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PEA SEEDS AND ALFALFA HAY PELLETS: TO INCREASE THE ECONOMIC RETURN OF POULTRY FARMS

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Abstract. The output of poultry products by poultry enterprises in the world was mainly determined by feeding techniques and poultry productivity. The productivity of poultry is characterised by the rate of egg-laying or the number of eggs produced per hen a year and affected by the availability and diversity of feed materials (especially protein). In recent years, researchers have focused on legumes of various species as promising sources of protein for livestock production, such as beans, peas, lupine, alfalfa etc.; therefore, in Latvia more attention is paid to the production of protein crops or legumes. The aim of the research was to identify the impact of domestically sourced legume seeds included in diets for laying hens on the economic performance of egg production. Two kinds of protein crops were examined by the research: peas `Bruno` and dried alfalfa pellets. Feeding laying hens with peas or dried alfalfa pellets made it possible to produce eggs with a heavier weight (55.28-67.07%), which in turn makes it possible to increase revenues (10.3-12.9%) from the sales of eggs with the same feed consumption

Keywords: poultry farming, egg production, peas, feed efficiency, alfalfa.
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Introduction

Livestock and poultry farming play a crucial role in meeting the nutritional needs of the population. In addition, the industry is of great economic importance in the context of rural development, as enterprises of all sizes provide jobs and incomes to the population, as well as agricultural inputs for the secondary sector. Poultry farming is an integral part of the agricultural industry, producing high-quality products for the domestic and export markets. In Latvia, poultry are raised not only on large and intensive poultry farms but also on small farms, which operate in accordance with the rules of both the conventional and the organic farming systems. In 2020, a total of 3347 farms keeping laying hens were registered in Latvia, which was 69.2% more than 10 years ago (ADC, 2022). The proportion of egg products in the total value of final agricultural output was 2.9%, while the total export value of eggs and egg products in 2020 was EUR 25.6 mln. (CSB, 2021).

In poultry farming, the economic efficiency of farms depends directly on the productivity of poultry, which is influenced by a number of factors: genetic, housing technologies, feed materials etc. Efficiency is a widely used term in economics and could be defined as the success of a firm in producing as much output as possible from a certain amount of raw materials (Farrel M.J., 1957), which is determined by the cost of raw materials and efficient use of resources, while producing quality products in line with market requirements. From the economic perspective, the factors directly related to feeding livestock make a significant impact on the economic performance of farms, which is largely due to the high proportion of poultry feed costs (60-75%) in the total production cost (Soto et al., 2013). Appropriate feed significantly helps to increase livestock productivity both in terms of quality and quantity. Combining various feed materials to prepare compound feed changes the price of the feed fed to laying hens and, consequently, the cost of producing the eggs. The main nutrients required for the diet of laying hens are metabolic energy, crude protein, amino acids, macronutrients, micronutrients, vitamins and essential fatty acids (Liu et al., 2015). Complete poultry feed traditionally contains unprocessed crop products: grains, maize processing products and crop processing products or by-products: soybean and sunflower meal, bran, rapeseed and linseed oil etc.

