ALTERAÇÃO DA COMPOSIÇÃO QUÍMICA, GORDURA E ÁCIDA E PROPRIEDADES FÍSICAS E TÉCNICAS DE GORDURA DE CORDEIRO SOB INFLUÊNCIA DE VÁRIAS FORRAGENS**CHANGE OF THE CHEMICAL, FAT AND ACID COMPOSITION AND PHYSICAL AND TECHNICAL PROPERTIES OF LAMB FAT UNDER INFLUENCE OF VARIOUS FODDER BACKGROUND**

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RESUMO

O papel das gorduras na nutrição é determinado pelo seu alto teor calórico e participação na construção dos tecidos do corpo, juntamente com proteínas e carboidratos. A nutrição enriquecida é de grande importância no complexo de questões que determinam sua utilidade. Assim, a questão do efeito dos probióticos e sorventes na dieta do organismo animal tornou-se muito relevante. O objetivo do trabalho foi uma avaliação comparativa da composição e propriedades do tecido adiposo de carneiros, consumindo juntos e separadamente preparações com efeito de sorção e probiótico. Os estudos foram realizados em duas etapas. Na primeira, durante o experimento científico e econômico, 80 carneiros recém-nascidos cresceram e se desenvolveram até um ano de idade, seguidos pelo abate de três animais de cada grupo. Na segunda etapa, as amostras de gordura interna foram examinadas de acordo com vários indicadores. A análise sensorial revelou que todas as amostras internas de gordura atendiam aos requisitos estabelecidos, enquanto a cor e consistência das amostras experimentais melhoraram. O teor de matéria seca, incluindo gordura nas amostras experimentais de tecido adiposo, aumentou e a umidade diminuiu. Os parâmetros físicos e técnicos da gordura interna também mudaram no aspecto intergrupo. Na amostra controle, o número de iodo diminuiu e o número de saponificação, ponto de fluidez e ponto de fusão aumentaram. O cálculo do valor energético indica que, na primeira amostra, o indicador aumentou 0,08 MJ (0,23%); Grupo II - por 0,16 MJ (0,45%) e grupo III - por 0,25 MJ (0,70%). De acordo com a soma de ácidos graxos monoinsaturados, o grupo jovem III estava na liderança. O conteúdo de ácidos graxos poliinsaturados foi o oposto. A eficácia biológica das gorduras é determinada pela proporção que foi melhor nas amostras experimentais. Assim, a inclusão de aditivos forrageiros na dieta dos carneiros da raça Romanov ajuda a melhorar a qualidade das matérias-primas.

Palavras-chave: *composição, gordura interna, probiótico, raça Romanov, aditivo de sorção.*

ABSTRACT

The role of fats in nutrition is determined by their high-calorie content and participation in the construction of body tissues, together with proteins and carbohydrates. Enriched nutrition is of great importance in the complex of issues that determine its usefulness. Thus, the question of the effect of probiotics and sorbents in the diet on the animal organism has become very relevant. The purpose of the work was a comparative assessment of the composition and properties of adipose tissue of rams, consuming together and separately preparations with sorption and probiotic effect. The studies were carried out in two stages. In the first, during the scientific and economic experiment, 80 newborn rams grew and developed up to a year of age, followed by the slaughter of three animals from each group. In the second stage, samples of internal fat were examined according to some indicators. Sensory analysis revealed that all internal fat samples met the established requirements, while the

color and consistency of the experimental samples improved. The dry matter content, including fat in the experimental samples of fat tissue, increased, and moisture decreased. The physical and technical parameters of internal fat also changed in the intergroup aspect. In the control sample, the iodine number decreased, and the saponification number, pour point, and melting point increased. Calculation of energy value indicates that in the first sample, the indicator increased by 0.08 MJ (0.23%); Group II – by 0.16 MJ (0.45%) and group III – by 0.25 MJ (0.70%). According to the sum of monounsaturated fatty acids, young group III was in the lead. The content of polyunsaturated fatty acids was the opposite. The biological effectiveness of fats is determined by the ratio that was better in the experimental samples. Thus, the inclusion of fodder additives in the diet of the rams of the Romanov breed helps to improve the quality of raw materials.

