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Effect of dehulled lupin seeds in feed mixture on muscle protein quality of broiler chickens

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Abstract: The aim of the study was to prepare and test the effect of diets with 50% and 100% replacement of soybean meal with dehulled seeds of white lupin (*Lupinus albus*) variety Zulika. Two hundred and forty ROSS 308 broiler chickens were divided into control group (C) and two experimental groups E_{50} (50% replacement of soybean meal with dehulled white lupin meal) and E_{100} (100% replacement of soybean meal with dehulled white lupin meal). The production parameters and the amino acid spectrum of breast and thigh muscles were evaluated up to 34 days of age. Final live weight of broiler chickens was not significantly affected by the substitution of soybean meal in starter, grower and finisher diets (C 2.3 ± 0.3 kg, E_{50} 2.4 ± 0.3 kg, E_{100} 2.4 ± 0.3 kg). Lupine meal-based diets positively influenced chicken health, which was reflected in a lower mortality rate in the experimental groups (E_{50} 5.0 %, E_{100} 2.5 %) compared to the control group (C 7.5 %). Differences in feed conversion were minimal (C 1.47 kg/kg, E_{50} 1.48 kg/kg, E_{100} 1.45 kg/kg). When evaluating the total amino acid content in the breast and thigh muscle of broiler chickens of the experimental groups (E_{50}, E_{100}), it can be noted that compared to the C group, the total contents of both essential and non-essential amino acids were significantly ($P \leq 0.05$) lower in the dry matter of thigh muscle.

Keywords: amino acids; muscle composition; ROSS 308; white lupine Zulika

The European Union's agricultural goal is currently to increase domestic production of plant protein and reduce dependence on imports. To achieve this, the long-term agricultural policy is needed to strengthen the European protein value chain, for example by growing legumes that fix atmospheric nitrogen and contribute to soil fertility in this way and last but not least reduce greenhouse gas emissions (Mathesius 2022). White lupin (*Lupinus albus*) seeds are an important source of amino acids (Mierlita et al. 2018). They can strengthen the self-sufficiency of the Czech Republic's protein

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feed base and reduce the amount of imported soya products for feed mixture production. It is possible to reduce fibre by dehulling the seeds which will increase not only the crude protein content but also its overall nutritional value (Strakova et al. 2021). White lupin seeds are recognised as a promising commodity for the feed industry.

The genus *Lupinus* includes more than 250 species. Low in alkaloids and high in crude protein are 'sweet' lupins which have been bred for use in nutrition (Panasiewicz 2022). This has stimulated renewed interest and lupin has become a source of protein in human and animal nutrition (Dijkstra et al. 2003). Crude protein is the most expensive item in poultry nutrition. Not only the amount of protein, but also the composition of amino acids is very important for proper nutrition, because protein and essential amino acids are essential for the growth of the organism (Hofmann et al. 2019). The high price of imported soy commodities, European inadequacy of its cultivation, as well as the issue of genetically modified crops which include most soy varieties (de Vos and Swanenburg 2018), increase the pressure on feed and food producers to use other sources of protein. White lupin varieties contain comparable amounts of crude protein to soybeans (Martinez-Villaluenga et al. 2006). For this reason, seeds of cultivated white lupin varieties are of interest as an alternative source of dietary protein in animal feed mixtures, e.g. for fattening pigs (Zraly et al. 2008; Kasprowicz-Potocka et al. 2016), rabbits (Volek et al. 2018) or broiler chickens (Suchy et al. 2006).

Attention is currently paid to the production of safe and functional feeds and foods (Carmona et al. 2019; Nowak et al. 2019). Viveros et al. (2007), Tufarelli et al. (2015) and Geigerova et al. (2017) assumed that dietary use of lupin meal may not only have a beneficial effect on performance indicators, poultry muscle quality, but also it may have health benefits for poultry. In Europe, two species, *Lupinus luteus* and *L. albus*, are mainly cultivated. In the Czech Republic, 5 varieties of lupin were registered and entered in the State Variety Book in 2020, where varieties such as Amiga, Dieta or Zulika have more versatile uses not only for the feed industry but also for the food industry.

