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Effect of concentrate supplementation on fattening performance and carcass composition of finished meat-goat kids

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Abstract. A study on the effective usage of the concentrated feed supplement to Boer meat goat kids was carried out within the framework of the project 'Zootechnical and economic efficiency of feeding of fodder pulses to ruminant's meat production'. Since the Boer goat breed in Latvia is still very rare, there is a lack of experience in the feeding and production of meat goat for better carcass traits and meat quality. This study was arranged in autumn period, using the Boer cross breed male kids born in 2018. In control group (OG) four kids were kept together with mothers till finishing and were fed by oats as concentrated feed supplement. In research group (BG) four goat kids were weaned from mothers and placed in shed to explain influence of mix of 85% of oats and 15% of fodder beans as protein supplement to the fattening outcomes. In the trial kids were weighed at the starting and ending of the trial. Carcass quality is assessed according to the European standard for the classification of carcasses of sheep, where EUROP letter designations have been used to denote musculature development, and the fat deposition level is indicated by numbers 1–5. The length of the carcass and the circumference of the hips were measured using the tape measure. The carcasses were analyzed by type of tissue: muscle, bone, fat. The fastest growing rate during the fattening period of 72 days was given to BG kids with a mean daily live weight gain of 72 g, while the OG kids achieved 69 g. After slaughter, the carcass yield of OG kids was from 42.5% to 51.4%, but for BG kids was 38.5% to 42.5%. The quality of the obtained carcasses was an average, and score for musculature was from R to P class, but the average score for fat deposition was from 2.25 to 2.75 points and higher fat cover was observed in BG kids. Higher proportion of lean meat (59.1%) and fat tissues (16.3%) were observed to OG kids, but higher proportion of bone (25.9%) was in BG kid's carcasses. The consumption of concentrated feed for 1 kg of live weight gain indicates the conversion of feed nutrients. The consumption of oats per kilogram of live weight gain was 3.21 kg for OG kids, but the consumption of the feed mix of oats and beans for BG kids was 2.83 kg. Based on physical parameters of goat kid carcass and high level of lean meat, fattening of Boer cross breed goat kids by using of oats or feed mix can be an ideal choice for farmers, which try to find new products and free market for consumers.

Key words: kids, carcass characteristics, meat quality.

INTRODUCTION

In the Baltic States goat farming focuses mainly on milk production, however, recently there has been increased interest and demand for goat meat. Boer goats were imported into Latvia in 2005 and used in cross breeding for the improvement of goat meat quality and quantity. At present, the Latvian goat breeding industry is in early stage of its development. Although there is a demand for goat meat in Latvia, the number of meat goats is decreasing. In order to successfully develop goat meat production, it is necessary to increase the number of animals and continue to promote goat meat production in Latvia (Lauksaimniecības zinojums par 2014. gadu ...).

If you breed meat goats, then you will not get milk because goats give milk only for kids. Meanwhile, there will be a lot of meat production and goat meat is very valuable. The favorite is 6–8-week old goat kid meat, which is very similar to lamb (Piliena & Spruzs, 2007).

Small ruminants are the most efficient transformers of low quality forage into high quality animal products with distinguished chemical composition and organoleptic characteristics (Zervas & Tsiplakou, 2011).

The feeding system effects on meat quality are more difficult to be identified because kids of different breed, weaned at different age and live weight or raised on different types of pastures have different growth rate and carcass characteristics like level of fatness, flavor, tenderness, taste, etc. It has been demonstrated that kids raised under a grazing system without any supplementation, present an inferior fatness degree and a higher meat fat concentration of n−3 PUFA and CLA (Zervas & Tsiplakou, 2011). Goat meat has different distribution of fat compared to that in sheep meat. At similar carcass weight goats may be expected to produce carcass with lower proportion of subcutaneous and intramuscular carcass fat and a higher proportion of non-carcass fat in the abdominal cavity, compared to sheep. This lower proportion of carcass fat is reflected in a higher proportion of bone in the carcass of goats (Morand-Fehr et al., 1991). Consumers are interested in goat meat as a source of relatively lean meat, especially in developed countries with a high incidence of cardiovascular diseases (Zervas & Tsiplakou, 2011).

The nutritional requirements of goats managed primarily for milk production and those managed primarily for meat production are quite similar with perhaps two notable differences. First, meat goats need only achieve a 4–7 month lactation with high initial milk flow, persistency beyond 4 months being of lesser concern. Secondly, lactating meat goats are not usually fed concentrates in addition to their forage diet because the extra kid growth achieved from the extra milk may well not repay the added costs. In those situations in which the plants are too low in protein, additional protein must be offered to maintain acceptable goat performance. High protein supplemental feedstuffs, used only occasionally by meat goat owners, are soybean meal, peas and field beans meal, urea and others. Choosing between alternative high protein feedstuffs is largely an economic decision (Pinkerton & Pinkerton, 2015).