Keywords: *composition, internal fat, probiotic, Romanov breed, sorption additive*

1. INTRODUCTION:

Fats, including animal fats, are an essential component of food. The significance of fats consists, first of all, in their high energy value, since the caloric content of 1 g of fat is 9 kcal, which is more than two times exceeds the caloric content of proteins and carbohydrates. The biological value of animal fat lies in the presence of vitamins A, D, E, K and polyunsaturated fatty acids in it (Bagautdinov *et al.*, 2018; Creemers, Van Passel, and Vigani, 2019; Dementyev *et al.*, 2018; Khaziakhmetov *et al.*, 2018a, 2018b; Kick, Zering, and Classen, 2017; Lamanov *et al.*, 2020; Sharipova *et al.*, 2017a).

The global trend indicates that the consumption of fats and butter has quadrupled compared with the level recorded 50 years ago. This was due to an increase in population, an increase in fat intake, and a change in cooking methods (Aslanova, Derevitsckaya, and Dydikin, 2018; Igenbayev *et al.*, 2019; Mironova, Nigmatyanov, Radchenko, and Gizatova, 2019a; Okuskhanova *et al.*, 2019; Sydykova *et al.*, 2019).

In 1950, the number of animal fats on the market was only slightly lower than vegetable oils. In 1970, animal fats accounted for only a quarter, and currently – only 15% (Gavrilova *et al.*, 2019; Gubaidullin, Mironova, and Islamgulova, 2010; Kalasov, Andrienko, Galieva, and Kasimova, 2019; Kosilov, Gazeev, and Yuldashbaev, 2016; Mironova, Nigmatyanov, Grunina, Sepiashvili, and Strigulina, 2019; Shkilev, Gazeev, and Nikonova, 2011).

The UN Food and Agriculture Organization estimated the total mean energy intake from plant and animal sources to be around 3380 kcal in Europe and the US with the animal source energy intake accounting for 943 kcal (27.9%). In developing countries, a similar figure is 2,261 kcal, and 331 kcal (14.6%) of energy is supplied through animal feed. In countries with transition economies, which include Russia, the total energy

supply is 2,906 kcal, and 671 kcal (23.1%) comes from animal feed. In recent years, there has been an accumulation of critical knowledge about the predominance of vegetable fats in the human diet. A study of the role of individual fatty acids in biochemical transformations indicates that animal fats are necessary for the normal functioning of the body, and possible negative consequences are reduced or even eliminated by the presence of individual fatty acids or other biologically active substances (Kuzmicheva, 2013; Khaziev *et al.*, 2018; Obolentsev, 2018; World Health Organization, 2003; Ziyangirova, Mironova, Gazeev, Galieva, and Galieva, 2019).

By analyzing data from the FAO report, a specific food production concept has been outlined. The idea is a point aimed at expanding the use of biological resources, thereby diversifying the nutritional composition of foods to satisfy the physiological needs of the population (Tagirov *et al.*, 2018; World Health Organization, 2003).

One of the approaches to expanding the species diversity of raw materials in the conditions of the Southern Urals is the use of mutton. The volume of its production in the Russian Federation is not more than 3% of the total mass of raw meat. Even though the Volga Federal District is the leader in the number of sheep, the volume of output is much less than the needs of the domestic market. Therefore, the development of sheep breeding will allow, firstly, to partially eliminate the shortage of meat raw materials and secondly to expand the range of products, including those with new properties (Gabitov *et al.*, 2018; P. Kornienko, Yusupov, Eremanenko, and R. Kornienko, 2008; Ponomarenko, Grishina, and Bekturov, 2017; Traisov, Sultanova, Yuldashbayev, and Esengaliyev, 2014; Traisov *et al.*, 2015).

Besides, the development of the sheep industry allows, in addition to food products, which include milk and meat, to supply the light industry with raw materials, such as wool and sheepskin

(Bogolyubova, Korotky, Zenkin, Ryzhov, and Buryakov, 2017; Sharipova *et al.*, 2017b; V. Vorobyev, D. Vorobyev, Zakharkina, Polkovnichenko, and Safonov, 2019).

