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Review article

Biological features of meat productivity formation in sheep

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The data from literature and our own research on the chemical and biochemical composition of muscle tissue, its biological functions and nutritional value are summarized in the article. The data on the chemical composition and nutritional value of meat of different animal species, including beef, veal, pork and lamb are generalized. It is shown that sheep meat is characterized by nutritional, taste and dietary properties. In terms of biological value, it is not inferior to beef and pork, and even superior in other respects. For example, lamb contains the same amount of protein and amino acids as beef and pork, and it contains more fat than beef, which makes it higher in calories. Lamb is a good source of vitamins and minerals (Calcium, Phosphorus, and Iron), and its content of Copper and Zinc is significantly higher than that of other meats. On the global market, lamb is valued higher than other types of meat. Carcasses of young lambs weighing 13–16 kg are in particularly high demand. The dietary value of young lamb is due to its protein composition, high content of vitamins A and E and group B, lipids, in particular phospholipids. However, although sheep meat is characterized by high nutritional and biological properties, its disadvantage is a significant content of saturated fatty acids, which is associated with the processes of rumen biohydrogenation. Thus, the problem of increasing the proportion of polyunsaturated fatty acids in lamb is extremely important for human health. With this aim, various biologically active additives are widely used in animal feeding, which can directly or indirectly increase the content of polyunsaturated fatty acids in their products. In particular, antioxidants are widely used to prevent double bond peroxidation and there by increase the content of polyunsaturated fatty acids in products. Rearing and fattening lambs is biologically feasible and economically profitable until they reach a live weight of 40–50 kg, as during this period the growth of muscle tissue is the largest compared to fat deposition, and feed consumption is the lowest.

Key words: sheep, meet productivity, biochemical composition, biological value, feeding, breed, crossing

Biological characteristics of muscle tissue composition

One of the main economic characteristics of farm animals is meatiness. Meat is an important food product that includes muscle, connective, fat, bone and cartilage tissue, blood and other substances. The biological structure of meat varies depending on the species, sex, breed, fatness, feeding and housing conditions. The organoleptic characteristics of meat include color, tenderness, aroma, taste, juiciness and appearance.

First of all, meat is one of the main sources of protein in the body, as muscle tissue proteins contain highly valuable essential amino acids. The most valuable part of meat is muscle tissue. The yield of muscle tissue is as follows (%): in cattle — 51–57; calves — 51–61; sheep — 55–56; pigs — up to 44% [9, 26].

On the one hand, the protein content of sheeps largely characterizes their morphological, functional and metabolic characteristics, and on the other hand, their nutritional value. Proteins of muscle tissue are different in physicochemical functions and biological properties and are characterized by a complex structure. In the study of muscle tissue proteins, the most important proteins are myofibrils, nuclei, sarcoplasm and sarcolemma.

The group of **sarcoplasmic** proteins (soluble proteins) includes myoalbumin, myoglobin, myogen, and globulin γ, which are heterogeneous systems with similar biological and physicochemical properties. Thus, the myogen fraction makes up about 20% of all muscle tissue proteins. Myogen is identical to albumin in its physicochemical properties, but has a globular shape and aldolase activity. These proteins mainly perform enzymatic functions related to the oxidative conversion of carbohydrates into other compounds. Myogen contains all the essential amino acid, i.e., myogen is a complete protein.

Approximately 1% of all muscle cell proteins is myoglobin, a muscle protein. Its main function is to transport oxygen delivered by blood cells to the enzyme systems of cells. Myoglobin is essentially a pigment — a chromoprotein that contains a heme complex of ferric porphyrin, which gives muscle tissue its characteristic red color. Myoglobin is characterized by a special property of easily combining with various gaseous substances: oxygen, nitric oxide, hydrogen sulfide, etc.

