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Extruded soybean in pig feeding in the nursery phase: performance

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Abstract
The objective of this study was to evaluate the replacement of soybean meal by extruded whole soybean in the feeding of pigs in the nursery phase. Thirty-six piglets (Landrace x Large White), with 45 days weighing on average 11.36 kg, distributed in a randomized block design, three treatments, six replicates, two animals per repetition were used. The treatments consisted of: control treatment (T1) basal diet, basal diet with 10% replacement of soybean meal by extruded soybean (T2), basal diet with 20% replacement of soybean meal by extruded soybean (T3). The variables analyzed were: average weight, feed intake, weight gain and feed conversion. The levels of ureatic activity, ether extract, crude protein, protein solubility and volatile moisture of extruded soybean were verified. No difference was found (P>0.05) between the inclusion levels of extruded soybean in piglet diets in the nursery phase for the variables studied. The processing of extruded whole soybean did not affect its digestibility. Extruded soybeans at a level of up to 20% included in piglet feeding during the nursery phase can be a possible substitute for soybean meal, without compromising the performance of the animals.
Keywords: alternative food; performance; pig farming; protein.

Soja extrusada na alimentação de suínos na fase de creche: desempenho

Resumo
Objetivou-se avaliar a substituição do farelo de soja pela soja integral extrusada na alimentação de suínos na fase de creche. Foram utilizados 36 leitões (*Landrace* x *Large White*), com 45 dias pesando em média 11,36 kg, distribuídos em delineamento em blocos casualizados, três tratamentos, seis repetições, dois animais por repetição. Os tratamentos consistiram: tratamento controle (T1) ração basal, ração basal com 10% de substituição do farelo de soja por soja extrusada (T2), ração basal com 20% de substituição do farelo de soja por soja extrusada (T3). As variáveis analisadas foram: peso médio, consumo de ração, ganho de peso e conversão alimentar. Foram verificados os níveis de atividade ureática, extrato etéreo, proteína bruta, solubilidade proteica e umidade volátil da soja extrusada. Não foi encontrada diferença (P>0,05) entre os níveis de inclusão de soja extrusada nas dietas de leitões na fase de creche, para as variáveis estudadas. O processamento da soja integral extrusada não afetou sua digestibilidade. A soja extrusada em nível de até 20% incluída na alimentação de leitões durante a fase de creche pode ser uma eventual substituta ao farelo de soja, sem comprometer o desempenho dos animais.
Palavras-chave: alimentação alternativa; desempenho; suinocultura; proteína.

Introduction

In weaning piglets undergo a sudden change in the environment in which they are, causing them to adapt to the new space, food and ambiance, so it is essential that the animal already has a nutritional and physiological pre-adaptation so as not to suffer a great productive impact (KUMMER *et al.*, 2009).

Currently, the technology used in pig production aims to decrease the weaning age to

increase the productivity of the matrices, which increases the number of piglets produced per soggy/year (MARTINS *et al.*, 2018). The success of this practice requires, however, the use of differentiated diets, containing ingredients with high digestibility for this period so critical of the piglet's life, since the accumulation of stressful situations is inevitable and leaves the animal susceptible to gastroenteric disorders (JUNQUEIRA *et al.*, 2008).

As a way to meet the need of post-weaning pigs in the nursery phase, it is interesting that the formulated diet is based on palatable ingredients with good availability of nutrients and that meet the requirements of the animals (JUNQUEIRA *et al.*, 2008). Extruded foods are becoming a reality in modern pig farming, as they meet the physiological requirements of piglets, thanks to the ease of digestion (DALLANORA; MACHADO, 2010).

The extrusion process breaks down the physical barriers that surround the granules of the ingredients, causing improvements in nutritional, digestive, and enzymatic aspects (FORMIGONI; FONTES, 2014). Extruded whole soybeans emerge in the market because it presents a wide range of benefits that directly impacts the performance of animals.

