Agronomy Research **15**(5), 2026–2038, 2017
https://doi.org/10.15159/AR.17.027

Peas and beans as a protein feed for dairy cows

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Abstract. The need for alternative protein sources to soybean meal, partially or fully substituted in the diets of dairy cows, is an urgent problem in farming nowadays. Soybean meal is the most common protein source included in feed concentrate for dairy cows in Latvia and in other European countries as well. Among possible alternatives, grain legumes seem interesting for dairy cow diets because of their rapid degradation in the rumen and readily available energy. Peas and beans will be an important source of proteins in feed. Biochemical tests were done on eight samples of domestically grown dried peas of average size, 11 samples of dried beans of average size and some samples of soybean meal to examine the chemical composition of the peas and beans. Peas and beans were included in the feed ration during a feeding trial on dairy cows. Milk yields and milk quality parameters were examined in the trial. The digestibility of peas of most varieties and breeding lines examined was considerably higher than that of soybean meal, while the digestibility of beans of all the varieties and breeding lines examined and of soybean meal was the same. The peas contained more reducing sugars, starches and had a higher value of NEL than the tested beans, which meant the peas had a higher nutritional value. The diets comprising beans and peas fed to the dairy cows increased the fat and protein contents of milk, compared with the control group and the beginning of the trial. The total amount of amino acids increased in the bulk milk samples of all the trial groups during the feeding trial.

Key words: peas, beans, dairy cows, nutritional value, productivity, milk quality.

INTRODUCTION

The need for alternative protein sources to soybean meal, partially or fully substituted in the diets of dairy cows, is an urgent problem in farming nowadays. The use of alternative sources of plant protein to soybean meal in diets for agricultural animals aims to reduce soybean imports into the EU and partially substitute genetically modified organisms in the food chain. Among possible alternatives, grain legume seem interesting for dairy cow diets because of their rapid degradation in the rumen and readily available energy (Wilkins & Jones, 2000; Volpelli et al., 2012). Pulses (peas, chickpeas, and beans) are an important source of proteins in food and feed. The protein contents of pulses are high, and the essential amino acid profiles of pulses are well-balanced.

Research studies indicate that some functional properties of pulse proteins may be comparable to those of other frequently used proteins such as soya (Boye et al., 2010). Protein is the source of amino acids and nitrogen in feeds. Livestock need it for growth and milk production. Protein is also needed by rumen bacteria, which digest much of the feed for ruminant animals like cattle, sheep and goats (Rayburn, 1996).

Legumes are not only a rich source of protein; they also contain fibre, which is essential for normal functioning of the digestive tract. Legumes are a rich source of vitamin B_6 that is required for normal amino acid metabolism and contain vitamin B_2, or riboflavin, which ensures energy exchange in cells, as well as fat and protein metabolism. Legumes also contain sugar and starch, which are the sources of energy and minerals such as magnesium that is important for normal cardiac function, manganese that is necessary for enzymes, such as transferases, and other elements that improve the metabolic processes of animals. Unlike protein products of animal origin, legumes contain much less fat (Mokoboki et al., 2000; Savadogo et al., 2000; Wilkins & Jones, 2000; Tessema & Baars, 2004; Huhtanen, 2005).

Information on the digestibility of nutrients is of great importance when identifying the nutritional quality of feeds. Digestibility is a measure of the biological availability of nutrients, and it is important in formulating a balanced ration in order to have maximum productivity in animals (Forejtova et al., 2005; Homolka et al., 2012).

Forage quality affects the potential of livestock to produce milk from the forage through the utilization of its nutrients. The level of animal productivity is controlled nutritionally through the daily intake of digestible nutrients and depends on the pace at which such nutrients can be metabolized and used for body processes (Bush et al., 1980; Karsli & Russell, 2002; Tessema & Baars, 2004; Căpriţă et al., 2012) The digestibility of a feedstuff and the fermentation pattern influence the daily dry matter intake (DMI), which is important for today's highly productive dairy cows. (Allen, 2000; Savadogo et al., 2000; Froidmont & Bartiaux-Thill, 2004).

Dietary factors can greatly affect the composition of milk of dairy cows, and nutrition offers the most effective ways for rapidly altering the composition of milk. Among milk components (fat, protein, lactose, minerals and vitamins), fat and protein are the two being most subjected to changes due to dietary manipulation (Santos, 2002). It is well accepted that amino acids, as building blocks of protein, play an essential role in the nutritional composition of a feedstuff (Haffner et al., 2000). The supply of amino acids by the mammary gland of dairy cows is elevated due to feeding higher amounts of rumen-undegradable protein.

