Agronomy Research **23**(1), 382–392, 2025
https://doi.org/10.15159/AR.25.045

Influence of pasture feed chemical composition on growth performance of Latvian darkhead lambs

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Received: February 1st, 2025; Accepted: May 11th, 2025; Published: May 19th, 2025

Abstract. Lamb fattening on pasture feed is widely used in the world and in Latvia as most of Latvian darkhead (LT) breed lambs are grazed on pasture with some addition of hay and straw. Clarifying the variable pasture grass chemical composition during the grazing season and comparing with growth performance of lambs can enable farmers to predict the fattening pace. The experiment was conducted during grazing seasons of year 2020 and 2021 at the ram breeding station owned by the Latvian Sheep hearder association. Pasture of 60% grasses and up to 20% of legumes and other broadleaf low grasses is recultivated every 4 to 5 years, grass is cut once a year, grazing is organized in rotational system of fenced paddocks where animals are moved periodically to ensure better feed quality as well as letting the previous paddock regrow. Total of 24 male LT breed lambs were used in the experiment. Pasture feed chemical composition was analysed from 13 samples in year 2020 and 9 samples in year 2021. The authors analysed pasture feed samples for nutritional content (dry matter - 27.1%, within a kg of dry matter protein - 12.5%, fiber - 26.2%, metabolizable energy - 10.8, etc.) and measured lamb growth parameters (average daily gain - 256.4 g d^{-1}, fattening duration - 78.6 days, end liveweight - 45.1 kg). The research demonstrates that pasture feed quality varies significantly between years and affects lamb growth performance, with lower feed quality prolonging fattening duration. Despite this variation, the authors conclude that pasture grass feed utilization for lamb growth performance was optimal, with lambs reaching target weights within acceptable timeframes. Practical conclusion of this research is that by using rotational grazing system lambs can be fattened to reach target liveweight, even with lower pasture grass feed quality due to weather conditions and fattening period takes longer, the target weight is sufficient. Utilitarian suggestion is to organize lamb weaning and begin the fattening period as early in the season as possible to avoid the decreased grass quality in autumn.

Key words: average daily gain, feed chemical composition, lamb fattening, Latvian darkhead sheep breed, pasture.

INTRODUCTION

While pasture is a convenient lamb fattening method that offers both financial and environmental gain, precise effect on lamb growth parameters for Latvian darkhead breed lambs have not yet been determined even though it is the most popular fattening choice for sheep hearders. LD breed is widely used local sheep breed that is two purpose

breed for wool and meat that is showing high care for its offspring. Best of the purebred lambs that show ram potential are used for breeding while the rest of lambs are sold for meat and for a farm to be profitable, sufficient growth performance needs to be reached. Pasture is a productive agricultural area that offers soil cover and habitat for diverse organisms as well as an opportunity for lambs to customize their choice of feedstuffs and regulate rumen environment (Cortes et al., 2006; Fraser et al., 2014). Even though pasture feed is extensive, uncontrollable and dependent of the weather, it still is the natural and original feed of ruminants and widely used across the world (Bernués et al., 2011; Baumont et al., 2014; Martin-Collado et al., 2019).

Research shows that with mixed swards of grasses and legumes similar live weight gain can be achieved than by using concentrate feed (Yilmaz et al., 2023) and movement allows lambs to consume more feed (Fanchone et al., 2010). Woodmartin et al. (2024a) has gone further and focused on various grass and legume combinations to determine the most efficient, showing that even intensive/semi-intensive sheep breed can show favourable growth and lactation results on pasture feed. Cultivated pasture normally consists of mixture of grasses such as *Agrostis spp*., *Festuca spp*., *Lolium spp*., and *Dactylis spp*. and protein plants like *Lotus spp*., *Medicago spp*. and *Trifolium spp*. Botanical composition and pasture maintenance together with temperature and precipitation determine feed quality and longevity of the sward - with diverse sward organisation pasture can be self-preserving its botanical proportion and quality for not only 4–5 but even twelve or more years before plowing and seeding is needed (Moot et al., 2024) and more botanically diverse swards improve its feed nutritive value increasing the live weight gains for 12% (Jerrentrup et al., 2020; Blaix et al., 2023). As well as producing meet, the pasture ecosystem also is a habitat for various other species and is an important part of bio-divercity, with its ability to hold and purify water and protect the soil from wind and water erosion, pasture-fed ruminant production claims to be one of the more sustainable in comparison with concentrate-fed animal production (Schils et al., 2022; Jaisli & Brunori, 2024).