Russia is famous for its more than century-old history of breeding Romanov sheep with a meat-and-wool direction of productivity. A distinctive feature of this breed is its good adaptability to sharply continental climate conditions, unpretentiousness to feeds, fecundity, early maturity, and polyestricity. The resulting lamb is characterized by good taste, the absence of a specific taste, high biological, and low energy value (Bogolyubova *et al.*, 2017; Chernitskiy, Shabunin, Kuchmenko, and Safonov, 2019; Dvalishvili and Vinogradov, 2015).

Although the animals of the Romanov breed are unpretentious to the feeding conditions, they can still maximize the productive potential of the sheep with a full and balanced diet (Okuskhanova *et al.*, 2019; Sedykh *et al.*, 2018). It is recommended to enrich the diet with feed additives of sorption action and probiotic. Then the choice of the object of study is since fats, like protein components of meat, play an important role in human life, provided they are reasonably consumed. Meat is the main source of animal fats, which supply vitamins A and D to the body and contribute to their absorption (Zabelina and Lushnikov, 1999).

The optimal total norm of consumption of animal and vegetable fats in the diet is 100-150 g per day, while animal fats should account for 70-75 g, vegetable fats – 30 g. For the organization of the herodietic ration, this ratio should be at the level of 1:1 (Andrienko, 2018; Efimova and Antonenko, 2016).

It is known that the composition of fat is represented by carbon, hydrogen, and oxygen, and by the chemical structure, they are complex substances. The fat molecule contains glycerin and fatty acids, which are classified as saturated and unsaturated. The group of saturated lamb fatty acids is represented by palmitic, stearic, and unsaturated – by oleic acids. According to their properties, palmitic and stearic acids at 15-20 °C retain their hardness, and oleic acid is in liquid form. Stearic acid, which is part of lamb fat, undergoes melting at a temperature of 69.2 °C, and upon solidification, it crystallizes.

According to the organoleptic properties, lamb fat should have white matte color and a specific smell. It is important to note that the fat of

adult animals has a more saturated and dark color than the fat of young animals.

The studies of domestic and foreign scientists indicate that if the nutrients of the diet are not used as a building material, then they are transported and stored in the body in the form of a reserve – fat. Not only lipids but also unused nitrogenous substances and carbohydrates turn into fat (Gadiev *et al.*, 2019; Erochin *et al.*, 2013; Khabibullin *et al.*, 2019).

Sheep are characterized by having a certain sequence in the deposition of fat: first – on the internal organs (kidneys, intestines, stomach), then – at the root of the tail, on the lower back, brisket (subcutaneous) and between the muscles (intramuscular). Fat accumulated in animals, in many respects, affects the taste, appearance, and calorie content of meat (Andrienko, 2018).

The purpose of this study was to study the physicochemical parameters, as well as the fatty-acid balance of the internal sheep's fat, obtained from animals consuming various supplements.

2. MATERIALS AND METHODS:

The studies were carried out according to the thematic plan of Bashkir State Agrarian University No. 01860076873. To obtain fat raw materials at the initial stage in the conditions of the Republic of Bashkortostan, scientific and economic experience was organized on rams of the Romanov breed, which were divided into four groups of 20 animals each. The number of animals was selected, taking into account the possibility of ensuring the reliability of the data. Groups were formed according to the principle of analogs from among newborn lambs. Feeding the young of the control group consisted of giving the main diet adopted on the farm. The diet of animals from the experimental groups additionally included additives that were added at the rate of 0.10 g / kg of live weight. For the sheep of group I, a sorption additive was used, group II was probiotic, group III used both together. The experiment lasted until the animals reached the age of one year. To conduct the second stage of research with the aim of comparative studying the chemical composition of internal fat at 12 months of age, a control slaughter of three animals from each group was organized according to the All-Russian Institute for Animal Breeding method (1978).

