Potravinarstvo Slovak Journal of Food Sciences

Slovak Journal of Food Sciences

Potravinarstvo Slovak Journal of Food Sciences
vol. 15, 2021, p. 40-51
https://doi.org/10.5219/1451
Received: 7 September 2020. Accepted: 22 December 2020.
Available online: 28 January 2021 at www.potravinarstvo.com

ISSN 1337-0960 (online)

THE POSSIBILITY OF IMPROVING MEAT QUALITY BY USING PEAS AND FABA BEANS IN FEED FOR BROILER CHICKENS

Liga Proskina, Sallija Cerina, Anda Valdovska, Irina Pilvere, Vilija Alekneviciene

ABSTRACT
The price-to-quality ratio of broiler chicken meat is one of the reasons why consumers use these products in their daily diet. The quality of poultry products such as meat is closely associated with the nutritional value and quality of feed fed to broilers. In composing broiler diets, the main focus is turned on crude protein (CP). Because of the trend for the poultry industry to reduce its dependence on soybean meal as a source of protein, the role of pulses in the supply of protein and energy, which could partly replace the soybean meal in poultry diets, increases. Due to considerable progress in plant breeding, the present research study used peas (*Pisum sativum*) of the var. 'Bruno' and var. 'Pinochio' as well as faba beans (*Vicia faba minora*) of the var. 'Lielplatone' was developed in Latvia. Higher protein diets induce a higher meat protein content, accordingly, feed proteins are hydrolyzed in the digestive system into amino acids (AA) that, after absorption, are used to form proteins and to build different body tissues. The most important AA was twofold lower in peas and faba beans than in soybean meal. Although the amount of AA in feed is not directly proportional to the content of AA in broiler chicken meat, the amount of AA in poultry feed can significantly affect an important meat quality criterion for consumers – the nutritional value of protein. Therefore, the research aimed to identify changes in AA composition and chemical composition – a qualitative property of poultry meat – as a result of adding pulses (peas and beans) to poultry diets. The research results showed that the diets with an addition of faba beans and peas had a positive effect on the level of essential amino acids (EAA) and non-essential amino acids (NEAA) in broiler meat, decreased cholesterol concentration in meat, and increased energy value of meat.

Keywords: faba beans; peas; broiler nutrition; meat quality

INTRODUCTION
In recent decades, poultry consumption tended to increase in most of the world, which could relate to the growing consumer interest and belief that white meat is better and healthier than red meat. According to research studies on consumer buying habits **(Kaygisiz, Bolat and Bulut, 2019; Xazela et al., 2017)**, the price and quality of broiler chicken meat are one of the reasons why consumers use these products in their daily diet. From a nutritional aspect, poultry meat is a valuable source of proteins, vitamins, and minerals, and has a relatively low-fat content. The chemical composition of muscle tissue is an important element of broiler meat quality **(Grashorn, 2005)**.

The set of properties that defines consumer perception of meat quality has expanded to include extrinsic factors, such as animal welfare, the sustainability of production and meat concerning human health, as well as a combination of muscle, fat, and moisture, the nutritional value of meat compositional analysis such as AA **(Purslow, 2017)**. Quality is defined as the usefulness of a good or service for consumption **(Juran and Godfrey, 1998)**; therefore, one can assert that the quality of food plays a great role in food purchases. However, the importance of consumer subjective views regarding product choices should be emphasized as well. The organoleptic characteristics of a food (e.g. color, taste, consistency) is what each consumer perceives individually; therefore, they could be regarded as subjective assessment criteria that depend on the individual perception of each consumer **(Mulvey, 2008)**. Consumers' expanded perception of food quality encompasses more than just organoleptic or other food characteristics. For consumers, the quality of food is the desired characteristics of the food that could justify the value-added of the food: e.g. the type of food production (organic or conventional), the environmental impact of food production, feed components used in production (protein sources, phytonutrients), functional properties of food (a low cholesterol level and fat content, a balanced amount of AA), etc. **(Yamada et al., 2008)**.

Food quality is strongly linked to the functional properties of the food and the health of individuals. From the standpoint of consumer interests, broilers should have not only high slaughter yields and desirable carcass conformation scores but also good aesthetic, sensory, and nutritional characteristics. This means that food should also contain biologically active principles making beneficial effects on the functions of the human body, contribute to the maintenance of health and reduce the risk factors for various diseases **(Maggini, Pierre and Calder, 2018)**. Under the presence of functional ingredients in various types of food, consumers are allowed to fully balance their diet and have vitamins, minerals, proteins, etc. **(Holban and Grumezescu, 2018)**. **Röhr et al. (2005)** point out that consumers are ready to pay a higher price if it is guaranteed that the producer supplies are safe and quality products. A similar finding was made by **Nagyová et al. (2019)**, indicating that 84% of respondents bought high-quality food and 60% bought it for health reasons.

The nutritional value of protein is determined by essential AA, while the composition, amount, and ratio of desired AA in products vary; therefore, more attention should be paid to the biological value of protein in food, as the spectrum and amount of AA are important for the health of the human body. **Kim, Do and Chung (2017)** point out that broiler meat is an excellent source of protein not only because of the quantity of the protein (20%) but also because of the quality of it – more than 40% of AA are essential ones.

It should be stressed that the quality of poultry products such as meat is closely associated with the nutritional value and quality of feed fed to broilers. Nutrition can have a crucial effect on the chemical composition of broiler meat. Broilers have high dietary protein requirements, due to the importance of protein as a major constituent of the biologically active compounds in the body, assistance of proteins in the synthesis of body tissues, and growth of the body. Furthermore, proteins are forming enzymes and hormones, which play important roles in the physiology of any living organism **(Beski, Swick and Iji, 2015)**. The enrichment of poultry meat with substances beneficial to human health has been studied for several decades **(Grashorn, 2005; Swaggerty et al., 2020; Selle et al., 2020)**. Each of the nutrients added to poultry feed causes a specific effect: they are biological and chemical substances that, when added to feed rations for broilers, are transformed by metabolic processes in the birds body and contribute to the digestion of feed, the growth, and development of the organism while at the same time producing higher quality products and achieving higher production efficiency. Positive effects are achieved both by improving food conversion and increasing the vitality of birds, stimulating their immune system, regulating the microflora of their digestive system, etc., as a result of which the quality of meat is enhanced.

In composing broiler diets, the main focus is turned on crude protein (CP) because the protein is the critical constituent of poultry diets together with the other nutrients **(Cheeke, 2005)**. One of the factors that can have a highly variable effect on the chemical composition and quality of poultry meat includes different protein and energy values of formulated feed rations. Higher protein diets induce a higher meat protein content, while reducing the fat content of the muscles. Feed proteins are hydrolyzed in the digestive system into AA that, after absorption, are used to form proteins and to build different body tissues **(Beski, Swick and Iji, 2015)**.

The level of protein in broiler feed on poultry farms in Latvia is mainly provided by imported feed materials containing CP – soybean meal (SBM) and sunflower products, cornflour, etc. –, which are mostly imported feed protein sources. **Regulation (EC) No 178/2002** lays down rules on the production, labeling, traceability, and control of feed that have been developed at the EU level, which are incorporated into the Member States' legislation. However, imported protein crops produced outside the EU are not subject to the same environmental, health, and GMO regulatory restrictions as EU-produced products, thereby affecting the quality of livestock products as well. In the world market, however, the prices of protein-rich feedstuffs continue rising **(Indexmundi, 2017)**, thereby significantly affecting the total price of feed and, consequently, the cost of livestock products. There is a trend for the poultry industry to reduce its dependence on soybean meal as a source of protein and replace it with sustainable alternatives. Consequently, interest in using grain legumes such as faba beans (*Vicia faba*) and peas (*Pisum sativum*) as alternatives to conventional protein sources has been increasing **(Nalle, Ravindran and Ravindran, 2010; Stagnari et al., 2017)**. Beans and peas play an increasingly important role in animal feed owing to their high-quality protein. Pulses can provide a diet rich in protein and AA. Research studies done in Latvia have revealed that the total amount of AA in domestically grown peas varies from 202.4 $g.kg^{-1}$ to 248.9 $g.kg^{-1}$, while in beans from 235.7 $g.kg^{-1}$ to 267.9 $g.kg^{-1}$; the amount of essential AA in peas was in the range of 67.6 – 74.2 $g.kg^{-1}$, while in beans in the range of 79.3 – 86.9 $g.kg^{-1}$ **(EUROLEGUME, 2018)**.

The amount of AA in feed is not directly proportional to the content of AA in broiler chicken meat because of a certain AA conversion rate from feed to meat in the bird organism. Nevertheless, the amount/level of AA in poultry feed can significantly affect a meat quality criterion – the nutritional value of protein – and can enhance the level of AA **(Temesgen, Retta and Tesfaye, 2018)**. Therefore, the research aimed to identify changes in AA composition – a qualitative property of poultry meat – as a result of adding pulses (peas and beans) to poultry diets.

Scientific hypothesis

The quality properties (amino acids and chemical composition) of meat that are important for consumers could be enhanced by including pulses (peas and faba beans) in broiler diets.

