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Increasing Meat Productivity and Improving Quality of Lamb Meat from Fine-Wool Sheep

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Abstract

The article shows the results of the reference slaughtering of purebred and crossbred rams obtained from ewes of the Precose breed and producers of meat-fat coarse wool breeds: the Edilbaevsk and the Kazakh Fatty. It has been found that the use of crossing fine-wool ewes with producers of meat-and-fat sheep breeds can significantly improve meat quality, and increase meat productivity of the sheep. The slaughter yield in hybrids significantly exceeded the yield of purebred rams. The crossbred Edilbaevsk calves were characterized by higher meatiness index of 4.08, which was much higher than that of purebred by 2.46. Crossbred rams from the second group were characterized by the greatest area of "loin eye" of 15.03 cm^2 with the least diameter of muscle fibers - 34.1 μm. Lamb meat from crosses with the Edilbaevsk breed was characterized by lower content of water – 2.0 – 2.2%, higher protein content of 0.3 to 1.0%, and fat of 0.6 to 1.6%, compared to the meat of purebred Precoses. The meat of these animals was more nutritious than meat from the coxal part of purebred rams – 161 kcal, shoulder part – 119 kcal, and lumbar part - 93 kcal. Lamb meat from this variant was characterized by a higher content of essential amino acids compared to meat from purebred peers by 0.76%. When crossing fine-wool ewes with meat-and-fat producers, the obtained hybrids have significantly increased the amount of phospholipids with simultaneous reduction of cholesterol content in the fat. In the fat crossbred rams, the content of essential fatty acids increases, compared to purebred peers, which significantly improves meat quality.

Keywords: meat productivity, slaughter weight, slaughter yield, loin eye area, muscle fiber diameter, chemical composition of meat and fat.

INTRODUCTION.

In the recent past (the 70-80s of the XXth century) the economy of sheep breeding in Russia has been mainly based on wool production, the share of which in the total cost of production has typically equaled to 70-80%, while currently, the economic efficiency of sheep breeding is primarily determined by the level of lamb meat production, since the production of wool has become widely unprofitable. Therefore, increasing meat productivity of sheep, increasing the production of lamb meat are the main ways of increasing efficiency of sheep breeding [1, 2, 3].

To increase production of lamb meat, Russia has many unemployed reserves. An efficient and affordable method of increasing production and improving quality of lamb meat is the wide use of various options of industrial crossing. This method of breeding allows to quickly, safely and at no additional cost increase productivity of animals and improve quality of the products through the use of specific inherited and conditional inclinations of the source breeds. However, given the low repeatability of the results of crossing various breeds in different areas of sheep breeding, there is the need for developing and determining the optimum options of crossing with the aim of increasing meat productivity of fine-wool breeds [4, 5, 6, 7, 8, 9, 10, 11]. In this regard, the study was aimed at studying efficiency of crossing ewes of the Precose breed with meat and fat producers of coarse-wooled breeds for increasing meat productivity of sheep and obtaining high-quality lamb meat.

METHODS

The material for the study were the rams obtained after purebred breeding and crossbreeding Precose ewes with producers of the Edilbaevsk and Kazakh fatty rams at the family farm of H. A. Alikhanova in the Michurinsky district of the Tambov region. Up to 4 months of age, the lambs were reared with ewes. In addition to mother's milk, the lambs received cereal and legume hay, and concentrated fodder. After weaning to 8 months of age, the rams were kept at natural pastures with the use of concentrated fodder.

Meat productivity of sheep was studied by the method of the All-Russia Research Institute of Cattle Breeding (1978). For this purpose, reference slaughter of 3 rams from each group was performed at the age of 8 months (GOST 31777 - 2012). Slaughter parameters and morphological composition of each carcass were determined. Chemical composition of the flesh of individual junctures was studied by the following methods: moisture according to GOST 9793-74, fat content - in a Soxhlet extractor, protein - by Kjeldahl, and ash – by dry mineralization of samples in a muffle furnace. The energy

value of the edible part of rams carcass was determined according to the method of A. P. Alexandrov (1983), amino acid composition of muscle tissue - by the method of ion exchange chromatography at an automatic analyzer AAA – 881. Physico-chemical properties of fat were determined by the melting point and the pour point, acidity, saponification number, and the iodine number. The content of total lipids in muscle fat was determined by the method of Folch, of phospholipids - by the method of Markov and Pokrovsky (1969), of cholesterol - by the method of Levchenko (1969), and the fatty acid composition of lipids – by the gas-liquid chromatography. The area of "loin eye" was determined by the cross sectional area of the longest muscle in the back with a planimeter across the section of the muscle. The samples for histological examination were taken in the area of the dorsal and lumbar vertebrae, and the thickness of 100 muscle fibers was determined under the microscope. The taste of meat and broth was assessed by a 20 point scale.

