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ILEAL APPARENT AND STANDARDIZED AMINO ACID DIGESTIBILITY OF SOYBEAN AND COLZA MEAL IN DIETS FOR FINISHING PIGS

Juan Edrei **Sánchez-Torres**[1], Ignacio Arturo **Domínguez-Vara**[1*], Luis **Castro-Bárcena**[1], Jorge Luis **Yañez-Hernández**[2], Miguel **Cervantes-Ramírez**[3], Ernesto **Morales-Almaraz**[1], José Luis **Bórquez-Gastelum**[1], Daniel **Trujillo-Gutierrez**[1]

[1] Departamento de Nutrición Animal, Facultad de Medicina Veterinaria y Zootecnia, Universidad Autónoma del Estado de México, Campus Universitario "El Cerrillo", Toluca, Estado de México, México. C. P. 50090.
[2] Facultad de Medicina Veterinaria y Zootecnia, Universidad Autónoma del Estado de Tlaxcala. La Loma Xicoténcatl, Tlaxcala de Xicoténcatl, México. C. P. 90000.
[3] Instituto de Ciencias Agrícolas, Universidad Autónoma de Baja California, Ejido Nuevo León, Mexicali, Baja California, México. C. P. 21705.
* Corresponding author: igy92@hotmail.com

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ABSTRACT

Agri-food chains generate by-products such as soybean and colza meal for animal feed. Their nutritional value is variable and should be analysed for better quality control before their inclusion in balanced diets. The objective was to determine the content and ileal apparent and standardized digestibility of protein and amino acids (AA) of soybean (PS) and colza meal (PC) as a source of protein in diets for finishing pigs. The experimental units were arranged in a 3×3 Latin square design repeated. The treatments (T) were T1: PS+corn starch, T2: PC+corn starch, and T3: corn starch (Control), which were randomly assigned to six pigs cannulated in distal ileum (PV 75±1.2 kg). The variables were contents and apparent ileal and standardized ileal digestibility of amino acids in soybean and colza meal. To determine digestibility, chromic oxide was added to the diets. The protein and fat contents were higher in the soybean meal. Ash, crude fibre, neutral detergent fibre, acid detergent fibre, phosphorus and calcium contents were higher in the colza meal. Essential amino acid content was higher in soybean meal, but methionine was higher in colza meal. Apparent ileal digestibility (DIA) of total amino acids was similar ($p > 0.05$) among protein ingredients; but for lysine and threonine it was higher ($p \leq 0.05$) in soybean meal, except methionine. Methionine DIA was 89.78 %, 3.88 % higher ($p \leq 0.05$) in colza meal. Standardized ileal digestibility (DIE) of total amino acids was similar ($p > 0.05$) among ingredients, but lysine and threonine were higher ($p \leq 0.05$) in soybean meal. DIE was different ($p \leq 0.05$) among ingredients for all amino acids except methionine. Ileal and standardized digestibility of all amino acids were higher in soybean meal, except methionine, which was higher in colza meal. The DIA of total amino acids was similar in both protein ingredients, except lysine and threonine in soybean meal and methionine in colza meal.

Key words: amino acids, pigs, digestibility, meals, soybean, colza.

INTRODUCTION

The feed and biofuel industries have increased the demand for cereal grains and oilseeds, increasing their cost and limiting their inclusion in diets for livestock species. These industries generate by-products whose chemical composition and digestibility require characterization for use in balancing and optimizing diets for swine (Woyengo *et al*., 2014).

Swine nutrition and feeding are based on balanced diets that cover the energy and amino acid (AA) requirements according to the physiological stage of the pig; but, minimizing nitrogen (N) excretion to the environment (National Research Council - NRC, 2012). Therefore, evaluating the bioavailability of each essential amino acid is a critical aspect to assess the nutritional quality of the ingredients, as well as to estimate the requirements of AA in pigs. These studies facilitate the generation, development and exchange of information worldwide (Moughan *et al*., 2013); three areas predominate in feeding programs on protein plant sources: amino acid digestibility, anti-nutritional factors, and metabolizable energy and net energy contents (Ruiz *et al*., 2020).