The aim of the present research was to evaluate beans and peas as a protein-rich feed for dairy cows as well as the productivity of the dairy cows and milk quality indicators.

MATERIALS AND METHODS

Biochemical tests were done on eight samples of domestically grown peas of average size (n = 5), 11 samples of faba beans of average size (n = 5) and some samples of soybean meal (n = 5). Crude protein (LVS EN ISO 5983-2:2009) and digestibility (cellulase method) were identified in the present research. The average results were summarised and analysed for the tests carried out in the years 2014 and 2015. Table 1 presents the varieties and breeding lines of peas and faba beans used for the biochemical tests.

The forage tests were done at the accredited Research Laboratory of Agronomic Analyses of Latvia University of Agriculture (LLU) according to the following standards: dry matter – Feed Analyses met.2.2.1.1: 1993, crude protein – LVS EN ISO 5983-2: 2009, fibre – ISO 5498: 1981, NDF% – LVS EN ISO 16472: 2006, ADF%,

NEL, MJ kg^{-1} – LVS EN ISO 13906: 2008, calcium – LVS EN ISO 6869: 2002, phosphorus – ISO 6491: 1998.

Table 1. Varieties and breeding lines of peas and faba beans investigated

No	Pea varieties	Bean varieties	Fodder
1	'Bruno'	'Ada'	Soybean cake
2	'Vitra'	'Lielplatone'	-
3	'Zaiga'	'Jogevas'	-
4	'Lasma'	'Fuego'	-
5	'Alma'	'Scirocco'	-
6	'Selga'	'Tolea'	-
7	Breeding line H-06-04-4	'Priekulu'	-
8	Breeding line H-86-19-3	'Priekulu 32'	-
9	-	'Bauskas'	-
10	-	'Valmieras'	-
11	-	Breeding line H-10-10-10	-

In vitro digestibility was estimated for totally 15 feed samples: peas 'Bruno', peas 'Capella', peas 'Looming', fodder beans (2 samples), fodder peas, soybean meal (2 samples), rapeseed meal, silage (grass+legume) (2 samples), hay (grass+legume) (2 samples), feed concentrate (meal) and feed concentrate (pellets). *In vitro* enzymatic digestibility was estimated at the accredited Research Laboratory of Agronomical Analyses of Latvia University of Agriculture employing the enzymatic method and procedure (De Boever et al., 1988). The *in vitro* digestibility method and procedure is as follows.

A small quantity (0.300 g) sample is weighed in a tube and 30 mL pepsin HCl solution is added (De Boever et al., 1988). The tube is closed with an overpressure cap, incubated at 38 °C for 24 hours and shaken twice a day. After 24 h the tubes are put in a warm water bath at 80 °C for 45 minutes. The solution is sucked out and washed three times with water of 60 °C and 30 mL of buffered cellulose solution is added. It is incubated at 39 °C for 24 hours and shaken twice a day, filtrated in a sintered glass crucible and washed 3 times with water of 60 °C. Then it is dried at 103 °C until a constant weight is obtained. Afterwards it is cooled in an exsiccator and weighed with a 0.1 mg precision. Then it is reduced to ash for at least 2 hours at 550 °C until a constant weight is obtained, cooled in an exsiccator and weighed again with a 0.1 mg precision. An equation for calculating the enzymatic activity is as follows:

$$\mathrm{DCom} = 100 \times \left(1 - \frac{(A - B) \times 1{,}000}{(C - D) \times 0.300}\right)$$

where DCom – in vitro enzymatic digestibility; A – weight of the crucible+residu after drying; B – weight of the crucible+residu after ashing; C – absolute dry matter in g kg^{-1}; D – ash in g kg^{-1}.

In each test, three standard samples were used to correct for fluctuations in enzyme activity. The digestibility of dry matter and protein in feed rations was calculated in terms of the amount of feed consumed by cows per day, the chemical content of forage and *in vitro* digestibility indices of feedstuffs.

For the determination of the amino acid content of feed and milk, samples were hydrolysed according to the procedures described in Commission Regulation

No 152/2009 (2009). Amino acid tests were performed by means of AccQ Tag technology (Waters Corp., Miliford, MA) and quantified by means of Shimadzu HPLC (low pressure gradient system) consisting of a solvent delivery module LC–10AT$_{VP}$, an automatic injector SIL–10AD$_{VP}$, a column oven CTO–10AC$_{VP}$, a spectrofluorometric detector RF–10A$_{XL}$, a system controller SCL–10A$_{VP}$, and an on–line degasser DGU–14A. Amino acid separation was performed using a Nova–Pak C18, 4 μm, 150 × 3.9 mm (Waters Corp., Miliford, MA) chromatography column at 37 °C.