MATERIAL AND METHODOLOGY

Management and birds

A feeding experiment was done on cross Ross 308 broiler chickens (n = 240). The stocking density complied with the rules of **Council Directive 2007/43/EC**; the max live weight density was 33 kg per m^2 or 12 chicks per m^2. The broilers were placed on the floor and sawdust was used for their bedding; the broilers were provided free access to feed and water. In the first week, the temperature in the poultry building was set at 31 °C; from the second week, the temperature was gradually reduced to 28 °C, and from the fourth week onwards, the temperature was set at 22 °C. The fattening period was 42 days and divided into three stages: from 1 – 10 days (starter), 11 – 26 days (grower) and

27 – 42 days (finisher), following the standards for the cross Ross 308 **(Aviagen, 2018)**. Additions of faba beans and peas were included in the feed of experimental groups only at the grower and finisher stages. On day 10, the broiler chickens (n = 240) having a similar body weight (BW) 276.00 ±23.2 g standard deviation (SD) were divided into 8 groups, and the experiment had two replications per treatment for each group (n = 30).

Dietary treatments

During the starter period, all the groups of broiler chickens were fed the same diet: wheat – 635.80 g.kg^{-1}; soybean meal (SBM) – 255.60 g.kg^{-1}; sunflower – 6.00 g.kg^{-1}; rapeseed cake – 13.00 g.kg^{-1}; technological, nutritional, physiological and zootechnical additives 89.60 g.kg^{-1}. The starter feed contained 24.93% of dry matter (DM) CP, 3.27% of DM crude fat, 2.16% of DM crude fiber, 5.70% of DM crude ash, 0.88% of DM calcium (Ca), 0.68% of DM phosphorus (P), 2980 kcal.kg^{-1} metabolizable energy (ME), – 1.00% of DM lysine (Lys), 0.40% of DM methionine (Met) and 0.31% of DM cysteine (Cys).

From the 11th day of the experiment, the diets were as follows: for the control group (C) – the basal diet (control, without peas and faba beans); for the seven experimental groups (group PB200 to group PB100 + FBL150) – the basal diet with SBM was partially replaced with different amounts of peas and faba beans. The peas 'Bruno' (PB) developed by the Institute of Agricultural Resources and Economics as well as the peas 'Pinochio' (PP) and the faba beans 'Lielplatone' (FBL) grown in Latvia were tested in the feeding experiment (Table 1). Crude protein contents in the pulses (dry matter) were as follows: PB – 300.00 ±23.62 g.kg^{-1}, PP – 284.26 ±61.54 g.kg^{-1}, FBL – 330.71 ±41.11 g.kg^{-1}, while in SBM it was 587.95 g.kg^{-1}. The pea and bean varieties studied contained equivalent amounts of crude fat, crude fiber, crude ash, calcium, and phosphorus. As is known from the results of the previous researches, the amount of pea and faba beans in broiler diets is limited due to the tannins they contain, which are anti-nutritive compounds and affect the nutritional flavor as well as the digestive system of the birds, thus limiting the number of peas and beans the amount of feed **(Crépon, 2006)**. This indicates that peas and beans cannot completely replace SBM in poultry feed not only because of antinutritional factors but also of their lower crude protein contents.

The feed mixtures for broilers were granulated appropriate for the grower and finisher stage 2.5 – 4.0 mm diameter, 4.0 – 8.0 mm in length, reaching a temperature of up to 84 °C during the granulation process. The granulation process did not significantly affect the chemical composition of peas and beans, even though the proportion of soluble protein increased by 0.61% and that of undegradable intake protein decreased by 5.97% in the total crude protein content of peas during the granulation process, compared with the non-granulated peas. Such a change in crude protein components may contribute to the digestibility and absorption of crude protein of peas in the bird organism.

The AA contents of peas, faba beans and SBM are reported in Table 2. The Lys content in peas was in the range of 1.40 – 1.50%, 1.71% in faba beans, and 2.80% in SBM, while the amount of Met in SBM was threefold higher than that in the peas and beans (Table 2). The amounts of other essential AA in peas and beans were also about twofold lower than that in SBM. This means that the amounts of AA most important for metabolism in the broiler organism were significantly lower in peas and faba beans than in SBM.

The EAA content of PB and PP was in the range of 8.70 – 9.38%, and 11.99% in FBL. SBM had an EAA content of 20.52%. This means that SBM had a higher EAA content than peas and faba beans by 11.14 – 11.82% and 8.53%, respectively. The NEAA content in pea protein was in the range of 8.16 – 9.62%, in faba bean protein – 11.57%, but 21.62% in SBM protein. This means that the NEAA content of SBM protein was 11.98 – 13.44% higher than that of pea protein and 10.03% higher than that of faba bean protein (Table 2).

The grower stage feed contained 23.63 – 25.64% of DM CP, while the finisher stage feed had a CP content of 22.01 – 24.48% of DM. At the grower stage, the 8th group was fed a lower CP content diet (0.8% lower than that for the C group) that contained a mixture of 150 g.kg^{-1} FBL and 100 g.kg^{-1} PB. However, at the finisher stage, such a mixture of 150 g.kg^{-1} FBL and 100 g.kg^{-1} PB in the diet had a lower CP content (by 2.47%), compared with the diet for the C group; however, the CP content in the diets for the experimental groups, compared with that for the C group, was not significantly different (p >0.05) at both feeding stages (Table 3). Using SBM, PB, PP, and FBL, for the experimental groups, a ME of 750 – 1196 kcal.kg^{-1} was provided at the grower stage and 664 – 1158 kcal.kg^{-1} at the finisher stage, exceeding the ME provided for the C group by 94 – 494 kcal.kg^{-1}, which might be explained by a 4 – 5 times higher ST content of peas and faba bean, compared with that of SBM. Such a difference in the CP content could not negatively affect the live weight of broilers at the selling age, compared with the C group. The contents of crude fat, crude ash, fiber, Ca and P in the broiler diets were equal for all the groups.

Chemical analysis

A test of the feed, peas, and faba beans were performed to calculate a precise feed ratio for the relevant period. During the experiment, feed tests for all the groups were performed on the 1st day, 10th day, and 27th day. At the final stage of the experiment (on day 42 of rearing), 10 birds from each group were slaughtered and dissected.

The biochemical analyses of feed and broiler breast samples were carried out at the Latvia University of Life Sciences and Technologies (LLU) Research Laboratory of Biotechnology **(LATAK, 1999)**. 100 g of each experimental diet was collected and sent for analysis.

Dry matter, crude protein, and ash were analyzed in the diets according to the method AOAC **(Herlich, 1990)**. The samples of meat were analyzed for DM **(ISO 6496, 1999)**, CP **(ISO 5983-2, 2009)**, crude fat **(ISO 6492, 1999)**, crude ash **(ISO 5984, 2002/COR 1:2005)**, P **(ISO 6491, 1998)**, yet the cholesterol level was determined using the method described by **Sperry and Webb (1950)**. AA contents in feed and meat were determined by FTIR spectroscopy.

A chemical score (C_S) for broiler breast meat was calculated for each AA using the following formula:

$$C_s = A_x / A_s \qquad (1)$$

where A_x is the content of an AA in the investigated protein (%) and as is the content of an AA in the standard protein (the same whole egg protein) **(Alfaig et al., 2014)**.

An AA score was determined by comparing the essential amino acid (EAA) contents of the samples to the AA contents suggested for humans **(Straková et al., 2009)**. The AA content recommended for children aged 2 – 5 years is used to calculate an AA score of the samples (Table 7) **(WHO, 1985; Straková et al., 2009)**. The essential AA index (EAAI) is a geometrical average of CS values **(Písaříková, Kráčmar and Herzig, 2005; Straková et al., 2009)**.

A biological value (B_y) for the experimental food materials was calculated from the EAAI using Oser's method **(Oser, 1959)** as follows:

$$B_y = 1.09 \times (\text{EAAI}) - 11.7 \qquad (2)$$

Statistical analysis

Statistical analyses were performed with SPSS for Windows version 20.0 statistical software package. The dietary energy and other variables were compared statistically by ANOVA. Statistical significance was calculated using a t-test. Differences between the control and experimental groups were considered significant at $p \leq 0.05$. Data were reported as mean ± SD.

RESULTS AND DISCUSSION

Any broiler diet has to have such EAA as Lys and Met. The Met content of peas was in the range of 0.20 – 0.22%, while that of faba beans was 0.21%; the Met content of SBM was higher – 0.61%. However, no significant difference in Met content between the feed mixtures for the experimental and control groups was identified (Table 4).

The AA content (g.kg^{-1} DM) in the experimental diets varied. The Cys content was significantly higher in diets PB200, PP200, but significantly lower in diets PB300 and PB100 + FBL100 at the grower stage. The Cys contents were similar for all the experimental groups at the finisher stage. The Lys content was significantly higher in diets PP300 and PB100 + FBL150 at both feeding stages. The analysis of AA composition (% of DM) in the C and experimental diets is presented in Table 4.

The highest values in the EAA group among the finisher feeds were recorded for Arg (0.96% of DM) and Leu (1.01% of DM), but the lowest value – Cys (0.3% of DM). In the non-essential AA group, Gln was found to be the most abundant (3.26% of DM), but Tyr had the lowest value (0.43% of DM). They were followed by His in diets PP200 (0.34% of DM) and PB300 (0.32% of DM), with the lowest values recorded for diets FBL100 and PB100 + FBL100 (0.29% of DM) (Table 4).

In total, the significantly higher average EAA levels (6.04, 6.44 and 6.28% of DM) and TAA amounts (12.8, 13.15 and 13.02% of DM) were recorded in experimental finisher stage diets PP200, PB300 and PB100 + FBL150, respectively, but the lowest – in the basal diet (Table 4).

Biochemical composition of broiler meat

The effect of various protein diets on meat quality parameters is shown in Table 5. The CP content was significantly (p <0.05) higher in breast meat of broilers fed diets FBL100 and PB100 + FBL100 (21.34 and 21.4% respectively), compared with the C group.