Main part.

The data obtained after slaughtering of purebred and crossbred rams at the age of 8 months (Table 1) also indicate a better quality of the meat of hybrids. In case of slaughtering rams at the age of 8 months, an increase in the weight of the carcass, internal fat and tail are observed, as well as the slaughter weight and the slaughter yield, which indicates better efficiency of slaughtering rams in this age.

The carcass weight of the crossbred rams obtained from crossing Precose ewes with Edilbaevsk producers surpassed significantly the carcass weight of purebred rams by 5.3 kg, and the difference between crosses with the Kazakh fat tail breed and the purebred animals was 3.74 kg (R≥0.99). Hybrids of both groups, compared to purebred rams, featured deposition of fat at the tailhead, the amount of which in the Edilbaevsk hybrids was higher than in the Kazakh ones by 0.2 kg. The amount of internal fat in crossbred rams was significantly higher than in purebred animals. The slaughter yield in hybrids significantly exceeded the yield of purebred rams. Similar trend was noted for carcass yield, too.

Table 1 - Slaughter qualities of experimental rams at the age of 8 months

Indicator	Groups		
	Precose x Precose	Edilbaevsk x Precose	Kazakh x Precose
Pre-slaughter live weight, kg	35.43±0.11	44.70±0.39**	42.42±0.39 **
Carcass weight, kg	14.52 ± 0.05	19.82± 0.06**	18.26± 0.37 *
Internal fat, kg	0.55 ± 0.02	0.88 ± 0.03*	0.72 ± 0.04 x
Tail fat, kg	-	0.97 ± 0.04	0.77 ± 0.04
Slaughter weight, kg	15.06 ± 0.03	21.67 ± 0.14**	19.73 ± 0.32 **
Carcass yield, %	41.17 ± 0.33	44.34 ± 0.25 *	43.05 ± 0.37 x
Slaughter yield, %	41.85 ± 0.85	48.47 ± 0.16 x	46.47 ± 0.37 x
Watering thickness, mm	2.97±0.07	3.83±0.12**	3.40±0.05*
Flesh content in the carcass, kg	10.31 ± 0.18	15.91 ± 0.12**	14.43 ± 0.29**
%	71.41 ± 1.01	80.29 ± 0.47 *	78.69 ± 1.24
bones and tendons, kg	4.21 ± 0.23	3.91 ± 0.09	3.83 ± 0.28
%	28.99 ± 1.49	19.71 ± 0.47 *	20.98 ± 1.33 *
Meatiness coefficient	2.46 ± 0.17	4.08 ± 0.12 *	4.02 ± 0.07*