In Mexico, soybean [*Glicine max* (L.) Merril] and colza (*Brassica napus*) seed production for oil extraction in 2016 was 510 000 Mg (Megagrams) of soybean and 4070 Mg of colza, but the national seed deficit is still significant (Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación - SAGARPA, 2017). Therefore, in this year, there was a greater amount of protein by-products available, and it is required to characterize their nutrients. Soybean meal (PS) and colza meal (PC) are the most important oil extraction residues; the process is performed by solvent or mechanical pressing of soybean and colza seeds. Both by-products are used in animal feed and are characterized by their high crude protein and AA content, but in colza there are higher fibre values that can affect the availability of protein and AA (NRC, 2012; Woyengo *et al*., 2016).

The PS and PC used in swine feed in Mexico come mainly from the United States and Canada, but the content and digestibility of AA is generally unknown. Lagos and Stein (2017) showed that the apparent ileal digestibility (DIA) of protein and AA of PS produced in other countries was different. The standardized ileal digestibility (DIE) values of amino acids of PS are higher than most other plant protein sources (Berrocoso *et al*., 2015; Liu *et al*., 2016a). Also, the DIE of AA from US soybean meal is higher than PS from other countries (Lagos and Stein, 2017).

Woyengo *et al.* (2016) determined the standardized ileal digestibility coefficients (DIE) of AA of four colza by-products in diets for finishing pigs, where PC (*B. juncea)* showed higher DIE of AA than that obtained from *B. napus*, therefore, it provided more digestible AA to cover the AA requirements of pigs.

In Mexico, swine nutritionists use the information on nutritional requirements generated in the country and in others. In particular, based on the NRC (2012) edition, which presents average and standard deviation values, which are products from several investigations. The information generated in this study will contribute to the construction of national databases, in the short and medium term, both of nutritional requirements (protein and AA) of finishing pigs of the Duroc x Landrace genotype, as well as tables of chemical composition of protein feedstuffs, soybean and colza meal (AA contribution and digestibility). This tabulated information could be used to balance diets under the concept of ideal protein, with lower protein excretion in faeces and urine to the environment and higher nitrogen use efficiency of the diets supplied. The hypothesis was that PS and PC have similar apparent ileal digestibility and standardized ileal digestibility of protein and AA. The objective of the study was to determine the apparent and standardized ileal digestibility and content of protein and amino acids of two protein by-products, soybean and colza meal, in diets for finishing pigs.

MATERIALS AND METHODS

The Bioethics and Animal Welfare Committee of the Faculty of Veterinary Medicine and Animal Husbandry of the Autonomous University of the State of Mexico (Universidad Autónoma del Estado de México - UAEM) reviewed and approved the surgical, experimental and swine breeding procedures in accordance with the Official Mexican Standard NOM-062-ZOO-1999 of SAGARPA in the Mexican Federal Register (SAGARPA/Diario Oficial de la Federación - DOF, 2001).

Experimental pigs and diets

A T-type cannula was surgically inserted into the distal ileum (Cervantes *et al*., 1999) in six castrated pigs (average PV 75±1.2 kg; F1 Duroc x Landrace). The pigs were dewormed, by subcutaneous injection, with 300 μg of ivermectin per kg body weight (1 mL per 33 kg body weight) (Ivomec Boehringer®) and were housed in individual metabolic units (1.2 x 1.2 m) that allowed them to move freely, consume the offered feed without rejection and remain clinically healthy during the entire experimental period. The cages had a plastic floor, polyvinyl chloride walls (0.9 m height), with an automatic hopper feeder and automatic drinker.

Samples of PS and PC were collected at the food plant of the Faculty of Veterinary Medicine and Animal Husbandry of the UAEM. To analyse their nutritional composition, from total batches of 5 Mg, primary samples were extracted from bags with a capacity of 50 kg (n = 15), then a composite sample of approximately 1 kg of each ingredient was formed, with sampling techniques described in the guide for the elaboration of statistical sampling in epidemiological surveillance programs: Microbiological and toxic residues (Organismo Internacional Regional de Sanidad Agropecuaria - OIRSA, 2017).

