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FABA BEANS AS AN ALTERNATIVE PROTEIN SOURCE FOR BROILER CHICKEN FEED

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Abstract. A lower price on poultry meat, compared with other meats (beef, pork etc.), affects the increasing demand for poultry meat. The productivity and production cost of broiler chickens are directly related to the amount of feed fed, the proportion of crude protein in the feed, and the biological value and price of the feed. The EU produces only 30% of the protein crops used for feed; thus, the large import of protein feed crops contribute to agricultural instability and production cost increases. To reduce the consumption of imported protein feeds and the production cost of poultry meat, it is necessary to assess opportunities to use a domestic protein crop as faba beans. The research aim is to identify economic gains from the production of broiler chicken meat if using domestic faba beans in broiler chicken diets. Specific research tasks are as follows: 1) to identify the effect of the use of faba beans on the cost of broiler chicken feed; 2) to assess changes in broiler chicken productivity due to faba bean diets. It is economically efficient to replace soybean protein with domestically produced faba beans in the feed ration for broiler chickens; it provides an adequate amount of crude protein and reduces the feed conversion ratio and production costs. A faba bean ration in the broiler chicken diet provides the broilers with necessary nutrients, thereby contributing to their growth and increases in their live weight, reducing feed costs and resulting in increases in economic return.

Key words: poultry production, production efficiency, legumes, faba beans in broiler diets.

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Introduction

The consumption of poultry meat tended to increase in many countries in the world in the last decades (Martinez et al., 2011; Poulta et al., 2010). A lower price on poultry meat, compared with other meats (beef, pork etc.), affects the increasing demand for poultry meat. The productivity and production cost of broiler chickens are directly related to the amount of feed fed, the proportion of crude protein in the feed, and the biological value and price of the feed. Although approximately 70 % of total production cost in poultry farming relates to feed (Marcu et al., 2013), increases in production efficiency and low production costs of poultry meat are achieved by means of a short production cycle, fast-growing broiler chicken crosses and complete, protein-rich diets.

Poultry diets mostly consist of maize, wheat and soya flour; for this reason, increases in the price of grains and protein feeds on the global market undoubtedly affect the production cost of poultry meat. As stated by the European Parliament, a considerable proportion of imported maize and soya used in animal diets is genetically modified. At the same time, producers of livestock products in the EU cannot do without plant protein imports from third countries, as there is a lack of crude protein-rich feedstuffs produced in the EU. The EU produces only 30 % of the total quantity of protein feed crops (Protein Crops…, 2014). Large imports of protein crops contribute to agricultural instability and negatively influence agricultural producers as well cause price volatility. The dependence of EU food producers on feed market price fluctuations affects the production cost of their products as well. According to the forecasts of Food and Agriculture Organisation of the United Nations, the price on grain (maize) is going to rise by 20 % in the period 2011-2020, which will hike the price of meat (poultry) by 30 % (AVEC Annual Report, 2012).

In Latvia, too, poultry enterprises provide the necessary protein level in poultry diets, including broiler chicken diets, with imported crude protein-rich feedstuffs. They are: feed yeast, soya, sunflower oil meal, maize flour etc. According to analyses of data on production costs in livestock farming, the greatest expenditures relate to feed costs; yet, a detailed analysis of costs shows that the greatest costs may be attributed to imported feed, its components,

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whereas the proportion of costs of domestic and own-produced feed is insignificant. So, to reduce the consumption of imported protein-rich feedstuffs in agricultural animal and poultry diets and to lower the production cost of meat, it is necessary to use protein crops produced domestically.

In recent years, the area sown with legumes (faba beans, peas), which is an important source of feed protein, considerably increased in Latvia. The total area under faba beans increased 19 times from 2010 to 2015 – from 1.3 thou ha in 2010 to 25.9 thou ha in 2015 –, while the area cropped with peas rose 3.2 times during the same period – from 1.2 thou ha in 2010 to 3.8 thou ha in 2015 (RSS, 2015).

Such a sharp increase in the area sown with faba beans has been promoted by the EU policy aimed at protecting and enhancing biological diversity on agricultural holdings. Legumes considerably reduce CO_2 emissions, thus, reducing the imports and consumption of mineral nitrogen. According to the EU Regulation No 1307/2013, a new payment scheme aimed at climate- and environment-friendly agricultural practices or the green payment scheme, which is closely associated with the single area payment scheme, is available within the direct payments scheme. The area sown with nitrogen-absorbing crops, including the area under faba beans, is eligible for the green payment scheme (RSS, 2015).

