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Characteristics of meat by-products: nutritional and biological value

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Abstract

This article describes the nutritional and biological value of meat by-products. Information on the chemical, amino acid, vitamin and mineral composition of the liver, heart, rumen and lung of cattle is given. By-products are characterized by a high content of minerals and vitamins, among which iron, phosphorus and B vitamins prevail. Rational processing of by-products allows them to be used instead of meat in the production of meat products. Replacement of the meat portion of the formulation in the production of meat products using by-products will reduce the cost of meat products and provide accessibility to various categories of the population, as well as enrich the products with certain nutrients.

Keywords: liver, heart, lung, nutritional value, ingredients, technology

Introduction

Animal slaughter involves obtaining not only meat, but also a considerable mass of by-products. By-products are the internal organs and parts of the animal obtained during the processing of cattle and pigs [1, 2]. The by-products are subdivided depending on the features of the morphological structure and methods of processing into:

- meat-bone - beef, horse, camel, deer heads; beef, lamb, horse, camel, deer tails;
- tongues, brains, liver, kidneys, heart, meat trimmings, lungs, spleens, diaphragm, trachea;

oesophagus meat, meat of heads; udders of cattle and milk glands of other kinds of slaughtered animals; testicles of beef and lamb;

- wool - heads of pigs and mutton, legs of pigs, legs with the navel joint of beef, horse and camel; ears and lips of beef, horse, camel and deer; tails, pelt, intercostal part, cheeks of pigs;
- mucous membranes - rumen with nets and rennet of beef, mutton, deer and camel; cattle manifold of beef, mutton, deer; stomachs of pigs, horses.

Offal products are distinguished by the type of slaughtered livestock, its fatness, thermal condition, structure and composition of the main tissues, nutritional value. They are subdivided depending on the type of animals (beef, lamb, pork), purpose (food, technical), structure and processing features (wool, meat-bone, flesh, stomach), as well as food value (1st and 2nd categories) [3, 4]:

- 1st category: tongues, liver, kidneys, brains, heart, beef udder, beef and mutton tails.
- 2nd category: heads without tongues, lungs, coleus (throat), rumen, rennet, pig stomach, ears, lips, pig and lamb legs, spleen, trachea, legs of beef and navel joints, pig tail, pickle meat (from esophagus).

Technical by-products include horns, horn-rod, head bones, genital organs, limbs of sheep and a number of other by-products of low nutritional value.

According to the thermal state, by-products can be chilled, and cooled.

Parenchymatous by-products include internal organs that do not perform motor functions - liver, lungs, kidneys, brain, spleen, udder. The second group is organs whose activity is connected with motor functions - heart, tongue, diaphragm, stomach. And the third group - the external parts of the animal - the head, legs, ears [5, 6].

Most beef by-products are used for food purposes. The most valuable of them are tongue, liver, kidneys, brains. Heart, lungs, trachea, esophagus, blood, diaphragm, meat from heads (cheeks), meat trimmings and intestines are used in sausage production [7, 8, 9]. Legs, meat and bone tails, stomach, larynx, ears, lips contain a lot of collagen and elastin, so they are used for making jellies and potpourri. Bones of the metacarpal and metatarsal bones which are used to make buttons and other items after the melting of the bone fat are classified as technical by-products [10]. Bone meal is produced from head bones, and meat bone meal, bone meal and blood meal [11]. In addition, the bones that are milled to the state of paste can be used in the food industry [12, 13, 14].

The yield of beef by-products of the 2nd category is 13.8 % of the weight of meat on the bones. Moreover, more than half of their total amount is not used in industrial processing [15]. The average yield of by-products is 22% of live weight in cattle, 20% in mutton, and 18% in pork. The yield of by-products to livestock live weight: liver - 1.65%; heart - 0.75%; lungs - 1.7%; rumen - 2.7%; kidneys - 0.39%.

The proportion of by-products in farm animals is from 10 to 12%. In relation to the weight of meat the yield of beef by-products is 22%, lamb by-products - 21%, pork by-products - 15%. The highest yield of meat by-products of slaughter cattle is liver, and rumen (almost 3%) of mucous by-products of ruminants [15, 16].

Meat by-products have the same microflora composition as meat. However, in the epidemiological aspect, the danger of by-products is much higher due to their increased contamination and high humidity, which creates very favorable conditions for the reproduction of microorganisms [17, 18].

