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Dietary impact of NDF from different sources on the apparent ileal digestibility of amino acids

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ABSTRACT

Nowadays the use of fiber rich by-products is increasing in pig feeding. However, dietary fiber has significant impact on the nutritive value of the feed; therefore knowledge on the effect of inclusion of different fibrous components on digestibility of nutrients, particularly amino acids is crucial. The aim of the present trial was to study how the apparent ileal digestibility of selected amino acids (lysine, methionine, cystine, threonine, isoleucine, arginine, tryptophan, valine) is changed as a response of increasing dietary NDF from different source such as wheat bran and soyhulls. For that purpose a total of 40 cannulated growing pigs (35 kg BW) were used in two replicates. Ten experimental treatments were achieved by including 0, 25, 50, 75 and 100 g wheat bran (WB) or soyhulls (SH) per kg of a corn, soybean based diet. The 5 days adaptation period was followed by a 3×12 hours of ileal digesta collection. The effect of different WB and SH levels on the apparent ileal digestibility of amino acids were analyzed separately by ANOVA. Our results show that dietary NDF has negative impact on the apparent ileal digestibility of amino acids and, however, the magnitude of this reducing effect is depending on the NDF source. Due to the fact that 25 g/kg of wheat bran and soyhulls level depress the apparent ileal digestibility of the most amino acids but higher rate of inclusion has no further negative effect, the amino acid supplementation should not be increased if more than 25 g/kg of wheat bran or soyhulls are used in diet formulation.
(Keywords: pig, apparent ileal digestibility, amino acids, wheat bran, soyhulls)

ÖSSZEFOGLALÁS

A különböző forrásból származó NDF hatása az aminosavak látszólagos ileális emészthetőségére

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Napjainkban a rostban gazdag melléktermékek használata folyamatosan növekszik a sertéstakarmányozásban. Ugyanakkor ismert, hogy a takarmányok rosttartalma jelentősen befolyásolja az abrakkeverékek táplálóértékét. Ezért rendkívül fontos annak ismerete, hogy a különböző rostdús komponensek szerepeltetése a keveréktakarmányokban miképpen befolyásolja a táplálóanyagok emészthetőségét, különös tekintettel az aminosavakra. Jelen kísérletben a takarmány NDF-tartalmának, mely búzakorpából vagy szójahéjból származott, az aminosavak (lizin, metionin, cisztin, treonin, izoleucin, arginin, triptofán, valin) látszólagos ilelális emészthetőségére gyakorolt hatását vizsgáltuk. E célból összesen 40

kanülös növendék sertést (35 kg ÉT) állítottunk kísérletbe két ismétlésben. Tíz kísérleti kezelést alakítottunk ki úgy, hogy a kukorica–szója összetételű alaptakarmányhoz 0, 25, 50, 75 és 100 g/kg búzakorpát vagy szójahéjat keverünk. Az 5 napos adaptációs szakaszt egy 3×12 órás ileum chymus gyűjtés követte. A takarmány búzakorpa és a szójahéj tartalmának az aminosavak látszólagos ileális emészthetőségére gyakorolt hatását melléktermékenként külön, variancia-analízissel végeztük. Eredményeink azt mutatják, hogy a takarmány NDF-tartalma negatívan befolyásolja az aminosavak látszólagos ileális emészthetőségét, ugyanakkor az emészthetőség csökkenés mértéke az NDF forrásától függ. Tekintettel arra, hogy a legtöbb aminosav látszólagos ileális emészthetőségét 25 g/kg feletti búzakorpa vagy szójahéj tartalom már nem csökkenti tovább, ezért a takarmányreceptúra összeállításakor az aminosav kiegészítést 25 g/kg búzakorpa vagy szójahéj mennyiség felett már nem szükséges tovább növelni.
(Kulcsszavak: sertés, látszólagos ileális emészthetőség, aminosavak, búzakorpa, szójahéj)

