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REGULAR ARTICLE

ILEAL DIGESTIBILITY OF AMINO ACIDS IN WHEAT GERM - A BY-PRODUCT OF THE MILL INDUSTRY

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ABSTRACT

The 6 cannulated gilts, with initial body weight (BW) 34.8 ± 0.7 kg, fitted with ileal T-cannula in terminal ileum were used for estimation apparent (AID) and standardized (SID) ileal digestibility of nitrogen (N) and amino acids (AA) in wheat germs. Animals were fed twice a day with tested diet in two equal doses at daily rate of 75 - 80 g.kg $^{-0.75}$. Water was offered *ad libitum*. The test feed was the only source of protein in the diet. After the 14 d postoperative period followed 6 d adaptation period during which animals fed an experimental diet, on d 7 we collected ileal digesta continuously for 24 h. Chromium oxide (Cr_2O_3) was used as an indigestible marker in amount of 0.3 % per kg of diet. We calculated AID and SID of AA and N using analytic estimated values of N, Cr_2O_3, and AA. The SID of AA in wheat germs ranged from 86.6 % (tyrosine) to 97.6 % (proline) ($P < 0.05$). Ileal digestibility for lysine was 95.3 %. Standardized ileal digestibility for essential amino acids (94.7 %) was 5.3 % greater ($P < 0.05$) in comparison with standardized ileal digestibility of nonessential amino acids (92.1 %). Apparent ileal digestibility of essential AA (92.7 %) was greater ($P < 0.05$) compared with nonessential AA (88.1 %). Wheat germs, a by-product from mill industry are an appropriate source of digestible AA for pigs. Ileal digestibility of AA and N in wheat germs is comparable with soybean meal.

Keywords: amino acids, digestibility, nitrogen, pigs, wheat germs

INTRODUCTION

An accurate determination of the bioavailability of amino acids is critical for evaluating the nutritional value of feed ingredients **(Stein *et al.*, 2007)**. Bioavailability is characterized as the proportion of ingested dietary amino acids that is absorbed in a chemical form that renders these amino acids potentially suitable for metabolism and protein synthesis **(Batterham, 1992; Lewis and Bayley, 1995)**. Because amino acids are absorbed in small intestine estimation of amino acid digestibility by ileal sampling is more preferable than fecal sampling **(Zebrowska, 1973; Sauer *et al.*, 1981)**.

Considering the current rapid growth in world population, there is bound to be an increase in demand for protein consumption. However, animal proteins are expensive and not available in many countries and regions. Therefore, in recent years, the search for new alternatives and cheap sources of good-quality proteins has become an important research trend **(Zhu *et al.*, 2006)**. Wheat germ is a by-product from wheat milling industry that has a potential as food ingredient **(Hettiarachchy *et al.*, 1996).** It is source of vitamin E, B group vitamins, proteins, dietary fiber, and minerals **(Amado and Arrigoni, 1992)** but there is lack of information on amino acid digestibility of this by-product **(NRC, 1998; Kaufmann *et al.*, 2003).**

The objective of this study was to estimate and compare apparent and standardized ileal digestibility of AA and N in wheat germs as non-traditional feed fed to growing pigs.

MATERIAL AND METHODS

Animals and experimental design

Altogether 6 cannulated gilts (initial BW 34.8 ± 0.7 kg) fitted with T-cannula in terminal ileum were used for estimation ileal digestibility of N and amino acids in wheat germs. Animals were housed in an experimental balance cages in a climate controlled room with an average ambient temperature 20.6 ± 0.2 ºC. After the 14 d postoperative period followed 6 d adaptation period during which animals fed an experimental diet. On d 7 we collected ileal digesta continuously for 24 h. The collection of ileal digesta started after attaching the plastic bags to the T-cannula at 7.00 a.m. and finished at 7.00 a.m. following morning. The samples of ileal digesta were acidified with 6M H_2SO_4 for minimizing the microbial activity and stored at -20 ºC for chemical analyses.

All experimental procedures were reviewed and approved by the Animal Care Committee of the Animal Production Research Center Nitra.

Diets and feeding

The composition of experimental diet is in table 1. The sole source of nitrogen was the tested feed in amount of 54.0 % per kg of diet.

Table 1 Component composition of experimental diet

Component	%
Wheat germs	54.0
Mono calcium phosphate	1.2
Limestone	1.2
Salt	0.4
Maize starch	42.6
Premix*	0.3
Chromic oxide	0.3

* 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

The content of dry matter, crude protein and amino acids in wheat germs is introduced in table 2. Chromic oxide we used as digestibility marker in amount of 3 g per kg of diet. Animals were fed twice a day at 7.00 and 16.00 h in daily amount of 75-80 $g.kg^{-0.75}$. Water was offered *ad libitum*.