Confinement feeding of diets with concentrate can affect various carcass characteristics as well as internal and carcass fat levels (Goetch et al., 2011). In addition to effects of dietary inclusion of concentrate, the level feed can affect mass of non-carcass organs and tissues as well as carcass weight and composition. Intake and average daily gain (ADG) by crossbred goats in a 90-day experiment increased as *ad libitum* access to concentrate, which was accompanied by increasing liver (% of empty BW) and internal (primarily omental) and total body fat mass (Mushi et al., 2009b). According the study of Wuliji et al. (2003) growing Spanish kids consumed more dehydrated alfalfa pellets than a 70% concentrate diet, resulting in similar ADG. Nonetheless, fat accreted in non-carcass tissues was greater for the concentrate diet. Goats appear to differ from cattle and sheep in performance benefits from diets very high in concentrate (Mushi et al., 2009a). For example, ADG and carcass weight of growing Angora wethers were similar between confinement feeding of diets consisting of 80% concentrate or 24% concentrate and 76% forage (20% cottonseed hulls and 56% alfalfa hay. Although above it was generalized that growth performance of goats is not improved by high dietary concentrate levels. Level of concentrate had few effects on meat quality, but the total level of fat in dissected rack tissue was greater for the highest vs. intermediate dietary concentrate level and the level of subcutaneous fat was greatest among diets for the diet highest in concentrate. But the research of Lee et al. (2008) found that there were considerably greater ADG for continuous feeding of the concentrate vs. hay diet (134 vs. 41 g) and much greater carcass weight for the concentrate diet. High internal fat deposition by goats has heightened interest in feeding practices to maintain high lean tissue gain and meat quality with little fat accumulation. One such method is limited intake of concentrate-containing diets, which in beef cattle offers a means of achieving efficient feed utilization perhaps by minimizing the maintenance energy requirement at least in part because of limiting energy use by splanchnic tissues (Galyean, 1999), as would be expected in goats as well (Tovar-Luna et al., 2007).

The objective of our study was to assess the efficiency of feeding a compound feed containing fodder beans to Boer kid meat productivity and to study its impact on meat quality.

MATERIALS AND METHODS

The study was carried out on a farm whose main activity is the production of goat meat. This study included 8 Boer cross breed goat kids born in this farm in spring 2018. The kids were divided into two groups of 4 animals each similar in age and live weight. After 7 days adaption period at beginning of fattening the control group kids average age was 209 days and the average live weight was 30.0 kg, but the research group kids average age was 215 days and the average live weight was 28.1 kg. Dietary treatment was conducted according to research scheme (Table 1).

Table 1. The research scheme

Groups	Number of kids	Concentrated feed
1st control group	4	Oats
2nd research group	4	85%oats + 15%fodder beans

In the summer, goats of all ages and genders were grazed in the farm, and 1st control group kids together with their mothers were separated from herd and fed with pasture grass, hay (*ad libitum)* and oats as additive of concentrated feed. For the purposes of the study, the 2nd research group kids at the age of 7 months were separated from their mothers and placed in a barn and fed with hay *(ad libitum*) and self-made grain mixture made of whole oats and bean flour.At the beginning of the study for 32 days the proportion of beans in the concentrated feed mixture was 10%, from the mid-term to the end of fattening – 20%, so the average proportion of fodder beans in the concentrated feed mixture was 15%. During the study there were counted the amount of consumed concentrated feed, but the amount of grass feed was *ad libitum*. All goat kids were slaughtered after 72 days of experimental period.

The following feed nutrient biochemical parameters were established 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; ether extract (EE) according ISO 6492:1999; starch according LVS EN ISO 10520:2001, calcium (Ca) according LVS EN ISO 6869:2002; phosphorus (P) according ISO 6491:1998; but the net energy for lactation (NEL) were calculated based on the results of the analysis performed. The quality indicators for nutrients were determined by the accredited laboratory of Agronomic analysis of the Latvia University of Life Sciences and Technologies.

In trial period goat kids were weighed at birth and at the age of 50 days and also at the beginning and at the end of fattening with an electronic scale (accuracy of 0.01 kg). Absolute live weight gain per day per period for analyzed kids was calculated by formula (1):

$$a = (W_t - W_0)/\mathrm{t} \quad (1)$$

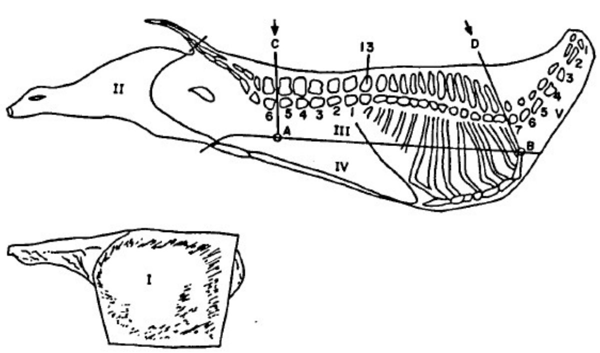
where a – live weight gain per day, g; W_t – live weight at the end of period, g; W_0 – live weight at the beginning of period, g; t – period, days.

At the end of the feeding period kids were held overnight without feed before slaughter. Each goat kid was weighed before slaughter to determine the slaughter live weight. Hot carcass weights were taken immediately after slaughter and removal of non-carcass components. Weight of non-carcass components recorded included heart, kidney and liver. Carcasses were chilled for 24 h at 4ºC. In 24 h *post mortem*, the carcasses were reweighed. Dressing percentage was computed as a proportion of the cold carcass weight to the slaughter live weight by formula (2).

