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CURRENT RESEARCH STATUS ON SOME NUTRITIONAL SOLUTIONS FOR SWINE FEEDING TO IMPROVE PRODUCTIVE PARAMETERS

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Abstract

In the context of the development of livestock industry, pig farming represents an important sector, making it essential to optimize the feeding regime to improve productive parameters. Recent research has focused on identifying and implementing innovative nutritional solutions that support swine performance, with the main objective of increasing resource use efficiency, improving feed conversion, and reducing environmental impact. Alternatives to conventional proteins, such as insect or algae-based proteins, have been investigated, which could reduce dependence on traditional protein sources like soy and lower production costs. That dietary adjustments can lead to increased body weight, improved feed conversion ratio, and reduced pig mortality. Moreover, personalized feeding tailored to the needs of each stage of swine growth has proven effective in maximizing productivity using Precision Nutrition and Data-Driven Feeding. However, achieving a significant impact requires closer collaboration between researchers, farmers, and the feed industry. The large-scale implementation of these promising nutritional solutions necessitates additional efforts in farmer education and ensuring access to advanced technologies and necessary resources.

Key words*: nutritional solutions, productive parameters, swine performance, sustainable development.*

INTRODUCTION

Pig farming is one of the most important branches of animal husbandry, with a significant impact on the national economy and the food market. In recent years, the emphasis on improving the productive parameters of pigs has led to an increasing need for innovative nutritional solutions that optimize the growth and health of these animals.

Proper nutrition plays a crucial role in productive performance, influencing both the growth rate and the quality of the meat produced (Manceron et al., 2014).

Nutrition is one of the most important factors influencing the productive performance of pigs. A balanced and adequate diet contributes to optimizing growth rate, improving feed conversion, and maintaining the overall health of the animals.

In the context of globalized markets and the increasing demand for high-quality pork products, producers are motivated to adopt advanced nutritional solutions that meet these requirements.

This article analyzes the current state of research on nutritional solutions for pigs and their impact on productive parameters.

MATERIALS AND METHODS

This study employed a bibliographic approach to systematically review, synthesize, and analyze relevant literature on the selected research topic. The methodology focused on identifying and evaluating peer-reviewed academic sources, including journal articles, books, conference proceedings, and reports, to gather comprehensive insights on the subject matter.

The bibliographic review followed a structured search protocol to ensure a wide and thorough inclusion of relevant literature. The following electronic databases were utilized for the literature search: PubMed; Scopus; Web of Science; Google Scholar.

The search criteria were further refined by using filters such as publication date (studies published between 2010-2023), language (English), and type of publication (peer-reviewed articles).

RESULTS AND DISCUSSIONS

Research in pig nutrition has evolved significantly, focusing on identifying and implementing solutions that ensure sustainable and efficient growth. This research has been driven by the need to reduce production costs, improve product quality, and minimize negative environmental impact.

Major research directions include the use of feed additives, alternative proteins, and nutritional supplements, as well as optimizing diet composition according to the growth stages of pigs. In the last decade, numerous studies have been conducted to evaluate the effectiveness of these solutions in the specific context of international and national farms.

Feed additives and their impact on productive performance

Feed additives have become a major topic of interest in pig nutrition due to their potential to improve feed digestibility and stimulate growth. The researchers have explored the use of additives such as probiotics, prebiotics, enzymes, and organic acids.

Probiotics and prebiotics have been studied for their ability to modulate the intestinal micro-flora, promoting gut health and improving nutrient absorption. Studies conducted on pig farms have shown that using these additives can reduce the incidence of digestive disorders and improve the feed conversion ratio (Jacela et al., 2010).

Like probiotics in pig feeding, it can be used *Lactobacillus* spp., which is known for their role in lactic acid production. these bacteria help maintain a healthy gut environment by lowering pH and inhibiting harmful pathogens. *Bifidobacterium* spp. promote gut health by competing with pathogens and supporting the development of a balanced gut microbiota. *Saccharomyces cerevisiae* (yeast) can improve feed digestibility and nutrient absorption, while also boosting immune function. *Enterococcus faecium* helps reduce pathogenic bacteria in the gut and can improve intestinal health and nutrient uptake (Méndez-Palacios et al., 2018).

