ECONOMIC GAINS FROM CONSUMPTION OF LEGUMES IN DAIRY FARMING

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Abstract. In many countries research investigations into protein sources have been conducted, as a high protein content feedstuff is the most expensive component of a feed ration. Faba beans and peas are highly productive crops and their economic role is large, seeds are prime quality feed concentrate for poultry and agricultural animals, as they comprise 22-35 % protein. The difference in the protein content of feedstuffs can considerably affect the cost of the feedstuffs. In this context the research aim is to identify economic gains from the consumption of legumes in dairy farming. Tackling problems with regard to opportunities to reduce milk production costs, a feeding experiment on dairy cows was carried out, replacing soybeans present in the diet with domestically grown legumes – faba beans and peas – to the extent of 22-24 % of the total amount of feed concentrate. An analysis of the effects of the use of faba beans and peas in the dairy cow diet on feed cost and productivity in the experimental period revealed that the daily feed ration cost decreased, the average milk yield was significantly higher and the feed cost per kg milk produced was lower than for the control group.

Keywords: legumes, feed cost, milk production.

Introduction

It is known that cow diets are a factor most promoting or hindering the manifestations of inherited genetic potential of cows, and high milk yields require more feed, especially feed concentrate. At the same time, the proportion of feed cost in total production cost in livestock farming is the highest [1; 2], of which a significant proportion is composed of feed concentrate that increases both the cost of a feed ration and the total production cost of milk. This means that the cost of feed concentrate is one of the cost items that may be varied towards reducing the milk production cost. Therefore, a great focus is placed on the use of cheaper feedstuffs in livestock farming.

Mostly soybean, rapeseed and sunflower cake and meal, the prices of which ranged, on average, from 0.37 EUR·kg^{-1} (rapeseed and sunflower meal) to 0.65 EUR·kg^{-1} (soybean meal) in 2015-2016, are used as sources of protein. Legume seeds – faba beans and peas – may be used as a significant source of protein in diets for dairy cows. Legume seeds are a good source of protein for agricultural animals [3; 4], as they contain 22-35 % protein [5], in some cases even 26-38 % protein [6].

The EU policy on the protection and enhancement of biodiversity on agricultural holdings [7] has contributed to an increase in the area sown with legumes in Latvia. Areas under nitrogen-fixing crops, including faba beans and peas, are eligible for financial support regarding environment-friendly agricultural practices; consequently, the total area under faba beans in Latvia in the period 2010-2016 increased approximately 24 times (from 1.3 thou. ha to 30.9 thou. ha) and that under peas – 7 times (from 1.2 thou. ha to 8.7 thou. ha), while the prices on both pulses, on average, were in the range of 0.29-0.30 EUR kg in the season of 2015-2016, which were lower than on the mentioned rapeseed, sunflower or soybean meal.

This means that the growing area under faba beans and peas in Latvia can supply agricultural animals with the necessary amount of protein as well as increase the proportion of domestic protein-rich feedstuffs in the consumption of feed and reduce the production cost of livestock products, i.e. contribute to higher efficiency.

It has to be pointed out that incorporating cheaper feedstuffs into a feed ration can affect the amount of nutrients that are physiologically necessary for the cow's organism, which meets the needs of the organism and provides a certain productivity level. In this case, animals might have health problems and their productivity might decrease, leading to economic losses resulting in lower profits from milk sales. For these reasons, in the period when a lot of farmers produce and supply to the domestic market faba beans and peas, it is necessary to consider whether it is efficient for a dairy farm to incorporate faba beans in cow diets.

In Latvia, dairy farms have built up experience in the use of legumes – faba beans and peas – in the form of fresh biomass and dried seeds. However, a few research studies that allow identifying the economic efficiency of legumes used in milk production are available.

Therefore, the overall aim of the present research is to identify changes in the economic indicators of milk production if replacing soybeans with faba beans and peas in the diet of dairy cows. To achieve the aim, the following specific research tasks are defined: 1) to identify changes in the indicators of cow productivity in the experimental period; 2) to determine the production cost of milk if replacing soybeans with faba beans and peas in the diet of dairy cows.

Materials and methods

The feeding experiment on dairy cows was conducted in the winter of 2015-2016 from December to February (90 days) on the farm "Upites" in Sigulda municipality. For the experiment, four analogues dairy cow groups were formed; each group comprised five experimental cows ($n = 5$). The dairy cows were selected for the experiment taking into account their lactation phase, live weight, milk yield in the previous lactation, average daily milk yield in the previous monitoring month and milk fat and protein contents.