Soybean and corn are the basis in the formulation of feed, being responsible for the supply of protein and energy to the animals, respectively. Soybean is the main source of protein of plant origin for poultry and pigs, about 35 to 37% crude protein (CP). However, its supply in the *in natura*l form can cause harm to animals, due to antinutritional factors, which lead to reduced performance and undesirable physiological effects, requiring its processing to be offered to animals (LIMA *et al.*, 2014).

The need for inactivation of the antinutritional factors of soybean stimulated in the development of techniques or processing, are several processing that can be used, such as micronization, extrusion, microwave, cooking, according to Bellaver *et al.* (2002). Among the existing processing the most important is the extrusion. Therefore, the research aimed to evaluate the performance of pigs in the nursery phase, fed diets with inclusion of extruded soybean in replacement to the soybean meal.

Material and Methods

The experiment was carried out in the Pig Farming Sector of the Federal Institute of Minas Gerais, Bambuí, Minas Gerais, Brazil. The study was approved by the Ethics Committee on the Use of Animals (CEUA) of IFMG, under registration number 04/2017.

The experiment was carried out in a randomized block design, divided into three treatments with six replicates of 2 animals each, totaling 36 animals, 18 males and 18 females. The animals underwent a period of adaptation of the test diets for 5 days.

The experiment included little Agroceres piglets, with 45 days of age ± 3 and an average weight of 11.36 ±0,42 kg. The work had castrated males and females in the treatments. In each series, the animals were housed in a daycare room, with suspended metal stalls. The stalls were equipped with a semi-automatic feeder and two pacifier-like commuting water coolers. The selection criterion was based on the weight and sex of the animals. The batches were divided at random in each treatment, maintaining the same number of females and males and homogeneous weight average.

The experiment was developed over 21 days, where pigs and diets were weighed at the beginning and at the end of the production cycle (45 and 66 days) to obtain the performance variables: average weight (AW) (kg), feed intake (FI) (kg), weight gain (WG) (kg) and feed conversion (FC) in the nursery phase (kg feed/kg of meat).

The feed was supplied twice a day, with the appropriate replacement of SE and the leftovers collected and weighed, for later correction of consumption. Feed conversion was obtained based on weight and average feed intake of the animals per repetition. In the control treatment (T1) it was provided for the animals to the base diet without the inclusion of extruded soybean (ES). To evaluate the performance, piglets were weighed, per experimental unit (stall), at the beginning and end of the experimental period (45 and 66 days of the age of the animals).

For the two test diets, the substitution method proposed by Sibbald & Slinger (1963) was adopted, and the test food, ES, replaced by 10% (T2) and 20% (T3) of the base diet (Table 1).

Table 1. Formulation and chemical composition of the base feed of piglets (Initial).

Ingredients	Substitution (0%)	Substitution (10%)	Substitution (20%)	CP (%)	ME (kcal/kg)	Ca (%)	Total P (%)	Lis (%)	Met+Cist
Corn	61.7	61.7	61.7	5.09	2060.78	0.018	0.049	0.12	0.197
Soybean meal	28.3	55,53	49,36	12.8	797.96	0.068	0.051	0.72	0.33
Sugar	5.0	5.0	5.0	----	37.37	----	----	----	----
Home Core*	5.0	5.0	5.0	----	----	0.5	0.24	0.065	0.02
Total	100	100	100	17.89	2896.11	0.59	0.34	0.905	0.55