The diets evaluated contained on dry basis (% BS) soybean meal (PS), colza meal (CP) and no nitrogen source (Table 1). The nutritional quality of PS and PC was evaluated individually (Table 2) and with the diets (Table 3). The nitrogen-free diet was used to estimate basal loss of endogenous amino acids (Nawas *et al*., 2017). To measure digestibility, diets included 3 g kg^{-1} chromium oxide (Cr_2O_3), as an external indigestible marker.

Table 1. Composition (g kg^{-1} BS) of the experimental diets.

Ingredients	Experimental diets		
	Soybean meal	Colza meal	Nitrogen free
Corn starch	511.00	523.90	852.00
Soybean meal	416.00	----	----
Colza meal	----	406.00	----
Sugar	30.00	30.80	50.00
Solka floc	----	----	30.00
Colza oil	12.00	12.30	20.00
Limestone	3.00	----	10.00
Monodicalcium phosphate	11.00	10.00	12.00
Salt	2.00	2.00	5.00
Vitamin premix†	5.00	5.00	5.00
Mineral premix¶	5.00	5.00	5.00
KCO_3, 56 % K	----	----	5.00
MgO, 58 % Mg	----	----	1.00
Chromium oxide	5.00	5.00	5.00

†Vitamin premix (UI g^{-1})=vitamin A, 4,500; vitamin D_3, 800; vitamin E, 30; vitamin K_3 menadione, 1. 6 mg kg^{-1}; biotin, 100 mg kg^{-1}; cyanocobalamin, 16 μg kg^{-1}; choline, 300 mg kg^{-1}; folic acid, 900 mg kg^{-1}; niacin, 16 mg kg^{-1}; pantothenic acid 10 mg kg^{-1}; pyridoxine 2.5 mg kg^{-1}; riboflavin 8 mg kg^{-1}; thiamin, 1.3 mg kg^{-1}.
¶Mineral premix (mg kg^{-1})=Co, 0.65; Cu, 12; Fe, 100; I, 0.50; Mn, 35; Se, 0.25; Zn, 100.

The nutrient content of the diets was calculated (Table 2). PS and PC were the only sources of nitrogen (protein and amino acids). The diets were formulated to meet the vitamin and mineral requirements of finishing pigs (NRC, 2012).

Experimental procedure

The experiment had three stages of 7 d each; the first 5 d were to adapt the pigs to the diet, followed by 2 d to collect ileal contents. Feed intake was limited to three times the maintenance digestible energy requirement (3×110 kcal of ED kg^{-1} $PV^{0.75}$; NRC, 2012), based on the metabolic body live weight of the pig at the start of each period. Feed was fed in two equal portions, at 0800 and 1500 h. The ileal contents of each pig and stage, were collected continuously from 0800 to 1800 h, homogenized and preserved frozen at -20 °C.

Sample collection, processing and analysis

The total ileal content, collected per pig and stage, were thawed and a composite sample was made; from this, 100 g were taken and dried in a Labconco FreeZone™ Freeze-Dry Systems 4.5 L 117-A65312906 (Czech, Republic). The freeze-dried diets, ingredients (PS and PC) and ileal contents were ground to a particle size of 1 mm with a mill (General Electric, 5KH39QN5525, Mexico). In diets and ingredients (Tables 2 and 3), the following were analysed: dry matter (method 930.15), crude protein (method 984.13 A-D), ether extract (method 920.39A), crude fibre (method 985.29) and

Table 2. Nutrient content (g kg^{-1} MS) and amino acid profile (%) analyzed in the experimental diets supplied.

Variable	Experimental diets		
	Soybean meal	Colza meal	Nitrogen free
Dry Matter	892.70	896.20	886.20
Crude protein	191.00	167.70	6.60
Ether extract	29.50	29.70	23.60
Ash	33.70	42.40	39.70
Crude fibre	27.40	28.00	23.00
Phosphorus	4.70	6.20	4.70
Calcium	5.20	5.20	5.20
Total essential AA, %:			
Arginine	1.05	1.14	0.01
Histidine	0.41	0.43	0.01
Isoleucine	0.70	0.75	0.01
Leucine	1.19	1.33	0.04
Lysine	0.95	1.05	0.01
Methionine	0.18	0.27	0.01
Phenylalanine	0.78	0.79	0.02
Threonine	0.59	0.75	0.01
Valine	0.75	0.92	0.03
Total non-essential AA, %:			
Alanine	0.66	0.79	0.02
Aspartic acid	1.70	1.47	0.02
Glutamine	2.71	3.12	0.08
Glycine	0.63	0.85	0.01
Proline	0.72	1.03	0.02
Serine	0.73	0.78	0.01
Tyrosine	0.52	0.52	0.02