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

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

Each carcass was evaluated for conformation and fatness according to the SEUROP carcass classification system for lambs (CEE No. 1249/2008). Carcass was classified for conformation (scale from S = Superior (0) to *P* = poor (5) and fatness (scale from 1 = traces of or no fat visible to 5 = very thick fat cover) according to the visual scores in the SEUROP system. After evaluation of conformation and fatness, the length of the carcass and the circumference of the hips are measured using a tape measure. The neck was then separated and carcass was split longitudinally on a saw. The left side of carcass was also separated into five prime cuts: shoulder blade and shoulder, hip with leg, ribs, flank, sirloin (Fig. 1).



where,
I – Shoulder blade and shoulder; II – Hip with leg (cut between 5/6 lumbar vertebrae); III – Ribs+ chest vertebrae + back vertebrae (from D to 13 vertebrae); IV – Flank; V – Neck; Sirloin (1–5 lumbar vertebrae with fillets).

Figure 1. Goat kid carcass parts (Colomer-Rocher et.al., 1987).

The cuts were weighed and expressed as a percentage of the total weight of the carcass. Fat depth (body fat) over the midpoint of *longissimus do*rsi muscle at the 13th rib was determined 24 h postmortem. The *M. longissimus dorsi* (MLD) were carefully dissected from the left side sampled, weighted and the ribeye area (REA) was measured on a transparent plastic grid (Fig. 2). The guidance for grid assessment of REA was based on a mathematical theorem for determining the area of a polygonal object located on a grid of equally spaced points, Pick's Theorem (Pick, 1899).

Figure 2. Grid with a contour of MLD.

For calculations of REA we used Pick (1899) theorem (3).

$$A = ID + (BD/2) - 1 \tag{3}$$

where A – area, cm^2; ID – interior dots; BD – boundary dots.

Each cut was dissected into components of meat, bone and fat. The dissection technique used for measuring muscle, bone, and fat composition was described by Colomer-Rocher et al. (1987). Firstly, the muscle was individually removed from their attachment and then the external fat was removed. Muscle, fat, and bone were separated and weighed individually.

After boning the carcasses, the tissue ratios were calculated: meat (muscle tissue + adipose tissue) and bone tissue, muscle tissue and bone tissue, muscle tissue and adipose tissue. Kidney and pericardial obesity was evaluated on a 1–3 point scale according to the standard method for estimating goat carcass (Colomer-Rocher et al., 1987), where 1 – minimal obesity, 2 – moderate obesity; 3 – very large obesity.

Using the data on consumed concentrated feed and the obtained live weight gain, the economic efficiency of the use of concentrated feed was calculated. Average daily gain was calculated from weight change within a given duration. Concentrate efficiency was calculated as the amount of concentrate consumed per unit of live weight gain.

Fattening performance and carcass parameters were analyzed with mathematical data processing methods. In all analyses, statistical significance was declared at $P < 0.05$. The physical data were subjected to analysis of variance (ANOVA). The results are reported as least square means (LSM) and the standard error of the mean (SEM).

RESULTS AND DISCUSSION

The evaluation of the results of the research was started with the analysis of the composition of the concentrated feed.

Since the study did not limit the feeding of grass – pasture grass and hay, and was not calculated the consumed amount, it is not possible to analyze the effect of the grass feed on the kid's growth rates. During the study, whole oats were fed as a source of energy for the control group's kids, while mix of grains and beans was additionally fed to the kids in the 2nd research group after a 7-day period of adaptation. At the beginning of the study for 32 days the proportion of beans in the concentrated feed mixture was 10%, from the mid-term to the end of fattening – 20%.

Table 2. Chemical composition of concentrated feed

Nutrient	Oat	Fodder bean	10% bean + 90% oat	20% bean + 80% oat
Dry matter (DM), %	91.77	86.90	91.28	87.78
Crude protein (CP), % DM	10.37	30.39	12.37	14.37
NDF, % DM	32.61	18.24	31.17	29.74
ADF, % DM	18.01	15.36	17.75	17.48
NEL, MJ kg^{-1} DM	7.17	7.38	7.19	7.21
Ether extract (EE), % DM	5.80	1.25	5.35	4.89
Starch, % DM	44.77	40.94	44.39	44.00
Ca, % DM	0.11	0.14	0.11	0.12
P, % DM	0.36	0.73	0.40	0.43

According to Table 2, the feed mix with higher proportion of fodder bean has higher energy (NEL) and protein content, while lower NDF, ADF, EE and starch content. Taking into account the climatic conditions of 2018, when a very hot and dry summer was observed, we assume that the quality of grass feed in the second half of the summer fell sharply, and that in order to provide the goat kids with the nutrients they need, it was necessary to include concentrated feed in feed ration, which provides additional nutrients during the fattening of the kid (Table 3).

Table 3. Feed nutrient intake per head per day from concentrated feed

Nutrient	1st control group	2nd research group		
		At the beginning	In mid term	At the end
DM, g	203.3	190.2	182.9	186.5
CP, g	21.1	23.5	26.3	24.9
NDF, g	66.3	59.3	54.4	56.8
ADF, g	36.6	33.7	32.0	32.9
NEL, MJ	1.5	1.4	1.3	1.3
EE, g	11.8	10.2	8.9	9.6
Starch, g	91.0	84.4	80.5	82.4
Ca, g	0.2	0.2	0.2	0.2
P, g	0.7	0.8	0.8	0.8

By adding fodder beans to the compound feed in 2nd research group, the daily intake of crude protein increases by 18.0%, but decreases the intake of starch (-9.5%), fat (-18.7%) and energy (-13.4%) compared to feeding of only oats as concentrated feed. Dietary protein requirements of growing goats vary with energy intake. Interactions between dietary energy and protein levels are common but may not always be observed due to method of diet formulation. In this regard, Kannan et al. (2006) did not influence average daily gain (ADG) or meat characteristics of dairy goats fed concentrate diets differing in CP and digestible energy (DE) concentrations.

