



Economic Efficiency of Ensuring Accelerated Growth of Young Sheep

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ABSTRACT

This study evaluated the effects of a specially formulated concentrate feed supplemented with a vitamin–mineral premix on the growth performance and economic efficiency of young sheep during pasture fattening in the Pavlodar region of Kazakhstan. The study involved 100 six-month-old young sheep divided into a control group ($n = 50$), consisting of Kazakh fat-tailed coarse-wool sheep receiving the farm's conventional concentrate feed, and an experimental group ($n = 50$), consisting of Kazakh fat-tailed semi-coarse-wool sheep receiving a formulated concentrate feed supplemented with a vitamin–mineral premix. During the 60-day fattening period, live weight gain was 9.10 ± 0.22 kg in the control group and 12.7 ± 0.35 kg in the experimental group, while average daily gain was 152.2 ± 3.68 and 211.2 ± 5.88 g/day, respectively. The differences between groups were statistically significant ($P < 0.001$). Thus, the experimental feeding system increased live weight gain by approximately 39.6% compared with the conventional feeding system. Economic analysis showed that the experimental group generated revenue of KZT 984,250 compared with KZT 705,250 in the control group, resulting in an additional economic return of KZT 279,000 for 50 sheep, or KZT 5,580 per head. The results demonstrate that supplementation of pasture-fattened young sheep with a nutritionally balanced concentrate containing a vitamin–mineral premix can improve growth performance and enhance the economic efficiency of sheep production under the conditions of the Pavlodar region of Kazakhstan.

Keywords: Young sheep, Pasture fattening, Kazakh fat-tailed sheep, Concentrate feed, Vitamin–mineral premix, Live weight gain

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INTRODUCTION

Developing the sheep industry in Kazakhstan requires preventing overgrazing, which degrades soil. Pasture management should aim to reduce the negative environmental impacts of grazing and implement technologies that optimize feeding systems and improve the quality of sheep production (Myrzabekov & Erokhin, 2005; Jiang *et al.*, 2012). Global demand for organic sheep products is growing.

Pasture fattening is important for producing low-cost lamb. In this context, ensuring adequate feeding of sheep on pasture is crucial for obtaining high-quality meat.

In Kazakhstan's meat-and-fat sheep production, two types of pasture fattening of sheep are widely used (Aboneev *et al.*, 2007; Katzman *et al.*, 2023). The first is intensive fattening, in which concentrates of up to 0.5 kg per head per day are added to the pasture diet for 60 days. The average daily live weight gain of

young sheep under this fattening system should be 200–250 g, while the live weight of young sheep at marketing should be 35–40 kg. The second is moderate fattening, in which young sheep are grazed for 90–100 days under conditions of adequate pasture availability. In both types of fattening, the timing of removing the animals from pasture fattening is determined based on the live weight of the young sheep (Aguayo-Ulloa *et al.*, 2013; Fischer *et al.*, 2024).

Under pasture-based sheep production conditions in Kazakhstan, young sheep can gain considerable live weight in a short period because pasture forage is low-cost. However, poor soil fertility and sharply continental climatic conditions are the main causes of deficiencies in mineral elements and vitamins in pasture forage. Even high-quality pasture forage cannot provide animals with a diet balanced in all essential nutrients. The required set of trace elements and vitamins should therefore be added to the diet when balancing rations, particularly for growing young sheep.

Concentrate feeds play an important role in sheep nutrition, particularly during fattening, as supplements to pasture and bulky feeds, balancing the diets of growing young sheep with

respect to protein and many other nutrients in accordance with feeding requirements. When concentrate feeds formulated to individual recipes compensate for deficient dietary elements, fattening young sheep show a marked increase in productivity. Feed digestibility increases due to a balanced diet in terms of concentrate protein, trace elements, and vitamins supplied through the premix.

Premixes in sheep feeding, particularly during fattening, play an important role as supplements to pasture and bulky feeds, balancing the diets of growing young sheep with respect to macro- and micronutrients and vitamins in accordance with feeding standards.

