as the mucosa serves as both a defence barrier and nutrient absorber. Energy availability, especially from butyric acid, fuels intestinal cell growth and migration, promoting epithelial development for improved health and performance.
The objective of this trial was to evaluate the effect of an encapsulated butyrate with slow release technology on the performance of the weaned piglet.

Material and methods
240 weaned piglets (both genders), averaging 23 days old and weaning weight of 6.7 kg, were divided into two groups: Control (C) and Encapsulated Butyrate Slow Release (EBSR) - ButiPEARL^{TM} Kemin Industries. Each group comprised 120 piglets, with 10 replicates (pens) of 12 piglets each, based on gender and weight. The study had 2 phases: Pre-starter 1 (24-31 days), Pre-starter 2 (32-38 days). Diets were tailored to meet the pigs' physiological requirements at each stage. Treatments were supplemented with encapsulated butyrate at 1000g/t and 750g/t for pre-starter 1 and pre-starter 2, respectively. At the end of all phases, weight and feed consumed were recorded. Tukey test was performed to compare all means using SAS software.

Results and discussion
During the pre-starter 1 phase, EBSR group had significant improvements on Average Daily Gain (ADG g/d), 235g/d vs 192g/d ($p<0.01$), Average Daily Feed Intake (ADFI g/d), 297g/d vs 278g/d) $p<0.05$) and Feed Conversion Rate (FCR) 1.28 vs 1.47 ($p<0.01$) for EBSR and C group. In addition, at the end of the phase, piglets in EBSR were significantly heavier (8.42 kg vs 8.12 kg $p<0.01$ for EBSR and C respectively). During the second phase – pre starter 2, EBSR group had a significant improvement on ADG (EBSR=301g/d vs C=276g/d $p<0.05$) and ADFI (EBSR=400g/d vs C=383g/d $p<0.05$).

Conclusion and implications
Weaning presents significant stressors for piglets, leading to reduced feed intake, compromising intestinal health, inducing inflammation, and impairing intestinal growth and adaptation post-weaning. The initial intake during this phase crucially impacts the piglet's future, underscoring the importance of maximizing feed intake the piglet. At a standardized weight of 8.42kg following pre-starter 1. The C group will require 2.52 kg of feed, whereas the EBSR group achieved the same weight with 2.2 kg, indicating a 0.32kg feed reduction per piglet. Considering the higher cost of initial diets in production cycles, these findings suggest substantial cost savings for farmers, even though they are the less used diets, whilst increasing performance and efficiency.
Administering Butyrate to intestinal cells significantly facilitated adaptation during the post-weaning phase, resulting in enhanced growth and improved feed conversion. This enhancement stemmed from better nutrient absorption attributed to improved intestinal integrity.

References
Lallès J. 2004. Physiology. Anim. Res. 53:301–316.

P1-32

Influence of acid binding capacity and acidification on diarrhea occurrence and performance in weaned piglets

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Introduction

The gastrointestinal tract of piglets is not fully developed at the time of weaning and does not produce enough hydrochloride in the stomach to digest nutrients with high acid-binding capacity (ABC) and inhibit the growth of bacteria in the intestine. While minerals have the highest ABC values, organic acids reduce the ABC of a diet. A lower ABC in the feed counters an undesirable increase in pH in the stomach and can have a positive effect on growth performance and intestinal health.

Material and Methods

Two basal diets, each with and without buffered formic acid (4 feed diets), were fed ad lib. to 24 weaned piglets (6 pens) per treatment to evaluate the impact on intestinal health and performance. In addition, drinking water was offered with (to achieve pH 4.3) or without addition of an organic acid mixture, based on formic- and propionic acid, resulting in a total of 8 different treatments. The piglets were housed starting with 8 kg and fed pre-starter feed for 2 weeks followed by starter feed for 4 weeks. Feed intake per pen and individual body weights were recorded weekly. The microbial content of drinking water samples were analyzed. Fecal consistency was evaluated using a 5-point scoring system. The feed diets were based on wheat, soybean meal, corn, and barley. The feed acid-supplemented groups received 0.8% buffered formic acid (Amasil NA).

Results and discussion

The reduction of ABC was achieved by replacing soybean meal with wheat, as well as reducing calcium and phosphorus-providing components and by replacing MCP with DCP. As a result, the crude protein content of the ABC-low pre-starter diet was 2.4% and the starter diet was 1.8% below the protein content of the ABC-high diets, and the phosphorus content was reduced by about 0.2%, and the calcium content by 0.24% (pre-starter) or 0.09% (starter). This, as well as the addition of ABC-reducing feed acid, is also reflected in the analytical results of the ABC of the four different feed diets overall (table 1).

Table 1: Analyzed nutrient levels (in % feed original substance) of pre-starter and starter

	PRE – STARTER				STARTER			
ABC	ABC – high ↑		ABC – low ↓		ABC – high ↑		ABC – low ↓	
Feed acid	-	+0.8%	-	+0.8%	-	+0.8%	-	+0.8%
Crude protein	21.7		19.3		20.0		18.2	
Total phosphorus	0.64		0.44		0.62		0.41	
Total calcium	0.98		0.74		0.73		0.64	
ǂ ABC -3 (mmol/kg)	800	750	665	660	725	750	630	650
ǂ ABC -4 (mmol/kg)	595	515	495	445	540	520	460	450

The amount of acid required to lower the pH value to the endpoint of ǂpH 3 or ǂpH 4 for 1 kg of feed during titration

Table 2: Two-factorial effects of the treatments on performance parameters, different capital letters indicate a significant difference within a statistical analysis, $p<0.05$.