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Soybeans are known to be a high-quality component of compound feed due to their high protein content (more than 40%) and balanced amino acid content and are an important source of protein (Ali et al., 2020) for poultry in most European countries. However, taking into account the business interests of poultry farming as a kind of economic activity, the economic goal of creating the nutrient content and composition of poultry feed is to achieve optimal farm performance at minimal costs. According to European Commission (2021), EU crop production is dominated by food-grade wheat and rapeseed, while high-protein content crops are imported from third countries. Over the last five years in the EU, cereals represented the largest source of feed protein (an average of 130.8 mln. tonnes or 14 mln. tonnes of crude protein) with self-sufficiency at 90%, whereas self-sufficiency in the second largest source of feed – soybeans (an average of 29 mln. tonnes or 13.37 mln. tonnes of crude protein) was only 5%. As a result, the economic efficiency of the EU poultry industry makes a significant impact on feed prices on commodity exchanges; therefore, it is important to reduce the livestock industry's dependence on fluctuations in the market prices of imported feed. Available research studies show that legumes such as beans, peas, lupine and alfalfa, which could be successfully grown in Europe and Latvia, contain moderately high levels of protein and their amino acid profiles are generally comparable to that of soybean meal (Ali et al., 2020; Olukosi et al., 2019) and can partially meet the need for feed protein. However, their use for feed in the EU has so far been very insignificant, only 3 mln. tonnes or 2% of the total quantity of feed protein consumed (European Commission, 2021). From the zootechnical perspective, an optimal amount of legume seeds in protein-rich feed (concentrates) for various species of animals and birds is indicated in the range of 15-30% (Nalle C., 2009; Volpelli et al., 2012), while that of protein-rich crop granules and silage should be in the range of 20% (Carrasco et al., 2016). Currently, an average amount of legume seeds in industrial compound feeds is only 1.5% of the total amount of protein-rich crops (Feed and food, 2020). This means that the capacity to use legume seeds makes it possible to significantly increase the amount of legume seeds in feed and self-sufficiency in protein in the EU. It should be noted that an increase in self-sufficiency in feedstuffs and a corresponding decrease in imported feed are prescribed by the guidelines for a sustainable agricultural conception based on agro-ecology and a systemic approach to promote sustainable, flexible, cost-effective and stable farming systems (Naglis-Liepa et al., 2021).

Accordingly, for sustainable growth in the egg production industry, it is necessary to decrease imports of protein-rich crops through producing protein-rich, domestically sourced compound feeds, while reducing the cost of production of livestock products without reducing the level of productivity in poultry farming.

Knowledge of the feed required for productive poultry and its rational and efficient use is based on the physiological and biological processes of animal metabolism (Zampiga et al., 2021). However, it should be emphasized that the feedstuffs used for animal feed make an impact on animal productivity and, consequently, on the economic performance of the farm. Therefore, the **aim** of the research was to identify the impact of domestically sourced legume seeds included in diets for laying hens on the economic performance of egg production.

Research approach and methods

To assess a possibility to include legume seeds in poultry feed for laying hens, various feed recipes were designed to include legume seeds: peas (*Pisum sativum*) and alfalfa (*Medicago sativa L*) pellets. The feeding experiment was conducted for 24 weeks (May-October) on Lohmann brown laying hens (starting at 50 weeks of age). The research was done in the commercial environment, at a hen house of the farm 'Imantas' where the hens were kept under a free-range system on deep litter, the floor in the hen house was covered with chopped wheat straw. Hens had access to pens located directly behind the hen house,

and each group used a separate pen. The laying hens (n=125) were divided into 5 analogous groups kept under conditions meeting animal welfare requirements. Diets for all the groups of laying hens were balanced in accordance with the dietary guidelines for the cross Lohmann Brown (Management Guide – Lohmann …, 2018).

For the experimental groups, the diets were balanced to meet the protein requirement. For the control and experimental groups, the diets contained ground maize (160-270 g kg^{-1}), barley (390-500 g kg^{-1}), oats (120-170 g kg^{-1}) and an industrial feed premix (80 g kg^{-1}). For the experimental groups, the diets were added peas in two different amounts (50 g kg^{-1} and 100 g kg^{-1}) and two different amounts of alfalfa pellets (50 g kg^{-1} and 100 g kg^{-1}). The required amounts of calcium carbonate and micronutrients were included in equal amounts in the diets for all the experimental groups. The amount of feed per laying hen per day in the control group (C) was the same as practised on the farm, i.e. 125 g per day with a protein content of 15.92±0.21 g. For the experimental groups, the amount of feed was reduced to 115 g per day per laying hen, providing an equivalent amount of protein per hen per day: 15.46±0.22 g for group T1, 15.48±0.58 g for group T2, 15.43±0.32 g for group T3 and 15.46±0.14 g for group T4.

The economic efficiency of compound feed used for egg production was identified in terms of rate of egg-laying (number of eggs laid during the experimental period), egg-laying intensity (Hen-Housed Egg Production (HHEP) for an experimental period) (the rate of egg-laying against the maximum rate of egg-laying during the experimental period divided by the initial number of laying hens and expressed in percentage terms) egg weight (eggs were weighed on an electronic scale to the nearest 0.01 g), feed cost, feed conversion 1 (kg of feed per 1000 eggs produced) and feed conversion 2 (kg of feed per kg of eggs produced).