ash (method 942.05) according to AOAC (2012). Neutral detergent fibre (FDN) and acid detergent fibre (FDA) were determined according to Van Soest *et al*. (1991) in an ANKOM200 digester (ANKOM Technology Corporation, Fairport, NY, USA); to remove the starch present, alpha amylase was added.

The amino acid profile in ingredients, diets and ileal content was analysed in the laboratories of the experimental station of the University of Missouri, USA (method 982.30; AOAC, 2012). To measure digestibility in diets and ileal content, chromic oxide (Cr_2O_3) content was added and analyzed by spectrophotometry at 440 nm after incinerating the sample for 12 h at 450 ˚C (Fenton and Fenton, 1979).

Calculations

The DIA of protein and AA of the diets was calculated with the indicator method Eq. [2] DIA=[1-[(ID×AF)/(AD×IF)]]×100. Where DIA is the ileal apparent digestibility in percent of a nutrient in the diet, ID=dietary indicator concentration (mg kg^{-1} MS), AF=dietary nutrient concentration in ileal digesta (mg kg^{-1} MS), AD=dietary nutrient

Table 3. Nutrient content (g kg^{-1} MS) and amino acid profile (%) in the ingredients used in the experimental diets supplied.

Variable	Ingredients		
	Soybean meal	Colza meal	Corn starch
Dry Matter	896.30	898.30	884.90
Crude protein	474.50	393.90	6.60
Ether extract	65.80	28.50	0.00
Ash	63.70	67.30	0.10
Crude fibre	66.00	95.00	0.00
Acid detergent fibre	66.60	119.60	0.00
Neutral detergent fibre	98.20	183.40	0.00
Phosphorus	6.40	12.00	0.00
Calcium	3.50	6.80	0.00
Total essential AA, %:			
Arginine	3.39	2.34	0.01
Histidine	1.25	1.06	0.01
Isoleucine	2.15	1.53	0.01
Leucine	3.62	2.76	0.04
Lysine	2.93	2.19	0.01
Methionine	0.55	0.62	0.01
Phenylalanine	2.39	1.58	0.02
Threonine	1.81	1.67	0.01
Valine	2.26	2.00	0.03
Non-essential AA, %:			
Alanine	1.99	1.68	0.02
Aspartic acid	5.28	2.70	0.02
Glutamine	8.24	2.59	0.08
Glycine	1.95	1.89	0.01
Proline	2.26	2.29	0.02
Serine	2.23	1.65	0.01
Tyrosine	1.77	1.09	0.02

concentration (mg kg^{-1} MS), IF=dietary indicator concentration in ileal digesta (mg kg^{-1} MS). Each pig fed with the nitrogen-free diet was used to calculate the basal loss of endogenous AA Eq. [3]. IAAend=AAdigesta×(Mdiet/Mdigesta), where: IAAend=basal endogenous loss of an amino acid (g kg^{-1} MS ingested), AAdigesta=concentration of that amino acid in ileal digesta (g kg^{-1} MS), Mdiet and Mdigesta=dietary and digesta marker concentrations (g kg^{-1} MS). The DIE of protein and AA of the diets was calculated from the correction of the DIA of the basal endogenous amino acid loss Eq. [7] DIE=DIE+[(EndoN/ConsN)×100], where DIE=standardized ileal digestibility in percentage of a nutrient, DIA=apparent ileal digestibility of a nutrient, EndoN=endogenous excreted amount of nutrient (mg kg^{-1} MS consumed, ConsN=amount of nutrient consumed (mg kg^{-1} MS consumed). To calculate the DIE, the loss of endogenous AA was subtracted from the DIA. The DIE of the AA of the ingredients was calculated by the difference method (Stein *et al*., 2007).

