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Efficiency of the use of field beans in fattening lambs

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Abstract. The breeding and feeding of self produced pulses to livestock is one of the important directions of research for reducing the production costs of livestock products. Experiment on the effective using of the field beans to lambs for fattening was arranged in three replications using the Latvian Dark-headed breed male lambs. The mixture of concentrated feed consisted of 50% of bean and 50% of oat. Lambs were weighed at the starting and ending of the trial. Carcass quality was assessed according to the European standard for the classification of carcasses of sheep. The fattening period lasted from 37 to 94 days, on average 63 ± 3.6 days. The average live weight gain per day was 247.4 ± 13.85 g, and live weight increased on average by 15.3 ± 0.94 kg. Significantly higher ($P < 0.05$) growth rate during fattening period reached lambs of 3rd group, where lambs started fattening above 27 kg of live weight, reaching a 276.8 ± 26.26 g daily live weight gain. The quality of the obtained carcasses was an average, and score for musculature was from R to O class, but the average score for fat deposition was from 3 to 4 points. The mixture of field beans and oats provided 19.3% of crude protein and 12.1 MJ of metabolizable energy 1 kg of dry matter, and its unlimited feeding provided medium lamb's growth rate. The level of feed conversion was 7.56 kg of dry matter.

Key words: beans, lamb, fattening, slaughter, carcass.

INTRODUCTION

Well-balanced and optimized nutrition of lambs is important precondition in breeding and production of lamb meat in high quality. For this purpose it is necessity for extra feeding of suckle lambs and optimal feeding after weaning with the aim to get live weight gain to 200 g per day and more. Shortage of different nutrients at first can lead to lower clip and quality of wool, amount and quality of meat, feed conversion for production of meat and wool, and to growth of suckle lambs finally (Kairisa & Selegovska, 2004).

In Latvia the basic feed for sheep is hay of good quality and concentrates. According Boughalmi & Araba (2016) studies, fattened lambs have a higher carcass weight and dressing percentage if the feed ration consists from concentrated feed and hay, as compared to ration which consist from concentrated feed and pasture grass. The best hay is hay from natural meadows (Latvietis, 2013). Concentrates mostly consist of barley, oats and wheat, which can be supplemented by protein feed, minerals and vitamins. Not only imported soya bean but also other protein crops – field beans

(*Vicia faba* L.), peas, lupines, vetches – are excellent forage because of their high protein content.

The most common protein feed for livestock is field beans which are an excellent source of both protein and energy for ruminants. The protein content of field beans is 29.6%, the soluble protein is 14.97%, undegraded intake protein (UIP) is 44.18% of crude protein (Osmane et al., 2015). The protein is extensively and rapidly degradable in the rumen and protein not degraded in the rumen should be accessible later in the intestinal tract (Ramos-Morales et al., 2010). Some heat treatments of beans can increase the proportion of protein that by-passes digestion in the rumen, but there is much variability in this effect and ultimately in how heat treatments affect animal performance (Yu et al., 2004). Compared to cereals, the content of lysine in field beans is relatively high and the contents of the sulphur-containing amino acids cysteine and methionine are low (Crepon et al., 2010). Min et al (2015) experiments have shown that phytochemical plant tannins can modify the fatty acid composition of meat, thus indirectly affecting its colour stability, antioxidant status and shelf life (Luciano et al., 2009) Tannins in field beans are located mainly in the hull. The presence of some tannins with field beans can protect protein from degradation in the rumen but allow it be subsequently digested post-ruminally (Martinez et al., 2004). They can also have beneficial effects in reducing bloat and enteric methane, and in providing an anthelminthic effect. However, high concentrations of some tannins can reduce feed intake and thus animal performance (Butter et al., 1999). Antinutritional substances in field beans are not currently considered problematic for fully-developed ruminants (Melicharová et al., 2009).

According Sinclair et al. (1991) increasing the dietary protein level resulted in an increase in cold carcass weight, chest width, carcass protein content, *M. longissimus dorsi* depth and fatness class and weight of liver and kidney. The use of field beans in varying proportions, in replacement of soybean meal and sunflower meal, did not affect lamb performance (Caballero et al., 1992). Moreover, carcasses from lambs fed field beans showed lower fatness than those from lambs fed soybean cake or lentil diets. According investigation of Boukhris et al. (2013) average daily gain of lambs was similar for all dietary treatments, which included soya bean or field bean. However, lambs fed by concentrates comprising 100 g kg^{1} field bean had the lowest proportion of fat in the carcass than that for lambs which received 200 g kg^{1} field bean or just soya as protein source. Unlimited feeding lead to lower carcass weight and dressing percentage compared to lambs that received limited amount of concentrated feed (Karaca et al., 2016).