Sensory assessment of fat was carried out by the organoleptic method, which is based on the perception of the senses – vision, smell, hearing,

touch, taste. Color and consistency were analyzed at a temperature of 15-20 °C, and the degree of transparency was established in the molten state of fat. To study the chemical composition of adipose tissue, an average sample was taken, and the All-Russian Institute for Animal Breeding method (1978) was applied. The mass fraction of moisture was determined according to State Standard 9793-74, the protein was established by the Kjeldahl total nitrogen determination method, the iodine number was determined by the Güble method, the melting point was determined by the capillary method, and the energy value was established by the Aleksandrov formula (1951); the amount of fatty acids – on a “Crystal-2000M” gas-liquid analytical chromatograph according to State Standard R-51.483-99.

The animals were kept according to the instructions and recommendations of Russian Regulations, 1987 (Order No.755 on 08/12/1977 the USSR Ministry of Health), as well as “The Guide for Care and Use of Laboratory Animals (Institute of Laboratory Animal Resources, Commission on Life Sciences, National Research Council, National Academy Press Washington, DC 1996)” (Institute of Laboratory Animal Resources, 1996; The USSR Ministry of Health, 1987). In the course of the research, efforts were made to minimize animal suffering and the least number of samples used.

The digital material obtained in the experiment was processed by the variation method of statistics Microsoft Office with determining the reliability of the difference at three levels of probability, according to Student.

3. RESULTS AND DISCUSSIONS:

The assessment of the quality of fat by organoleptic indicators showed that regardless of the type of additive used, all samples of internal fat met the established requirements (Table 1).

At the same time, some intergroup differences in the consistency of the samples are noted. In particular, the best consistency of fat is noted in the sample obtained from animals of groups I and II, which is characterized as dense. The introduction of feed additives into the diet positively affected the color of the product. The fat of the experimental samples was characterized by white color, without a clear yellowish tint, which meets the requirements of normative and technical documentation.

Because its constituent components

determine the quality of fat, a chemical analysis was carried out (Figure 1).

It was found that the highest solids content was observed in experimental samples of adipose tissue. So, the advantage of the rams of the first experimental group over the young ones of the control group was 0.30%; group II – 0.47%; group III 0.72%. A similar distribution between groups is also noted in the content of chemically pure fat. It is enough to note that the difference in favor of the experimental young rams of the I, II, and III groups was 0.20%; 0.39% and 0.60%. In all cases, in the lead were the rams consuming the tested additives together.

By a mass fraction of moisture, the intergroup difference was the opposite. In animals of the control group, the studied indicator increased by 0.23%; 0.47 and 0.69%, respectively. For a more accurate analysis of the influence of the feed additive on the qualitative characteristics of the fat of rams, physicochemical studies of internal fat were carried out (Table 2).

The previously established differences in the chemical composition of adipose tissue of different localization affected the energy value. In experimental samples of fat (I, II, III), compared with the baseline, the energy value of 1 kg fat increased by 0.08 MJ (0.23%), 0.16 MJ (0.45%), and 0.25 MJ (0.70%), respectively.

Saponification number is an indicator for determining the authenticity of fatty oils. Fats containing mainly triglycerides are analyzed by the average molecular weight of the fatty acids included in them. Moreover, fats rich in saturated acids have a high melting point, while unsaturated fats have a low melting point.

The introduction of test additives in the diet of animals contributed to the improvement of technological parameters of internal fat.

The results of the study indicate that the introduction of additives into the diet did not adversely affect the pour point of the internal fat of ram carcasses of all the samples studied. The intergroup differences in the value of the melting temperature and the Güble number were insignificant within the physiological norms.

In assessing the quality of fat, significant importance is given to the qualitative composition of fatty acids. In this regard, the fat-acid gas-chromatographic analysis of the triglycerides that make up the internal (omentum + perinephric) adipose tissue of sheep fat was carried out. The

analysis of these studies indicates an increase in the content of many saturated fatty acids in the experimental samples compared with the control (Table. 3). The superiority of young rams from I-III groups in the content of capric fatty acid over peers of the control group was 0.01–0.02%, myristic – 0.03-0.07%, palmitic – 0.06-0.08%, stearic – 0.05-0.06%. Among monounsaturated fatty acids, oleic predominates. The value of the studied indicator in young animals of the first experimental group was higher than in control by 0.04%, II – by 0.2%, III – by 0.21%.