Statistical analysis

Data were analysed in a 3×3 repeated Latin square and the MIXED procedure of SAS® (SAS Institute Inc., 2004) was used. Each pig was a randomized experimental unit and subject. The comparison of means was performed with Tukey's test ($p \leq 0.05$); and for the assignment of literals in the generalized difference matrix, the macro procedure pdmix800.sas was used, which standardizes the generated matrix of *pdiffs* values from the multiple comparison of means test from the Latin square, into another with the corresponding assignment of literals.

RESULTS AND DISCUSSION

Nutritional characteristics of ingredients

PS is the main source of protein and AA used in fattening swines and breeding pigs diets. The crude protein, lysine and threonine contents of PS (Table 3) were similar to those shown by the NRC (2012). In Mexico, PS used for feeding livestock species comes mainly from the United States (SAGARPA, 2017), and contains 47.4 % on average of crude protein and 2.93 % lysine. These values match those found by Lagos and Stein (2017) in PS from the United States. In this study, the crude protein and lysine contents observed, are similar to those reported by Lagos and Stein (2017) and SAGARPA (2017).

PC is the second most used vegetable protein source worldwide to feed livestock species; in Mexico, this by-product comes mostly from Canada (SAGARPA, 2017). The average crude protein content of PC varies from 36.5 to 42.3 %, and regarding AA PC provides (%) 1.99 lysine, 1.48 threonine and 0.69 methionine (Mejicanos *et al*., 2016). In this research, PC had an average crude protein content of 39.39 %, which is within the range mentioned above; in contrast, lysine content was higher 2.19 % and methionine content lower 0.62 % in regard to that indicated by Mejicanos *et al*. (2016).

Woyengo *et al.* (2016) found that *B. juncea* and *B. napus* colza meals had similar crude protein content (38.1 *vs*. 38.4 %), but different lysine (1.99 *vs*. 2.14 %), ether extract (2.46 vs. 2.85 %) and FDN (18.3 vs. 26.1 %). Also, the values in this study are similar to those published in NRC (2012). Some of the classification criteria for soybean and colza plant varieties are given by their ability to adapt to the type of soil and geographical region. As well as the maturity of the plant at the time of cutting or harvest where it is grown; consequently, this can influence the nutritional content of these oilseeds (Panagiota *et al*., 2014).

Apparent ileal digestibility

The DIA of histidine, alanine, glutamine, glycine and proline were similar ($p > 0.05$) in both ingredients. The DIA of lysine and threonine in PS was 6.29 and 3.44 % higher ($p \leq 0.05$) than the DIA of the same AA in PC. However, the DIA of methionine in PC was 3.88 % higher than in PS. Regarding arginine, isoleucine, leucine, phenylalanine, valine, aspartic acid, tyrosine and valine, the DIA in PS was higher ($p \leq 0.05$) than in PC. The DIA in total AA was similar in both ingredients ($p > 0.05$) (Table 4). Kong *et al.*

Table 4. Apparent ileal digestibility of amino acids (%) in soybean and colza meal based diets fed to finishing pigs.

Variable	Experimental diets		EEM†	p Value ≤
	Soybean meal	Colza meal		
Essential AA, %:				
Arginine	88.74 a	86.11 b	0.100	0.045
Histidine	84.69	84.02	1.135	0.404
Isoleucine	84.10 a	78.59 b	1.006	0.005
Leucine	83.69 a	80.90 b	0.953	0.019
Lysine	84.76 a	78.47 b	1.058	0.001
Methionine	85.90 b	89.78 a	1.016	0.001
Phenylalanine	83.80 a	81.64 b	1.009	0.016
Threonine	74.42 a	70.98 b	1.249	0.001
Valine	78.62 a	74.46 b	1.067	0.001
Non-essential AA, %:				
Alanine	75.42	76.91	1.793	0.174
Aspartic acid	80.99 a	77.70 b	1.320	0.010
Glutamine	83.52	86.06	1.733	0.176
Glycine	60.53	67.50	3.194	0.087
Proline	60.20	68.92	10.02	0.368
Serine	81.13 a	76.19 b	0.982	0.001
Tyrosine	84.56 a	81.75 b	0.864	0.001
Total	79.62	78.60	1.361	0.225

†Standard error of the mean. ab: Means per row with different literals are different ($p \leq 0.05$).

