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Fodder beans and peas in the diet of dairy cows

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Abstract. The Holstein-Friesian Black-and-White cows were grouped into four treatments groups according to the analogue principle (n = 4 × 5). Lactating dairy cows were included in the trial in the initial lactation phase with the average milk yield of 23.00 kg per day, fat content 4.10% and 3.20% protein content in milk. The analyses of the chemical composition of legume grains show, that crude protein and undegraded intake protein (UIP) were higher in fodder beans than in peas, respectively 29.97% and 25.04% of dry matter but UIP content, respectively 40.51% and 39.69% of crude protein. There was a total of 17 amino acids detected in legume grains and soybean meal. The highest concentration of arginine, leucine, glutamic acid, aspartic acid and isoleucine was in fodder beans, respectively 0.76%, 0.58%, 0.67%, 0.42% and 0.29% more than in peas. Even though the daily milk yields decreased for all the cow groups during the experiment, which was normal during the lactation period, yet the milk yield decreases for the trial groups. The highest total amount of amino acids in milk was detected in 3rd and 2nd trial cow groups, respectively, 4.00 g kg^{-1} and 3.90 g kg^{-1} which was fed fodder beans and peas. The milk sale and feed cost summary records for the trial that lasted 90 days show that economic efficency of peas plus beans has been positive.

Key words: fodder beans, peas, feed values, amino acids, dairy cows, milk, cost.

INTRODUCTION

Animal supply with healthy feed is a very important factor in the increase of productivity, in rational use of feed and in preservation of animal's health. Moreover, most protein crops are legumes and are therefore very interesting for crop rotation for dairy cow farmers and, overall, for sustainability. The rumen degradability and the soluble fractions (albumins and globulins) of the protein are higher in the grain legumes compared with soybean meals and thus, grain legumes are more suitable as supplements to low-protein forages.

Consequently, livestock farmers worldwide are under increasing pressure to maximise their use of home-grown feeds. So, the cultivation of grain legumes such as, fodder beans (*Vicia faba var. minor*), high protein pea (*Pisum sativum*) on farm could solve the problem and improve the sustainability of the farm (Martini et al., 2008).

Legume grains contain 22–35% proteins, which may provide animal dietary requirements, as well as increase share of local protein sources in feed, diminishing the

costs at the same time. Despite all this, the use of inappropriate proteins or amounts may cause an increase in production costs and decrease efficiency. Field beans have relatively high crude protein level and contain a considerable amount of energy in the form of starch, which makes them a unique feed that can be substituted for higher-priced protein and energy commodities like soybean meal (Tufarelli et al., 2012). Field peas are highly digestible and highly fermentable in the rumen, but have a slower starch and protein fermentation rate than several other common feeds. Therefore, fodder beans and peas be used as an important forage legume to enhance feed values for dairy ruminants, especially of importance to today's high yielding dairy cows (Jensen, 2002; Ipharraguerre & Clark, 2005).

The European Union policy on the protection and enhancement of biodiversity on agricultural holdings has contributed to an increase in the area sown with legumes in Latvia. Areas under nitrogen-fixing crops, including fodder beans or field beans and peas, are eligible for financial support regarding environment-friendly agricultural practices; consequently, the total area under field beans in Latvia in the period 2010–2016 increased approximately 11 times (from 2.8 thousand hectares to 31.4 thousand hectares) and that under peas – 7 times (from 1.2 thousand hectares to 8.9 thousand hectares). The sown areas of pulses continue to grow. In 2016, the total area of pulses increased by 32.1%, of which the area of field beans rose by 5.4 thousand hectares or 20.9% (Agriculture of Latvia, 2017).

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 proteinrich feedstuffs in the consumption of feed and reduce the production cost of livestock products, i.e. contribute to higher efficiency (Proskina & Cerina, 2017).

The aim of the present research was to investigate the fodder beans and peas in the diets of dairy cows.

MATERIALS AND METHODS

Trials were carried out on the farm 'Upites', Allazu Parish, Allazmuiza Municipality. For the trial, four analogue (according to yield, lactation phase, live weight, fat content and protein content) treatments groups of 20 animals of Holstein-Friesian Black-and-White cows were used in the study. Preparatory period lasted from October 1 to 30, 2015, but feeding trial was carried out from December 2015 to February 2016, i.e. for 90 days. The experimental design is presented in Table 1.