Lupin seeds are among the natural sources of arginine, an amino acid that is a semi-essential amino acid for poultry and its synthetic form is not used in feed industry due to economic purposes. Martins et al. (2005) and Viveros et al. (2007) pointed to improvements in the health status of animals fed lupin seeds, manifested by lower mortality, improved vascular endothelial function and lower blood cholesterol levels. The seeds of some white lupin varieties are also an important source of n-3 PUFA (Zapletal et al. 2015) and also an important source of raffinose oligosaccharides, which show positive prebiotic effects on poultry health (Geigerova et al. 2017).

The aim of this study was to investigate the effect of partial (50%) or complete (100%) replacement of soybean meal with meal from dehulled seeds of white lupin cv. Zulika on the muscle quality of broiler chickens.

MATERIAL AND METHODS

Welfare statement

When calculating the number of individuals per unit area, the standard of 15 individuals/1 m^2 or 30 kg/1m^2 area was respected. The experiment was carried out in an accredited stable of the University of Veterinary Sciences Brno in accordance with current legislative rules and approved by the Ethics Committee of the Central Commission for Animal Welfare at the Ministry of Agriculture of the Czech Republic.

Broiler husbandry

Biological monitoring of ROSS 308 broiler chickens was carried out in the accredited stable of the University of Veterinary Sciences Brno. Fattening of chickens was done without sex differentiation, in each group there were 50% females and 50% males. Each experimental group consisted of 80 birds with two replicates and the fattening was carried out until the 34th day of chicken age. Three dietary groups of broilers were used in the experiment; control (C) group and two experimental groups E_{50} and E_{100} which involved 50% and 100% replacement of soybean meal with white lupin (Zulika variety) meal from dehulled seeds, respectively. The selection of suitable white lupin variety and the recommended percentage of replacement of soybean meal with lupin meal were based on the solution of the project NAZV MZe ČR QJ1510136. Complete feed mixtures were balanced and optimised including

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additives by a company producing commercial feed mixtures for poultry (ZZN Pelhřimov a.s., Pelhřimov, Czech Republic).

In broiler chickens, the light regime was 23 h of light and 1 h of darkness at the beginning of the fattening phase, and 18 h of light and 6 h of darkness during the growth phase. Commercially produced complete feed mixtures prepared according to utility model No. 31533U and drinking water were given to broilers *ad libitum* throughout the fattening period via tube feeders and drinkers. The following feed ingredients were used for the commercial preparation of complete feed mixtures: wheat, maize, lupin meal, soybean meal, oil, additives. Three-phase feeding program was used in the experiment: 1^{st}–13^{th} day of fattening was fed starter (BR1) in crushed form, 14^{th}–27^{th} day of fattening was fed grower (BR2) and 28^{th}–34^{th} day of fattening was fed finisher (BR3), both in pelleted form.

The detailed composition of the feed mixtures (including the percentage of each ingredient) is as follows: BR1 – wheat (C 45%, E_{50} 45%, E_{100} 41%), maize (C 15%, E_{50} 15%, E_{100} 15%), lupin meal (C 0%, E_{50} 6%, E_{100} 36%), soybean meal (C 30%, E_{50} 26%, E_{100} 0%); BR2 – wheat (C 50%, E_{50} 50%, E_{100} 48%), maize (C 13%, E_{50} 13%, E_{100} 13%), lupin meal (C 0%, E_{50} 17%, E_{100} 32%), soybean meal (C 28%, E_{50} 13%, E_{100} 0%); BR3 – wheat (C 59%, E_{50} 58%, E_{100} 54%), maize (C 10%, E_{50} 10%, E^{100} 10%), lupin meal (C 0%, E_{50} 15%, E_{100} 28%), soybean meal (C 22%, E_{50} 9%, E_{100} 0%).

