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UTILIZATION OF AMINO ACIDS OF BROKEN RICE IN GROWING PIGS

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ABSTRACT

The six cannulated gilts (initial body weight 35.8 ± 0.5 kg) fitted with a T-cannula in terminal ileum, were used to determine the apparent (AID) and standardized (SID) ileal digestibility of nitrogen (N) and amino acids (AA) in broken rice. Animals were fed twice daily in a two equal doses at a daily rate of 80 $g.kg^{-0.75}$. Water was offered *ad libitum*. The tested feed was the sole source of protein in the diet. The N-free diet was used to determine the ileal endogenous flow of AA and N. Chromium oxide (Cr_2O_3) was added to the diets as an indigestible marker in an amount of 0.3 % per kg of diet. After a 14 d postoperative period a 6 d adaptation period followed during which the animals were fed with an experimental diet. On d 7 ileal digesta was collected continuously for 24 h. The AID and SID of AA and N were calculated using analytically determined values of N, Cr_2O_3 and AA. The SID of AA was in a range from 81.6 % (tyrosine) to 112.6 % (proline) ($P < 0.05$). Ileal digestibility for lysine, alanine and leucine were 94.1, 94.3 and 94.7 % ($P > 0.05$), respectively. There were no differences between standardized ileal digestibility of essential amino acids (94.3 %) and nonessential amino acids (95.3 %). Regarding the ileal digestibility of AA, broken rice, a by-product from the food industry, is an appropriate source of digestible AA for growing pigs.

Keywords: amino acids, broken rice, digestibility, pig

INTRODUCTION

In animal production systems, it has been traditional to feed conventional feeds notably cereals, oil cakes and meals to both ruminants and non-ruminants. The non-traditional feed resources are those feeds that have not been traditionally used in animal feeding and are not normally used in commercially produced rations for livestock **(FAO, 1985)**. There are many by-products which are not routinely used in animal nutrition. Many by-products have a substantial potential value as animal feedstuffs. The use of agro-industrial by products in animal nutrition may be economically worthwhile, since conventional feedstuffs are often expensive (**Mirzaei-Aghsaghali and Maheri-Sis, 2008**). In pig nutrition the soy bean meal and corn are the standards for supplying energy and protein in the diets, but there are many alternatives that can be used to meet the nutritional requirements of pigs while reducing the cost of diets **(Thacker and Kirkwood, 1990)**.
Rice is a main carbohydrate source in human nutrition and its use in pig nutrition is limited by price and availability **(Vicente *et al*., 2008)**. Most varieties of rice provide approximately 7 % of energy as protein of reasonably good quality. The amino acid score, based on lysine content is about 60 **(Roxas *et al.*, 1975)**. Broken rice is characterized as by-product derived from production smooth or polished rice. The inclusion of broken rice in the diet in substitution of corn increases nutrient digestibility and daily weight gain with little effect on gain:feed ratio **(Mateos *et al.*, 2006)**. The information about amino acid utilization from broken rice is limited **(NRC, 1998; AFZ, 2000)**. The amino acids are absorbed in small intestine and therefore the ileal digestibility is the best method for determining amino acid digestibility in organism **(Sauer *et al.*, 1981; Sauer and Ozimek, 1986).**
The objective of this study was to determine the ileal digestibility of AA and N in broken rice fed to growing pigs.

MATERIAL AND METHODS

All experimental procedures were reviewed and approved by the animal care committee of the Research Institute of Animal Production.

Animals and experimental design

In a digestibility study, the 6 gilts with an initial body weight 35.8 ± 0.5 kg were used for the determination of ileal digestibility amino acids (AA) and nitrogen (N) in broken rice. The animals fitted with an ileal t-cannula in a terminal ileum **(Nitrayová *et al.*, 2011)** were housed in a balance cages in a room with a controlled environment at an average ambient temperature 20.6 ± 0.2 ºC. After a 14 d recovery post-operative period a 6 d adaptation period followed during which the pigs were fed with a tested diet. On d 7 ileal digesta was collected for 24 h. After this period the N-free diet was fed to determine the ileal endogenous flow of AA and N. The collection of ileal digesta started at 7.00 a.m. after attaching plastic bags to the cannulas. The samples of ileal digesta, stored in plastic containers, were acidified with 6M H_2SO_4 to achieve a pH 3.5 for minimizing microbial activity and consequently were frozen at – 20 °C and stored for analysis.

Diets and feeding

The composition of experimental diet and N-free diet is given in table 1. The only source of N in the experimental diet was the tested feed component. Chromic oxide was added in the diets as an indigestible marker in an amount of 3 $g.kg^{-1}$ of diet. The broken rice, in a dry milled form, was included in the diet in an amount of 96.4 %.