INTRODUCTION

The use of fibrous by-products in pig feeding is increasing (*Verstegen and Tamminga,* 2005). Benefit of using cheep by-products can be realized only if their presences do not compromise the nutrient supply of the livestock in terms of supporting their digestible energy and ileal digestible amino acid requirement. Dietary fiber has significant impact on the digestive processes and the nutritive value of the feed, therefore knowledge on the effect of inclusion of different fibrous components and quantitative data on the effect of dietary fiber on digestibility of nutrients, particularly amino acids is crucial when by-products are used in diet formulation. The term fiber is a group of heterogeneous polysaccharides affecting the digestive processes differently due to its physico-chemical properties. It has been reported in several studies that more conventional measures of crude fiber, such as neutral detergent fiber (NDF) or soluble and insoluble dietary fiber (SDF, IDF) provide a reasonable means to predict the effect of fiber on nutrient digestibility in various types of pig feed ingredients (*Noblet and Henry,* 1993; *Bakker,* 1996; *Bach-Knudsen,* 1997). Two frequently used by-products, wheat bran and soyhulls contain comparable amounts of NDF (49% and 67%, respectively); however, the composition of NDF is different (*Dust et al*., 2004). The proportion of hemicellulose and cellulose is 68% and 21% in NDF for wheat bran and 26% and 70% for soyhulls, respectively (*Dust et al.,* 2004). Therefore it raises the question whether different composition of NDF from wheat bran and soyhulls affects differently the digestibility of amino acids.

The objective of the trial conducted with growing pigs was to study how the apparent ileal digestibility of selected amino acids (lysine, methionine, cystine, threonine, isoleucine, arginine, tryptophan, valine) changes subject to the increasing dietary NDF from different source such as wheat bran and soyhulls.

MATERIALS AND METHODS

Animals and housing

The trials were conducted with a total of 40 pigs, 4 hybrid barrows per treatment, in 2 replicates (8 data/treatment), with a mean initial body weight of 35±3 kg. Prior to digestibility studies the animals were fitted with PVTC-cannula. The surgical operations were performed in accordance with *van Leeuwen et al.* (1991).

Table 1

Composition and analyzed nutrient content of the experimental diets with wheat bran (g/kg)

Ingredients (1)	Treatments (2)				
	WB-0	**WB-25**	**WB-50**	**WB-75**	**WB-100**
Corn (3)	725.34	710.57	694.03	679.37	662.75
Soybean meal (CP: 48%) (4)	208.00	198.00	190.00	1801.00	172.00
Wheat bran (5)	**0.00**	**25.00**	**50.00**	**75.00**	**100.00**
Fat (vegetable) (6)	30.00	30.00	30.00	30.00	30.00
MCP	11.20	10.70	10.15	9.60	9.08
Limestone (7)	9.90	9.95	9.95	9.95	9.98
NaCl	3.85	3.85	3.85	3.85	3.55
Lysine-HCl	2.78	2.91	2.97	3.09	3.16
DL-methionine	0.35	0.37	0.37	0.39	0.40
L-threonine	0.49	0.55	0.59	0.65	0.69
L-Tryptophan	0.09	0.10	0.09	0.10	0.10
Vit.-min. premix* (8)	3.00	3.00	3.00	3.00	3.00
Cr_2CO_3	5.00	5.00	5.00	5.00	5.00
Total (9)	**1000.0**	**1000.0**	**1000.0**	**1000.0**	**1000.0**
Nutrient content (10)					
Dry matter (11)	898.0	893.0	890.0	885.0	890.0
MEs** (MJ/kg)	14.4	14.3	14.2	14.1	14.0
NEs** (MJ/kg)	10.0	9.9	9.8	9.7	9.7
Crude protein (12)	166.0	162.0	159.0	162.0	160.0
Crude fat (13)	61.0	69.0	70.0	67.0	72.0
Crude fiber (14)	19.0	24.0	27.0	28.0	32.0
Crude ash (15)	50.0	46.0	50.0	50.0	51.0
N-free extract (16)	602.0	592.0	584.0	578.0	575.0
NDF	**135.0**	**142.0**	**152.0**	**160.0**	**167.0**
ADF	62.0	64.0	67.0	69.0	71.0
ID LYS**	8.2	8.1	8.0	8.0	7.9
ID M+C**	4.7	4.6	4.6	4.6	4.5
ID THR**	4.9	4.8	4.8	4.8	4.7
ID TRP**	1.4	1.4	1.4	1.4	1.4
Ca	6.6	6.9	6.4	6.6	6.7
P	6.1	5.9	6.0	6.0	6.2

*1 kg premix contains (*1 kg premix tartalmaz*)**:** Vit. A: 2500000 IE, Vit. D_3 : 400000 IE, Vit. E.: 15000 IE, Vit. K_3: 875 mg, Vit. B_1: 375 mg, Vit. B_2 : 2000 mg, Ca-D-panthotenat: 15000 mg, Vit. B_6-vit. 500 mg, Vit. B_{12}: 8.9 mg, Niacin: 12500 mg, Folic acid: 275 mg, Biotin: 25 mg, Colin: 75000 mg, Fe: 45000 mg, Zn: 45000 mg, Mn: 20000 mg, Cu: 13500 mg, Ca: 85.5 g, I: 300 mg, Se: 150 mg; **calculated value (*számított érték*)

