Testing of Two Varieties of Lupin Seeds as Substitutes for Soya Extracted Meal in Vegetable Diets Designed for Young Broilers

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Abstract

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The main aim of this experiment was to verify the suitability of two Polish varieties of dehulled lupin seed (the low-protein SONET variety and the high-protein JUNO variety) as protein components to replace 50% of soya extract meal in feeding mixtures designed for the feeding of young broilers. The results of this experiment demonstrate that suitable treatment of lupin seed (dehulling) may significantly increase its nutritional value. Dehulling provides a product (core) in which the level of nitrogen-containing substances is by 27% higher than that in the original seed, providing an important protein component to be added in feeding mixtures for chickens. The experiment has also shown that production performance depends on the particular Lupinus variety used. Chickens fed on the JUNO variety seed (Group E1) reached a live weight of 2.332 kg on Day 40, which is comparable with the control group of chickens (2.337 kg; Group C). However, chickens in Group E2 fed on the SONET variety seed had a conclusively lower average weight (2.280 kg) ($P \leq 0.05$). Feed consumption per kg of weight gain at this level of average live weight was as follows: 1.89 kg (Group C), 1.85 kg (Group E1), and 1.93 kg (Group E2). The results confirm the suitability of dehulled lupin seed as a substitute for soya extract meal. When designing the composition of feeding mixtures one has to know the exact nutritional composition of the particular lupin variety. One important finding from a nutritional point of view is that the seed of the *Lupinus* genus is a major source of the amino acid arginine, which is often deficient in the feeding mixtures.

Growth of chickens, Lupin seeds, JUNO variety, SONET variety, performance

In connection with the ban on the use of meat-and-bone meal in animal feeds and with the increasing share of vegetable components in diets designed for farm animals, research is currently focusing on the development of new feeds, particularly protein-based feeds, to substitute meat-and-bone meal in traditional diets. Efforts are being made due both to economic and social perspective to either fully or at least partially replace soya beans and soya bean products (soya extract meals) with domestic (European) protein feeds. The seed of the *Lupinus* genus as one of the European cultural plants represents a promising alternative in this respect. The seed of some lupin varieties contains almost 50% nitrogenous substances, making lupin seed a potentially useful high-protein feed.

The potentially advantageous use of lupin seeds in feeding mixtures designed for young broilers is discussed in studies by Gualtieri and Rapaccini (1990), Teixiera and Dos (1995) and Roth-Maier and Paulicks (2003). Non-starch polysaccharides contained in the seed may, however, pose some problems from a dietetic point of view by increasing the viscosity of intestinal content (Kocher et al. 2000) and elevating water content in droppings, as reported by Farrell et al. (1999). This problem can be overcome by supplementing the feeding mixture with some enzymes, as reported by RothMaier and Kirchgessner (1995), Gdala (1998), Brenes et al. (2003), Steenfeldt et al. (2003)

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and Mieczkowska et al. (2004). Another important fact to consider is that from a nutritional point of view the levels of some of the essential amino acids in lupin seed are lower than those in soya meal (e. g. methionine, lysine, tryptophan). This is documented in studies by Perez-Alba et al. (1990), RothMaier and Kirchgessner (1993), Lettner and Zollitsch (1995), and Ravindran et al. (2002). Deficient amino acids can be added in the form of identical synthetic compounds.

Uziebo et al. (1996) has shown that some alkaloids associated with bitter lupin varieties may act as anti-nutritional factors. Therefore, most experiments are carried out using sweet lupin varieties, which are more likely to be used in animal nutrition than bitter varieties. The majority of the above-described dietetic problems can be successfully overcome if lupin seed is dehulled. A number of authors, e.g. Smulikowska et al. (1995), Annison et al. (1996), Rubio et al. (1998), Gdala (1998), Rubio et al. (2003) and Mieczkowska et al. (2005), reported a positive effect of treatment of lupin seed by dehulling. Furthermore, in the case of some lupin varieties dehulling provides a product (core) of a considerably higher nutritional value, which can be used to replace soya extract meal, as proven by some authors, e. g. Koreleski et al. (1987), RothMaier and Kirchgessner (1994) and Lettner and Zollitsch (1995).