Research results and discussion

Quality feed and compound feed play a particularly important role in the intensive production of table eggs. Laying hens react to an unbalanced diet by reducing the rate of egg-laying, which makes a negative impact on the financial performance of the farm. Large poultry farms mainly use balanced compound feed, whereas small farms often use on-farm produced compound feed, which consists mostly of grains supplemented with an adequate amount of protein-rich feedstuffs. According to Spring (2014), the cost of feed for poultry is a major problem for laying hen farmers, as the price of feed is high and the selling price of eggs is low. The price of eggs in Latvia has decreased by 22% from January 2018 to December 2020, while the EU average egg price has decreased by 28% from January 2018 to December 2020 (Annual Agricultural Report, 2021). High feed prices are often referred to as a cause of losses for poultry farms.

From an economic point of view, according to Fatica et al. (2022), pea diet was cheaper than soy diet (0.40% as feed and 5.00% as dry matter (DM). Research by Koivunen et al. (2015) found that if including up to 300 g kg^{-1} peas in the poultry diet, the protein from peas was able to replace approximately 44% of the protein from soybean meal (SBM) without making negative impacts on the production performance and egg quality. However, in their research on ground alfalfa hay fed to laying hens, Laudadio et al. (2014) found that no significant decrease in productivity or egg quality was observed, and the inclusion of ground alfalfa hay in the poultry diet might be the most cost-effective and appropriate way for increasing egg-laying intensity and egg quality. In research studies on the organic farming system, laying hens were fed alfalfa silage, which resulted in higher egg quality, however, the rate of egg-laying, egg weight and production costs did not differ significantly from those in the control group (Wüstholz et al., 2017). At the same time, it should be noted that there are few research studies on the economic performance of various legume seeds and the impact on feed costs for the farm. In our experiment, the cost of feed for hens was

calculated per 100 kg of feed. If providing an equivalent amount of protein in the diet, according to the experimental data, the feed cost varied within 5.56%. The lowest feed costs were found for group T1, which was fed with 5% peas `Bruno` (33.46 EUR) and for group T2 fed with 10% peas `Bruno` (33.89 EUR), which was EUR 0.54 or 1.59% less for group T1 and EUR 0.11 or 0.32% less for group T2 than for the control group (Table 1). For group T3, which was fed a diet with 5% alfalfa hay pellets, the feed cost was equivalent to that for the control group. The highest feed cost was found for group T4, the diet of which contained 10% alfalfa pellets, i.e. EUR 35.35 per 100 kg-1, which was EUR 1.35 or 3.97% more expensive than the feed fed to the control group.

Table 1

Composition and cost of feed for laying hens

Feedstuffs	Price, Eur kg^{-1} (no VAT) *	C (control)		T1 (exper.)		T2 (exper.)		T3 (exper.)		T4 (exper.)	
		kg	EUR	kg	EUR	kg	EUR	kg	EUR	kg	EUR
Ground maize	0.36	25.00	9.00	19.00	6.84	27.00	9.72	16.00	5.76	20.00	7.20
Barley	0.31	50.00	15.50	50.00	15.50	39.00	12.09	50.00	15.50	45.00	13.95
Oats	0.22	13.00	2.86	14.00	3.08	12.00	2.64	17.00	3.74	13.00	2.86
Peas	0.28	×	×	5.00	1.40	10.00	2.80	×	×	×	×
Alfalfa hay pellets	0.47	×	×	×	×	×	×	5.00	2.35	10.00	4.70
Premix	0.75	8.00	6.00	8.00	6.00	8.00	6.00	8.00	6.00	8.00	6.00
Calcium carbonate	0.16	4.00	0.64	4.00	0.64	4.00	0.64	4.00	0.64	4.00	0.64
Total:	**×**	**100.00**	**34.00**	**100.00**	**33.46**	**100.00**	**33.89**	**100.00**	**33.99**	**100.00**	**35.35**
% against group C	×	×	100.00	×	-1.59	×	-0.32	×	-0.03	×	3.97
± against group C, EUR	×	×	×	×	-0.54	×	-0.11	×	-0.01	×	1.35