1. táblázat: A búzakorpát tartalmazó kísérleti takarmányok összetétele és mért táplálóanyag-tartalma

Összetevők(1), Kezelések(2), Kukorica(3), Szójadara (NF: 48%)(4), Búzakorpa(5), Zsír (növényi olaj)(6), Takarmánymész(7), Vitamin és ásványi anyag premix(8), Összesen(9), Táplálóanyag-tartalom(10), Szárazanyag(11), Nyersfehérje(12), Nyerszsír(13), Nyersrost(14), Nyershamu(15), N-mentes kivonható anyag(16)

Table 2

Composition and analyzed nutrient content of the experimental diets with soyhulls (g/kg)

Ingredients (1)	Treatments (2)				
	SH-0	**SH-25**	**SH-50**	**SH-75**	**SH-100**
Corn (3)	725.34	706.82	692.05	671.66	655.00
Soybean meal (CP: 48%) (4)	208.00	202.00	192.00	188.00	180.00
Soyhulls (5)	**0.00**	**25.00**	**50.00**	**75.00**	**100.00**
Fat (vegetable) (6)	30.00	30.00	30.00	30.00	30.00
MCP	11.20	11.15	11.15	11.10	11.05
Limestone (7)	9.90	9.50	9.12	8.70	8.33
NaCl	3.85	3.85	3.85	3.85	3.85
Lysine-HCl	2.78	2.69	2.71	2.56	2.52
DL-methionine	0.35	0.40	0.47	0.50	0.56
L-threonine	0.49	0.49	0.53	0.51	0.54
L-Tryptophan	0.09	0.10	0.12	0.12	0.14
Vit.-min. premix* (8)	3.00	3.00	3.00	3.00	3.00
Cr_2CO_3	5.00	5.00	5.00	5.00	5.00
Total (9)	**1000.0**	**1000.0**	**1000.0**	**1000.0**	**1000.0**
Nutrient content (10)					
Dry matter (11)	898.0	896.0	896.0	897.0	898.0
MEs** (MJ/kg)	14.4	14.3	14.1	14.0	13.8
NEs** (MJ/kg)	10.0	9.9	9.8	9.7	9.6
Crude protein (12)	166.0	164.0	160.0	162.0	157.0
Crude fat (13)	61.0	62.0	61.0	64.0	65.0
Crude fiber (14)	19.0	28.0	37.0	43.0	54.0
Crude ash (15)	50.0	51.0	49.0	48.0	49.0
N-free extract (16)	602.0	591.0	589.0	580.0	573.0
NDF	**135.0**	**148.0**	**159.0**	**167.0**	**179.0**
ADF	62.0	72.0	81.0	89.0	99.0
ID LYS**	8.2	8.1	8.1	8.0	7.9
ID M+C**	4.7	4.6	4.6	4.5	4.5
ID THR**	4.9	4.9	4.8	4.8	4.7
ID TRP**	1.4	1.4	1.4	1.4	1.4
Ca	6.6	7.0	6.6	6.7	6.6
P	6.1	5.9	5.8	6.0	5.8

*1 kg premix contains (*1 kg premix tartalmaz*)**:** Vit. A: 2500000 IE, Vit. D_3 : 400000 IE, Vit. E.: 15000 IE, Vit. K_3: 875 mg, Vit. B_1: 375 mg, Vit. B_2 : 2000 mg, Ca-D-panthotenat: 15000 mg, Vit. B_6-vit. 500 mg, Vit. B_{12}: 8.9 mg, Niacin: 12500 mg, Folic acid: 275 mg, Biotin: 25 mg, Colin: 75000 mg, Fe: 45000 mg, Zn: 45000 mg, Mn: 20000 mg, Cu: 13500 mg, Ca: 85.5 g, I: 300 mg, Se: 150 mg; **calculated value (*számított érték*)

2. táblázat: A szójahéjat tartalmazó kísérleti takarmányok összetétele és mért táplálóanyag-tartalma

Összetevők(1), Kezelések(2), Kukorica(3), Szójadara (NF: 48%)(4), Szójahéj(5), Zsír (növényi olaj)(6), Takarmánymész(7), Vitamin és ásványi anyag premix(8), Összesen(9), Táplálóanyag-tartalom(10), Szárazanyag(11), Nyersfehérje(12), Nyerszsír(13), Nyersrost(14), Nyershamu(15), N-mentes kivonható anyag(16)

Before the surgical operation, during the regeneration period and during the adaptation period of the trial the animals were kept in special individual pens, while in the collection phase of the trial they were kept in metabolic cages designed for growing pigs. The room temperature and relative humidity were regulated in accordance with the requirements of growing pigs.