The analysis of the results of the study was continued with growth rates, i.e. changes in the kids' live weight during the fattening.

To carry out the research, 8 kids were separated from the goat herd. The control group 4 kids average age at beginning of fattening was 209 days and the average weight was 30.0 kg, but the control group 4 kids were on average 5.7 days older and 1.9 kg lighter (Table 4).

Table 4. The age and live weight of kids at the beginning of fattening

Group	Age at beginning of fattening, days				Live weihgt at beginning of fattening, kg			
	$\bar{x} \pm s_{\bar{x}}$	min	max	V,%	$\bar{x} \pm s_{\bar{x}}$	min	max	V,%
1st control	209.0 ± 9.71	184	228	9.3	30.0 ± 2.92	24.0	35.5	19.5
2nd research	214.7 ± 6.29	204	228	5.8	28.1 ± 2.68	23.0	33.0	19.0

Where V, % – coefficient of variation; s_x – standard error of the mean.

According Table 4, kids of both groups were adjusted by age at the beginning of fattening, but relatively unadjusted by the live weight – the coefficient of variation 19.0–19.5%, however, no significant differences ($P > 0.05$) were found between the groups.

The age of the kids and their live weight before slaughter are summarized in Table 5. The 2nd research group's kids were 1 day younger and 2.16 kg lighter ($P > 0.05$) than the control group kids. When the fattening was started, the kids in the 2nd reasearch group were by 6.4% lighter, but at the end of the fattening, they were by 6.1% lighter, indicating that after including of feed bean mixture to the feed ration, there was no increase in live weight as expected. In the control and research groups during the fattening period the live weight of the kids increased by 5.46–5.20 kg, respectively. The fattening period of the control group kids was 79 days, and of the research group kids – 72 days old, reaching a daily live weight gain of 69 and 72 g, respectively.

Table 5. Live weight and daily live weigt gain of goat kids

Indices	1st control group (n = 4)			2nd research group (n = 4)		
	Average	V,%	SEM	Average	V,%	SEM
Birth live weight, kg	3.3	15.3	0.26	3.65	13.7	0.25
Live weight at age of 50 days, kg	12.43	4.6	0.28	11.53	11.5	0.66
Daily live weight gain till age of 50 days, g	183	3.3	3.5	158	19.1	15.4
Age at the end of fattening, days	288	6.7	9.71	287	4.4	6.29
Live weight at the end of fattening, kg	35.46	14.6	2.59	33.30	17.9	2.99
Daily live weight gain till end of fattening, g	112	16.1	9.3	103	17.4	9.1
Daily live weight gain in fattening period, g	69	34.8	11.8	72	36.2	12.8

Where V, % – coefficient of variation; SEM – standard error of the mean.

According to the data in Table 5, the birth weight of 2nd research groups kids were by 0.35 kg higher than that of the control group kids, but the difference are not significant ($P > 0.05$). The all control group kids were born as twins, but the research group's 2 kids were single at birth. Birth weight of goat's decreases with increasing litter size (Todaro et al., 2006). Pre-weaning growth rate is greater for single kid litters compared with kids of multiple births depending on factors influencing milk production. Concentrate supplementation should increase pre-weaning growth when milk yield is low regardless of litter size but not with moderate-high milk yield when concentrate substitutes for milk (Goetsch et al., 2011, Todaro et al., 2006). Asizua et al. (2014) found that the growth rates of both the grazing goats and supplemented goats were similar, and average daily gain (ADG) for Boer crossbreed kids on pastures were 60–80 g. According to Uganda scientists investigation the increase in ADG resulting from concentrate intake was considerable especially in the last 34 (56–90) days of the trial where growth rate of the supplemented goats was more than double that of the control goats (Asizua et.al., 2014).

For six Boer goat kids crossing level for both the control group and the study group kids (3 in each group) is 50.00–82.03%, and for one kid in each group this is only 16.80%. The average daily live weight gain up to age of 50 days reaches only 160–183 g. According to breeding program of Boer goats the fertility should be 180–200%, and the ADG up to 50 days should be 180–230g (Ciltsdarba programma..., 2016). According to the data in Table 5 the feeding of goat mothers should also be reviewed on the farm to achieve the growth rates of kids indicated in the Boer goat breeding program.

After the slaughtering of the kids the result of the carcass yield (dressing) was calculated (Table 6).