After slaughtering animals, myoglobin in the upper layers of meat is converted into a myoglobin-oxygen compound, oxymyoglobin, by adding oxygen (the reaction is reversed), which has a bright red color. The darker color in the deeper layers of muscle tissue is due to the presence of reduced myoglobin. During prolonged storage of meat, oxymyoglobin is oxidized and turns into metmyoglobin, and the meat becomes brownish-brown in color.

Globulin γ makes up about 20% of all proteins and is a mixture of proteins, some fractions of which perform enzymatic functions.

The structure of muscle tissue, in fact, in the water-soluble fraction of proteins, contains myoalbumin (1–2%). Myoalbumin is a typical albumin, but it differs from blood albumin both in its amino acid composition and physicochemical properties [32].

Sarcoplasmic proteins contain a small amount of nucleoproteins, which are mainly concentrated in ribosomes. Their special characteristic is the presence of the nucleic acid molecule ribose in the structure.

The biological and nutritional value of sarcoplasmic proteins is quite high and is due to the presence of sulfur-containing amino acids, which are known to perform various biological functions in the human body [29].

Myofibrillar proteins consist of myosin, actin, actomyosin, tropomyosin, etc. In fact, myofibrillar proteins determine the nutritional and biological value of meat due to their high content of essential amino acids [32, 47].

Myosin is the most valuable protein in muscle tissue in terms of biological properties (40% of all proteins). However, it is difficult to isolate this protein from muscle tissue because it interacts with other structural myofibrillar proteins and with various ions: in particular, Calcium, Potassium, and Magnesium, and also interacts with ADP and ATP. The structure of the myosin molecule contains approximately 5000 residues of essential amino acids. One myosin molecule can bind three molecules of ADP or two molecules of pyrophosphate.

Myosin is located in the cell in a complex with lipids — with cholesterol. As an enzyme, myosin catalyzes the conversion of adenosine triphosphoric acid to adenosine phosphoric acid and phosphoric acid with the release of water and a large amount of energy, which is necessary for the functioning of muscle fibers [16].

Actins are proteins that form the cytoskeleton of cells. Actin exists in two forms: globular — G-actin (ball-shaped molecules) and fibrillar — F-actin (elongated molecules), which differ in their physical and chemical properties. In a living muscle fiber, at rest, actin is in a fibrillar form and it is possible for fibrillar actin to turn into globular actin, a reversible reaction. The amino acid composition of actin is characterized by a significant proline content, which prevents the formation of an α-helix. It is impossible to isolate actin by conventional methods, such as extraction with water or salt solutions, so actin is classified as a stromal protein.

A very important compound is actomyosin, a complex of actin and myosin proteins that form the basis of the contractile filaments of muscle fibers. The characteristic biological functions of actomyosin are its interaction with adenosine triphosphoric acid and magnesium ions.

About 10–12% of myofibril protein, or 2.5% of the total muscle tissue protein, is tropomyosin. This is a complicated structural protein complex of myofibrils consisting of two proteins: tropomyosin B and troponin, which is soluble in water but is released from muscle tissue only by salt solutions with high ionic strength. The tropomyosin B-troponin complex is bound to thin filaments of myofibrils by the protein actin. The main function of tropomyosin during muscle contraction is to transport calcium ions.

Other water-soluble proteins have been isolated from myofibrils, such as α- and β-actinins in small amounts, which are components of Z-membranes.

The **nuclei** of muscle cells are constructed mainly of nucleoproteins, which make up about 50% of dry matter. Nucleoproteins are extracted with alkalis or sodium chloride. The structure of nuclear nucleoproteins includes deoxyribonucleic acids.

Histones are protein components of nucleoproteins that contain diamino acid molecules, arginine and lysine, which create an alkaline character. In addition to nucleoproteins, the nuclei of muscle cells contain the so-called "acidic protein" (about 30–50% of the dry matter of the nucleus), the molecular structure of which contains the essential amino acid tryptophan (2.5%) [6].

Thus, the nuclei of muscle cells contain at least three protein fractions — nucleoproteins, acidic and residual proteins.