Treatments, diets and feeding

Two NDF sources were used in a total of ten treatments. In treatments WB-0, WB-25, WB-50, WB-75 and WB-100 the NDF source of the base diets was wheat bran at 0, 25, 50, 75 and 100 g/kg, while in treatments SH-0, SH-25, SH-50, SH-75 and SH-100 it was soyhulls at 0, 25, 50, 75 and 100 g/kg. The base diets were formulated according to the *NRC* (1998) nutrient recommendations. The nutrient content of the experimental diets were identical except for their crude fiber, NDF and DE content. The composition and the nutrient content of the diets are given in *Table 1* and *2*, the amino acid content in *Table 3* and *4*.

The daily feed allowance of the pigs was 2.6 times of their maintenance requirement. The feed was distributed in two equal parts and given at 8:00 a.m. and 08:00 p.m. The relatively long time between the two feedings was due to the schedule of the digesta collection. Drinking water was available to the animals as needed.

Digesta collection procedures

The trials were consisted of a 5 days adaptation and a 3×12 hours collection period. During the trial the feed intakes of the animals were recorded by gram precision, per each treatment. In the collection phases the total amount of the digesta was collected continuously (for 12 hours) according to the recommendations of *Tanksley and Knabe* (1984). The volume of the collected digesta was weighed continuously and thereafter 30% of the total collected volume was freeze-dried after homogenization. The laboratory analysis was conducted with the samples so prepared. The live weight of the trial animals were recorded at the start of the adaptation period and at the start and end of the collection period.

Table 3

Analyzed amino acid content of the experimental diets with wheat bran (g/kg)

Amino acids	Treatments				
	WB-0	**WB-25**	**WB-50**	**WB-75**	**WB-100**
Lysine	10.0	9.9	9.8	9.7	9.8
Methionine	3.1	3.1	3.0	3.0	3
Cystine	2.9	2.9	2.9	2.9	2.9
Methionine+Cystine	6.0	6.0	5.9	5.9	5.9
Threonine	6.6	6.6	6.5	6.5	6.5
Tryptophan	1.9	2.0	1.9	1.9	1.9
Arginine	10.1	10.0	9.9	9.8	9.9
Isoleucine	6.5	6.4	6.3	6.2	6.3
Valine	7.6	7.5	7.4	7.3	7.4

3. táblázat: A búzakorpát tartalmazó kísérleti takarmányok mért aminosav-tartalma

Table 4

Analyzed amino acid content of the experimental diets with soyhulls (g/kg)

Amino acids	Treatments				
	SH-0	**SH-25**	**SH-50**	**SH-75**	**SH-100**
Lysine	10.0	9.8	9.7	9.6	9.4
Methionine	3.1	3.1	3.2	3.1	3.1
Cystine	2.9	2.9	3.0	2.8	2.8
Methionine+Cystine	6.0	6.0	6.2	5.9	5.9
Threonine	6.6	6.5	6.4	6.4	6.3
Tryptophan	1.9	1.9	1.9	1.8	1.8
Arginine	10.1	9.9	9.7	9.6	9.4
Isoleucine	6.5	6.5	6.3	6.3	6.2
Valine	7.6	7.5	7.4	7.3	7.2

4. táblázat: A szójahéjat tartalmazó kísérleti takarmányok mért aminosav-tartalma

Laboratory analysis
The nutrient and amino acid content of the diets and the amino acid content of the digesta samples were determined in accordance with *AOAC* (2000).

Statistical analysis
The experimental data were analyzed using ANOVA, *SAS* (1999). In case of a significant treatment effect, the statistical reliance of differences among treatments was verified with Tukey test (*SAS*, 1999).

