Qualitative composition of purebred and crossbred lamb fat

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Abstract. The physical and chemical properties and structure of lamb fat are derived from the qualitative composition and content of saturated and unsaturated fatty acids. Higher levels of saturated fatty acid in sheep fat increase the melting point and yield a solid lard. Characteristic fat deposition in the carcass of young sheep is closely related to meat productivity and nutritional value of mutton. The paper presents the results to prove the influence of the genotype of purebred Tsigai rams and their crosses from the Romanov, Texel and Edilbay rams. Crossbred young animals of all genotypes are proved to have an increased content of polyunsaturated fatty acids. The amount of lipids in intramuscular fat in crossbred Romanov rams is 1.68% more, Texel – 13.97% and Edilbay – 21.79%, while the cholesterol content is lower by 1.47%, 6.35% and 5.21%, respectively.

1. Introduction
Sheep is not a significant producer of tallow. Fat in the body of sheep classified into different breed types in the period of postembryonic development is deposited in a certain sequence and in different quantities, having different nutritional value and taste [1-3]. They distinguish between subcutaneous fat that forms coating of the carcass and has the lowest nutritional value, intermuscular fat that imparts “marbling” to the meat and, finally, interior fat that covers the internal organs with a thick layer, protecting them from external damage [4]. Heat treatment of fat showed that a high content of saturated fatty acids, palmitic and stearic, makes it high-melting at a temperature ranging from +44 to 55 °C with a digestibility of 68-80% [3].

However, despite having a sufficient number of useful properties, due to its specific characteristics, the fat of these animals is used mainly in the national cuisines of the Caucasus and Central Asia, especially in the regions where fat-tailed sheep are bred [2, 5]. Of particular interest are research data on the distribution of adipose tissue in the body of young sheep coming under different genotypes.

Lamb fat is composed of higher saturated and unsaturated fatty acids, the structure of which derives from its basic physical and chemical properties. The increased content of saturated fatty acids in sheep lard contributes to the formation of solid fats with a high melting point [6, 7]. The ratio of definite classes of lipids and fatty acids, the scale of adipose tissue largely depend on the genotype of sheep, therefore, the quality of fat in young crossbred sheep is of particular interest [8, 9].

2. Materials and methods
The paper aims to study the contribution of a certain genotype to the blending ratio and properties of fat in young sheep. Scientific and economic tests were supported by JSC “Satinskoye” in Tambov region. To explore the effect of different genotypes on the blending ratio and properties of fat in young
sheep, there were four groups of 15 purebred and crossbred rams in each. The first group was composed of purebred animals of the Tsigai breed (Ts x Ts), the second – Tsigai x Romanov crossbreeds (Ts x R), the third – Tsigai x Texel (Ts x T) and the fourth – Tsigai x Edilbay (Ts x E). Experimental young sheep of all groups were kept in identical economic conditions, including feeding, keeping and caring for the animals.

At the age of eight months, three rams from three groups were slaughtered in order to evaluate their meat productivity, the composition and quality of interior, subcutaneous and intermuscular fat, using a technique developed by FRC for Animal Husbandry [10].

The physical and chemical properties of fat were determined against the melting and freezing temperature, acidity, saponification number, and iodine value. The content of total lipids in the intermuscular fat was determined by the Folch method, phospholipids – by the method of Markova and Pokrovsky, cholesterol – by the method of Levchenko, fatty acid content of fat – by gas-liquid chromatography.

3. Results and Discussion

First of all, the way in which subcutaneous, intermuscular, intramuscular adipose tissues were synthesized and distributed in the body of experimental young animals was determined (Table 1).

The results in Table 1 show increased fat deposits in all groups of hybrid young sheep. However, the Edilbay crossbreeds were found to exhibit a significant superiority for fat by 1.31 kg (P ≥ 0.999) or 75.7% in comparison with the purebred Tsigai rams. A similar pattern was observed in the amount of carcass fat and subcutaneous fat, which is due to the accumulation of tail fat in the hind parts of sheep in the amount of 0.92 kg.

No significant differences for interior fat were found to be present in experimental rams of all genotypes. Notably, the Edilbay crossbreeds had the highest content of interior fat.

Table 1. Distribution of adipose tissue in the body of experimental rams

| Group and genotype of young sheep | Total fat kg | % | Interior fat kg | % | Carcass fat kg | % | Including Subcutaneous kg | % | Intermuscular kg | % |
|----------------------------------|-------------|---|----------------|---|---------------|---|--------------------------|---|------------------|---|
| 1- Ts x Ts                       | 1.81±0.09   | 100 | 0.58±0.03 | 32.0 | 1.23±0.07 | 68.0 | 0.87±0.04 | 48.1 | 0.36±0.02 | 19.9 |
| 2- Ts x R                        | 1.89±0.05   | 100 | 0.59±0.02 | 31.2 | 1.30±0.04 | 68.8 | 0.91±0.03 | 48.2 | 0.39±0.06 | 20.6 |
| 3- Ts x T                        | 2.05±0.07   | 100 | 0.68±0.06 | 33.2 | 1.54±0.06 | 75.1 | 1.04±0.07 | 50.7 | 0.50±0.04* | 24.4 |
| 4- Ts x E                        | 3.18±0.12** | 100 | 0.70±0.07 | 22.0 | 2.48±0.11** | 78.0 | 1.72±0.08* | 54.1 | 0.76±0.08* | 23.9 |

There was a different trend for intermuscular fat that significantly exceeded in the Texel and Edilbay crossbreeds, in contrary to the purebred rams, by 0.14 kg (P ≥ 0.95) and 0.4 kg (P ≥ 0.99), respectively, while the relative value increased by 4, 5% and 4%. The Tsigai rams were distinguished by the minimum accumulation of intermuscular fat. The studies suggest that the process of accumulating adipose tissue during normalized feeding of animals is directly related to their genotype.

