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Influence of wether genotype on nutrient yield and the energy value of muscle tissue

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Abstract. Within the framework of the study, the effect of crossbreeding Romanov and Edilbaev sheep breeds on the quality characteristics and energy value of meat was investigated. The research subjects were purebred wethers of the Romanov breed (group I), their first- and second-generation crossbreeds with the Edilbaev breed (½ Romanov × ½ Edilbaev — group II; ¼ Romanov × ¾ Edilbaev — group III). Analysis of the obtained data revealed a significant crossbreeding effect on the studied parameters. In particular, crossbred individuals from groups II and III substantially outperformed purebred animals from group I in terms of dry matter content in muscle tissue — by 41.56 and 54.48%, respectively; protein yield — by 39.42 and 50.45%; extractable fat level — by 52.80 and 76.06%. Furthermore, purebred wethers from group I showed lower values compared to the first- and second-generation crossbreds (groups II and III) in energy concentration per 1 kg of muscle tissue

(by 172 and 328kJ); energy yield in carcass tissue (by 23.93 and 32.03 MJ); maturity level (by 0.55 and 1.02%). At the same time, the protein-to-fat ratio remained nearly identical across all groups. The second-generation crossbreds (Group III) demonstrated the highest values across the entire set of analysed parameters.

Keywords: sheep breeding, purebred sheep, Romanov breed, Edilbay crossbreds, wether, chilled carcass, muscle tissue, energy value, protein, fat, ratio, meat maturity, meat ripeness

Authors contribution: Yu.A. Yuldashbaev supervised the scientific aspects of the study; V.I. Kosilov developed the research program and coordinated the study; E.A. Nikonova and I.A. Rakhimzhanova conducted the experimental work; R.G. Kalyakina performed the statistical analysis; O.A. Bykova interpreted the results and prepared the manuscript. All authors approved the final version of the manuscript.

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Introduction

Ensuring the national food security requires the intensification of all branches of animal husbandry [1–5]. A priority direction for the development of the industry should be considered the increase in the production volume of meat products and semi-finished products output [6–8]. The key reason for such emphasis is the high biological value of meat, determined by the presence of complete proteins containing all essential amino acids, the dietary intake of which is an indispensable condition for the human physiological functioning [9–12].

In Russia, sheep breeding is developing as a low-input livestock sector due to the high adaptive plasticity of sheep and their low requirements for feeding and housing conditions [13–16]. Furthermore, lamb meat is free from religious and national restrictions and is characterized by high nutritional and energy value, making sheep production available in almost all regions of the country. In meat sheep breeding, maximum efficiency is achieved when raising crossbred young stock. Due to the heterosis effect, such animals demonstrate pronounced superiority in productive traits. The Edilbay breed is increasingly used as an improving paternal line, since its genetic characteristics are consistently transmitted to offspring. Crossbreds inherit the outstanding meat qualities and high nutritional value characteristic of this breed.

The aim of the study was to evaluate the effect of crossing Romanov ewes with Edilbay rams on the energy value and qualitative characteristics of muscle tissue in crossbred wethers.

Materials and methods

During the study, three experimental groups of ram lambs were formed, each consisting of 15 animals. The grouping was carried out based on their genotypic characteristics: Group I — purebred young stock of the Romanov breed, Group II — first-generation crossbreds with equal genetic contribution (½ Romanov × ½ Edilbaevskaya), Group III — second-generation crossbreds with a predominance of the Edilbaevskaya breed (¼ Romanov × ¾ Edilbaevskaya). At three months of age, all animals in Groups I–III were castrated using an open method with complete removal of the testes.

Animal handling and experimental procedures complied with the instructions and recommendations of the Model Law of the Interparliamentary Assembly of CIS Member States "On the Treatment of Animals", Article 20 (Resolution No. 29–17 of October 31, 2007), the Directive of the European Parliament and the Council of the European Union on the protection of animals used for scientific purposes https://ruslasa.ru/wp-content/unloads2017/06/Directive_201063-rus.pdf, and Federal Law No. 498-FZ of December 27, 2018 (as amended on July 24, 2023) "On Responsible Treatment of Animals and Amendments to Certain Legislative Acts of the Russian Federation".

When the young animals reached ten months of age, a control slaughter was carried out involving three animals of each genotype (wethers).

After slaughter and primary carcass processing (deboning and trimming), samples of the *longissimus dorsi* muscle were collected for chemical analysis. Based on laboratory data regarding the chemical composition of the selected samples, the concentration and gross yield of dry matter, extractable fat, and protein per 1 kg of muscle tissue, as well as their energy value, maturity (ripeness), and nutrient ratio, were determined.