The experimental groups were fed an equal ration of coarse feeds – hay and feed concentrate – as basic feed. Grain and rapeseed cake, which contain a certain amount of protein and supply the cows with starch for energy, were included in the feed concentrate fed to all the cow groups in equal amount. The present research does not perform dietary energy calculations, but analyses the provision of protein to the cows in the economic aspect if replacing soybeans with faba beans and peas in the cow diet.

In their research studies, a number of authors have found that faba beans may comprise up to 350 g·kg^{-1} of the ration of feed concentrate fed to cows [8]. However, according to some research investigations, pulses may make up not more than 200 g·kg^{-1} of the ration of feed concentrate fed to dairy cows. Latvian researchers Barbals and Brosova [9] recommend incorporating not more than 2 kg of faba beans a day to meet the protein and energy requirements of dairy cows and not to harm the health of the cows.

Table 1

Feed ration and crude protein per cow per day during the trials

Group	Feedstuff	Silage	Hay	Grain	Rapeseed oil cakes	Beans "Lielplatones"	Peas "Bruno"	Soybean cakes	Total
1st group	Feed, kg	30	6	5	1	0.9	0.9	x	43.8
	CP, g	1116	658	477	314	239	209	x	3012
	FC, EUR·kg^{-1}	0.60	0.48	0.75	0.40	0.26	0.27	x	2.92*
2nd group	Feed, kg	30	6	5	1	x	1.9	x	43.9
	CP, g	1116	658	477	314	x	441	x	3005
	FC, EUR·kg^{-1}	0.60	0.48	0.75	0.40	x	0.57	x	2.96*
3rd group	Feed, kg	30	6	5	1	1.7	x	x	43.7
	CP, g	1116	658	477	314	452	x	x	3016
	FC, EUR·kg^{-1}	0.60	0.48	0.75	0.40	0.49	x	x	2.88*
4th group, control	Feed, kg	30	6	5	1	x	x	1	43
	CP, g	1116	658	477	314	x	x	442	3007
	FC, EUR·kg^{-1}	0.60	0.48	0.75	0.40	x	x	0.65	3.04*
CP–Crude protein; FC–Feed costs; *–Total feed costs include the costs of mineral feed (0.16 EUR per cow per day)									

In the experiment, the feed concentrate fed to the control group (4th group) comprised 1 kg soybean cake (140 g·kg^{-1} feed concentrate), while the daily feed ration for the experimental groups contained a mixture of 0.9 kg of faba beans, sort "Lielplatones" (100-120 g·kg^{-1} feed concentrate) and 0.9 kg of peas, sort "Bruno" (100-120 g·kg^{-1} feed concentrate) (1st group), 1.9 kg of peas sort "Bruno" (220-240 g kg^{-1} feed concentrate) (2nd group) and 1.7 kg of faba beans sort "Lielplatones" (220-240 g·kg^{-1} feed concentrate) (3rd group), replacing soybean cake in the feed ration (Table 1).

The daily amount of milk produced was registered and the fat and protein contents of the milk were determined in the experiment. The amount of milk produced was recalculated in terms of energy corrected milk (ECM) by using equation 1 [10]:

$$ECM = MilkYield \times \frac{0.383 \times MilkFat,\% + 0.242 \times Milk\,\mathrm{Pr}otein,\% + 0.7832}{3.14}. \quad (1)$$

Feed cost per kg of milk produced was calculated employing a method for calculating average cost per unit of production (total feed cost divided by the quantity of output) widely used in economic analysis. The research identified differences in the average milk yield and the average composition of milk between the experimental groups and the control group as well as between the end and the beginning of the trial.

Data on the performance of dairy cow productivity were analysed by: a Mann–Whitney test to identify differences relative to the control group and a Wilcoxon signed-rank test to identify differences between data at the beginning and the end of the experiment. Significant differences were accepted if $p < 0.05$ [11; 12]. All statistical analyses were performed using SPSS for Windows version 20.0.

Results and discussion

The need for cheaper protein-rich feedstuffs in livestock farming has been referred to in a number of research studies, which is due to the high proportion of feed cost; as pointed out by Czuowska and Zekao [13], in dairy farming the feed cost accounts for 66 % of total production cost. However, it has to be taken into consideration that the feedstuffs incorporated in cow diets can significantly change milk yields and the cash flow of dairy farms. For this reason, Lima et al. [14] assessed the economic efficiency of feed components used in their dietary experiment in the context of productivity indicators and production cost, thereby identifying the most economically efficient feed ration providing the highest returns.