Question is no longer whether pasture can be efficient, but how much exactly does it determine lamb growth (Moot et al., 2024; Woodmartin et al., 2024a). Hence this research shows exact feed chemical composition together with Latvian darkhead extensive breed lamb average daily gain (ADG) and duration of fattening to reach optimal pre-slaughter live weight so that productivity predictions can be distinguished. As the botanical composition pasture sward used in this research reflects an average real-life farm conditions so that the gained results can be shared with Latvian sheep hearders association members so that they can have a preview of pasture-grazed lamb productivity without doing their own feed analysis several times each year.

MATERIALS AND METHODS

Animals

Research was conducted during grazing seasons of years 2020 and 2021 at breeding ram evaluation station ‘Klimpas’ in Jeru parish, Valmiera district (see Fig. 1). Each year 12 male Latvian darkhead breed lambs were fattened on pasture and weighed to detect their growth rate. Data analysis holds information for 23 lambs since one began to wither and was slaughtered earlier. Experiment size matched to the prerequisite of

purebred LT lambs of the same age and sex to be used in this research, as well as the personnel capacity on site. Research was divided into two trials each year by groups of 6 male lambs and that varied in timing within season – 2020 first trial lasted from June until September and 2021 trial – July until October. Data from the matching three months are used in analysis as three fattening periods - July, August and September.

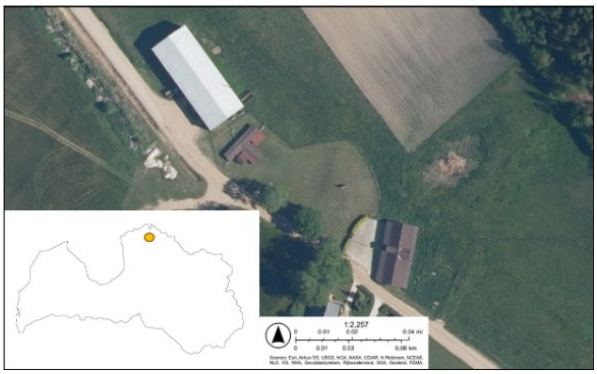

Figure 1. Research location.

Lambs were bought from pasture management system farms and were kept within same groups as before purchase to minimize stress and parasite infection, therefore adaptation period was not needed. Fattening began when lambs were visibly comfortable on the pasture which was 5–8 days respectively for the first and second year during which lambs received anti-parasite treatment. Rotationally managed pasture of paddocks of 0.5 ha held six lambs each and groups were moved when grass quality was visibly depleting. In the year 2020 lambs were moved 13 times, in 2021 – 9 times. Due to higher precipitation, the sward was lusher in the second year of research, so the lambs weremoved fewer times. In addition of 24-hour grazing, lambs had *ad libidum* access to straw, water and mineral feed. By the sides of pasture paddocks were shelters to avoid heat or precipitation. Weighting was organised in the mornings before the fattening, during three periods and before slaughter using an electronic scale (precision 0.01kg). Range of lamb age upon purchase was from 68 up to 84 days and live weight was from 18.5 up to 24.5 kg. Optimal fattening results for Latvian darkhead lambs are 45 kg of liveweight reached within 5.5 months or 165 days of age.

Table 1 shows the weather conditions measured in meteorological station 5 km away from the ram station.

