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ADAPTATION OF NUTRIA MEAT TO INDUSTRIAL TECHNOLOGIES OF THE MEAT INDUSTRY

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Summary. This research is to determine the features of identification of products of the slaughter of nutria while post-slaughter veterinary-sanitary control, to assess the slaughtered yield, to study the peculiarities of the chemical and biochemical composition of the products of the slaughter of nutrias. This will allow, under the conditions of import substitution, to extend the source of raw materials for the production of sausage products and assortment of meat ready-to-cook foods. This paper represents the results of the veterinary and sanitary assessment of nutria meat as a prospective raw material for the meat processing industry in Ukraine. The peculiarities of identification of slaughter products of nutria are determined by the presence of fat deposits, rounded form lipoma, and the structure of internal organs while post-slaughter veterinary and sanitary control of nutrias' carcasses. It is proved, nutrias have been shown to have a sufficiently high slaughter yield of 57.5 ± 2.3% as compared to rabbits. It has been proven that nutria has a fairly high lethal yield compared to a crawl. The difference in the slaughter rate of female and male species was negligible and was 4.5 ± 1.4%. Nutrias' Meat Index is 4.9 ± 0.7. The high content of flesh on the spinal-chest and the thigh makes it possible to recommend these parts to produce portion (pieces) semi-finished products According to physicochemical composition nutria meat is characterized by an increased content of moisture (90.27 ± 2.18%), high content of protein (20.82 ± 1.15%) and low content of fat (8.34 ± 0.71%), which makes it possible to attribute this kind of meat to dietary.

Keywords: nutria meat, veterinary-sanitary control, slaughtered yield

Introduction. One of the main fields of the meat industry is to create meat products with high qualitative, functional, and flavor characteristics, with a high level of protein in the product balanced by the amino acid composition, which will ensure competitiveness among the existing assortment. In this regard, the urgent task is to attract additional sources of meat raw materials, such as nutrias, which has high protein content and extraordinary flavor characteristics (Angelyuk, Bystrova and Gorbunova, 2014).

Nutria belongs to herbivorous animals, characterized by high growth rates, which allows obtaining not only valuable skin but also dietary meat in the short term. Although more than one hundred thousand heads of nutria are slaughtered annually in Ukraine, the issues of the veterinary and sanitary control of their meat and offal are insufficiently covered and require careful study.

Unlike other types of meat, nutria meat is somewhat darker in color. This might be explained by the fact that it contains a significant amount of muscle hemoglobin (800–1000 mg%, and rabbit meat — 150–200 mg%). In terms of organoleptic characteristics, it is not inferior to rabbit meat. Nutria meat has a pleasant sweet taste, has no specific flavors and smells (Glotova et al., 2013; Volkova and Esenbaeva, 2017; Saadoun and Cabrera, 2019). Nutria meat is thin-fibrous — the thickness of the fibers is 37–40 μm (for comparison, turkey meat — 50–51 μm), it is delicate and characterized by good juiciness. It contains relatively many (3.5–5.0%) nitrogenous non-proteinaceous extracts: creatine, carnitine, carnosine, adenylic acid, purine bases, etc.; for example, in the meat of farm animals the content of extractives is 1.0–2.5%. The fat of the nutria is fusible, resembling a pig in consistency and color. 100 g of nutria meat contains 4.716 g of fat, 23.99 g of protein, 156–213 kcal of energy (Nalyvaiko et al., 2019).

Nutria meat (bone-free in carcass, internal fat and offal) is characterized by the following chemical composition: 100 g of nutria meat contains 140 cal of energy, 18.3 g of digestible protein, 6 g of fat, 4.5 g of raw ash (Kagadiy et al., 2015; Angelyuk, Bystrova and Gorbunova, 2014).

Muscle and adipose tissue, their quantitative ratio in carcasses, qualitative composition and processing conditions have the greatest technological importance in sausage production. The ratio of muscle and connective, fat, bone and cartilage tissues in the carcass of the nutria is at the level of beef and is 69–72%:13–14%:15–17%, respectively (Kozlova, Sidorova and Cheremenina, 2017; Głogowski, Pérez and Clauss, 2018; Nalyvaiko et al., 2019).