Nutritive value of meat by-products

The chemical composition of by-products is similar to that of meat, but the nutritional value of by-products is lower, as they contain more incomplete proteins (collagen, elastin), fat and fat-like substances. By nutritional value, by-products of the I category are equivalent to meat, so they are successfully used in the production of high-grade sausages, canned foods, sold directly through the trade network and are in great demand among the population, they are used to produce delicacy products [19, 20].

Depending on the category, by-products differ in the mass fraction of collagen. At the same time, by-products of the II category, rich in collagen, are of limited use. They are used to produce bologna, by-products, liver, semi-smoked sausages and canned foods. Second category by-products are similar to connective tissues by their properties. Their chemical composition consists of proteins from 10.5 to 25.2%, fats from 2.3 to 14.1%, water from 60.9 to 85.0%. In addition to the rumen, which contains 6.8% collagen from the mass of the crude tissue, the tendons contain 87.6% of the mass of total proteins represented by collagen. The ears and lips contain 72% and 52% of collagen from the sum of all proteins, respectively. Collagen is a protein that is the main structural component in the vertebrate body, accounting for about 1/3 of the mass of all proteins [21, 22].

By biological value the by-products of the II category are close to the first grade meat. By the content of essential amino acids beef spleen is the most close to meat (1.4% tryptophan, 9.4% lysine, up to 7.4% isoleucine and 3.2% methionine + cystine). Rumen, beef lungs and kidneys are rich sources of essential amino acids. By-products of the 2nd category contain a large mass fraction of salt-soluble protein, recognized for its functionality in forming the structure of meat systems and promising for the development of meat emulsions. The 2nd category by-products contain considerable amounts of animal protein: in the spleen, lungs, rumen, rennet, coleus, esophageal meat - 15-19 %; in the ears, lips - 21-25 %. The spleen contains 13.2% complete

protein; lungs and esophagus, 10% each. These by-products contain a significant amount of salt-soluble protein (spleen - 7 %, lungs - 4.4 %), and by this indicator they significantly exceed muscle tissue (Table 1) [23].

The proteins included in by-products are characterized by high heterogeneity and complexity. In terms of the total protein content, they are almost as good as meat, but they differ sharply in their completeness. The most typical protein-scleroprotein is collagen [24].

The fat content in some by-products of the first category is higher than in meat. The composition of fat includes mainly neutral fats with a large number of fat-like substances - phosphatides, cholesterol, cerebrosides. There is a relatively high content of arachidonic and linoleic acids [25]. By-products are a significant source of minerals and vitamins (Table 2, 3).

Table 1– Chemical composition of by-products, %

Indicator	Beef by-products			
	Liver	Heart	Rumen	Lung
Moisture	72.9	77,5	80,0	77,5
Protein	17.4	16,0	14,8	15,2
Fat	3.1	3,5	4,2	4,7
Ash	1.3	1,0	1,1	1,0
Extractive substances	5,3	2,0	-	-

Table 2 - Vitamin composition of by-products, mg/%

Vitamins, mg/%	Liver	Heart	Rumen	Lung
A	8,0	0,02		0,014
B1	0,38	0,36		0,047
B2	3,0	0,75	0,15	0,23
B3	6,3			
Folic acid	220-240			
B6	0,73	0,3		0,04
B12	0,015	0,001		0,003
PP (niacin)	17,5	5,0	1,6	4,0
E	1,28	0,75		
C	33,0	4,0		38,5

By-products are characterized by a high content of minerals and vitamins, among which iron, phosphorus and B vitamins are dominant. Spleen, lungs, rumen, tongue, and rennet are rich in iron (Table 3) [26].

Table 3 - Mineral composition of by-products, mg/100g

Mineral	Liver	Heart	Rumen	Lung
Sodium	104,0	100,0		198
Potassium	240	260	1219	340
Calcium	8,7	7,3	67	10
Magnesium	18,0	18,0		14
Phosphorus	314,0	210,0	594	224
Iron	6,9	4,8	15.5	7,95

Zinc	5,0	2,1	2.0	1,61
Copper	3,8	0,4	0.38	0,26
Iodine, μg	6,3	7,3		
Manganese, μg	315,0	59,0	0.017	

The nutritional value of by-products is determined not only by the total protein content, but also by their amino acid composition, which is presented in Table 4 [26, 27].