The **sarcolemma** is a slim, elastic membrane that covers each muscle fiber and consists of membranes. In addition to proteins, the membranes contain phospholipids, which play a determinative function in the permeability of the membrane. Phospholipids consist of: sphingomyelin, phosphatidylethanolamine, phosphatidylcholine, phosphatidylinositol, lysophosphatide, and phosphatidylserine in approximately identical amounts. The surface of the sarcolemma is covered with connective tissue fibers, which consist of proteoids — connective tissue proteins: collagen, reticulin, and elastin, and in the intercellular space of muscle fibers there are mucoid proteins and mucins that perform protective functions and reduce friction of muscle bundles.

The muscles of young intensively growing animals contain more elastin and collagen. With an increased level of fattening, as well as with an increase in fat content in meat, the proportion of connective tissue proteins decreases [6, 22].

Stromal sarcolemmal proteins, unlike myofibrillar and sarcoplasmic proteins, contain mainly nonessential amino acids, so their nutritional and biological value, as well as digestibility, are low. With the age of animals, the content of stromal proteins increases, and the quality of meat decreases accordingly. The collagen molecule consists of about 50% glycine, proline and oxyproline, with small amounts of tyrosine and methionine, and does not contain cysteine, tryptophan and cystine. Elastin contains more glycine and much less proline and oxyproline [47]. The nutritional value of meat is determined by the amino acid index ("quality protein index"), the ratio of tryptophan (the most complete muscle tissue protein) to oxyproline (inferior connective tissue proteins) [15]. The higher index means higher quality of meat.

On the outside of the sarcolemma, as well as in the intermuscular spaces, there is a nervous apparatus of cells with nerve fibers, consisting of neurokeratins and lipoproteins.

The percentage composition of muscle tissue proteins is as follows: myosin — 35; myogen — 20 and globulin — 20; actin — 15; other proteins — 10 [29].

Lipids, along with proteins, play an important role in the structure of skeletal muscle, which, on the one hand, are structural units (cholesterol, phospholipids), and on the other hand, are depots of the necessary metabolic energy (triacylglycerols) [49].

Glycerophospholipids in myofibrils (sarcoplasmic reticulum) catalyze the activity of many enzymes. Sarcolemmal membranes also contain glycerophospholipids. Their qualitative composition does not differ from that of glycerophospholipids in subcellular structures. However, the total content of phospholipids in the membrane is lower than in mitochondria.

The main sources of polyunsaturated fatty acids are skeletal muscle phospholipids, which have a wide range of biological effects in the human body, and their quantitative content in meat affects its nutritional and biological value. In fact, lamb is the richest in phospholipids [26].

The sarcoplasm of muscle tissue contains reserve lipids at the mitochondrial poles in the form of small droplets. In addition, reserve lipids are found in significant amounts in intercellular spaces, between muscle fiber bundles in the connective tissue layers. The quantitative content of triacylglycerols in muscle fibers differs depending on the species of animal. During intense work, the content of reserve lipids in the intercellular spaces is reduced to a minimum.

In addition, ethanol glycerophosphatides, cholinesterase phospholipids, sphingomyelin plasmogens, etc. have been isolated from muscle tissue glycerophosphatides. In fact, these lipid fractions are characterized by a higher content of unsaturated fatty acids (65–75%) than glycerophosphatides of other tissues. The quantitative content of glycerophosphatides in muscle tissue is 0.2–1.0% [40].

Muscle tissue contains unesterified and esterified cholesterol from sterols (as a percentage of dry tissue): 0.8% in smooth muscle, 0.5% in cardiac muscle, and 0.3% in skeletal muscle. Attention should be paid to the unique feature of cholesterol-protein complexes in mammalian muscle tissue, due to the strong bond of cholesterol with proteins. Depending on the type of animal, age, sex, state, feeding and housing conditions, the total lipid content in muscle tissue, as well as their structural components, varies significantly.