Table 1. Mean temperature and rainfall during the grazing season of years 2020 and 2021 with its difference from 10 year climatic norm

Year	Month	Mean temp., °C	Difference, %	Rainfall, mm	Difference, %
2020	July	16.2	–8.9	81.0	21.8
	August	16.5	–0.6	45.2	–39.6
	September	13.9	18.8	70.8	–27.8
2021	July	21.3	19.7	43.4	–34.7
	August	15.7	–5.4	84.3	12.5
	September	10.1	–13.7	67.9	22.6

Climatic norm there is 17.8 °C in July, 16.6 °C in August and 11.7 °C in September for the mean daily temperature and 66.5 mm of rainfall in July, 74.9 mm in August and 55.4 mm in September (Environmental data archive, 2025). Weather was fluctuating and can be an important factor to feed quality.

Feed chemical composition. Chemical feed analysis was carried out in certified Agrochemical laboratory in Latvia University of Life Sciences and Technology. 13 samples in year 2020 and 9 samples in year 2021 were taken from square plots crossing pasture fields and collecting an average 1 kg mixed sample from each plot. Timing of grass samples was organized together with the lamb move to the next paddock. Grass was cut 6 cm above ground. Following methods were used: for Dry matter (DM) - LVS NE ISO 6498:2012, 7.5; Protein - LVS EN ISO 5983-2:2009; Fiber - ISO 5498:1981; Neutral detergent fiber (NDF) - LVS EN ISO 16472:2006; Acid detergent fiber (ADF) - LVS EN ISO 13906:2008; Metabolizable energy was calculated in the laboratory; Ash - ISO 5984:202/Cor 1:2005; Calcium (Ca) - LVS EN ISO 6869:2002; Phosphorus (P) - ISO 6491:1998.

Data analysis

Feed chemical composition (n = 22) and lamb growth performance data (n = 23) were analysed in Microsoft Excel, using *Descriptive Statistics* for the average results for each of the two years of research separately and combined, differences between feed composition were determined between years, between months within each year as well as each month between both years (i.e. July in 2020 and July 2021) by using *t-test. Correlation analysis* was used to discover correlations between nutrient content in the feed to find a simple way of predicting feed efficiency. Data normality was checked by standard deviation and no values were detected as outliers. Largest deviation is for the average daily gain in July and August of year 2021. Average daily gain (ADG) was calculated by following formula:

$$A = \frac{W_t - W_0}{t}, \quad (1)$$

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

RESULTS AND DISCUSSION

Feed chemical composition

Combined average results for whole research show (mean ± s.e.) 27.1 ± 1.62% of dry mater in which 12.5 ± 0.66% is protein, 26.2 ± 0.83% is fiber (that is made by 51.4 ± 1.74% NDF and 33.0 ± 1.28% ADF), 10.8 ± 0.16 MJ kg^{-1} metabolizable energy (ME), 62.5 ± 0.97% total digestible nutrients (TDN from dry matter) and 2.3 ± 0.08% dry matter intake from animals 100 kg of live weight (DMI), 1.48 ± 0.46% Ca and P – 0.39 ± 0.03%. Pasture grass composition varies significantly by year and by months within each year (Table 2 and 3). Dry matter content was 30.7% higher in year 2021 than 2020 with a significant difference of 73.9 g kg^{-1} as well as increased fiber content by 14.5% and 36 g kg^{-1} DM with its NDF content significantly rising by 21.7%. That leads to decrease in valuable nutrients such as protein reduction by 26% or 36.5 g kg^{-1} and ME reduction from 11.2 to 10.4 MJ kg^{-1}. Significant increase of dry matter and fiber while protein and energy levels are lowered show general loss of nutritional value in reduced TDN and DMI (Table 2) and could slow down the overall fattening process.