Table 1. Scheme of the trial

Group of cows	Number of cows	Basic feed ration
1st trial	5	BF + 10–12% *Pisum sativum* 'Bruno' + 10 –12% *Vicia faba minor* 'Lielplatone'
2nd trial	5	BF + 20–24% *Pisum sativum* 'Bruno'
3rd trial	5	BF + 20–24% *Vicia faba minor* 'Lielplatone'
4th control	5	BF with soybean meal

The average live weight of cows in all groups were 650 kg the mean age was 3.0 lactations. The cows were in the initial phase of lactation were included in the experiment with the average yield of 23.00 kg per day, fat content 4.10% and protein content 3.20%, lactation days 60–100 ($P > 0.05$). The cows were kept under the tied-housing system, milked twice a day at an interval of 12 hours are kept on the same farm, under equal feeding, housing and exploitation condition.

During the trial, the dairy cows received the basic feed ration (BF) which consisted, calculation per cow per day of: 40 kg silage (grass+legume), 3 kg hay (grass+legume), 4 kg fodder (grains), 4 kg complementary, 0.15 kg mineral additive. In the experimental periood (90 days), the cows all groups were fed the same diet except that the diet of the cows in the control group was supplemented with 1 kg soybean meal that of the 1^{s} trial group with 1.82 kg (0.85+0.97 kg) that of the peas+beans, that of the 2nd group with 1.9 kg peas and that of the 3rd trial group with 1.7 kg beans (Table 2).

Table 2. Dairy cows feeding during the trials

Feedstuffs	Amount, kg	1st trial	2nd trial	3rd trial	4th control
Silage	40	40	40	40	40
Hay	3	3	3	3	3
Concentrated feed	4	4	4	4	4
Complementary feed	4	4	4	4	4
Peas+beans	-	1.82	-	-	-
Peas	-	-	1.9	-	-
Beans	-	-	-	1.7	-
Soybean meal	-	-	-	-	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	3,276	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 feeding ration varied according to each cow's milk yield and physiological state, and was corrected monthly depending on the results of control milk yield, dry period and state of health.

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When elaborating the feeding rations, we took into consideration the following: amount of feedstuffs, dry matter (DM), net energy for lactation (NEL, MJ), amount of crude protein and macro-elements (Ca, P), (Nutrient Requirements…, 2001). Chemical tests were done in total fifteen samples, beans ($n = 5$), peas ($n = 5$) and soybean meal ($n = 5$). Each cows individual milk yield and whole groups average, content of milk fat and protein was recorded, basing on the control milk yield sheets. Control of the milk yield in cows groups was performed each day, individual milk yields were controled once a month.

A full value nutrition analyses were conducted by the accredited Scientific Laboratory of the Agronomical Analyses under the Latvia University of Agriculture. Amino acid analyses were carried out in Baisogala, Lithuania, in the Institute of Animal Sciences. Chemical analyses of the feed samples was carried out in accordance with the ISO 6498: 1998 standards, dry matter – Feed Analyses met.2.2.1.1: 1993, crude protein – LVS EN ISO 5983-2: 2009, starch – LVS EN ISO 10520:2001, crude fat – ISO 6492:1999, digestible undegraded intake protein (UIP) – calculation method, crude fibre – ISO 5498: 1981, neutral detergent fiber (NDF%) – LVS EN ISO 16472: 2006, acid detergent fiber (ADF%), net energy for lactation (NEL, MJ kg^{-1}) – LVS EN ISO 13906: 2008, crude ash – ISO 5984:2002/Cor 1:2005, calcium – LVS EN ISO 6869: 2002, phosphorus – ISO 6491: 1998 (General requirements for the competence…, 2017) and digestibility (cellulase method) (De Boever et al., 1988). 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). Amino acid separation was performed using a Nova-Pak C18, 4 mm, 150 × 3.9 mm (Waters Corp., Miliford, MA) chromatography column at 37 °C. The quantity of milk produced was identified by measuring productivity – standard litres of energy corrected milk, which was calculated by the following formula (Garcia et al., 2006):

$$ECM = \text{Milk yield x } \frac{0.383 \text{ x Milk Fat, \%} + 0.242 \text{ x Milk Protein, \%} + 0.7832}{3.14} \quad (1)$$

where *ECM* – energy corrected milk.