Lipids provide high caloric value, tenderness, and flavor of meat, but excessive amounts of them in any meat lead to a decrease in the proportion of protein and, in fact, to a decrease in its nutritional and biological value. Fats from different animal species differ little in caloric content, but they differ in digestibility. Pig fat (96–98%) and beef fat (96–98%) have the highest digestibility, while lamb fat is less digestible (80–90%) [44].

An important energy component and one of the main carbohydrates in muscle tissue is glycogen, which is used during muscle work and stored at rest. During intense muscle work, glycogen is broken down anaerobically in glycolysis to form lactate. The quantitative content of glycogen in muscle tissue depends on the physiological state of the animals, age and fatness. The glycogen and glucose content in muscle tissue samples immediately after slaughter is as follows: 0.3–0.9% (sometimes 2.0%) and 0.05% glucose. In the subsequent post-slaughter period, muscle tissue glycogen conversion is the root cause of many further biochemical transformations [40].

Non-protein compounds of nitrogen-containing substances in muscle tissue also perform specific functions in the process of metabolism and energy: adenosine triphosphoric acid, carnitine, creatine, carnosine, anserine, creatine phosphate, purine bases, free amino acids (intermediate products of protein metabolism), as well as uric acid, urea and ammonium salts (which are their final breakdown products). Extractive substances are important for characterizing the nutritional value of meat, as they have aromatic, flavor, and biologically active properties and actually give the meat broth a specific smell and taste [36]. The content of non-protein nitrogen in muscle tissue samples immediately after slaughter contains 0.3% of non-protein nitrogen, based on wet weight (1.2% on dry weight).

Muscle tissue performs its functions (locomotive, support, protective, heat exchange, blood and lymph circulation, respiratory movements, communication, and contraction of internal organs — gastrointestinal tract, bronchi, genitourinary system) due to the specific activity of enzyme systems. Skeletal muscle has high ATPase and glycolytic activity [43, 51].

The sarcoplasm (matrix) contains many enzymes for the synthesis of proteins, lipids, and polysaccharides. The mitochondria are responsible for the aerobic (oxygen) oxidation of metabolic products — the Krebs cycle and the chain of electrons transport. However, different muscle fibers, depending on their functional characteristics, are characterized by different concentrations of enzyme systems that catalyze anaerobic and aerobic conversion. Red muscle fibers are characterized by a higher content of mitochondria than white muscle fibers; this indicates that there are 6 times more active respiratory enzymes in red muscle fibers than in white ones.

The nuclei of muscle cells contain glycolytic, hydrolytic and oxidizing enzymes, as well as enzymes for programming the synthesis of nucleic acids (DNA polymerase and RNA polymerase).

The organoleptic characteristics of meat include appearance, color, tenderness, juiciness, aroma, and taste. The quality of lamb depends significantly on the age of the animal, sex, housing conditions and physiological state. Lamb, compared to mutton, contains more protein and water, less fat [46]. The difference in meat quality between a 5-month-old lamb and an adult sheep is much greater than between meat from pigs of the same age range. According to the age of the slaughtered animals, lamb is divided into three categories: lamb, young lamb (meat of animals up to one year old) and mutton. The first two categories are considered dietary meat, and all mutton must be processed.

There are the following generally accepted classifications of meat by animal type (beef, pork, lamb), sex, age, and thermal condition (steamed, chilled, frozen).

As noted below, depending on the type of animal, sex, housing conditions, and their fatness, the composition of meat varies significantly. The smallest changes are noticeable in the mass fraction of protein, which is the most valuable component of meat, as well as minerals, and the largest changes are in the mass fractions of water and fat. For example, meat from fattened pigs has more than 35% fat, while meat from underfed calves has about 1%, and sheep — up to 26%.

Although lamb is characterized by high nutritional and biological properties, its disadvantage is the high content of saturated fatty acids. Due to hydrogenation processes, less than 1.8% of polyunsaturated fatty acids reach the small intestines [33].