Feed	**Acidification**		**Daily weight gain (g/day)**			**Feed intake (g/day)**			**Feed conversion ratio (1:)**		
ABC	feed	water	prestarter	starter	total	prestarter	starter	total	prestarter	starter	total
ABC feed (main effect)											
High ↑			213	637	495	236	871	658	1.21	1.40	1.38
Low ↓			174	535	415	209	733	551	1.35	1.42	1.41
Acidification (main effect)											
	-	-	148^{a}	541^{a}	410^{a}	188^{a}	722^{a}	540^{a}	1.41^{b}	1.41	1.42
	x	-	219^{b}	614^{b}	481^{bc}	234^{ab}	839^{b}	630^{b}	1.21^{a}	1.40	1.37
	-	x	170^{a}	574^{ab}	439^{ab}	207^{a}	776^{ab}	583^{ab}	1.34^{ab}	1.41	1.41
	x	x	237^{b}	619^{b}	492^{c}	261^{b}	870^{b}	665^{b}	1.15^{a}	1.42	1.38

The reduction of ABC resulted in a nominal decrease in performance (not statistically significant). Overall, the addition of 0.8% feed acid, regardless of the ABC (low/high), led to a 17% increase in feed intake and a 17% increase in daily weight gain at the same feed conversion ratio (FCR). In the pre-starter phase, the feed acid reduced the FCR by 14% (table 2). This effect was particularly evident in the ABC high feed. The combination of acidification of drinking water and feed did not show a confirmed additional effect, but the microbial content in the water was reduced by at least half. Diarrheal diseases in a pen were more frequent in treatments without feed acid in the 3rd and 4th week of the experiment.

Conclusion and implications

ABC is an important tool in the diet formulation of piglet feed to relieve the still developing digestive system. A moderate reduction of ABC with simultaneous administration of feed acid can have advantageous effects on performance and piglet health.

P1-33

Review of the effect of *Saccharomyces cerevisiae* Sc47 supplementation in sows on reproduction performance under commercial conditions

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Keywords: yeast, probiotic, reproduction, meta-analysis

Introduction

Sustainable pig production is characterized by economic profitability through the improvement of productive output, while maintaining good animal health and welfare, and without compromising environmental resources. Actisaf® Sc47 (Phileo by Lesaffre, France) is a yeast probiotic available on the market (hereafter named yeast Sc47). It has been shown to provide health benefits by successfully modulating the pig microbiota (Kiros et al., 2018), helping improve feed digestibility (Kiros et al. 2019), controlling pathogen pressure (Trckova et al., 2014), and offering immunomodulatory benefits (Zanello et al., 2013). This review aimed to summarize the recent field experience with yeast Sc47 supplementation of sows during late gestation and through lactation on reproductive performance under commercial conditions.

Material and methods

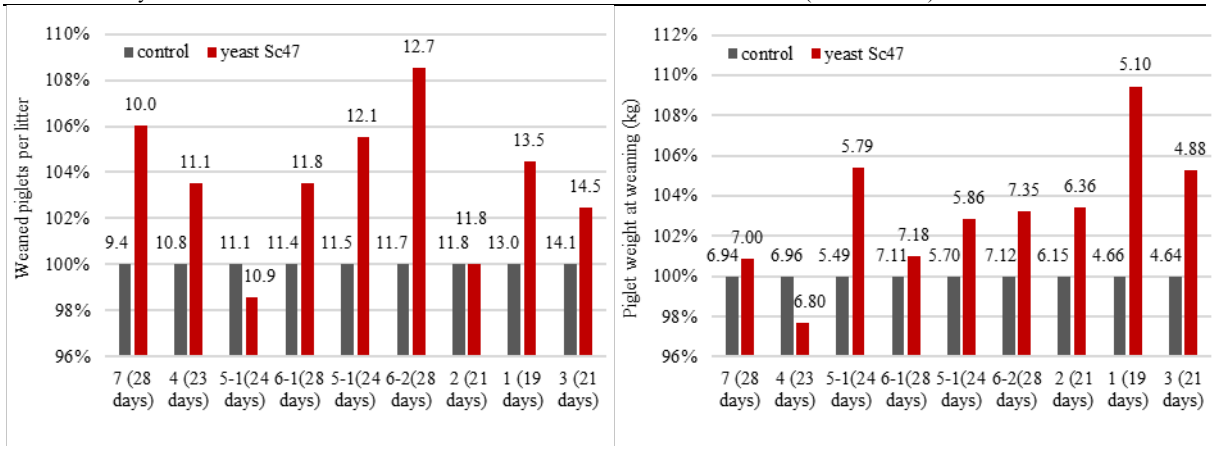
The review was performed in Phileo by Lesaffre trial central database. Field randomized trials or historical production data records where a yeast Sc47 supplementation during the last month of gestation until weaning was tested, were selected. Only studies for which the experimental conditions could be verified, considered reliable and performed by independent research teams were taken into consideration. Parameters recorded in an insufficient number of studies or for which no variability was available were excluded. The statistical model included the fixed effect of the treatment (yeast Sc47 or control), the random effect of the trial and the block effect of the breeding cycle. Size effect was calculated by mean difference with 95% confidence interval (CI). Heterogeneity among studies was estimated by I^2 value. The studies which drived a significant part of overall heterogeneity were removed from the analysis (Higgins and Thompson, 2022). The statistical analysis was conducted using the R package meta from R software (version 4.0.3) (Balduzzi et al., 2019).

