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The effect of variety, supplementation with tryptophan, dehulling and autoclaving on utilization of field bean (*Vicia faba* L.) seeds by broiler chickens

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ABSTRACT

During 21 days experiment on 110, 8-day-old Astra B male chicks, two varieties of field bean (FB): *Nadwiślański* and *Dino* were compared with soya bean oil meal as a source of supplementary protein in wheat-triticale diets. The isocaloric, isoprotein and fortified with DL-methionine diets contained 30% of FB seeds were fed unsupplemented or supplemented with 0.2 g L-tryptophan per kg.

The AME_N of raw seeds of both FB varieties and of FB var. *Dino* processed in different ways (raw, dehulled, autoclaved, autoclaved and dehulled) was determined on 4-week-old cockerels.

The seeds of both varieties of FB, fortified with methionine, were as effective as soya bean oil meal as a supplementary protein source in wheat-triticle diets. Supplementation with tryptophan had no positive effect on chick performance.

The AME_N of FB var. *Dino* was lower than of FB var. *Nadwiślański* (11.0 vs 11.4 kJ/g DM, respectively). After autoclaving, the AME_N of FB var. *Dino* increased by 7%, after dehulling by 15%.

KEY WORDS: field bean, broiler chicken, dehulling, heating, metabolizable energy

INTRODUCTION

The high lysine content of the field bean (*Vicia faba* L.) protein makes it a good supplement to the cereal protein in poultry feeds. The first amino acid that limits the biological value of field bean protein is methionine, followed by tryptophan (Eggum, 1980; Pastuszewska et al., 1978). A deficit of these amino acids may thus be expected in mixtures of field beans with wheat and triticale.

The nutritional value of FB seeds also depends on the susceptibility of its protein and carbohydrates to enzymatic digestion and on the presence of antinutrients – tannins, lectins, trypsin inhibitors and phytic acid – that may

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interfere with digestion and metabolism (Carnovale et al., 1988; Eggum, 1980; Ernest, 1987; Pastuszewska, 1985; Rubio et al., 1989). Tannins are concentrated mainly in the hulls of FB seeds, while the concentration of trypsin inhibitors and lectins is higher in cotyledons. The hulls comprises from 13 to 15% of the seed (Eggum, 1980; Pastuszewska, 1985).

The apparent metabolizable energy value (AME_N) of FB seeds for poultry equals approximately 11 MJ/kg DM and is higher than that of soya bean meal but lower than that of wheat and triticale. The metabolizable energy of FB seeds increases due to dehulling (Longstaff et al., 1991) and autoclaving (Guillaume, 1973; Ryś and Fraś, 1980).

The aim of the study was to compare the Polish standard FB variety *Nadwiślański* and a newer variety, *Dino*, as energy and protein sources for broiler chicks and to evaluate the effect of dehulling and autoclaving on the metabolizable energy of FB seeds of var. *Dino*.

MATERIAL AND METHODS

Raw field bean seeds *Nadwiślański* and *Dino* from the 1988 harvest and *Dino* from the 1989 harvest – unprocessed, dehulled, autoclaved (heated for 10 min. in an autoclave at 100°C) or autoclaved and dehulled were used in the experiments. The samples of FB were obtained from the region of Olsztyn.

The basic chemical composition and fibre content of all the seeds were determined by conventional methods. Their amino acid composition was determined using a Beckman amino acid analyser. Methionine and cystine were assayed after oxidation with performic acid, tryptophan after hydrolysis with barium hydroxide. Trypsin inhibitor activity (Kakade et al., 1974) and tannin content (Adams and Novellie, 1975) were determined in raw and processed seeds var. *Dino*, 1989.

Experiment 1

FB seeds var. *Nadwiślański* and *Dino* from the 1988 harvest were compared as sources of supplementary protein, partially replacing soya bean oil meal protein in wheat-triticale diets.

The experiment was conducted on 110, 8-day-old Astra B broiler cockerels with the average initial weight of 101 ± 5 g. The birds were housed in pairs in cages equipped with heaters and feed and water supply. One group comprised 11 pairs of birds.

The cockerels were fed the experimental diets (Table 4) to appetite for 3 weeks. Body weight and feed consumption were measured weekly and the body weight gain and feed utilization were calculated for each pair of birds. The significance of the differences among the groups was assessed using Duncan's multiple range test.

