



Extrusion cooking improves the metabolisable energy of faba beans and the amino acid digestibility in broilers



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ABSTRACT

The study was conducted to investigate the nutritional value of 5 cultivars of *Vicia faba* L. seeds. The study group included 132 male one-day-old Ross 308 chickens. The birds were randomly assigned to 11 dietary treatments (12 replications in each). Birds were kept in individual cages. Nutrient digestibility was calculated using the difference method. From day 1 to 16, birds received only basal diets. From day 17 to 21, in 10 of the treatments, diets contained faba bean meal in raw or extruded form (Merlin, Olga, Albus, Amulet, Kasztelan) and the basal diet in the ratio 40:60. On days 19 and 20, excreta were individually collected, and then all chickens were sacrificed and ileal digesta were sampled for determination of ileal digestibility. The apparent metabolizable energy (AME_N) of raw faba bean seeds ranged from 8.12 to 12.16 MJ/kg; the lowest was determined for the Albus and the highest for the Amulet cultivars. Albus faba bean contained more crude protein (347 g/kg DM) than the other cultivars. The lowest concentration of crude protein was determined in cv. Kasztelan (281 g/kg DM). The AME_N of faba beans was negatively correlated with their content of oligosaccharides ($r = -0.80$; $P \leq 0.001$), raffinose ($r = -0.79$; $P \leq 0.001$) and phytic P ($r = -0.55$; $P \leq 0.001$). Similar negative correlations were observed with respect to the apparent digestibility of dry matter, starch, crude protein and the ileal amino acid digestibility. Extrusion cooking of faba beans decreased their concentration of NDF, ether extracts, trypsin inhibitor, phytic P and resistant starch as well as total and free sialic acid in digesta ($P \leq 0.05$). Extrusion improved the AME_N values of raw faba bean seeds and the nutrient digestibility in broilers ($P \leq 0.05$).

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1. Introduction

Faba bean seeds can be used as a valuable source of protein, energy and other nutrients in broiler chicken nutrition (Wiryawan et al., 1995). However, faba bean seeds also contain variable amounts of anti-nutritional factors such as tannins, protease inhibitors, oligosaccharides (raffinose, stachyose and verbascose) and non-starch polysaccharides (NSP), which can negatively affect nutrient utilization and animal performance (Gatel, 1994). Studies published over the last decade have shown that the main factor, which reduces broiler chicken performance, are tannins (Blair et al., 1970; Wareham et al., 1991). According to some researchers, tannin content in conventional faba beans may decrease amino acid and starch digestibility (Longstaff and McNab, 1991; Flores et al., 1994). The phenolic groups of tannins bind to enzymes and other proteins and form insoluble tannin-protein complexes resistant to the digestive enzymes of monogastric animals. Hydrogen bonds and hydrophobic interactions appear to be the principal linkages involved (Artz et al., 1987). As a result, there has been increased

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Table 1
Basal diet composition and nutritional value.

Item	g/kg
Maize	600
Soya bean meal	293.5
Soya bean oil	41.6
Fish meal	29.4
Monocalcium phosphate	10.3
Limestone (<2 mm)	5.1
Premix ^a	10
NaCl	2
NaHCO ₃	0.1
D,L-Methionine	2.7
L-Lysine	1.7
L-Threonine	0.6
TiO ₂	3
Proximate analysis	
Metabolizable energy (MJ/kg)	12.55
Crude protein	210.0
Ca	9.2

^a Provides per kg diet: IU: vit. A 11 250, cholecalciferol 2500; mg: vit. E 80, menadione 2.50, vit. B12 0.02, folic acid 1.17, choline 379, D-pantothenic acid 12.5, riboflavin 7.0, niacin 41.67, thiamin 2.17, D-biotin 0.18, pyridoxine 4.0, ethoxyquin 0.09, Mn 73, Zn 55, Fe 45, Cu 20, I 0.62, Se 0.3, salinomycin 60.

interest in the development of low-tannin faba bean cultivars that could be used in large amounts for feeding poultry (Crepon et al., 2010). Current low-tannin faba bean cultivars are characterized by low concentrations of tannins, but they still contain other anti-nutritional factors, which can reduce nutrient digestibility. Results have so far shown that low-tannin faba beans are characterized by better amino acid digestibility than conventional faba beans (Woyengo and Nyachoti, 2012). However, the digestibility coefficients of amino acids contained in low-tannin faba beans are still lower than those contained in soybean meal (Woyengo and Nyachoti, 2012), but they are higher than those in peas (Ravindran et al., 2005).

In recent years, only a few publications have appeared which have discussed the effect of low-tannin faba beans on broiler chicken performance (Moschini et al., 2005; Gous, 2011), while the nutritional value of faba beans was only determined in one study (Woyengo and Nyachoti, 2012). It is not well known which anti-nutritional factors in the new low-tannin faba bean cultivars can still decrease their nutritional value and whether the level of anti-nutritional factors differs between cultivars. The impact of the legume cultivar on its nutritional value has been studied for peas (Smulikowska et al., 2001; Hejdysz et al., 2015) and for narrow-leafed lupins (Kaczmarek et al., 2014), but not for faba beans.

According to some researchers, extrusion cooking of faba bean seeds is a process which may improve the performance of broiler chickens (Diaz et al., 2006). An appropriate processing temperature is critical for the elimination of heat-labile anti-nutritional factors found in legume seeds (Nalle et al., 2011). The extrusion process increases both the digestibility of individual feed components and the destruction of pathogens (Nalle, 2009). However, some studies have shown that the reduction in protein digestibility caused by thermal treatment is the result of protein aggregation (Wang, 2000; Carbonaro et al., 2005). The effect of extrusion cooking on the nutritional value of faba beans is not well understood. Moreover, there is no comparative information on the influence of extrusion cooking on the nutritive value of low-tannin faba beans.

Therefore, this work tries to determine and explain the causes of variations in the nutrient digestibility and AME_N levels of low-tannin cultivars of faba beans for broiler chickens. Additionally, the study examined the effects of extrusion cooking on the chemical composition, nutrient digestibility and AME_N of low-tannin faba beans for broiler chickens.

2. Material and methods

2.1. Faba bean seeds

Faba bean (*Vicia faba*) seeds of the following 5 cultivars were harvested in 2013: Merlin, Olga, Albus, Amulet, and Kasztelan, registered in 2001, 2003, 2003, 2008 and 2006, respectively (COBORU, 2011). In the experiment, all the faba bean cultivars used were characterized by low concentrations of tannins. Seeds (Olga, Albus, Amulet, Kasztelan) were obtained from the Plant Breeding Stations in Strzelce, Łódzkie Voivodeship, Poland, whereas the Merlin cultivar was obtained from Selgen, The Czech Republic. Part of the low-tannin faba bean seeds were extruded using a KMZ 2 extruder (Russia) (500 kg/h). The conditions during the extrusion process were: moisture about 22%, exposition time 10 s, temperature 135 ± 10 °C, and pressure of 30 kg cm².

2.2. Diets

The basal diet used in the trial is present in Table 1 and was mixed in the ratio 60:40 (w/w) with the corresponding faba bean meals. To allow the digestibility to be determined, 3 g/kg titanium dioxide was included as a non-absorbable marker. All experimental diets were offered in mash form ad libitum.

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