Results

Among the 7 selected trials, 6 were randomized trials and 1 was a historical data record. Two of the randomized trials were performed on two consecutive breeding cycles of the same animals. The trials involved more than 3,000 weaned litters. The meta-analysis showed that administering yeast Sc47 to sows during the las month of gestation and through lactation resulted in an increase of 0.30 piglets weaned per litter. Live yeast Sc47 supplementation also led to 230g higher individual bodyweight and 4.12 kg heavier litters at weaning (Table 1).

Table 1. Reproductive performance of sows supplemented with yeast Sc47 during late gestation and thorough lactation over 7 field trials

Parameter	Number of studies included	Mean Difference (with 95% CI)	P-value
Total born per litter	7	+0.20 (-0.32 to + 0.72)	0.45
Born alive per litter	8	+0.56 (+0.14 to +0.99)	0.009
Weaned per litter	9	+0.30 (+0.27 to +0.33)	<0.001
Average litter weight (kg)	7	+4.12 (+1.89 to +6.35)	<0.001
Average piglet weight (kg)	6	+0.23 (+0.09 to +0.36)	<0.001
Number of days of lactation	4	-0.84 (-1.19 to -0.50)	<0.001



Figures. Effect of Sc47 on number of weaned piglets (left) and piglet average weaning weight (kg) (right) born to sows supplemented during the last month of gestation and the lactation period. Labels denote distinct testing sites, with sites 5 and 6 undergoing two consecutive reproductive cycle assessments. Results are sequenced according to ascending order of the number of weaned piglets. Lactation duration is noted between parentheses.

Conclusion

Supplementing sow diets with live yeast Actisaf® Sc47 from the end of the gestation period increased the reproductive performance of sows, which contributes to the overall sustainability of pig farming.

References

Balduzzi, S., Rücker, G.,Schwarzer, G. (2019) How to Perform a Meta-Analysis with R: A Practical Tutorial. BMJ Mental Health, 22, 153-160.
Kiros, T. G., Derakhshani, H., Pinloche, E., D'Inca, R., Marshall, J., Auclair, E., Khafipour, E., Van Kessel, A. (2018). Effect of live yeast Saccharomyces cerevisiae (Actisaf Sc 47) supplementation on the performance and hindgut microbiota composition of weanling pigs. Scientific reports, 8(1), 5315.
Kiros, T. K., Agyekum, A. K., Wang, J., D'Inca, R., Beaulieu, D. A., Auclair, E., Van Kessel, A. G. (2019). Supplementation with live yeast increases rate and extent of in vitro fermentation of nondigested feed ingredients by fecal microbiota. Journal of animal science, 97(4), 1806–1818.
Higgins, P.T.J. and Thompson, S.G. (2022) Quantifying Heterogeneity in a Meta-Analysis. Statistics in Medicine, 21, 1539-1558.
Trckova, M., Faldyna, M., Alexa, P., Sramkova Zajacova, Z., Gopfert, E., Kumprechtova, D., Auclair, E., D'Inca, R. (2014). The effects of live yeast Saccharomyces cerevisiae on postweaning diarrhea, immune response, and growth performance in weaned piglets. Journal of animal science, 92(2), 767–774.
Zanello, G., Meurens, F., Serreau, D., Chevaleyre, C., Melo, S., Berri, M., D'Inca, R., Auclair, E., & Salmon, H. (2013). Effects of dietary yeast strains on immunoglobulin in colostrum and milk of sows. Veterinary immunology and immunopathology, 152(1-2), 20–27.

P1-34

Full title: The impact of *Bacillus*-based probiotics on reducing ammonia emissions in grower-finisher pigs

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Introduction: Swine industry economics are as volatile today as they ever have been. Furthermore, the environmental impact of pig farming is evident and there is a high global need to mitigate the issue. The main factors influencing environmental pollution are feeding as well as handling, storage, and utilization of slurry. Ammonia is one of the major pollutants in the production of pigs with dietary nitrogen being the main precursor of ammonia production (Canh 1998). Maximizing the efficiency of protein degradation is key when it comes to limiting nitrogen losses. Previous internal and research studies have shown that administration of the dual strain *Bacillus*-based probiotic, BioPlus® YC, ensures great protease activity, influencing the breakdown of proteins and thus the digestibility and retention of nitrogen (Jørgensen et al. 2016). Therefore, the objective of this study was to evaluate the impact of administrating this probiotic product to grower-finisher pigs on emission of ammonia.

Material and methods: Healthy grower pigs were allocated to 2 treatments (T1: Control and T2: Probiotic, BioPlus® YC: 1.28E+09 CFU per kg/feed) of 48 replicate pens/treatment balanced for body weight and sex. Each pen held 6 pigs, entire males or females. The study comprised 2 batches of pigs with batch 1 running from June to September and batch 2 from November to February. Each batch was housed in 4 rooms with 12 pens and each room contained either Control or Probiotic treatment (2 rooms/treatment group/batch). Pigs were fed dry, pelleted feed *ad libitum* during the grower period from day 1 to 41 and during the finisher period from day 42 to day 80 at first delivery to slaugther. Emission of ammonia (mg/m3) was measured with a photoacoustic gas monitor every 15 minutes during the entire study period. The result of ammonia emission is presented as kg (of gas) per place and year and was analyzed using a General Linear Model (in SAS 9.4) with treatment as fixed factor and batch and time as random factors.