As sheep is a ruminant, the feeding of sheep is very similar to feeding of cow. Therefore profitable sheep breeding is not possible without complete nutrition. As most lambs require 10–14 kg of feed to produce 2 kg of liveweight (1 kg of carcase weight), ration costs are a major issue within a feedlotting program (Duddy et al., 2016).

The objective of this study was assessing the suitability of field beans in lamb finishing diets.

MATERIALS AND METHODS

A study on the possibilities of feeding of field beans to lambs was carried out in collaboration with the Latvian Sheep Breeders Association at the breeding control station in three replications. The study was carried out in the autumn and winter period,

using the Latvian Dark-headed male lambs born in the middle of summer (late June or July) in 2014, 2015 and 2016. 19 lambs were purchased after weaning from mothers 3 to 3.5 months old with a live weight of 19.8 kg to 30.2 kg. They were placed by 3 or 4 in one pen in outdoor shed, and the straw was used as bedding material. For research purposes and analyzing of data they were divided into 3 research groups according their live weight. Mixture of ryegrass and clover 2nd cut hay and grain meal was fed unlimited, and the amount of consumed food was regularly counted. Water was provided from the automatic water bowls. The fattening of lambs started after a two week adaptation period. Based on the fact that lambs with higher live weight are able to consume a larger amount of feed (Nutrient requirements ..., 2007), data from the study were analyzed taking into account the lambs' live weight at the beginning of fattening (Table 1).

Table 1. The research scheme

Research groups	Live weight of lambs at the beginning of fattening, kg	Number of lambs
1.	till 25	6
2.	25–27	6
3.	above 27	7

In order to bring the main nutrient content closer to the concentrated feed mix, the bean and oat meal mixture was in equal proportion to 50% and 50%. The following feed nutrient biochemical parameters were analyzed before the start of the trial according with generally accepted methods of analysis: dry matter (DM) according ISO 6496:1999 method; neutral detergent fiber (NDF) according LVS EN ISO 16472:2006; acid detergent fiber (ADF) according LVS EN ISO 13906:2008; crude protein (CP) according LVS EN ISO 5983-2:2009; calcium (Ca) according LVS EN ISO 6869:2002; phosphorus (P) according ISO 6491:1998; ash according ISO 5984:2002/Cor 1:2005, but metabolizable energy (ME) was calculated in laboratory based on the results of the ADF analysis (Rohweder, 1984; Ositis, 1996). The quality indicators for nutrients were determined by the accredited laboratory of Agronomic analysis of the Latvia University of Agriculture.

Lambs were weighted at the start and end of the study. Using the obtained live weight results, the absolute increase in live weight per day (A) were calculated by formula (1):

$$A = \frac{Wt - Wo}{t} \quad (1)$$

where W_t – live weight at the end of the period, kg; W_0 – live weight at the beginning of the period, kg; t – period, days.

Lambs were slaughtered in a certified slaughterhouse, reaching at least 40 kg of live weight. Before slaughtering of lambs, 12-hour fasting period was applied without limiting of water intake. After slaughter of lambs, chilled carcases (24 hours after slaughter) were weighed and the carcass dressing (K) was calculated according to the formula (2):

$$K = \frac{Km}{Wk} \cdot 100 \quad (2)$$

where K – carcass dressing, %; Wk – live weight before slaughtering, kg; Km – carcass weight, kg.

The carcase quality was assessed according to the European Standard for the Classification of Sheep Carcasses (Markovic et al., 2014), where EUROP letter designations were used to indicate musculature development. The evaluation of the obtained data is based on the numerical values: E – excellent (1), U – very well developed (2), R – good (3), O – average (4), P – weak (5). The level of fat stratification is designated by numbers from 1 to 5, where 1 – very low, 2 – low, 3 – medium high, 4 – high, 5 – very high. Using the tape measure, the length of the carcase and the thigh girth were measured. The cold carcasses were weighed and sawed into two symmetrical sides along backbone. One side was divided into the main tissue components: muscle, bone, fat and connective tissue. Using the obtained results, the tissue ratio was calculated: meat (muscle + fat) and bone, muscle and fat, muscle and bone.