After completion of slaughter and primary carcass processing, samples of the *longissimus dorsi* muscle were selected for chemical analysis. Subsequently, during deboning, the edible fraction of the carcass was isolated, followed by separation of muscle tissue. Laboratory analyses of the chemical composition of the *longissimus dorsi* muscle made it possible to determine the concentration of dry matter, protein, and extractable fat per 1 kg of muscle tissue; calculate the gross yield of these components in the muscle tissue of the entire carcass; assess the energy value of the product; determine the meat maturity (ripeness) index; and analyze the ratio of major nutrients.

During the experimental work, all possible measures were taken to minimize the suffering of experimental animals and reduce the number of experimental samples used.

Results and discussion

The increased consumer demand for meat products is primarily driven by their qualitative characteristics. A special place here is occupied by nutritional and energy value, determined by the chemical composition and nutrient content of the muscles.

The study demonstrated that the investigated traits are genetically determined (Fig. 1).

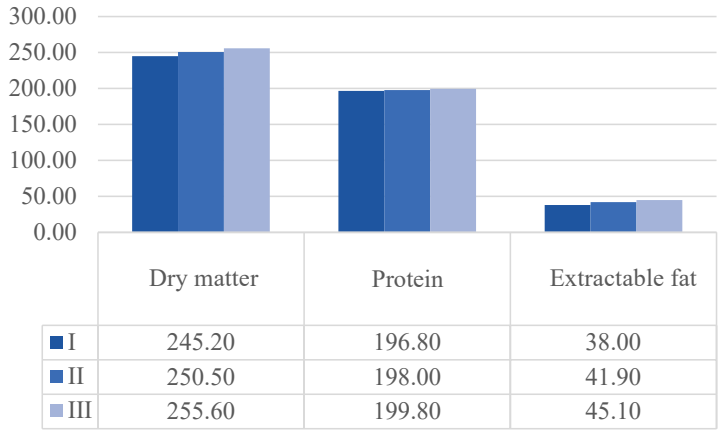

Fig. 1. The content of nutrients in 1 kg of muscle tissue, g

Source: compiled by Yu.A. Yuldashbaev, V.I. Kosilov, E.A. Nikonova, R.G. Kalyakina.

The nutritional value of muscle tissue largely depends on dry matter concentration. Purebred wethers of Group I were inferior to crossbred contemporaries by 5.3 g (2.16%) and 10.4 g (4.24%), respectively.

Intergroup variation in dry matter content was associated with differences in protein and extractable fat levels. The lowest concentrations of these components were observed in Group I animals. Crossbred wethers of Groups II and III exceeded purebred counterparts in protein content by 1.2 g (0.61%) and 3.0 g (1.52%), respectively, and in extractable fat by 3.9 g (10.26%) and 7.1 g (16.68%), respectively.

Thus, crossbred wethers of Group II and III exhibited more intensive fat deposition than purebred animals of Group I, while differences in protein content between groups remained relatively small.

For an objective evaluation of muscle tissue nutritional value, determining nutrient concentration per kilogram alone is insufficient. The total yield of nutrients in the entire carcass muscle mass provides a more informative indicator.

Assessment of slaughter results and laboratory analyses confirmed the genetic determination of total nutrient yield (Table 1).

Table 1

The yield of nutrients in the muscle tissue of the carcass of purebred and crossbred wethers, g

Group	Content in the carcass muscle tissue		
	Dry matter	Protein	Extracted fat
I	2778.1	2229.7	430.5
II	3932.8	3108.6	657.8
III	4291.5	3354.6	757.8

Source: complied by Yu.A. Yuldashbaev, V.I. Kosilov, I.A. Rahimjanova, T.A. Sedyh.

The ranking pattern of wethers according to gross output and concentration of nutrients in carcass muscle tissue is identical. Purebred wethers deposited significantly lower amounts of dry matter in muscle tissue than crossbreds from Groups II and III, by 1154.7 g (41.55%) and 1513.4 g (54.48%), respectively. Protein yield in crossbreds exceeded that of purebred animals by 878.9 g (39.42%) and 1124.9 g (50.45%), while fat yield exceeded purebred values by 227.3 g (52.80%) and 327.3 g (76.05%), respectively.

Meat products are valued not only for biologically complete protein but also as an important energy source. Intergroup differences in nutrient synthesis resulted in unequal energy values of 1 kg of muscle tissue (Fig. 2.).