Source: author's calculations based on feeding experiment

**** at market prices in January 2020 in Latvia.***

It could be concluded that alfalfa pellets increased feed costs, which might to some extent limit the inclusion of this feedstuff in the diet for laying hens. During the feeding experiment (184 days), a total of 13 207 eggs were produced by all the groups. The most eggs were produced by group T2 laying hens (2778 pcs), the diet of which contained 100 g kg^{-1} peas and group T3 laying hens (2776 pcs) fed a diet containing 50 g kg^{-1} alfalfa pellets, which was 11.66% and 11.58%, respectively, more that in the control group.

Table 2

Productivity indicators of laying hens in the experimental groups

Indicators	C (control)	T1 (exper.)	T2 (exper.)	T3 (exper.)	T4 (exper.)
Total eggs, pcs	2488	2681	2778	2776	2484
% against group C	×	7.76	11.66	11.58	-0.16
HHEP*, %	54.09	58.28	60.39	60.35	54.00
Average egg weight, g	68.58±6.85	73.37±6.29	67.22±5.49	69.65±5.54	68.57±5.58
% against group C	×	6.98	-1.98	1.56	-0.02

Source: author's calculations based on feeding experiment

****HHEP - Hen-Housed Egg Production for the experimental period (184 days)***

In group T1 (2681 eggs), the rate of egg-laying was 7.76% higher than that in the control group. The lowest rate was found in group T4, which was similar to that in the control group. The results of the

experiment revealed that the inclusion of legumes – peas (groups T1 and T2) and alfalfa pellets (group T3) – in the diets yielded a positive result, thereby giving the farm additional revenue from egg production.

During the experimental period, the laying intensity of hens (HHEP) ranged from 54.00 to 60.39%, which was 21 to 27 percentage points lower than indicated in the 2020 manual by the company Lohman Breeders during the respective laying period under intensive production conditions (Lohmann Brown-Classic…, 2020). This could be partly explained by extensive production conditions on the farm and the extent to which the feed was balanced. The average egg weights in experimental groups T1 (73.37±6.29 g) and T3 (69.65±5.54 g) were 6.98% and 1.56% higher, respectively, than in the control group (68.58±6.85 g), while in groups T2 and T4 the average egg weights were 1.98% and 0.02% lower than that in the control group.

Overall, the average weight of eggs produced by all the experimental groups was higher than that indicated in the 2020 manual by the company Lohman Breeders – the average weight of eggs in the respective laying period ranged from 64.2 to 69.5 g. Laying intensity was higher in groups T1, T2 and T3, fed with peas and alfalfa pellets, than in the control group.

Table 3

Consumption and cost of feed for laying hens

Indicators	C (control)	T1 (exper.)	T2 (exper.)	T3 (exper.)	T4 (exper.)
Feed per chicken per day, kg	0.125	0.115	0.115	0.115	0.115
Feed conversion 1 (1 000 egg production), kg	231.11	197.31	190.42	190.56	212.96
% against group C	×	-14.62	-17.60	-17.54	-7.85
± against group C, kg	×	-33.79	-40.68	-40.55	-18.15
Feed conversion 2 (1 kg egg production), kg	3.37	2.88	2.78	2.78	3.11
% against group C	×	-14.62	-17.60	-17.54	-7.85
± against group C, kg	×	-0.49	-0.59	-0.59	-0.26
1 000 egg production, EUR	78.58	66.02	64.53	64.77	75.28
% against group C	×	-12.56	-14.04	-13.81	-3.29
± against group C, EUR	×	-15.98	-17.87	-17.57	-4.19

Source: author's calculations based on feeding experiment

The addition of peas and alfalfa pellets to feed for laying hens increased the productivity of laying hens and reduced feed consumption. Feed conversion 1 or feed consumption per 1000 eggs produced by all the experimental groups was less than 18.15-40.68 kg or 7.85-17.60% lower than that in the control group (231.11 kg of feed). However, to produce 1 kg of eggs, the experimental groups consumed 0.260 to 0.590 kg less feed than the control group (3.37 kg) did.