Table 6. Means (± S.E.) of carcass measurements

Group	Dressing, %	Carcass length, cm	Hip circumference, cm	Body fat thickness, cm	Ribeye area, cm^2
1st control	45.1 ± 2.12^a	71.0 ± 3.72	56.7 ± 4.64	0.27 ± 0.05	14.5 ± 0.73
2nd research	39.9 ± 0.94^b	63.0 ± 2.79	52.5 ± 2.54	0.35 ± 0.09	11.6 ± 1.40

In the control group the cold carcass yield (dressing) was between 42.5% and 51.4%, but in the research group between 38.5% and 42.5%. According to several researchers (Solaimana et al., 2011; Asizua et al., 2014; Turner at al., 2014) investigations pure and cross breads Boer goats dressing percentage were from 43.0% to 56.4% and feeding has significant effect on dressing percentage. In Solaimana et al. (2011) investigation *M. longissimus dorsi* ribeye area (REA) for pure Boer goats was 9.8 cm2, where in our research REA wary from 11.6 to 14.5 cm^2. Estimates of REA have been reported to indicate relative muscling in meat goats (Browning et al., 2012). According Turner et al. (2014), the REA:body weight (BW) ratio was 0.24–0.31 and was not different among different feeding groups, but in our research ratio among REA:BW was 0.41 in control group and 0.35 in trial group ($P > 0.05$), which mean the higher meatiness of our kids carcasses. Mourad et al. (2001) found that dressing percentage, carcass conformation, carcass compactness, and leg conformation of West African dwarf goats improved with increasing BW. Substantially lower dressing percentage in various goat genotypes in Kenya occurred with slaughter at 7.2 vs. 14.7 and 23.9 months of age (Ruvuna et al., 1992).

According to the results, the carcass yield of 2nd research group kids was by 5.2% less ($P < 0.05$) than in the control group. After slaughter were obtained carcasses weighing on average 13.38 kg (2nd research group) to 16.08 kg (1st control group).

The carcasses of the 2nd research group were by 8 cm shorter, 4.2 cm smaller hip circumference, 0.8 mm more fat layer at the last rib (no significant difference), but in overall with weaker muscle development according to the SEUROP carcass evaluation system (Table 7).

Table 7. Carcass conformation and evaluation of body organs

Group	Conformation, number R	O	P	Carcass fatness, points	Kidney fat, g	Kidney fatness, points,	Heart fat, g	Heart fatness, points
1st control	2	2	0	2.75	5.00 ± 2.9	1.25	17.50 ± 4.8^{a}	1.25
2nd research	0	2	2	2.25	9.50 ± 4.9	1.50	50.50 ± 13.4^{b}	2.25

A very important indicator for goat kid carcasses is the stratification of fat because of the amount of subcutaneous fat depends the quality of the meat during storage. If there is a small layer of fat, the storage and freezing of the carcasses may be difficult because the carcasses are damaged by dehydration. When visually evaluating the entire carcass, higher fat deposits are presented in the 1st control group carcasses – 2.75 points, compared to the 2nd research group – 2.25 points. The amount of fat in the carcass is clearly related to the dietary energy availability, with diets of higher energy density producing fatter carcasses (Chestnutt, 1994). In our investigation kids from 1st control group received concentrated feed higher in energy content which lead to fatter carcasses. When the diets are isoenergetic, the protein level produces only slight and frequently non significant modifications in fatness (Jason & Mantecon, 1993). A number of studies have demonstrated that lambs raised under a grazing system without any supplementation presented a slightly inferior fatness degree, as a consequence of the lower energy intake from pasture, combined with the higher energy expenditure of the grazing animals in relation to those supplemented with concentrate, since the amount of carcass fat depots is related positively with the energy intake (Chestnutt, 1994). When grazing lambs were supplemented with concentrate, the total body fat increased from 21.8% to 32% (Murphy et al., 1994; Carrasco et al., 2009).

The evaluation of carcasses also includes evaluation of pericardial and kidney obesity. Lower kidney and pericardial obesity ($P < 0.05$) has been found in the control group of the kids (Table 7), which can be explained by increased exercise possibilities and physical activity in pasture, possibly with better kid health. Asizuza et al. (2014) found that the considerable increase in non-carcass fat with supplementation was probably partly responsible for the relatively low live weight gain per kg of concentrate. Supplementation compared to sole grazing increased non-carcass fat (pericardial, kidney, omental, mesenteric, scrotal) with 2.9–4.7 as percent-units of empty body weight. Increase in internal and carcass fat in goats due to increasing intake of energy in diets has been reported by various authors (Goetsch et al., 2011; Zervas & Tsiplakou, 2011). Effects of feeding regime on the distribution of non-carcass components as percentage of empty body weight is studied by Ugandan researchers, where kidney fat were from 0.5 (pasture feeding) to 1.8% (supplemented feeding) (Asizua, 2014), but in our investigation kidney fat were only from 0.01 (1st control group) to 0.03% (2nd research group) of final body weight. According Asizua et al. (2014) investigation, pericardial fat content is not affected by feeding regime and is 0.2% of empty body weight, but our study shows that it is affected by feed supplementation where content of pericardial fat were 0.05 (1st control group) to 0.15% (2nd research group) of final body weight.

In the marketplace, in the interests of consumers, most carcasses are jointed and offered at a different price, which can be explained by the different proportion of bones in cuts. As the most valuable carcass cuts are the hip with leg, the sirloin and the ribs that meat consumers have classified in the Extra category; the less valuable part is included in 1st category – shoulder blade and shoulder, while 2nd category includes the flank and the neck (Colomer-Rocher et.al. 1987) (Table 8).