Note: The data are veracious at P≥0.95*, P≥0.99**, P≥0.999***

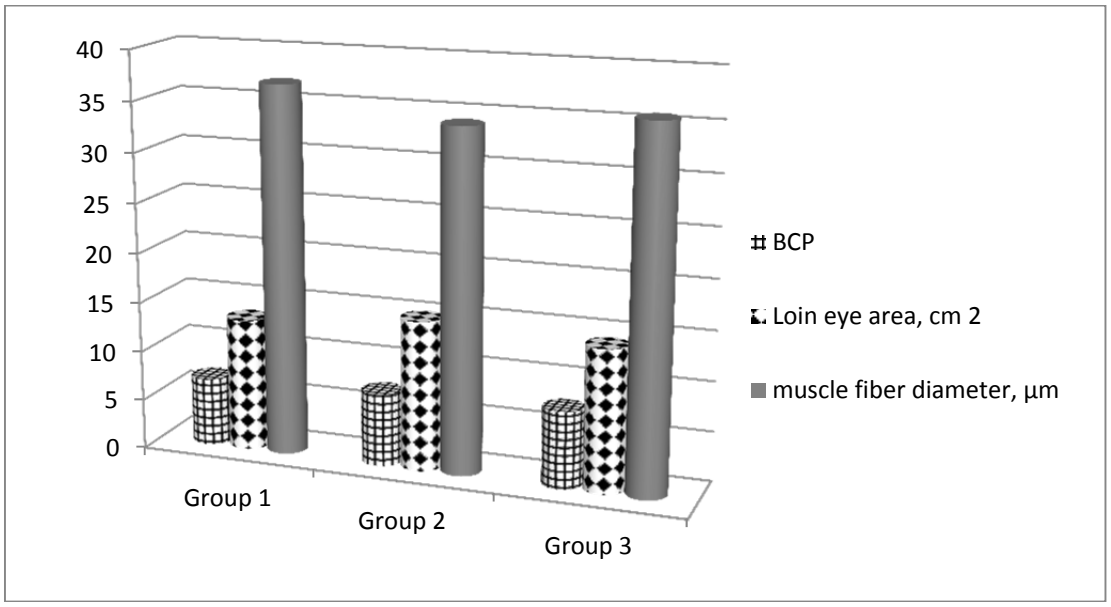

Figure 1. Quality indicators of muscle tissues

Meatiness qualities of sheep can be more fully judged by the contents of edible (flesh) and not edible (bones and tendons) components in the carcass, and by the area coefficient [12, 13]. Morphological butchery of experimental rams showed superiority of hybrids in terms of flesh content in the carcass. Hybrids from the variant Edilbaevsk x Precose by flesh content in the carcass were superior to the purebred counterparts by 5.6 kg ($P \geq 0.999$) or 8.88% ($P \geq 0.95$). Rams from crossing Precose with the Kazakh fat-tailed breed by the content of flesh in the carcasses were superior to the purebred animals by 4.12 kg ($P \geq 0.999$). At the same time, by the content of bones and tendons in carcasses, no substantial and veracious difference was found. The maximum meatiness coefficient was observed in the variant with Edilbaevsk x Precose, which was significantly superior to purebred animals by 1.62, and to crosses in the other variants - by 0.06.

One of the indicators that characterize meat quality is its amount per 1 kg of bones, which can be assessed by measuring the area of "loin eye" - the cross-section of the longest muscle in the back (Fig. 1) [14].

The figure shows that the area of "loin eye" in crossbred rams from the second group was higher by 1.73 cm^2 than in the relatively purebred counterparts, and in the rams from group 3 this indicator was higher than in the first group of experimental animals by 0.97 cm^2. Comparison of crossbred rams from the second and the third groups showed superiority of the second group by 0.76 cm^2. Meat tenderness and taste largely depend on the thickness of muscle fibers. The thicker the fibers are, the worse the meat quality is. By the results of the studies, analysis of muscle fibers diameter showed the opposite trend in the animals of the second group: muscle fibers appeared thinner than those in other groups, and the difference was 2.83 μm and 1.16 μm, respectively. As to the protein and quality indicator (Fig. 1), its higher level was noted in the meat of rams from the third group, which was veraciously higher than in counterparts in the second group by 0.4, and in the first group - by 0.9.

The value of lamb meat depends not only on the quality of the carcass, its morphological and varietal composition, but also on the chemical composition of meat, based on which one can access maturity of its biological and energetic value as a food product [13, 15].

In this regard, studying chemical composition of rams' flesh of various genotypes is of particular interest for assessing the nutritional value of the product. Given that the most valuable are first-grade junctures – coxal, spinal-scapular and lumbar, the chemical composition and energy value of meat from these junctures was assessed (Table 2). For all tested junctures, water content in the hybrids was lower than in purebred rams. The smallest amount of water was noted in the lumbar part in purebred and crossbred animals, and the greatest amount - in the shoulder part. Higher fat content was observed in all junctures of hybrids, too, although veracious difference was found only in the coxal part of animals of the Edilbaevsk and Precose hybrids - 1.6% ($P \geq 0.95$).

By protein content in the scapular juncture, a significant difference between the Edilbaevsk hybrids and Precose was established, which amounted to 1.0 % ($P > 0.99$), and in the lumbar juncture between breeds Kazakh and Precose, which amounted to 0.8% ($P > 0.95$). A higher ash content was observed in the meat from all junctures of crossbred rams, though a significant difference was observed by this indicator only between the purebred and the Edilbaevsk crossbreeds in all junctures, as well as between groups of hybrids.