Increased fat content was found in broilers from the C group (1.85% of DM) and diet PB300 (1.84% of DM), but a significant decrease was observed in the broilers from groups PP300 and PB100 + FBL100. No significant difference in the crude ash content was recorded among the treatments (p >0.05).

There was a significant reduction (p <0.05) in the cholesterol concentration of broiler breast meat from the broilers fed diet PP200 supplemented with 200 g.kg^{-1} PP (110.5 mg.100g^{-1}) and FBL100 – with 100 g.kg^{-1} FBL (110.6 mg.100g^{-1}). In general, cholesterol concentration in meat decreased in all the experimental groups (except PB300) in comparison with the C group (Table 5).

Table 1 Feed ingredient composition of the basal and experimental diets.

Items	C	PB200	PP200	PB300	PP300	FBL100	PB100 + FBL100	PB100 + FBL150
Grower stage (11th – 26th day)								
SBM, g	227	122	124	70	73	164	112	80
PB, g	-	200	-	300	-	-	100	100
PP, g	-	-	200	-	300	-	-	-
FBL, g	-	-	-	-	-	100	100	150
Sunflower, g	150	150	150	150	150	150	150	150
Rapeseed cake, g	150	150	150	150	150	150	150	150
Wheat, g	649	649	649	649	649	649	649	649
Finisher stage (27th – 42nd day)								
SBM, g	201	106	108	58	61	144	96	67
PB, g	-	200	-	300	-	-	100	100
PP, g	-	-	200	-	300	-	-	-
FBL, g	-	-	-	-	-	100	100	150
Sunflower, g	50	50	50	50	50	50	50	50
Rapeseed cake, g	200	200	200	200	200	200	200	200
Wheat, g	698	698	698	698	698	698	698	698

Note: C – Control group; from PB 200 to PB100 + FBL 150 the experimental broiler groups; SBM – soybean meal, PB – peas 'Bruno', PP – peas 'Pinochio', FBL – faba beans 'Lielplatone`.

Table 2 Amino acid contents of peas, faba beans and soybean meal (% DM).

Items	PB	PP	FBL	SBM
Met	0.22 ±0.01	0.20 ±0.01	0.21 ±0.23	0.61 ±0.20
Cys	0.30 ±0.03	0.28 ±0.04	0.33 ±0.22	0.68 ±0.19
Lys	1.50 ±0.16	1.40 ±0.22	1.71 ±0.74	2.80 ±0.64
Thr	0.77 ±0.12	0.76 ±0.15	0.97 ±0.56	1.82 ±0.50
Arg	1.78 ±0.48	1.66 ±0.62	2.54 ±0.84	3.34 ±0.78
Ile	0.85 ±0.18	0.80 ±0.24	1.14 ±0.67	2.10 ±0.14
Leu	1.47 ±0.39	1.35 ±0.49	2.05 ±1.07	3.45 ±0.86
Val	0.95 ±0.17	0.90 ±0.22	1.21 ±0.68	2.21 ±0.61
His	0.50 ±0.15	0.40 ±0.21	0.69 ±0.41	1.20 ±0.11
Phe	1.04 ±0.10	0.95 ±0.13	1.14 ±0.74	2.32 ±0.14
Total EAA	9.38 ±1.74	8.70 ±2.33	11.99 ±0.61	20.52 ±2.54
Tyr	0.64 ±0.14	0.56 ±0.20	0.84 ±0.55	1.63 ±0.49
Gly	0.90 ±0.18	0.83 ±0.24	1.17 ±0.09	2.00 ±0.54
Ser	1.01 ±0.13	0.97 ±0.18	1.22 ±0.07	2.37 ±0.66
Ala	0.92 ±0.12	0.88 ±0.16	1.10 ±0.6	2.06 ±0.45
Asp	2.40 ±0.25	2.36 ±0.33	2.82 ±0.21	5.27 ±1.39
Glu	3.75 ±0.94	2.56 ±1.32	4.42 ±0.92	8.29 ±0.41
Total NEAA	9.62 ±1.71	8.16 ±2.41	11.57 ±1.03	21.62 ±1.08

Note: SBM – soybean meal, PB – peas 'Bruno', PP – peas 'Pinochio', FBL – faba beans 'Lielplatone', % DM – percentage of dry matter. Data are presented as means ±SD – standard deviation.

Table 3 Composition of feeds used in the broiler feeding experiment at the grower and finisher stages.

Items	C (control)	PB200	PP200	PB300	PP300	FBL100	PB100 + FBL100	PB100 + FBL150
				Grower stage				
CP, % DM	24.43 ±0.33	25.64 ±0.28	24.87 ±0.31	24.59 ±0.33	25.09 ±0.59	25.37 ±0.71	24.05 ±0.25	23.63 ±0.48
DM, %	87.93 ±0.28	87.94 ±0.42	87.84 ±0.31	87.79 ±0.25	87.41 ±0.27	88.27 ±0.28	88.05 ±0.42	87.48 ±0.25
CFa, % DM	3.62 ±0.30	3.20 ±0.26	3.22 ±0.24	2.83 ±0.29	3.41 ±0.32	3.43 ±0.20	3.16 ±0.38	3.80 ±0.20
CAsh, % DM	6.01 ±0.33	5.89 ±0.21	5.45 ±0.33	5.02 ±0.41	5.34 ±0.33	5.70 ±0.28	5.72 ±0.42	5.86 ±0.34
CFb, % DM	3.19 ±0.06	4.37 ±0.59	3.34 ±0.06	4.04 ±0.05	3.47 ±0.11	4.89 ±0.06	4.10 ±0.27	3.95 ±0.13
Ca, % DM	1.04 ±0.01	0.99 ±0.06	0.88 ±0.01	0.75 ±0.01	0.79 ±0.08	0.92 ±0.03	0.89 ±0.01	0.92 ±0.01
P, % DM	0.68 ±0.02	0.68 ±0.02	0.68 ±0.03	0.62 ±0.03	0.66 ±0.03	0.70 ±0.02	0.69 ±0.03	0.67 ±0.01
ME, kcal.kg^{-1*}	750 ±78	1048 ±61^{S}	1045 ±24^{S}	1196 ±48^{S}	1193 ±86^{S}	844 ±14	992 ±32	1040 ±53^{S}
				Finisher stage				
CP, % DM	22.01 ±0.22	22.15 ±0.45	22.11 ±0.51	22.91 ±0.07	23.02 ±0.16	22.46 ±0.37	23.29 ±0.17	24.48 ±0.56
DM, %	88.14 ±0.15	87.82 ±0.14	87.87 ±0.37	87.78 ±0.56	88.07 ±0.14	88.17 ±0.46	87.91 ±0.16	87.87 ±0.15
CFa, % DM	4.91 ±0.45	5.03 ±0.14	4.71 ±0.45	3.89 ±0.48	4.21 ±0.56	4.25 ±0.40	3.93 ±0.51	4.08 ±0.36
CAsh, % DM	6.40 ±1.08	5.61 ±1.50	5.62 ±1.37	5.29 ±0.41	5.58 ±1.25	8.58 ±0.89	5.76 ±0.43	5.45 ±0.40
CFb, % DM	4.23 ±0.07	4.48 ±0.16	4.63 ±0.34	4.09 ±0.22	4.46 ±0.31	5.02 ±0.05	5.73 ±0.11	5.87 ±0.17
Ca, % DM	1.08 ±0.01	0.86 ±0.03	0.85 ±0.01	0.74 ±0.02	0.86 ±0.04	1.09 ±0.02	0.93 ±0.01	0.81 ±0.04
P, % DM	0.74 ±0.042	0.62 ±0.015	0.66 ±0.036	0.60 ±0.05	0.68 ±0.029	0.68 ±0.030	0.65 ±0.055	0.66 ±0.050
ME, kcal.kg^{-1*}	664 ±16	993 ±21^{S}	990 ±29^{S}	1158 ±19^{S}	1153 ±33^{S}	777 ±22	941 ±18^{S}	998 ±31^{S}

Note: % DM – percentage of dry matter, CP – crude protein, CFa – crude fat, CFb – crude fiber, CAsh – crude ash, Ca – calcium, P – phosphorus, ME* - metabolizable energy, intake from SBM, beans and peas. Data are presented as means ± SD – standard deviation. Means with superscript letter ^{S} are significantly different at p <0.05 in comparison with the control group. The numbers of each columns that do not have letter have a meaningful difference (p >0.05).

The meat energy value contents were higher in the breast of broilers fed PB100 + FBL100 diets supplemented with 100 g.kg^{-1} FBL with 100 g.kg^{-1} PB (107.84 kcal.100g^{-1}), but the lowest – in the C group – from the dietary treatment with SBM (95.26 kcal.100g^{-1}). No significant difference (p >0.05) in meat energy value was recorded among the treatments.

Amino acid contents in breast muscle

The effects of dietary treatments on the AA contents of broiler breast meat from the eight experimental groups are shown in Table 6.

The results indicated that in most cases, the average level of total AA (TAA) was increased in meat from the broilers fed diets PB100 + FBL100 and PB100 + FBL150. The Met content was significantly higher in muscle from diet PB100

+ FBL150, while Cys – in broiler meat from groups PB200, PB100 + FBL100, and PB100 + FBL150. Compared with the C group diet, diets PB300 and FBL100 significantly decreased (p <0.05) the TAA, whereas diet PB100 + FBL150 increased (p <0.05) the TAA content.