Table 4

Egg sale revenues by egg weight grading

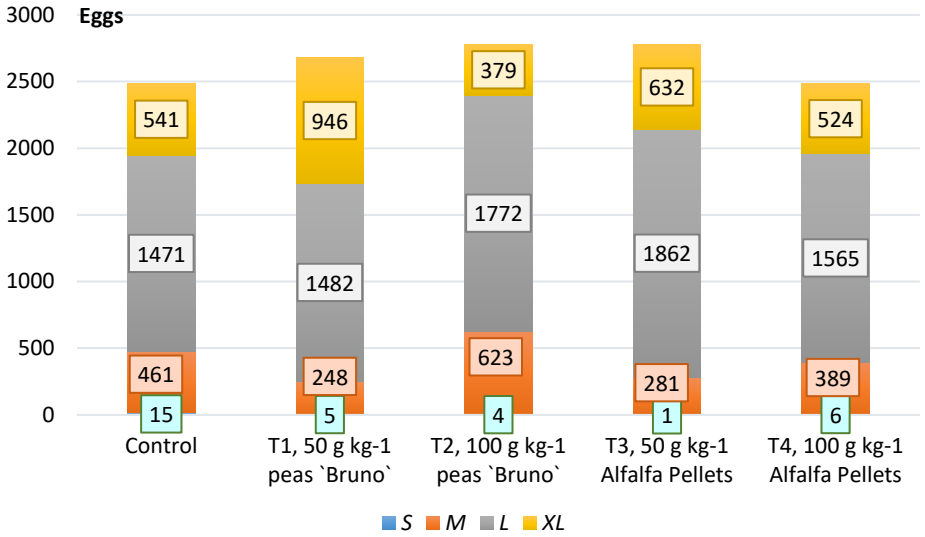
Indicators	**Egg weight grades**				**Total**
	S	*M*	*L*	*XL*	
	>53, g	*53.0-62.9, g*	*63.0-72.9, g*	*73.0<, g*	
Average price, EUR per pc*	0.10	0.20	0.22	0.25	×
C (control)	15	461	1471	541	2488
% of total eggs	0.60	18.53	59.12	21.74	100
Revenue from egg sales, EUR	1.5	92.2	323.62	135.25	552.57
T1 (experimental)	5	248	1482	946	2681
% of total eggs	0.19	9.25	55.28	35.29	100
Revenue from egg sales, EUR	0.50	49.60	326.04	236.50	612.64
T2 (experimental)	4	623	1772	379	2778
% of total eggs	0.14	22.43	63.79	13.64	100
Revenue from egg sales, EUR	0.40	124.60	389.84	94.75	609.59
T3 (experimental)	1	281	1862	632	2776
% of total eggs	0.04	10.12	67.07	22.77	100
Revenue from egg sales, EUR	0.10	56.20	409.64	158.00	623.94
T4 (experimental)	6	389	1565	524	2484
% of total eggs	0.24	15.66	63.00	21.10	100
Revenue from egg sales, EUR	0.60	77.80	344.30	131.00	553.7

Source: author's calculations based on feeding experiment

**** at retail prices as at 20/01/2022 in Latvia***

The highest cost to produce 1000 eggs was found for the control group at EUR 78.58; among the experimental groups, the highest feed cost (EUR 75.28) was found for group T4, while the lowest costs were found for group T2 (EUR 64.53) and group T3 (64.77 EUR).

An important indicator for egg production farms is the number of eggs produced; however, from the perspective of sales, an important indicator is the grade and size of eggs produced, which significantly affects the selling price of eggs. Even with a large number of eggs produced, revenue for the farm is small if the egg weight is light. The weight of eggs determines which category they fall into and how much the producer gain from the sales of the eggs. Category A eggs produced during the experiment were graded by size: XL – more than 72 g, L – 63-72 g, M – 53-62 g and S – less than 53 g (Commission Regulation (EC), 2008), and potential revenue from the sales of eggs was calculated according to the average selling price of eggs of the respective size in the market.



