















## Influence of including pecan shelling by-product into pig diets: performance, carcass traits and visceral organ weights

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**Abstract.** Ten pigs (65.55 kg IBW) were used in a 42-d trial to evaluate the influence of partial replacement of corn with pecan shelling by-product grindings (PSB) on performance, carcass traits and visceral organ weights. Treatments consisted of corn-soybean meal-based diet containing 0% or 10% PSB, where PSB replaced 0% or 13% of corn (as-fed basis) in a two-phase finishing feeding program. There was not difference on average daily gain and feed efficiency between dietary treatments for either phase I and II or for the whole finishing period. Fecal score as a measure of intestinal activity was not different between dietary treatments, except for the browner feces produced from pigs fed on PSB supplemented diets. No differences on carcass traits, and visceral organ weights were observed when corn was partially replaced by PSB in the diets of finishing pigs, however, those animals fed on PSB supplemented diets had a lower backfat depth. Combined, including pecan shelling by-product grindings in a partial substitution of corn in finishing diets of pigs had no negative effects on pigs' performance, carcass traits, and visceral organ weights. This feeding strategy allows a marginal reduction in feed cost and improve the recycling of human non-edible feedstuff into a high-quality pork product for human nutrition.

**Keywords:** pig production; non-conventional feedstock; carcass characteristics

## Influencia de la inclusión de polvillo de nuez pecan en dietas de cerdos: comportamiento productivo, características de la canal y peso de órganos viscerales

**Resumen.** Se utilizaron diez cerdos (65.55 kg PV inicial) en una prueba de 42 días para evaluar la influencia del reemplazo parcial de grano de maíz por polvillo de nuez pecan (PSB) sobre el comportamiento productivo, características de la canal y peso de los órganos viscerales. Los tratamientos consistieron en dietas a base de grano de maíz-pasta de soya conteniendo 0% ó 10% de PSB, donde PSB reemplazó 0% ó 13% del grano de maíz (base tal como se ofrece) en un programa de alimentación de finalización en dos fases. No hubo diferencias en la ganancia diaria de peso y eficiencia alimenticia entre tratamientos durante la fase I y II o para toda la fase de finalización. La actividad intestinal tampoco fue afectada por el consumo de PSB evaluada por la calificación de las heces, sin embargo, los cerdos alimentados con dietas suplementadas con PSB produjeron heces más oscuras. No se observó diferencia en las características de la canal y peso de los órganos viscerales cuando se reemplazó parcialmente el maíz por el PSB en las dietas de cerdos en finalización, sin embargo, los animales alimentados con la dieta suplementada con PSB tuvieron menor espesor de la grasa dorsal. En conjunto, la inclusión de polvillo de nuez pecan en sustitución parcial del grano de maíz en dietas para cerdos de finalización no tuvo efectos negativos sobre el comportamiento productivo, las características de la canal y el peso de los órganos viscerales. Esta estrategia de alimentación permite una reducción marginal del costo del alimento y mejora el reciclado de ingredientes no consumibles por el humano in productos cárnicos de alta calidad para la nutrición humana.

**Palabras clave:** producción porcina; ingredientes no tradicionales; características de la canal

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## Influência da inclusão do subproduto da casca de noz-pecã em dietas de suínos: desempenho, características de carcaça e peso de órgãos viscerais

**Resumo.** Dez suínos (65,55 kg IBW) foram utilizados em um experimento de 42 dias para avaliar a influência da substituição parcial do milho por moagem de subproduto da casca de noz-pecã (PSB) no desempenho, características de carcaça e peso dos órgãos viscerais. Os tratamentos consistiram de dieta à base de milho e farelo de soja contendo 0% ou 10% de PSB, onde PSB substituiu 0% ou 13% de milho (na base da ração) em um programa de terminação em duas fases. Não houve diferença no ganho médio diário e na eficiência alimentar entre os tratamentos dietéticos para as fases I e II ou para todo o período de terminação. O escore fecal como medida da atividade intestinal não foi diferente entre os tratamentos dietéticos, exceto para as fezes mais acastanhadas produzidas por suínos alimentados com dietas suplementadas com PSB. Não foram observadas diferenças nas características de carcaça e nos pesos dos órgãos viscerais quando o milho foi parcialmente substituído por PSB nas dietas de suínos em terminação, no entanto, os animais alimentados com dietas suplementadas com PSB apresentaram menor profundidade de toucinho. Combinados, incluindo a moagem de subprodutos da casca de noz-pecã em substituição parcial ao milho em dietas de terminação de suínos, não houve efeitos negativos sobre o desempenho dos suínos, características de carcaça e peso dos órgãos viscerais. Essa estratégia de alimentação permite uma redução marginal no custo da ração e melhora a reciclagem de ração humana não comestível em um produto suíno de alta qualidade para nutrição humana.