Nutritional composition of white lupin and complete feed mixtures

For the accuracy of comparison, individual nutritional parameters were expressed in g per 1 kg of dry matter. Complete analyses were carried out after drying the sample; in the present study, only values for crude protein (CP) content are presented, whereas nitrogen was determined by the Kjeldahl method using the Buchi analyser (Centec automatika, spol. s.r.o., Praha, Czech Republic). As part of the analyses the sample was analysed for the content of amino acids (Asp, Thre, Ser, Glu, Pro, Gly, Ala, Val, Met, Ile, Leu, Tyr, Phe, His, Lys, Arg), after acid hydrolysis by an automatic amino acid analyser AAA 400 (INGOS a.s., Prague, Czech Republic) on the basis of the colour-forming reaction of amino acids with the oxidizing agent ninhydrin.

Production and muscle quality parameters

Feed conversion ratio, live weight and mortality of broilers were monitored during the experiment. From 20 selected broilers (selected according to the average slaughter weight) from each group (10 females and 10 males), the right breast and thigh muscles were sampled at the end of fattening (day 34). Subsequently, the drymatter of the muscle was determined for crude protein and amino acid composition. The analytical part of the work was carried out in the laboratory of the Faculty of Veterinary Hygiene and Ecology of the Univer sity of Veterinary Sciences Brno according to the procedure described for the analysis of complete feed mixtures.

Statistical methods

Unistat (v.5.6) for Excel was used for statistical analysis of the data. Evaluation of mean values and their differences was performed by multiple comparisons using the Tukey HSD test at asignificance level of $P \leq 0.05$. Each indicator is characterised by the value of the mean (x) and standard deviation (± SD).

RESULTS AND DISCUSSION

The average values of the nutrient content of seed with hull and dehulled seed of white lupin cv. Zulika are presented in Table 1. The feed mixtures were optimised on the basis of dehulled white lupin seed.

The optimisation of the feed mixtures based on dehulled lupin seeds affected the crude protein content, when the lower crude protein content in the experimental feed mixtures was probably related to the lower content of individual essential and non-essential amino acids. An increase in Met and Arg was observed in the lupin meal mixtures. For Met, the increase was mainly due to the addition of Met because as mentioned by Sujak et al. (2006) all lupin species are characterised by ashortage of methionine. In contrast, the increase in Arg can be directly linked to the content of lupin meal in the experimental diets, as lupin protein is characterised by a high content of this amino acid (Table 2).

Soybean meal did not significantly affect the live weight of broiler chickens. At the end of fattening

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Table 1. Crude protein and amino acid content of seed and dehulled seed of white lupin (*Lupinus albus*) variety Zulika in g/kg of dry matter, including the difference between seed and dehulled seed

Zulika	Seed	Dehulled seed	Difference
Crude protein	387	446	–58.2
Aspartic acid	40.2	76.5	–36.3
Threonine	12.7	15.0	–2.3
Serine	18.6	22.8	–4.2
Glutamic acid	81.2	99.2	–18.
Proline	20.8	19.6	1.2
Glycine	13.6	16.2	–2.6
Alanine	10.6	12.4	–1.8
Valine	14.6	17.2	–2.6
Methionine	0.20	0.70	–0.5
Isoleucine	12.4	19.6	–7.2
Leucine	26.1	32.8	–6.7
Tyrosine	17.0	21.4	–4.4
Phenylalanine	14.4	17.2	–2.8
Histidine	8.80	10.6	–1.8
Lysine	18.0	21.3	–3.3
Arginine	37.2	46.7	–9.5
Sum AA	346	449	–103