Table 2. Mean results of chemical analysis for pasture grass in years 2020 and 2021

Nutritional elements	Year				*P-value*
	2020		2021		
	x	s.e.	x	s.e.	
Dry matter, g kg^{-1}	240.8	16.8	314.7	25.8	0.05
Protein, g*	139.5	8.2	103.0	5.7	0.001
Fiber, g*	247.3	10.6	283.3	9.9	0.05
NDF, g	472.5	21.2	575.0	14.2	0.001
ADF, g	299.6	11.5	374.1	19.0	0.01
ME, MJ kg^{-1}	11.2	0.1	10.4	0.3	0.01
DMI, g*	24.9	1.2	21.0	0.5	0.01
TDN, g*	647.7	8.5	597.6	14.8	0.01

* grams in 1 kg of dry matter, NDF – neutral detergent fiber, ADF – acid detergent fiber, ME – metabolizable energy, TDN – total digestible nutrients, DMI – dry mater intake.

Nutrient fluctuation in pasture feed follows the development of season by having more protein and energy in July than in September as plants mature and develop more fiber (Capstaff & Miller, 2018). Changes in weather can distort this process, like July and August are nearly the same as July and September in year 2021 as grass should be maturing closer to autumn. Considering both these significant differences in both fiber and protein, ME remains even during all the research. Increased temperature and reduced rainfall can influence early autumn's pasture to be of equal fiber content as in July both years of the research (Table 3) (Adamovic et al., 2017). Pasture of year 2020 in months of July and September consisted of more protein than August by (mean ± s.e.) 145.5 ± 14.9 g kg^{-1} and 144.1 ± 3.4 g kg^{-1} respectively.

Feed chemical composition comparison of various periods of grazing season fluctuate from steady mean air temperatures from July to September in 2020 while precipitation plummet in August, and showing a decrease of protein content for 13%. During grazing season August in 2021 is closest to climatic norm and yet coincides with lowest protein and ME content while fiber content is the highest throughout the whole research (Table 3).

Table 3. Mean results of chemical analysis for pasture grass by month and both years

Fattening period	Dry matter, g kg^{-1}	1 kg DM^{-1}		
		protein, g^{-1}	fiber, g^{-1}	ME, MJ kg^{-1}
July 2020	240.8 ± 30.4^{a}	145.5 ± 14.9^{ab}	237.4 ± 16.1^{a}	11.1 ± 2.4^{a}
August 2020	223.8 ± 13.5^{a}	126.7 ± 4.2^{a}	247.9 ± 18.0^{a}	11.4 ± 2.4^{a}
September 2020	271.4 ± 7.6^{b}	144.1 ± 3.4^{b}	280.4 ± 4.4^{b}	11.1 ± 2.5^{a}
July 2021	383.2 ± 56.2^{a}	107.8 ± 5.8^{a}	274.5 ± 5.8^{a}	10.8 ± 0.7^{a}
August 2021	317.3 ± 7.4^{ab}	76.1 ± 0.8^{b}	306.3 ± 22.7^{b}	9.4 ± 2.2^{a}
September 2021	291.4 ± 7.6^{b}	118.3 ± 0.4^{c}	270.0 ± 3.0^{a}	10.7 ± 1.9^{a}

$^{a, b, c}$ – different letters show significant differences within a year ($P < 0.05$).

Hurley et al., 2021 detected differences in chemical composition of nutrients in two types of pasture swards. Grass-only and grass-clover mix and found lower protein content in summer than spring or autumn for both swards. Dry matter peaks inversely in

summer but NDF and ADF increases gradually towards autumn while protein content drops in summer. For a grass-only sward it grows again a little bit in autums while for a grass-clover mix sward protein in autumn exceeds even the spring level, which is the case also for this research in year 2021. Another team of researchers conducted large literature studies and found out that average dry matter content for animal feed plants is 41%, NDF 57%, ADF 32% and average crude protein - 15% with mean digestibility of 62% (Orr et al., 2019), meaning that pasture in this research has better DM, less protein and similar NDF and ADF.