Source: author's calculations based on feeding experiment

Fig. 1. **Distribution of eggs produced during the experiment by egg weight grading**

Overall, across all the groups, the majority of eggs (8152 pcs or 55.28-67.07%) corresponded to size L with a weight of 63.0-72.9 g. The second largest number of eggs produced (3022 pcs) corresponded to extra-large size XL with a weight of more than 73 g. Size M eggs totalled 2002, representing 15% of the total number of eggs produced. Groups T1, T2 and T3 produced 2681-2778 eggs, thereby allowing the producer to earn EUR 609.59-623.94 if selling the eggs by weight class, which would be 10.3-12.9% more than potential revenue from the eggs produced by the control group and group T5. It should be noted that 31 eggs corresponding to size S, i.e. weighing up to 53 g, were produced throughout the feeding experiment.

Across all the groups, according to the results of the experiment, the largest proportion was comprised of size L eggs; a positive result was that the groups fed with both peas and alfalfa pellets produced 6.39-26.58% more size L eggs than the control group did. However, the number of small (size S) eggs produced by these groups was many times smaller.

An analysis of differences between the costs of feed for hens and revenues from egg sales (Table 5) reveals that the groups fed with 5% and 10% peas (T1 and T2) and the group fed with 5% alfalfa pellets (T3) provided significantly higher revenues (10.32-12.92%) than the control group did, which was due to higher rates of egg-laying as well as a larger number of eggs of sizes L and XL produced by these groups, compared with the control group. The cost-revenue difference found for these groups was 22.0-24.38% higher than that for the control group. The revenue from eggs produced by group T4 fed with 10% alfalfa pellets was equal to that for the control group; however, the difference between egg sales and feed costs exceeded that for the control group by 2.7%, which could be explained by a larger number of eggs of sizes L and XL produced by this group.

Table 5

Feed costs and sale revenues during the experimental period

Indicators	C (control)	T1 (exper.)	T2 (exper.)	T3 (exper.)	T4 (exper.)
Feed costs for egg production, EUR	195.50	177.00	179.28	179.81	187.00
± against group C, EUR	×	-18.50	-16.22	-15.69	-8.50
% against group C	×	-9.46	-8.30	-8.03	-4.35
Revenue from egg sales, EUR	552.57	612.64	609.59	623.94	553.70
± against group C, EUR	×	60.07	57.02	71.37	1.13
% against group C	×	10.87	10.32	12.92	0.20
Revenue-cost difference, EUR	357.07	435.64	430.31	444.13	366.70
± against group C, EUR	×	78.57	73.24	87.06	9.63
% against group C	×	22.00	20.51	24.38	2.70

Source: author's calculations based on feeding experiment

An increasing number of consumers believe that the price of food indicates the quality of it, while others still believe that the price indicates the attitude of the producer to sustainability and the non-financial value invested in it, incl. the improved welfare of food-producing animals. At the same time, the willingness of consumers to pay more for the final product if the producer ensures sustainability in production should be stressed. In poultry farming, it is the willingness of consumers to pay more for eggs produced under the free-range system (1–free-range conditions or 0–free-range conditions on an organic farm) compared with traditional caging techniques. In this case, it should be pointed out that the retail prices of eggs produced under the free-range system are between 25% and 40% higher (Chang et al., 2010) than those of eggs produced by laying hens kept in barns or in cages.

Conclusions, proposals, recommendations

1) The analysis of economic aspects regarding including domestically sourced feeds – peas `Bruno` and dried alfalfa granules – in diets for laying hens revealed that the feeds could be recommended for use on poultry farms to increase productivity.
2) The experimental data showed that the inclusion of 50-100 g kg^{-1} peas and 50 g kg^{-1} dried alfalfa pellets in poultry diets led to an increase in egg-laying intensity, improved feed conversion and reduced feed cost for egg production.
3) Feeding laying hens with peas or dried alfalfa pellets led to heavier weight eggs (sizes XL and L), which made it possible to increase revenue from egg sales with the same feed consumption.

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