Absence of the normative-technical documentation in Ukraine and other countries (Russia, Belarus, Georgia, and others) for the basic types of the meat products from nutria, such, as the boiled, smoked sausages, delicacies,

and also the necessity of complex estimation of quality and physical and chemical characteristics of nutria meat, predetermined necessity of researches on application of this type of meat raw material in the technology of meat products (Kozlova, Sidorova and Cheremenina, 2017; Shebela et al., 2015). Complex veterinary and sanitary measures are of great importance in organizing the technological process of processing meat raw materials (Paliy et al., 2018).

The aim of the work is to establish the features of identification of products of the slaughter of nutria while post-slaughter veterinary-sanitary control, to assess the slaughtered yield, to study the peculiarities of the chemical and biochemical composition of the products of the slaughter of nutrias.

Materials and methods. The experimental part of the work was carried out in the Department of Infectology, Quality and Safety of Agricultural Products of the Luhansk National Agrarian University and in the meat processing enterprise in the Lugansk Region (Ukraine) The objects of the study were nutrias of black breed of private farming of business owner Kuznetsov V. I. (Kharkiv). Nutrias are kept in open-air cages with a covered walking area. The area of the open-air cage makes 8 m^2, and the area with a covered walking area is 3 m^2. Ten nutrias are kept in each cage (1 male and 9 females). The area for walking is equipped with a pool with an area of 0.8 m^2. The water in the pool during the warm period of the year (April–October) is changed every day. The walls of the aviaries are built of brick, and the walking areas are fenced with an iron fence. For the construction of floors, a metal mesh covered with the crushed stone was used. The farm uses a combined (concentrate-root-herbal) type of feeding. When compiling the diet, it is taken into account that each individual of young nutria must eat 20 g of roughage per day, and an adult one — 40 g/day.

There was made slaughter of nutrias at the age of 9 months to carry out research. The weight of females was 4.7 ± 0.3 kg, males — 5.1 ± 0.7 kg, and the fatness index was 0.077 and 0.082, respectively.

The slaughter and the veterinary and sanitary control of nutria carcasses were carried out under the 'Rules of Antemortem Veterinary Inspection of Animals and Veterinary-Sanitary Examination of Meat and Meat Products' (SDVMMAPU, 2002). Weighing of carcasses and internal organs was carried out on electronic platform scales of the brand CERTUS Balance CBA-600 and CERTUS Balance CBA-6000 (Japan).

A comparative characteristic of indices of nutria meat was carried out against to rabbit meat (Volkova and Esenbaeva, 2017).

The mass fraction of hygroscopic moisture in meat was determined by the method of drying samples at a temperature of 150°C for 30 min in accordance with the requirements of GOST 9793-74 'Meat products. Methods for determination of moisture content' (Gosstandart, 1974). For testing the muffle stove of SNOL-7.2/1100 was used.

The mass fraction of fat in meat was determined in a Soxhlet apparatus in accordance with GOST 23042-86 'Meat and Meat Products. Methods of Fat Determination' (Gosstandart, 1986).

The mass fraction of fat (x, %) was calculated by the formula (1):

$$x = \frac{m_1 - m_2}{m} \times 100, \quad (1)$$

where: m — mass of the test sample, g;

m_1 — mass of extraction retort with the pieces of phosphorus, g;

m_2 — mass of extraction retort with the pieces of phosphorus and fat after drying, g.

The mass fraction of albumen in products was determined by the method of Kjeldahl in accordance with requirements of GOST 25011-81 'Meat and Meat Products. Methods of protein determination' (Gosstandart, 1981). The method is based on the mineralization of the sample according to Kjeldahl, distillation of ammonia into a solution of sulfuric acid, followed by titration of the test sample. For testing the system 'BEHR Labor-Technik' was used.