The chemical composition of tested diet is shown in table 2. The animals were fed diets twice daily at 7.00 a.m. and 16.00 p.m. in a two equal doses in a daily amount of 80 $g.kg^{-0.75}$. The water was offered *ad libitum*.

Table 1 Ingredient composition of tested diet and N-free diet (g.kg^{-1} as fed basis)

Item	Diet	
	Broken rice	**N-free**
Ingredient		
Broken rice	964.0	
Monocalcium phosphate	21.0	
Limestone	6.0	
Salt	3.0	
Premix[1]	3.0	3.0
Chromic oxide	3.0	3.0
Sunflower oil		50.0
Sucrose		100.0
Cellulose		50.0
Mineral mixture[2]		55.0
Maize starch		739.0

Legend: [1] Provided the following per kg of diet: retinol 1.2 mg; cholecalciferol 25 mg; α-tocopherol 10 mg, menadione 0.2 mg; riboflavin 4 mg; pyridoxine 2.5 mg; d-pantothenic acid 10 mg; niacin 20 mg; folic acid 0.5 mg; biotin 0.1 mg; cyanocobalamin 30 µg; choline 500 mg; Fe 92 mg; Zn 103 mg; Mn 40 mg; Cu 19 mg; Co 0.5 mg; Se 0.16 mg
[2] Provided the following per kg of diet: monocalcium phosphate, 31 g; limestone, 15 g; salt, 4.4 g; KCl, 3.8 g; MgO 0.8 g

Table 2 Analyzed content of nutrients in tested diet (g.kg^{-1} air-dry basis)

Analyzed content of nutrients	
Nutrient	
Dry matter	877.51
Crude protein	75.77
Essential amino acids	
Arginine	9.5
Histidine	2.0
Isoleucine	3.3
Leucine	6.1
Lysine	2.9
Methionine	1.8
Phenylalanine	4.0
Threonine	4.4
Valine	5.2
Non-essential amino acids	
Alanine	4.4
Aspartic acid	9.7
Cysteine	1.4
Glutamic acid	15.0
Glycine	4.1
Proline	4.5
Serine	4.0
Tyrosine	3.1

Chemical analysis

The samples of diets and lyophilized samples of ileal digesta were milled and analyzed for content of dry matter, crude protein **(AOAC, 1990)** and the content of chromic oxide **(Williams *et al.*, 1962).** The content of AA after acid hydrolyzes with 6M HCl and the content of methionine with cysteine after oxidative hydrolyzes was determined using automatic analyzer amino acid AAA 400 (fy Ingos Prague).

Calculation and statistical analyses

The digestibility values of apparent ileal digestibility (AID) and standardized ileal digestibility (SID) of AA and N were calculated according to **Stein *et al.* (2007)** using following formulas:

$$AID, \% = 100 \times [1-(Ni \times Cd)/(Nd \times Ci)]$$

where Nd; Cd is content of nutrient and chromic oxide in diet (g.kg^{-1} DM) and Ni; Ci is content of nutrient and chromic oxide in ileal digesta (g.kg^{-1} DM).

$$SID, \% = AID+100*IFL/AAd$$

where IFL is ileal endogenous flow of AA (g.kg^{-1} DM) and AAd is content of amino acids in ileal digesta (g.kg^{-1} DM).

Statistical analyses of experimental data were performed using ANOVA of **Statgraphic Plus package v. 3.1. (1997)**. When significant value for treatment effect ($P < 0.05$) was observed, the differences between means were assessed using Fisher's LSD procedure. Each animal was considered as an experimental unit. Analysis of variance was conducted to evaluate the ileal digestibility of amino acids and nitrogen in broken rice.

RESULTS AND DISCUSSION

The AID and SID values of AA and N for broken rice are shown in table 3. The SID was in a range from 81.6 to 112.4 % ($P < 0.05$) for tyrosine and proline, respectively. The SID for lysine, first limiting amino acid for pigs, was 94.1 %, and there was observed no significant difference in comparison with the most of AA except of proline and tyrosine. There were no differences in apparent and standardized ileal digestibility between sum of essential and non-essential amino acids. The values of amino acid digestibility determined in our study are comparable with amino acid digestibility introduced by **Gottlob *et al.* (2006)** in rice protein concentrate. Digestibility for cysteine and methionine in rice protein concentrate was higher compared with those in our study. **Kaufmann *et al.* (2003)** reported lower digestibility for lysine in different samples of rice bran. The digestibility ranged from 62.6 – 82.2 %. Standardized ID for proline at above 100 % was due to high endogenous flow of proline found using the N - free diet. Also other authors reported the standardized ileal digestibility for proline at above 100 % in different samples of feed due to the high endogenous flow of proline **(Stein *et al.*, 2001, 2005; Gottlob *et al.*, 2006)**.