Results and discussion: During the full grower-finisher period, ammonia emitted was significantly lower in rooms housing pigs administrated with the probiotic (Figure 1) (-7%). The emission of ammonia was highest during wintertime (batch 2) (1.0 kg ammonia/place & year) compared with summertime (batch 1) (0.7 kg ammonia/place & year) ($P < 0.05$) and highest during the finisher period (1.0 kg ammonia/place & year) compared with the grower period (0.6 kg ammonia/place & year) ($P < 0.05$).

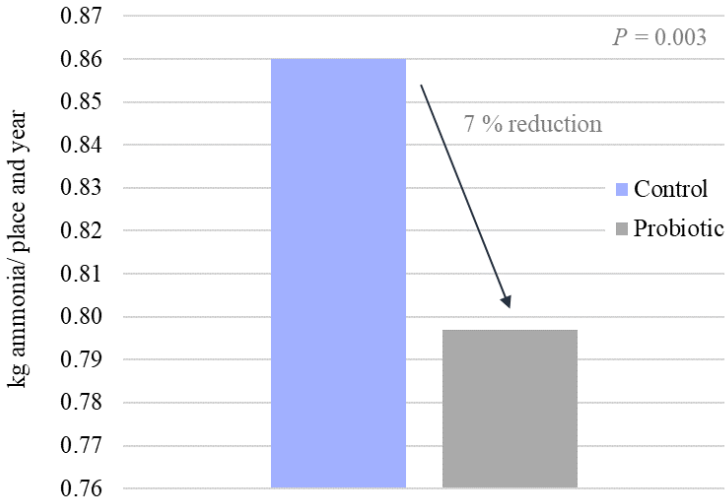

Figure 1. Emission of ammonia (kg/place and year) in rooms housing grower-finisher pigs receiving a control diet or rooms housing pigs receiving a diet with the *Bacillus*-based probiotic.

Conclusion and implications: Initial studies indicate that the *Bacillus*-based probiotic, BioPlus® YC, can enhance nitrogen retention. This study confirms our hypothesis that administering the probiotic product to grower-finisher pigs reduces emission of ammonia, likely due to enhanced utilization of dietary protein. Ultimately, probiotic application can help reduce the environmental impact of pig farming.

References:

Jørgensen, J. N., Laguna, J. S., Millán, C., Casabuena, O., & Gracia, M. I. (2016). Effects of a Bacillus-based probiotic and dietary energy content on the performance and nutrient digestibility of wean to finish pigs. Animal Feed Science and Technology, 221, 54-61.

Canh, T. T. (1998). Ammonia emission from excreta of growing-finishing pigs as affected by dietary composition. Wageningen University and Research.

P1-35

The use of calcium humophosphate improves the sustainability of pig feed while maintaining performances

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Key words: Phosphorus ; sustainability ; phytic acid ; calcium humophosphate ; piglet

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I- Introduction

Phosphorus (P) is an essential nutrient in animal nutrition with key roles in skeleton structure, energy metabolism and oxygen delivering. Being below P requirements in swine nutrition leads to decreased animal performances and increased economic losses. There are different sources of P in the diet, and usually inorganic **phosphate** supplementation is needed but it may increase total feed costs. The **sustainability** of this supplementation also represents a key challenge, and **phosphorus** emissions in the environment must be controlled. To answer those challenges, feed industry uses phytase to valorize phosphorus from **phytic acid**, allowing to reduce inorganic feed phosphate incorporation. In the small intestine, with a pH higher than in the stomach, phytic acid has the capacity to bind with cations and protein, forming very stable complexes and decreasing their availability as well as of its own P. **Calcium (Ca)** is one of the cation with the best affinity with phytic acid, making it a major anti-nutritional factor (Woyengo and Nyachoti, 2013). **Calcium humophosphate** (CHP ; P=21.6% ; Ca=15%), recently patented, is made of phosphoric acid, calcium carbonate and humic substances. It may have the capacity to bind with Ca, reducing its antinutritional effect towards phytic P, and thus improving its digestibility. Thanks to this mode of action, **the incorporation of inorganic phosphate can be reduced**, while maintaining production performances. In addition, **humic substances**, well described in the literature, show benefits on gastrointestinal tract health (microbiota, intestinal structure and binding capacities) (de Lourdes Angeles *et al,* 2022) and on diarrhea (Trckova *et al*, 2015). Therefore, CHP could represent a good solution to improve the **environmental and economical sustainability** of the animal industry.

II- Material and methods

A total of 468 healthy weaning piglets [(LD x LW) x DUROC], with an average initial body weight of 5.79 ± 0.92 kg, were involved for a 37 days trial. At weaning, piglets were classified by body weight, distributed into pens of 13 animals (gender mix with the same ratio males/females in each department) and randomly housed in the 36 experimental pens. The animals were divided into two groups (18 replicates/group). The first group was supplemented with a standard dose of monocalcium phosphate (MCP; P=22% ; Ca=16.5%), and the second group was supplemented with calcium humophosphate (CHP). The phosphorus digestibility coefficient assigned to **MCP was 83% and 102% for CHP, leading to a lower phosphorus incorporation for CHP**. Weight (three days after weaning and at the end of experiment), feed intake, average daily weight gain (ADWG), feed conversion ratio (FCR) and mortality were monitored during the experiment. In addition, **fecal diarrhea incidence** was followed during the first 20 days, and fecal samples were taken on the last day to analyze **phosphorus emissions**.