The highest values in the EAA group were recorded for Arg (3.14 g.kg^{-1} DM) and Leu (3.81 g.kg^{-1} DM), but the lowest value – Cys (0.58 g.kg^{-1} DM). In the NEAA group, Gln was found to be the most abundant (7.54 g.kg^{-1} DM), but Tyr had the lowest value – (1.4 g.kg^{-1} DM). In total, the highest average EAA level (23.15 g.kg^{-1} DM) was recorded in experimental diet PB100 + FBL150 (with 150 g.kg^{-1} FBL with 100 g.kg^{-1} PB), but the lowest (20.13 g.kg^{-1} DM) – in diet PB200. On average, diets PP300, PB100 + FBL100 and PB100 + FBL150 increased the total EAA content in breast muscle, but the TAA level was increased by only diets PB100 + FBL100 and PB100 + FBL150 (41.94 and 42.59 g.kg^{-1} DM, respectively).

The chemical score, amino acid score, EAA index, and biological value

The calculated indicators of breast meat samples are set out in Table 7. The chemical score, the AA score, the EAA index and the biological value of all the tested AA were significantly different between the control and the treatment groups.

A comparison of the protein-supplemented diet groups revealed that the chemical and AA scores were increased in the meat of groups PB100 + FBL100 and PB100 + FBL150 (supplemented with faba beans and peas), but were decreased in the breast meat of broilers fed diets PP200 and PB300 (supplemented with 200 g.kg^{-1} PP and 300 g.kg^{-1} PB, respectively).

Regarding the EAAI and biological value, there were significant increases between the control (C) group and groups PB100 + FBL100 and PB100 + FBL150, respectively.

The results of the use of faba beans in the poultry diet have been contradictory **(Crépon, 2006)**. Faba beans have a quite high level of protein (about 26%), but the presence of anti-nutritional constituents, such as vicine and convicine, and the low level of Sulphur AA content reduce their nutritional value in poultry meat.

Some studies showed adverse effects on poultry performance or growth performance similar to control diets at various inclusion levels **(Dal Bosco et al., 2013)**. Some results indicated that replacing SBM with alternative protein sources had a positive effect on the dietetic value of poultry meat, whereas other data indicate something opposite **(Milczarek, Osek and Pachnik, 2016)**. Parameters used to determine protein quality included chemical score, AA score, essential AA index (EAAI), and biological value **(Aronal, Huda and Ahmad, 2012)**. Proteins with a high content of essential AA are the most important components of poultry meat **(Straková et al., 2002)**.

As is known, birds, especially broiler chicks, have an intense growth rate and high genetic potential for productivity. Therefore, broilers need to feed with a high (20 – 25%) crude protein level. Before the start of the feeding test, the chemical composition of peas, beans, and imported soybeans are grown in Latvia was determined. Regarding chemical composition of a pea, faba bean and soybean used in the trial, our results are in agreement with published data of other authors **(Koivunen et al., 2016)** who reported on significantly lower content of crude protein, crude fat, and ash in faba beans and peas in comparison with soybean meal. However, our results showed a significantly higher content of starch and crude fiber in peas and faba beans. This agrees with the results of **Koivunen et al. (2016)**. Unfortunately, pea starch is less susceptible to enzyme hydrolysis than starch in any of the cereal grains **(Laudadio and Tufarelli, 2010)**. In contrast to the current study, in the study of **Laudadio and Tufarelli (2010),** the content of crude fiber in soybean was higher as in peas. Faba beans are protein and energy-rich legume seeds well adapted to grow in various climatic zones of Europe and widely used for feed and food **(Grosjean et al., 2000)**.

AA composition is key to the evaluation of a dietary protein source. In the present research study, feeding pulses led to a significantly higher level of EAA, NEAA, and TAA in the diets. Among the analyzed finisher stage samples, basal feed with an addition of 200 g.kg^{-1} PP or 300 g.kg^{-1} PB or 150 g.kg^{-1} FBL with 100 g.kg^{-1} PB had a higher content in almost all the groups of AA; however, Sulphur AA (Met and Cys) were the exception in most cases.

AA, termed functional AA, includes Ala, Arg, Asp, Gln, Gly, Pro, and Ser and are important not only for intestinal integrity, nutrient transport, and metabolism but also in immune response **(Dai, Wu and Zhu, 2011; Ren et al., 2013)**. Some authors emphasize the importance of EAA (Lys and Met) in broiler feed. The productivity of broilers, to a great extent, is determined by the EAA content of feedstuffs. This AA is not synthesized in the broiler organism; therefore, the acids must be consumed with feed in a certain quantity and at a certain ratio **(Beski, Swick and Iji, 2015)**. Lys and Met are among the most limiting AA, which is important for the growth of the organism and in the balance of nitrogen.

Met is classified as the first insufficient AA in the organism, as it is available in a limited amount in plant proteins. Met is required to provide the building blocks for immune cells and tissues, therefore, it is an EAA for animals, poultry, including broiler, in particular. Met is required for the growth of feathers and the synthesis of proteins **(Bunchasak, 2009)**.

The second most important EAA needed for the growth of broilers is Lys, which contributes to the growth of chest muscle tissues as well as the growth pace of broilers **(Kidd et al., 2004)**. Deficiency in Lys causes blood circulation problems, a lower level of hemoglobin as well as leads to smaller muscles and bone deterioration **(Burnham, 2005)** and, consequently, the death rate of broilers increases and an increase in the weight of their muscles is lower, which can cause considerable economic losses.

The research showed that soybean meal had a higher EAA content than peas and faba beans by 11.14 – 11.82% and 8.53%, respectively (Table 3). It has to be taken into consideration that the SBM had such anti-nutritive factors as protease inhibitors – trypsin, chymotrypsin, pectin, goitrogens, and other substances that could affect the digestibility of protein present in the feed, metabolic nitrogen retention, and excretion **(Yasothai, 2016)**.

Table 4 Amino acid contents (% of DM) in broiler feeds.