TABLE 1

Chemical composition (in % DM) and metabolizable energy (AME_N kJ/g DM) of field bean seeds

Field bean, variety, year of harvest	Dry matter %	Crude protein	Crude fibre	Crude fat	Crude ash	N-free extractives	AME_N experimental	AME_N calculated[2]	AME_N/GE %
Dino, 1988	87.1	28.8	8.3	1.3	3.6	58.0	10.96 ± 0.87	11.73	58
Nadwiślański, 1988	87.2	29.2	9.1	1.4	3.6	56.7	11.40 ± 0.63	11.64	60
Dino, 1989									
raw	87.4	29.0	8.4	1.6	3.5	57.5	11.13 ± 0.67	11.78	60
raw dehuled	87.6	31.2	2.3	1.7	3.5	61.3	12.86 ± 0.80	12.59	66
autoclaved	88.2	29.5	6.6	1.8	3.5	58.6	11.94 ± 0.75	12.11	63
autoclaved dehulled	88.0	30.0	4.5	1.9	3.4	60.2	13.04 ± 0.72	12.35	69

1) experimental data

2) calculated according to European Table of Energy Values for Poultry Feedstuffs (1986)

Experiment 2

The AME_N value – apparent metabolizable energy corrected for zero nitrogen balance – of the evaluated seeds was determined in 2 balance experiments conducted on 80, 4-week-old Astra B cockerels with the average body weight about 760 g. The chicks were housed in individual cages equipped for the quantitative collection of excreta, in a controlled environment with 24 h light/d. 10 birds constituted an experimental group.

Basal diet was composed of (g/kg): ground wheat 695, soya bean oil meal 266 and a vitamin-mineral supplement (without antibiotics or methionine) 39. The experimental diets were composed of the basal diet and finely ground FB seeds mixed in a 60:40 ratio on a dry matter basis.

The basal and experimental diets were cold pelleted, 100 g/per bird were offered daily in 3 portions. After 2 days the birds were kept fasting for 24 h, and then were offered the same diets for the next 48 h. Feed consumption was measured, excreta were collected daily during the last 48 h and 24 h of consecutive fast, frozen immediately and stored at −18°C. Dry matter and total N were determined in lyophylised excreta using conventional methods, gross energy value of feed and excreta was measured using an adiabatic bomb calorimeter. The AME_N of the seeds was calculated according to Pesti and Ware (1986).

TABLE 2

Content of tannin, trypsin inhibitor and dietary fibre in field bean var. *Dino* (1989) – raw and processed (in % DM)

Component	Raw	Raw dehulled	Autoclaved	Autoclaved dehulled
Tannis[1]	0.83	0.24	0.66	0.37
Trypsin inhibitor				
TIU/mg protein	16.67	17.48	3.29	4.02
Crude fibre	8.41	2.32	6.61	4.46
ADF	11.75	3.42	11.00	6.70
NDF	15.02	6.28	11.18	8.93
ADL	1.39	0.35	1.29	0.75

[1]equivalent of tannic acid

RESULTS AND DISCUSSION

Both FB varieties contained approximately 29% protein on a dry matter basis (Table 1). The amino acid composition of the protein from both FB varieties, given in Table 3, was similar to that reported by Pastuszewska (1985) and Eggum (1980). In comparison with soya bean protein, the protein of field bean had higher

lysine and arginine content and lower sulphur-containing amino acids and tryptophan content. Comparison of the varieties showed that the FB *Nadwiślański* had slightly more sulphur-containing amino acids (2.35 vs 2.21) while the FB *Dino* had more tryptophan (1.04 vs 0.97) and lysine (6.34 vs 6.26 g/16 gN).

TABLE 3

Amino acid composition of field bean protein (g/16 g N)

Amino acid	*Nadwiślański*	*Dino*	*Dino*, 1989			
	1988	1988	raw	raw dehulled	autoclaved	auoclaved dehulled
Lys	6.26	6.34	6.36	6.45	6.34	6.43
Lys available	–	–	5.78	5.87	5.77	5.86
Cys	1.36	1.26	1.22	1.21	1.22	1.21
Met	0.99	0.95	0.73	0.77	0.74	0.75
Thr	3.65	3.72	3.81	3.83	3.81	3.86
Try	0.97	1.04	1.04	0.96	1.04	1.00
Arg	9.95	9.72	10.38	10.78	10.73	10.50

The small differences in the amino acid content between the varieties were not reflected in the results of the experiment 1 (Table 5). No differences were found either between the experimental groups and control (soya bean) group. Supplementation of the diets with tryptophan had no effect on performance or feed utilization. The level of lysine and threonine in the diets containing field beans (Table 4) somewhat exceeded the requirements of broiler chicks of this age. This, in conjunction with no reaction to tryptophan supplementation, indicates that after supplementation with methionine, field bean protein has similar nutritional value in mixed feeds as soya bean oil meal protein. This is in agreement with the observation of Eggum (1980) and the authors cited therein.

The AME_N of FB *Nadwiślański* was somewhat higher than that of FB *Dino* (Table 1).

Dehulling of *Dino* seeds resulted in the removal of a significant proportion of both tannins and fiber (Table 2). The dehulled seeds had an approximately 15% higher energy value than raw seeds and its gross energy utilization increased by about 10%. It seems that this should be attributed more to the changes in the chemical composition of the dehulled fraction which, in comparison with whole seeds contained more protein and nitrogen-free extractives and less fibre, than to the decrease in the tannin concentration. Longstaff and McNab (1991) observed a decrease in the activity of lipase and α-amylase in the content of the duodenum and small intestine of chick as the level of FB hulls in the diet arose, but only when the proportion of hulls reached 30% did the digestibilities of fat and starch decreased. Both, in the study cited above and in the report by Longstaff et al.