Table 1. Composition and nutritional value of meat of different animal species

Meat	Chemical compostion, %				Energetic value of 100 g	
	water	protein	fat	mineral	kCal	kJ
Beef	55–69	16.2–19.5	11–28	0.8–1.0	180–320	750–1340
Veal	68–70	19.1–19.4	5–12	1.0–1.3	140–190	580–790
Pork	49–58	13.5–16.4	25–37	0.7–0.9	300–390	1250–1630
Lamb	48–65	12.8–18.6	16–37	0.8–0.9	220–380	920–1590

Plant feeds contain a large amount of polyunsaturated fatty acids, in particular, linoleic and linolenic acids, Cis-double bonds of these acids are toxic to rumen bacteria that hydrogenate them, as a result of which the organs and tissues of ruminants contain a large amount of stearic and oleic acids and a small amount of polyunsaturated fatty acids [13, 30, 48]. At the same time, some trans-isomers of oleic (trans-11) and linolenic (cis-9, trans-11) acids synthesized in the processes of rumen biohydrogenation have biological activity that partially compensates for the deficiency of polyunsaturated fatty acids of the ω-3 family [2, 11, 13, 30].

Thus, the problem of increasing the proportion of polyunsaturated fatty acids in sheep meat is quite important for human health. With this aim, various biologically active additives are widely used in animal feeding, in particular ruminants, which can directly or indirectly increase the content of polyunsaturated fatty acids in their products. In particular, antioxidants are widely used to prevent double bond peroxidation and thereby increase the content of fatty acids in products [21, 24, 48].

Lipids present in the diet of animals also affect the composition of fatty acids, as they reduce the processes of biohydrogenation, which increases the content of polyunsaturated fatty acids in the fat of these animals [27, 41].

For example, the introduction of high doses of α-tocopherol into the diet activates the synthesis of trans-11–18:1 and cis-9, trans-11–18:2 fatty acids in the rumen, and also leads to a decrease in the formation of trans-10–18:1 and trans-10, cis-12–18:2 fatty acids [3, 4, 12], and the addition of selenium salts and vitamin E (0.5 and 300 mg/kg in terms of dry matter of feed) changes the fatty acid composition of skeletal muscle by increasing the content of unpaired, polyunsaturated, branched and trans-11 fatty acids [3].

There are contradictory data in the literature regarding the influence of nutritional factors and breed characteristics of sheep on the content of total lipids and their individual components (phospholipids, sterols, fatty acids) in muscle and adipose tissue. In particular, Sosta R. G. et al. showed that the content of saturated (C12:0, C14:0, C18:0, C20:0) and monounsaturated fatty acids increased in the longest muscle of lambs fed a high energy diet compared to a low energy diet. Different genotypes were also characterized by different contents and ratios of saturated and unsaturated fatty acids. At the same time, diet and genotype did not affect cholesterol levels [10]. Similar results were obtained by other researchers [25]. In particular, Auroussean B. et al. (2007) noted that lambs kept on pasture had a better fatty acid profile due to higher concentrations of conjugated linoleic acid (C18:2 — CLA), C18:3 n-3 and C18:2 n-6 [1]. However, Bonagurio S. et al. obtained the opposite effect in experiments on Texel lambs fed different diets [8].

The influence of various factors on the formation of sheep meat productivity

The meat productivity of sheep is determined by many factors, among which genetic and organizational and economic factors are the most important.

In particular, different sheep breeds differ significantly in terms of meat productivity. For example, Askanian crossbreds (early maturing meat and wool sheep) are significantly superior in meat quality to Tsygai and thin-fleshed sheep. Precos and Askanian fine fleece sheep produce wool of low tone. However, Precos sheep have a better meat productivity, characterized by higher slaughter yield, higher meat content, meat with higher moisture and fat content, which makes it juicier and fattier.