Items	C	PB200	PP200	PB300	PP300	FBL100	PB100 + FBL100	PB100+ FBL150
				Grower stage				
Met	0.49 ±0.018	0.5 ±0.019	0.48 ±0.017	0.45 ±0.018	0.47 ±0.019	0.48 ±0.023	0.49 ±0.028	0.45 ±0.0.017
Cys	0.33 ±0.015	0.35 ±0.016^{S}	0.35 ±0.015^{S}	0.31 ±0.011^{S}	0.33 ±0.010	0.33 ±0.021	0.31 ±0.014^{S}	0.33 ±0.018
Lys	0.97 ±0.059	1.00 ±0.061	1.10 ±0.067	0.99 ±0.057	1.06 ±0.066^{S}	0.92 ±0.012	0.96 ±0.057	1.04 ±0.066^{S}
Thr	0.67 ±0.031	0.72 ±0.029	0.73 ±0.032	0.69 ±0.034	0.68 ±0.038	0.74 ±0.061	0.74 ±0.049	0.67 ±0.026
Arg	0.98 ±0.073	1.13 ±0.055^{S}	1.12 ±0.060	1.09 ±0.067	1.19 ±0.043	1.04 ±0.040	1.13 ±0.041^{S}	1.20 ±0.050^{S}
Ile	0.60 ±0.037	0.69 ±0.024	0.69 ±0.026	0.66 ±0.029	0.72 ±0.030^{S}	0.65 ±0.081	0.70 ±0.014	0.68 ±0.026
Leu	1.02 ±0.051	1.14 ±0.035	1.14 ±0.038	1.08 ±0.042	1.16 ±0.039	1.10 ±0.025	1.18 ±0.049^{S}	1.11 ±0.037
Val	0.74 ±0.034	0.81 ±0.023	0.81 ±0.025	0.79 ±0.028	0.84 ±0.026	0.79 ±0.044	0.85 ±0.021	0.82 ±0.025
His	0.35 ±0.012	0.37 ±0.011	0.36 ±0.012	0.36 ±0.013	0.37 ±0.014	0.35 ±0.032	0.38 ±0.009	0.38 ±0.010
Phe	0.63 ±0.029	0.71 ±0.016	0.70 ±0.026	0.68 ±0.019	0.71 ±0.017	0.72 ±0.021	0.71 ±0.021	0.68 ±0.014
Total EAA	6.78 ±0.258	7.42 ±0.173^{S}	7.48 ±0.187^{S}	7.10 ±0.194	7.53 ±0.289^{S}	7.12 ±0.171	7.45 ±0.064^{S}	7.36 ±0.190^{S}
Tyr	0.53 ±0.020	0.58 ±0.031	0.55 ±0.018	0.55 ±0.019	0.56 ±0.022	0.53 ±0.032	0.57 ±0.007	0.58 ±0.018
Gly	0.64 ±0.019	0.68 ±0.013	0.68 ±0.014	0.66 ±0.016	0.69 ±0.013	0.67 ±0.005	0.71 ±0.014	0.68 ±0.014
Ser	0.75 ±0.027	0.81 ±0.021	0.81 ±0.023	0.78 ±0.025	0.78 ±0.041	0.83 ±0.025	0.82 ±0.028	0.78 ±0.021
Ala	0.63 ±0.021	0.68 ±0.013	0.69 ±0.015	0.66 ±0.015	0.69 ±0.014	0.66 ±0.015	0.69 ±0.002	0.68 ±0.015
Asp	1.08 ±0.099	1.36 ±0.053	1.32 ±0.055	1.28 ±0.061	1.38 ±0.067^{S}	1.23 ±0.042	1.35 ±0.000	1.35 ±0.056
Glu	3.46 ±0.124	3.56 ±0.132	3.65 ±0.143^{S}	3.43 ±0.143	3.38 ±0.160	3.62 ±0.166	3.67 ±0.219^{S}	3.36 ±0.121
Total NEAA	7.09 ±0.225	7.67 ±0.168	7.70 ±0.168	7.36 ±0.169	7.48 ±0.162	7.54 ±0.190	7.81 ±0.262	7.43 ±0.161
TAA	13.87 ±0.504	15.09 ±0.335^{S}	15.18 ±0.435^{S}	14.46 ±0.462	15.01 ±0.310^{S}	14.66 ±0.421	15.25 ±0.325^{S}	14.79 ±0.411
				Finisher stage				
Met	0.39 ±0.016	0.37 ±0.011	0.41 ±0.018	0.37 ±0.004	0.37 ±0.005	0.37 ±0.009	0.36 ±0.007	0.37 ±0.018
Cys	0.26 ±0.014	0.27 ±0.10	0.30 ±0.005	0.29 ±0.011	0.29 ±0.010	0.29 ±0.005	0.29 ±0.004	0.30 ±0.015
Lys	0.72 ±0.067	0.81 ±0.051	0.91 ±0.052	0.94 ±0.052^{S}	0.84 ±0.022^{S}	0.82 ±0.026	0.81 ±0.035	0.86 ±0.056^{S}
Thr	0.56 ±0.024	0.58 ±0.022	0.63 ±0.023	0.57 ±0.019	0.59 ±0.017	0.59 ±0.021	0.58 ±0.028	0.62 ±0.021
Arg	0.79 ±0.065	0.84 ±0.056	0.92 ±0.054	0.96 ±0.060^{S}	0.94 ±0.061	0.85 ±0.067	0.84 ±0.085	0.96 ±0.055^{S}
Ile	0.54 ±0.033	0.55 ±0.031	0.63 ±0.030	0.62 ±0.025	0.56 ±0.015	0.58 ±0.015	0.56 ±0.021	0.59 ±0.034
Leu	0.43 ±0.047	0.49 ±0.223	0.50 ±0.020	1.01 ±0.054^{S}	0.89 ±0.044^{S}	0.91 ±0.046^{S}	0.91 ±0.057^{S}	0.99 ±0.019^{S}
Val	0.62 ±0.035	0.67 ±0.031	0.72 ±0.031	0.71 ±0.029	0.64 ±0.015	0.66 ±0.015	0.64 ±0.021	0.67 ±0.037
His	0.31 ±0.017	0.31 ±0.018	0.34 ±0.012	0.32 ±0.012	0.30 ±0.006	0.29 ±0.016	0.29 ±0.007	0.30 ±0.029
Phe	0.56 ±0.038	0.59 ±0.034	0.68 ±0.008^{S}	0.65 ±0.023	0.61 ±0.013	0.59 ±0.025	0.60 ±0.014	0.62 ±0.002
Total EAA	5.18 ±0.409	5.48 ±0.304	6.04 ±0.213^{S}	6.4 ±0.236^{S}	6.03 ±0.174	5.95 ±0.214	5.88 ±0.283	6.28 ±0.309^{S}
Tyr	0.43 ±0.021	0.49 ±0.008	0.50 ±0.019	0.49 ±0.005	0.48 ±0.005	0.49 ±0.006	0.48 ±0.011	0.48 ±0.008
Gly	0.56 ±0.015	0.57 ±0.013	0.59 ±0.009	0.60 ±0.013	0.59 ±0.013	0.57 ±0.015	0.58 ±0.014	0.60 ±0.012
Ser	0.67 ±0.017	0.66 ±0.018	0.68 ±0.051	0.67 ±0.021	0.65 ±0.024	0.66 ±0.026	0.65 ±0.035	0.70 ±0.012
Ala	0.57 ±0.019	0.59 ±0.019	0.61 ±0.047	0.62 ±0.020	0.58 ±0.019	0.59 ±0.021	0.58 ±0.028	0.62 ±0.016
Asp	1.03 ±0.079	1.15 ±0.053	1.24 ±0.048	1.27 ±0.055^{S}	1.21 ±0.051	1.16 ±0.061	1.15 ±0.078	1.26 ±0.051^{S}
Glu	3.26 ±0.080	3.10 ±0.042	3.14 ±0.059	3.06 ±0.030^{S}	3.04 ±0.033^{S}	3.05 ±0.040^{S}	3.00 ±0.057^{S}	3.08 ±0.049
Total NEAA	6.52 ±0.119	6.56 ±0.124	6.76 ±0.134	6.71 ±0.128	6.55 ±0.127	6.52 ±0.155	6.44 ±0.212	6.74 ±0.121
TAA	11.70 ±0.455	12.04 ±0.361	12.8 ±0.301^{S}	13.15 ±0.231^{S}	12.58 ±0.301	12.47 ±0.563	12.32 ±0.795	13.02 ±0.234^{S}

Note: Data are presented as means ± SD -standard deviation. Means with superscript letter ^{S} are significantly different at p <0.05 in comparison with the control group. The numbers of each columns that do not have letter have a meaningful difference (p >0.05).

Our results demonstrated the CP content in the diets for the experimental groups, compared with that for the C group, was not significantly different (p >0.05), yet the overall contents of EAA in groups PP200, PP300, PB100 + FBL150 and TAA in group PP200 were significantly higher than those in the C group at both the grower and the finisher stages. It means that the diet with peas and faba beans contained higher-quality CP than that for the C group (SBM).

From the nutritional aspect, poultry meat is an important source of proteins, vitamins, and minerals, and at the same time has relatively low-fat content, therefore the chemical composition of muscle tissue is an important criterion of broiler meat quality. The biochemical parameters of broiler meat observed in the research indicated that the inclusion of faba beans and peas (100 – 200 g.kg^{-1} of the basal diet) in the feed as higher protein diets can induce a higher meat protein content and, at the same time, reduce the fat content of muscles owing to a decrease in the protein-calorie ratio **(Bogosavljevic-Boskovic et al., 2010)**.

Although authors **Dal Bosco et al. (2013)** reported on a negative effect of faba bean diets due to a lower level of some EAA (Met, Cys, Thr, and Trp) and the presence of vicine, convicine, and tannins as anti-nutritional factors,

Table 5 Effect of a dietary protein source on the biochemical composition of broiler meat.

Items	C	PB200	PP200	PB300	PP300	FBL100	PB100 + FBL100	PB100 + FBL150
DM, %	22.33 ±0.74	24.47 ±0.84	23.26 ±1.61	23.41 ±0.68	23.33 ±1.29	22.46 ±0.45	24.04 ±1.11	24.05 ±0.42
CP, % DM	20.32 ±1.28	21.23 ±0.95	20.09 ±0.07	20.71 ±0.39	21.05 ±0.47	21.34 ±0.73^S	21.41 ±0.93^S	20.76 ±0.34
CFa, % DM	1.85 ±0.08	1.76 ±1.01	1.78 ±1.05	1.84 ±0.70	1.51 ±0.55	1.55 ±1.68	1.53 ±0.70	1.71 ±0.81
CAsh, % DM	1.38 ±0.02	1.58 ±0.09	1.41 ±0.10	1.40 ±0.06	1.51 ±0.03	1.51 ±0.13	1.55 ±0.06	1.52 ±0.01
Ca, % DM	0.01 ±0.00	0.01 ±0.00	0.01 ±0.00	0.01 ±0.00	0.01 ±0.01	0.02 ±0.01	0.01 ±0.01	0.01 ±0.01
P, % DM	0.21 ±0.01	0.12 ±0.01	0.20 ±0.02	0.22 ±0.01	0.21 ±0.01	0.21 ±0.01	0.22 ±0.01	0.22 ±0.01
Cholesterol, mg.100g^{-1}	128.1 ±8.70	118.2 ±23.11	110.5 ±7.56^S	137.5 ±9.20	118.7 ±18.13	110.6 ±9.95^S	118.6 ±6.96	122.6 ±41.77
Meat energy value, kcal.100g^{-1}	95.26	104.11	99.31	104.13	102.31	100.50	107.84^S	106.05

Note: % DM – percentage of dry matter, CP – Crude protein, CFa – Crude fat, CAsh – Crude ash, Ca – Calcium, P – phosphorus. Data are presented as means ±SD – standard deviation. Means with superscript letter ^{S} are significantly different at p <0.05 in comparison with the control group. The numbers of each columns that do not have letter have a meaningful difference (p >0.05).

Table 6 Amino acid contents in breast muscle of broilers at 42 days of age, g.kg^{-1}.