RESULTS AND DISCUSSION

The effect of wheat bran inclusion on the apparent ileal digestibility of amino acids
Apparent digestibility of amino acids in diets with different wheat bran content is presented in *Table 5*. According to our data the highest lysine digestibility was measured in the diet without inclusion of wheat bran (WB-0). The increased amount of wheat bran in the diet resulted slightly decreased lysine digestibility but no significant difference was found among treatments ($P \geq 0.05$). The digestibility of methionine in diets with wheat bran (WB-25, WB-50, WB-75, WB-100) was 83.3% on average, however, it was lower by 2.4% than the values measured in control group (WB-0). Statistically verifiable difference occurred only between WB-0 and WB-75 ($P \leq 0.05$). Similar tendency was found in case of cystine. The digestibility of cystine was 74.2% on average of diets with wheat bran inclusion; it was lower by mean of 3.0% than the value measured in control group (77.2%). Significant difference was found only between the control and treatment WB-50 ($P \leq 0.05$). Increasing the level of wheat bran in the diet from 0 to 100 g/kg decreased the apparent ileal digestibility of threonine and tryptophan from 69.5 to 64.9% and from 77.1 to 74.3%, respectively. Statistically verifiable differences occurred only between treatment WB-0 and WB-100 in case of both amino acids ($P \leq 0.05$). The treatments did not influence the digestibility of arginine ($P > 0.05$). Inclusion of 75 and 100 g/kg of WB in the diet significantly decreased the apparent ileal digestibility of isoleucine and valine ($P \leq 0.05$).

Table 5

The effect of what bran inclusion on the apparent ileal digestibility of amino acids (%)

Amino acids	Treatments			RMSE		
	WB-0	WB-25	WB-50	WB-75	WB-100	
Lysine	81.0[a]	80.2[a]	79.3[a]	79.6[a]	79.3[a]	2.2
Methionine	85.7[a]	83.6[ab]	83.1[ab]	83.0[b]	83.3[ab]	1.8
Cystine	77.2[a]	74.5[ab]	73.7[b]	74.1[ab]	74.3[ab]	2.4
Methionine+Cystine	81.6[a]	79.2[ab]	78.5[b]	78.6[b]	78.9[b]	1.7
Threonine	69.5[a]	68.2[ab]	66.4[ab]	65.6[ab]	64.9[b]	2.8
Tryptophan	77.1[a]	76.5[ab]	75.9[ab]	74.6[ab]	74.3[b]	1.9
Arginine	81.0[a]	79.2[a]	79.8[a]	78.7[a]	78.1[a]	2.3
Isoleucine	77.6[a]	75.6[ab]	74.3[ab]	72.4[b]	73.5[b]	2.8
Valine	73.4[a]	72.4[ab]	71.1[ab]	69.6[b]	70.2[b]	2.2

[a, b]: means within rows lacking a common superscript differ significantly P ≤0.05 (*[a, b]: az egy sorban lévő átlagok azonos kitevő nélkül statsztikailag különböznek P ≤0,05*); RMSE: root mean square error (*Négyzetes középérték hiba*)

5. táblázat: A búzakorpa bekeverési arányának hatása az aminosavak látszólagos ileális emészthetőségére (%)

The effect of soyhulls inclusion on the apparent ileal digestibility of amino acids

Apparent digestibility of amino acids of diets with soyhulls (SH) inclusion is presented in *Table 6*. According to our data the highest lysine digestibility was measured in treatment SH-0 (80.4%). Inclusion of 25 g SH/kg of feed resulted approximately 6% unit decrease in lysine digestibility (P≤0.05), but higher soyhulls level did not reduced it further (P>0.05). The tendencies for digestibility of methionine and cystine were similar to those for lysine. The decrease of digestibility of these amino acids was 4.3 and 5.8%, respectively (P≤0.05), when diets contained soyhulls, however, no significant difference occurred among SH-25, SH-50, SH-75 and SH-100. The digestibility of threonine was 68.9% in control treatment and significantly decreased by 3.7% and 8.3% units when 25 and 50g soyhulls was included per kg of feed, respectively (P≤0.05). Higher level of SH in the diet (SH-75 and SH-100) was not accompanied by a further decrease of threonine digestibility (P>0.05). The tendencies were similar when evaluating the digestibility of arginine but only level of 75 g/kg (SH-75) and 100 g/kg (SH-100) resulted significant decrease in digestibility of it (P≤0.05). The apparent ileal digestibility of isoleucine and valine followed the same trend like lysine, methionine and cystine; presence of soyhulls (SH-25, SH-50, SH-75, SH-100) decreased the digestibility of isoleucine and valine significantly from 77.1 with a mean of 7.2% unit and from 72.8 with a mean of 9.7% unit, respectively (P≤0.05).