Common prebiotics in pig nutrition are fructooligosaccharides - promote the growth of beneficial bacteria like *Bifidobacteria* and *Lactobacillus*; mannan-oligosaccharides enhances gut health by promoting beneficial bacteria and binding to pathogens, preventing them from adhering to the gut lining; inulin stimulates the growth of beneficial bacteria while improving digestion and nutrient absorption; galactooligosaccharides feed beneficial bacteria and improve gut microbial balance, supporting better digestive health (Shim, 2005; Kiernan et al., 2023).

Enzymes, particularly those that break down plant fibers, have also been evaluated for their effect on the digestibility of fiber-rich feeds. While pigs naturally produce some digestive enzymes (e.g., amylase, protease, lipase), they are often insufficient to fully digest certain components of the diet, especially when it contains plant-based feedstuffs like cereals and legumes. These enzymes help release essential nutrients from feed ingredients, thereby increasing diet efficiency and contributing to faster and more uniform pig growth. Carbohydrases break down complex carbohydrates, which are abundant in plant-based feed ingredients such as cereals, grains, and legumes. Pigs, especially young ones, have limited ability to digest some carbohydrates, particularly the non-starch polysaccharides found in plant cell walls. Xylanase breaks down arabinoxylans into simpler sugars, improving nutrient digestibility and energy extraction. β-Glucanase breaks down β-glucans, which are found in grains like oats and barley, enhancing the digestibility of these feed components. Amylase helps break down starches into sugars, improving the energy availability from grains such as corn and wheat. Cellulase breaks down cellulose, a key component of plant cell walls, although its use is less common due to the difficulty of fully digesting cellulose in pig diets (Durán, 2014; Aranda-Aguirre et al., 2021).

The use of organic acids in pig feeding has gained significant attention due to their beneficial effects on gut health, growth performance, and overall feed efficiency. Organic acids (citric acid, propionic acid, fumaric acid, lactic acid, formic acid, benzoic acid) serve as natural alternatives to antibiotics, especially in post-weaning piglets, by helping to control pathogenic bacteria, improve nutrient absorption, and promote optimal digestive conditions. When supplemented in pig diets, organic acids can improve feed utilization,

reduce gastrointestinal disorders, and enhance overall growth performance. They work by lowering the pH of the gastrointestinal tract, creating an environment less favorable for pathogenic bacteria, and more conducive to beneficial microbes and optimal nutrient digestion (Suiryanrayna & Ramana, 2015).

Alternative Proteins: Innovative Solutions for Cost Reduction and Improved Sustainability

Proteins are an essential component of pig diets, with a direct impact on their growth and development. In the context of rising prices for conventional proteins such as soy, researchers have explored alternatives that are both effective and environmentally sustainable (DiGiacomo & Leury, 2019; Lestingi, 2024).

Insect and algae proteins are two of the most promising alternative protein sources that have been investigated. These not only offer a rich nutritional profile but also have a lower environmental impact, requiring fewer resources for production compared to conventional crops.

Insect proteins are considered an excellent source of essential amino acids and have been successfully tested in pig diets, demonstrating an efficiency comparable to traditional proteins. The studies have shown that partially replacing conventional proteins with insect proteins does not compromise pigs' productive performance and may even improve certain aspects of animal health (Lestingi, 2024).

Species like black soldier fly larvae (*Hermetia illucens*), mealworms (*Tenebrio molitor*), and common housefly (*Musca domestica*) are commonly used in animal feed formulations (Wang & Shelomi, 2017; Hong et al., 2020; Hong & Kim, 2022).

Insects contain protein levels comparable to or higher than traditional sources like soy or fishmeal. For instance, black soldier fly larvae have been reported to contain 40-50% protein on a dry matter basis, while mealworms contain approximately 45-50%. These proteins are rich in essential amino acids such as lysine and methionine, which are crucial for pig growth and muscle development (Nowak et al., 2016; Veldkamp, T.; Bosch, 2015).

Insects are also a good source of lipids, ranging from 15-35% depending on the species and life stage. These fats provide essential fatty acids, such as linoleic acid, which contribute to energy balance and overall health in pigs (da-Silva et al., 2024).

Insects provide a wide range of micronutrients. Black soldier fly larvae, for instance, are rich in calcium and phosphorus, which are important for bone development and metabolic functions in pigs. Insects also contain bioactive compounds, such as antimicrobial peptides, that can enhance gut health and immune function in pigs (Wang & Shelomi, 2017).

Pigs fed insect protein often show comparable or even superior growth rates to those fed traditional protein sources. Research indicates that insect meals, especially from black soldier fly larvae, can improve the feed conversion ratio (FCR), meaning pigs require less feed to gain the same amount of weight, thus enhancing feed efficiency. In some studies, FCR improvements of up to 10% have been observed when insects are included in the diet (DiGiacomo & Leury, 2019).