The mass fraction of a total nitrogen (x, %) was calculated by the formula (2):

$$x = \frac{0.14 \times (V_1 - V_2)}{m}, \quad (2)$$

where: m — mass of the test sample, g;

V_1 — volume exactly 0.1 mol/dm^3 — 0.05 mol/dm^3 acids (0.1 n. — 0.1 n.) was spent on titration of the test sample, cm^3;

V2 — volume exactly 0.1 mol/dm^3 — 0.05 mol/dm^3 acids (0.1 n. — 0.1 n.) was spent on titration of the control sample, cm^3.

The mass fraction of a total protein (X, %) was calculated by the formula (3):

$$X = 6.25 \times x, \quad (3)$$

where x — the average mass fraction of a total nitrogen in the test sample calculated by the formula (2), %.

An energy value is the amount of energy, that appears at biological oxidization of fats, proteins, and carbohydrates, contained in products. It is expressed in kilocalories (kcal) or kilojoules (kJ).

The energy released during oxidation 1 g of fat is 9.0 kcal, 1 g of carbohydrates — 3.75 kcal, and 1 g of proteins — 4.0 kcal. To receive the power value in the SI system units, we used the next coefficient of count: 1 kcal = 4,184 kJ (Nalyvaiko et al., 2019).

Thus, the energy value of meat (per 100 g) is calculated by the formula (4):

$$A = \big((a \times 9) + (b \times 3.75) + (c \times 4)\big) \times 4.184, \quad (4)$$

where: a — mass fraction of fat, %;

b — mass fraction of carbohydrates, %;

c — mass fraction of protein, %.

Results and discussion. At the first stage of the research, while the post-mortem veterinary-sanitary examination, we have studied the features of the structure of carcasses and internal organs of nutrias intending to establish the species belonging. Determining the meat species belonging is one of the most important tasks of veterinary and sanitary control, the purpose of which is to exclude the falsification of meat raw materials.

It has been established that the carcasses of nutria are rounded, thick, and the muscles in the shoulder and pelvic girdle are well developed. Muscle tissue is pale pink in color. Subcutaneous fat is found in the area of the withers, knee fold, elbow joint, shoulder blade, chest and root of the tail. The integumentary and internal adipose tissues are painted in yellowish-white tones. The anatomical feature of nutria should be considered the presence of a lipoma, located between the shoulder blades above the spinous processes of 5–8 thoracic vertebrae, which has a rounded shape and a lobed structure. Its average size is $(2.87 \pm 0.07) \times (4.12 \pm 0.14) \times (0.59 \pm 0.08)$ cm. It should be noted that such a lipoma is absent in rabbits and cats.

The spleen is brown-red in color, lanceolate, elongated, with rounded edges. The color of the spleen pulp is normally red-cherry. The whitish-grayish points of the trabeculae are clearly visible in the section. The parenchyma does not protrude beyond the edges of the capsule. When scraping from the surface of the incision with the back of the knife, a small amount of pulp is removed.

The heart is dark red in color, oval with a blunt apex. To the right and somewhat in front of the aorta the right heart appendage is located, and to the left — the left heart appendage, which are blindly ending protrusions of the atria (right and left, respectively). The heart is enclosed in a pericardial bag. Outside it is covered with epicardium. The weight of the heart in female nutria is on average 9.54 ± 0.28 g., and in males — 9.65 ± 0.21 g.

The lungs of the nutria consist of seven lobes: on the left lung, three lobes are well defined — apical, cardiac and diaphragmatic, on the right four lobes are well pronounced — apical, cardiac, diaphragmatic and additional. Six lobes of the right and left nutria lungs (apical, cardiac, diaphragmatic) are approximately the same size. There are deep interlobar clippings reaching the bronchi. The right and left bronchi are free of lung tissue, 1.0–1.5 cm from the bifurcation site. The weight of the lungs in females is 20.85 ± 1.19 g, and in males of the same age — 21.63 ± 1.38 grams.