AA = amino acid

(day 34), the mean live weight of broiler chicks was 2.3 ± 0.3 kg (C), 2.4 ± 0.3 kg (E_{50}) and 2.4 ± 0.3 kg (E_{100}). Lupin diets had a positive effect on chick mortality during fattening, which was reflected by lower mortality in the experimental groups. Overall, mortality rate in fattened chickens was 7.5 % (C), 5.0 % (E_{50}) and 2.5 % (E_{100}). White lupins have only a negligible amount of starch (Nalle et al. 2012), but a high amount of soluble and insoluble non-starch polysaccharides and oligosaccharides (Annison et al. 1996). This improvement in health status is related to the oligosaccharide content of lupin seeds and the increased arginine content of lupin protein, which has a positive effect on the cardiovascular system of chickens, manifested by reduced mortality, especially in fast-growing broiler chickens. Similar results were found by Geigerova et al. (2017), who studied the chicken gastrointestinal microbiota composition. Feed conversion, i.e. feed consumption per 1 kg live weight gain of chickens, is a very important indicator that presents the production efficiency of the feed mixture. Differences in the feed conversion ratio between control group (1.47 kg/kg) and experimental groups (1.48 kg/kg and 1.45 kg/kg for E_{50} and E_{100}, resp.) were negligible. From these results, it can be concluded that there was no difference in the production efficiency of control and experimental diets. Similar results were reported by Teixeira and Dos (1995).

Regarding the basic nutritional parameters of muscle (dry matter and crude protein content – namely its quality, i.e. amino acid content), it is necessary to state that there are not any literature sources dealing with the effect of 50% and 100% replacement of soybean meal with white lupin seed meal on the nutritional value of breast and thigh muscle in broiler chickens. At present, scientific studies on broiler chickens are focused, for example, on the issue of possible feed restriction and the effect of grazing on carcass composition and meat quality in fast-growing chickens (Tumova et al. 2024) or effect of diets based on the house fly (*Musca domestica*) larvae extract on growth performance of broiler chickens (Park 2023). Another important area is the study of poultry rearing conditions leading to a reduction of myopathies and minimization of losses caused by this problem (Valenta et al. 2023).

The results presented in Table 3 show that in fattened chickens, there were no significant differences between control and experimental groups in the mean crude protein content of the breast muscle. Our results are consistent with the findings published by Olkowski (2018) and Tumova et al. (2022). They revealed a significant ($P \leq 0.05$) reduction in the crude protein content in the dry matter of the thigh muscle of fattened chickens (Table 3) in both experimental groups compared to the control. Olkowski (2018) did not recommend feeding a lupin meal-based diet to broiler chickens during the first 3 weeks of growth because lupin is not as nutritious as soybean. Kaczmarek et al. (2016) reported a growth depression in broilers fed the diets with >150 g/kg white lupins. A similar negative effect was also reported in turkey poults where there was a 6% reduction in the growth intensity when the diet containing 30% of lupin was fed (Halvorson et al. 1983).

From the results of the dry matter analysis of breast muscle for essential (Table 4) and non-essential amino acids (Table 5) in the present study, it can be concluded that the experimental diets did not have a statistically significant effect on the content of individual amino acids in breast

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Table 2. Changes in crude protein and amino acid content in g/kg of dry matter of BR1, BR2 and BR3 feed mixtures when replacing soybean meal with dehulled lupin seed meal, difference between feed mixtures C and E_{50} and C and E_{100}