As for the energy value, more calories were contained in the meat from the lower junctures of animals of all genotypes. With that, meat of crossbred rams from the second group was the most calorigenic.

The quality of lamb meat protein is characterized by its amino acid composition, therefore, the amino acid composition plays an important role in determining meat quality of sheep. The amino acid composition should also be studied to find the regularities of the proteins and amino acids metabolism in animals [10,14]. Given the role of amino acids in building proteins in the muscle tissue, its amino acid composition was studied (Table 3). Analysis of amino acid composition of meat of experimental animals showed that the content of essential amino acids in crossbred animals was superior to that in their purebred counterparts. The maximum amount of essential amino acids was found in rams of genotype Ed x P – 37.32, which exceeded that in the purebred counterparts by 0.76%, and in genotype KK x P by 0.33%. One should note the veraciously higher content of amino acids, such as leucine, isoleucine, methionine in the meat of rams from this group, compared to purebred animals, and leucine and phenylalanine in genotype KK x P.

As to non-essential amino acids, their highest amount of 63.44% was noted in purebred rams. The difference in terms of this indicator between the first and second groups was 0.76%, and between the first and third groups - 0.43%. A statistically significant increase was observed in genotype Ed x P for amino acids such as valine, and a decrease in the content of all other amino acids except for glutamic and aspartic acids, compared to the Precose rams. In genotype KK x P, compared to the Precose, only the increase in valine and alanine, and the decrease in proline, glycine, and glutamic acid were veracious.

Fat tissue forms in sheep in the form of subcutaneous, intermuscular, intramuscular fat, and is deposited in internal organs, tail and the rump. Thus, first of all, physico-chemical properties of the inner and rump fat of the experimental rams were studied. The results of studying its physico-chemical properties are shown in Table 4.

The obtained data show that by the physico-chemical constants of rams' fat, tail fat has relatively lower melting and solidification point, high saponification value and low acidity, compared to other types of fat. As to internal fat, the melting and solidification point, the saponification value, they are lower in purebred rams than in hybrids, while acidity is lower in the crossbreeds with the Kazakh fat tail breed, and iodine number – in the Edilbaevsk breed. In perirenal fat, all the physico-chemical constants are lower in purebred rams, compared to cross-breeds with the Edilbaevsk and the Kazakh fat-tail rams.

Table 2. Chemical composition and energy value of lamb junctures and their carcasses

Name of lamb juncture	Content, %				Energy value of 1 kg of flesh, kcal
	water	fat	protein	ash	
Group 1					
Coxal	67.8 ±0.85	14.2±0.45	17.1±0.26	0.9±0.05	2,021
Scapular	68.1±0.45	14.9±0.60	16.1±0.20	0.9±0	2,046
Lumbar	64.4±0.43	18.3±0.75	16.8±0.40	0.9±0.02	2,374
Group 2					
Coxal	65.8±1.40*	15.8±0.60*	17.4±0.30	1.01±0.05**	2,182
Scapular	66.1±0.81*	15.7±0.45	17.1±0.10**	1.00±0.05**	2,165
Lumbar	62.8±0.55*	18.9±0.43	17.3±0.30	1.01±0.02*	2,467
Group 3					
Coxal	66.7±0.91*	15.1±0.52	17.3±0.20	0.9±0.05	2,114
Scapular	67.2±0.79	15.3±0.45	16.6±0.36	0.9±0.05	2,104
Lumbar	63.8±0.62	19.3±0.60	16.0±0.17*	0.9±0.05	2,451

Note: The data are veracious at P≥0.95*, P≥0.99**, P≥0.999***.