Faba beans are a high-yield crop whose economic role is very significant. Faba beans are an excellent feed concentrate for domestic poultry and agricultural animals, as they contain 22-35% protein, according to some research studies, even 26-38% protein (Zute, 2014). This means that a mixture of faba beans and peas, which contain 20-23% protein, can provide the necessary amount of protein for poultry as well as increase the proportion of domestic protein-rich feedstuffs and lower the production cost of products in farming, i.e. to reach higher efficiency.

Although faba beans are a significant source of protein, a few research studies on the use of domestically grown faba beans in agricultural animal and poultry diets in the economic aspect have been conducted to date. That is why, the research aim is to identify economic gains from the production of broiler chicken meat if using domestic faba beans in broiler chicken diets. To achieve the **aim**, the following specific research **tasks** were set: 1) to identify the effect of use of faba beans on the cost of broiler chicken feed; 2) to assess changes in broiler chicken productivity due to faba bean diets.

Materials and methods

The economic efficiency of use of protein-rich crops grown in Latvia for broiler chicken diets was assessed employing the experimental method, i.e. faba beans and their mixture with peas were added to the diets, so that the dietary component examined represents the key factor affecting the productivity of broiler chickens. The analytical research employed the monographic method, analysis and synthesis, data grouping etc. The research used research papers by national and foreign scientists, data provided by the Rural Support Service (RSS) and the Central Statistical Bureau as well as findings of the research project "Enhancing of Legumes Growing in Europe through Sustainable Cropping for Protein Supply for Food and Feed" (EUROLEGUME).

The feeding experiment was conducted on broiler chickens of the cross Ross 308, which were split into four analogous groups (n=30). The chickens were reared in an intensive system on the permanent litter, with a density of 12 chicks on 1 m2 under adequate animal welfare conditions. Feed and drinking water were persistently available to all group chickens.

In accordance with the recommendations for rearing the cross Ross 308, the chickens are sold at the age of 38-42 days (Broilers ROSS

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Management Handbook, 2014). The bodyweight at slaughter increased progressively with the age. The net gain, which takes into account both the feed and rearing costs, reached a maximum between 42 and 49 days of age, and then decreased (Baeza et al., 2011). Poultry enterprises traditionally use a 42-day broiler production cycle (Kleyn, 2002).

Based on the intensity of growth of broilers and their organism requirements, diets for broilers are divided into three stages: pre-start (0-10 days), grower (11-26 days) and finisher (27 days to the selling age). All group broilers were fed diets of equal energy content that were balanced in accordance with the nutrition specifications for the cross ROSS 308 (Broilers ROSS Management Handbook, 2014).

To provide the necessary amount of crude protein in the diet, the broiler ration was supplemented with wheat grains and soybean oil meal in accordance with the standards adopted in the country. Starting from the 11th day, the experimental groups' diets were supplemented with faba beans and their mixture with peas in different amounts, proportionally reducing the amount of soybean oil meal (3-8%) in the ration of each experimental group according to the experimental scheme (Table 1).

The economic efficiency of consumption of feed by broilers was identified using the feed conversion ratio that may be calculated by formula 1:

$$FCR = \frac{\text{Total Feed Consumed}}{\text{Total Live Weight}} \quad (1)$$

where:

FCR - feed conversion ratio (ROSS-308 Broilers Management Handbook, 2014).

However, the economic indicators of broiler productivity and growth were calculated using the production efficiency factor. It takes into account the live weight, age and survival of broilers and their feed conversion and may be calculated by the formula 2:

$$PEF = \frac{\text{Livability} \times \text{Liwe Weight (kg)}}{\text{Age in Days} \times FCR} 100 \quad (2)$$

Where:

PEF - production efficiency factor;

FCR - feed conversion ratio (Broilers ROSS Management Handbook, 2014).

Data on broiler chicken live weight were analysed by the analysis of variance (ANOVA) at the significance level α=0.05.