Insects are generally well-digested by pigs, with high protein digestibility rates reported for black soldier fly larvae and mealworm meals. Studies have shown that pigs can efficiently utilize the nutrients in insect-based feeds, with digestibility coefficients similar to those of soy and fishmeal. The acceptability of insect-based feed to pigs has been a subject of research, with most studies reporting that pigs readily consume insect-containing diets without issues of reduced feed intake or rejection (Kar et al., 2021). The flavor and texture of insect meals, combined with their high nutrient density, make them a suitable feed option for swine (DiGiacomo & Leury, 2019).

Insects, particularly their chitin-rich exoskeletons, have been shown to modulate gut microbiota by promoting the growth of beneficial bacteria, such as *Lactobacillus* and *Bifidobacterium*. This can enhance gut health, nutrient absorption, and overall immunity in pigs (Kar et al., 2021).

Insects produce antimicrobial peptides that have been demonstrated to reduce pathogen load in the gut. For example, black soldier fly larvae contain compounds that inhibit the growth of harmful bacteria like *Escherichia coli* and *Salmonella*, thus contributing to improved gut health and reduced infection risk (Yu et al., 2019).

The use of insects in pig nutrition also offers significant environmental benefits, making them a sustainable alternative to traditional feed sources. Insect farming requires far less land and water than conventional feed protein sources like soy or fishmeal. For example, black soldier fly larvae can be produced on food waste, agricultural by-products, or organic waste streams, making them a circular economy solution that reduces the ecological footprint of pig production. Insects emit fewer greenhouse gases during production compared to livestock feed crops such as soy. By integrating insects into pig feed, the overall carbon footprint of pork production can be reduced, aligning with global efforts to mitigate climate change (FAO, 2024; Groeneveld et al., 2021).

Algae have emerged as a promising alternative protein source in animal nutrition, particularly in pig diets, due to their high protein content, rich nutrient profile, and sustainable production. This has attracted considerable attention in both research and the agricultural industry

Algae are another protein source that has gained attention in nutritional research. Algae can be grown on non-arable land and can utilize waste streams (e.g., CO_2 and wastewater), reducing their environmental impact. This makes them an eco-friendly alternative that aligns with the push for more sustainable livestock production systems.

Algae, particularly microalgae (e.g., *Spirulina platensis, Chlorella vulgaris,* and *Schizochytrium*), are known for their high protein content, which can range from 20% to 70%, depending on the species and growing conditions. Algae also contain essential amino acids that are critical for pig growth and development, making them comparable to conventional protein sources like soybean meal and fishmeal (Holman et al., 2013).

In addition to protein, algae are rich in: lipids, particularly omega-3 fatty acids like DHA (docosahexaenoic acid), which can enhance the fatty acid profile of pork; vitamins such as B12, E, and carotenoids like beta-carotene; minerals including iron, calcium, and magnesium (Ribeiro et al., 2021).

Research has shown that algae can promote growth in pigs, particularly weanling pigs. The protein and essential amino acids in algae support muscle development, while the bioactive compounds may enhance feed efficiency (Lugarà et al., 2022).

Algae contain bioactive components like polysaccharides and polyunsaturated fatty acids (PUFAs) that may support gut health and immune function in pigs. Some studies suggest that algae can improve gut microbiota composition, reduce gut inflammation, and increase the pigs' resistance to disease (Kovač et al., 2013).

The inclusion of algae in pig diets has been shown to improve pork quality. Specifically, omega-3-rich algae can enhance the fatty acid profile of pork, resulting in healthier meat with a higher content of beneficial fats (Sánchez-Muros et al., 2014).

While algae have clear benefits, there are several factors to consider when the farmers want to use this forage. The production cost of algae can be higher compared to traditional feed ingredients like soybean meal. However, technological advancements and large-scale production may lower these costs in the future (Austic et al., 2013).

Algae cell walls can be difficult to digest for pigs due to their high fiber content. Processing methods such as cell wall disruption or the use of enzymes can improve digestibility and nutrient availability (Austic et al., 2013).

Some algae species may have a strong odor or taste, which could affect feed intake. Research is ongoing to find ways to enhance the palatability of algae-based feeds (Chisti, 2014).

Research in Romania has begun exploring the potential of algae in pig feed, with preliminary results suggesting an improvement in productive parameters, particularly in meat quality and animal health (Nistor, 2010; Popescu, 2016; Teodorescu et al., 2023).