Table 3 The apparent (AID) and standardized (SID) ileal digestibility of amino acids and nitrogen in broken rice (%)

Parameter	Digestibility			
	AID		SID	
n	6		6	
	Mean	SEM	Mean	SEM
N*	81.9	1.0	94.4	1.0
Essential amino acids				
Arginine	92.0	0.4 ^{l}	95.9	0.4 ^{de}
Histidine	84.8	0.8 ^{efgh}	92.7	0.8 ^{bc}
Isoleucine	86.6	0.7 ^{ghij}	95.5	0.7 ^{cde}
Leucine	86.6	0.7 ^{ghij}	94.7	0.7 ^{bcde}
Lysine	81.8	1.0 ^{cd}	94.1	1.0 ^{bcde}
Methionine	89.3	0.5 ^{jkl}	95.2	0.5 ^{cde}
Phenylalanine	85.2	1.0 ^{fghi}	93.1	1.0 ^{bcd}
Threonine	82.1	1.2 ^{cde}	92.2	1.2 ^{b}
Valine	87.1	0.7 ^{hij}	95.1	0.7 ^{bcde}
Non-essential amino acids				
Alanine	84.2	0.8 ^{defg}	94.3	0.8 ^{bcde}

Aspartic acid	88.1	0.7	ijh	95.0	0.7	bcde
Cysteine	81.0	0.9	bc	92.9	0.9	bc
Glutamic acid	90.1	0.5	kl	95.8	0.5	de
Glycine	78.2	0.8	b	96.6	0.8	e
Proline	81.6	1.8	cd	112.4	1.8	f
Serine	82.9	1.1	cdef	93.8	1.1	bcde
Tyrosine	71.8	2.1	a	81.6	2.1	a
EAA*	86.2	0.3		94.3	0.3	
NEAA*	82.2	1.2		95.3	1.2	

Legend: [abcdefgij] Means in a column followed by different letters were significantly different ($P < 0.05$), SEM – standard error of the mean, *N – nitrogen, EAA – essential amino acids, NEAA – non-essential amino acids

Broken rice is characterized as by-product originated from the production smooth or polished rice. Broken rice comprises mainly of germs, chipped and broken kernels. The chemical composition is similar to the whole grain. Because of its low content of fiber and high energy value, it is a valuable energy feed, especially for substituting other energy feeds in diets for pigs and poultry **(FAO, 1985)**. The content of acid detergent fiber in broken rice is 0.7 % **(Chumpawadee *et al.*, 2007).**

Broken rice has been used at a level of 53.8 % in diets for growing finishing pigs to substitute traditional feeds without a negative effect on performance **(Khajaren *et al.*, 1979)**. The inclusion of broken rice in the diet in substitution for corn increases nutrient digestibility **(Mateos *et al.*, 2006)**. There was observed high digestibility for dry matter and organic matter **(Chumpawadee *et al.*, 2007).** Rice grain is characterized by its high starch content and low level of non-starch polysaccharides **(Choct, 2002)**. Starch encapsulation is lower for rice compared with corn **(Slaughter *et al.*, 2001; Svihus *et al.*, 2005).** Rice has also a smaller size of starch granules **(Tester *et al.*, 2004)**, lower amylose content, and less lipid-amylose complexes **(Vandeputte and Delcour, 2004)** in comparison with corn. Therefore, rice starch is expected to be more available to enzyme action than cornstarch **(Vicente *et al.*, 2008)**. Non-starch polysaccharides have a negative effect on the digestibility and utilization of nutrients **(Low, 1985)** and the low level of this constituents in broken rice **(Choct, 2002)** is the reason that the digestibility of amino acids in broken rice determined in our study was above 90 %. To compare, the average digestibility of amino acids was 80.1 % in corn, 89.9 % in wheat and 83.5 % in barley **(Stein *et al.*, 2001).** Feeding rice instead of corn increased nutrient digestibility and improved the structure of the ileal mucosa in pigs **(Vicente *et al.*, 2009)**.

CONCLUSION

The broken rice is a good source of digestible amino acids for growing pigs. The use of broken rice in diets for pigs is the possible way how to use the by-products originated from the food industry, but its use may be limited if the price compared to other cereals is higher.

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