Milk quality analyzes were performed determining the milk fat and protein content, the method ISO 9622-2013 (E) / IDF 141: 2013 (E).

The biometric data was processed using by the computer program *SPSS 16.0*. Data were analyzed by: Mann-Whitney test at significance level 0.05 to define differences in comparison of control group and Wilcoxon signed-rank test to define differences between data at the start and end of the experiment at significance level $P < 0.05$.

RESULTS AND DISCUSSION

Chemical composition of beans, peas and soybean meal

The analysis of feeding rations, consumed by cows during trials, by their chemical content proved that, generally, rations meet the demands of standards. Slight diferences were found in the provision of mineral elements to the all groups cows. The feeding rations statisfied the need of cows for dry matter, feed energy, crude protein, calcium and phosphorus in Table 2.

The chemical composition of fodder beans, peas and soybean meal are presented in Table 3. As can be seen from Table 3 data, the content of dry matter in peas 'Bruno' and fodder beans 'Lielplatone' was high, 90.78% and 90.44% respectively but in soybean meal – 87.41%. Crude protein content was the highest in soybean meal – 50.61% and beans – 29.97%, while in peas – 25.04% of dry matter. Soybean meal had significantly high content of UIP – 73.99% of crude protein. After summarizing reference data, undegraded intake protein (UIP) content in soybean meal in the rumen fluctuates within the range of 75 to 78 per cent (Singh et al., 2012). Relatively high percentage of UIP was also in fodder beans – 40.51%, whereas in peas it was 39.69% of the crude protein.

According to the reference-provided information, the amount of UIP can make up 46% of crude protein content (Batterham & Egan, 1986).

The very soluble nature of the protein in beans that makes them easily degraded in the rumen will provide a pulse of nitrogenous substrate for rumen microbes, and diets need to be formulated to best harness this supply to provide essential amino acids for the ruminant itself (Yu et al., 2004). Meanwhile, the highest ADF content was demonstrated by beans – 11.36%, then peas – 9.59% and the lowest in soybean meal – 6.91%.

Table 3. The chemical composition of fodder beans, peas and soybean meal, on dry matter basis, %

Indicator	Beans (*Vicia faba minor*) 'Lielplatone'	Peas (*Pisum sativum*) 'Bruno'	Soybean meal
Dry matter, %	90.44	90.78	87.41
Crude protein, %	29.97	25.04	50.61
UIP of crude protein, %	40.51	39.69	73.99
Crude fat, %	1.09	1.22	1.60
Starch, %	43.29	48.54	7.62
Crude fiber, %	9.5	7.21	3.57
NDF, %	15.79	20.58	13.98
ADF, %	11.36	9.59	6.91
NEL, MJ kg^{-1}	7.7	7.84	7.89
Crude ash, %	3.61	3.28	1.76
Ca, %	0.12	0.07	0.42
P, %	0.66	0.43	0.71
Digestibility, %	80.00	81.40	81.80

Crude fat concentration in beans is low – 1.09%, in peas 1.22% but highest content of crude fat was in soybean meal – 1.60% of dry matter. The highest content of starch was in peas – 48.54%, beans – 43.29% but the lowest in soybean meal – 7.62% of dry matter. According to the reference data, different soybean sorts have different starch content that varies from 8.11 to 9.40 per cent of dry matter (Batterham & Egan, 1986). The highest crude fiber content was in fodder beans – 9.5% and peas – 7.21% but in soybean meal the content of the crude fiber is relatively low – 3.57%.

NDF content was higher in peas – 20.58% but in beans and soybean meal, NDF content was lower, respectively, by 4.79% and 6.60% of dry matter. Conversely the higher content of ADF showed beans – 11.36%, peas – 9.59% but the lowest content of NDF was in soybean meal – 6.91%.

The energy value (NEL) in peas, beans and soybean meal was at a similar level, respectively – 7.84 MJ kg^{-1} 7.70 MJ kg^{-1} and 7.89 MJ kg^{-1}. The crude ash content was similar to that of beans and peas, 3.61% and 3.28% respectively, which was higher than 1.85% and 1.52% than soybean meal. The highest calcium content was in soybean meal – 0.42% but the lowest in beans – 0.12% and in peas – 0.07% of dry matter. The highest content of phosphorus was for soybean meal – 0.71% and in beans – 0.66% but lower in peas – 0.43% of dry matter.