Since the nutrient content depends on both the botanical composition and the weather conditions, spring gives the early nutrition from grass leaves, summer has the highest proportion of stems, resulting in higher fiber content, while legumes mature in the other half of summer restoring leaf amount in the sward that brings up the protein. Fattening experiments in pasture are challenging due to the limited knowledge – regardless of feed samples taken from each paddock, the feed preference of lambs are not detected. Year 2021 was rainier than climatic norm that could possibly cause lambs to seek shelter instead of roaming on pasture and feeding. Nutritional provision of individual plants of patches of plants with similar dry matter content or nutritient content differ significantly in terms of the nutritive value offered to animals (Lee, 2018).

Associated effects of pasture feed nutrient composition show that DMI is higher from swards with more protein, keeping the NDF levels steady throughout the season that results in higher animal productivity (Niderkorn & Baumont, 2009) due to variation in nitrogen availability and utilization efficiency (Capstaff & Miller, 2018).

All significant ($P < 0.05$) correlation analysis for nutritional elements reveals very strong negative correlation between ME and fiber content ($r = –0.86$), strong negative corelation between fiber and protein ($r = –0.70$) as well as between protein and dry matter ($r = –0.63$). While a strong positive correlation is between ME and protein ($r = 0.77$), and fiber and dry matter ($r = –0.61$) indicating that higher content of dry matter will likely result in higher fiber content in the feed with less protein and metabolizable energy (Table 4) and by knowing botanic composition of a mixed sward one can derive credible prognosis about protein, fiber and ME variability.

Table 4. Correlation analysis for nutrients in pasture feed

Nutrients in pasture feed	Dry matter, %	Protein, %	Fiber, %
Protein, %	**-0.63**	1	
Fiber, %	**0.61**	**-0.70**	1
ME, MJ kg^{-1}	-0.37	**0.77**	**-0.86**

These correlations show that by increasing dry matter, one can expect a decrease in metabolizable energy and protein but by managing the sward in a way that grass doesn't reach seeding stage. By moving animals, cutting the grass for hay and letting it to regrow in mid-season or early autumn, and having legumes can provide higher protein that will maintain the energy levels (Blaix et al., 2023; McGrane et al., 2023; Woodmartin et al., 2024a) as well as maintain the biodiversity of sward that leads to high animal performance (Fraser et al., 2004; Jerrentrup et al., 2020).

Lamb growth performance

LT breed lamb growth parameters upon purchase are summarized in Table 5 and show that lambs of the first year were (mean ± s.e.) 77.8 ± 1.75 days old and lambs of the second year were 1.9 days younger – 75.7 ± 1.41 days old, also significantly heavier by 3.8 kg which might be explained with better lactating ewes before weaning. Similar reasearch but with cross lambs that had partial blood of such meat breeds as Suffolk, Texel and Charollais observed average live weight of 35.2 ± 5.23 kg and 29.7 ± 4.81 kg upon 97 ± 6.5 and 93 ± 5.7 days of age when starting fattening on pasture feed (Orr et al., 2019), and were older and heavier than LT purebreed lambs.

Table 5. Lamb growth parameters before the fattening trial

Parameters	Year				*P-value*
	2020		2021		
	x	s.e.	x	s.e.	
Age before fattening, days	77.8	1.75	75.7	1.41	n.s.
Live weight before fattening, kg	25.9	0.98	22.1	0.50	0.01
ADG before fattening, g d^{-1}	270.4	12.94	225.2	5.60	0.01

Lamb live weight in both years of this research was observed to grow by average of (mean ± s.e.) 20.1 ± 0.68 kg in 78.6 ± 1.89 days, reaching average pre-slaughter live weight of 45.1 ± 0.54 kg at 158.3 ± 1.63 days of age with ADG of 256.48 ± 6.74 g d^{-1}, which is considered to be optimal growing performance for Latvian darkhead breed lambs (Breeding programme for Latvian darkhead sheep, 2023). Comparing with Orr et al. (2019) reached similar results with 44.9 ± 2.32 kg and 44.7 ± 2.99 kg pre-slaughter live weight at 203 ± 10.6 and 148 ± 10.6 days of age.