Materials and Methods

The main aim of the experimental investigation was to verify the production performance of feeding mixtures containing dehulled seeds of the two lupin varieties (JUNO and SONET) as a substitute for 50% of soya extract meal. The resultant feed was administered to young broilers during their growth, i.e. until the age of 40 days. A total of 240 one-day-old broilers (ROSS 308 hybrid combination) were purchased for this experiment. The chickens were reared on deep bedding in an accredited experimental enclosure with controlled light, temperature, zoo-hygienic and feeding regimens. Rearing conditions fully complied with the requirements of the rearing and feeding of ROSS 308 broilers specified in the respective technological instructions for this kind of broilers. Broilers were divided into three groups, each containing 80 chickens (40 females and 40 males) (i. e. one control group and two experimental groups). The experimental groups (E1 and E2) received feed containing seed of either the JUNO lupin variety or of the SONET lupin variety. The control group (C) was fed on the feeding mixture containing soya extract meal as the major source of protein. The difference between the feeding mixtures used in experimental groups and in the control group was that 50% of soya extract meal in experimental feeding mixtures was replaced by meal made of dehulled seeds from one of the two lupin seed varieties being tested. Feeding was ensured by plastic tube feeders and hanging watering feeders designed for poultry (Plasson MK II type). Broilers were fed *ad libitum* with the BR 1 mixture up to the age of 20 days, followed by the BR 2 mixture from Day 21 until Day 40; the experiment was stopped on Day 40. The composition of feeding mixtures is shown in Table 1. The feeding mixture BR 1 in the control group contained 32% of soya extract meal, while in experimental groups it contained 16% of soya extract meal and 16% of dehulled seeds of the particular lupin variety (JUNO for Group E1 and SONET for Group E2). The feeding mixture BR 2 in the control group contained 28% of soya extract meal, while in experimental groups it contained 14% of soya extract meal and 14% dehulled seeds of one of the two lupin varieties (JUNO for Group E1 and SONET for Group E2). Feeding mixtures were supplemented with minerals and vitamins using the premix ZBCHS Vit. - SK (at a dose of 0.5%), which also contains enzymes such as 3-phytase, endo-1.4-beta-xylanase, and endo-1.4-betaglucanase. During the experiment, broilers were weighed on Days 1, 10, 20, 30, and 40. Feed conversion, i.e. the consumption of feed per kg of broiler's live weight gain, was calculated. Indicators such as the state of broiler's health, vitality, behaviour, feed intake, water consumption, the quality of droppings and mortality were monitored daily throughout the whole experiment. The results obtained were processed by using mathematical statistical methods implemented using the UNISTAT program. The following statistical parameters were evaluated for each group: arithmetic mean (x) and standard deviation (sd). The differences between average values were evaluated using Student's *t*-test at a significance level of $P > 0.05$ (non-significant - NS), $P \leq 0.05$ (*), $P \leq 0.01$ (**).

Results and Discussion

The results of this experiment have confirmed the suitability of meal made of dehulled lupin seeds as a substitute for soya extract meal in diets designed for young broilers. Based on utility indicators observed in chickens it can be concluded that a 50% substitution of soya extract meal with meal made of dehulled seeds of the JUNO lupin variety produced no conclusive effect on the production performance of the tested feeding mixtures in contrast to the SONET lupin variety.

Table 1. Content of nutrients in g per kg of the feeding mixture

BR 1	Control	Experiment E1 JUNO	Experiment E2 SONET
Crude protein[1]	228.8	241.0	222.0
Fat	63.0	70.5	70.3
Crude fibre	29.0	20.1	19.3
Nitrogen-free extract	507.5	492.8	493.9
Crude ash	64.2	61.4	60.5
Lysin	13.5	12.7	10.4
Methionin	5.3	4.5	4.2
Arginin	14.3	19.4	13.2
Threonin	8.5	8.5	6.7
ME (MJ/kg)	12.0	12.3	12.0
BR 2	Control	Experiment E1 JUNO	Experiment E2 SONET
Crude protein[1]	212.0	222.7	199.7
Fat	62.4	69.8	69.6
Crude fibre	27.8	20.1	19.3
Nitrogen-free extract	531.9	518.9	543.7
Crude ash	58.7	56.2	61.6
Lysin	12.1	11.3	9.4
Methionin	5.0	4.3	4.1
Arginin	14.2	18.7	13.3
Threonin	7.7	7.6	6.0
ME (MJ/kg)	12.0	12.3	12.2

[1] (N × 6.25)

Table 2. Average live weight of young broilers during the course of their growth

Broilers´ age	Control C mean (kg)		Experiment E1 JUNO mean (kg)			Experiment E2 SONET mean (kg)		
	n = 80	mean ± sd	n = 80	mean ± sd	C – E1	n = 80	mean ± sd	C – E2
Day 10	0.189	± 0.0211	0.182	± 0.0251	NS	0.181	± 0.0258	*
Day 20	0.668	± 0.0616	0.660	± 0.0704	NS	0.629	± 0.0699	**
Day 30	1.457	± 0.1222	1.428	± 0.1194	NS	1.408	± 0.1175	*
Day 40	2.337	± 0.1719	2.332	± 0.1638	NS	2.280	± 0.1843	*