The scheme of cow diets is shown in Tables 2 and 3. During the trial, the dairy cows received the basic feed ration, which consisted of the following components measured per cow per day: 40 kg of silage (grass+legume), 3 kg of hay (grass+legume), 4 kg of fodder (grains), 4 kg of complementary and 0.15 kg of mineral additives.

Table 2. Scheme of cow diets

Group	1st group – trial	2nd group – trial	3rd group – trial	4th group –control
Feed ration	CF + 10–12% Pisum sativum 'Bruno' + 10–12% Vicia faba variety minora	CF + 20–24% Pisum sativum 'Bruno'	CF + 20–24% Vicia faba variety minora	CF + soybean cake

CF – conventional feed (different grains and rapeseed cake).

Table 3. Dairy cow diets during the trials

Feedstuffs	Amount, kg	1st group	2nd group	3rd group	4th control group
Silage	40	40	40	40	40
Hay	3	3	3	3	3
Feed concentrate	4	4	4	4	4
Complementary additive	4	4	4	4	4
Peas+beans	-	1.82	-	-	-
Peas	-	-	1.9	-	-
Beans	-	-	-	1.7	-
Soybean meals	-	-	-	-	1
Mineral additive	0.15	0.15	0.15	0.15	0.15
Feed ration contains:					
Dry matter, kg	-	21.60	21.70	21.50	20.80
Crude protein, g	-	3,266	3,261	3,76	3,258
NEL, MJ	-	142.7	143.8	139	137.20
Calcium, g	-	153	157	155	162
Phosphorus, g	-	82.0	83.0	85.0	82.0

The difference in diet between the trial groups and the control group was that the trial groups of cows were fed diets composed of 1.82 kg of peas+beans (0.85 kg + 0.97 kg, respectively) (1st trial group), 1.9 kg of peas (2nd trial group) and 1.7 kg of beans (3rd trial group), while the control group received 1 kg of soybean meal (4th group).

The feed ration varied according to each cow's milk yield and physiological state and was monthly corrected according to the lactation cycle.

The parameters of the feed ration corresponded to the NRC (2001), these dietary norms were set for cows with a live weight of 650 kg, a milk yield of 30 kg per day, a 4.10% fat and a 3.20% protein content of milk and a lactation period of 60–100.

The obtained results were statistically processed and analysed. To identify the magnitude of difference in the indicators of faba beans, peas and soybean meal, the data were analysed employing a nonparametric method – a Mann-Whitney U–criteria test. To identify cow productivity differences in comparison with the control group, the data were analysed by a Mann–Whitney test, and a Wilcoxon signed–rank test was done to identify differences in data between the beginning and the end of the experiment at a confidence interval of 95% ($\alpha = 0.05$). The data processing was performed using the data processing program *SPSS 16.0*.

RESULTS AND DISCUSSION

Biochemical composition of peas and beans

Data on the crude protein (CP) contents and the digestibility of peas and faba beans of the varieties and breeding lines examined, compared with soybean meal, are presented in Tables 3 and 4. After processing the data, one can see that the CP contents of peas and faba beans of the varieties and breeding lines examined show mainly significant differences ($p < 0.05$). The varieties and breeding lines that showed significant differences in the indicators were assigned the same number as presented in Table 5.

Table 4. Crude protein contents and digestibility of peas of the varieties and breeding lines examined (2014–2016 average data)