Our results suggest that inclusion of fiber rich feedstuffs to the diet has negative effect on amino acid digestibility. In agreement with our data several studies show that increasing dietary NDF decreases the apparent ileal digestibility of certain amino acids (e.g. *Lenis et al.,* 1996; *Yin et al.,* 2000; *Dilger et al.,* 2004). The reasons of lower digestibility might be the NDF bounded amino acids and the high amount of endogenous amino acid loss. Both wheat bran and soyhulls contain a high proportion of NDF

bounded N, 25% and 16% of total protein, respectively (*NRC*, 1998), that is unavailable during the small intestinal digestion (*Schulze,* 1994). By increasing level of wheat bran and soyhulls inclusion the proportion of soybean meal decreased in the diet and therefore a higher rate of the protein was originated from the low digestibility components. Moreover, the higher fiber content in case of WB and SH containing diets resulted in a higher endogenous amino acid loss and therefore a lower apparent ileal digestibility (*Yin et al.,* 2000). The endogenous amino acid loss originating from enzymes, mucus, and protein from desquamated cells, is related frequently to the amount of consumed NDF (*Furuya and Kaji,* 1992; *Schulze,* 1994). Furthermore, in cases of wheat bran and soyhulls inclusion, the increasing level of NDF bounded protein which is indigestible, might result in a higher proteolytic activity leading to an accelerated erosion of the mucus layer (*Piel et al.,* 2007) and/or it acts as a factor stimulating mucus secretion (*Santoro et al.,* 1999) and reducing its reabsorption (*Mosenthin et al.,* 1994; *Grala et al.,* 1998).

Table 6

The effect of soyhulls inclusion on the apparent ileal digestibility of amino acids (%)

Amino acids	Treatments			RMSE		
	SH-0	SH-25	SH-50	SH-75	SH-100	
Lysine	80.4[a]	75.3[b]	74.2[b]	74.0[b]	73.9[b]	2.4
Methionine	85.4[a]	81.6[b]	81.3[b]	81.0[b]	80.6[b]	1.9
Cystine	76.8[a]	72.6[b]	70.7[b]	70.2[b]	70.3[b]	1.7
Methionine+Cystine	81.3[a]	77.2[b]	76.2[b]	75.9[b]	75.7[b]	1.6
Threonine	68.9[a]	65.2[b]	60.6[c]	61.4[c]	61.7[c]	2.4
Tryptophan	76.9[a]	77.0[a]	72.6[b]	72.2[b]	72.6[b]	2.5
Arginine	80.3[a]	80.0[a]	77.3[ab]	76.5[b]	76.3[b]	2.3
Isoleucine	77.1[a]	71.5[b]	68.8[b]	69.9[b]	69.3[b]	2.5
Valine	72.8[a]	63.2[b]	63.6[b]	63.7[b]	62.0[b]	2.7

[a, b]: means within rows lacking a common superscript differ significantly P≤0.05 ([a, b]*: az egy sorban lévő átlagok azonos kitevő nélkül statsztikailag különböznek P≤0,05*); RMSE: root mean square error (*Négyzetes középérték hiba*)

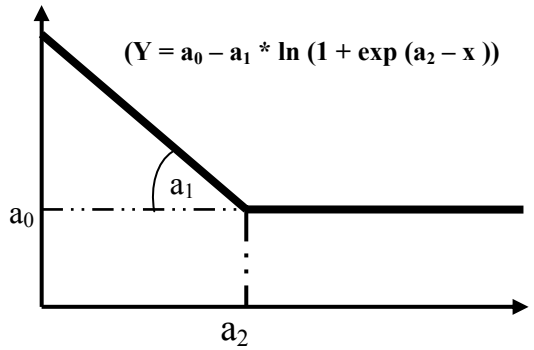
6. táblázat A szójahéj bekeverési arányának hatása az aminosavak látszólagos ileális emészthetőségére (%)