**Palavras-chave:** suinocultura; matéria-prima não convencional; características da carcaça

### Introduction

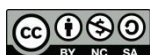
In animal agriculture, feeding accounts for roughly between 60 to 70% of total animal production cost (Pomar and Remus, 2019). However, a decade ago feed cost for swine already was over 72% (Zijlstra and Beltranena, 2013) and it increased with the appearing of the COVID-19 pandemic and further affected by current war in Ukraine (Zijlstra and Beltranena, 2022), the latter, one of the world largest cereal grain suppliers. Local agro-food-industries generates by-products that are treated as waste with negative effects on the environment (Sadh et al., 2018). These by-products are heterogeneous in nutrients content and bioactive compounds composition (Zijlstra and Beltranena, 2009). The bioactive compounds in most non-conventional feedstock bring health benefits or greater risk when feed at low or high level of inclusion rate into the swine diet, respectively. The risk can be managed through feed processing as well as with controlled inclusion rate during feed formulation for a more predictable results on pig performance (Zijlstra and Beltranena, 2013). At times of great economic uncertainty, feeding pigs with local non-conventional feedstock may help to reduce feed cost and shortage availability of main commodities, especially corn, while improving circular economy (Sadh et al., 2018). This is

especially important for México where maize is a staple food and at times an unbalanced competition of corn for food or feed exist (Muscat et al., 2020). The pecan shelling industry generates by-products such as husk, shell, shattered pecan kernel, and pecan shelling by-product grindings (PSB; “polvillo de nuez”; De la Rosa et al., 2011), which all have limited usage in livestock feeding. Local backyard pig producers include PSB into their swine feeding program, but results on performance are inconsistent (by word of mouth). The basis of this is not known but the excessive PSB inclusion rate into the swine diet may be the fault. The PSB supplementation at 10% inclusion rate into the diet at midgestation did not influence on sows’ performance (Buenabad et al., 2022). Partially substituting corn with pecan shelling by-product which are rich in fat and phytochemicals increases the energy content of the diet but also the risk on reducing feed palatability and digestibility with possible mixed results on performance and carcass traits. Then, the objective of the present trial was to evaluate the influence of partial replacement of corn with pecan shelling by-product on performance, carcass traits, and visceral organ weights in finishing pigs.

### Materials y Methods

Ten pigs (York × Landrace × Duroc; 65 to 110 kg BW) were used to evaluate the influence of partial replacement of corn with pecan shelling by-product grindings in a finishing diet on performance, carcass traits and visceral organ weights. Pigs were randomly assigned into one of two dietary treatments. The pigs used in this trial were

cared for in accordance with the guidelines established in the Official Mexican Regulations on Animal Care (NOM-062-ZOO-1999, 2001). Experimental diets were based on corn-soybean meal and fortified with vitamins and minerals (Table 1) and formulated to meet or exceed nutrient requirements of finishing pigs (NRC, 2012).



Treatments (Table 1) consisted of a corn-soybean meal-based finishing diets containing 0% or 10% pecan shelling by-product grindings (PSB), where PSB replaced 0% or 13% of corn (as fed basis). Finishing pigs were fed in two phases (phase I, 60 to 90 kg; phase II, 90 to 120 kg) to meet closely pigs nutrient requirement (NRC, 2012); in phase I, pigs received no ractopamine supplementation whereas at phase II they so. Pens were 54 m<sup>2</sup> with 36 m<sup>2</sup> overhead shade, nipple drinker, and

concrete feeder bunk. Pigs were fed *ad libitum* and were allowed free access to drinking water. Initial and final body weights (BW) were recorded to calculate the average daily gain (ADG). Feed disappearances were recorded at weekly basis. Backfat depth was estimated in all pigs by ultrasound at the P2 region (average of bilateral measurements) before they were shipped to the processing plant. Pigs were euthanized by electrical stunning and exsanguination.