It is characteristic that in sheep, wool and meat productivity are interrelated, but have a significant opposite. If the result of the breeding process is high woolenness, the development of meat qualities is usually reduced and *vice versa*. At the same time, bred meat and wool sheep with crossbred wool (early maturing) combine high wool and meat productivity well [9].

Table 2. Amino acids composition of different animal species meat

Amino acids \ Meat	Beef	Pork	Lamb
Essential aminoacids, % to total protein			
Arginine	6.6	6.4	6.9
Valine	5.7	5.0	5.0
Histidine	2.9	3.2	2.7
Isoleucine	5.1	4.9	4.8
Leucine	8.4	7.5	7.4
Lysine	8.4	7.8	7.6
Methionine	2.3	2.5	2.3
Threonine	4.0	5.1	4.9
Phenylalanine	4.0	4.1	3.9
Tryptophan	1.1	1.4	1.3
Nonessential amino acids, % to total protein			
Alanine	6.4	6.3	6.3
Aspartic acid	8.8	8.9	8.5
Glycine	7.1	6.1	6.7
Glutamic acid	14.4	14.5	14.4
Proline	5.4	4.6	4.8
Serine	3.8	4.0	3.9
Tyrosine	3.2	3.0	3.2
Cystine	1.4	1.3	1.3

Crossbreeding methods (related and unrelated) are one of the most important factors in increasing the productivity (meat and wool) of sheep. Thus, in the case of unrelated crossbreeding (outbreeding) of ewes of fine-fleeced breeds with rams of semi-fine-fleeced breeds, the resulting offspring have 4–8% more live weight than the offspring from fine-fleeced ewes, a higher slaughter yield by 1–1.5% and a higher meat content by 0.4–1.0%. Even better results are obtained by crossing three or more breeds [15, 41, 44].

The type of animal constitution is one of the most important factors affecting the productive qualities of animals, including sheep. Animals of different constitutional types (strong, dense, coarse, delicate, loose) differ significantly in constitutional strength, exterior and interior indicators, productive and adaptive factors [31, 34]. Sheep of each type of constitution are characterized by peculiarities of wool and meat productivity and their reproductive capacity. The integral indicator is the meat productivity of sheep, in fact, the quality composition of meat. It has been established that when comparing the productivity (of different constitutional and productive types) of Askanian fine-fleece sheep, the most valuable in terms of biological indicators is the meat of lambs of coarse constitution type, due to the best protein-fat ratio (2.06 : 1.0), the highest content of total proteins (19.99%), in fact, the γ-globulin fraction, the lowest amount of unesterified cholesterol (10.52%), the optimal content of total lipids (9.72%), with a higher amount of phospholipids (24.21%) [38].

It is known that the biosynthesis of proteins plays a key role in the growth of animals, including sheep, with a content of up to 75% in terms of dry matter of skeletal muscle. Animal skeletal muscle consists of white and red muscle fibers. Static muscle is dominated by white muscle fibers, and dynamic muscle is dominated by red muscle fibers. Dynamic and statodynamic (shoulder, large round, pelvic, sacral) muscle fibers are thin slim-fiber, they contain more complete proteins and less incomplete proteins [22]. The skeletal muscles of sheep of different ages contain (based on raw weight): protein — 16.0–23.0%; lipids — 2.0–5.0%; carbohydrates — 0.5–3.5%; extractable nitrogenous substances — 1.0–1.7% and minerals — 0.8–1.8%.

High protein content and an optimal ratio between the content of essential and nonessential amino acids ensure high nutritional value of any type of meat. According to some authors, the amino acid composition of beef, pork and lamb meat is almost similar [15].