Table 2

Indicators of productivity in the groups of dairy cows by month and for the entire experimental period (December to February)

Indicators	1st group	2nd group	3rd group	4th group, control
Average milk yield per day, kg: Nov*	28.88±4.41	31.28±2.21	29.68±5.45	28.14±7.07
Dec**	28.90±2.20	30.42±3.24	36.84±3.22[2]	29.82±4.17[2]
Jan**	28.78±2.67	28.72±3.31	34.1±3.71[2]	27.72±4.00[2]
Feb**	26.45±3.35	28.34±3.23	32.00±3.40[2]	26.12±4.07[2]
Fat content, %: Nov*	3.80±0.83	4.07±0.41	4.02±0.58	4.33±0.33
Dec**	4.29±0.49	4.12±0.67	4.38±0.51	4.50±0.62
Jan**	4.42±0.65	4.40±0.22[3]	4.60±0.76	4.76±0.20[3]
Feb**	4.35±0.39	4.79±0.44	4.44±0.55	4.74±0.52
Protein content, %: Nov*	3.23±0.33	3.19±0.20[4]	3.15±0.19	3.36±0.15[5]
Dec**	3.22±0.32	3.22±0.24	3.11±0.25	3.25±0.23
Jan**	3.26±0.34	3.35±0.23	3.33±0.29	3.47±0.27
Feb**	2.72±0.39	3.33±0.19[4]	3.27±0.24	3.47±0.23[5]
Total milk yield per trial, kg[a]	12643.40	13134.30	15475.70	12575.50
difference relative to control, kg	67.90	558.80	2900.20	x
Total fat yield, kg[a]	550.51	580.07	691.91	585.91
difference relative to control, kg	-35.41	-5.84	106.00	x
Total milk protein, kg[a]	390.38	433.32	500.16	426.70
difference relative to control, kg	-36.32	6.61	73.46	X

*–initial stage;**–trial period; [a]–per trial period (from December to February, 90 days); Means with different superscript numbers ('1','2' etc.) are significantly different at $P < 0.05$ in comparison with the control group or initial stage.

In the experiment on dairy cows a decrease in cow productivity, compared with the beginning of the experiment, was observed in the control, 1st and 2nd groups (Table 2), which may be explained by seasonal milk yield fluctuation, yet the observed decrease in productivity was not significant.

An analysis of the changes in cow productivity if incorporating peas (Table 2), beans or a mixture of both pulses in feed concentrate fed to the cows shows no significant differences between the control group and the experimental groups, except for the 3rd group (1.9 kg of beans in the daily feed ration),

the productivity of which, compared with the control group, was significantly higher ($p < 0.05$) and, in total, this group produced 2900 kg of ECM more than the control group did in the entire experimental period. The experimental results showed that compared with the control group, the cow diets comprising faba beans and peas did not significantly affect the fat and protein content of milk. However, it has to be noted that in the experimental period the total decrease in the amount of milk protein produced (by 36.3 kg) was observed in the 1st group (0.9 kg of faba beans and 0.9 kg of peas in the daily feed ration), while a significant total increase in the amount of milk protein produced was recorded in the 3rd group (1.7 kg of beans), which, to a great extent, may be explained by higher milk yields in this group.

Compared with the control group, significant change in the fat content of milk in the experimental groups was observed neither in the first nor in the second trial ($p > 0.05$); however, compared with the beginning of the trial, the total amount of milk fat produced decreased both in the first and the second trial, which may be explained by a decrease in milk yields in that period. An exception was the 3rd group in the second trial (1.9 kg of beans in the daily feed ration), as the total amount of milk fat produced by this group was slightly greater. In the entire experimental period, this group produced 106.3 kg of milk fat more than the control group did (Table 2).

Other research investigations point out that if replacing soybean cake with peas in the ration of feed concentrate for dairy cows (150 g kg^{-1}), no significant changes were observed in the key indicators of cow productivity: milk yield, fat content of milk and protein content of milk [15]. In their research studies, a similar finding was made by Tufarelli et al. [8], who replaced soybeans with faba beans (345 g kg^{-1}) in the ration of feed concentrate for highly productive dairy cows (with the average milk yield of 35 kg per day). However, Mordenti et al. [16] point out that faba beans and peas incorporated in the feed ration for dairy cows (200 g·kg^{-1}) increased the fat content of milk, whereas the milk yield did not change.