Precision Nutrition and Data-Driven Feeding

The use of precision nutrition techniques allows farmers to tailor diets to the specific needs of pigs based on factors like age, weight, breed, and health status. Advancements in technology and data analytics provide the tools to optimize feed formulations and reduce waste.

Tailoring feed formulas to different growth phases ensures that pigs receive the precise nutrients they need at each stage, avoiding over- or underfeeding. This reduces feed costs and nutrient excretion. The nutritional needs of pigs

vary significantly depending on age, weight, and stage of development, and adjusting the diet to meet these needs can lead to significant improvements in productive performance (Banhazi et al., 2012).

The diet during the weaning period is essential to ensure a smooth transition from maternal milk to solid food. Researchers have shown that a diet rich in energy and proteins, supplemented with enzymes and probiotics, can reduce weaning stress and support rapid and healthy growth (Pop et al., 2006).

The growth and fattening phases require nutrition that supports rapid growth and proper muscle development. Here, the focus is on balancing proteins, carbohydrates, and lipids to optimize feed conversion into muscle mass. Researches have explored the use of cereal-based diets enriched with alternative protein sources and feed additives, demonstrating significant improvements in growth rate and feed efficiency (Simeanu, 2018).

Automated feeders equipped with sensors and artificial intelligence can monitor individual pig feed intake and growth rates in real time (Gaillard et al., 2020). These systems adjust feed formulations dynamically, improving growth performance and feed efficiency.

Continuous monitoring and adjustment are at the core of precision feeding. The systems collect data from various sensors, which is then processed to determine the exact nutrient mix each pig or group needs at any given time. The goal is to maximize growth efficiency while reducing feed wastage and nutrient excretion (Pomar & Remus, 2019).

Systems gather data on feed intake, weight gain, health status, and environmental conditions (e.g., temperature, humidity) to adjust feeding in real time (Flachowsky & Kamphues, 2012; Niemann et al., 2011).

Based on the data, the system can change the ratio of protein, fat, fiber, and micronutrients in the feed to match current nutritional needs (Lovato et al., 2017).

Systems can modify feed delivery not only based on nutritional needs but also on factors such as environmental stress (e.g., heat stress) or health issues (Niemann et al., 2011).

Implementation and practical challenges

Although research shows considerable potential for improving pigs' productive parameters through innovative nutritional solutions, implementing these in practice presents significant challenges. One of the main challenges is educating farmers about the benefits of these solutions and the correct application methods. Additionally, the initial costs of implementing advanced nutritional solutions can be a barrier for many farms, especially small and medium-sized ones.

Another challenge is the limited access to necessary resources, such as alternative proteins or high-quality feed additives, especially in more isolated rural regions. Moreover, closer collaboration between researchers, feed producers, and farmers is needed to ensure the successful large-scale implementation of these solutions.

The future of nutritional research is moving towards developing personalized feeding strategies tailored not only to the growth stages of pigs but also to the specific conditions of each farm. There is also growing interest in nutritional solutions that reduce environmental impact, such as low-carbon diets and the use of local and renewable resources.

CONCLUSIONS

The current state of research on nutritional solutions for pigs shows considerable potential for improving productive parameters. The use of feed additives, alternative proteins, and personalized diets can lead to more efficient growth, improved meat quality, and reduced environmental impact. However, to fully capitalize on these findings, close collaboration between researchers, farmers, and the feed industry is essential, along with continued investment in education and advanced technologies. The large-scale application of these solutions can significantly contribute to the sustainable development of pig sector, offering important economic and ecological benefits.

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REFERENCES

Aranda-Aguirre, E., Robles-Jimenez, L.E., Osorio-Avalos, J., Vargas-Bello-Pérez, E., & Gonzalez-Ronquillo, M. (2021). A systematic-review on the role of exogenous enzymes on the productive performance at weaning, growing and finishing in pigs. *Vet. Anim. Sci.*, 14, 100195. doi: 10.1016/j.vas.2021.100195

Austic, R.E., Mustafa, A., Jung, B., Gatrell, S., & Lei, X.G (2013). Potential and limitation of a new defatted diatom microalgal biomass in replacing soybean meal and corn in diets for broiler chickens. *J. Agric. Food Chem.*, 61, 7341-7348.

Banhazi, T. M., Lehr, H., Black, J. L., Crabtree, H., Schofield, P., Tscharke, M., & Berckmans, D. (2012). Precision livestock farming: an international review of scientific and commercial aspects. *Int. J. Agric. Biol. Eng., 5*(3), 1–9.