Mineral and vitamin composition of meat is important for its biological value. It is known [14] that lamb is a good source of B vitamins, in particular, biotin, thiamine and nicotinic acid, B_{12}, but is somewhat inferior to pork and beef in terms of pantothenic acid and vitamin B_6. Sheep meat contains (mg%): biotin — 5.9; nicotinic acid — 4.3–5.2; B_{12} — 2.5; pantothenic acid — 0.58; B_6 — 0.29; riboflavin — 0.18–0.22; thiamine (B_1) — 0.13–0.16; folic acid — 0.07–0.09. Meat vitamins are characterized by relative stability and are not destroyed during heat treatment. Boiled meat retains up to 75% and 45–60% of vitamin B_6. Vitamin B_{12} is the most resistant to heat treatment [14].

Meat contains virtually no vitamin C, and small amounts of fat-soluble vitamins A, D and partially vitamin E. There is a pattern that the more fat the meat contains, the higher content of fat-soluble vitamins and the lower content of water-soluble vitamins.

There are almost no differences in the content of Iron, Phosphorus and Calcium in meat samples from different animal species. Among the peculiarities, it can be noted that the hind part of lamb is the richest in Phosphorus, Copper and Zinc [14].

The color of meat directly depends on the presence of the pigments myoglobin and hemoglobin. However, the color of meat is also influenced by the sex of the animal, the type of feeding and housing conditions. Meat from young animals is pale pink in color, while meat from older animals is dark red. It should be noted that the meat of sheep is less intensely colored than that of rams. During the stall period, when the animal receives less green feed, its meat is lighter. When sheep are kept at pasture, they move nore, their meat is darker in color and has better flavor. If there is a deficiency of Fe in the feed, the meat has a less intense color.

The age and sex of animals, muscle load, fatness, the ratio of elastin to collagen, and marbling (connective tissue content, thickness of muscle fibers) affect the tenderness of meat. In fact, the specific flavor of lamb is given by hirsinic acid.

The influence of individual feed components on sheep productivity and quality

The cost of feed determines the unit cost of production by 58–60%, so the issue of reducing the cost of production is an urgent task in the sheep industry by taking into account the needs of animals for the necessary nutrients and biologically active substances, taking into account their availability in feed and the availability of eating, assimilation and transformation into products.

First of all, it is of particular importance to provide complete protein in animal feeding. The biosynthesis of proteins in the body is continuous, which makes it possible to renew the proteins of animal tissues. Proteins perform a number of vital functions: protective, energetic, catalytic, transport, hormonal and immune. It has been proven that protein deficiency leads to a decline in nutrient metabolism and an increase in feed costs per unit of production, delayed growth and development of animals, and a decrease in reproductive function [5, 7, 39, 44, 49].

Animal rearing conditions have a significant impact on the quality composition of fatty acids in meat. For example, lambs raised in pasture type of housing produce meat that is biologically healthier for the consumer than those raised in stall housing. This is manifested in higher concentrations of conjugated linoleic acid (C18:2 — CLA), linoleic acid (C18:3 n-3), long-chain fatty acids n-3 and higher ratios of C18: n-6: C18:3 n-3 [1].

Vegetable feed for ruminants is the main source of feed protein. For animals, their share in the total protein balance is 94–95%, of which 60–70% is accounted for by grain and forage crops and 25–30% by pasture, haylage, and crop processing products [17, 35, 50].

The literature shows that in different regions of Ukraine, the protein deficit in feed is 25–35%, which leads to a deficit of many macro- and microelements, vitamins, and amino acids [20, 23, 28].