Amino acid composition	Experimental feed mixture composition				
	C	E_{50}	Difference	E_{100}	Difference
BR 1					
Crude protein	247	237	10.4	243	3.9
Aspartic acid	23.8	23.6	0.2	23.4	0.4
Threonine	9.6	9.6	–0.04	9.6	–0.02
Serine	12.1	12.0	0.1	12.5	–0.4
Glutamic acid	41.1	40.8	0.3	40.7	0.4
Proline	17.8	15.8	2.0	15.6	2.2
Glycine	10.5	10.0	0.5	9.9	0.6
Alanine	11.5	10.1	1.4	8.7	2.8
Valine	11.6	11.6	0.0	10.5	1.1
Methionine	3.7	5.5	–1.8	5.4	–1.6
Isoleucine	10.9	10.6	0.3	10.4	0.5
Leucine	20.1	19.5	0.6	19.3	0.8
Tyrosine	10.3	10.4	–0.1	11.1	–0.8
Phenylalanine	12.9	12.1	0.8	10.3	2.6
Histidine	7.0	5.7	1.3	4.5	2.5
Lysine	16.6	16.7	–0.1	17.5	–0.9
Arginine	19.4	20.6	–1.2	26.0	–6.6
BR 2					
Crude protein	217	211	6.5	204	13.0
Aspartic acid	20.8	20.2	0.6	18.6	2.2
Threonine	9.0	8.6	0.4	8.3	0.6
Serine	11.1	10.7	0.4	10.1	1.0
Glutamic acid	40.7	40.7	0.0	40.5	0.2
Proline	17.4	14.8	2.6	12.9	4.5
Glycine	9.3	8.7	0.6	7.9	1.4
Alanine	10.1	8.8	1.3	6.5	3.7
Valine	10.5	9.5	1.0	8.5	2.1
Methionine	3.0	4.9	–1.9	5.2	–2.2
Isoleucine	9.4	7.8	1.6	8.2	1.2
Leucine	17.7	13.7	4.0	14.5	3.2
Tyrosine	7.9	7.7	0.2	6.7	1.3
Phenylalanine	11.6	8.5	3.1	6.5	5.2
Histidine	6.4	5.9	0.5	5.3	1.0
Lysine	15.1	14.6	0.5	14.4	0.7
Arginine	17.1	20.2	–3.1	21.1	–4.0
BR 3					
Crude protein	200	183	16.7	192	8.6
Aspartic acid	18.3	17.8	0.5	17.1	1.2
Threonine	8.2	8.3	–0.2	7.6	0.5
Serine	10.1	8.9	1.2	9.7	0.4
Glutamic acid	43.9	39.7	4.2	40.9	3.0
Proline	17.1	11.9	5.2	13.8	3.3
Glycine	8.3	7.6	0.6	7.4	0.9

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???	C	E_{50}	Difference	E_{100}	Difference
Alanine	7.7	7.2	0.5	6.2	1.5
Valine	9.9	8.0	1.9	8.2	1.7
Methionine	2.6	4.0	–1.4	4.6	–2.0
Isoleucine	8.8	7.4	1.4	7.7	1.1
Leucine	11.0	13.2	–2.2	13.8	–2.8
Tyrosine	4.1	5.4	–1.3	6.3	–2.1
Phenylalanine	7.0	6.1	1.0	4.8	2.2
Histidine	5.6	4.9	0.7	5.2	0.5
Lysine	13.4	12.6	0.8	12.9	0.5
Arginine	15.4	17.1	–1.7	19.7	–4.3

C = control; BR1 = starter; BR2 = grower; BR3 = finisher; E_{50} = 50% replacement of soybean meal with dehulled lupin seed meal; E_{100} = 100% replacement of soybean meal with dehulled lupin seed meal

Table 3. Mean values of dry matter (DM) and crude protein (CP) in the breast and thigh muscle of broiler chickens in g/kg of dry matter; n = 20

Variable	Group	Breast muscle	Thigh muscle
	C	250 ± 8.8	277 ± 8.9
DM	E_{50}	251 ± 10.2	286^{b} ± 11.3
	E_{100}	257 ± 7.4	297^{a} ± 14.2
	C	830 ± 25.0	722^{a} ± 28.4
CP	E_{50}	817 ± 51.8	691^{b} ± 48.8
	E_{100}	813 ± 42.3	666^{b} ± 25.6

[a,b]Means with a common letter are significantly different at $P \leq 0.05$

C = control; E_{50} = 50% replacement of soybean meal with dehulled lupin seed meal; E_{100} = 100% replacement of soybean meal with dehulled lupin seed meal

muscle, in contrast to the dry matter of thigh muscle, where the lower content ($P \leq 0.05$) of amino acids was observed in both experimental groups compared to the control group (Tables 4 and 5). Lys was the most abundant essential amino acid in the dry matter of breast and thigh muscle while Met was the least abundant amino acid, irrespective of whether the muscle was from control or experimental groups of chickens.