*Vitamin-mineral core guarantee levels: Pantothenic acid 240 mg/kg; phosphoric acid 864 mg/kg; folic acid 0.44 mg/kg; antioxidant 200 mg/kg; acidifying acid 1500 mg/kg; bacilus subtillis 2.5 CFU/kg; bacilli lincheniforms 2.5 CFU/kg; biotin 0.4 mg/kg; calcium 30 g/kg; calcium 10 g/kg; chlorine 59 g/kg; copper 600 mg/kg; choline 1850 mg/kg; sulphur 5000 mg/kg; iron 600 mg/kg; fluoride 470 mg/kg; flavoring 1300 mg/kg; phosphor g/kg; iodine 3 mg/kg; lactose 100 g/kg; lysine 18 g/kg; manganese 200 mg/kg; methionine 400 0 mg/kg; niacin 200 mg/kg; *Saccharomyces cerevise* 2 CFU/kg; selenium 1.2 mg/kg; sodium 10 g/kg; tyrosine 160 mg/kg; vit A 40000 IU/kg; vit B1 6 mg/kg; vit B12 140 mg/kg; vit B2 32 mg/kg; vit B6 8 mg/kg; vit D3 6400 IU/kg; vit E 240 IU/kg; vit K3 14 mg/kg; zinc 12 mg/kg.

The analysis of extruded soybean was carried out in the Animal Nutrition Laboratory of the Federal Institute of Minas Gerais - Bambuí campus, and the levels of ureatic activity, ethereal extract, crude protein, protein solubility, and volatile humidity were verified (Table 2).

Table 2. Nutritional Composition of Extruded Soybeans.

Analysis	Results			
	Value	Unit	Default	
			Minimum	Maximum
Ureatica Activity	0.01	Ph	-	0.20
Ethereal Extract by Acid Hydrolysis	18.74	%	20.00	-
Crude Protein	40.65	%	36.00	-
Protein Solubility	85.97	%	80.00	-
Volatile Humidity at 105 °C	66.60	%	-	12.00

Data on performance were evaluated through a variance analysis (ANOVA), and compared through a Tukey's test when the values were significant with $\alpha = 0.05$. All statistical analyses were performed using R software.

Results and Discussion

There was no difference ($p<0.05$) for the levels of ES inclusion in the performance variables AW, FC, WG, and FC (Table 3).

Table 3. Average weight (AW) (kg), feed intake (FI), daily weight gain (DWG), and feed conversion (FC) at the end of the nursery phase.

Variables	Experimental Diets			P-value	CV (%)
	0% SIE	10% SIE	20% SIE		
Initial Weight	11.267	11.417	10.767	0.589	10.07
Final Weight	23.933	24.783	24.033	0.774	9.19
AFI (Kg)	0.983	1.000	1.000	0.854	18.01
TWG(Kg)	12.667	13.367	13.267	0.854	17.74
DWG (Kg)	0.633	0.668	0.668	0.512	17.74
FC (Kg/Kg)	1.820	1.718	1.590	0.485	19.70

[1]ES: Extruded soybean, AFI: average feed intake, TWG: total weight gain, DWG: daily weight gain, FC: feed conversion.

The pig weight at the end of the nursery phase was similar (p>00.5) for animals fed with 0, 10, and 20% of the inclusion of extruded whole soybean. There is a wide variety of alternative foods available that require evaluation to be used in animal diets.

In pig farming, there is a great deal of concern about newly weaned piglets, since in the first week after weaning is considered a period of great challenges, highlighting the diet, and in the lactation phase its diet is based on breast milk and after weaning occurs the transition from the liquid diet to totally solid diet (feed), so there is a concern with the quality of the feed provided to the newly weaned piglets (ARAÚJO, 2007).

Mendes *et al.* (2004) analyzing the effect of processed soybean protein on pig feeding, concluded that the soybean protein processed for weeded piglets increased animal performance. Ayoade *et al.* (2012) working with a mixture of carbohydrates and extruded whole soybean in the finishing pig feed observed that enzymatic supplementation increased the nutritive value of extruded soybean flour for finishing pigs.

According to Shurson and Johnston (1998), it is important to provide the contact of the piglet with the antigenic proteins of soybean from weaning, promoting the adaptation of the animal to these products. The insertion of 20 to 40% of soybean meal, even on complex diets, for piglets weaned at 12 days of age will negatively influence the performance of the animal. Quadros *et al.* (2008) also did not observe a significant effect for performance of castrated male pigs and finishing females when supplied with soybean husk levels to.