Sheep are grazing animals that are well-adapted to eating large quantities of plant fodder, which is the main source of feed protein. However, vegetable feeds are not always able to provide the animal body with all the necessary biologically active nutrients. Of particular importance for sheep, as deficient nutrients, along with the general components of nutrition (protein, energy, carbohydrates), are the macronutrient Sulfur and sulfur-containing amino acids — methionine and cystine, which have a stimulating effect on the growth and development of animals, improve the quality of wool and meat products [37]. In our experiments, which were conducted on Askanian fine-fleshed lambs of the Taurian type, it was found that the longest back muscle of 4-month-old animals, compared to 5-month-old animals, contained a greater amount of total phospholipids due to a higher content of nitrogen-containing fractions, in particular, phosphatidylethanolamine and phosphatidylcholine, which are metabolically active components of cell membranes, which, in turn, may indicate an increase in the intensity of metabolic processes in them, as well as better nutritional and biological value of such meat [40]. The longest muscle of younger animals had a lower content of total fat (by 1.74%) and dry matter (by 1.08%), but contained a higher amount of soluble proteins due to a higher content of β- and γ-globulins. Nevertheless, the muscle tissue of 5-month-old lambs contained a significant amount of prealbumin and albumin fractions. Summarizing, it can be concluded that the nutritional and biological value of lambs meat of 4 months of age is better compared to the meat of lambs of 5 months of age [18, 40]. The addition of the essential amino acids methionine, lysine, and a salt of the macronutrient Sulfur to the diets of young sheep had a positive effect on the biological value and biochemical composition of muscle tissue by increasing the content of proteins, in particular, albumin and phospholipids [19]. It should also be noted that the differences in average daily live weight gain in animals of the experimental groups were 17.3–29.5% higher compared to the control group [42].

Conclusions

From the above review, it can be concluded that sheep meat is characterized by high nutritional, taste and dietary properties due to the balanced content of high-quality proteins, minerals and vitamins, and therefore lamb meat is valued higher on the world market than meat of other animal and poultry species.

Meat productivity of sheep is determined by many factors. Among them, genetic and nutritional factors are the most important. It is especially important to provide sheep with adequate protein, since its deficiency leads to a decrease in growth, reproductive function, and increased feed costs per unit of production.

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Біологічні особливості формування м’ясної продуктивності овець*

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Узагальнено дані літератури і власних досліджень про хімічний і біохімічний склад м’язової тканини, її біологічні функції та харчову цінність. Представлено узагальнені дані щодо хімічного складу і поживної цінності м’яса різних видів тварин, зокрема яловичини, телятини, свинини та баранини. Показано, що м’ясо овець характекризується поживними, смаковими і дієтичними властивостями; за біологічною цінністю не поступається яловичині і свинині, а за іншими показниками навіть переважає їх. У баранині міститься така ж кількість протеїну й амінокислот, як і в яловичині та свинині, а жиру у ній більше, ніж у яловичині, тому баранина є калорійнішою. Вона є добрим джерелом вітамінів, мінеральних елементів (Кальцію, Фосфору, Феруму), а за вмістом Купруму та Цинку вона значно переважає інші види м’яса. На світовому ринку ягнятина ціниться вище, ніж інші види м’яса. Особливо високий попит на туші молодняку 13–16 кг. Дієтичність молодої ягнятини зумовлена її протеїновим складом, високим вмістом вітамінів А і Е та групи В, ліпідів, зокрема фосфоліпідів. Щоправда, хоча м’ясо овець і відзначається високими харчовими та біологічними властивостями, недоліком його є значний вміст насичених жирних кислот, що пов’язано з процесами рубцевої біогідрогенізації. Отже, проблема збільшення у баранині частки поліненасичених жирних кислот є надзвичайно актуальною для здоров’я людей. З цією метою у годівлі тварин широко застосовують різні біологічно активні добавки, здатні прямо чи опосередковано впливати на збільшення вмісту полі ненасичених жирних кислот у їхній продукції. Зокрема, широко застосовуються антиоксиданти, які запобігають пероксидному окисненню подвійних зв’язків і тим самим збільшують вміст поліненасичених жирних кислот у продукції. Вирощування і відгодівлю ягнят біологічно доцільно й економічно вигідно проводити до досягнення ними маси тіла 40–50 кг, позаяк у цей період приріст м’язової тканини найбільший порівняно з відкладанням жиру, а витрати кормів — найменші.

Ключові слова: вівці, м’ясна продуктивність, біохімічний склад, біологічна цінність, годівля, порода, схрещування

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