The data obtained in the study were analyzed using mathematical methods of data processing. The average values of the characteristics, the standard error and the coefficient of variation are calculated. The significance of the average values difference is determined by the t-test. The small letters of the Latin alphabet: a, b, c were used to indicate the significance of the differences ($P < 0.05$) between the study groups.

RESULTS AND DISCUSSION

The results summarized in Table 2 show, there were no significant differences in the number of lambs at birth or in age at the beginning of fattening. A significant difference ($P < 0.05$) was observed in live weight of lambs at the beginning of study, which indirectly indicates the milk productivity of sheep mothers as well as feeding management of lambs on farms.

The chemical composition of the grain meal mixture is summarized in Table 3.

Table 2. Litter size, age and live weight of lambs at the beginning of fattening

Research group	Litter size	Age, days	Live weight, kg
	$\bar{x} \pm S_{\bar{x}}$		
1.	1.83 ± 0.307^{a}	90 ± 4.8^{a}	22.5 ± 0.70^{a}
2.	2.00 ± 0.258^{a}	91 ± 3.5^{a}	26.3 ± 0.25^{b}
3.	1.86 ± 0.143^{a}	97 ± 5.1^{a}	28.0 ± 0.41^{c}

$^{a, b, c}$ – values followed by different letters are significantly different between groups ($P < 0.05$).

Table 3. Chemical composition of grain meal mixture (n = 3)

Indices	DM, %	In dry matter						
		CP, g	NDF, g	ADF, g	ME[1], MJ	Ash, g	Ca, g	P, g
Average	89.5	193.5	194.6	136.9	12.1	54.5	5.6	5.4
Standard error	0.40	6.36	8.83	19.05	0.12	2.43	0.46	0.52
Min.	88.8	183.2	184	105.4	12.5	50.4	4.8	4.5
Max.	90.1	205.1	212.1	171.2	11.7	58.8	6.4	6.3
Variation V, %	0.8	5.7	7.9	24.1	1.7	7.7	14.3	16.8

[1] Calculated as: Metabolizable energy (ME) MJ kg^{-1} dry matter = 0.155 × TDN, where TDN is total digestible nutrients, % in dry matter (Ositis, 1996) and %TDN = 88.9 - (0.779 × ADF%) (Rohweder, 1984).

According to Barzdina & Kairisa (2016), the average daily gain for Romanov and Dorper crossbread lambs is 291 g. To reach the planned 40 kg live weight prior to slaughtering of lambs, the fattening period lasted from 37 to 94 days, on average 63 ± 3.6 days. During Barzdina & Kairisa (2016) research, the average live weight gain per day

was 247.4 ± 13.85 g, and live weight increased on average by 15.3 ± 0.94 kg during fattening period.

In our study a significantly shorter fattening period was observed to lambs in groups 2 and 3 (Table 4). First group lambs were fed on average by 26 days longer than in group 3 and by 16 days longer than lambs of 2nd group (P <0.05). During the study, the live weight of 1st group lambs increased by an average of 16.8 ± 1.47 kg.

Table 4. Fattening period and live weight gain of lambs

Research group	Fattening period, days	Live weigt gain per period, kg	Live weight gain per day, g
	$\bar{x} \pm S_{\bar{x}}$		
1.	78 ± 3.8[a]	16.8 ± 1.47[a]	218.0 ± 18.74[a]
2.	62 ± 6.2[b]	14.7 ± 1.80[a]	242.4 ± 22.18[ab]
3.	52 ± 4.3[b]	14.6 ± 1.74[a]	276.8 ± 26.26[b]

[a, b] – values followed by different letters are significantly different between groups (P < 0.05).

Significantly higher growth rate during fattening period reached lambs of 3rd group, reaching a 276.8 ± 26.26 g daily live weight gain. The difference in live weight gain between the first and third group lambs is 58.8 g (P < 0.05) per day. The age of 1st group lambs at the end of fattening period was 178 days, but the age of 3rd group lambs was only 160 days. The difference in live weight gain is because the younger lambs have a higher growth rate than older lambs.

The average age of the lambs prior to slaughter was 167 ± 4.6 days and average live weight was 42.8 ± 0.77 kg (Table 5). 3rd group lambs were slaughtered by 18 days younger – on age of 160 ± 9.3 days with an average of 44.8 ± 1.40 kg live weight. There is significant difference (P < 0.05) in live weight at the end of fattening period between 1st and 3rd groups of lambs, and also in live weight prior to slaughter between 1st and 3rd groups and between 2nd and 3rd groups of lambs.