III- Results and discussion

The following table presents the main results:

Table 1. Performances, diarrhea rate, mortality and P in feces

Group	MCP (N=234)	CHP (N=234)	p-value
Weight at D0 (kg)	5.798	5.790	NS
Weight at D37 (kg)	21.649	21.715	NS
ADWG (g)	429	430	NS
FCR	1.36	1.35	NS
Mortality (%)	1.282	0	NS
Diarrhea rate (%) (11-18 day)	22.4	10.5	**<0.05**
P in feces (% dry matter)	0.958	0.889	NS

All performance parameters are not impacted by the use of CHP, despite the decrease in phosphate incorporation and total phosphorus in the diet. Diarrhea rate has been significantly decreased, thanks to the properties of the specific organo-mineral complex of CHP.
P in feces was numerically decreased by **7.2%** while we were expecting a theoretical reduction of 10%. However, this parameter presented a high variability, which can be explained by the sampling methodology. An increase of the consecutive days of fecal sampling number could have improved it.

IV- Conclusions and implications

Piglets supplemented with calcium humophosphate at a lower dose didn't show any difference on piglets growth performances. We can assume that CHP fulfils its role and encourage the absorption of phytic acid **phosphorus**, working in synergy with phytase. Results on **phosphorus emissions** are promising and may represent a positive effect of CHP on the environment. In addition, a new hypothesis emerges: CHP may favor a good gut health, allowing a reduction in diarrhea.
CHP supplementation reduces the incorporation of total phosphorus in the diet, while maintaining the same performances and allowing a beneficial action on gastrointestinal tract. CHP is a lever of action to improve the **economic and environmental sustainability** of pig farming.

V- References

WoyengoT. A. and NyachotiC. M.. 2013. Review: Anti-nutritional effects of phytic acid in diets for pigs and poultry – current knowledge and directions for future research. Canadian Journal of Animal Science. 93(1): 9-21

de Lourdes Angeles M, Gómez-Rosales S, Téllez-Isaias G. 2022. Mechanisms of Action of Humic Substances as Growth Promoters in Animals [Internet]. Humus and Humic Substances - Recent Advances.

Trckova M, Lorencova A, Hazova K, Sramkova Zajacova Z. 2015. Prophylaxis of post-weaning diarrhoea in piglets by zinc oxide and sodium humate

P1-36

Use of a clay and algae-based decontaminant on sows naturally exposed to mycotoxins in gestation and lactation.

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Mycotoxin contamination in pig feed is a recurring problem leading to chronic exposure of the animals, even when mycotoxin levels are below official recommendations (Alizadeh *et al.*, 2015). Deoxynivalenol (DON) and its derivates are among the main mycotoxins impacting pig production in Europe and the United States (Gruber-Dorninger *et al.*, 2019). This study evaluates the effect of a clay and algae-based mycotoxin decontaminant on the reproductive performance of sows exposed to chronic natural mycotoxin contamination from 35 days of gestation to weaning.
The sows (n=207) were divided in two groups: the control group received no mycotoxin decontaminant, and the test group was fed a diet supplemented with the decontaminant at a level of 1.5 kg/T of feed. The level of mycotoxins in the feed was measured by LC-MS/MS. The sows' body condition was evaluated on days 35 and 112 of gestation and at weaning, and sows were weighed on day 35 and at weaning. The farrowing performance was monitored (total born, born alive, stillborn piglets and mummies) and litters were weighed at 48h (after cross foster) and at weaning. Lactation performance (sows' feed intake, piglet mortality and morbidity, litter weights at weaning) was also evaluated.
A mean contamination of 956 ppb DON, 125 ppb 15-o-acteyl-DON, 338 ppb fumonisins B1 + B2 and 62 ppb zearalenone was reported in the feeds. Despite a comparable starting weight between the control and test groups at allotment ($P = 0.67$), sows in the test group had a higher weight than the control sows at entry in farrowing ($P < 0.01$), and a body condition score of 0.12 point higher ($P = 0.04$). Sows being limit fed in gestation, this indicates a better feed efficiency in the test group. A greater number of live-born piglets was observed in supplemented sows than in control sows (+4%; $P < 0.01$), as well as fewer mummified and stillborn piglets (-39%; $P < 0.05$ and -34%, $P < 0.01$, respectively). In contrast, no differences between groups were observed in the weight and growth of piglets before weaning ($P > 0.10$).
The results indicate that the decontaminant supplementation improves the body condition and farrowing performance of sows. This could be explained by a reduced impact of mycotoxins on feed efficiency (Andretta *et al.*, 2015). Contrary to expectations, based on previous studies (de Grave *et al.*2021) no differences in litters' performance were observed between the groups. This may be due to a marginally lower feed intake of lactating sows in the test group (not significant), or to a lower exposure to mycotoxins (DON in particular) in lactation than in gestation.
To conclude, this study shows that the tested decontaminant can improve the body condition and farrowing performance of mycotoxin-exposed sows at levels below current recommendations.

References:
Alizadeh A., Braber S., Akbari P., Garssen J., Fink-Gremmels J., 2015. Deoxynivalenol impairs weight gain and affects markers of gut health after low-dose, short-term exposure of growing pigs. Toxins, 7, 2071-2095.
Andretta I., Kipper M., Hauschild L., Lehnen C.R., Remus A., Melchior R., 2015. Meta-analysis of individual and combined effects of mycotoxins on growing pigs. Sci. Agr., 4, 328-331.
De Grave X.B., Saltzman J., Laurain J., Rodriguez M.A., Molist F., Dänicke S., Santos R.R., 2021. The ability of an algoclay-based mycotoxin decontaminant to decrease the serum levels of zearalenone and its metabolites in lactating sows. Front. Vet. Sci., 8, 704796.
Gruber-Dorninger C., Jenkins T., Schatzmayr G., 2019. Global mycotoxin occurrence in feed: a ten-year survey. Toxins, 11, 375.