Table 8. Carcass parts

Carcass parts	1st control group (n = 4)			2nd research group (n = 4)		
	Average	V,%	SEM	Average	V,%	SEM
Half-carcass weight, kg	7.63	17.7	0.68	5.98	21.2	0.64
Hip + leg, kg	2.31	21.5	0.25	1.90	22.6	0.22
Flank, kg	0.59	8.5	0.03	0.57	49.6	0.14
Sirloin, kg	0.63[a]	12.5	0.04	0.34[b]	30.0	0.05
Ribs+ chest vertebrae + back vertebrae, kg	2.59[a]	22.4	0.29	1.67[b]	21.2	0.18
Shoulder blade + shoulder, kg	1.51	16.4	0.12	1.49	16.1	0.12
Proportion of half-carcass parts:						
Hip + leg, %	30.09	8.1	1.22	31.79	9.4	1.51
Flank, %	7.92	20.8	0.83	9.21	31.2	1.44
Sirloin, %	8.41	15.3	0.65	5.74	19.3	0.56
Ribs+ chest vertebrae + back vertebrae, %	33.71	5.6	0.94	28.10	12.2	1.72
Shoulder blade + shoulder, %	19.87	3.6	0.36	25.12	8.5	1.08

Where V, % – coefficient of variation; SEM – standard error of the mean.

Higher proportion of the most valuable and the most expensive parts (extra category) has from 1st control group carcasses, where the sirloin reaches 8.41% ($P < 0.05$) and the rib cuts reaches 33.71% ($P < 0.05$) of the half carcass, while the hip and leg cuts are larger in the 2nd research group carcasses, reaching 31.79% of the half carcass weight. In general, the cuts included in the Extra category for the carcasses of the 1st control group is 72.21%, but for the carcasses of the 2nd research group by 6.58% less – 65.63% of the half carcass.

The results of the carcass tissue parts and the ratio between muscles and fat tissue and also between meat (Muscles + fat tissues) and bones are shown in Fig. 3.

For the most demanded tissue parts of the consumer – the muscle tissue, the highest proportion in the carcass was obtained from the control group carcasses, on average – 59.1%, which indicates a tendency of increased formation of muscle mass to the kids fed oats. Oats have an increased starch and fat content, which provide kids with a higher amount of easy-to-use energy during the fattening period, which has a positive effect on kid's growth and fattening. The highest proportions of inferior parts – bone tissue derived from the carcasses of the 2nd research group – 25.9%, but these differences are not significant ($P > 0.05$). According to Solaimana et al. (2011) research proportion of bone, muscle and fat in Boer goat carcass was 25.9%, 54.1% and 19.9% respectively, which is quite close to our investigation. As with other ruminant livestock species, fat is the most variable component of goat carcasses (Mahgoub et al., 2004). Castration generally increases carcass fatness depending largely on plane of nutrition (Ruvuna et al., 1992; Abdullah and Musallam, 2007). Fat is deposited relatively more rapidly in carcass and non-carcass tissue pools by females than intact males, with wethers being intermediate (Mahgoub et al., 2004). Such differences are most likely with diets relatively high in energy and concentrate feedstuffs. That is, limited nutrient intake maximizes lean tissue accretion and minimizes fat deposition regardless of gender.

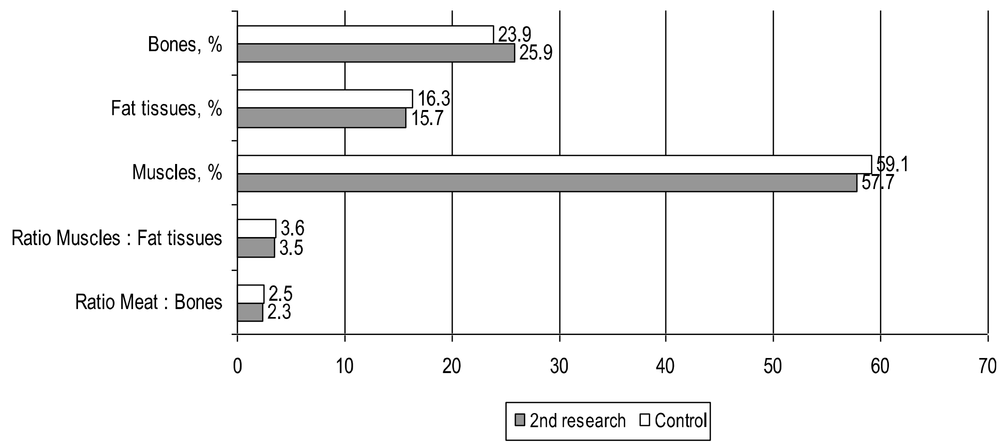


Figure 3. Carcass tissue parts and the ratio.

The highest meat-to-bone ratio is derived from the 1st control group carcasses, where to 1 kg of bones we got 2.5 kg of meat. However, ratio between muscle tissue and fat tissue in both groups of carcasses had practically similar, with 3.5 kg to 3.6 kg of lean muscle per 1 kg of fat tissue. The carcass fat content is highly variable and can be influenced by breed, age, sex, nutrition, BW, physiological condition and physical activities (Owen et al., 1978; Kirton, 1988). As fat is nearly water free and high in energy density, this is enormous energy storage, with low slaughter value but very important as energy storage for the goat (Asizua et al., 2014).