(1991), cotyledon fractions and hulls from FB of various varieties were mixed in different proportions. TME_N of these compositions was determined and found to decrease proportionately to the percentage of hulls in the mix. This indicates that the energy of FB hulls is not utilized by chickens.

TABLE 4

Composition of the diets in experiment 1 (g/kg)

Ingredients	Control	*Dino* 1988		*Nadwiślański* 1988	
		unsupplemented	+ Trp	unsupplemented	+ Trp
Ground field bean seeds	–	300	300	300	300
Ground corn[1]	686	532	532	532	532
Soya bean oil meal	270	124	123.8	124	123.74
Constant components[2]	44	44	44	44	44
Tryptophane[3]	–	–	0.2		0.26
Calculated					
AME_N, MJ/kg	10.98	10.64	10.64	10.76	10.76
Crude protein, %	18.73	18.64	18.64	18.73	18.73
Lys, %	0.94	0.98	0.98	0.98	0.98
Met + cyc, %	0.79	0.69	0.69	0.70	0.70
Try, %	0.24	0.22	0.24	0.214	0.24
Thr, %	0.62	0.64	0.64	0.64	0.64

[1]triticale and wheat (1:1)

[2]limestone 14 g, dicalcium phosphate 16 g, NaCl 4 g, DL-methionine 1 g, vit. A 8000 IU vit. D_3 1200 IU, vit. E 10 mg, vit. K 2 mg, vit. B_2 4 mg, vit. B_6 4 mg, vit. B_{12} 0.015 mg, nicotinic acid 12 mg, Ca pantothenate 8 mg, folic acid 0.2 mg, choline Cl 150 mg, Mn 50 mg, J 0.3 mg, Zn 30 mg, Se 0.1 mg, Co 0.4 mg

[3]in unsupplemented diets equivalent amount of wheat starch was added

TABLE 5

Results of experiment 1 (average from 3 weeks)

Item	Control	*Dino* 1988		*Nadwiślański* 1988	
		unsupplemented	+ 0.2 Trp	unsupplemented	+ 0.2 Trp
Body weight gain, g	614	614	618	618	580
Feed conversion ratio, g feed/g gain	2.28	2.22	2.26	2.40	2.31

differences between groups statistically not significant ($P \leqslant 0.05$)

Autoclaving field bean seeds for 10 min at 100°C reduced the activity of trypsin inhibitors by 80%, as well as the tannin and NDF content (Table 2), leading to a 7% rise in the energy value of the seeds and a 5% increase in gross

energy utilization. These results agree with those of Ryś nad Fraś (1980) who determined the ME of unprocessed FB seeds var. *Major* to equal 11.89 kJ/g and of autoclaved – 12.64 kJ/g, which is 6% higher. Guillaume (1973) found even a 12% rise (from 12.98 to 14.65 kJ/g) in the ME of FB seeds after autoclaving.

Removing a significant part of the hulls from autoclaved seeds increased their metabolizable energy value by 9%. Application of both processes (autoclaving and dehulling) gave a product with an energy value close to that of cereal grain and gross energy utilization improved by 15%.

Partial removal or inactivation of factors having an unfavourable effect on digestion gave a somewhat better result than could be expected from just changes in chemical composition (Table 1). However, as Eggum (1980) emphasizes, improved utilization of field bean seeds by dehulling and autoclaving does not compensate the financial costs of processing.

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STRESZCZENIE

Wpływ odmiany, uzupełniania tryptofanem, obłuszczania i ogrzewania na wykorzystanie nasion bobiku (*Vicia faba* L.) przez kurczęta

W trwającym 21 dni doświadczeniu na 110, 8-dniowych kogutkach Astra B porównywano wartość uzupełniającą dwóch odmian bobiku i śruty sojowej w dietach zawierających pszenicę i pszenżyto. Do diet wprowadzono 30% bobiku, zawartość białka, energii i metioniny wyrównywano do poziomu diety kontrolnej. Diety zawierające bobik podawano nieuzupełnione lub uzupełnione 0,2 g L-tryptofanu na kg.

AME_N nasion odmian *Nadwiślański* i *Dino* ze zbiorów 1988 roku oraz nasion odmiany *Dino* ze zbiorów 1989 roku – surowych, obłuszczonych, ogrzewanych, ogrzewanych i obłuszczonych – oznaczano na 4-tygodniowych kogutkach brojlerach.

Obie odmiany bobiku po uzupełnieniu metioniną miały wartość porównywalną ze śrutą sojową jako źródło białka uzupełniającego w diecie pszenno-pszenżytniej. Uzupełnienie tryptofanem nie wpłynęło dodatnio na przyrosty kurcząt ani na wykorzystanie paszy. AME_N bobiku odmiany Dino była nieco mniejsza niż odmiany *Nadwiślański* (11,0 vs 11,4 kJ/g SM). Ogrzewanie zwiększyło AME_N odmiany *Dino* o 7%, obłuszczanie o 15%.