Items	C	PB200	PP200	PB300	PP300	FBL100	PB100 + FBL100	PB100+ FBL150
Met	1.38 ±0.02	1.37 ±0.01	1.23 ±0.02	1.21 ±0.09^S	1.32 ±0.05	1.27 ±0.03	1.37 ±0.12	1.49 ±0.01^S
Cys	0.61 ±0.03	0.64 ±0.01^S	0.62 ±0.01	0.61 ±0.01	0.62 ±0.01	0.58 ±0.00^S	0.65 ±0.02^S	0.64 ±0.01^S
Lys	4.06 ±0.13	3.03 ±0.95^S	3.80 ±0.18	3.77 ±0.21	3.91 ±0.10	3.75 ±0.13	4.01 ±0.16	4.03 ±0.17
Thr	1.99 ±0.11	2.04 ±0.04	1.87 ±0.07^S	1.86 ±0.11^S	1.96 ±0.04	1.86 ±0.06^S	1.96 ±0.11	2.02 ±0.06
Arg	2.99 ±0.05	3.14 ±0.01^S	2.95 ±0.02	2.81 ±0.13	2.88 ±0.05	2.73 ±0.10^S	2.98 ±0.14	3.07 ±0.03^S
Ile	2.38 ±0.08	2.45 ±0.04^S	2.09 ±0.08^S	2.19 ±0.11	2.29 ±0.06	2.18 ±0.04	2.33 ±0.10	2.38 ±0.02
Leu	2.63 ±0.84	1.47 ±0.07^S	3.52 ±0.16	3.52 ±0.16	3.58 ±0.12^S	3.50 ±0.07	3.71 ±0.17^S	3.81 ±0.07^S
Val	2.37 ±0.09	2.44 ±0.01	2.17 ±0.10	2.20 ±0.10	2.30 ±0.05	2.18 ±0.01	2.39 ±0.09	2.34 ±0.01
His	1.43 ±0.04	1.50 ±0.02	1.40 ±0.08	1.39 ±0.03	1.54 ±0.01^S	1.34 ±0.06	1.50 ±0.07	1.47 ±0.02
Phe	1.99 ±0.04	2.04 ±0.06	1.87 ±0.03	1.76 ±0.06	1.85 ±0.03	1.74 ±0.08^S	1.85 ±0.08	1.90 ±0.06
Total EAA	21.84	20.13	21.54	21.31	22.25^S	21.13	22.77^S	23.15^S
Tyr	1.59 ±0.04	1.63 ±0.10	1.50 ±0.07	1.45 ±0.04	1.47 ±0.06	1.40 ±0.09^S	1.47 ±0.09	1.55 ±0.02
Gly	2.22 ±0.06	2.17 ±0.03	2.58 ±0.36^S	2.00 ±0.07	2.23 ±0.05	1.95 ±0.05	2.27 ±0.05	2.12 ±0.03
Ser	1.71 ±0.07	1.78 ±0.01	1.60 ±0.09	1.63 ±0.14	1.67 ±0.01	1.58 ±0.07	1.67 ±0.11	1.77 ±0.03
Ala	2.48 ±0.14	2.57 ±0.06	2.49 ±0.08	2.31 ±0.24^S	2.46 ±0.10	2.34 ±0.14	2.54 ±0.17	2.47 ±0.08
Asp	4.05 ±0.14	4.20 ±0.09	3.81 ±0.09	3.69 ±0.30	3.94 ±0.10	3.76 ±0.21	3.98 ±0.36	4.09 ±0.27
Gln	7.22 ±0.15	7.54 ±0.10^S	6.84 ±0.07^S	6.78 ±0.06^S	6.94 ±0.14	6.84 ±0.09^S	7.25 ±0.09	7.46 ±0.03^S
Total NEAA	19.27	19.89^S	18.83	17.85^S	18.71	17.88^S	19.17	19.44
TAA	41.11	40.02	40.37	39.16^S	40.96	39.01^S	41.94^S	42.59^S

Note: Data are presented as means ±SD – standard deviation.

which reduce energy and protein digestibility by forming tannin-protein complexes, our findings demonstrated that addition to diets of faba bean protein alone or in a mix with peas could elevate the content of dry matter in broiler meat **(Dal Bosco et al., 2013)**.

We found a similar situation regarding the content of CP in dry matter. The highest content was shown by the diets containing 100 g.kg^{-1} FBL with 100 g.kg^{-1} PB (PB100 + FBL100). Also, the crude ash content of dry matter increased statistically significantly (p <0.05) in the muscle of broilers within all the experimental groups, especially in the group fed basal feed with 200 g.kg^{-1} PB of the total diet.

Our results are not in agreement with the data published by other authors **Milczarek, Osek and Pachnik (2016)** who reported that the introduction of different varieties of faba beans in starter/grower feed for broilers did not affect the content of basic meat components – dry matter, crude ash, and crude protein.

Even though our results demonstrated also an increase in crude fat content within all the experimental groups in comparison with the C group of broilers, **Milczarek, Osek and Pachnik (2016)** reported that the use of faba beans in the diet of broilers modified the muscle fatty acid profile in a health-enhancing direction.

Concerning Ca, our research demonstrated that the addition of faba beans and peas in various amounts did not affect statistically significantly the level of Ca in broiler muscle meat. We founded the same situation regarding the level of P. Therefore, we would suggest that diets with faba beans and peas do not harm key minerals in broiler meat.

An important indicator of meat quality is the content of cholesterol. As regards this parameter, our experiment showed a statistically significant decrease in all the experimental diets, except for the group of broilers fed 300

Table 7 Calculated nutritional indicators of broiler chicken muscle tissue.

	Chemical score of AA (%)							
Items	**C**	**PB200**	**PP200**	**PB300**	**PP300**	**FBL100**	**PB100 + FBL100**	**PB100+ FBL150**
Met	33.66 ±2.19	33.41 ±1.84	30.0 ±1.19	29.51 ±1.67	32.20 ±2.30	30.98 ±2.68	33.41 ±2.04	36.34 ±1.73
Cys	25.42 ±0.59	26.67 ±0.53	25.83 ±0.79	25.42 ±1.58	25.83 ±1.59	24.17 ±1.93	27.97 ±0.64	26.67 ±1.18
Phe	31.59 ±1.99	32.38 ±1.85	29.68 ±1.02	27.94 ±0.93	29.37 ±1.07	27.62 ±1.30	29.37 ±1.39	30.16 ±1.75
His	68.1 ±2.37	71.43 ±3.53	66.67 ±4.08	66.19 ±4.44	73.33 ±4.12	63.81 ±4.05	71.43 ±2.44	70.0 ±3.44
Ile	29.75 ±2.08	30.63 ±1.92	26.13 ±1.02	27.38 ±0.93	28.63 ±1.06	27.25 ±1.30	29.13 ±2.38	29.75 ±1.58
Leu	28.59 ±1.37	15.98 ±1.80	38.26 ±0.38	38.26 ±1.03	38.91 ±1.49	38.04 ±1.72	40.33 ±2.38	41.41 ±1.12
Val	32.47 ±1.79	33.42 ±1.66	29.73 ±0.82	30.14 ±1.33	31.51 ±1.23	29.86 ±1.50	32.74 ±1.92	32.05 ±1.52
Lys	56.39 ±6.15	42.08 ±5.60	52.78 ±0.99	52.36 ±1.70	54.31 ±1.78	52.08 ±2.17	55.69 ±7.44	55.97 ±4.78
Thr	40.61 ±1.82	41.63 ±1.73	38.16 ±0.98	37.96 ±1.18	40.0 ±1.35	37.96 ±1.68	40.0 ±1.78	41.22 ±1.46
Met	55.2 ±3.60	54.8 ±3.02	49.2 ±1.94	48.4 ±2.74	52.8 ±3.77	50.8 ±4.41	54.8 ±3.35	59.6 ±2.84
Cys	24.4 ±0.57	25.6 ±0.50	24.8 ±0.76	24.4 ±1.15	24.8 ±1.24	23.2 ±1.51	26.0 ±0.61	25.6 ±0.91
His	75.26 ±2.63	78.95 ±3.90	73.68 ±4.51	73.16 ±4.90	81.05 ±4.55	70.53 ±4.48	78.95 ±2.70	77.37 ±3.80
Ile	85 ±5.94	87.5 ±5.48	74.64 ±2.92	78.21 ±2.63	81.79 ±3.04	77.86 ±3.71	83.21 ±6.82	85.0 ±4.50
Leu	39.85 ±14.7	22.27 ±0.53	53.33 ±0.52	53.33 ±1.43	54.24 ±2.08	53.03 ±2.40	56.21 ±1.91	57.73 ±1.31
Val	67.71 ±3.46	69.71 ±3.23	62.9 ±1.54	62.86 ±2.77	65.71 ±2.56	62.29 ±3.13	68.29 ±3.50	66.86 ±3.01
Lys	70.0 ±7.64	52.24 ±6.95	65.52 ±1.23	65.0 ±2.12	67.41 ±2.20	64.66 ±2.69	69.14 ±9.24	69.48 ±5.93
Thr	58.53 ±2.62	60.0 ±2.49	55.0 ±1.43	54.71 ±6.14	57.65 ±5.55	54.71 ±6.55	67.65 ±2.57	59.41 ±4.61
EAAI (%)	393.28 ±7.32	376.7 ±10.07	383.33 ±10.71	379.06 ±15.18	399.08 ±16.33	374.43 ±19.97	405.74 ±8.35^{S}	411.55 ±12.08^{S}
Biological value	416.98 ±7.99	398.9 ±10.98	406.13 ±11.67	401.47 ±17.80	423.29 ±17.80	396.42 ±21.77^{S}	430.56 ±9.10^{S}	436.89 ±13.17^{S}

Note: Data are presented as means ± SD -standard deviation.

g.kg^{-1} PP of the total diet. This could be explained by the highest content of CP from peas (21.05% of DM) in this experimental PP300 group in comparison with the other experimental diets. Our results are in agreement with those of researchers **Kiczorowska, Samolińska and Andrejko (2016)** who also reported on the hypocholesterolemic effect of pea seeds (*Pisum sativum L.*).

An important criterion of meat quality is the energy value of meat that was higher in all the experimental groups (from 4.25% in group PP200 to 13.20% in group PB100 + FBL100) than in the C group. Our results are not in agreement with the data of authors **Dal Bosco et al. (2013)** who reported that the introduction of faba beans in starter and grower feeds for broiler chickens did not affect the meat energy value. This probably could be explained by the high value of the dry matter in broiler meat as a result of our experiment. But, the inclusion of 200 – 300 g.kg^{-1} peas of the basal diet in the experimental broiler feed demonstrated a lower energy value than that for the PB100 + FBL150 group fed 150 g.kg^{-1} FBL with 100 g.kg^{-1} PB, which could be explained by an imbalance between energy intake and energy expenditure **(Bogosavljevic-Boskovic et al., 2010)**.

