Scientific Papers. Series D. Animal Science. Vol. LXVI, No. 2, 2023
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

PEAS (*Pisum sativum* L.) AND LUCERNE (*Medicago sativa* L.) A VALUABLE PROTEIN SOURCES AS ALTERNATIVES TO SOYBEAN MEAL IN SWINE NUTRITION - A REVIEW

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Abstract

This review aims to evaluate partially substitution of soybean meal with peas (Pisum sativum) and lucerne (Medicago sativa) in pigs' feeding. Peas and lucerne offer favourable nutritional profiles, containing substantial levels of protein, essential amino acids, and dietary fibre. The two ingredients can be economically viable alternatives to soybean meal due to their relatively lower cost and availability in certain regions, reducing feeding costs, thus benefiting pig producers. Partially substituting soybean meal with peas and lucerne can alleviate the environmental burden associated with soybean production, because it is required less land and water resources, and their cultivation has a lower environmental footprint, making them sustainable choices for pig feed formulation. Although peas and lucerne may contain certain anti-nutritional factors, such as trypsin inhibitors and phytates, which can interfere with nutrient utilization and digestion in pigs, a proper processing technique, such as heat treatment or enzyme supplementation, are necessary to mitigate the negative effects of these compounds and improve nutrient availability. The palatability of the diet may be influenced by factors such as flavour, texture, and aroma, therefore a careful formulation and gradual introduction of these alternative protein sources can help ensure adequate feed intake and prevent any potential negative effects. The digestibility of protein and other nutrients of peas and lucerne can be lower compared to soybean meal, which may impact nutrient utilization and growth performance. However, optimization of formulation, feed processing, and enzyme supplementation can help overcome these challenges and improve nutrient digestibility.

Key words: *alfalfa, alternatives, peas, pigs, protein, soybean meal.*

INTRODUCTION

According to FAOSTAT (2021), the first five global soybean crop producers are Brazil, United States of America (U.S.A.), Argentina, India and China. The European Union (EU) demands for plant proteins, both for food and feed purposes is increasing and its self-sufficiency rate in terms of soya crude proteins is relatively low, at approximately 5%. As a result, the EU heavily relies on imports, primarily sourced from South America, to meet its demand for soya (Debaeke et al., 2022). Overall, the EU's initiatives are to reduce soya imports and promote its own production of protein-rich crops trying to enhance self-sufficiency (Rauw et al., 2023). On the other hand, a more appropriate solution will be to replace partially if not totally soybean meal (SBM) with other protein options sources for food and feed, sort of "protein transition", to reduce negative environmental impacts, and to promote sustainable agriculture practices and animal welfare (Duluins et al., 2022). As of 2021, the European Union (EU) had a livestock population consisting of 142 million pigs, 76 million bovine heads utilized for meat and dairy production, 62 million sheep, and 12 million goats. Following pig meat, poultry is the second most widely consumed meat in the EU. In 2013, the EU raised approximately 891.4 million broilers, and as of 2021, there were 376 million laying hens (EU feed, 2023). The impact of Avian Influenza and COVID-19 caused Romania a decline of 5.9% compound feed production, and the presence of African Swine Fever (ASF) affected pig feed production in 2020 Romania by a significant decline (-4.5%) while other European countries overcome these obstacles and achieve substantial growth in pig feed demand (https://fefac.eu).

In 2020, Italy, Serbia, France, and Romania emerged as the primary soybean producers within the expanded European Union (EU), but when considering continental Europe as a whole the main soybean-producing nations were Russia and Ukraine (Debaeke et al., 2022). The primary utilization of soybeans involves their extraction into oil and soybean meal. Almost 75% of the global soybean meal production is designated for pigs or poultry feeding (Singh & Krishnaswamy, 2022). The soy protein is notable for its essential amino acids content: lysine, threonine, and tryptophan with high digestibility for pigs compared to other protein sources. Also pig diets, soy products serve as a significant source of energy, soybean meal containing digestible and metabolizable energy levels comparable to corn (Stein et al., 2013). According to National Research Council (NRC, 2012), the content of crude protein (CP), gross energy (GE), digestible energy (DE), metabolizable energy (ME), net energy (NE) of soybean meal and other soybean products present different values: full-fat soybeans (37.56% CP, 5227 kcal/kg GE, 4193 kcal/kg DE, 3938 kcal/kg ME, 2874 kcal/kg NE), dehulled SBM (47.73% CP, 4256 kcal/kg GE, 3619 kcal/kg DE, 3294 kcal/kg ME, 2087 kcal/kg NE), nondehulled SBM (43.90% CP, 4257 kcal/kg GE, 3681 kcal/kg DE, 3382 kcal/kg ME, 2148 kcal/kg NE), extruded expelled SBM (44.56% CP, 4692 kcal/kg GE, 3876 kcal/kg DE, 3573 kcal/kg ME, 2344 kcal/kg NE), enzyme treated SBM (55.62% CP, 4451 kcal/kg GE, 3914 kcal/kg DE, 3536 kcal/kg ME), fermented SBM (54.07% CP, 4533 kcal/kg GE, 3975 kcal/kg DE, 3607 kcal/kg ME), soy protein concentrate (65.20% CP, 4605 kcal/kg GE, 4260 kcal/kg DE, 3817 kcal/kg ME, 2376 kcal/kg NE), soy protein isolate 84.78% CP, 5386 kcal/kg GE, 4150 kcal/kg DE, 3573 kcal/kg ME, 2187 kcal/kg NE). Hence, while soy remains an important protein source for pigs, it is crucial to explore alternatives that can effectively lower feeding costs and support the pork industry and farmers.