Therefore, this study aimed to evaluate the growth performance and economic efficiency of pasture fattening in young sheep aged 6–8 months receiving a specially formulated concentrate feed containing a vitamin–mineral premix in the Pavlodar region of Kazakhstan. The assessment focused on dietary nutrient balance, live weight gain, average daily gain, and economic returns compared with the farm's conventional feeding system.

MATERIALS AND METHODS

Study site and experimental animals

The study was conducted at Toraighyrov University based on “KH Ak Bas-Pavlodar” LLP (Pavlodar Region, Republic of Kazakhstan) (Huy *et al.*, 2024; Bekseitov *et al.*, 2025). The study was carried out on young sheep aged 6 to 8 months of the Kazakh fat-tailed coarse-wool breed (control group) and the Kazakh fat-tailed semi-coarse-wool breed (experimental group) by introducing into the animals' diets a concentrate feed with a premix for fattening young sheep developed by the authors. The control group consisted of sheep of the Kazakh fat-tailed coarse-wool breed receiving the farm's conventional concentrate feed. The experimental groups of young sheep were formed based on age, live weight, conformation, and animal class.

After undergoing veterinary examination and the necessary treatments, the selected 6-month-old young sheep intended for fattening (pasture fattening) were divided into separate flocks. The control group consisted of young sheep of the Kazakh fat-tailed coarse-wool breed available at the farm. The experimental group consisted of young sheep of the Kazakh fat-tailed semi-coarse-wool breed. The pasture fattening period lasted 60 days (Table 1).

Table 1. Live weight of the selected young sheep intended for fattening.

Indicators	Groups of sheep	
	Control (n = 50)	Experimental (n = 50)
M ± m	43.4 ± 0.28	43.3 ± 0.22
Cv	1.18	1.19

Experimental design and feeding management

We studied the fattening performance of young sheep from 6 months of age over two months using the following experimental design (Table 2).

Table 2. Experimental design.

Experimental periods	Days	Groups of sheep	
		Control	Experimental

Preparatory period	30	Pasture fattening of young sheep of the Kazakh fat-tailed semi-coarse-wool and Kazakh fat-tailed coarse-wool breeds with supplementation with farm-produced concentrate feed at 400 g/day	
		Pasture fattening of young sheep of the Kazakh fat-tailed coarse-wool breed with supplementation with farm-produced concentrate feed at 400 g/day	Pasture fattening of young sheep of the Kazakh fat-tailed semi-coarse-wool breed with supplementation with the experimental concentrate feed at 400 g/day
Experimental period	60		
Final period	30	Pasture fattening of young sheep of the Kazakh fat-tailed semi-coarse-wool and Kazakh fat-tailed coarse-wool breeds with supplementation with farm-produced concentrate feed at 400 g/day	

Feeding and housing conditions were identical for the experimental and control groups throughout all experimental periods. During the experimental fattening period, the young sheep were fed an experimental concentrate feed with a premix consisting of barley, oats, wheat, and peas in a ratio of 30:30:30:10%, respectively, at a rate of 0.4 kg per head per day, provided in two feedings (morning and evening) to promote intensive muscle mass gain. The only difference was that the experimental group's diet included a concentrate feed supplemented with an additional premix formulated based on laboratory analyses of the feeds.

The young sheep were fattened on pasture forage with supplementary feeding (Omarova *et al.*, 2018; Aktas, 2025). They were provided with separate pastures, supplemented with the experimental concentrate feeds, and had regular access to drinking water.

Throughout the entire fattening period, the young sheep received the required amounts of vitamin and mineral supplements as part of the premixes formulated by the authors. Six-month-old young sheep were fattened on pasture forage with supplementary feeding of the premix developed by the authors as part of the concentrate feed (Badee & Hidaka, 2014; Huber *et al.*, 2025).

Pasture assessment and feed analysis

A survey of the pasture lands of “KH Ak Bas-Pavlodar” LLP was conducted at geobotanical plots in spring and summer to assess the condition of vegetation and the productivity of pasture forage.