Lamb growth performance by year is shown in Table 6 and states significant differences of fattening duration, pre-slaughter age and total live weight gain during fattening between years 2020 and 2021, while average daily gain and end live weight show no significant differences.

Table 6. Lamb growth performance in years 2020 and 2021

Parameters	Year				*P-value*
	2020		2021		
	x	s.e.	x	s.e.	
Fattening duraton, days	71.5	1.96	86.4	0.47	0.001
Pre-slaughter age, days	154.8	2.30	162.1	1.77	0.05
Total live weight gain during fattening, kg	17.7	0.44	22.8	0.71	0.001
ADG during fattening, g d^{-1}	249.3	9.81	264.3	9.04	n.s.
Pre-slaughter live weight, kg	45.3	0.84	44.9	0.47	n.s.

Fattening results coincide with pasture feed quality differences between years - pasture of 2021 was lower in feed value than in year 2020 and lamb growth parameters show 14.9 extra days to reach optimal pre-slaughter live weight. Sumarry of results show significant differences in lamb live weight during all periods within the research as well as between the two years (Table 7).

Lambs on pasture feed exceeded 300 g of ADG at least in one month of each year. In 2020 it was growing steadily and reached the peak at the end of fattening which can be accociated with larger live weight upon lamb purchase in the beginning of research. Whereas, the overall growth rate in year 2021 is distorted - the fastest growth rate was at the beginning of fattening period in July, that is counterintuitive due to less protein and ME in the pasture feed in the same month. A possible scenario is exactly for that reason lambs were eating excessively to compensate the lack of nutritional value. Accociated effect of feed nutrients and ADG by periods are combined in Figs 2 and 3.

Table 7. Lamb live weight and ADG by fattening period

Period	Live weight, kg	ADG, g d^{-1}
July 2020	29.1 ± 0.90^{A}	176.6 ± 31.21^{aA}
August 2020	33.4 ± 0.71^{A}	233.8 ± 16.25^{aA}
September 2020	41.6 ± 1.50^{A}	313.5 ± 27.41^{bA}
July 2021	26.4 ± 0.69^{B}	340.9 ± 49.92^{aB}
August 2021	30.4 ± 0.01^{B}	188.3 ± 36.53^{bA}
September 2021	35.2 ± 1.03^{B}	229.4 ± 16.46^{bB}

$^{A, B, C}$ – different uppercase letters show significant differences between years ($P < 0.05$); $^{a, b, c}$ – different lowercase letters show significant differences between periods ($P < 0.05$).

Stable protein and fiber content in year 2020 corresponds with steady average daily gain. Second year of the research pasture feed had significantly lower ($P < 0.001$) protein and higher fiber content and lamb growth rate decreased as is visible in August of year 2021. Fattening duration for this group of lambs was nearly two weeks longer (14.9 days) than in year 2020 with pasture feed of higher protein content meaning that pasture quality determines financial convenience of fattening lambs on pasture feed. Even though the mid-season protein levels are low, especially in year 2021, the average daily gain enhances, leading to think of microbial protein that might result from energy levels that allow fiber to digested easily thanks to a ruminal microbiome that is well adapted to pasture feed (Friggens et al., 2017; Woodmartin et al., 2024b). Lambs of year 2021 began the first fattening period with similar liveweight but nearly two times different average daily gain. Since animal protein is by far the most easily digestible, weaning ADG is lower by 50 grams a day than lambs of year 2020, who seem to have better access to milk but it also means thart they have not jet accustomed to eating grass. Wheareas lambs of the second year were growing slower before weaning but well prepared to eat grass and started off the grazing season with