P1-37

Experimental design: Effect of stocking density, extra feeder, sex, and animal distribution strategies on post-weaning piglets' performance

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Key words stocking density, round feeder, sex, weight category, piglet performance

Introduction Minimizing variation between experimental units is one of the foremost goals of conducting randomized controlled trials as reducing variability can lead to an increased likelihood of finding a statistically significant difference if one exists. There are numerous factors that can increase body weight (BW) variability during the nursery period, the largest of which are weaning weight and weaning stressors (Wellock et al., 2004). However, experimental design is perhaps the most influential method of reducing variability. A completely random allocation of piglets to the different pens, results in low variation between pens, but higher variation within a pen. Whereas, distributing pigs based on their BW category, results in lower variation within a pen (animals from similar BW result in less exclusion at the feeder, but more competition), but higher variation between pens. Moreover, other factors, such as sex (splitting males from females), extra round feeder (to help piglets find feed from the start and reduce competition with larger animals at the feed hopper) and stocking density (low vs high) can contribute to decrease this variation. Research that investigates techniques for formation of experimental units and their effects on statistical analysis are limited in the literature. Therefore, the trial aims to evaluate the effects of different factors, such as stocking density, the presence/absence of an extra round feeder, sex, and BW categories on post weaning piglet performance.

Material and methods A total of 1104 weaned piglets (6.41 ± 1.6 kg initial BW) were randomly distributed over 48 pens based on sex (n=24), BW category (n=8), stocking density (n=24), and with or without a Rotecna round feeder (n=24). First, all males and females were split. The BW category distribution strategy ranked pigs from each sex from lightest to heaviest and created 3 groups based on BW (small – medium – heavy) and each pen was randomly assigned pigs from only 1 weight category. Number of pigs per pen varied, either 20 (low stocking density – 03m²/pig) or 26 (high stocking density – 0.23m²/pig). All piglets were housed in 6 m² pens and had ad libitum access to a feed hopper (5 eating places) and a drinker throughout the entire evaluation period. A 3-phase (pre-starter, starter 1 and 2) feeding program was used on a 54-d trial period. Piglets were weaned at day 24. BW and feed intake was recorded at the start and end of each phase, to calculate the average daily gain (ADG), average daily feed intake (ADFI), and feed conversion ratio (FCR). Mortality and morbidity were recorded daily. Data were analysed using the General Linear Model procedure of JMP (version 17.0) with the pen serving as the experimental unit for all analyses. Mean values were calculated using LSM statement. P values of < 0.05 were classed as significant and those between 0.05-0.1 were considered trends. Significantly different means were separated using the Tukey's HSD post-hoc test.

Results and discussion Each of the experimental factors (stocking density, sex, round feeder, BW category) were considered as fixed factors in the model. No interactions were found. BW category had a significant effect on almost all performance parameters in all phases ($p<0.0001$), except for ADG ($p=0.0530$) and FCR ($p=0.1136$) in pre-starter period and overall mortality ($p=0.4708$). Small animals had significant lower final BW (20.59 – 24.06 – 26.49kg), ADG (275 – 308 – 330 g/a/d), ADFI (376 – 454 – 505 g/a/d- and higher FCR (1.37 – 1.48 – 1.53) compared to medium animals, and medium compared to heavy animals. A higher culling percentage (8.5 – 4.5 – 2.1%) was observed for the small BW piglets ($p=0.0001$). Sex significantly affected ADG in pre-starter ($p=0.0002$), starter 2 ($p=0.0496$) and overall period ($p=0.0107$), resulting in better overall growth for females than males (311 vs 297 g/a/d). Moreover, mortality was significantly lower in females compared to males ($p=0.0191$) (1.6 vs 3.6%). Providing an extra round feeder to the pens did not result in any differences on piglets' performance except for a significant reduced mortality ($p= 0.0048$) (1.4 vs 3.9%). Stocking density did not affect performance during the first 14 days of the trial (pre-starter period). The effect of an increased stocking density only became visual from phase 2 onwards (when animals get heavier and room is more restricted), resulting in an overall higher ADG (315.6 vs 292.6 g/a/d) and lower FCR (1.42 vs 1.50) for animals held at the low density ($p<0.0001$ and $p=0.0004$, respectively).

Conclusion and implications

As hypothesized, the various factors of experimental design had a significant effect on performance parameters. Unfortunately, pen uniformity was not monitored during this trial to draw conclusions on within pen variability, but between pen variability is shown to be highly affected by distribution methods in this research. Therefore, it is highly recommended to consider these factors when looking for differences in nutritional or dietary treatments.

References

Wellock, I. J., G. C. Emmans, and I. Kyriazakis. 2004. Modeling the effects of stressors on the performance of populations of pigs. J. Anim. Sci. 82:2442–2450. doi:10.2527/2004.8282442x.