Table 4 - Amino acid composition of by-products, mg/100g of protein

Amino acid	By-products			
	Liver	Heart	Rumen	Lung
Essential				
Valine	6900	5100	5600	10750
Isoleucine	4800	4700	3590	3840
Leucine	8300	7800	7310	10920
Lysine	7500	7500	5600	8850
Methionine + cystine	4000	3600	2620	5170
Threonine	4200	4100	4000	5340
Tryptophan	1200	1200	900	1440
Phenylalanine+tyrosine	8600	6600	6800	7340
Nonessential				
Alanine	5900	5700	6130	10730
Arginine	6500	3800	7110	8150
Aspartic acid	7000	7100	9150	11950
Histidine	4400	2600	1700	2200
Glycine	4900	4100	6490	16100
Glutamic acid	10200	11500	14200	12200
Oxyproline	1000	1300	5970	5230
Proline	5300	5400	7160	9540
Serine	3400	3400	4830	6950

Liver

Liver surpasses other by-products in the content of complete proteins (17.9-18.8%), contains organically bound trivalent iron. Also liver contains sufficient phosphorus, magnesium and zinc in its composition. High fat-absorbing ability allows the liver to be successfully used to produce products of smear consistency - liver sausages and pates [28, 29]. The liver is involved in all kinds of metabolism, as it is the first to take all substances coming into the blood from the intestine. It regulates carbohydrate metabolism. The liver performs glycogenic function (glycogen breakdown and synthesis), aerobic oxidation of lactic acid (Fig. 1) [30].

The main mass of the dry matter of the liver is protein. Proteins are represented mainly by globulins about 13% (of the total number of liver proteins, accounting for 17%), albumin accounts for only about 1%. The liver is characterized by a significant amount of iron-containing proteins. Iron-containing liver proteins are the reserve sources of iron necessary for hemoglobin synthesis [31].

The weight of the liver of cattle is 3.5-9 kg, of pigs - up to 2.5 kg, of sheep - up to 0.6-0.7 kg. Liver contains 15-17% protein, 5% fat, 2-5% glycogen (sometimes up to 18%) and up to 1.5% mineral substances. Protein liver is mainly complete. There are also iron-containing proteins and brown pigment, in which iron is

in oxide form (trivalent). Liver proteins are more difficult to digest with pepsin than meat proteins. Liver lipids comprise more than half of phospholipids, so it is unstable to oxidative processes during storage in frozen form [32].

Due to its high vitamin content, liver is useful for vision, growth and bone repair. It is indispensable for blood, because it promotes the transport of iron and the production of red blood cells. Liver is an antioxilant, breaks down and removes cholesterol, and is useful for immunity [33, 34].

Liver is one of the best sources of vitamin A. One portion of beef liver in a human menu provides more than 100% of the daily requirement for vitamin A. Adequate intake of vitamin A reduces the risk of diseases such as cataracts and breast cancer [35]. Liver is also rich in vitamin K, which is essential for bone health. Vitamin K helps the body to process calcium and add it to the bones. As a result, it helps maintain the strength of the skeletal system. Getting enough vitamin K in the diet is associated with a decreased risk of chronic diseases such as osteoporosis. Vitamin K is also important for maintaining a healthy blood system [36].

The high content of hematopoietic factors in liver (iron, copper, zinc and vitamin B12) determines its use in the treatment of anemia. As a source of vitamin A, liver is used in the treatment of urolithiasis and lesions of the mucous membranes and skin. Boiled liver retains 90-100% of vitamin A. However, during long-term storage in frozen form of liver chemical processes are active, deteriorating organoleptic properties and destroying vitamins [37]. Heat treatment highly dehydrates liver, but, ground after cooking, it has the ability to absorb fat. That is why liver is used in the production of pates, liver sausages, fillings for cakes and other culinary products [38].