Classical geobotanical methods developed by Lavrenko and Korchagin (1959–1972) were used as the methodological basis. These methods included descriptions of phytocenoses on 100 m² sample plots, route-based botanical surveys to analyze vegetation cover and floristic composition (“Flora of Kazakhstan”), and visual assessment of species abundance according to the Drude scale (soc, cop3, cop2, cop1, sp, sol, un). The floristic composition, projective cover, community structure and vertical stratification, phenological stages of development, and degree of anthropogenic transformation were assessed using a six-point scale ranging from background conditions to destruction of vegetation. Geographic referencing

and pasture productivity were also determined. Control points were recorded using a Garmin 72 GPS device (WGS 84 coordinate system). At each point, test cuts were performed in triplicate at a height of 5 cm over an area of 1 m². Productivity was determined in centners per hectare based on the recalculated aboveground biomass.

The chemical composition of the feeds was analyzed at the independent feed laboratory KZ NOVA LAB, affiliated with Cumberland Valley Analytical Services (USA).

Formulation of the concentrate feed and premix

The premix formulations and the concentrate feed for fattening young sheep were produced in the laboratory of Toraighyrov University NJSC using the methodology of T.K. Bekseitov and E.K. Akhazhanov (Bekseitov *et al.*, 2025; Shen & Bao, 2025). The feeding standards for young sheep developed by Kalashnikov *et al.* 2018; Evans *et al.* 2025 were also used. To balance mineral elements, we used data from Kalnitsky (2008), while we used data from Kuznetsov (2006) to calculate mineral supplements and vitamins.

For comparison, the feeding requirements for young sheep being fattened for meat production, with a planned average daily gain of 200 g per head per day, are as follows: dry matter (DM) – 1.10; metabolizable energy (ME) – 11.9; energy feed units (EFU) – 1.2; crude protein (CP) – 170 g; digestible protein (DP) – 120 g; crude fiber (CF) – 105 g; calcium (Ca) – 6.1 g; phosphorus (P) – 3.6 g; and salt – 6 g (Kalashnikov *et al.*, 2018; de Vries *et al.*, 2024; Taylor *et al.*, 2025).

We analyzed the experimental animals' diet to assess the adequacy of its nutritional composition.

We analyzed the sheep diets and formulated a new diet using feeds available on the farm, incorporating a premix formulation into the concentrate feed currently used on the farm (Kalnitsky, 2008; Berger *et al.*, 2024).

To improve the efficiency of the diet, based on the laboratory analyses of the feeds and using feedstuffs available on the farm, we formulated a concentrate feed with a premix designed to most effectively compensate for deficiencies in crude and digestible protein, manganese, iron, copper, zinc, and cobalt, as well as vitamins A, E, and D, taking into account the animals' requirements (Kalnitsky, 2008; Mayer *et al.*, 2024). The required amount of concentrate feed was calculated and produced for the experimental group of animals (Table 3).

Table 3. Formulation of the experimental concentrate feed for fattening young sheep from 6 to 8 months of age.

Nº	Ingredients	%
1	Barley	20.0
2	Oats	30.0
3	Wheat	17.0
4	Peas	23.0
5	Sunflower meal	7.0
6	Premix	1.0
7	Monocalcium phosphate	1.0
8	Common salt	1.0
Nutritional value:		
	Energy feed units (EFU)	1.15
	Dry matter, g	885
	Crude protein, g	159.3

Digestible protein, g	137.5
Crude fiber, g	13.5
Calcium, g	1.32
Phosphorus, g	3.25

The premix formulation was calculated based on an analysis of the existing diet of 6-month-old fattening young sheep, according to a specified percentage ratio relative to the mass of the concentrate feed. The required amount of concentrate feed was calculated for the experimental livestock population (Table 4).

Table 4. Formulation of the experimental premix incorporated into the concentrate feed for fattening young sheep from 6 to 8 months of age.