Digestibility of the analyzed forage was high. The highest rate was demonstrated by soybean meal and peas – 81.80% and 81.40% respectively. Conversely, feeds with high digestibility will often result in a higher feed intake and increased growth (Hongmin et al., 2006).

Amino acids content of beans, peas and soybean meal

There was a total of 17 amino acids detected in legume grains and soybean meal. The highest concentration of arginine, leucine, glutamic acid, aspartic acid and isoleucine was in fodder beans, respectively 0.76%, 0.58%, 0.67%, 0.42% and 0.29% of dry matter more than in peas (Table 4). Methionine, cystine, lysine, threonine, histidine, phenylalanine, tyrozine, glycine, serine and alanine amount in beans and peas was similar. The highest concentration of amino acids was shown soybean meal.

However, compared to cereals, the content of lysine in beans is relatively high and the contents of the sulphur-containing amino acids cysteine and methionine are low. According to reference materials, beans mainly contain lysine, with minor concentrations of methionine and tryptophan (Crepon et al., 2010).

Table 4. The amino acids content, on dry matter basis, %

Amino acids	Beans (*Vicia faba minor*) 'Lielplatone'	Peas (*Pisum sativum*) 'Bruno'	Soybean meal
Methionine	0.21	0.22	0.61
Cystine	0.33	0.30	0.68
Lysine	1.71	1.50	2.80
Threonine	0.97	0.77	1.82
Arginine	2.54	1.78	3.35
Isoleucine	1.14	0.85	2.10
Leucine	2.05	1.47	3.45
Valine	1.21	0.95	2.21
Histidine	0.69	0.50	1.20
Phenylalanine	1.14	1.04	2.32
Tyrosine	0.84	0.64	1.63
Glycine	1.17	0.90	2.00
Serine	1.22	1.01	2.37
Proline	-	0.77	-
Alanine	1.10	0.92	2.06
Aspartic acid	2.82	2.40	5.27
Glutamic acid	4.42	3.75	8.29

Productivity and milk quality during the trial

The cow productivity during the trial is shown in Table 5. Even though the daily milk yields decreased for all the cow groups during the experiment, which was normal during the lactation period, yet the milk yield decreases for the 1st, and 2nd trial groups were smaller – 2.22 kg and 2.10 kg, respectively, compared with the initial stage of the experiment. The greatest decrease in cow productivity was observed for the control group – by 3.98 kg of energy corrected milk but a smaller decrease was observed for the 3 rd group – by 0.26 kg of ECM, compared with the initial stage of the experiment ($P < 0.05$). As the cows' productivity decreased during the experimental and lactation period, the fat and protein contents of milk increased in the trial groups, compared with the control group. The fat content of milk slightly increased, on average, by 0.04% in the 3rd and 1st groups and by 0.01% in the 2nd group, compared with the control group, and from 0.33% to 0.37% 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 ($P < 0.05$).

Table 5. Cow productivity during the trial, on average, kg ECM (n = 4 × 5)

Group of cows	November*	December**	January**	February**	Comparison between initial and final values
1st trial	22.7 ± 3.47	23.5 ± 5.21	22.2 ± 3.44	20.5 ± 2.59	-2.22
2nd trial	23.5 ± 5.47	21.6 ± 3.35	21.8 ± 3.16	21.4 ± 4.87	-2.10
3rd trial	20.7 ± 2.23	19.7 ± 1.35	20.3 ± 2.34	20.5 ± 2.58	-0.26
4th control	24.6 ± 6.78	24.9 ± 6.81	21.9 ± 3.38	20.6 ± 2.52	-3.98 S
p–value (relative to control)					
Group of cows	November*	December**	January**	February**	*P*-value (between initial and final values)
1st trial	0.465	0.600	0.917	0.917	0.225
2nd trial	0.917	0.347	0.917	0.754	0.138
3rd trial	0.251	0.251	0.917	0.916	0.893
4th control	-	-	-	-	0.043S

* initial stage; S significant differences (P < 0.05); ** trial period.