During the fattening of the goat kids, consumed concentrated feed was recorded. The amount and economical effect of concentrated feed during the fattening is summarized in Table 9.

Table 9. Economical effect of feeding of concentrated feed for goat kids

Group	Daily concentrated feed for 1 kid		Concentrated feed to 1 kg of live weight gain	
	Amount, kg	Cost, EUR	Amount, kg	Cost, EUR
1st control	0.222	0.036	3.21	0.51
2nd research	0.208	0.038	2.83	0.52

According the results the control group's kids used more concentrates per day for 1 kid than the 2nd research group's kids, but the cost per day for one kid was by 5.5% lower than for the kids group, where as protein feed was included fodder beans. In turn, the amount of feed consumed per 1 kg of live weight gain was lower for the 2nd research group kids, and in this case the cost of consumed concentrated feed was only by 1 euro cents or by 1.9% higher than the control group. It means, that feed effectiveness in both groups is rather hight and in fattening of goat kids is acceptable using of both feeding systems.

CONCLUSIONS

Results of this study provide new knowledge about the influence of different concentrated feeds on Boer goat kid's productivity. Usually in farms is used only one grain source for concentrated feed for fattening of kids, but our experimental activities had shown that by inclusion of fodder beans as protein source in feed ration of goats kids, it provided moderate fast growing (average daily gain was 72 g per kid during 72 days of fattening) by using a 2.83 kg concentrated feed mix for 1 kg of live weight gain. Feeding the grain mixture resulted in a 39.9% carcass yield and in a 65.47% Extra category cuts of carcass weight. Cost of oatmeal and fodder bean consumed per day per animal was 3.8 cents; concentrated feed costs per 1 kg live weight gain – 0.52 EUR. Feed effectiveness in both groups is rather hight and in fattening of goat kids is acceptable using of both feeding systems. Overall, meat goat kids finished on grass feed compounded with oats or oat-bean mix produced desirable final live weights (> 33 kg) for niche markets in the Latvia. Chevon could be a low-fat, red meat option for human diets in the Latvia and other countries.

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REFERENCES

Abdullah, Y.A. & Musallam, H. 2007. Effect of different levels of energy on carcass composition and meat quality of male black goat kids. *Livestock Science* **107**, 70–80.

Asizua, D., Mpairwe, D., Kabi, F., Mutetikka, D., Kamatara, K., Hvelplund, T., Weisbjerg, M.R., Mugasi, S.K. & Madsen J. 2014. Growth performance, carcass and non-carcas scharacteristics of Mubende and Mubende_Boer crossbred goats under different feeding regimes. *J. Livestock Science* **169**, 63–70.

Browning, R., Jr., Phelps, O., Chisley, C., Getz, W.R., Hollis, T. & Leite-Browning, M.L. 2012. Carcass yield traits from kids from a complete diallel of Boer, Kiko, and Spanish meat goat breeds semi-intensively managed on humid subtropical pasture. *J. of Animal Science* **90**, 709–722.

Carrasco, S., Ripoll, G., Sanz, A., Alvarez-Rodriquez, J., Panea, B., Revilla, R. & Joy, M. 2009. Effect of feeding system on growth and carcass characteristics of Churra Tensina light lambs. *Livestock Science* **121**, 56–63.

Chestnutt, D.M. 1994. Effect of lamb growth rate and growth pattern on carcass fat levels. *J. Animal Production* **58**, 77–85.

Ciltsdarba programma Būru šķirnes kazām 2016. – 2025. gadam: http://latkaza.lv/wp-content/uploads/2018/04/Buru-kazu-cildsdarba_programma_2017_2025.pdf (in Latvian).

Colomer-Rocher E., Morand-Fehr P. & Kirton A.H. 1987. Standard methods and procedures for goat carcass evaluation, jointing and tissue separation. *Livestock Production Science* **17**, 149–159.