NS = non-significant $P \leq 0.01$ ** $P \leq 0.05$ *

The corresponding results are shown in Table 2. It follows from Table 2 that when 50% of soya meal was replaced with the product made of dehulled lupin seeds of the JUNO variety (Group E1), the broilers' average live weight remained unaffected during the course of the experiment (Days 10, 20, and 30) and at the end of the experiment (Day 40). In contrast, a 50% substitution of soya extract meal with the product made of dehulled lupin seeds of the SONET variety decreased the production performance of the feeding mixture. This was manifested by a conclusively lower ($P \leq 0.05$) live weight of broilers throughout the whole experiment (Days 10 and 30) and at the end of the experimental feeding (Day 40), as compared with the control group (C). On Day 20 the difference in average live weight was tested as highly conclusive ($P \leq 0.01$). At the end of feeding, i.e. on Day 40, control chickens had an average live weight of 2.337 kg, while those in experimental groups E1 (JUNO) and E2 (SONET) had average live weights of 2.332 kg and 2.280 kg, respectively. The possibility of replacing soya

meal has also been confirmed in studies conducted by Koreleski et al. (1987), RothMaier and Kirchgessner (1994), and Lettner and Zollitsch (1995), who showed that the final production performance of feeding mixtures depends strongly on the particular variety used. Most authors came to the conclusion that the optimum content of lupin seeds in the feeding mixtures is up to 20%, which is in accordance with our findings. Higher portions of lupin seeds (i.e. above 20%) decrease the quality of dropping, feed conversion and utility as documented by Farrell et al. (1999) and RothMaier and Kirchgessner (1994). Variations in the production performance of feeding mixtures based on soya extract meal and dehulled lupin seed can be attributed to the differential levels of nitrogen-containing substances such as essential amino acids. On the basis of our own analyses (related to 100% dry matter) it was revealed that dehulled seed in the lupin product increases the content of nitrogen-containing substances by approximately 27%. Particularly, in the case of the JUNO variety it increases from 458.9 g/kg to 586.3 g/kg, while in the case of the SONET variety it rises from 331.6 g/kg to 422.2 g/kg. Soya extract meal contains 51.2 g of nitrogen-containing substances per kg, whereas the product obtained from the JUNO variety by dehulling has a higher portion of nitrogen-containing substances. However, in the case of the product made of the SONET variety the levels of nitrogen-containing substances are lower. The level of nitrogen-containing substances is closely related to the content of essential amino acids. The levels of some of the most important amino acids in soya extract meal and dehulled seeds are as follows: lysine - 31.50 g/kg (soya extract meal), 26.12 g/kg (dehulled, JUNO), 12.23 g/kg (dehulled, SONET), methionine - 7.2 g/kg (soya extract meal), 2.13 g/kg (dehulled, JUNO), 1.56 g/kg (dehulled, SONET), threonine - 20.10 g/kg (soya extract meal), 19.50 g/kg (dehulled, JUNO), 8.30 g/kg (dehulled, SONET), arginine - 37.50 g/kg (soya extract meal), 69.5 g/kg (dehulled, JUNO), 30.87 g/kg (dehulled, SONET). Analogous differences were detected for other amino acids. It follows from the results of our analyses that lysine and sulphur-containing amino acids, particularly methionine, are the most critical amino acids in lupin seeds, as concluded from the results of analyses reported by Gualtieri and Rapaccini (1990), and RothMaier and Kirchgessner (1993). Deficiencies in these amino acids can be corrected by supplementing feeding mixtures with synthetic amino acids, as reported by Perez-Alba et al. (1990).

The nutritional and dietetic value of lupin seeds, which increases as a result of dehulling is discussed by Smulikowska et al. (1995), Annison et al. (1996), Rubio et al. (1998), Gdala (1998), Rubio et al. (2003), and Mieczkowska et al. (2005). The spectrum of amino acids in lupin seeds (i. e. *Lupinus* genus) is characterised by a high content of arginine. This finding was also confirmed in our laboratory by the analysis of a large number of different lupin varieties. In this respect lupin seed can be considered as a significant source of this particular essential amino acid. The above-mentioned authors have reported that dehulling decreases the levels of non-starch saccharides, while the digestibility of both ileal dry matter and other nutrients present in feed, including the metabolised energy that can be utilised in poultry, increases. Yellow varieties of lupins, which also include the JUNO variety tested in our experiment, are particularly promising with regard to the nutrition of monogastric animals and particularly poultry because they have already been used in feeding mixtures for chickens, as reported by Teixiera and Dos (1995), Mieczkowska et al. (2005) and RothMaier and Paulicks (2003). The above-mentioned values of live weight were obtained from chickens having the following consumption of feed per kg of live weight gain on Day 40: 1.89 kg in the control group, 1.85 kg in Group E1 (JUNO) and 1.93 kg in Group E2 (SONET). Feed consumption per chicken at the above-mentioned feed conversion during the course of the experiment was as follows: 4.417 kg in the control group, 4.314 kg in the experimental group E1 (JUNO) and 4.401 kg in the experimental group E2 (SONET). The results of feed conversion and feed consumption are shown in Table 3. It follows from