**Table 1** –Ingredients of diets of pigs fed pecan shelling by-product grindings (PSB; as-fed basis)

Item	<sup>1</sup> Phase I PSB, %		<sup>2</sup> Phase II PSB, %	
	0	10	0	10
<b>Corn</b>	77.50	67.50	74.00	64.00
<b>Soybean meal</b>	19.00	19.00	22.50	22.50
<b>Pecan shelling by-product grindings</b>	-	10.00	-	10.00
<b>Canola oil</b>	1.00	1.00	1.00	1.00
<b>Feed supplement</b>	2.50	2.50	2.50	2.50
	100.00	100.00	100.00	100.00

<sup>1</sup>Phase feeding I of finishing pigs (60 to 90 kg BW);

<sup>2</sup>Phase feeding II of finishing pigs (90 to 120 kg BW)

Two pigs from each dietary treatment were used to calculate carcass yield and visceral organ mass. The data from this trial was subject to a two-step statistical analysis. First, homogeneity of variance was checked through Levene's test and the normal distribution by

Kolmogorov–Smirnov test. Based on the outcome, the data was then analyzed using student's t-test for equal or unequal variance (Statistix 10, Analytical Software, Tallahassee, FL). The significant level was set at P<0.05.

## Results and Discussion

Industrial swine production relies on corn-soybean meal-based diets (Stein et al., 2016) as the “gold standard of feeding”, however in the case of Mexico this business model is neither environmental nor socially sound for a place where people depend heavily on maize as staple food. However, little has been done domestically regarding feeding evaluation on partial substitution of corn with feedstock to reduce the competition of food for feed in line with the national interest toward food self-sufficiency. Across the country, agro-food-industry generate several by-products that are human-nonedible that swine can readily convert into a high-quality pork products for human nutrition (Zijlstra and Beltranena, 2022). However, as for any candidate feedstock it must past a strict productive or safety assessment in respect to an outstanding feedstuff before to be included into feeding formulations (Glenn, 2008). Treatment effects on growth performance of finishing pigs are presented in Table 2. In finishing phase I (79.55 kg average BW), the partial substitution of corn with pecan shelling by-product grindings in the diet (10% inclusion rate) of pigs did not affect (P>0.10) average daily gain and gain efficiency. Feed intake was not analyzed statistically but it

was numerically equal between dietary treatments. Similarly, at finishing phase II (101.43 kg of average BW), there were not difference (P>0.10) on weight gain and gain to feed ratio between 0% or 10% PSB supplemented diets. During all finishing period, feed intake was not recorded individually for each experimental unit and then no meaningful conclusion could be draw regarding feed palatability as a direct influence of phytochemicals (tannins; De la rosa et al., 2011) concurred increased with PSB supplementation. In general, tannins at low inclusion rate brings some health benefits, but at higher inclusion rate increases the risk to reduce feed palatability in young pigs (Caprarulo et al., 2021), however, it seems that it was not the case in here. Overall, the average daily gain and feed efficiency for the entire finishing phase averaged 1.04 kg/d and 0.37, respectively, which was in closed agreement with expected performance for pigs at similar physiological condition (NRC, 2012). Moreover, the observed performance of pigs fed on diets supplemented with this novel feedstock rich in fat and phytochemicals (De la Rosa et al., 2011) with antinutritional activity apparently did not affect bioavailability of mayor nutrients during the finishing phase.

**Table 2.** Growth-performance of pigs fed pecan shelling by-product grindings (PSB) during finishing. Means  $\pm$  SD, Student's t-test.