When evaluating the total amino acid content in the present study, it can be noted that the essential, non-essential and total amino acid content (Table 6) in the dry matter of breast muscle was lower ($P \leq 0.05$) in both experimental groups compared to the control group. In the dry matter of thigh muscle, the differences in the essential, non-essential and total amino acid content were mostly significantly ($P \leq 0.05$) lower in experimental groups as compared to the control group.

Table 4. Mean values of essential amino acids in the breast and thigh muscle of broiler chickens in g/kg of dry matter

Variable	Group	Breast muscle	Thigh muscle
	C	36.8 ± 2.5	34.2^{a} ± 3.3
Threonine	E_{50}	36.9 ± 1.9	29.0^{b} ± 3.3
	E_{100}	36.3 ± 2.0	27.6^{b} ± 3.6
	C	42.3 ± 3.4	38.4^{a} ± 4.0
Valine	E_{50}	41.5 ± 4.1	33.6^{b} ± 3.1
	E_{100}	43.8 ± 2.6	32.5^{b} ± 3.2
	C	22.2 ± 2.5	20.2^{a} ± 2.4
Methionine	E_{50}	23.4 ± 2.2	17.3^{b} ± 2.1
	E_{100}	23.7 ± 4.6	17.0^{b} ± 3.0
	C	40.0 ± 2.5	36.7^{a} ± 3.8
Isoleucine	E_{50}	40.5 ± 1.9	31.7^{b} ± 2.3
	E_{100}	40.3 ± 2.7	31.7^{b} ± 3.2
	C	64.9 ± 8.6	61.2^{a} ± 6.7
Leucine	E_{50}	64.1 ± 9.6	54.0^{b} ± 6.1
	E_{100}	67.2 ± 3.7	51.3^{b} ± 5.0
	C	32.3^{b} ± 4.7	31.4^{a} ± 3.7
Phenylalanine	E_{50}	34.7^{a} ± 1.8	30.3^{b} ± 12.0
	E_{100}	34.2 ± 1.8	26.0^{b} ± 2.7
	C	49.6^{a} ± 22.0	53.1^{a} ± 23.5
Histidine	E_{50}	41.4 ± 7.9	27.4^{b} ± 8.8
	E_{100}	33.0^{b} ± 9.4	23.8^{b} ± 8.4
	C	83.0 ± 4.6	75.2^{a} ± 8.5
Lysine	E_{50}	84.9 ± 6.2	63.6^{b} ± 7.7
	E_{100}	81.7 ± 13.2	63.7^{b} ± 5.7
	C	62.8 ± 4.2	59.8^{a} ± 4.6
Arginine	E_{50}	62.0 ± 8.6	52.5^{b} ± 4.7
	E_{100}	65.7 ± 7.8	49.7^{b} ± 9.4

[a,b]Means with a common letter are significantly different at $P \leq 0.05$

C = control; E_{50} = 50% replacement of soybean meal with dehulled lupin seed meal; E_{100} = 100% replacement of soybean meal with dehulled lupin seed meal

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Table 5. Mean values of non-essential amino acids in the breast and thigh muscle of broiler chickens in g/kg of dry matter; n = 20

Variable	Group	Breast muscle	Thigh muscle
	C	75.8 ± 4.6	70.7^{a} ± 6.5
Aspartic acid	E_{50}	76.6 ± 4.6	61.1^{b} ± 5.7
	E_{100}	77.5 ± 4.2	60.0^{b} ± 2.9
	C	31.7 ± 2.5	30.1^{a} ± 2.4
Serine	E_{50}	31.9 ± 2.0	26.4^{b} ± 2.4
	E_{100}	32.7 ± 1.8	28.1 ± 7.4
	C	116 ± 8.3	111^{a} ± 8.0
Glutamic acid	E_{50}	117 ± 8.2	101^{b} ± 11.1
	E_{100}	116 ± 8.9	95.4^{b} ± 9.3
	C	36.3 ± 4.9	36.0 ± 4.8
Proline	E_{50}	37.2 ± 2.2	34.5 ± 2.6
	E_{100}	39.9 ± 11.7	35.0 ± 1.8
	C	36.7 ± 2.7	37.9 ± 3.1
Glycine	E_{50}	36.8 ± 2.2	37.6 ± 2.7
	E_{100}	36.5 ± 1.9	36.7 ± 2.6
	C	50.5^{a} ± 4.2	47.8^{a} ± 3.5
Alanine	E_{50}	34.9^{bd} ± 4.7	32.1^{b} ± 6.3
	E_{100}	41.4^{bc} ± 7.9	36.0^{b} ± 5.2
	C	39.2 ± 4.4	34.4^{a} ± 3.7
Tyrosine	E_{50}	37.2 ± 2.7	26.9^{b} ± 2.6
	E_{100}	40.1 ± 5.4	28.5^{b} ± 2.5