Galyean, M.L. 1999. Review: restricted and programmed feeding of beef cattle-definitions, application, and research results. *Animal Science* **15**, 1–6.
Goetsch, A.L., Merkel, R.C. & Gipson, T.A. 2011. Factors affecting goat meat production and quality. *Small Ruminant Research* **101**, 173–181.
ISO 6491:1998. Animal feeding stuffs. Determination of phosphorus content. ISO/TC34/SC10, ICS: 65.120, ed.2, 7 pp.
ISO 6496:1999. Animal feeding stuffs. Determination of moisture and other volatile matter content. ISO/TC34/SC10, ICS: 65.120, ed.2, 7 pp.
Jason, G.R. & Mantecon, A.R. 1993. The effects of dietary protein level during food restriction on carcass and non carcass components, digestibility and subsequent compensatory growth in lambs. *Animal Production* **56**, 93–100.
Kannan, G., Gadiyaram, K.M., Galipalli, S., Carmichael, A., Kouakou, B., Pringle, T.D., McMillin, K.W. & Gelaye, S. 2006. Meat quality in goats as influenced by dietary protein and energy levels, and postmortem aging. *Small Ruminant Research* **61**, 45–52.
Kirton, H. 1988. Characteristics of goat meat, including carcass quality and methods of slaughter. In: *Goat Meat Production in Asia. Proc. of a Meat Workshop*, Tando Jam, Pakistan, pp. 13–18.
Lauksaimniecības gada ziņojums par 2014. gadu: https://www.zm.gov.lv/public/files/CMS_Static_Page_Doc/00/00/00/63/66/LS_gadazinojums_2015.pdf (in Latvian).
Lee, J.H., Kouakou, B. & Kannan, B. 2008. Chemical composition and quality characteristics of chevon from goats fed three post-weaning diets. *Small Ruminant Research* **75**, 177–184.
LVS EN ISO 13906:2008. Animal feeding stuffs. Determination of acid detergent fibre (ADF) and acid detergent lignin (ADL) contents. ISO 13906:2008, ISO/TC34/SC10, 17 pp.
LVS EN ISO 16472:2006. Animal feeding stuffs. Determination of amylase-treated neutral detergent fibre content. ISO 16472:2006, ISO/TC34/SC10, 15 pp.
LVS EN ISO 5983-2:2009. Animal feeding stuffs. Determination of nitrogen content and calculation of crude protein content. ISO 5983-2:2009, ISO/TC34/SC10, ICS: 65.120, ed. 2. part 2, 15 pp.
LVS EN ISO 6869:2002. Animal feeding stuffs. Determination of calcium, magnesium and sodium. ISO 6869:2000, ISO/TC34/SC10, ed.1,15 pp.
Mahgoub, O., Lu, C.D., Hameed, M.S., Richie, A., Al-Halhali, A.S. & Annamalai, K. 2005. Performance of Omani goats fed diets containing various metabolizable energy densities. *Small Ruminant Research* **58**, 175–180.
Morand-Fehr, P., Bas, P., Blanchart, G., Daccord, R., Giger-Reverdin, S., Gihad, E.A., Hadjipanagiotou, M., Mowlem, A., Remeuf, F. & Sauvant, D. 1991. Influence of feeding on goat milk composition and technological characteristics. **In**: Morad-Fehr, P. (ed.): *Goat Nutrition, vol. 46. EAAP Publication*, Pudoc, Wageningen, pp. 209–224.
Murphy, T.A., Loerch, S.C., Mc Clure, K.E. & Solomon, M.B. 1994. Effects of restricted feeding on growth performance and carcass composition of lambs subjected to different nutritional treatments. *J. Animal Science* **72**, 3131–3137.
Mushi, D.E., Safari, J., Mtenga, L.A., Kifaro, G.C. & Eik, L.O. 2009a. Effects of concentrate levels on fattening performance, carcass and meat quality attributes of Small East African ×Norwegian crossbred goats fed low quality grass hay. *Livestock Science* **124**, 148–155.
Mushi, D.E., Safari, J., Mtenga, L.A., Kifaro, G.C. & Eik, L.O. 2009b. Growth and distribution of non-carcass components of Small East African and F1 Norwegian crossbred goats under concentrate diets. *Livestock Science* **126**, 80–86.
Owen, J.E., Norman, G.A., Philbrocks, C.A. & Jones, N.D. 1978. Studies on the meat production characteristics of Botswana goats and sheep. 3. Carcass tissue composition and distribution. *Meat Science* **2**, 59–74.

Pick, G. 1899. Geometrisches zur Zahlenlehre. Sitzungber.Lotos, *Naturwissen Zeitschrift*, Prague, **19**, pp. 311–319. (in German).
Piliena, K. & Spruzs, J. 2007. *Kazkopiba.* Talsi, 99 pp. (in Latvian).
Pinkerton, F. & Pinkerton, B. 2015. Feeding programs for meat goats. http://www.goatworld.com/articles/nutrition/feedingprograms.shtml.
Ruvuna, E., Taylor, I.E., Okeyo, M., Wnyoike, M. & Ahuya, C. 1992. Effect of breed and castration on slaughter weight and carcass composition of goats. *Small Ruminant Research* **7**, 175–183.
Solaimana, S., Mina, B.R., Gurunga, N., Behrendsb, J. & Tahaa, E. 2011. Assessing feed intake, growth performance, organ growth, and carcass characteristics of purebred Boer and Kiko male kids fed high concentrate diet. *Small Ruminant Research* **98**, 98–101.
Todaro, M., Corrao, A., Carmela, M.A.B., Alicata, M.L., Schinelli, R. & Giaccone, P. 2006. Use of weaning concentrate in feeding of suckling kids: Effects on meat quality. *Small Ruminant Research* **66**, 44–50.
Tovar-Luna, I., Goetsch, A.L., Puchala, R., Sahlu, T., Carstens, G.E., Freetly, H.C. & Johnson, Z.B. 2007. Effects of moderate feed restriction on energy expenditure by 2-year-old crossbred Boer goats. *Small Ruminant Research* **72**, 25–32.
Turner, K.E., Cassida, K.A. & Zerby, H.N. 2014. Meat goat kids finished on alfalfa, red clover or orchardgrass pastures: Carcass merit and meat quality. *Meat Science* **98**, 629–636.
Wuliji, T., Goetsch, A.L., Sahlu, T., Puchala, R., Soto-Navarro, S., Merkel, R.C., Detweiler, G. & Gipson, T. 2003. Effects of different quality diets consumed continuously or after a lower quality diet on characteristics of growth of young Spanish goats. *Small Ruminanat Research* **50**, 83–96.
Zervas, G. & Tsiplakou, E. 2011. The effect of feeding systems on the characteristics of products from small ruminants. *Small Ruminant Research* **101**, 140–149.