Chisti, Y. (2013). Constraints to commercialization of algal fuels. J. *Biotechnol*., 167, 201-214.

da-Silva, W.C., Silva, É.B.R.D., Silva, J.A.R.D., Martorano, L.G., Belo, T.S., Sousa, C.E.L., Camargo-Júnior, R.N.C., Andrade, R.L., Santos, A.G.S., Carvalho, K.C., Lobato, A.D.S.M., Rodrigues, T.C.G.C., Araújo, C.V., Lima, J.S., Neves, K.A.L., Silva, L.K.X., Lourenço-Júnior, J.B. (2024). Nutritional Value of the Larvae of the Black Soldier Fly (*Hermetia illucens*) and the House Fly (*Musca domestica*) as a Food Alternative for Farm Animals-A Systematic Review. *Insects, 15*(8), 619

Devi, S.M., & Kim, I.H. (2014). Effect of medium chain fatty acids (MCFA) and probiotic (*Enterococcus faecium*) supplementation on the growth performance, digestibility and blood profiles in weanling pigs. *Vet. Med*., 59, 527–535.

DiGiacomo, K., & Leury, B.J. (2019). Insect meal: A future source of protein feed for pigs? *Animal*, 13, 3022-3030.

Durán, R. (2014). Review of the use of enzymes in pig nutrition. Implementation and profitability depending on the diets. *Professional Pig Community*, https://www.pig333.com/articles/review-of-the-use-of-enzymes-in-pig-nutrition_8347/

FAO (2024). Economic and environmental benefits from using black soldier fly larvae to digest organic waste. https://www.fao.org/science-technology-and-innovation/resources/stories/detail/economic-and-environmental-benefits-from-using-black-soldier-fly-larvae-to-digest-organic-waste/en

Flachowsky, G., & Kamphues, J. (2012). Carbon footprints for food of animal origin: what are the most preferable criteria to measure animal yields? *Animals (Basel)*, 2, 108–126.

Gaillard, C., Brossard, L., & Dourmad, J.Y. (2020). Improvement of feed and nutrient eficiency in pig production through precision feeding. *Animal Feed Science and Technology,* 268, 114611. 10.1016/j.anifeedsci.2020.114611.

Groeneveld, I., Elissen, H.J.H., van Rozen, K., & van der Weide, R.Y. (2021). *The profitability potential of black soldier fly (BSF) larvae raised on pig manure at farm level.* Wageningen Research, Report WPR-890. https://doi.org/10.18174/549892

Holman, B.W.B., & Malau-Aduli, A.E.O. (2013). Spirulina as a livestock supplement and animal feed. *J. Anim. Physiol. Anim. Nutr*., 97, 615–623.

Hong, J., Han, T., & Yong Kim, Y. (2020). Mealworm (*Tenebrio molitor* Larvae) as an Alternative Protein Source for Monogastric Animal: A Review. *Animals, 10*(11), 2068. https://doi.org/10.3390/ani10112068.

Hong, J., & Kim, Y.Y. (2022). Insect as feed ingredients for pigs. *Anim Biosci., 35*(2), 347–355.

Jacela, J.Y., DeRouchey, J.M., Tokach, M.D., et al. (2010). Feed additives for swine: Fact sheets – prebiotics and probiotics, and phytogenics. *J. Swine Health Prod., 18*(3), 132–136.

Kar, S.K., Schokker, D., Harms, A.C., Kruijt, L., Smits, M.A., & Jansman, A.J.M. (2021). Local intestinal microbiota response and systemic effects of feeding black soldier fly larvae to replace soybean meal in growing pigs. *Sci. Rep*., 11, 15088. doi: 10.1038/s41598-021-94604-8

Kiernan, D.P., O'Doherty, J.V., & Sweeney, T. (2023). The effect of prebiotic supplements on the gastrointestinal microbiota and associated health parameters in pigs. *Animals, 13*(19), 3012. https://doi.org/10.3390/ani13193012

Kovač, D.J., Simeunović, J.B., Babić, O.B., Mišan, A.Č., & Milovanović, I.L. (2013). Algae in food and feed. *Food Feed Res*., 40, 21-32.

Lestingi, A. (2024). Alternative and Sustainable Protein Sources in Pig Diet: A Review. *Animals, 14*(2), 310. https://doi.org/10.3390/ani14020310

Lovato, G.D., do Vale, M.M., de Oliveira, V., Klein, D.R., & Branco, T. (2017). Application of a precision nutrition tool for growing and finishing pigs. *R. Bras. Zootec., 46*(9), 755-759.