P1-38

Full title

How copper can impact pig growth: comparing the effects of tribasic copper chloride and monovalent copper oxide on piglet performance after weaning

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Keywords: Copper sources, performance, piglet, weaning

Introduction

Copper (Cu), at high dietary levels, has been used for a long time as a growth promoter in different production animals. According to the literature, one of the mechanisms by which Cu can increase weight gain in weaned piglets is through improved gut health and microbiota modulation. Cu can be supplemented in the feed through various divalent sources (sulfate, chlorides, chelates, carbonates) or through a monovalent Cu source (CoRouge®). The effects of Cu on killing bacteria differ according to its redox state: the monovalent Cu form has a stronger antibacterial effect in anaerobic conditions than the divalent Cu (Popov et al., 2020). In vivo studies showed that monovalent Cu improved piglet performance compared to the sulfate source (Forouzandeh et al., 2022) due to its effect on intestinal microbiota, but evaluation versus other divalent sources remains to be tested. Assuming the mode of action of Cu is related to an improvement in microbiota modulation, we hypothesize that monovalent Cu can be supplemented at lower levels than the tribasic Cu chloride, due to the higher antibacterial properties of the monovalent form of Cu. The objective of this study was to compare two copper sources on piglet performance after weaning.

Material and methods

A total of 1189 piglets (PIC 800 x Fast 276) were weaned between 18 and 21 d of age. The trial started at 42d of age and lasted up to 63 d of age. Animals were selected based on their weight and allotted into 5 groups with 8 replicates/group and 30 piglets per group (barrows and gilts). Basal diet was based on corn, soybean meal, bakery by products, DDGS and choice white grease, with 1000 FTU of phytase included. The treatments were: NC, a negative control with 10 ppm of Cu supplemented on the premix ($CuSO_4$); PC, a positive control with 150 ppm of Cu by tribasic Cu chloride (TBCC, IntelliBond C®, Selko, USA); CR100, 100 ppm of Cu supplemented by a monovalent source of Cu (CoRouge®, Animine, France); CR75, 75 ppm of Cu supplemented by a monovalent source of Cu; CR50, 50 ppm of Cu supplemented by a monovalent source of Cu. Data were analyzed using JMP Statistical Software. A p-value ≤ 0.05 was considered to indicate significant differences.

Results and discussion

In the first 7 d of the trial, ADG was significantly affected by the treatments (P=0.01), where the supplementation of 75 and 100 ppm of monovalent Cu resulted in the highest values (381 g/d) compared to the NC (336 g/d). PC (372 g/d) and CR50 (358 g/d) showed intermediate values. No effects on ADFI and FCR were observed. In the second phase (from 7 to 14 d of the trial), pigs fed CR100 maintain numerically higher ADG, which was explained by statistically higher (P<0.01) ADFI (998 g/d). All other treatments showed similar ADFI values (average of 918 g/d). Overall (d 0 to 22 of the trial), CR100 showed statistical (P<0.01) higher ADFI (993 g/d) and ADG (599 g/d) than the PC (939 g/d and 581 g/d, respectively). CR75 and CR50 did not differ (P>0.05) from PC in terms of ADG (CR50 = 581 and CR75 = 585 g/d) and ADFI (CR50 = 943 and CR75 = 953 g/d). The advantages of monovalent copper over a divalent source have been observed in broilers (Hamdi et al., 2018) and pigs (Blavi et al., 2021; Forouzandeh et al., 2022), but the tested source was the sulfate reference. The better performance observed in the previous publications were related not only to the microbiota control, but also to reduced risk of oxidative stress and inflammation. The present study now highlights the same improvement on performance over TBCC.

Conclusion and implications

The supplementation of copper at supra-nutritional levels increased growth performance compared to the negative control. However, the use of the monovalent source of copper at lower levels, 50 and 75 ppm, can provide similar performance to TBCC at supra nutritional levels (150 ppm). The best technical results were obtained when monovalent Cu was supplemented at 100 ppm of Cu.

References

Blavi L., Solà D., Monteiro A., Pérez J.F., Stein H.H. 2021. Inclusion of dicopper oxide instead of copper sulfate in diets for growing–finishing pigs results in greater final body weight and bone mineralization, but reduced accumulation of copper in the liver. Journal of Animal Science. doi:10.1093/jas/skab127

Forouzandeh A., Blavi L., Perez J.F., D'Angelo M., Gonzalez-Solé F., Monteiro A., Stein H.H., Solà-Oriol D. 2022. How copper can impact pig growth: comparing the effect of copper sulfate and monovalent copper oxide on oxidative status, inflammation, gene abundance, and microbial modulation as potential mechanisms of action. Journal of Animal Science. doi: 10.1093/jas/skac224

Hamdi M., Solà D., Franco R., Durosoy S., Roméo A., Pérez J.F. 2018. Including copper sulphate or dicopper oxide in the diet of broiler chickens affects performance and copper content in the liver. Animal Feed Science and Technology. doi: 10.1016/j.anifeedsci.2018.01.014

Popov S., Saphier O., Popov M., Shenker M., Entus S., Shotland Y., Saphier M. 2020. Factors Enhancing the Antibacterial Effect of Monovalent Copper Ions. Current Microbiology. doi: 10.1007/s00284-019-01794-6

P1-39

Title: **Supplementation of a novel phytase alone or in combination with xylanase and β-glucanase reduced carbon footprint and achieved a production benefit from wean-to-finish in pigs**