Research results and discussion

Effect of faba bean diets on broiler chicken feed costs

In raising the production efficiency of broiler chicken meat, it is important to achieve increases in the live weight of broilers as well as to reduce the cost of feed consumption in order to increase the productivity efficiency index. In this aspect, an important factor is the cost of feed and the cost of crude protein available in feed.

The soybean oil meal added to the experimental feed mixture contained, on average, 50.61 % crude protein in the dry matter sample and 44.24 % in the natural one. However, the amount of crude protein in the dry matter of faba beans ranged from 26.86 % to 31.68 %, while for peas it ranged within 18.57-26.38 %. The soybean oil meal contained 1.72-1.96 times more crude protein than it was in peas and faba beans; it indicated that peas and beans could not fully replace soybean oil meal in standard poultry feed mixtures because of a lower crude protein content – the crude protein was substituted only partially.

To provide the amount of crude protein needed for broilers at the growth stage (10-26 days), they were fed a diet containing 28-30 % soybean oil meal, while at the finishing stage (from 27 days) they were fed a diet with 18-24 % soybean oil meal (Ross 308 Broiler: Nutrition Specifications, 2014).

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Table 1

Basic and conditioned feeds evaluated in the dietary experiment on broiler chickens

Broiler group	Experimental feed ration
Group 1 – control (n=30)	Basic feed (BF)
Group 2 – trial (n=30)	BF with 5% Vicia faba minora 'Lielplatone'
Group 3 – trial (n=30)	BF with 10% Vicia faba minora 'Lielplatone'
Group 4 – trial (n=30)	BF with 10% Pisum sativum 'Bruno' + 5% Vicia faba minora 'Lielplatone'

Source: authors' construction based on the feeding experiment

At the growth and fattening stages, 3-8% soybean oil meal in the ration for the experimental groups was replaced with faba beans and peas grown in Latvia, which reduced the cost of feed for the experimental groups (Table 2).

Table 2

Cost of feeds used for broilers in the dietary experiment

Indicator	Growth stage (11-26 day)				Finishing stage (27-42 day)			
	1*	2	3	4	1*	2	3	4
Soybean meal content in feed, %	28.00	25.06	22.11	20.05	21.00	18.06	15.12	13.04
Cost of feed with soybean meal, EUR	0.48	0.43	0.38	0.34	0.44	0.38	0.32	0.27
Pea content, g kg-1 feed	-	-	-	100.0	-	-	-	100.0
Pea price, EUR kg-1 feed	-	-	-	0.03	-	-	-	0.03
Faba bean content, g kg-1 feed	-	50.0	100.0	50.0	-	50.0	100.0	50.0
Faba bean price, EUR kg-1 feed	-	0.01	0.03	0.01	-	0.01	0.03	0.01
Feed price, total , EUR kg-1	0.480	0.44	0.41	0.39	0.44	0.39	0.35	0.32
Feed price to control, EUR		-0.04	-0.07	-0.09	-	-0.05	-0.09	-0.12

** control group*

Source: authors' calculations based on the dietary experiment

The market price of faba beans and peas grown in Latvia was 0.29-0.30 EUR kg^{-1} on average, while that of soybean oil meal was 0.65 EUR kg^{-1}. The price of feed for the control group at the intensive growth stage (11-26 days) was 0.48 EUR kg^{-1} and 0.44 EUR kg^{-1} on average at the fattening stage (from 27 days). By replacing soybeans with faba beans and peas in the diet for the experimental groups, the cost of a unit of feed decreased by 0.04-0.09 EUR kg^{-1}. As one can see, the cost of faba beans and peas is lower than that of soybean oil meal; yet, the amount of crude protein and its cost per feed unit are important in identifying the economic efficiency of feedstuffs (Table 3).

According to the calculations, the cost of crude protein available in soybean oil meal is 0.18-0.38 EUR kg^{-1} higher than that in faba beans and peas (Table 3).