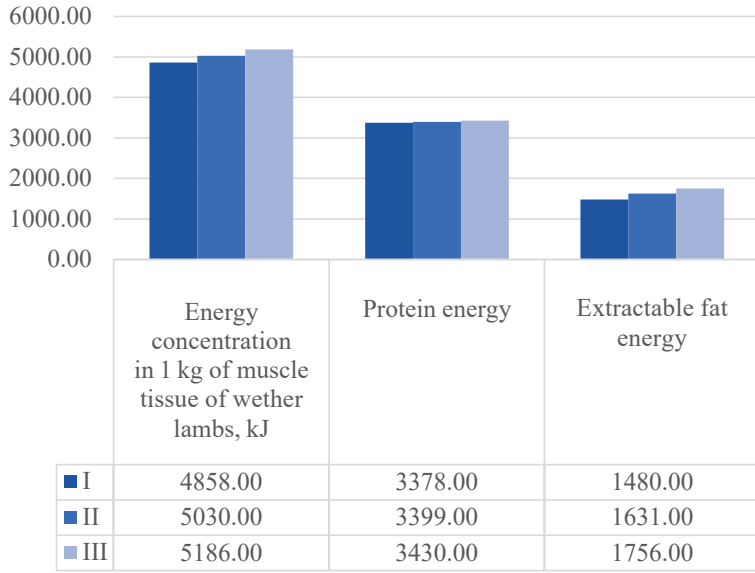

Fig. 2. Energy concentration in 1 kg of muscle tissue of wether lambs, kJ
Source: compiled by Yu.A. Yuldashbaev, V.I. Kosilov, I.A. Rahimjanova, T.A. Sedyh.

Noted that the lowest energy values were recorded in purebred wethers of Group I. Compared with Group II crossbreds, their values were lower by 172 kJ (3.55%) and compared with Group III by 328 kJ (6.75%). This was associated with the lower concentration of energy-containing nutrients in the muscle tissue of purebred animals.

Analysis of the protein-to-fat balance showed that all genotypes exhibited an optimal nutrient ratio. However, crossbreds from Groups II and III demonstrated a higher degree of muscle tissue maturity, with no significant differences detected between these two groups (Table 2).

Table 2

Energy value and maturity of wether muscle tissue

Group	Total energy in the muscle tissue of the carcass, MJ	The ratio of protein to fat in muscle tissue	Muscle tissue maturity, %
I	55.04	1:0.19	5.04
II	78.97	1:0.21	5.59
III	87.07	1:0.23	6.06

Source: compiled by Yu.A. Yuldashbaev, V.I. Kosilov, I.A. Rahimjanova, T.A. Sedyh.

Evaluation of total energy yield in muscle tissue showed the same ranking pattern. The superiority of Groups II and III over purebred wethers amounted to 23.93 MJ (43.48%) and 32.03 MJ (58.19%), respectively.

Second-generation crossbreds (Group III) demonstrated the highest nutritional and energy values of muscle tissue across all evaluated parameters.

Conclusion

The obtained data clearly indicate the superiority of crossbred animals over purebred contemporaries in terms of nutrient content and energy value of muscle tissue. These findings confirm the potential of the tested crossbreeding system involving Romanov and Edilbay sheep breeds.

Second-generation crossbreds consistently demonstrated the highest values across all analyzed traits, which can be explained by the pronounced expression of crossbreeding effects.

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Влияние генотипа валушков на выход питательных веществ и энергетическую ценность мышечной ткани

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Аннотация. Раскрыто влияние скрещивания овец романовской и эдильбаевской пород на энергетическую ценность и качественные показатели мяса. Подопытными объектами являлись чистопородные валушки романовской породы (I группа), ее помеси первого и второго поколений с эдильбаевской породой (½ романовская × ½ эдильбаевская — II группа, ¼ романовская × ¾ эдильбаевская — III группа). Исследование выявило достоверное влияние скрещивания в отношении качественных показателей и энергетической ценности мяса. В частности, помесные баранчики существенно превосходили чистопородных по содержанию сухого вещества в мышечной ткани — на 41,56 и 54,48 %; по выходу белка — на 39,42 и 50,45 %; по уровню экстрагируемого жира — на 52,80 и 76,06 % соответственно. Кроме того, у чистопородных валушков I группы, по сравнению с помесями первого и второго поколений (II и III группы), зафиксированы более низкие значения концентрации энергии в 1 кг мышечной ткани (на 172 и 328 кДж), ее выходу в ткани туши (на 23,93 и 32,03 МДж), спелости (зрелости) (на 0,55 и 1,02 %). При этом соотношении белка и жира было практически одинаково. Максимальные значения по комплексу анализируемых показателей продемонстрировали помеси второго поколения (III группа).

Ключевые слова: овцеводство, чистопородные овцы, романовская порода, помеси с эдильбаевской, кастрированные баранчики, охлажденная туша, съедобная часть туши без жира, калорийность, белок, жир, спелость, зрелость

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