Table 3. Amino acid composition of the meat of experimental rams, %

Essential amino acids	Groups			Non-essential amino acid	Groups		
	1	2	3		1	2	3
Leucine	7.43±0.18	7.52±0.10**	7.5±0.15*	Alanine	6.35±0.07	6.22±0.01**	6.43±0.01***
Lysine	8.2±0.40	8.28±0.31	8.28±0.11	Aspartic acid	8.5±0.23	8.31±0.18	8.4±.036
Threonine	4.9±0.16	4.91±0.10	4.84±0.27	Cystine	1.3±0.02	1.23±0.02*	1.21±0.02
Isoleucine	4.82±0.10	5±0.40*	4.92±0.30	Glutamic acid	14.4±0.05	14.5±0.02	14.26±0.02**
Histidine	3.71±0.15	3.73±0.27	3.76±0.32	Glycine	6.7±0.02	6.46±0.03*	6.58±0.03*
Methionine	2.3±0.10	2.38±0.21**	2.37±0.11	Proline	4.8±0.02	4.56±0.02	4.75±0.03**
Tryptophan	1.3±0.07	1.32±0.07	1.34±0.03	Serine	3.9±0.03	3.68±0.032**	3.71±0.018
Phenylalanine	3.9±0.22	4.18±0.37	3.98±0.52*	Tyrosine	3.2±0.04	3.1±0.04**	3.08±0.02
				Oxyproline	1.9±0.03	1.82±0.02**	1.74±0.02
				Arginine	7.41±0.04	7.5±0.05	7.57±0.05
				Valine	4.98±0.80	5.3±0.51*	5.28±0.31*
Total	36.56	37.32	36.99	Total	63.44	62.68	63.01

Note: The data are veracious at P≥0.95*, P≥0.99**, P≥0.999***.

Table 4. Physico-chemical composition of fat of rams

Indicators	Group 1	Group 2	Group 3
Internal fat			
Melting point, C^0	48.03±0.20	48.50±0.05	48.30±0.18
Freezing point, C^0	37.30±0.26	38.10±0.05*	38.0±0.05
Saponification value	190.30±0.28	191.37±0.59	196.0±0.07***
Acidity	1.90±0.01	2.03±0.02*	1.72±0.02**
Iodine number	36.9±0.10	36.19±0.16*	38.09±0.04***
Perirenal fat			
Melting point C^0	50.10±0.05	50.56±0.07**	50.53±0.12*
Freezing point, C^0	41.0±0.10	41.93±0.07**	42.50±0.18**
Saponification value	190.66±0.76	191.33±0.76	192.33±1.04
Acidity	1.90±0.01	2.06±0.02**	1.96±0.05
Iodine number	32.16±0.16	32.40±0.47	33.50±0.20**
Tail fat			
Melting point C^0	-	39.36±0.07	40.83±0.17
Freezing point, C^0	-	32.40±0.13	33.0±0.10
Saponification value	-	194.0±0.50	195.66±0.57
Acidity	-	1.70±0.05	1.70±0.05
Iodine number	-	44.90±0.05	44.90±0.10

Note: The data are veracious at P≥0.95 - *, P≥0.99 - **, P≥0.999 - ***.

Table 5. The lipid composition of muscle tissue in experimental rams

Indicators	Unit of measurement	Groups of animals		
		1	2	3
Total lipids	%	1.87±0.10	1.94±0.15	2.06±0.07
Triglycerides	%	1.08±0.19	1.15±0.07	1.11±0.09
Phospholipids	%	0.68±0.01	0.74±0.01*	0.72±0.01*
Cholesterol	мг/%	30.01±0.18	28.07±0.25**	29.00±0.18*

Note: The data are veracious at P≥0.95 - *, P≥0.99 - **, P≥0.999 - ***.