No	Varieties and breeding lines	Crude protein, % in DM	Digestibility, %
1	'Bruno'	26.37 ± 0.055 ^{2,3,4,5,6,7,8}	82.0 ± 0.141 ^{2,3,4,5,6,7,8}
2	'Vitra'	25.06 ± 0.120 ^{1,3,4,5,6,7,8}	82.5 ± 0.071 ^{1,3,4,5,6,7,8}
3	'Zaiga'	21.93 ± 0.040 ^{1,2,4,5,6,7,8}	83.2 ± 0.141 ^{1,2,4,5,6,7,8}
4	'Lasma'	20.11 ± 0.083 ^{1,2,3,5,6,7,8}	83.4 ± 0.071 ^{1,2,3,5,6,7,8}
5	'Alma'	22.67 ± 0.066 ^{1,2,3,4,6,7,8}	81.4 ± 0.071 ^{1,2,3,4,6,7,8}
6	H-06-04-4	22.37 ± 0.221 ^{1,2,3,4,5,7,8}	83.7 ± 0.100 ^{1,2,3,4,5,7,8}
7	H-86-19-3	23.21 ± 0.160 ^{1,2,3,4,5,6,7}	82.9 ± 0.072 ^{1,2,3,4,5,6,8}
8	'Selga'	18.59 ± 0.144 ^{1,2,3,4,5,6,7,}	82.5 ± 0.069 ^{1,2,3,4,5,6,7}
9	Soybean cake	50.42 ± 2.94 ^{1,2,3,4,5,6,7,8}	81.7 ± 0.774 ^{2,3,4,6,7,8}

Data are presented as means ± SD (n = 5 in each group). Means with different superscript numbers (^{1,2,3,4,5,6,7,8,9,10,11}) are significantly different among varieties ($p < 0.05$).

Overall, in the experiment, the highest CP content was identified in the pea variety 'Bruno' (26.37%) (used in the feeding trial), while the best digestibility (83.7%) was specific to the pea breeding line H-06-04-4, compared with the other pea varieties. The highest CP content of faba beans was identified in the variety 'Priekulu' (31.36%), while the faba bean variety 'Jogevas' had the best digestibility (81.50%), compared with the other faba bean varieties and breeding lines. The CP content of soybean meal was higher than that of peas and faba beans (51.31%), but the digestibility of it was lower (81.65%) and showed no trend towards a significant difference, compared with the pea varieties and breeding lines.

Table 5. Crude protein contents and digestibility of faba bean of the varieties and breeding lines examined (2014–2016 average data)

No	Varieties and breeding lines	Crude protein, % in DM	Digestibility %
1	'Ada'	30.75 ± 0.106 ^{2,3,4,5,6,7,8,10,11}	79.5 ± 0.071 ^{2,3,4,6,7,8,9,10,11}
2	'Lielplatones'	29.41 ± 0.444 $^{1\ 3\ 4\ 5\ 6\ 7}$	79.2 ± 0.068 ^{1,3,4,5,6,7,8,10,11}
3	'Jogevas'	29.68 ± 0.014 $^{1\ 2\ 4\ 5\ 6\ 7\ 8\ 10\ 11}$	81.5 ± 0.100 ^{1,2,4,6,7,9,10,11}
4	'Fuego'	26.66 ± 0.379 ^{1,2,3,5,6,7,8,9,10,11}	77.5 ± 0.076 ^{1,2,3,5,6,7,8,9,10,11}
5	'Scirocco'	28.42 ± 0.015 ^{1,2,3,4,6,7,8,9,10,11}	79.1 ± 0.505 ^{2,4,6,9}
6	'Tolea'	31.68 ± 0.92 ^{1,2,3,4,5,8,9,10,11}	80.1 ± 0.070 ^{1,2,3,4,5,7,8,9,10,11}
7	'Priekulu'	31.36 ± 0.485 ^{1,2,3,4,5,8,9,10,11}	78.9 ± 0.071 ^{1,2,3,4,6,8,9,10,11}
8	'Piekulu 32'	28.78 ± 0.072 ^{1,3,4,5,6,7,9,11}	79.1 ± 0.105 ^{1,2,4,6,7,9,10,11}
9	'Bauskas'	30.20 ± 0.704 ^{4,5,6,7,8,}	78.6 ± 0.08 ^{1,3,4,5,6,7,8,10,11}
10	'Valmieras'	29.18 ± 0.416 ^{1,3,4,5,6,7,11}	79.8 ± 0.09 ^{1,2,3,4,6,7,8,9,11}
11	H-10-10-10	29.35 ± 0.212 ^{1,3,4,5,6,7,8,10}	79.8 ± 0.149 ^{1,2,3,4,6,7,8,9,10}
12	Soybean cake	50.42 ± 2.940 ^{1,2,3,4,5,6,7,8,9,10,11}	81.7 ± 0.774 ^{1,2,4,5,6,7,8,9,10,11}

Data are presented as means ± SD (n = 5 in each group). Means with different superscript numbers (^{1,2,3,4,5,6,7,8,9,10,11}) are significantly different among varieties ($p < 0.05$).

A comparison of digestibility between soybean meal and beans shows significant ($p < 0.05$) differences for a number of bean varieties and the breeding line. The digestibility of soybean meal is better.