The indicators of polyunsaturated arachinic and arachidonic fatty acids did not change and were in the range of 0.25-0.26% and 0.27%, respectively. The indices of linoleic fatty acid in rams of the first experimental group decreased by 0.06% compared to the control group, of the second experimental group – by 0.1%, the third experimental group – 0.03%; linolenic – by 0.05%; 0.03% and 0.03%, respectively. When analyzing the total mass fractions of the fatty acid content, certain intergroup differences are noted (Table 4).

According to the amount of monounsaturated fatty acids, young rams from group III were in the lead. Its superiority over control peers in terms of the studied indicator was 0.37%, over analogs of the first group – 0.09%, II – 0.33%. The content of polyunsaturated fatty acids was the opposite. It is enough to note that in young animals, this indicator was higher than in experienced peers of the I, II, and III groups – by 0.1%, 0.12%, and 0.06%, respectively.

It should be noted that the amount of saturated fatty acids was higher in animals consuming test supplements. So, they have this indicator increased by 0.14%, 0.16%, and 0.21%, compared with the control peers.

A comparative analysis of the ratio characterizing the biological effects of fats indicates a similar dynamics in young animals of all experimental groups. Thus, the introduction of sorption and probiotic additives into the diet of rams did not have a significant effect on the biological effectiveness of fats. However, there was a slight positive tendency in the experimental samples.

The search for measures to provide the population with full-fledged food products, due to the species diversity of raw materials, is a strategic task of the agricultural sector (Andreeva *et al.*, 2018; Andrienko, 2018; Filippova *et al.*, 2017; Gadiev *et al.*, 2019; Gubaidullin, Kanareykina, and

Timerbulatova, 2014; Khabibullin *et al.*, 2019; Khaziahmetov *et al.*, 2018; Kosilov, Nikonova, Wilver, and Kubatbekov, 2016; Zabelina and Lushnikov, 1999). It is proposed to intensify the sheep breeding industry by improving the feeding system of Romanov rams with subsequent analysis of the quality of the obtained raw materials. The organoleptic assessment revealed intergroup differences in the consistency of samples with the best characteristics, characterized by density, in samples I and II. In this case, the fat of the test samples was white, without a clear yellowish tint.

The chemical analysis of internal mutton fat revealed a decrease in the proportion of moisture (by 0.23-0.69%), an increase in the share of solids (by 0.30-0.72%), fat (by 0.20-0.60%) and therefore, the energy value of 1 kg of fat (0.08-0.25 MJ (0.23-0.70%) in experimental samples of adipose tissue.

The physical-technical properties of the fat of all the studied samples when sorption and probiotic additives were added to the diet of rams did not have a negative effect. At the same time, specific differences between the groups in connection with the use of different fodder backgrounds were insignificant and did not go beyond the normative.

The study of the qualitative composition of fatty acids revealed an increase in the proportion of some saturated fatty acids (capric, myristic, palmitic, stearic) in the experimental samples, compared with the control. Among monounsaturated fatty acids, oleic predominates. Indicators of polyunsaturated fatty acids of arachinic and arachidonic did not change, but the content of linoleic and linolenic fatty acids in the rams of the experimental groups decreased.

The comparative analysis of the ratio characterizing the biological effectiveness of fats indicates its improvement in animals consuming test supplements.

4. CONCLUSIONS:

Thus, the chemical composition and physical properties of the internal raw fat tended to change in the intergroup aspect. At the same time, its energy saturation increased due to the accumulation of chemically pure fat, and the biological value decreased due to a decrease in the total amount of polyunsaturated fatty acids. However, the changes occurring in the adipose tissue of young sheep were within the

physiological norm and corresponded to breed characteristics. The data obtained indicate that only a differentiated approach to the quality of raw materials, taking into account a balanced feed background of sheep, makes it possible to choose the most optimal variant of its rational use.