In most of the studies the relationship between crude fiber or NDF level and apparent ileal digestibility of amino acids are described as being linear (*Sauer et al.,* 1991; *Lenis et al.,* 1996; *Yin et al.,* 2000), however, based on our data we assume that best fit can be found if linear-plateau function is used. The linear-plateau function is a two-phase-graph with a slope and a constant phase, and shows that after a certain level of wheat bran or soyhulls inclusion, the digestibility of amino acids do not decline further (*Figure 1*). According to the results of *Yin et al*. (2000) the depression effect of fiber on apparent digestibility of amino acids was mainly the result of higher endogenous amino acid loss (EAAL). If this is the case also in the present study, then the linear-plateau function demonstrates that the EAAL increases up to a certain fiber level and then remains

constant. The hypothesis is supported by data of *Taverner et al*. (1981) suggesting that the ileal output of endogenous N increased with dietary fiber up to approximately 100 g NDF/kg, but not thereafter. In this latter study for increasing NDF content of the diet wheat and cellulose were used. In the present study beyond 25 and 50 g/kg soyhulls inclusion the digestibility of amino acids was not different statistically among treatments. In accordance with our data inclusion of 30 and 60 g/kg soyhulls decreased the digestibility of some amino acids, but 90 g/kg soyhulls (65.6 g/kg dietary NDF) did not reduce further the apparent ileal digestibility of lysine, tryptophan and agrinine compared to diets containing 60g/kg soyhulls (75.9 g/kg dietary NDF) in the study of *Dilger et al*. (2004).

Figure 1

Linear-plateau relationship with sharp transition



1. ábra: Lineár-plató függvény éles töréssel

Comparing the two fiber sources pregnant difference appears between the magnitudes of their digestibility reducing effect. Wheat bran inclusion decreased the apparent ileal digestibility of amino acids with a range of 1.4–5.2% unit, and that was in a range of 4.7–10.8% unit for soyhulls. Although diets with soyhulls inclusion contained higher NDF (ranged between 135–179 g/kg for SH diets and 135–167 g/kg for WB diets), the difference in fiber content does not explain the quantitative reduction in apparent digestibility coefficient. It is likely that soyhulls induced greater losses of amino acid containing sources (*Dilger et al.,* 2004). The reason for it is complex and probably includes type and solubility of fiber and presence of antinutritional factors. Soyhulls contain undigestible oligosaccharides like xylan (*Aspinall et al.,* 1966) that may act as antinutritive factor (ANF). The variable ANF contents of feedstuffs are known to affect intestinal mucus secretion and may affect EAAL (*Myrie et al.,* 2008). It has been frequently reported that the solubility of fiber might influence the endogenous secretion of protein. Feed that contains soluble fiber increases the water-holding capacity and thus the viscosity of the digesta, causing an increase in physical abrasion of epithelial cells by the digesta (*Sauer,* 1976). The increased viscosity might also result in less mixing of the digesta with the endogenous enzymes due to suppressed intestinal contractions (*Cherbut et al.,* 1990). Considering that soyhulls and wheat bran contain 830 and 450 g/kg total dietary fiber with an insoluble to soluble fiber ratio of 5.0 (*Dust et al.,* 2004) and 14.0

(*Bach-Knudsen,* 1997), respectively it is understandable that soyhulls inclusion reduces more the AID of amino acids than wheat bran. Since it is feasible that the source of NDF determines the endogenous amino acid loss, therefore it is recommended to study the effect of different NDF sources on the standardized or true, rather than only apparent ileal digestibility of amino acids.

CONCLUSIONS

Based on our results it can be concluded that dietary NDF has negative impact on the apparent ileal digestibility of amino acids and, however, the magnitude of this reducing effect is depending on the NDF source. Due to the fact that 25 g/kg of wheat bran and soyhulls level depress the apparent ileal digestibility of the most amino acids but higher rate of inclusion has no further negative effect, the amino acid supplementation should not be increased if more than 25 g/kg of wheat bran or soyhulls are used in diet formulation.

REFERENCES

AOAC (2000). Official Methods of Analysis. 17 th Edition. Association of Official Analytical Chemist. Arlington, VA.

Aspinall, G.O., Hunt, K., Morrison, I.M. (1966). Polysaccharides of soybeans: II. Fractionation of hull cell-wall polysaccharides and the structure of a xylan. J. Chem. Society. 21. 1945-1949.

Bach-Knudsen, K.E. (1997). Carbohydrate and lignin contents of plant materials used in animal feeding. Anim. Feed Sci. Technol., 67. 319-338.

Bakker, G.C.M. (1996). Interaction between carbohydrates and fat in pigs - impact on energy evaluation of feeds. PhD. Wageningen University, the Netherlands.

Cherbut, C., Albina, E., Champ, M., Doublier, J.L., Lecannu, G. (1990). Action of guar gums on the viscosity of digestive contents and on the gastrointestinal motor function in pigs. Digestion. 46. 205-213.

Dilger, J., Sands, S., Ragland, D., Adeola, O. (2004). Digestibility of nitrogen and amino acids in soybean meal with added soyhulls. J. Anim. Sci., 82. 715-724.