Nº	Ingredient	Unit	Amount
1	Vitamin A*	IU	10
2	Vitamin D*	IU	420
3	Vitamin E*	IU	35
4	Iron (Fe)	g	1.0
5	Manganese (Mn)	g	2.0
6	Zinc (Zn)	g	1.0
7	Copper (Cu)	g	0.2
8	Cobalt (Co)	g	0.1
9	Wheat bran (filler)	g	up to 1000

* Vitamin A – 0.003 mg, Vitamin D – 0.0105 mg, Vitamin E – 31.5 mg.

The premix is incorporated into the concentrate feed for fattening young sheep aged from 6 to 8 months at a rate of 1% of the concentrate feed mass (Table 5).

Table 5. Distribution of premix ingredients in the filler (Wheat Bran).

Nº	Ingredient	Unit	Content in the concentrate compound feed		
			Per 10 kg	Per 1 kg	Per 0.4 kg
1	Vitamin A*	million IU	2	0.2	0.08
2	Vitamin D*	million IU	0.3	0.03	0.012
3	Vitamin E*	g	1	0.1	0.04
4	(Fe)	g	5	0.5	0.2
5	Manganese (Mn)	g	20	2.0	0.8
6	Zinc (Zn)	g	30	3.0	1.2
7	Copper (Cu)	g	2.5	0.25	0.1
8	Cobalt (Co)	g	1.0	0.1	0.04
9	Wheat bran (filler)	g	9938.2	993.82	397.5

Live weight measurements and growth calculations

The productive characteristics of the experimental animals (live weight) were evaluated in accordance with the Ministry of Agriculture of the Republic of Kazakhstan Instruction on Sheep Grading (2015). Live weight was determined by individual weighing using platform electronic scales with an accuracy of 0.1 kg. The live weight of the lambs was determined at 6 and 8 months of age.

The average daily gain (ADG) was calculated using the following formula:

ADG = (LW final – LW initial) / t, where LW final is the final live

weight, LW initial is the initial live weight, and t is the duration of the period (days).

Statistical analysis

The obtained results were processed using methods of variation statistics according to Plokhinsky, Merkureva, and Lakin, using Student's t-test and Microsoft Excel 2007 software.

RESULTS AND DISCUSSION

Botanical composition and nutritional value of pasture forage

In the natural feather grass–fescue–wormwood pastures of «KH Akbas-Pavlodar» LLP, the main dominant species are fescue, feather grass, Austrian wormwood, couch grass, and various species of forbs. Perennial grasses account for 66.7% of the herbage, legumes for 8.3%, and forbs for 25%. The surveyed natural forage lands are grass–forb pastures and are suitable for haymaking. **Table 6** presents the results of the botanical analysis.

Table 6. Botanical composition of the pastures of «KH Akbas-Pavlodar» LLP.

Nº	Herbage composition	Quantity (kg)	%
1	Fescue	15	41.7
2	Feather grass	5	13.9
3	Couch grass	4	11.1
4	Ural licorice	3	8.3
5	Austrian wormwood	9	25.0
		36	100

Pasture nutritional value is not constant. Depending on the season, climatic conditions, moisture availability, and soil fertility, the chemical composition of pasture plants changes systematically. We studied the chemical composition of forage grasses growing on the farm's pasture lands. The results showed that the main indicator, crude protein, decreases as pasture forage grows and develops. As the grasses grow and develop, pasture forage fiber content increases. In other words, the forage grasses become coarser and begin to dry out. The chemical composition of the pasture lands of "KH Akbas-Pavlodar" LLP was as follows: EFU – 0.23; DM – 241.4 g; ash – 6.7 g; CP – 30 g; DP – 15.6 g; CF – 66 g; Ca – 2.4 g; P – 0.8 g; Mn – 13.5 mg; Fe – 40 mg; Cu – 1.1 mg; Zn – 1.7 mg; Co – 0.02 mg.

Nutrient balance of the diets

Laboratory analysis of the feeds revealed an imbalance in the diet's nutrient content.