Table 5. Age and live weight of lambs prior to slaughter, cold carcass weight and carcass dressing

Research group	Age at the end of fattening, days	Live weight at the end of fattening, kg	Live weight prior to slaughter, kg	Cold carcass weight, kg	Carcass dressing, %
	$\bar{x} \pm S_{\bar{x}}$				
1.	178 ± 5.2[a]	40.7 ± 0.56[a]	39.5 ± 0.55[a]	18.2 ± 0.40[a]	45.9 ± 0.53[a]
2.	164 ± 7.4[a]	42.4 ± 1.35[ab]	40.9 ± 1.32[a]	18.8 ± 0.74[a]	45.9 ± 0.90[a]
3.	160 ± 9.3[a]	44.8 ± 1.40[b]	43.5 ± 1.25[b]	19.5 ± 0.79[a]	44.8 ± 1.09[a]

[a, b] – values followed by different letters are significantly different between groups (P < 0.05).

According Kairisa & Barzdina (2016a) research, the age prior to slaughter of Latvian dark-headed lambs fed by concentrated feed was similar – 165 days, but lambs were on average by 8.1 kg heavier, reaching 50.7 kg of live weight before slaughter and carcass dressing was 44.8%. In our trial 24 hours after the end of fattening period, carcass weight loss was an average of 3% before slaughter. There was no significant difference between the weight of the cold carcasses and the calculated carcass dressing of all study groups. The lowest carcass dressing percentage was obtained from one of the lambs of the 3rd group, only 39.7%, but the largest for one of the lamb in the 2nd group – 48.1%. It should be noted that the lambs were not cut before slaughter, resulting in the weight of skin for some lambs reaching 7 kg or 15% of live weight.

The results of carcass quality assessment are summarized in Table 6. None of the qualitative characteristics of the carcasses have shoved significant differences due to the fact that the cold carcass weight in all study groups was quite similar from 18.2 kg (group 1) to 19.5 kg (group 3). The obtained results on the length of the carcass and the thigh girth conform with the previously published ones, where the length of carcasses of the Dark-headed lambs was on average 72.2 to 75.3 cm, and the thigh girth from 67.6 to 70.0 cm (Kairisa & Barzdina, 2016b). In general, the development of muscle tissue of four carcasses (21%) was estimated by the O class (moderately developed), but the others (79%) with the R class (well developed). The fat cover for 5 carcasses (26%) was estimated at 3 points, while the remaining (74%) at 4 points, which means that the carcasses are with high level of fat stratification.

Table 6. The quality indices of lambs carcasses

Research group	Carcass lenght, cm	Thigh girth, cm	Fat layer at the 13th rib, mm	Development of muscles, points	Fat stratification, points
	$\bar{x} \pm S_{\bar{x}}$				
1.	71.2 ± 1.22	62.2 ± 0.91	2.9 ± 0.27	3.33 ± 0.167	4.00 ± 0.000
2.	70.2 ± 2.14	62.7 ± 2.47	3.2 ± 0.48	3.25 ± 0.171	3.67 ± 0.211
3.	75.0 ± 3.65	66.1 ± 3.38	2.4 ± 0.21	3.29 ± 0.184	3.57 ± 0.202

From the obtained results, it was concluded that lamb carcasses of group 1 had a weaker musculature compared to carcasses from other groups and a higher fat cover. According to Barzdina & Kairisa (2006) research, muscular tissue development in Latvian Dark headed lamb carcass in 50 cases corresponded to class R and in 50% cases to class O. In our investigation 79% of carcasses were evaluated according to class R. According to the assessment of fat tissue stratification, 74% of carcasses were estimated at 4 points, which indicated on quite well muscular tissue development and too high fat tissue stratification in carcass. Results of research with Estonian whitehead sheep shows that in 53.7% cases muscular tissue assessment in lamb carcass correspond to class R, but assessment of fat tissue stratification indicates that in 65.1% cases it is above 2 (Piirsalu, 2003; Piirsalu & Mettis, 2005).

In the carcasses of all lambs the proportion of muscle tissue was 52.3% on average, the fat content was 21.4%, and the bone density was 25.7%. The proportion of the carcass tissue parts is summarized in Table 7. The obtained results show that a larger proportion of muscle tissue was in the carcasses of lambs in 1st group, and the lowest in carcasses of 2nd group lambs.