(2014), measured the DIA of AA in the soybean meal from Korea in finishing pig diets and determined that the DIA of lysine, threonine, methionine and tryptophan was 79.3, 69.0, 84.7 and 78.4 %, respectively.

In this study, the DIA of lysine in PS was 84.76 % (Table 4), a value 5.46 % higher than that found by Kong *et al*. (2014). On the other hand, Oliveira and Stein (2016) measured the DIA of AA in growing pigs and obtained DIA values of lysine, threonine, methionine and tryptophan of 87.3, 78.9, 88.1 and 87.3 %, respectively. In this study, the DIA of lysine in PS was 2.54 % lower than that found by Oliveira and Stein (2016). Likewise, the DIA of threonine and methionine in PS was 74.42 and 85.90 %, these values are higher than those indicated by Kong *et al.* (2014), and lower than Oliveira and Stein (2016).

Adebiyi *et al*. (2015) evaluated the DIA of AA from soybean and colza meals in growing pigs (PV 35±2. 6 kg), the diets provided the same content of ED 3442 kcal kg^{-1} MS and crude protein 195 g kg^{-1} MS, but different content 35 and 69 g kg^{-1} MS crude fibre, and 135 and 172 g kg^{-1} MS FDN, respectively; the authors published higher DIA values for essential and non-essential AA, and total AA in the soybean meal diet compared to the colza meal diet. In that study, the DIA value of total AA of the soybean meal diet was similar (77.9 *vs*. 79.62 %) to that of the PS diet in this study. In contrast, the DIA value of total AA of the diet with colza meal reported by Adebiyi *et al.* (2015) was lower (68.2 *vs*. 78.6 %) compared to the PC diet of this research (Table 4).

Liu *et al.* (2016b) measured the DIA of colza meal from Canada and the protein ingredient had 386 g kg^{-1} MS crude protein and 2.1 % lysine; the DIA value in total amino acids was 76.78 %, which is 5.2 % lower than that observed for PC in this study. In swine nutrition, there are several factors that influence the digestibility of AA, such as the type and level of inclusion of the protein ingredient in the diet. As well as the fibre content that has a direct influence because it affects the rate of passage of the feed through the gastrointestinal tract (Zhang *et al*., 2013). In this study, the lower DIA observed in AA of PC may have been due to the higher crude fibre and FDN content relative to PS (Table 3).

Woyengo *et al*. (2016) found, in finishing pig diets, that *B. juncea* colza meal by-product had higher DIA coefficients in the AA arginine, histidine, isoleucine, lysine, and valine than *B. napus* colza meal, and they argued that the reduced DIA of these nutrients was likely due to the higher FDN content of *B. napus* colza meal. In addition, Bueckert and Clarke (2013) pointed out that the higher fibre content of *B. napus* colza seed is due to its thicker coat. However, the optimal fibre level with different protein ingredients in diets for fattening swines, from which the DIA of AA is reduced, is yet to be determined.

Standardized ileal digestibility

The DIE of AA is the digestibility of AA from the ingested feed, without considering AA of endogenous origin (Casas *et al*., 2018). The DIE of methionine in PS was 86.69 %, a value 3.61 % lower ($p \leq 0.05$) than in PC (90.30 %). The DIE values of lysine and threonine in PS were 85.18 and 75.24 %, so their DIE was 6.32 and 3.61 % higher ($p \leq 0.05$) than in PC. The DIE of histidine, alanine, glutamine, glycine and proline, in both ingredients, were similar ($p > 0.05$). The DIE of arginine, isoleucine, leucine, phenylalanine, valine, aspartic acid, serine and tyrosine in PS was higher ($p \leq 0.05$) compared to PC. The DIE in total AA was similar ($p > 0.05$) in both protein meals (Table 5).

The aforementioned is similar to what was found by Adebiyi *et al*. (2015) in DIA in growing pigs and the DIE values of crude protein, essential and non-essential AA, and total AA were higher in soybean meal diet compared to colza meal diet. The DIE value of total AA of the soybean meal diet, obtained by Adebiyi *et al*. (2015), is higher than that of the PS diet of this research; in contrast, the DIE value of total AA of the colza meal diet, according to Adebiyi *et al*. (2015) was lower compared to the PC diet of this study.