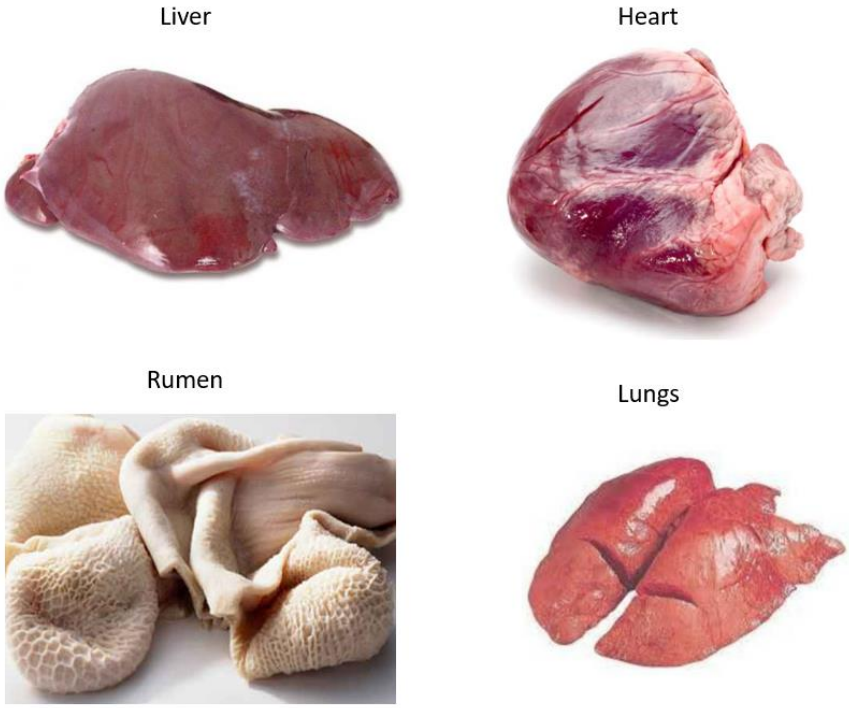

Fig. 1. Beef by-products (pictures from open sources)

Heart

The heart contains the least amount of protein (16 %), which includes a lot of complete proteins with high content of methionine, phospholipids, as well as phosphorus, iron and vitamins of B group and PP. The heart has tough muscle tissue, so it is usually used for meat products in small quantities and with preliminary grinding [39]. Beef heart is low in calories and high in vitamin B12 and iron. The heart contains 3.5-4% lipids, with more than half of them being phospholipids. Heart contains more vitamin B12, pantothenic acid, riboflavin, thiamine, and iron and copper than in meat [40]. Long heat treatment (stewing) or chopping is necessary to

increase the culinary value. When used in cooking, the heart is soaked in cold water for 1-2 hours before cooking [41].

Lung

Lung is by-product of the II category, consisting of pulmonary parenchyma - thin-walled epithelial sacs - alveoli, which due to the blood capillaries and a fine mesh of elastic and reticulin fibers has a spongy structure. A specific feature of lung tissue is a peculiar folded mucous membrane and cartilaginous rings and cavities in the bronchi of a larger diameter.

After thermal treatment the pulmonary parenchyma is destroyed, loses its sponginess and gets more intense coloring. The structure of cartilaginous formations (rings or plates) is almost completely preserved and allows reliable differentiation of this organ. The lung is inferior to muscle tissue in the content of high-grade proteins, but is a good source of biologically active and vital substances: amino acids, vitamins, macro- and microelements. Lung is not used much in food industry [42, 43].

Lungs contain about 15% of proteins, of which 40% are incomplete. The particular feature of the protein composition is the high content of elastin, which does not reduce its rigidity and elasticity during cooking. Lungs are used in the production of liver sausages, as well as in pie fillings with the addition of liver [44, 45].

Rumen

Rumen promotes activation of peristalsis of the gastrointestinal tract and has a number of other positive properties. It is rich in enzymes, micro- and macroelements. In terms of total protein content, of which about 50% is the connective tissue, rumen is close to beef [46, 47]. Beef rumen, being an animal raw material and with a cellular structure, due to its structure (smooth muscle tissue formed by two layers, the fibers of each are arranged perpendicular to each other, connective tissue, which has increased rigidity), and the nature of proteins (collagen content reaches 50% of total proteins), has low consumption properties [48, 49].

The inner surface of the rumen wall is formed by large flattened villi. The villi and underlying mucosal and submucosal layers revealed a large number of fibrous elements represented mainly by collagen fibers of different thickness. These fibers are gathered in dense thick bundles, intersecting in different directions, forming a complex three-dimensional network [50]. It should be noted that rumen is mainly used in the production of liver sausages.

Meat trimmings

Meat trimmings of cattle are close to beef in chemical and amino acid composition. However, due to the significant content of connective tissue and lymph nodes, its processing into high-grade sausage products is difficult. The amino acid composition of meat trimmings and high-grade meat is almost identical, except for the absence of tryptophan in the former, the amount of which in the meat is almost 2 times higher. The meat trimmings can be gelled with a meat yield of 68-72%, but this requires a great deal of manual labor. The factors limiting the use of meat trimmings include their specific unpleasant smell [51, 52].

Conclusion

Thus, meat by-products are one of the resources of protein nutrition. They are widely used as an ingredient for the production of meat products, culinary products, as well as for the production of pharmaceutical drugs. Using by-products for replacing the part of meat in the formulation for the production of combined canned meat products will reduce the cost of meat products and balance them in relation to individual nutrients. As by-products are rich sources of essential phospholipids, a number of vitamins and mineral substances, their use as the basic components or for replacement of a part of meat will allow to balance composition of meat products on the specified nutrients.

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