Dust, J.M., Gajda, A.M., Flickinger, E.A., Burkhalter, T.M., Merchen, N.R., Jr. Fahey, G.C. (2004). Extrusion conditions affect chemical composition and in vitro digestion of select food ingredients. J. Agric. Food Chem., 52. 2989-2996.

Furuya, S., Kaji, Y. (1992). The effects of feed intake and purified cellulose on the endogenous ileal amino acid flow in growing pigs. Br. J. Nutr., 68. 463-472.

Grala, W., Verstegen, M.W.A., Jansman, A.J.M., Huisman, J., Wasilevsko, J. (1998). Nitrogen utilization in pigs fed diets with soybean and rapeseed products leading to different ileal endogenous nitrogen losses. J. Anim. Sci., 76. 569-577.

Lenis, N.P., Bikker, P., van der Meulen, J., van Diepen, J.Th.M., Bakker, J.G.M., Jongbloed, A.W. (1996). Effect of dietary neutral detergent fiber on ileal digestibility and portal flux of nitrogen and amino acids and on nitrogen utilization in growing pigs. J. Anim. Sci., 74. 2687-2699.

Myrie, S.B., Bertolo, R.F., Sauer, W.C., Ball, R.O. (2008). Effect of common antinutritive factors and fibrous feedstuffs in pig diets on amino acid digestibilities with special emphasis on threonine. J. Anim. Sci., 86. 609-619.

Mosenthin, R., Sauer, W.C., Ahrens, F. (1994). Dietary pectin's effect on ileal and fecal amino acid digestibility and exocrine pancreatic secretions in growing pigs. J. Nutr., 124. 1222-1229.

Noblet, J., Henry, Y. (1993). Energy evaluation systems for pig diets: a review. Livest. Prod. Sci., 36. 121-141.

NRC (1998). Nutrient requirements of swine. National Academy Press, Washington, DC.

Piel, C., Montagne, L., Sève, B., Lallès, J.P. (2007). Dietary fibre and indigestible protein increase ileal glycoprotein output without impacting colonic crypt goblet cells in weaned piglets. Livest. Sci., 108. 1-3. 106-108.

Santoro, L.G., Grant, G., Pusztai, A. (1999). In vivo degradation and stimulating effect of phaseolin on nitrogen secretion in rats. Plant Foods for Human Nutrition. 53. 223-236.

SAS (1999). Statistical Analysis System Institute, SAS User's guide, version 8. SAS Inst. Inc. Cary, NC, USA.

Sauer, W.C. (1976). Factors affecting amino acid availability for cereal grains and their components for growing monogastric animals. PhD. University of Manitoba.

Sauer, W.C., Mosenthin, R., Ahrens, F., Hartog, L.A. (1991). The effect of source of fiber on ileal and fecal amino acid digestibility and bacterial nitrogen excretion in growing pigs. J. Anim. Sci., 69. 4070-4077.

Schulze, H. (1994). Endogenous ileal nitrogen losses in pigs: dietary factors. PhD. Agricultural University Wageningen, Wageningen, The Netherlands

Tanksley, T.D., Knabe, D.A. (1984). Ileal digestibilities of amino acids in pig feeds and their use in formulating diets. In: Recent Advances in Animal Nutrition. Butterworths, London, 75-95.

Taverner, M.R., Hume, I.D., Farrell, D.J. (1981). Availability to pigs of amino acids in cereal grains. (I) Endogenous levels of amino acids in ileal digesta and faeces of pigs given cereal diets. Br. J. Nutr., 46. 149-158.

Yin, Y.L., McEvoy, J.D.G., Schulze, H., Hennig, U., Souffrant, W.B., McCracken, K.J. (2000). Apparent digestibility (ileal and overall) of nutrients and endogenous nitrogen losses in growing pigs fed wheat (var. Soissons) or its by-products without or with xylanase supplementation. Livest. Prod Sci., 62. 119-132.

van Leeuwen, P., van Kleef, D.J., van Kempen, G.J.M., Huisman, J., Verstegen, M.W.A. (1991). The post.valve T-caecum cannulation technique in pigs applicated to determine the digestibility of amino acids in maize, groundnut and sunflower meal. J. Anim. Physiol. Anim. Nutr., 65. 183-193.

Verstegen, M.W.A., Tamminga, S. (2005). The challenges in animal nutrition in the 21st century. In: 12th International Symposium on Animal Nutrition. University Press, Kaposvár, 3-30.

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