The indicator of feed digestibility is as important as the composition of feed. A high feed digestion rate increases the amount of nutrients in an animal's organism, thus providing a high overall productivity level. The digestibility of peas of the breeding line H-06-04-4 (83.70%) was considerably ($p < 0.05$) better than that of the pea variety 'Lasma' (83.40%) and soybean meal (81.65%). The bean varieties and the breeding line, compared with soybean meal, on average, had the same or slightly worse digestibility.

The contents of crude fibre and its fractions ADF, % and NDF, % were higher in beans, while NEL MJ kg^{-1} was higher in peas than in beans (Fig. 1). Table 6 shows that the highest NEL MJ kg^{-1} was found in the pea breeding line H-06-04-4, while among pea varieties with white flowers the best performers were 'Lasma' and 'Zaiga' and among pea varieties with pink flowers – 'Selga' and 'Vitra'.Among the faba bean varieties, the highest NEL MJ kg^{-1} (Table 6) was found in the variety 'Jogeva'.

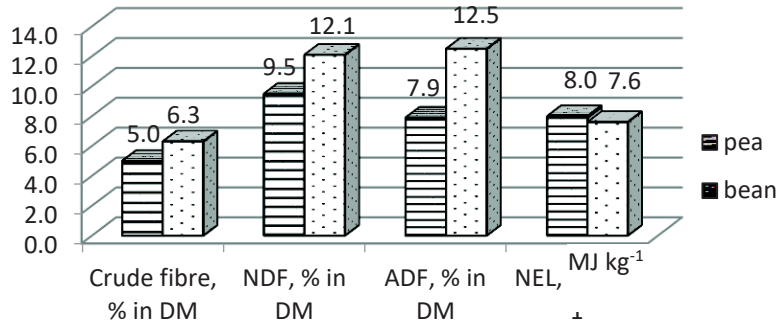

Figure 1. Fibre contents of peas (n = 16) and beans (n = 22) and NEL – average data.

Table 6. Biochemical composition of peas and beans (average data)

Indicators	DM, %	Fat, %	Reduced sugar, %	Starch, %	Crude fibre, %	NDF, %	ADF, %	NEL, MJ kg^{-1}	Ca, %	P, %
Peas										
Bruno	87.97	1.24	0.57	51.65	7.08	13.98	8.8	7.91	0.08	0.42
Vitra	88.33	1.26	0.27	53.53	6.87	9.9	8.24	7.95	0.08	0.4
Zaiga	89.71	1.53	0.23	52.65	4.06	8.58	7.33	8.03	0.12	0.37
Lasma	90.3	1.31	0.21	56.9	3.91	8.07	6.98	8.05	0.09	0.33
Alma	90.47	1.37	0.26	49.89	5.65	11.31	9.68	7.84	0.12	0.35
H-06-04-4	89.73	1.39	0.21	54.25	3.62	7.38	6.65	8.08	0.12	0.38
H-86-19-3	89.76	1.39	0.21	51.4	4.47	8.35	7.65	8.0	0.15	0.54
Selga	90.27	1.44	0.26	56.48	4.09	8.75	8.15	7.96	0.09	0.37
Faba Beans										
Ada	89.15	1.18	0.18	46.06	6.04	13.63	12.0	7.65	0.12	0.62
Lielplatones	88.46	1.01	0.16	47.15	5.86	14.77	12.4	7.62	0.13	0.6
Jogeva	89.01	1.12	0.15	46.9	5.4	9.73	9.41	7.86	0.12	0.62
Fuego	89.72	1.06	0.13	47.99	7.15	12.44	14.62	7.44	0.13	0.58
Scirocco	89.38	1.21	0.12	46.32	6.42	12.38	12.81	7.59	0.13	0.66
Tolea	89.75	0.92	0.15	44.79	5.83	12.04	11.27	7.71	0.11	0.55
Priekulu	90.28	1.05	0.16	44.22	6.67	11.42	12.81	7.59	0.12	0.69
Priekulu 32	90.08	0.99	0.16	45.77	6.89	11.41	15.53	7.61	0.11	0.69
Bauskas	89.97	0.94	0.1	46.07	6.0	10.68	13.61	7.56	0.12	0.62
Valmieras	90.56	1.03	0.1	45.47	6,45	11.52	11.58	7.69	0.12	0.78
XXX	88.92	0.77	0.11	44.61	6.48	12.75	11.65	7.68	0.11	0.58
Soybean										
Soybean 1	88.23	2.27	0.31	7.95	3.41	13.74	10.3	7.8	0.41	0.72
Soybean 2	87.41	2.42	0.22	7.62	3.57	13.98	9.02	7.89	0.42	0.71

In comparison with the bean varieties, all of the pea varieties and breeding lines had higher reducing sugar contents. The highest sugar content was found in 'Bruno' (0.57%) – the pea variety with pink flowers. Among the bean varieties, the highest sugar content was found in the breed 'Ada' (0.18%).