Lugarà, R., Realini, L., Kreuzer, M., & Giller, K. (2022). Effects of maternal high-energy diet and spirulina supplementation in pregnant and lactating sows on performance, quality of carcass and meat, and its fatty acid profile in male and female offspring. *Meat Sci.,* 187, 108769. doi: 10.1016/j.meatsci.2022.108769

Manceron, S., Ben-Ari, T., & Dumas, P. (2014). Feeding proteins to livestock: Global land use and food vs. feed competition. *OCL Oilseeds Crops Fats Lipids 2014*, *21*(4).

Méndez-Palacios, N., Méndez-Mendoza, M., Vázquez-Flores, F., Castro-Colombres, J.G., & Ramírez-Bribiesca, J.E. (2018). Productive and economic parameters of pigs supplemented from weaning to finishing with prebiotic and probiotic feed additives. *Anim. Sci. J., 89*(7), 994-1001.

Niemann, H., Kuhla, B., & Flachowsky, G. (2011). Perspectives for feed-efficient animal production. J. *Anim. Sci.*, 89, 4344–4363.

Nistor, E., Bampidis, V., Pet, L., & Ciolac, V. (2010). Impact of EU enlargement on the Romanian meat industry. *Sci. Pap. Anim. Sci. Biotechnol*., 43, 364–368.

Nowak, V., Persijn, D., Rittenschober, D., & Charrondiere, U.R. (2016). Review of food composition data for edible insects. *Food Chem*., 193, 39–46.

Pomar, C., & Remus, A. (2019). Precision pig feeding: a breakthrough toward sustainability. *Anim Front., 9*(2), 52–59.

Pop, I.M. et al. (2006). *Animal nutrition and feeding*, vol. I-III. Iasi, RO: Tipomoldova Publishing House.

Popescu, A. (2016). Research on concentration of pork production in Romania. *Sci. Pap. Ser. Manag. Econ. Eng. Agric. Rural. Dev.*, 16, 405–410.

Ribeiro, D.M., Martins, C.F., Costa, M., Coelho, D., Pestana, J., Alfaia, C., Lordelo, M., de Almeida, A.M., Freire, J.P.B., & Prates, J.A.M. (2021). Quality traits and nutritional value of pork and poultry meat from animals fed with seaweeds. *Foods*, 10, 2961.

Sánchez-Muros, M.J., Barroso, F.G., & Manzano-Agugliaro, F. (2014). Insect meal as renewable source of food for animal feeding: A review. J. *Clean. Prod*., 65, 16–27.

Simeanu, D. (2018). *Animal nutrition and feeding*. Iasi, RO: Ion Ionescu de la Brad Publishing House.

Shim, S.B. (2005). *Effects of prebiotics, probiotics and synbiotics in the diet of young pigs*. Ph.D. Thesis, Animal Nutrition Group, Wageningen Institute of Animal Sciences, Wageningen University and Research Centre, Wageningen, The Netherlands.

Suiryanrayna, M.V.A.N., & Ramana, J.V. (2015). A review of the effects of dietary organic acids fed to swine. *Animal Sci. Biotechnol*., 6, 45. https://doi.org/10.1186/s40104-015-0042-z.

Teodorescu, C., Burcea, M., Lequeux-Dincă, A.I., Merciu, F.C., Jipa, A.N., & Szemkovics, L.Ş. (2023). Swine Breeding in the Villages of Vâlcea County, Oltenia (Romania) - Tradition or Necessity? *Agriculture, 13*(3), 733. https://doi.org/10.3390/agriculture13030733

Veldkamp, T., & Bosch, G. (2015). Insects: A protein-rich feed ingredient in pig and poultry diets. *Anim. Front.,* 5, 45–50

Wang, Y.S., & Shelomi, M. (2017). Review of black soldier fly (*Hermetia illucens*) as animal feed and human food. *Foods, 6*(10), 91. https://doi.org/10.3390/foods6100091.

Yu, M., Li, Z., Chen, W., Rong, T., Wang, G., & Ma, X. (2019). *Hermetia illucens* larvae as a potential dietary protein source altered the microbiota and modulated mucosal immune status in the colon of finishing pigs. J. *Anim. Sci. Biotechnol.,* 10, 50. doi: 10.1186/s40104-019-0358-1