Adipose tissue has a high value (digestibility) provided that the melting point is closest to the human body temperature. Lamb is inferior to other types of meat and has a higher melting point of fat, equal to 38-55 °C. The value of this indicator depends on the fatty acid composition of triglycerides that make up the fat – the more the unsaturated fatty acids (oleic, linolenic, linoleic, etc.), the lower the melting point. The iodine value indirectly shows the amount of unsaturated fatty acids in the fat – the more the unsaturated fatty acids, the more valuable the fat is. A high saponification number indicates an increased content of acids of relatively low molecular weight [5].

Therefore, the physical and chemical properties of interior fat were investigated in experimental rams. The results are shown in Table 2. Based on the results, the physical and chemical properties of all types of adipose tissue significantly depend on the genotype of animals.
Table 2. Physical and chemical properties of interior fat of different sheep genotypes

| Index                             | Group No. and genotype of young sheep |
|----------------------------------|--------------------------------------|
|                                  | 1-Ts x Ts                            | 2-Ts x R                         | 3-Ts x T                         | 4-Ts x E                         |
| Melting point, °C                | 45.3±0.18                            | 45.1±0.11                        | 44.3±0.10**                      | 44.9±0.13*                       |
| Freezing point, °C               | 34.8±0.23                            | 34.0±0.16*                       | 33.2±0.12**                      | 33.9±0.11*                       |
| Saponification number           | 189.2±0.78                           | 190.6±0.32                       | 191.6±0.35*                      | 194.5±0.87**                     |
| Acidity                         | 1.82±0.01                            | 1.75±0.02*                       | 1.65±0.05*                       | 1.68±0.04*                       |
| Iodine value                    | 35.9±0.21                            | 35.2±0.12*                       | 33.9±0.36**                      | 34.1±0.34**                      |

Note: the data are reliable at $P \geq 0.95$ - *; $P \geq 0.99$ - **; $P \geq 0.999$ - ***

The findings indicate that the fat of the crossbreeds has a relatively low melting and freezing points, a higher saponification number and low acidity as compared to the purebred animals. There is a significant difference between the purebred and crossbred Texel and Edilbay rams for all physical and chemical constants. The Romanov crossbreeds exhibited a reliable superiority over the purebred rams by such indices as freezing point, acidity and iodine value.

The iodine value for interior fat in all target hybrid rams decreases by 0.7-2.0 in comparison with purebreds, and the higher the content of unsaturated fatty acids, the higher the iodine value.

The qualitative indicators of adipose tissue are determined by its chemical composition, the indicators of which for interior fat are given in Table 3.

Table 3. Composition of interior (perineal) fat in experimental rams

| Index                             | Group No. and genotype of young sheep |
|----------------------------------|--------------------------------------|
|                                  | 1-Ts x Ts                            | 2-Ts x R                         | 3-Ts x T                         | 4-Ts x E                         |
| Moisture, %                      | 15.82±0.14                           | 15.36±0.21                       | 15.22±0.15*                      | 15.11±0.20*                      |
| Dry matter, %                    | 84.18±0.28                           | 84.64±0.25                       | 84.78±0.32                       | 84.89±0.29                       |
| Absolute fat, %                  | 79.37±0.31                           | 79.48±0.25                       | 79.49±0.33                       | 79.50±0.34                       |
| Protein, %                       | 4.11±0.10                            | 5.22±0.15                        | 5.25±0.12*                       | 5.38±0.16*                       |
| Ash, %                           | 0.11±0.02                            | 0.11±0.01                        | 0.11±0.03                        | 0.11±0.01                        |
| Energy value of 1 kg of raw fat, kJ | 31812                               | 31822                             | 31832                             | 31842                             |

Note: the data are reliable at $P \geq 0.95$ - *; $P \geq 0.99$ - **; $P \geq 0.999$ - ***

The energy value of adipose tissue depends on the fat content and this is a straight-line relationship. Unlike other types of fat, the amount of pure fat in the interior fat is the highest, which is attributed to its high energy saturation, especially in crossbred animals [6, 11].

When meat is processed, the lipid composition of muscle tissue that contributes to the quality of meat is of paramount importance.

The quality of meat is greatly influenced by intramuscular lipids that determine the smell, tenderness and taste of meat, as well as the method of meat processing.