Compared with the bean varieties, all the varieties of peas had higher starch contents. Among the pea varieties with white flowers, the highest starch content was found in 'Lasma', while among the pea varieties with pink flowers – in 'Selga'.

The average calcium (Ca) content in the varieties of peas was 0.11% (n = 8) and 0.12% (n = 11) in the varieties of beans. The average phosphorus (P) content was higher in beans 0.64% (n = 11) than in peas – 0.40% (n = 8).

The obtained results of biochemical composition tests showed that the varieties and breeding lines of beans and peas grown in Latvia contained the proteins necessary in feed and may be used in cow diets, replacing an equivalent amount of soybean protein.

The analysis of feed rations fed to cows during the trials, in terms of chemical composition, proved that, in general, the rations met the standards. Slight differences were found in the provision of mineral elements to all the groups of cows. The feed rations satisfied the need of cows for dry matter, dietary energy, crude protein, calcium and phosphorus (Wilkins & Jones, 2000).

Voluntary intake and digestibility of forages are characteristics that affect the animal's performance. Under those management conditions, the herd's productivity relied heavily on the quality of feedstuffs produced, measured either in terms of

composition and digestibility or in terms of fermentation characteristics. Therefore, it was important to determine feed quality characteristics, such as digestibility of dry matter and crude protein content for the formulation of balanced rations for ruminants (Mould, 2003; Huhtanen, 2005).

The results of a nutrient digestibility test on dairy cows are presented in Table 7. The research results show that dry matter digestibility in 2015 in the control group (4) was 68.73%, while in the trial groups (1, 2 and 3) – 69.29%, 69.42% and 69.06%, which was higher than in the control group by 0.56%, 0.69% and 0.33%, respectively.

Table 7. Digestibility of dry matter and protein in dairy cows in 2015–2016

Indices		1st trial group	2nd trial group	3rd trial group	4th control group
Dry matter digestibility, %	2016	69.29 ± 0.02	69.42 ± 0.02	69.06 ± 0.04	68.73 ± 0.07
	2015	69.02 ± 0.01	69.09 ± 0.07	68.75 ± 0.03	68.41 ± 0.007
Both years on average, %		69.16 ± 0.19	69.26 ± 0.23	68.91 ± 0.21	68.57 ± 0.22
Protein digestibility, %	2016	65.82 ± 0.10	65.97 ± 0.01	65.72 ± 0.01	65.67 ± 0.07
	2015	66.94 ± 0.007	67.04 ± 0.01	66.86 ± 0.08	66.82 ± 0.01
Both years on average, %		66.38 ± 0.79	66.51 ± 0.75	66.29 ± 0.80	66.25 ± 0.81

The results show that dry matter digestibility in the 1st and the 2nd trial groups of cows was similar – in the range of 69.02–69.09%, while in the 3rd trial and the 4th control groups – in the range of 68.75–68.41%. The digestibility test results show that in both trial years, on average, higher dry matter digestibility was found in the 2nd group, in the feed ration of which 'Bruno' peas were included, and in the 1st group whose ration comprised peas + beans.

The results show that in 2015 protein digestibility in the groups of cows was similar in the range of 65.67–65.97%. Protein digestibility in the control group of cows was 65.6s7%, which was lower than in the trial groups of cows by 0.15%, 0.30% and 0.05%, respectively. The highest protein digestibility was demonstrated by the 2nd trial group of cows – 65.97% and the 1st trial group of cows – 65.82%.

In 2016, protein digestibility increased in all the groups of cows, in comparison to the previous year. The highest protein digestibility was demonstrated by the 2nd trial group of cows – 67.04%, which was higher than in the other trial groups of cows by 0.10%, 0.18% and 0.22%, respectively. The research results show that in both trial years, on average, protein digestibility in the groups of cows was in the range of 66.25–66.51%.