Tilman et al. (2002) consider that the challenging is to maintain the sustainability, in terms of both pollution and resource depletion, if we take into consideration that protein holds vital nutritional importance as nitrogen is an essential component of DNA, RNA, and protein (Smil, 2002a).

The objective of this review was to identify and compare experimental studies realized on pigs in which soybean meal was partially or totally introduced by different inclusion dietary percentages of peas and lucerne.

MATERIALS AND METHODS

To fulfil the review's objective a number of 37 bibliographic studies from literature were consulted. Relevant articles were identified from scientific databases with keywords: protein, alternatives, soybean meal, peas, alfalfa, pigs. As searching strategy, we used to identify relevant studies by accessing information from web engines, selection-based search engines, and web portals, such as: Google Scholar, CiteULike, BASE, Microsoft Bing, MetaCrawler, Scopus, Web of Science - Core Collection, UOW Library SEARCH, Library Databases.

RESULTS AND DISCUSSIONS

PEAS (*PISUM SATIVUM*) POSSIBLE ALTERNATIVE TO REPLACE PARTIALLY SOYBEAN MEAL IN SWINE DIETS

Field pea (*Pisum sativum* L.) is an important source of dietary starch (approximately 300 g/kg) and protein (approximately 200 g/kg), with lower levels of crude protein (CP) and lysine (Lys) compared to SBM, but higher levels than cereal grains, more fiber than SBM, corn, or wheat (Woyengo et al., 2014). This is accompanied by the highest net energy (NE) value, likely due to its digestible starch and fermentable fiber content, according to NRC (2012). Stein et al. (2010) noticed that young pigs fed with 600 g/kg of raw field pea, replacing corn and SBM, had a constant feed intake, but their growth was reduced during the first two weeks and throughout the entire 28-day trial. Petersen et al. (2014) suggest that peas can be used as a substitute for soybean meal (SBM) in swine diets, leading to reduced feed costs. To enhance its nutritional properties, it is recommended to process field pea by grinding it and subjecting it to cold-pelleting (70-75°C), steam-pelleting (80-85°C), or extrusion (115°C), followed by re-grinding (Hugman et al., 2020). Heat treatment can effectively eliminate heat-labile protease inhibitors and lectins, thus improving nutrient digestibility of field pea and enhancing the growth performance of pigs. Leguminous seeds have the potential to contain trypsin inhibitors. Pigs can tolerate trypsin inhibitor levels of up to 3.0 trypsin inhibitor units/mg or 4.7 mg trypsin inhibitor/g in their diet (Woyengo et al., 2017). Trypsin inhibitor activity causes negative effects such as decreasing growth and feed efficiency (Chubb, 1982), causing pancreatic hypertrophy (Green & Lyman, 1972), and increasing endogenous protein loss with decreased exogenous protein absorption (Barth et al., 1993) therefore trypsin inhibitor must be denatured by heat and catalytic decomposition.

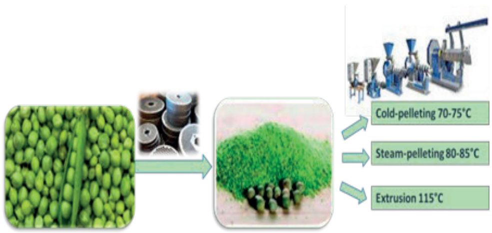

Figure 1. Enhance pea's nutritional properties by cold-pelleting, steam-pelleting and extrusion