Zhou *et al.* (2017) evaluating that the effect of supplementation of different concentrations of whole extruded soybean (EFS) in diets based on corn and soybean meal for lactating matrices, demonstrated that diets supplemented with EFS had a positive effect on milk composition and performance. Oliveira *et al.* (2012) did not obtain significant results in their research with the substitution in the diet of piglets weaned at 21 days, similarly to the results of this study.

Bertol *et al.* (2001) when evaluating four substitution levels (0, 20, 40 and 60%) of soybean meal by extruded whole soybean in the diet of piglets weaned at 21 days of age, observed an increasing linear effect for daily weight gain (DWG), daily feed intake (DFI) and average weight (AW) and linear reduction of feed conversion (FC) for the period from 0 to 14 days after weaning. However, in the period of 15 to 35 days after weaning, there was no difference for DWG and DFI, there was a linear increase in FC as the levels of extruded whole soybean were increased, demonstrating a worsening in feed conversion, contradicting the results found in this experiment, where the levels studied 0, 10 and 20% did not interfere in the average weight, feed intake, weight gain and feed conversion.

Soares *et al.* (2000) when studying the effect of fermented whole soybean, extruded the whole soybean, and soybean meal in place of milk powder for piglets at 14 days of age, they observed that weight gain (WG) was better for piglets that received the diet containing powdered milk, while the animals that received diets containing fermented whole soybean and soybean meal presented the same WG.

These authors reported that pigs that received the diet containing extruded whole soybean presented lower WG, the authors attributed the result to better digestibility of milk protein powder. Pigs weaned early present low feed intake and weight gain when fed with plant proteins because they present difficulties in digestion and absorption.

When evaluating the trypsin inhibitor concentration in soybean protein sources, observed a lower concentration for soybean meal (15.76), falling below 20% considered limit level, while for fermented whole soybean and extruded the whole soybean presented levels above the established, the high value found for extruded whole soybean (96.61%) may have explained the worst results for the variables of weight gain and feed conversion (SOARES *et al.*, 2000).

In table 2 shows the results of the chemical composition of the extruded whole soybean. Soybeans because it is a vegetable with high levels of protein and energy is an excellent alternative of protein food, presenting 17 to 18% and oil and 35 to 37% crude protein with high biological value and contains in its composition essential amino acids favorable to the feeding of pigs.

The ureatica activity of soybean is an important factor to identify the presence of toxic factors present in soybean among them we can mention trypsin inhibitors. The result found is within the established standard value that 0.20

pH units and also according to the established range, which is 0.05 to 0.30 pH units (MENDONÇA *et al.*, 2015).

Mendes *et al.* (2004), when evaluating the effect of different forms of thermal processing on the digestibility and energy values of whole and semi-integral soybean, found 0.18 pH units for extruded semi-integral soybean value above that found in this study.

Protein solubility analysis evaluates the degree of soybean processing. The solubility variation range of 73 to 85% seems to be consistent as optimal processing. Values below 70% indicate overheating, and values above 85% are related to under processed soybean (BRUMANO; GATTÁS, 2004). The value found for protein solubility in this study is within the established limit, showing that extruded whole soybean was processed adequately.

It is important to be aware of soybean processing, because when soybean or soybean meal underheating occurs, it may contain antinutritional factors that will not be inactivated and may influence the digestive process of pigs and overheating reduces the digestibility of amino acids (BERTOL *et al.*, 2011). Extruded whole soybeans have a wide range of benefits that directly impact the performance of animals. Its use as an ingredient results in a high-quality feed, suitable for nourishing animal species.

Conclusion

Extruded soybean (up tp 20%) can be a possible substitute for the soybean meals used in piglet feeding during the nursery phase, without affecting the performance of the animals and the digestibility of diet.

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