Table 7. Proportion of carcass tissues, %

Research group	Muscles	Fats	Bones
	$\bar{x} \pm S_{\bar{x}}$		
1.	53.3 ± 1.05^{a}	19.8 ± 1.02^{a}	26.5 ± 0.32^{a}
2.	51.2 ± 0.77^{a}	23.4 ± 1.41^{b}	24.9 ± 0.96^{a}
3.	52.4 ± 0.99^{a}	21.2 ± 1.24^{ab}	25.8 ± 0.61^{a}

Although the visually estimated fat content of lambs of the group 1 was the highest –an average of 4 points, however, the total carcase fat content was lower, on average 19.8%, which is 3.6% ($P < 0.05$) less than of group 2 and 1.4% lesser than of lamb's carcasses of group 3. 1st group lambs had longer fattening period, they reach slaughter weight later and during this period the formation of muscle tissue was more intense than the formation of fat tissue.

The results of carcass tissue ratio are summarized in Table 8. In the study, the average meat and bone ratio of all lamb carcasses was 2.9, muscle and fat 2.5, but muscle and bone 2.0. The highest proportion of meat and bone, as well as muscle and bone was obtained for carcasses of lambs of group 2, due to the fact that the carcasses of this group had the smallest part of bones – 24.9% and the largest part of fat – 23.4%, but these differences are not significant ($P > 0.05$). The best muscle and fat ratio of the carcasses was at first group.

Table 8. Ratio of lambs carcass parts

Research group	Meat / bone	Muscle / fat	Muscle / bone
	$\bar{x} \pm S_{\bar{x}}$		
1.	2.76 ± 0.044	2.73 ± 0.171	2.01 ± 0.050
2.	3.03 ± 0.148	2.25 ± 0.205	2.07 ± 0.079
3.	2.86 ± 0.096	2.53 ± 0.175	2.03 ± 0.059

The most important indicator for lamb's breeders is the feed consumption of lambs what resulted in live weight gain. The consumption of feed for 1 kg of live weight gain indicates the conversion of feed, or the use of nutrients in the lamb body. During the study, for the 1 kg of live weight gain lambs consumed in average 3.33 kg of grass hay and 5.21 kg of concentrated feed, totally 7.56 kg of feed dry matter, indicating a worse conversion of feed compared to a Barzdina & Kairisa (2015) study on unlimited feeding of concentrated feed. In this study, dietary intake for 1 kg of live weight gain was 3.00 kg of hay and 4.7 kg of concentrated feed. In a study in Iran (Majdoub-Mathlouthi at al., 2013), in feeding of Barabarine lamb by unlimited amount of oat straw and 600 g of concentrated feed in ration, consisted from soya bean cake, wheat bran, corn grains and mineral feed, feed conversion rate was 9.3 units. Feeding of alfalfa hay for an unlimited diet for lambs of the Sufolk breed, the feed conversion ratio was 9.17 (Phillips et al., 2002). The studies of other authors (Emailizadeh et al., 2012; Khevani et al., 2014) indicate the feed conversion rate from 4.0 to 7.4, which is quite close to our study.

CONCLUSIONS

The research resulted in new knowledge about the possibilities of using field beans in diet of fattening lambs. A mixture of concentrated feed, created by using the 50% of field beans and 50% of oats, provided one kg of dry matter with 193.5 g of crude protein and 12.1 MJ of metabolizable energy. Unlimited feeding of this concentrated feed to Latvian dark-headed lambs provided an average of 247.4 g of live weight gain per day without any digestion disorders in lambs. Significantly better fattening results are obtained with lambs starting fattening at 3 months of age with live weight above 27 kg. Lambs of this group compared to 1st group lambs had a significantly shorter fattening period – 52 days, which is by 26 days less ($P < 0.05$), resulting in a significantly higher increase in live weight gain per day – 276.8 g, which is by 58.8 g higher ($P < 0.05$). The study did not show any significant differences in carcase quality assessment, but a significantly higher proportion of fat was obtained for 2nd group lamb carcasses, on average 23.4%. The quality of the obtained carcasses is moderate, muscle tissue development is in the R and O classes (79% of carcasses were evaluated according to class R), but the fat tissue stratification is from 3 to 4 points (74% of carcasses were estimated at 4 points), which indicated on quite well muscular tissue development and too high fat tissue stratification in carcass. In future researchers have the task to conduct

experiments with the aim of improving quality of carcass obtained from Latvian dark-headed lambs. For the production of one kg of live weight gain 3.33 kg of grass hay and 5.21 kg of grain meal mixture, or 7.56 kg of dry matter, were consumed.

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