The sheep diets were deficient in trace elements, particularly zinc and cobalt, which are essential for growing young sheep. Adequate protein is essential for the complete nutrition of growing sheep. Per 1 feed unit, 90–100 g of digestible protein is required; in the experimental animals' diets, the actual digestible protein content was 91.7 g. The experimental animals achieved this protein level by consuming pasture forage. The fiber content in the dry matter of the diets of 6-month-old lambs did not exceed 13%, since high fiber content generally reduces the digestibility of dietary nutrients. Among mineral nutrients, phosphorus deficiency is usually observed. Sheep generally require 3.5–4.0 g of phosphorus per feed unit. In our diet,

phosphorus content was 4.3 g compared with 8.9 g of calcium, with a recommended level of 6.1:3.6. Thus, the Ca ratio was 2.1, within the limits permitted by existing sheep feeding standards. Among the most important trace elements for sheep are cobalt and zinc; their contents in the diet were 0.74 and 17.2 mg, respectively. Thus, Co and Zn deficiencies amounted to 0.24 mg and 46.8 mg, respectively. For other trace elements, the deficiencies were 9 mg for copper, 13 mg for iron, and 57.7 mg for manganese. The experimental group's diet compensated for these deficiencies through the premix we developed. The nutritional value of the experimental animals' diets was as follows (**Table 7**).

Table 7. Diets of experimental sheep at «KH Akbas-Pavlodar» LLP.

Nutritional value of feeds	Unit of measurement	Diets of the experimental sheep group			
		Control (n = 50)		Experimental (n = 50)	
		Quantity	Balance	Quantity	Balance
Energy feed units (EFU)	Feed units	1.39	+0.19	1.31	+0.11
Dry matter (DM)	g	1206.0	+206	1199	+099
Crude protein (CP)	g	157.0	-13.0	169	-1.0
Digestible protein (DP)	g	81.0	-23.4	109.6	-0.4
Crude fiber (CF)	g	225	+150	236.4	+131.4
Ca	g	8.8	+2.7	8.9	+2.8
P	g	4.1	+0.5	4.3	+0.2
Mn	mg	62.2	-57.7	163.5	+43.5
Fe	mg	167	-13	204.1	+24.1
Cu	mg	7.0	-9.0	17.1	+1.1
Zn	mg	17.2	-46.8	67.6	+3.5
Co	mg	0.74	-0.24	0.5	0.0
Vitamin A	IU	-	-10.0	10.0	0.0
Vitamin E	IU	19.25	-40.75	62.35	+2.35
Vitamin D	IU	11.9	-418.1	432.0	+2.0

For intensively growing fattening young sheep, feeds should contain substantially higher levels of digestible protein to support muscle tissue growth.

At the same time, vitamin A is essential for young sheep during the fattening period to promote rapid live weight gain. Vitamin A deficiency slows growth and reduces resistance to infections. Vitamin D3 is necessary for the regulation of calcium and phosphorus metabolism in the body of growing young sheep and for bone tissue mineralization. Vitamin E acts as a natural antioxidant and contributes to muscle tissue growth in young sheep. It also prevents muscular dystrophy. Iron supports glucose absorption, muscle growth, and healthy development in young sheep. Manganese and copper are necessary for connective tissue metabolism and increasing average daily gain. Cobalt and zinc are essential for normal metabolism and growth. When formulating the premix, efforts were made to avoid excessive dietary zinc, which can significantly increase

lead concentrations in the animals' bodies and reduce growth rate. According to published data, when excess zinc and lead were introduced into the diets of piglets, the animals' average daily gain over 9 weeks decreased almost sixfold.

In contrast, feed intake decreased by more than twofold (Omarova et al., 2018; Eriksen et al., 2025; Otieno et al., 2025). Excess copper in animal diets contributes to copper toxicosis, which can lead to liver necrosis. Elevated iron levels in the diet, particularly in growing young animals, reduce live weight gain. Excessive manganese in the diet of fattening young sheep reduces pasture forage intake and fiber digestibility, resulting in decreased average daily live weight gains. When formulating the premix, we also considered that excessive vitamin A intake can inhibit growth.