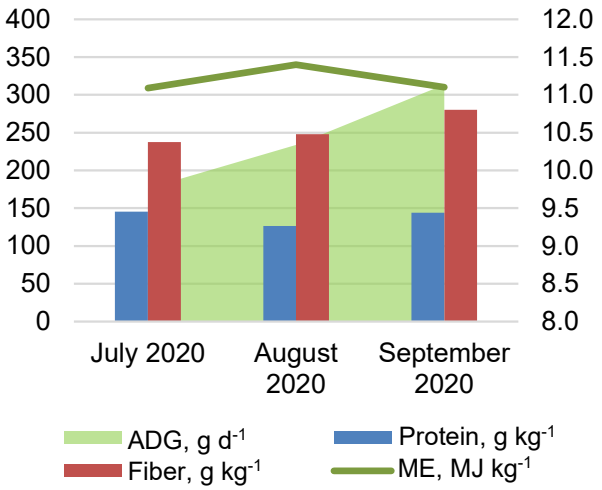

Figure 2. Lamb ADG according to major feed elements in pasture grass in year 2020.

excellent growth rate. Nevertheless, the average ADG of season was less that year 2020 due to poor weather conditions that caused lower feed quality. Fattening duration was prolonged and is a factor to consider when lambing is organized and timing of the fattening can surely fit within season while nutrients and digestibility in the pasture is still enough. As research in Norway clarifies that high quality sward from July until September can result in lambs of 44 kg live weight while low quality sward can offer only 38 kg live weight lambs (Flaten, 2023). Dorset breed lamb average daily gain of 295 g can result in 47 kg pre-slaughter weight in 40 days more than lambs fattened with concentrate feed ($P < 0.0001$) (Jacques et al., 2011). Intensive feeding for Latvian darkhead breed can offer 334.7 ± 10.0 g d^{-1} ADG (Trapina et al., 2023) that exceeds results of pasture feed by 78 grams per day.

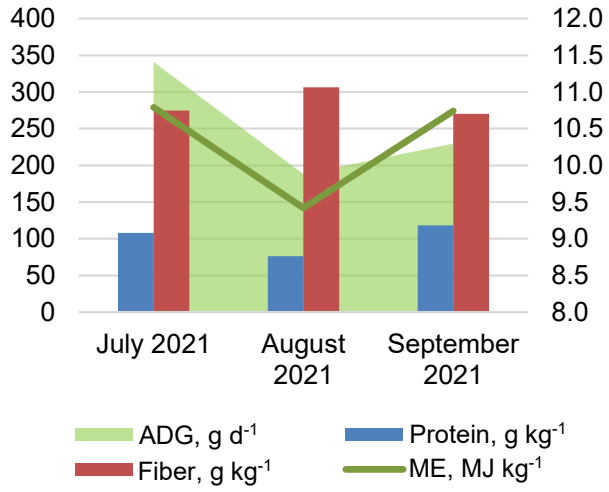

Figure 3. Lamb ADG according to major feed elements in pasture grass in year 2021.

CONCLUSIONS

Lamb growth performance in this research is moderate and yet productive even with variations in both feed chemical content and lamb average daily gain. Latvian darkhead is an appropriate sheep breed to be fattened on pasture feed that has both – grasses and legumes in it.

Lower quality of pasture feed results in slower growth rate. Considering prolonged fattening duration, the time to reach optimal live weight was still reached in 5.2 months of age while the optimal duration is considered to be 5.5 months.

As a limitiation for the current research can be named the variation between average grass feed sample of each paddock does not reflect exact plant combination that lambs have chosen to eat and influence of the feed chemical composition on lamb growth parameters is approximate.

Further investigation on financial and environmental gains due to not having the expense of additional feed as well as less of soil tilling emissions is a direction for future research so that associative effects of conveniency can be clarified.

ACKNOWLEDGEMENTS. The authors express their gratitude to breeding ram evaluation station personnel and Latvian Sheep hearders association for providing the animals and carrying out the feeding trail.

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