Table 3. Feed consumption and feed conversion throughout the experiment

Day	Feed conversion (kg)				Feed consumption (kg)	
	Days 1 - 10	Days 1 - 20	Days 1 - 30	Days 1 - 40	broiler/40days	broiler/day
Control	1.61	1.53	1.69	1.89	4.417	0.110
Experiment E1 JUNO	1.62	1.54	1.69	1.85	4.314	0.108
Experiment E2 SONET	1.61	1.70	1.74	1.93	4.401	0.110

the results obtained that the lowest conversion and the lowest consumption of the respective feeding mixture in chickens was observed when soya extract meal was replaced with dehulled seed of the JUNO lupin variety. Although feed consumption in chickens in the experimental group E2 (SONET) for 40 days was lower (4.401 kg) than that in the control group (4.417 kg), feed conversion in this group was higher. In order to enhance the digestibility of nutrients, feeding mixtures were supplemented with the following enzymes: 3-phytase (EC 3.1.3.8), endo-1,4-beta-xylanase (EC 3.2.1.8) and endo-1,4-beta-glucanase (EC 3.2.1.4) by using the premix ZBCHS Vit. - SK. The importance of supplementing feeds based on lupin seeds with these enzymes is pointed out by Mieczkowska et al. (2004), Kocher et al. (2000), and by Gdala (1998). Although Antoniewicz et al. (1992) has found an enhanced availability of phosphorus in lupin seeds as compared with legumes such as field bean (*Vicia faba*), the use of phytase in feeding mixtures fed to broilers is substantiated.

Another positive finding of this experiment is that broilers in both experimental groups were in excellent health and showed no clinical symptoms of any disease. Zero mortality was found in experimental chickens during growth, and only one chicken died in the control group (0.80%). It is obvious that the excellent state of the broilers' health also reflects the ideal conditions in the experimental enclosure, which differ from the respective operational conditions in agricultural practice.

Testace dvou odrůd semen lupiny jako náhrady sojového extrahovaného šrotu ve vegetabilních dietách pro výkrm kuřat

Cílem experimentu bylo ověřit vhodnost použití dvou polských odrůd odslupkovaných semen lupin, nízkoproteinový SONET a vysokoproteinové JUNO jako vhodné proteinové komponenty do krmných směsí určených pro výkrm brojlerových kuřat, jako 50 % náhrady sojového extrahovaného šrotu. Výsledky experimentu dokládají, že vhodným ošetřením lupinového semene (odslupkováním) lze významně zvýšit jeho nutriční hodnotu. Odslupkováním lze získat produkt (jádro) s vyšším obsahem dusíkatých látek o 27 % ve srovnání se semenem, které lze použít jako vhodnou proteinovou komponentu do krmných směsí, určenou k výkrmu kuřat. Produkční účinnost, jak dokumentují výsledky experimentu, je dána použitou odrůdou lupiny. Vykrmovaná kuřata ve 40. dnu výkrmu u odrůdy JUNO (skupina P1) dosáhla živé hmotnosti 2,332 kg, srovnatelné s kuřaty kontrolní skupiny (K) 2.337 kg, na rozdíl od odrůdy SONET (skupina P2), u které dosáhla kuřata průkazně ($P \leq 0.05$) nižší průměrnou hmotnost 2,280 kg. Tuto průměrnou živou hmotnost dosáhla kuřata při spotřebě krmné směsi na 1 kg přírůstku živé hmotnosti 1,89 kg (K), 1.85 kg (P1) a 1.93 kg (P2). Výsledky potvrzují vhodnost náhrady sojového extrahovaného šrotu odslupkovanými semeny lupin. Při sestavování krmných směsí je však nutné znát přesně živinové složení použité odrůdy. Za významné z hlediska výživy lze považovat poznatek, že semena rodu *Lupinus* jsou významným zdrojem aminokyseliny argininu, která je v krmných směsích pro drůbež často deficitní.

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