Live weight gain and average daily gain

According to the experimental results, young sheep live weight gain during the preparatory period was uniform, ranging from 9.4 to 10.2 kg. The average live weight of the sheep before the pasture fattening period was 23.3 kg.

Live weight gain during the experiment and average daily live weight gain in the experimental group, which received a nutrient-balanced concentrate feed with a premix, amounted to 12.7 kg and 211.2 g, respectively, compared with 9.1 kg and 152.2 g, respectively, in the control group (Table 8).

Table 8. Live weight gain and average daily live weight gain of fattening young sheep.

Indicators	Groups of sheep			
	Control		Experimental	
	M ± m	Cv	M ± m	Cv
Live weight gain	9.10 ± 0.22	2.42	12.7 ± 0.35***	2.8
Average daily gains	152.2 ± 3.68	2.40	211.2 ± 5.88***	2.7

Differences between the control and experimental groups in live weight gain and average daily gains were statistically significant at $P < 0.001^{**}$.

The average daily gains of the young sheep receiving the experimental concentrate feed with the premix exceeded those of the young sheep receiving the conventional supplementary feed by 3.6 kg and 59.0 g, respectively. This substantial difference was largely due to balancing the diet for protein by increasing the proportion of peas in the concentrate feed from 10% to 23% and additionally including sunflower meal in the experimental concentrate feed. The concentrate feed makes it possible to balance diets in terms of dry matter, protein, and the diet's NDF and ADF content. It increases the body weight of the lambs by 39.6%.

The average daily gain of the lambs planned by us at an average of 200 g per day was mainly achieved through the use of good-quality pastures and specially developed supplementary feed: concentrate feeds for fattening lambs at a rate of 0.4 kg per head per day.

Replenishment of deficiencies in protein, mineral elements, and vitamins in the diets of the experimental sheep had a positive effect on the growth, development, and productivity of growing young sheep. Particular attention was paid to the proper dosage of cobalt and zinc as the most effective trace elements in lamb diets.

Economic efficiency

Using concentrate feed to fatten young sheep from 6 to 8 months of age generated additional revenue of KZT 984.25 thousand in the experimental group. This was 39.6% higher than the revenue obtained from the control group. The economic efficiency of fattening using concentrate feed for young sheep from 6 to 8 months of age amounted to KZT 5.58 thousand per head (Table 9).

Table 9. Economic efficiency of accelerated growth of young sheep.

Indicators	Sheep groups	
	Control group	Experimental group
Live weight at the beginning of the experiment, kg	43.4 ± 0.28	43.3 ± 0.22
Live weight at the end of the experiment, kg	52.5 ± 0.32	55.9 ± 0.34
Concentrate feed consumption, kg	1440	1440
Cost of concentrate feed, KZT/kg	75	
Cost of concentrate feed during the fattening period, KZT	108 000	
Live weight gain, kg	9.10 ± 0.22	12.7 ± 0.35
Cost per kg of live weight, KZT	1550	1550
Value of live weight gain, KZT	14105	19685
Number of sheep	50	50
Revenue, KZT	705250	984250
Profit, KZT	597250	876250
Economic efficiency, KZT	-	279000
Economic efficiency per head, KZT	5580	

CONCLUSION

Thus, the premix developed by the authors as part of the concentrate feed makes it possible to use feed grain and other farm-produced concentrated feeds rationally and efficiently, while more fully realizing the genetic potential and productive capacity of 6–8-month-old fattening young sheep. Based on the results obtained, the following conclusions can be drawn:

1. Feeding the experimental concentrate feed supplemented with the premix to the animals significantly increased live weight gain in young sheep of the Kazakh fat-tailed semi-coarse-wool breed. It resulted in average daily live weight gains of 210–212 g.
2. Using concentrate feed to fatten young sheep from 6 to 8 months of age generated additional revenue of KZT 984.25 thousand from the experimental group. The economic efficiency of fattening amounted to KZT 5,580 per head.

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