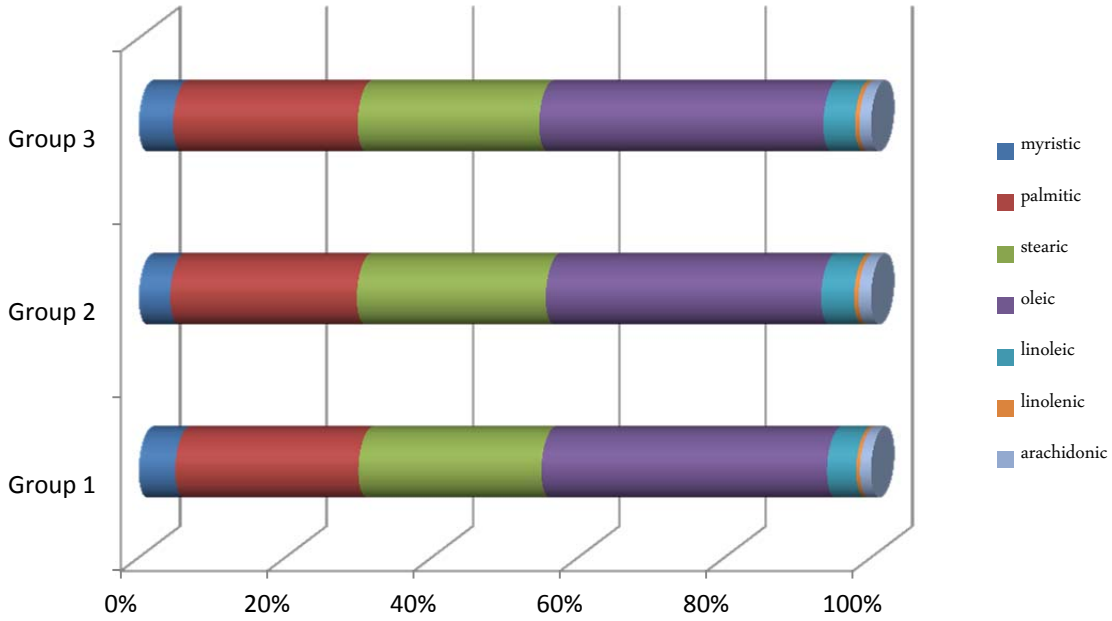

Figure 2 – Fatty acid composition of lamb fat

However, the lipid composition of muscle tissue is of the greatest interest. Intramuscular lipids affect the tenderness, the taste and the smell of meat. Lipids quality plays an important role in meat processing. The results of studying the lipid composition of muscle fat are shown in Table 5.

The data from analyzing the lipid composition of the muscle tissue showed that the total amount of lipids in cross-breeds was higher than in purebred rams, but the difference was not veracious. A similar tendency was also noted for the content of triglycerides.

Phospholipids are a very physiologically important group of lipids, which are part of the protein-lipid complex of cells, therefore, their veracious increase in the muscle fat in cross-breeds is positive. With that, one should positively note the significant decrease of cholesterol level in the meat of cross-bred rams. Hybrids with the Edilbaevsk breed contained less cholesterol by 1.94 mg% (P≥0.99), and with the Kazakh fat-tailed - by 1.01 mg% (P≥0.95), compared to purebred rams.

Fat quality is characterized by the content of fatty acids, and therefore, the fatty acid content in internal fat of rams of various genotypes was studied; the results are shown in Figure 2.

The data shown in the Figure indicate a reduced content of myristic and oleic acids in the fat cross-breeds, but a higher content of palmitic acid. At the same time, in terms of the total amount of polyunsaturated fatty acids, namely, linoleic, linolenic and arachidonic ones, the fat of cross-breeds is superior to the fat of purebred rams. The veracious increase in the content of linoleic acid is noted in cross-breeds of the second group by 0.51%, of the third – by 0.32%; of linolenic acid - by 0.11% and 0.08%; of the arachidonic acid - by 0.18% and 0.10%, respectively. The increased content of polyunsaturated fatty acids indicates the improved quality of internal fat of experimental rams.

Assessment of lamb meat should be multifaceted. Chemical and physical methods of studying the quality of products provide an opportunity to determine composition of its constituent nutrients, and the texture. However, these indicators cannot be used for determining the taste of meat. In this regard, one of indicators of product quality is the tasting assessment, which determines its suitability to satisfy human needs. It should be noted that the outcome of organoleptic assessment depends on the individual habits of the taster, too. Despite some bias, this assessment sometimes is final and decisive in determining the quality of food. The tasting assessment of boiled and roasted lamb meat from experimental animals showed high taste qualities of the meat from crossbred rams in the second group, where the total taste score of boiled meat was 19.2, and of roasted meat was 19.1, which was 2.3 or 13.9%, and 2.5 or 15.1%, respectively, higher than the corresponding indicators of processed meat of pure Precose rams. Broth

from the meat of lambs in the second group was more intense and delicious. The total flavor score of the broth from the meat of rams in this group was set by tasters to 28.6, which was 3.9 points, or 15.8% higher than that of the broth made from the meat of purebred Precose animals, and 2.4 points, or 9.2% better than the indicator for the meat of animals in the third group.

CONCLUSION

The results of the study showed that interbreeding contributed to increasing meat productivity indexes of fine-wool sheep. Therefore, crossing of fine-wool ewes with meat and fat-producing fat-tailed breeds will significantly increase the meat productivity of these sheep, and improve the quality of lamb meat, which is especially important in today's market and in the conditions of increased demand for lamb meat.

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