The digestibility test results show that on average in both years higher protein digestibility was demonstrated by the groups of cows that were fed 'Bruno' peas and peas + faba beans. The analysis of feed rations fed to cows during the trials showed that, in general, the rations met the requirements of standards. Slight differences were found in the provision of mineral elements to all the groups of cows. The dry matter digestibility test results show that dry matter digestibility in the 1st and the 2nd trial group of cows was similar – in the range of 69.02–69.09%, while in 3rd trial and the control group was in the range of 68.75–68.41%. Protein digestibility was the highest in the 2nd trial group of cows – 67.04%, which was higher than in the other groups of cows by 0.10%, 0.18% and 0.22%, respectively.

The research results show that in both trial years, on average, protein digestibility in the groups of cows was in the range of 66.25–66.51%. The digestibility test results showed that on average dry matter and protein digestibility was higher in the 2nd trial group, the feed ration of which included 'Bruno' peas, and 1st trial group that received peas + beans.

Productivity and milk quality during the dietary experiment

The indicators of cow productivity and milk quality are presented in Tables 8, 9 and 10. The greatest decrease in milk yields was observed for the control group – by 3.98 kg of energy corrected milk (ECM); a smaller decrease was observed for the 3rd group – by 0.26 kg of ECM, compared with the initial stage of the experiment.

Table 8. Average data on the productivity of experiment cows

Experimental group	Average milk yield per day (kg)				Comparison between initial and final values (kg)
	Nov*, 2014	Beginning of xperiment	Middle of experiment	End of experiment	
1st group	22.68	23.52	22.24	20.46	-2.22
2nd group	23.48	21.58	21.76	21.38	-2.10
3rd group	20.74	19.70	20.28	20.48	-0.26
4th group (control)	24.62	24.92	21.96	20.64	-3.98^S
	p–value (relative to control)				
	Nov, 2014	Beginning of experiment	Middle of experiment	End of experiment	
1st group	0.465	0.600	0.917	0.917	0.225
2nd group	0.917	0.347	0.917	0.754	0.138
3rd group	0.251	0.251	0.917	0.916	0.893
4th group (control)	-	-	-	-	0.043^S

^{S} – significant differences ($p < 0.05$); *–initial stage.

However, changes in productivity are mainly associated with the cows' physiological processes during their lactation and pregnancy cycle (Volpelli et al., 2012; Anderson et al., 2002). Even though the daily milk yields decreased in all the cow groups during the experiment, which was normal during the lactation period, yet the milk yield decreases in the experimental groups (1st, 2nd and 3rd) were smaller – 2.22, 2.10 and 0.26 kg, respectively, compared with the initial stage of the experiment ($p < 0.05$).

The milk chemical test results are presented in Tables 9 and 10. As the cows' productivity decreased during the experimental and lactation period, the fat and protein contents of milk increased in the 1st, 2nd and 3rd groups, compared with the control group (4th).

The fat content of milk slightly increased, on average, by 0.04%-points (0.82%) in the 3rd and 1st groups and by 0.01%-points (0.20%) in the 2nd group, compared with the control group, and from 0.33% to 0.37% ($p < 0.05$) compared with the initial stage of the experiment. The fat content of milk decreased by 0.36% in the control group, compared with the initial stage of the experiment. The diet comprising pulses made a positive effect on the protein content of milk during the experiment. The protein content of milk increased in all the experimental groups.

Table 9. Fat content of milk (average data)

Experimental group	Fat content of milk (%)				Comparison between initial and final values, %
	Nov*, 2014	Dec, 2014	Jan, 2015	Feb, 2015	
1st group	4.6	4.7	4.7	4.9	0.3
2nd group	4.74	4.6	4.5	4.9	0.2
3rd group	4.6	4.8	4.8	4.9	0.4
4th group (control)	5.3	4.9	4.4	4.9	-0.4
	p–value (relative to control)				
	Nov, 2014	Dec, 2014	Jan, 2015	Feb, 2015	
1st group	0.602	0.465	0.465	1.000	0.345
2nd group	0.465	0.251	0.917	0.917	0.686
3rd group	0.465	0.465	0.602	0.754	0.138
4th group (control)	-	-	-	-	0.500

S – significant differences($p < 0.05$); *–initial stage.