AA are absorbed at the intestinal level and have effects on the physiology of the intestine, and AA might also affect muscle composition and meat quality. Macroorganisms cannot synthesize EAA or indispensable AA and therefore the acids have to be supplied in the diet. Researchers **Probst (2009)** and **Koivunen et al. (2016)** inform that various diets can cause significant changes in the content of EAA and NEAA in broiler meat. However, our experiment demonstrated that diets with an addition of faba beans and peas have shown a positive effect on the level of EAA and NEAA in broiler meat.

The nutritional value of meat is usually assessed based on parameters such as the content and composition of proteins, levels of AA, and content of fat **(Straková et al., 2002)**. The calculated indicators in meat samples showed that the chemical score, the AA score, the EAAI, and the biological value of tested AA were significantly increased in the PB100 + FBL150 group broilers fed diets supplemented with 150 g.kg^{-1} FBL with 100 g.kg^{-1} PB.

CONCLUSION

In the present research study, the replacement of protein sources with peas and faba beans was more apparent because the AA composition in the breast muscle, the biological value, and the broiler meat quality have positively changed. It could be concluded that broiler feed rations may comprise peas ‘Bruno’, ‘Pinochio’, and faba beans ‘Lielplatone’ grown in Latvia. The faba beans along with peas could be used to replace part of soybean meal as a source of protein.

There was a significant reduction (p <0.05) in the cholesterol concentration of broiler breast meat from the broilers fed diet PP200 supplemented with 200 g.kg^{-1} PP (110.5 mg.100g^{-1}) and FBL100 – with 100 g.kg^{-1} FBL (110.6 mg.100g^{-1}) in comparison with the C group, however cholesterol concentration in meat decreased in all the experimental groups (except PB300). The CP content was significantly (p <0.05) higher in breast meat of broilers fed diets FBL100 and PB100 + FBL100.

The significantly higher average EAA levels (6.04, 6.44 and 6.28% of DM) and TAA amounts (12.8, 13.15, and 13.02% of DM) were recorded in experimental finisher stage diets PP200, PB300, and PB100 + FBL150. The chemical score, the AA score, the EAAI, and the biological value of tested AA were significantly increased in group PB100 + FBL100 and PB100 + FBL150 broilers fed diets supplemented with a mixture of 100 – 150 $g.kg^{-1}$ FBL with 100 $g.kg^{-1}$ PB.

REFERENCES

Alfaig, E., Angelovičová, M., Kral, M., Bučko, O. 2014. Effect of probiotics and thyme essential oil on the essential amino acid content of the broiler chicken meat. *Acta Scientiarum Polonorum, Technologia Alimentaria*, vol. 13, no. 4, p. 425-432. https://doi.org/10.17306/J.AFS.2014.4.9

Aronal, A. P., Huda, N., Ahmad, R. 2012. Amino Acid and Fatty Acid Profiles of Peking and Muscovy Duck Meat. *International Journal of Poultry Science*, vol. 11, no. 3, p. 229-236. https://doi.org/10.3923/ijps.2012.229.236

Aviagen. 2018. *Ross Broiler Management Handbook*. 148 p. Available at: https://en.aviagen.com/assets/Tech_Center/Ross_Broiler/Ross-BroilerHandbook2018-EN.pdf

Beski, S. S. M., Swick, R. A., Iji, P. A. 2015. Specialized protein products in broiler chicken nutrition: A review. *Animal Nutrition*, vol. 1, no. 2, p. 47-53. https://doi.org/10.1016/j.aninu.2015.05.005

Bogosavljevic-Boskovic, S., Pavlovski, Z., Petrovic, M., Doskovic, V., Rakonjac, S. 2010. Broiler meat quality: Proteins and lipids of muscle tissue. *African Journal of Biotechnology*, vol. 9, no. 54, p. 9177-9182. Available at: https://www.ajol.info/index.php/ajb/article/view/125762

Bunchasak, C. 2009. Role of Dietary Methionine in Poultry Production. *The Journal of Poultry Science*, vol. 46, no. 3, p. 169-179. https://doi.org/10.2141/jpsa.46.169

Burnham, D. 2005. Dietary strategies to lower nitrogen load in poultry. *In Proceeding of Canadian Eastern and Nutrition Conference*, p. 20.

Cheeke, P. R. 2005. *Applied Animal Nutrition: Feeds and Feeding*. 3rd ed. Madison, USA : Pearson Prentice Hall, 624 p. ISBN-13: 978-0131133310.

Council Directive 2007/43/EC of 28 June 2007 laying down minimum rules for the protection of chickens kept for meat production.

Crépon, K. 2006. Nutritional value of legumes (pea and faba bean) and economics of their use. In Garnsworthy, P. C., Wiseman, J. *Recent advances in animal nutrition*. Nottingham, UK : Nottingham University press, p. 332-366. ISBN 9781904761020. https://doi.org/10.5661/recadv-06-331

Dai, Z. L., Wu, G., Zhu, W. Y. 2011. Amino acid metabolism in intestinal bacteria: Links between gut ecology and host health. *Frontiers in Bioscience*, vol. 16, no. 5, p. 1768-1786. https://doi.org/10.2741/3820

Dal Bosco, A., Ruggeri, S., Mattioli, S., Mugnai, C., Sirri, F., Castellini, C. 2013. Effect of faba bean (*Vicia faba var. minor*) inclusion in starter and growing diet on performance, carcass and meat characteristics of organic slow-growing chickens. *Italian Journal of Animal Science*, vol. 12, no. 4, p. 472-478. https://doi.org/10.4081/ijas.2013.e76

EUROLEGUME. 2018. *Final Report Summary - Enhancing of legumes growing in Europe through sustainable cropping for protein supply for food and feed*. Available at: https://cordis.europa.eu/project/id/613781/reporting

Grashorn, M. A. 2005. Enrichment of Eggs and Poultry Meat with Biologically Active Substances by Feed Modifications and Effects on the Final Quality of the Product. *Polish Journal of Food and Nutrition Sciences*, vol. 55, no. 1, p. 15-20.

Grosjean, F., Cerneau, P., Bourdillon, A., Bastianelli, D., Peyronnet, C., Duc, G., Lacassagne, L. 2000. Valeur alimentaire pour la volaille de féveroles isogéniques (*Vicia faba* L) avec ou sans tannins et avec ou sans vicine (Feed value for poultry of isogenic field beans (*Vicia faba* L) with or without tannins and with or without vicine). *Sciences et Techniques Avicoles*, vol. 32, no. 1, p. 17-23. (In French)

Herlich, K. 1990. *Official methods of analysis of the association of official analytical chemists*. 15th ed. vol. 1. Arlington, USA : Association of official analytical chemists, Inc. p. 684. ISBN 0-935584-42-0.

Holban, A. M., Grumezescu, A. M. 2018. *Food Quality: Balancing Health and Disease*. 1st ed. Cambridge, USA : Academic Press, p. 530. ISBN: 9780128114940. https://doi.org/10.1016/B978-0-12-811442-1.00023-7

Indexmundi. 2017. *Commodity Prices - Price Charts, Data, and News - IndexMundi*, Indexmundi. Available at: https://www.indexmundi.com/commodities/

ISO 5983-2. 2009. *Animal feeding stuffs - Determination of nitrogen content and calculation of crude protein content - Part 2: Block digestion and steam distillation method.*

ISO 5984. 2002/COR 1:2005. *Animal feeding stuffs — Determination of crude ash — Technical Corrigendum 1*. Cor 1, 2005.

ISO 6491. 1998. *Animal feeding stuffs — Determination of phosphorus content — Spectrometric method.*

ISO 6492. 1999. *Animal feeding stuffs — Determination of fat content.*

ISO 6496. 1999. *Animal feeding stuffs — Determination of moisture and other volatile matter content.*

Juran, J. M., Godfrey, A. B. 1998. *Juran's Quality Handbook*. 5th ed. New York, USA : McGraw-Hill Professional, 1872 p. ISBN-13: 978-0070340039.