In this research, the PS and PC evaluated were from by-products obtained after oil extraction from the seeds, which were subjected to heat and pressure processes, which could affect the integrity of the protein and, consequently, the digestibility of the AA in both ingredients (Landero *et al*., 2012). Quality control of soybean and colza by-products should consider that heat excess treatment reduces the presence of

Table 5. Standardized ileal digestibility of amino acids (%) in diets based on soybean and colza meals fed to finishing pigs.

Variable	Experimental diets		EEM†	p Value ≤
	Soybean meal	Colza meal		
Essential AA, %:				
Arginine	89.45 a	87.07 b	0.979	0.039
Histidine	85.11	84.37	1.151	0.361
Isoleucine	84.51 a	78.99 b	1.022	0.005
Leucine	84.08 a	81.25 b	0.970	0.019
Lysine	85.18 a	78.86 b	1.040	0.001
Methionine	86.69 b	90.30 a	1.039	0.001
Phenylalanine	84.22 a	82.02 b	1.027	0.015
Threonine	75.24 a	71.63 b	1.280	0.001
Valine	79.35 a	75.06 b	1.093	0.001
Non-essential AA, %:				
Alanine	76.50	77.81	1.839	0.221
Aspartic acid	81.46 a	78.25 b	1.345	0.011
Glutamine	83.87	86.37	1.746	0.182
Glycine	63.40	69.63	2.963	0.106
Proline	71.41	73.52	8.430	0.515
Serine	81.82 a	76.83 b	0.995	0.001
Tyrosine	85.00 a	82.21 b	0.887	0.001
Total	80.82	79.66	1.302	0.171

†Standard error of the mean. [ab]Means per row with different literals are different ($p \leq 0.05$).

trypsin inhibitors (IT), but can also increase Maillard-type reactions, and consequently negatively affect protein and amino acid digestibility. In particular, lysine and cystine, whose use at the level of intermediary metabolism would not be possible for protein synthesis. In contrast, soybean and colza seeds with insufficient heating may have much of the IT present without inactivation (Almeida *et al*., 2014).

The difference in AA digestibility may also be due to factors associated with plant origin and variety (Panagiota *et al*., 2014). According to Woyengo *et al*. (2016), *B. juncea* colza meal had higher DIE coefficients of total AA, lysine and EN value compared to *B. napus* colza meal. Consequently, the former contributed more digestible AA to the diet and net energy to meet the requirements of finishing pigs.

Diets with high crude fibre content result in greater loss of endogenous AA, due to increased fibre contact with the gastrointestinal tract wall, resulting in greater cellular desquamation that is not accounted for in the DIE (Zhengqun *et al*., 2016). According to Jha and Berrocoso (2016) soluble dietary fibre can affect the digestibility of protein and AA due to an increase in digesta viscosity; consequently, the contact between enzymes, digestive contents and absorptive surface in the small intestine is reduced. Likewise, Liu *et al.* (2016b) indicated that the lignin (LDA) and cellulose content of the diet can affect the digestibility of nutrients by increasing the volume and rate of digesta passage along the gastrointestinal tract of the pig.

In this research, hemicellulose (FDN) content was different among diets (Table 3), but this factor did not affect the DIA or DIE of total AA, as it occurred in the study by Adebiyi *et al*. (2015), in which FDN values were similar to those in this research. Zhang *et al*. (2013) indicated that a high level of fibre in the diet of pigs can reduce appetite and feed intake, and also increase endogenous nitrogen and AA flux to the intestine; in addition to reducing energy use efficiency and digestibility of feed protein and AA.

CONCLUSIONS

The content and values of apparent ileal and standardized ileal digestibility of essential amino acids present in soybean meal were higher compared to colza meal, except for methionine. The apparent ileal digestibility of total essential and nonessential amino acids was similar in both protein ingredients except lysine and threonine, with higher values in soybean meal. Because of this availability, the capacity of the preparations differed in meeting the requirements of finishing pigs.

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