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Table 3

Costs of crude protein of peas, beans and soya meal

Indicator	Peas	Faba beans	Soybean meal
Trial feed trading price, EUR kg-1	0.30	0.29	0.65
Protein content in feed, g kg-1	232.07	265.62	442.38
Cost of crude protein, EUR kg-1	1.29	1.09	1.47
Cost of crude protein, as compared with soybean meal, EUR kg-1	-0.18	-0.38	-

Source: authors' calculations based on the feeding experiment

Table 4

Feed consumption and feed costs for trial broilers

Indicator	Experimental group			
	1*	2	3	4
Growth stage feed costs, EUR kg^{-1}	0.480	0.443	0.408	0.388
Finishing stage feed costs, EUR kg^{-1}	0.440	0.392	0.346	0.317
Average feed costs, EUR kg^{-1}	0.460	0.418	0.377	0.353
Feed consumption per broiler during the breeding period, kg	4.30	4.30	4.40	4.36
Total feed cost for growing a broiler, EUR	1.978	1.795	1.659	1.537
compared with the control group, EUR	-	-0.183	-0.319	-0.441
compared with the control group, %	-	-9.25	-16.13	-22.30
Feed costs for production of 1 kg live weight gain, EUR	0.758	0.667	0.609	0.578
compared with the control group, EUR	-	-0.091	-0.149	-0.180
compared with the control group, %	-	-12.01	-19.66	-23.75

** control group*

Source: authors' calculations based on the feeding experiment

The price of feed for the control group was 0.48 EUR kg^{-1} at the growth stage (11-26 days) and 0.44 EUR kg^{-1} at the finishing stage (27-42 days). By including peas and beans grown in Latvia in the diet (for the experimental groups), the costs of feed fed to the broilers were within the ranges of 0.388-0.443 EUR kg^{-1} (11-26 days) and 0.317-0.392 EUR kg^{-1} (27-42 days). Overall, the cost of feed to produce a broiler in the control group (Group 1) was the highest (EUR 1.978), whereas that in the experimental groups was 9.25-22.3 % lower, i. e. from EUR 1.795 (Group 2) to EUR 1.537 (Group 4). The decrease in feed cost to produce 1 kg of live weight of broilers for the experimental groups reached 12.01-23.75 % compared with the control group. It means that it was possible to provide an adequate amount of crude protein and to lower the unit production cost by replacing soybean oil meal with peas and faba beans in the broiler diet for the experimental groups.

Effect of faba bean and pea diets on broiler chicken productivity

The efficiency of use of peas and faba beans in broiler diets was assessed according to the most important productivity indicators: change in live weight, daily live weight gain rate, feed consumption, cost per 1 kg live weight and productivity index.

The live weight of broilers at the selling age, i. e. 42 days of age was, on average, from

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2608.93±284.73 g for group 1 (control) to 2725.10±299.47 g for group 3 (with 10 % faba beans in the diet) (Table 5).

Table 5

Broiler chicken live weight control before feed change and prior to slaughter

Group	Broiler chicken live weight, g		
	10 days of age	**27 days of age**	**42 days of age**
Group 1 – control	284.81 ± 21.36	1503.85 ± 171.46	2608.93 ± 284.73
Group 2 – trial	290.89 ± 27.22	1725.11 ± 237.05	2690.56 ± 298.10
Group 3 – trial	288.23 ± 19.19	1706.20 ± 173.55	2725.10 ± 299.47
Group 4 – trial	271.50 ± 22.12	1657.83 ± 185.29	2660.53 ± 312.18
Group	**P value comparison between the control and trial groups**		
Group 1 – control	-	-	-
Group 2 – trial	NS	S*	NS
Group 3 – trial	NS	S*	NS
Group 4 – trial	S**	S*	NS

*Data are presented as means ± SD (standard deviation); S** significant difference (P<0.05), less live weight; S*: significant difference (P<0.05), higher live weight; NS: not significant difference (P>0.05)*

Source: authors' calculations based on the feeding experiment

Although the live weight of broilers at the age of 42 days in all the experimental groups exceeded the control group indicators by 1.97-4.45 %, yet, no statistical differences were observed among the groups (Table 5). It has to be noted that before the experiment the live weight of broilers in group 4 was considerably lower (P<0.05); yet, after replacing soya protein with a 5 % mixture of faba beans and peas, an intensive live weight gain increase was achieved and at the age of 27 days the live weight of broilers (1657.83 g) in this group was significantly greater (P<0.05) than that in the control group (Table 5).

Feed absorption and conversion is an important criterion that affects the productivity of broilers. The effectiveness of use of feed is characterised by the feed conversion ratio (FCR), which is computed as a ratio of the amount of feed consumed to the gain in live weight. In broilers highest proportion from feed ingested are used for growth because for maintenance function have low requirements. Therefore, feed efficiency is very good in broilers which induced decreased FCR value (Leeson et al., 1996). A lower FCR indicates better feed conversion and higher economic efficiency, which means that less feed has to be consumed to gain 1 kg live weight of broilers.