Item	PSB, %		P-Value
	0	10	
IBW, kg	65.24 $\pm$ 7.65	65.86 $\pm$ 6.12	0.891
FBW, kg	109.00 $\pm$ 7.38	109.60 $\pm$ 9.37	0.913
<b>Phase I (60 to 90 kg BW; 28 days)</b>			
Average daily gain, kg	1.01 $\pm$ 0.04	0.99 $\pm$ 0.13	0.716
Average daily feed intake(pooled)	2.76	2.76	-
Gain: Feed	0.37 $\pm$ 0.02	0.36 $\pm$ 0.05	0.618
<b>Phase II (90 to 120 kg BW; 14 days)</b>			
Average daily gain, kg	1.10 $\pm$ 0.16	1.15 $\pm$ 0.17	0.648
Average daily feed intake(pooled)	3.00	3.00	-
Gain: Feed	0.37 $\pm$ 0.05	0.38 $\pm$ 0.06	0.625

In this regard, apart from meeting pig's nutrient requirement while using novel feedstocks in diets of pigs, antinutritional factors have to be controlled as well for which inclusion rate plays a major role (Woyengo *et al.*, 2014). Finished pigs in Mexico are commonly shipped to slaughter at roughly 80 to 100 kg BW, with heavy pigs associated with pork export regions while lighter ones with domestic market (SIAP, 2021). In current trial, the pigs BW encompassed those representing the animals shipped to harvest at lighter as well as those at heavier final BW for which the gathered data can have meaningful application for pig production in Mexico. Treatment effects on carcass traits and visceral organ weights of finishing pigs are presented in Table 3. The final BW, hot carcass weight and dressing percentage of pigs was not affected ( $P>0.10$ ) by the amount of corn substituted with pecan shelling by-product grindings in the finishing diet. Moreover, including PSB into the finishing diet reduced ( $P=0.044$ ) backfat depth in pigs, which is a desirable characteristic in modern pork production. In current trial, leaner pigs had numerical lower dressing percentage which seems to be in line with previous results where selected pigs for leanness

concurrently had larger gastrointestinal tract and slightly less weight per carcass (Ciplef *et al.*, 1993). The liver, kidney and heart of pigs was not influenced ( $P>0.10$ ) by the partial substitution of corn in the diet of finishing pigs. Visceral organ size expressed as absolute or as percentage of body weight improves the understanding of pig's physiological capacity for growth (Efelson *et al.*, 2021). In line with growth-performance results, visceral organ weight relative to whole-body weight was in close agreement with data obtained from animals fed on corn-soybean meal based-diets (Efelson *et al.*, 2021), which can be interpreted as no meaningful change in pig's metabolism by the addition of the novel feedstock into the diet. In this regard, a rule of thumb to maintain a more predictable animal performance while including a novel feedstock into pigs' diets has to do with controlling inclusion rate (Woyengo *et al.*, 2014). Overall, it is clear that the partial replacement of corn (13% of corn replaced) with PSB in the diet of finishing pigs is not the solution for the unbalanced competition of food for feed in Mexico, but it may contribute to reduce feed cost, and improve the recycling of human nonedible feedstuff into high quality pork products highly demanded in the domestic market.

**Table 3.** Treatment effects on carcass characteristics and organ weight in finishing pigs.

Item	PSB, %		P-Value
	0	10	
BW, kg	114.50 $\pm$ 9.19	115.50 $\pm$ 0.71	0.892
Backfat, mm	10.10 $\pm$ 2.53	6.30 $\pm$ 2.49	0.044
Hot carcass weight, kg	85.00 $\pm$ 5.66	84.25 $\pm$ 0.35	0.869
Carcass yield, %	74.28 $\pm$ 1.03	72.95 $\pm$ 0.76	0.288
<b>Visceral organ weight, % of BW</b>			
Liver, %	1.47 $\pm$ 0.05	1.33 $\pm$ 0.01	0.150
Kidney, %	0.32 $\pm$ 0.02	0.30 $\pm$ 0.03	0.614
Heart, %	0.35 $\pm$ 0.04	0.36 $\pm$ 0.04	0.836

## Conclusions

The findings suggest that partial replacing corn (13%) with pecan shelling by-product grindings in the diet of pigs have not negative influence on growth-performance, carcass traits and visceral organ weights, but it reduced the backfat depth in finishing pigs.

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