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Table 1. *Organoleptic indicators of internal fat of rams*

Group	Indicator			
	Color	Smell and taste	Transparency	Consistency
Control	White with a yellowish tint	Characteristic for this species, recessed from fresh raw materials	Transparent	Solid
I	White matte	Characteristic for this species, recessed from fresh raw materials	Transparent	Dense
II	White matte	Characteristic for this species, recessed from fresh raw materials	Transparent	Dense
III	White matte	Characteristic for this species, recessed from fresh raw materials	Transparent	Solid

Table 2. *Properties of internal fat of rams*

Indicator	Group			
	control	I	II	III
Iodine number, g/%	30.59±0.14	30.65±0.21	30.72±0.04	30.78±0.23
Saponification number, mg/%	190.3 ±0.20	189.0 ±0.14	191.2 ±0.14	191.9 ±0.11
Pour point, °C	37.1 ±0.17	36.8 ±0.13	36.8 ±0.15	36.2 ±0.20
Melting point, °C	42.36±0.16	42.31±0.23	42.23±0.17	42.14±0.22
Energy value of 1 kg of fat, MJ	35.50	35.58	35.66	35.75

Table 3. *Results of fatty acid analysis of samples of internal adipose tissue, %*

Protein component	Group			
	control	I	II	III
Monounsaturated fatty acids				
Palmitoleic C _{16:1}	1.36±0.025	1.39±0.049	1.43±0.044	1.44±0.015*
Heptadecene C _{17:1}	0.62±0.021	0.64±0.044	0.69±0.025*	0.70±0.025*
Oleic C _{18:1}	33.26±0.222	33.30±0.199	33.46±0.156	33.47±0.057
Polyunsaturated fatty acids				
Linoleic C _{18:2}	4.86±0.076	4.80±0.135	4.76±0.067	4.83±0.122
Linolenic C _{18:3}	1.06±0.037	1.01±0.022	1.03±0.111	1.03±0.016
Arachinic C _{20:0}	0.25±0.007	0.26±0.007	0.26±0.015	0.25±0.007
Arachidonic C _{20:4}	0.27±0.004	0.27±0.007	0.27±0.007	0.27±0.004
Saturated fatty acids				
Capric C _{10:0}	0.20±0.015	0.22±0.011	0.21±0.011	0.22±0.011
Lauric C _{12:0}	0.33±0.011	0.31±0.023	0.32±0.011	0.32±0.019
Myristine C _{14:0}	7.25±0.022	7.28±0.018	7.31±0.014*	7.32±0.023*
Palmitic C _{16:0}	24.74±0.054	24.81±0.047	24.80±0.043	24.82±0.082
Stearic C _{18:0}	22.19±0.074	22.24±0.067	22.25±0.074	22.25±0.049

Table 4. Fatty acid composition of internal adipose tissue, % of the total content

Indicator	Group			
	control	I	II	III
Amount of monounsaturated fatty acids (MUFA)	35.24±0.215	35.33±0.153	35.57±0.170	35.61±0.078
Amount of polyunsaturated fatty acids (PUFA), including	6.44±0.102	6.34±0.157	6.32±0.064	6.38±0.135
Linoleic C_{18:2}	4.86±0.076	4.80±0.135	4.76±0.067	4.83±0.122
Linolenic C_{18:3}	1.06±0.037	1.01±0.022	1.03±0.111	1.03±0.016
Arachinic C_{20:0}	0.25±0.007	0.26±0.007	0.26±0.015	0.25±0.007
Arachidonic C_{20:4}	0.27±0.004	0.27±0.007	0.27±0.007	0.27±0.004
Amount of saturated fatty acids (SFA)	54.72±0.145	54.86±0.049	54.88±0.100	54.93±0.072
Ratios characterizing the biological effectiveness of fats:				
MUFA: PUFA: SFA	1:0.2:1.6	1:0.2:1.6	1:0.2:1.5	1:0.2:1.5
PUFA: SFA	0.12	0.11	0.11	0.11
Ratio ω-6:ω-3	4.8	5.0	5.0	5.0

Figure 1. Chemical composition of internal sheep fat