Table 2 The content of dry matter, crude protein and amino acids in wheat germs ($g.kg^{-1}$ as fed basis)

Item	Amount
Dry matter	896.68
Crude protein	251.7
Essential amino acids	
Arginine	29.5
Histidine	7.5
Isoleucine	10.6
Leucine	19.2
Lysine	20.2
Methionine	5.6
Phenylalanine	11.2
Threonine	12.8
Valine	15.6
Nonessential amino acids	
Alanine	17.5
Aspartic acid	27.2
Cysteine	4.4
Glutamic acid	37.0
Glycine	17.8
Proline	12.4
Serine	11.9
Tyrosine	8.2
EAA*	14.7
NEAA*	17.0

*EAA – essential amino acids, NEAA – nonessential amino acids

Chemical analyses

We analyzed content of dry matter, crude protein **(AOAC, 1990)**, chromic oxide **(Williams *et al.*, 1962)** and amino acids in samples of diet and lyophilized samples of ileal digesta

The content of amino acids after acid hydrolyses with 6M-HCl and methionine with cysteine after oxidative hydrolysis were estimated using automatic analyzer of amino acids AAA 400 (fy Ingos Praha).

Calculation

The apparent (AID) and standardized (SID) ileal digestibility of N and amino acids we calculated according to the following formula:

$$AID, \% = 100 \times [1-(N_i \times C_d)/(N_d \times C_i)]$$

where N_d; C_d is content of nutrient and chromic oxide in diet ($g.kg^{-1}$ DM) and N_i; C_i 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

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 experimental unit. Analysis of covariance was conducted to evaluate the effect of diet on the ileal digestibility of amino acids and nitrogen

RESULTS AND DISCUSSION

The apparent (AID) and standardized (SID) ileal digestibility of amino acids and nitrogen for wheat germs is introduced in table 3. The AID of amino acids ranged from 83.4 % (tyrosine) to 96.5 % (arginine), whereas the SID ranged from 86.6 % (tyrosine) to 97.6 % (proline) ($P < 0.05$). The higher SID for proline was as a result of higher endogenous ileal flow of proline. The SID for lysine, methionine and threonine was 95.3; 95.9 and 90.5 % respectively ($P < 0.05$). Apparent and standardized ileal digestibility of EAA was higher than for NEAA ($P < 0.05$). In comparison with our results, **Petrikovič *et al.* (2005)** reported a lower ileal digestibility for lysine (89.0 %), methionine (92.1 %), and for threonine (81.3 %). Similar results presented **AFZ (2000)**. Digestibility of protein in wheat germ varied from 85.5

to 92.8 % **(Saunders and Kohler, 1972)**. Wheat germ, one of the main by-products from the flour milling industry, is the most nutritious part of the wheat kernel **(Haridas *et al.*, 1980)**. Besides the high content of vitamins, minerals, phytochemicals **(Garcia *et al.*, 1972; Amado and Arrigoni, 1992; Pietrzak and Collins, 1996)** wheat germs contain high content of protein and essential amino acids **(Ge *et al.*, 2001)**.

Table 3 Apparent (AID) and standardized (SID) ileal digestibility of AA and nitrogen for wheat germs (%)

Parameter	Ileal digestibility					
	AID			SID		
	Mean	SEM		Mean	SEM	
n	6			6		
N*	79.0	± 1.9		84.6	± 1.9	
Arginine	96.5	± 0.3	c	97.6	± 0.3	g
Histidine	93.3	± 0.6	de	95.1	± 0.6	fg
Isoleucine	92.4	± 0.9	de	94.7	± 0.9	ef
Leucine	92.1	± 0.9	de	94.4	± 0.9	ef
Lysine	93.8	± 0.8	dec	95.3	± 0.8	fg
Methionine	94.3	± 0.7	ec	95.9	± 0.7	fg
Phenylalanine	91.9	± 0.8	de	94.4	± 0.8	ef
Threonine	87.6	± 1.1	bc	90.5	± 1.1	bc
Valine	92.0	± 1.0	de	94.2	± 1.0	ef
Alanine	91.4	± 1.0	d	93.6	± 1.0	def
Aspartic acid	91.4	± 0.9	d	93.5	± 0.9	def
Cysteine	84.9	± 1.4	ab	88.0	± 1.4	ab
Glutamic acid	92.5	± 1.0	de	94.5	± 1.0	ef
Glycine	88.5	± 1.3	c	92.1	± 1.3	cde
Proline	88.0	± 1.1	c	97.6	± 1.1	g
Serine	88.0	± 1.0	c	91.2	± 1.0	cd
Tyrosine	83.4	± 1.4	a	86.6	± 1.4	a
EAA*	92.7	± 0.4	i	94.7	± 0.4	i
NEAA*	88.1	± 0.6	j	92.1	± 0.6	j

[abcdefg] Means in a column followed by different letters were significantly different ($P < 0.05$)

[ij] 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

Wheat germ protein contains seventeen amino acids especially the essential amino acids lysine, methionine, and threonine, in which many cereals are deficient and therefore, is a potential nutritious food supplement **(Yiqiang *et al.*, 1999)**. As reported **Moran *et al.* (1968**) wheat germ protein is at least an equivalent protein source to soybean protein. Soybean meal is characterized by high digestibility of amino acids and because of high protein content, the soybean meal is mainly used in poultry and pigs nutrition **(Banaszkiewicz, 2011).** This is consistent with our results. Ileal digestibility of most amino acids in wheat germs was similar or slightly higher than was reported for soybean meal **(Bellaver and Easter, 1998; González-Vega *et al.*, 2011)**.

CONCLUSION

The digestibility of amino acids and nitrogen of wheat germs is comparable with soybean meal which is the main protein source in diets for pigs. Based on obtained results it is possible to recommend the use of wheat germs as an alternative protein source, originated form mill industry, in the diets fed to pigs.

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