Literary sources contain few data on the amount of cholesterol and triglycerides in the muscle tissue of young sheep [4, 9]. Therefore, there is a need for a more detailed study of this issue,
depending on the genotype of sheep. The results obtained from the studies into the lipid composition of muscle fat are shown in Table 4.

Based on the data in Table 4, the total lipid content in the intramuscular fat in the crossbred Romanov rams increased by 1.68%, the Texel crossbreeds – by 13.97% and the crossbred Edilbay young animals – by 21.79% compared to their Tsigai peers.

**Table 4. Composition of intramuscular fat and lipid content in experimental rams**

| Index            | Group No. and genotype of young sheep | 1- Ts x Ts | 2- Ts x R | 3- Ts x T | 4- Ts x E |
|------------------|--------------------------------------|------------|-----------|-----------|-----------|
| General lipids, %| 1.79±0.03                            | 1.82±0.04  | 2.04±0.05 | 2.18±0.06 |           |
| Triglycerides, % | 1.12±0.04                            | 1.14±0.07  | 1.25±0.08 | 1.38±0.07 |           |
| Phospholipids, % | 0.67±0.01                            | 0.68±0.02  | 0.77±0.03 | 0.84±0.03 |           |
| Cholesterol, mg/%| 29.92±0.21                           | 29.48±0.23 | 28.02±0.18* | 28.36±0.15** |           |

Note: the data are reliable at: P ≥ 0.95 *; P ≥ 0.99 **; P ≥ 0.999 ***.

Of the various functions of lipids that are crucial for young sheep, structural and energy are pivotal. With this in view, there are 2 basic groups of lipids: structural (cholesterol) and reserve (triglycerides).

Due to their hydrophilic properties, lipids of the first group tend to combine with molecules of other substances and form new structural elements of cells. Triglycerides play the role of an energy reserve that is consumed when needed. A higher total amount of all lipids in the intramuscular fat of hybrid animals is associated with a growing content of triglycerides and phospholipids. There is a parallel decrease in cholesterol content: in group 2 – 1.47%, in 3 – 6.35%, and in 4 – 5.21% compared to the muscle fat of group 1.

**Table 5. Fatty acid composition of interior fat in experimental rams, %**

| Fatty acids | Group No. and genotype of young sheep | 1- Ts x Ts | 2- Ts x R | 3- Ts x T | 4- Ts x E |
|-------------|--------------------------------------|------------|-----------|-----------|-----------|
| Myristic    | 4.98±0.12                            | 4.32±0.05* | 4.50±0.11* | 4.65±0.15 |           |
| Palmitic    | 25.02±0.07                           | 25.08±0.09 | 25.05±0.06 | 25.25±0.08 |           |
| Stearic     | 25.02±0.11                           | 24.78±0.12 | 24.52±0.14* | 24.79±0.17 |           |
| Oleic       | 38.98±0.23                           | 39.02±0.32 | 39.08±0.22 | 39.88±0.28 |           |
| Linoleic    | 3.99±0.09                            | 4.21±0.03  | 4.22±0.05  | 4.02±0.04  |           |
| Linolenic   | 0.55±0.02                            | 0.72±0.03** | 0.78±0.04** | 0.59±0.02  |           |
| Arachidonic | 1.46±0.05                            | 1.78±0.04** | 1.85±0.06** | 1.52±0.03  |           |

Note: the data are reliable at: P ≥ 0.95 *, P ≥ 0.99 **, P ≥ 0.999 ***.

The cholesterol content in skeletal muscle depends on how actively these muscles are working. In smooth muscles, it is higher than in the heart, and especially in skeletal muscles. In muscle tissue, cholesterol is mainly represented by its free form. In the composition of muscle tissue, cholesterol is mainly free.

The quality of fat characterizes the content of fatty acids it contains. Therefore, a study was carried out to examine the fatty acid interior (perineal) fat of rams of different genotypes, the results of which are shown in Table 5 and Figure 1.

The data in Table 5 indicate that the crossbreeds of groups 2 and 3 had a decreased amount of myristic and stearic acids in fat, but, at the same time, a higher content of oleic acid. In hybrid young animals of the Ts x R and Ts x T variant, myristic acid was 0.66% (P ≥ 0.99) and 0.48% (P ≥ 0.95) lower, respectively, and stearic acid – by 0.5% (P ≥ 0.95) in the Ts x T variant. This difference is valid. However, in terms of the total content of polyunsaturated fatty acids – linoleic, linolenic and arachidonic – the fat of the crossbred animals surpassed that of purebred rams. In the crossbred young
animals of the second group, the content of linolenic acid was significantly higher by 0.17%, the third – 0.23%, and arachidonic – by 0.32% and 0.39%, respectively.

A higher content of polyunsaturated fatty acids in experimental rams indicates an improvement in the quality of internal fat.

![Fatty acid composition of interior fat in experimental rams](image)

**Figure 1.** Fatty acid composition of interior fat in experimental rams

### 4. Conclusion

Based on the foregoing, the data on the crossing of semi-fine-wool Tsigai ewes with semi-fine-wool Texel and coarse-wool Edilbay and Romanov rams suggest that it improves the composition and quality of fat in hybrid sheep.

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