Kaygisiz, F., Bolat, B. A., Bulut, D. 2019. Determining factors affecting consumer's decision to purchase organic chicken meat. *Brazilian Journal of Poultry Science*, vol. 21, no. 4, 8 p. https://doi.org/10.1590/1806-9061-2019-1060

Kiczorowska, B., Samolińska, W., Andrejko, D. 2016. Effect of micronized pea seeds (*Pisum sativum* L.) as a substitute of soybean meal on tissue fatty acid composition and quality of broiler chicken meat. *Animal Science Journal*, vol. 87, no. 11, p. 1396-1406. https://doi.org/10.1111/asj.12592

Kidd, M. T, McDaniel, C. D, Branton, S. L, Miller, E. R, Boren, B. B, Fancher, B. I. 2004. Increasing amino acid density improves live performance and carcass yields of commercial broilers. *Journal of Applied Poultry Research*, vol. 13, no. 4, p. 593-604. https://doi.org/10.1093/japr/13.4.593

Kim, H., Do, H. W., Chung, H. 2017. A comparison of the essential amino acid content and the retention rate by chicken part according to different cooking methods. *Korean Journal for Food Science of Animal Resources*, vol. 37, no. 5, p. 626-634. https://doi.org/10.5851/kosfa.2017.37.5.626

Koivunen, E., Partanen, K., Perttilä, S., Palander, S., Tuunainen, P., Valaja, J. 2016. Digestibility and energy value of pea (*Pisum sativum* L.), faba bean (*Vicia faba* L.) and blue lupin (narrow-leaf) (*Lupinus angustifolius*) seeds in broilers. *Animal Feed Science and Technology*, vol. 218, p. 120-127. https://doi.org/10.1016/j.anifeedsci.2016.05.007

LATAK. 1999. *Accredited testing laboratory, Latvian National Accreditation.*

Laudadio, V., Tufarelli, V. 2010. Growth Performance and Carcass and Meat Quality of Broiler Chickens Fed Diets

Containing Micronized-Dehulled Peas (*Pisum Sativum* Cv. Spirale) as a Substitute of Soybean Meal. *Poultry Science*, vol. 89, no. 7, p. 1537-1543. https://doi.org/10.3382/ps.2010-00655

Maggini, S., Pierre, A., Calder, P. C. 2018. Immune function and micronutrient requirements change over the life course. *Nutrients*, vol. 10, no. 10, 27 p. https://doi.org/10.3390/nu10101531

Milczarek, A., Osek, M., Pachnik, M. 2016. Meat quality of broiler chickens fed mixtures with varied levels and varieties of faba bean. *Acta Scientiarum Polonorum Zootechnica*, vol. 15, no. 4, p. 29-40. https://doi.org/10.21005/asp.2016.15.4.03

Mulvey, L. 2008. *Identifying Needs in Poultry Meat Quality Research.* Report No: FMT/REP/104174/1.

Nagyová, Ľ., Andocsová, A., Géci, A., Zajác, P., Palkovič, J., Košičiarová, I., Golian, J. 2019. Consumers´ awareness of food safety. *Potravinarstvo Slovak Journal of Food Sciences*, vol. 13, no. 1, p. 8-17. https://doi.org/10.5219/1003

Nalle, C. L., Ravindran, V., Ravindran, G. 2010. Nutritional value of faba beans (*Vicia faba* L.) for broilers: Apparent metabolisable energy, ileal amino acid digestibility and production performance. *Animal Feed Science and Technology*, vol. 156, no. 3-4, p. 104-111. https://doi.org/10.1016/j.anifeedsci.2010.01.010

Oser, B. L. 1959. *An Integrated Essential Amino Acid Index for Predicting the Biological Value of Proteins*. In Albanese, A. A. Protein and Amino Acid Nutrition. London, UK : Academic Press, p. 281-295. https://doi.org/10.1016/B978-0-12-395683-5.50014-6

Písaříková, B., Kráčmar, S., Herzig, I. 2005. Amino Acid Contents and Biological Value of Protein in Various Amaranth Species. *Czech Journal of Animal Science*, vol. 50, no. 4, p. 169-174. https://doi.org/10.17221/4011-CJAS

Probst, Y. 2009. *Nutrient Composition of Chicken Meat*. RIRDC Publication No 08/210, Project No PRJ-001502. Wollongong, Australia : University of Wollongong. 83 p. ISBN 1 74151 799 0. Available at: https://www.agrifutures.com.au/wp-content/uploads/publications/08-210.pdf

Purslow, P. P. 2017. *New Aspects of Meat Quality*. *From Genes to Ethics*. 1st ed. Cambridge, UK : Woodhead Publishing, 744 p. ISBN 978-0-08-100593-4.

Regulation (EC) 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety.

Ren, W., Zou, L., Ruan, Z., Li, N., Wang, Y., Peng, Y., Liu, G., Yin, Y., Li, T., Hou, Y., Wu, G. 2013. Dietary l-proline supplementation confers immunostimulatory effects on inactivated Pasteurella multocida vaccine immunized mice. *Amino Acids*, vol. 45, p. 555-561. https://doi.org/10.1007/s00726-013-1490-4

Röhr, A., Lüddecke, K., Drusch, S., Müller, M. J., Alvensleben, R. V. 2005. Food quality and safety - Consumer perception and public health concern. *Food Control*, vol. 16, no. 8, p. 649-655. https://doi.org/10.1016/j.foodcont.2004.06.001

Selle, P. H., de Paula Dorigam, J. C., Lemme, A., Chrystal, P. V., Liu, S. Y. 2020. Synthetic and crystalline amino acids: Alternatives to soybean meal in chicken-meat production. *Animals*, vol. 10, no. 4, p. 729-749. https://doi.org/10.3390/ani10040729

Sperry, W. M., Webb, M. 1950. A revision of the Schoenheimer-Sperry method for cholesterol determination. *The Journal of biological chemistry*, vol. 187, no. 1, p. 97-106.

Stagnari, F., Maggio, A., Galieni, A., Pisante, M. 2017. Multiple benefits of legumes for agriculture sustainability: an overview. *Chemical and Biological Technologies in Agriculture*, vol. 4, no. 2, 13 p. https://doi.org/10.1186/s40538-016-0085-1

Straková, E., Jelinek, P., Suchý, P., Antoninova, M. 2002. Spectrum of amino acids in muscles of hybrid broilers during prolonged feeding. *Czech Journal of Animal Science*, vol. 47, no. 12, p. 519-526.

Straková, E., Suchý, P., Herzig, I., Steinhauser, L., Šerman, V., Mas, N. 2009. Amino Acid Profile of Protein from Pelvic Limb Long Bones of Broiler Chickens. *Acta Veterinaria Brno*, vol. 78, no. 4, p. 571-577. https://doi.org/10.2754/avb200978040571

Swaggerty, C. L., He, H., Genovese, K. J., Callaway, T. R., Kogut, M. H., Piva, A., Grilli, E. 2020. A microencapsulated feed additive containing organic acids, thymol, and vanillin increases in vitro functional activity of peripheral blood leukocytes from broiler chicks. *Poultry Science*, vol. 99, no. 7, p. 3428-3436. https://doi.org/10.1016/j.psj.2020.03.031

Temesgen, M., Retta, N., Tesfaye, E. 2018. Chicken Amino Acid and Fatty Acid : Effect of Feeding Taro Leaf in the Diet. *Acta Scientific Nutritional Health*, vol. 2, no. 1, p. 12-18.

WHO. 1985. *Energy and protein requirements*. World Health Organization Technical Report Series 742. Geneva, Switzerland: World Health Organization, 112 p. ISBN 9241207248.

Xazela, N. M., Hugo, A., Marume, U., Muchenje, V. 2017. Perceptions of Rural Consumers on the Aspects of Meat Quality and Health Implications Associated with Meat Consumption. *Sustainability*, vol. 9, no. 5, p. 830-841. https://doi.org/10.3390/su9050830

Yamada, K., Sato-Mito, N., Nagata, J., Umegaki, K. 2008. Health claim evidence requirements in Japan. *The Journal of Nutrition*, vol. 138, no. 6, p. 1192S-1198S. https://doi.org/10.1093/jn/138.6.1192S

Yasothai, R. 2016. Antinutritional Factors in Soybean Meal and Its Deactivation. *International Journal of Science, Environment and Technology*, vol. 5, no. 6, p. 3793-3797. Available at: http://www.ijset.net/journal/1377.pdf

Acknowledgments:

The research received funding from the ERDF Post-doctoral Research Support Program (project No.1.1.1.2/16/I/001), research proposal "Assessment of the Bioeconomic Efficiency of Use of Legumes for Feed" (No.1.1.1.2./VIAA/1/16/181), and the scientific research project "Enhancing of Legumes Growing in Europe through Sustainable Cropping for Protein Supply for Food and Feed" (EUROLEGUME), Agreement No. 613781.

Conflict of Interest:

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

Ethical Statement:

This article does not contain any studies that would require an ethical statement. The study was restricted to routine on-farm observations and measurements collection that did not inconvenience or stress the animals, meat samples were collected after the birds were slaughtered at a slaughterhouse.

Contact address:
*Liga Proskina, Latvia University of Life Sciences and Technologies, Faculty of Economics and Social Development, Svetes, street no. 18, LV-3001, Jelgava, Latvia, Tel.: +371 28206624,
E-mail: liga.proskina@llu.lv
ORCID: https://orcid.org/0000-0002-3337-7838

Sallija Cerina, Institute of Agricultural Resources and Economics, Zinatnes street no. 2, Priekuli, LV-4126, Latvia, Tel.: +371 26528261,
E-mail: sallija.cerina@arei.lv
ORCID: https://orcid.org/0000-0002-4029-4555

Anda Valdovska, Latvia University of Life Sciences and Technologies, Faculty of Veterinary Medicine and Research Laboratory of Biotechnology. K. Helmaņa street no. 8, Jelgava, LV-3004, Latvija, Tel.: +371 26525501,
E-mail: anda.valdovska@llu.lv
ORCID: https://orcid.org/0000-0003-2044-5042

Irina Pilvere, Latvia University of Life Sciences and Technologies, Faculty of Economics and Social Development, Svetes, street no. 18, LV-3001, Jelgava, Latvia, Tel.: +371 29217851,
E-mail: irina.pilvere@llu.lv
ORCID:https://orcid.org/0000-0002-8467-1949

Vilija Alekneviciene, Vytautas Magnus University, Faculty of Bioeconomy Development, Research Institute for Bioeconomy, Universiteto 10, Akademija, LT-53361 Kaunas district, Lithuania, Tel.: +370 612 28771,
E-mail: vilija.alekneviciene@adu.lt
ORCID: https://orcid.org/0000-0002-6501-8792

Corresponding author: *