The research results are similar to the data obtained in Lithuania and USA, where feeding milking cows with peas, the amount of proteins in milk increased the most (Kudlinskiene et al., 2016; Diaz, 2017). The protein content of milk increased in all the experimental groups. The protein content of milk increased average by 0.31% in the 1st group, 0.17% in the 2nd group and 0.27% in the 3rd group, compared with the control group, and by 0.59%, 0.36% and 0.44%, respectively, compared with the initial stage of the experiment (P > 0.05). In a similar research in Italy, it was detected that the amount of proteins in milk increased for the cows that were fed with beans, in contrast with cows that were fed with soybean meal, as we also stated in our field study (Belliere et al., 2008).

The content of total amount of amino acids in milk is shown in Table 6. 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, 4.00 g kg^{-1} and 3.90 g kg^{-1}, respectively. The lowest increase was in the bulk milk samples of the 1st trial group 1.80 g kg^{-1}, respectively, compared with the initial stage of the experiment. However, an increase in the total amount of amino acids was observed in the control group, respectively 2.30 g kg^{-1}. Meanwhile, trial group 3rd, which were fed beans, showed the amount of total amino acids in milk that was 1.70 g kg^{-1} higher than in control group that was fed soybean meal (P < 0.05).

Table 6. The content of total amount of amino acids in milk (n = 4 × 5)

Group of cows	Total amount of amino acids, g kg^{-1}		
	November*	February	Comparison between initial and final values, g kg^{-1}
1st trial	30.2 ± 0.44	32.0 ± 0.68	± 1.80
2nd trial	29.2 ± 0.49	33.1 ± 0.71	± 3.90
3rd trial	30.5 ± 0.37	34.5 ± 0.52	± 4.00
4th control	31.4 ± 0.32	33.7 ± 0.39	± 2.30

* initial stage; S significant differences (P < 0.05).

The economic efficiency is a key criterion for determining the benefit of one or another feed product fed out. The milk sale and feed cost summary records for the trial that lasted 90 days show that economic efficency of peas plus beans has been positive (Table 7).

Table 7. Milk and feed costs for a cow during the trial of 90 days

Indicator	1st trial	2nd trial	3rd trial	4th control
Milk obtained, kg	9,931.5	9,720	9,090	10,125
Milk wholesale price, EUR kg^{-1}	0.21	0.21	0.21	0.21
Income from milk sales, EUR	2,085.61	2,041.20	1,908.90	2,126.25
Total feed costs per group, EUR	1,313.33	1,330.88	1,296.23	1,366.88
Feed costs per kg of milk yield, EUR kg^{-1}	0.132	0.136	0.142	0.135
Benefit, EUR	772.28	710.32	612.67	759.37
Compared the control	±12.91	-49.05	-146.70	-

The highest economic efficiency in milk production and distribution was shown by group 1st, whose forage included fodder peas+beans, while the lowest efficciency - by group 3rd, which was fed fodder beans. The highest economic efficiency in terms of profit was provided by cows from group 1st – 772.28 EUR, which is 12.91 EUR more than control group.

CONCLUSIONS

1. The obtained results of chemical composition of legume grains the content of dry matter in peas and field beans was high, 90.78% and 90.44% respectively. Crude protein content was the highest in soybean meal – 50.61% and fodder beans – 29.97%, while in peas – 25.04% of dry matter. The highest content of starch was in peas – 48.54%, beans – 43.29% but the lowest in soybean meal – 7.62% of dry matter.

2. Upon the whole, it can be concluded that the highest rate of essential amino acids was detected in soybean meal and fodder beans, while the lowest – in peas.

3. The cow productivity indicators decreased for all the groups, which was normal during the lactation period, yet the daily milk yield decreases for the trial groups were smaller – 2.22 kg, 2.10 kg and 0.26 kg, respectively, compared with the initial stage of the experiment and the control group.

4. The highest total amount of amino acids in milk was detected in 3rd and 2nd trial cow groups, respectively, 4.00 g kg^{-1} and 3.90 g kg^{-1}, which was fed fodder beans and peas but the lowest amino acid amount was detected in trial group 1st – 1.80 g kg^{-1}, which was fed peas plus fodder beans compared with the initial stage of the experiment ($P < 0.05$).

5. The milk sale and feed cost summary records for the trial that lasted 90 days show that economic efficency of peas plus beans has been positive The highest economic efficiency in milk production and distribution was shown by group 1st, which was fed peas+ beans while the lowest efficciency – by group 3rd which was fed fodder beans.

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