Table 10. Protein content of milk (average data)

Experimental group	Protein content of milk (%)				Comparison between initial and final values, %
	Nov, 2014*	Dec, 2014	Jan, 2015	Feb, 2015	
1st group	3.1	3.4	3.3	3.7	0.6^S
2nd group	3.2	3.4	3.2	3.5	0.4^S
3rd group	3.2	3.3	3.2	3.6	0.4^S
4th group (control)	3.1	3.1	2.9	3.3	0.3
	p–value (relative to control)				
	Nov, 2014*	Dec, 2014	Jan, 2015	Feb, 2015	
1st group	0.917	0.251	0.117	0.074	0.043^S
2nd group	0.754	0.117	0.173	0.599	0.043^S
3rd group	0.60	0.35	0.120	0.300	0.043^S
4th group(control)	-	-	-	-	0.225

S – significant differences($p < 0.05$); *–initial stage.

The protein content of milk increased by 0.31%-points or 9.28% in the 1st group, 0.17%-points or 5.09% in the 2nd group and 0.27%-points or 8.08% in the 3rd group, compared with the control group, and by 0.59, 0.36 and 0.44%-points, respectively, compared with the initial stage of the experiment. The fat content increased by 0.29%-points in the control group, compared with the initial stage of the experiment, yet the differences were insignificant ($p > 0.05$).

During the experiment, the milk quality indicators did not differ much from the results of other research studies and were within the normal range, which proved the positive effects of diets comprising beans and peas for dairy cows (Jemeljanovs et al., 2008; Tufarelli et al., 2012; Volpelli et al., 2012).

The total amount of amino acids increased in the milk samples of all the trial groups. The highest increase was found in the bulk milk samples of the 3rd and the 2nd trial group, 6.06 and 5.98 g kg^{-1}, respectively. The lowest increase was in the bulk milk

samples of the 1st trial group (4.37 g kg^{-1}). However, an increase in the total amount of amino acids was observed in the control group, too (2.67 g kg^{-1}).

CONCLUSIONS

1.The obtained results of biochemical composition tests showed that the varieties and breeding lines of beans and peas grown in Latvia contained the proteins necessary in feed and may be used in cow diets, replacing an equivalent amount of soybean protein.

2.The analysis of feed rations fed to cows during the trials showed that, in general, the rations met the requirements of standards. Slight differences were found in the provision of mineral elements to all the groups of cows.

3.The dry matter digestibility test results showed that dry matter digestibility in the 1st trial (pea+bean+CF) and the 2nd trial (pea+CF) groups of cows was similar in the range of 69.02–69.09%, while in the 3rd trial (bean+CF) and control (soybean meal+CF) groups of cows – in the range of 68.75–68.41%.

4.The highest protein digestibility was demonstrated by the 2nd trial group of cows – 67.04%, which was higher than in the other trial groups of cows by 0.10%, 0.18% and 0.22%, respectively. The research results show that in both trial years, on average, protein digestibility in the groups of cows was in the range of 66.25–66.51%.

5.The digestibility test results showed that on average dry matter and protein digestibility was higher in the 2nd trial group, the feed ration of which included 'Bruno' peas, and 1st trial group that received peas + beans.

6.During the experiment, the cow productivity indicators decreased in all the groups, which was normal during the lactation period, yet the daily milk yield decreases in the experimental groups (diets comprising peas and beans) were smaller – 2.22, 2.10 and 0.26 kg, respectively, compared with the initial stage of the experiment and the control group (a diet comprising soybean meal).

7.The fat content of milk from the 3rd group (beans+CF) and the 1st group (peas+beans+CF) slightly increased, on average, by 0.04%-points or 0.82%, while that from the 2nd group (peas+CF) – by 0.01%-points or 0.20%, compared with the 4th (control) group (soybean meal+CF) ($p < 0.05$). The protein content of milk increased by 0.31%-points or 9.28% in the 1st group, 0.17%-points or 5.09% in the 2nd group and 0.27%-points or 8.08% in the 3rd group, compared with the control group.

8.The research results proved that the use of legumes as domestic feedstuffs for the purpose of raising the nutritional value of the feed and balancing protein in the feed ration for dairy cows is important and promising, as the legumes help better maintain the milk yield level during the lactation period and enhance the milk quality indicators.

9.The total amount of amino acids increased in the bulk milk samples of all the groups of cows.

10. The highest increase was found in the bulk milk samples of the 3rd and the 2nd trial group, 6.06 and 5.98 g kg^{-1}, respectively.

ACKNOWLEDGEMENTS. The present work was carried out at Latvia University of Agriculture and has been supported by the European Seventh Framework Project FPT-KBBE-2013-7. Project No. 613781 'Enhancing of legumes growing in Europe through sustainable cropping for protein supply for food and feed' (EUROLEGUME).

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