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Introduction:
Enzyme supplementation in pig diets can improve feed efficiency by increasing the digestibility of nutrients and energy and reducing nutrient excretion to the environment. Applying a proper nutrient matrix for enzymes would help to formulate diets without added inorganic phosphates and with a lower protein and energy content, thereby reducing imprudent excretion of nutrients to the environment and improving sustainability. A novel consensus 6-phytase variant (PhyG) dosed at 1,000 FTU/kg increased P digestibility by 23.5% points in grower pigs (Ve1ayudhan et al., 2021). Phytate has shown to have a negative impact on the digestibility of nutrients other than P due to adverse interactions with these nutrients. The extra-phosphoric beneficial effect of PhyG on digestibility of Ca, energy, and amino acids has been demonstrated in previous studies (Espinosa et al., 2021; Espinosa et al., 2022). Moreover, the use of xylanase and β-glucanase blend (XB) in an energy-deficient diet linearly improved growth performance, linked with increased digestibility (Kiarie et al., 2012). This study tested the effect of PhyG alone or in combination with XB, when added to an energy and nutrient-reduced diet on production performance and carbon footprint in pigs from wean-to-finish.

Material and methods:
A total of 192 weaned pigs were randomized to 4 treatments with 12 (4 piglets/pen) and 24 pens (2 pigs/pen) per treatment (1:1 male to female) for nursery and grow-finish phases, respectively. Diets were wheat-corn-barley-rye-based and fed in 5 phases (pre-starter, 7–11 kg, starter, 11–25 kg, grower I, 25–55 kg, grower II, 55–85 kg and finisher, 85–110 kg BW). Treatments included: 1) a nutritionally adequate positive control (PC); 2) a negative control (NC1) without added inorganic phosphate, reduced (based on specific PhyG dose) in net energy (NE), calcium (Ca), digestible amino acids (AA) and sodium (Na) vs. PC, supplemented with PhyG at 1,000, 1000, 750, 500 and 500 FTU/kg during pre-starter, starter, grower I, II and finisher phase, respectively (NC1+PhyG-low); 3) a negative control (NC2) without added inorganic phosphate, supplemented with PhyG at 2,000, 2,000, 1,000, 750 and 750 FTU/kg in each phase with reduction in NE, Ca, dig AA and Na vs. PC based on the specific PhyG dose (NC2+PhyG-high), and; 4) a negative control (NC3): as 2) but supplemented with XB to provide 2,400 U/kg xylanase and 304 U/kg β-glucanase, with additional reduction in NE and dig AA based on the contribution of XB vs NC1 (NC3+PhyG-low+XB). Pigs were weighed individually at the start and the end of each phase. Daily feed intake was recorded per pen basis, feed conversion ratio was calculated based on pen feed intake and pen body weight gain per phase and overall, corrected for mortality. On the last day of the experiment, pigs were slaughtered to determine carcass measurements. Data was analyzed by ANOVA, and means separation was by Tukey's HSD test.

Results and discussion:
Growth performance in all enzyme-supplemented diets was maintained or improved compared to PC. The final BW was 114.5, 114.8, 115.6 and 116.7 kg and overall (7 to 110 kg) FCR was 2.20, 2.19, 2.22, 2.23 in PC, NC1+PhyG-low, NC2+PhyG-high and NC3+PhyG-low+XB, respectively ($P > 0.05$). The NC3+PhyG-low+XB treatment significantly improved ADG and BW vs. PC in starter (620 g and 28.2 kg vs. 557 g and 26.4 kg) and grower I (859 g and 65.1 kg vs. 777 g and 60.0 kg) respectively; FCR was reduced in grower II (2.10 vs. 2.25; $P < 0.05$). Carcass parameters were unaffected by treatments. Compared to PC, NC1+PhyG-low, NC2+PhyG-high and NC3+PhyG-low+XB conferred a 5.5, 6.1 and 7.3 % reduction in total feed cost (ingredients price, October 2023)/kg BWG and 4.4, 6.0 and 6.9% reduction in the total carbon footprint (FeedPrint, WUR, The Netherlands, CO_2 eq., g)/kg BWG respectively

Conclusion and implications:
The results showed that application of phytase and NSP enzymes with a full matrix in feed formulation is an effective approach to improve sustainability and reduce production cost in pigs from wean-to-finish. The reduction in total carbon footprint with enzyme-supplemented diets will be of particular interest to today's producers focusing on sustainable animal meat production, without affecting the growth performance and production outcomes.

References:
1) Espinosa, C. D., M. S. F. Oliveira, D. E. Velayudhan, Y. Dersjant-Li, and H. H. Stein. 2021. Influence of a novel consensus bacterial 6-phytase variant on mineral digestibility and bone ash in young growing pigs fed diets with different concentrations of phytate-bound phosphorus. J. Anim. Sci. 99:skab211.
2) Espinosa, C. D., L. J. Torres, D. E. Velayudhan, Y. Dersjant-Li, and H. H. Stein. 2022. Ileal and total tract digestibility of energy and nutrients in pig diets supplemented with a novel consensus bacterial 6-phytase variant. J. Anim. Sci. 100:skac364.
3) Kiarie, E., Owusu-Asiedu, A., Peron, A., Simmins, P. H., and Nyachoti, C. M. 2012. Efficacy of xylanase and β-glucanase blend in mixed grains and grain co-products-based diets for fattening pigs. Livestock Science, 148(1-2), 129-133.
4) Velayudhan, D. E., M. Gracia, O. Casabuena Rincon, L. Marchal, and Y. Dersjant-Li. 2021. Effect of a novel consensus bacterial 6-phytase variant in grower pigs fed corn-soybean meal-based diets formulated with a full nutrient matrix and no added inorganic phosphorus. J. Anim. Sci. 99:skab176