$^{a–d}$Means with a letter are significantly different at $P \leq 0.05$
C = control; E_{50} = 50% replacement of soybean meal with dehulled lupin seed meal; E_{100} = 100% replacement of soybean meal with dehulled lupin seed meal

Table 6. Mean values of essential (Σ eAA), non-essential (Σ nAA) and total amino acids (Σ AA) in the breast and thigh muscle of broiler chickens in g/kg of dry matter; n = 20

Variable	Group	Breast muscle	Thigh muscle
	C	433 ± 32.9	410^{a} ± 17.9
Σ eAA	E_{50}	429 ± 24.9	339^{b} ± 30.1
	E_{100}	426 ± 21.1	323^{b} ± 17.5
	C	387 ± 22.8	368^{a} ± 20.9
Σ nAA	E_{50}	372 ± 18.6	320^{b} ± 26.6
	E_{100}	384 ± 23.9	320^{b} ± 14.5
	C	821 ± 53.0	778^{a} ± 34.8
Σ AA	E_{50}	801 ± 41.4	659^{b} ± 54.5
	E_{100}	810 ± 38.5	643^{b} ± 30.5

^{a,b}Means with a letter are significantly different at $P \leq 0.05$
C = control; E_{50} = 50% replacement of soybean meal with dehulled lupin seed meal; E_{100} = 100% replacement of soybean meal with dehulled lupin seed meal

CONCLUSION

It is evident from the results that in the feed mixture intended for the fattening of broiler chickens, 50% or 100% of soybean meal can be replaced by the meal from dehulled lupin seeds. Dehulling of seeds can provide a product with an increased crude protein content compared to whole seeds. The substitution affected the nutrient composition of the feed mixtures, which was reflected in a slightly reduced content of crude protein and individual amino acids (except arginine), when the optimised lupin meal-based feed mixtures did not have a negative effect on the performance of broiler chickens. Compared to the control group, lower mortality and negligible differences in feed conversion were observed in experimental groups. However, the administration of lupin meal-based diets resulted in a reduction in the content of most essential and non-essential amino acids in thigh muscle dry matter. Feed mixtures with a slight decrease in crude protein and amino acids may have a preventive effect and reduce the sudden mortality of broiler chickens, which is usually associated with high growth intensity of broiler chickens, when the live weight of broiler chickens is already increasing non-physiologically in the last phase of intensive fattening, in the present study realised by 32–35 days of age. Higher arginine content and the antioxidant and prebiotic effect of lupin meal have a very positive effect on the health status of broiler chickens, which was reflected in a significant reduction in mortality in groups of broiler chickens where the feed mixtures were formulated on the basis of lupin meal. In order to properly optimise complete feed mixtures for monogastric animals, it is necessary to respect the type of white lupin variety and its nutritional value due to some variability of nutrients between white lupin varieties. On the basis of the results, a 50% replacement of extracted soybean meal by dehulled white lupin meal of the Zulika variety is recommended, which provides a better optimisation in the formulation of feed mixture recipes due to the combination of the two protein components. The energy saving can also be beneficial to agricultural practice, because it is not necessary to subject the lupin meal to heat treatment to deactivate the antinutritional substances, as it is done with soybean meal. Another benefit, particularly for Europe, is that white lupin is not genetically modified.

Conflict of interest

The authors declare no conflict of interest.

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