Hugman et al. (2020) noticed that the substitution of 300 g soybean meal/kg and 100 g wheat/kg with 400 g field pea/kg in the diet of weaned pigs resulted in decreased apparent total tract digestibility coefficients for GE and CP, as well as the predicted NE value, an increase in average daily feed intake (ADFI), but did not show a corresponding increase in average daily gain (ADG), a reduced feed efficiency. Therefore, the heat processing is not necessary for optimal growth in nursery pigs (10-21 kg). Field pea can be a source of both starch and amino acids while maintaining the growth performance of weaned pigs. Landero et al. (2014) studied on 260 pigs (average 8.5 kg live weight) one week after weaning (19 days old) up to 300 g of soybean meal (SBM) per kilogram and 100 g of wheat per kilogram with 100, 200, 300, or 400 g of field pea/kg (*Pisum sativum* L., subsp. *Hortense*) in two phases: phase 1 - two weeks (1 to 14 days), to phase 2 - three weeks (15 to 35 days). The study findings indicate that up to 400 g per kilogram field pea can be used as a complete replacement for soybean meal (SBM) in nursery diets, provided that the diets were formulated to have equal net energy (NE) value and standardized ileal digestible (SID) amino acid content.

LUCERNE (*MEDICAGO SATIVA* L.) POSSIBLE ALTERNATIVE TO REPLACE PARTIALLY SOYBEAN MEAL IN SWINE DIETS

Alfalfa (*Medicago sativa* L.) is a perennial forage characterized by an abundant biomass production, favourable nutritional composition, and adaptability, utilized in animal feed as hay, meal, and silage. Alfalfa (lucerne) is highly valued for its rich protein content, which possesses a well-balanced amino acid profile. Additionally, alfalfa contains essential vitamins, carotenoids, and certain growth and reproduction factors, further enhancing its nutritional value for animals (Shi et al., 2014). Alfalfa exhibits the highest CP yield per hectare (2,000 to 3,000 kg), surpassing soybean, peas, and wheat. However, due to its composition rich in cellulose, hemicellulose, and lignin, which are fibrous components that are difficult to digest by monogastric animals, dried lucerne is unsuitable as a feed ingredient for certain young "high-performance" animals such as hens, chickens, calves, and piglets. Zijlstra & Beltranena (2007) stated that alternative protein sources can be distinguished based on their origin: feedstuffs derived from crop production and raw materials obtained through crop fractionation, including by-products and co-products The first group suitable for swine feeding include pea bean (*Pisum sativum*), lupin (*Lupinus* spp.), common bean (*Phaseolus vulgaris*), sunflower (*Helianthus annuus*), faba bean (*Vicia faba*), grass pea (*Lathyrus sativus*), and dehydrated alfalfa meal (*Medicago sativa*). The second group, crop fractionation, include corn and wheat gluten meal, concentrated potato protein, and wheat and corn distiller's dried grain. By combining both groups of alternative protein sources are reduced the need for additional dietary energy and amino acid supplementation.

The crude protein level is a crucial indicator of the nutritional quality of forage, and alfalfa stands out with a relatively high content of crude protein (18% to 20%) and a balanced composition ratio of amino acids, including lysine, tryptophan, with high digestibility. Notably, alfalfa is rich in lysine (0.80%) and methionine (0.23%) (Blume et al., 2021). Several studies were realized by supplementing alfalfa in piglet's diets, Adams et al. (2019) administrated 12% alfalfa and noticed positive effects concerning ADG and ADFI, piglets diarrhea incidence decreased; alfalfa meal 5% decreased the piglet diarrhea and mortality incidence (Liu et al., 2018), the positive effects of 5% fiber alfalfa was registered by an improved ADG, FCR, short-chain fatty acids (SCFAs) and abundance of cellobiolytic and anti-inflammatory bacteria which reduced the diarrhea (Sun et al., 2021).

Freire et al. (2000) supplemented 20% alfalfa meal in weaned piglet's diets and registered a decreasing digestive transit time and NDF and ADF digestibility, a dry matter apparent digestibility, nitrogen and energy.

Other authors found that alfalfa inclusion in pigs' diets had positive effects on growth, reproductive performance, health condition, and meat quality (Lindberg et al., 1995). This is attributed to several mechanisms. Firstly, the dietary fibre present in alfalfa can stimulate intestinal peristalsis, increase the activity of digestive enzymes, and promote the growth of beneficial bacteria in the intestines. This fermentation process produces short-chain fatty acids, which improve intestinal health. Furthermore, the high-quality protein and amino acids found in alfalfa contribute to improved animal health conditions. The presence of vitamins and mineral elements in alfalfa also plays a vital role in various physiological functions within the pig's body. Additionally, bioactive molecules present in alfalfa have been shown to enhance antioxidant and anti-inflammatory levels. Overall, supplementation of pig diets with alfalfa has been found to enhance reproductive performance in sows, improve growth performance in piglets, and enhance production performance and pork quality in growing-fattening pigs.