Table 3

Milk production costs and protein consumption

Indicator	1st group	2nd group	3rd group	4th group, control
Feed cost per cow, per day, EUR	2.92	2.96	2.88	3.04
Difference relative to control, EUR	-0.12	-0.08	-0.16	x
Total feed cost per group, per trial, EUR	1313.33	1330.88	1296.23	1366.88
Difference relative to control, EUR	-53.56	-36.01	-70.66	x
Difference relative to control, %	-3.90	-2.60	-5.20	x
Average feed cost per kg of milk yield, EUR·kg^{-1}	0.104	0.101	0.084	0.109
Difference relative to control, %	-4.43	-6.78	-22.94	x
Feed protein per kg of milk yield, g·kg^{-1}	107.22	102.97	87.70	107.60
Difference relative to control, %	-0.35	-4.30	-18.49	x
Revenue from milk sales per group per trial, EUR*	2655.11	2758.20	3249.90	2640.86
Income over feed costs per group per trial, EUR	1341.79	1427.33	1953.67	1273.98
Difference relative to control, %	5.30	12.00	53.40	x

* purchase price of milk 0.21 EUR·kg^{-1}

According to the research studies by Silva et al. [17], the activity's economic analysis by production costs and the economic efficiency index, such as gross and net rates, is an aid in decision-taking within the agricultural enterprise. Table 3 shows the difference between revenue from milk sales and cow feed costs (income over feed costs) for the experimental period.

The feed costs in all the experimental groups (1st-3rd groups) were 2.6-5.2 % lower, given the market prices of faba beans and peas in comparison with the price of soybeans. The greatest saving in costs (EUR 70.66) was observed in the 3rd group (220-240 g of faba beans per kg of feed concentrate), EUR 53.56 were saved in the 1st group (100-120 g·kg^{-1} peas and 100-120 g·kg^{-1} beans) and the smallest saving in costs (EUR 36.01) was found in the 2nd group (220-240 g·kg^{-1} peas).

A comparison of feed costs between the control and the experimental groups shows that the feed cost per kg of milk produced in the 1st group was 4.4 % lower. Therefore, the difference between

revenue from milk sales and feed costs (income over feed costs) was 5.3 % greater in the experimental groups than in the control group.

However, the 3rd group, which, compared with the control group, had lower feed costs, demonstrated the best result – a 22.9 % or 2.5 cent lower feed cost per kg of milk produced. A similar trend was observed for the 2nd group – the feed cost in this group was 6.8 % lower than that in the control group.

The smallest amount of feed protein consumed per kg of milk produced was observed in the 3rd group (87.7 $g \cdot kg^{-1}$), which, compared with the control group, was 18.49 % lower. However, the amount of feed protein consumed per kg of milk produced in the 1st group and the control group was the same.

Conclusions

After analysing the experimental results, one can conclude that the experimental feed ration containing faba beans allowed reducing feed costs at the same or higher dairy cow productivity level. It means that replacing soybeans with faba beans resulted in higher returns from the feedstuffs, i.e. the same productivity at less inputs. However, higher production efficiency was achieved by incorporating 1.7 kg of faba beans (220-240 $g \cdot kg^{-1}$) of the total amount of feed concentrate in the daily feed ration for dairy cows.

Compared with the control group, the experimental groups that were fed faba beans and peas demonstrated the following effects:

1. The cost of the daily feed ration was lower: by EUR 0.16 per day for the 3rd group (1.7 kg of faba beans in the daily feed ration), EUR 0.12 for the 1st group (0.9 kg of faba beans and 0.9 kg of peas in the daily feed ration) and EUR 0.08 for the 2nd group (1.9 kg of peas in the daily feed ration);
2. The average daily milk yield was significantly ($p < 0.05$) higher for the 3rd group (1.7 kg faba beans); therefore, this group produced significantly greater amounts of milk, fat and protein. The productivity indicators of the other groups were similar to those of the control group;
3. The feed cost per kg of milk produced was 4.4-22.9 % lower. The best performance with a 22.9 % or 2.5 cent lower feed cost per kg of milk produced was demonstrated by the 3rd group, in the daily feed ration of which 1 kg of soybeans were replaced with 1.7 kg of faba beans.

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