The real consumption of feed for group 3 and group 4 was higher by 1.39-2.32 % than that for the control group, while the consumption of feed for group 2 was similar to that for the control group. However, feed conversion for all the experimental groups after faba beans and peas were added to feed mixtures was lower by 0.61-3.64 % than that for the control group. The highest feed conversion ratio was observed for the control group at 1.65 kg feed per kg live weight gain. The best results were achieved in group 2 where 1.65 kg feed were necessary to produce 1 kg live weight, which was 0.05 kg less than for the control group (Table 6). It indicates that the conversion of nutrients in the intestinal tract of broilers in this group took place more intensively than that in the other experimental groups. High feed consumption to produce 1 kg live weight was observed for group 4 (1.64 kg/kg). It means that in such a combination, the use of the mixture of faba

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beans and peas is as effective and efficient as the use of a single legume in the broiler diet.

Table 6

Productivity per broiler chicken obtained in the dietary experiment

Indicator	Experimental groups			
	1*	2	3	4
Broiler chicken live weight at the age of 42 days, g	2608.93 ±284.73	2689.75 ±298.10	2725.10 ±299.47	2660.53 ±312.18
% relative to control	100.00	103.09	104.45	101.97
Feed consumption per broiler during the breeding period, kg	4.30	4.30	4.40	4.36
% relative to control	100.00	100.00	102.32	101.39
Feed conversion ratio (FCR), kg kg-1	1.65	1.60	1.61	1.64
% relative to control	100.00	96.36	97.57	99.39
Production efficiency factor (PEF)	383.96	408.11	409.39	393.80
± relative to control	-	24.16	25.44	9.85

** control group; Data are presented as means ±SD (standard deviation)*

Source: authors' calculations based on the feeding experiment

The economic aspects of interaction among the live weight, survival, feed conversion and production length of broilers are characterised by the production efficiency factor (PEF). The highest PEF indicates optimum return on production resources (Samarakoon, Samarasinghe, 2012). It shows that the most appropriate selling age of broilers is reached at the highest PEF. In the context of the experiments, the PEF was employed to identify economic return on feeding faba beans compared with the use of soya protein in the broiler diet.

The PEF for all the experimental groups was 9.85-25.44 units higher than that for the control group (383.96), which proves that it is economically efficient to replace some amount of soya protein with the protein of faba beans and peas grown domestically in the broiler diet. The highest PEF was identified for group 3 at 409.39, i.e. 25.44 units more than for the control group (Table 6).

Conclusions, proposals, recommendations

1) By replacing soya with faba beans and peas in the diets of broilers in the experimental groups, the feed unit cost decreased by 0.04-0.09 EUR kg^{-1}. The costs of 1 kg crude protein in faba beans (1.09 EUR kg^{-1}) and peas (1.29 EUR kg^{-1}) were lower - EUR 0.38 and EUR 0.18, respectively compared with the cost of crude protein in soybeans (1.47 EUR kg^{-1}).

2) The cost of feed to produce a broiler was the highest for the control group (EUR 1.978), while the lowest cost was observed for group 4 (EUR 1.537); the costs for the experimental groups were 9.25-22.3 % lower.

3) At the age of 42 days, the live weight gain rates for all the experimental groups exceeded that for the control group by 1.97-4.45 %, which indicated higher feed conversion for the experimental groups; yet, no statistically significant differences were observed among the groups.

4) Feed conversion or the consumption of feed to gain 1 kg live weight for all the experimental groups after faba beans and peas were added to feed mixtures was lower by 0.61-3.64 % than that for the control group.

5) The production efficiency factor for all the experimental groups was lower

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(by 9.85-25.44 units) compared with the control group; it indicates it is economically efficient to replace some amount of soya protein with the protein of faba beans and peas grown domestically in the broiler diet.

6) The experimental results showed that the rations of faba beans in the broiler diet, which replace soybean oil meal, meet the physiological requirements of the organism of broilers and provides the broilers with necessary nutrients, thereby contributing to their growth and increases in their live weight, reducing feed costs and resulting in increases in economic return.

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