Since its introduction in France, a specific livestock concentrates known as PX 1 (leaf lucerne concentrate) has been utilized for particular animal species. This concentrate is nutritionally advantageous for monogastric animals like pigs, primarily due to its low indigestible fibre content and high levels of protein, vitamins, and pigments (Zanin,1998). Additionally, poultry benefits greatly from PX 1 due to its pigmenting properties, which enhance the coloration of chicken meat and egg yolks. When pigs are fed a daily dosage of 6-8 grams per kilogram of body weight of leaf Lucerne concentrate, they experienced an enhanced growth rates due to its low fibre content which contributes to its high protein digestibility (84%). A reduced faecal pollution, as the animal absorbs a relatively lower amount of nitrogen for an equivalent protein intake was noticed

Bourdon et al. (1980) demonstrated the effectiveness of PX 1 as a protein supplement for pig growth in a wheat-based diet, when incorporated at 10-20% levels, a digestible energy value of 3,735 kcal/kg DM (compared to 4,000 kcal/kg DM for soybean) and a metabolizable energy value of 3,322 kcal/kg DM (compared to 3,750 kcal/kg DM for soybean). The apparent utilization coefficient of digestible energy, at 72.7%, slightly lower (by 2%) compared to soybean oil cake. Consequently, when combined with wheat, lucerne LC serves as an ideal protein supplement for pig growth, partially or entirely replacing soybean cake.

Saponins, which are glycosides, possess a bitter taste, and their concentration in lucerne leaves is double that of the stems. As the plant matures, the saponin content diminishes. Poultry are more vulnerable to the effects of saponins compared to pigs. When saponin levels reach 0.4-0.5% in poultry feed, it leads to reduced feed consumption, decreased egg production, and weight loss in birds. This is because saponins interact with the physicochemical properties in the gut, inhibiting the uptake of specific nutrients such as monosaccharides and cholesterol (Cheeke & Shull, 1985).

Symptoms associated with the consumption of lucerne meal in non-ruminant animals, such as chicks and pigs, include anorexia, listlessness, gastroenteritis, and weight loss. The primary concern in these animals is the retardation of growth rate, primarily attributed to reduced feed intake. Lucerne meal contains antinutritional factors, including tannins, which are present in concentrations ranging from 0.1% to 3.0%. The high tannin content in lucerne meal negatively affects cellulose activity and consequently impairs the digestion of crude fibre. Additionally, tannins decrease the digestibility of dry matter, protein, and other nutrients (Ramteke et al., 2019).

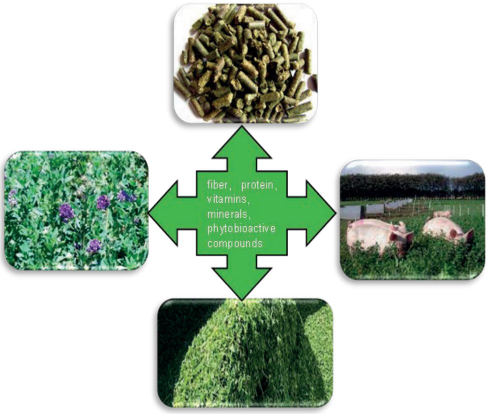

Figure 2. Alfalfa nutritional value in pigs' diet

Relying heavily on a single protein source like soybean meal can influence negatively the lack of diversity in the pig's diet. This can limit the range of nutrients available to the animals and increase the risk of nutritional imbalances. Anti-nutritional factors in soybean can interfere with nutrient absorption and digestion. Introducing new protein alternatives such as peas and alfalfa provides a broader array of nutrients, promoting a more balanced diet for the pigs. Peas and alfalfa offer different nutritional profiles compared to soybean meal (Laudadio et al., 2012). They are rich in protein, amino acids, and other essential nutrients, making them suitable alternatives for meeting the nutritional requirements of pigs. Therefore, by diversifying protein sources, we can potentially enhance the nutritional value of the pigs' diet.

CONCLUSIONS

Exploring new protein alternatives like peas and alfalfa can help overcome these challenges and provide a safer and more digestible protein source for pigs. The cost of soybean meal can vary due to factors such as market conditions, trade tariffs, and transportation costs. Finding alternative protein sources can provide more options for pig farmers, allowing them to choose cost-effective protein alternatives based on regional availability and pricing.

In conclusion, finding new protein alternatives to replace soybean meal in pigs' diets promotes dietary diversity, reduces environmental impact, improves nutritional value, addresses allergenicity and anti-nutritional factors, and offers potential cost savings for pig farmers.

ACKNOWLEDGEMENTS

This research work was carried out with the support of Ministry of Research, Innovation and Digitization and also was financed from Project PN 23-20.01.01.

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