The nutria liver is well developed, consists of five independent lobes and an additional one. Four lobes — the right and left medial and lateral — large, approximately equal in size, the fifth lobe is smaller in size, square in shape resembling a plate, located between the right and left medial lobes, perpendicular to their surface. The additional lobe of the liver resembles a growth up to 1.5 cm in diameter. The color of the liver is from dark brown to brown-red. The weight of the liver in female nutria is 149.3 ± 4.34 g, and in male 6-month-old nutria — 140.3 ± 0.63 g, and in 12-month-old nutria — 153.71 ± 2.88 g. The adrenal glands are rounded, 1.4 ± 0.2 cm long, located in the lumbar region near the front of each kidney. It should be noted that the rabbit and cat liver, unlike the nutria liver, has a mastoid process.

The nutria kidney shape is also specific: the right kidney is bean-shaped and the left kidney is triangular. The kidneys of a rabbit and cat are bean-shaped.

The mammary glands in females are not located on the abdomen, as in other species of animals, but high on the sides along the back. There are 8–10 nipples, 4–5 on each side, and they are located at a distance of 6–7 cm from each other.

The nutria vertebral column consists of 56–57 vertebrae, of which 7 are cervical, 13 are thoracic, 6 are lumbar, 4 are fused sacral and 26–27 are caudal. At the 8^{th} caudal vertebra, the spine ends. Nutria has 15 pairs of ribs, including 8 — real and 5 — false. The collarbone is connected to the scapula and the first rib.

Nutrias have been found to have a high slaughter rate (live weight): males — $59.8 \pm 1.6\%$, females — $55.2 \pm 2.1\%$. The difference in the slaughter rate of female and male species was negligible and was $4.5 \pm 1.4\%$.

During post-mortem examination of carcasses and internal organs of nutria, no apparent pathological anatomical changes were found, the degree of exsanguination was good, carcasses had a characteristic pink-red color.

Important indicators that determine the appropriateness of the use of raw meat in the meat industry are the meat productivity of animals and the ratio of muscle, fat and bone tissue. Meat productivity is characterized by live and lethal weight of the animal, as well as a slaughter yield.

It was established that nutria has a rather high slaughter yield (to live weight): males — $59.8 \pm 1.6\%$, females — $55.2 \pm 2.1\%$. The difference in the slaughter yield of females and males is insignificant and amounted to $4.5 \pm 1.4\%$.

By the yield of slaughter products, nutria is not inferior to rabbits (Table 1). After analyzing the data of Table 1, we can conclude that the carcass of the nutria is fleshy — the bones with the head make up $12.5 \pm 0.5\%$, while in the rabbit — $10.7 \pm 0.2\%$. The yield of fresh-killed nutria meat is 16.82% higher compared to rabbit meat. It should be noted that when slaughtering nutria, illiquid wastes account for $8.3 \pm 1.45\%$ of the carcass weight, which is 1.5% less compared to slaughtering a rabbit.

To confirm the effectiveness of the use of nutria meat in the meat industry, we cut the nutria carcass into pieces based on the anatomical features of the carcass in order to study the composition and yield of carcass muscle tissue (Fig. 1). It is known that the more muscle tissue in meat, the greater its nutritional value as a protein product.

Table 1 — Nutria slaughter yield (M ± m, n = 15)

Name of the product	Yield to carcass weight, %	
	nutria	rabbit
Fresh-killed meat including:	57.5 ± 2.30	52.4 ± 1.53
Internal fat	4.4 ± 0.15	7.2 ± 0.20
Kidneys	0.6 ± 0.25	0.6 ± 0.16
Head	8.8 ± 0.42	6.5 ± 0.19
Fur	16.6 ± 2.12	11.3 ± 2.12
Ears, paws, tail	3.1 ± 1.32	3.2 ± 1.17
Blood	1.8 ± 0.21	2.1 ± 0.13
Liver	3.5 ± 0.40	3.5 ± 0.41
Head, lungs, trachea	1.6 ± 0.10	1.3 ± 0.15
Guts (no contents)	4.9 ± 0.84	6.3 ± 0.64
Illiquid waste	8.3 ± 1.45	9.8 ± 0.12

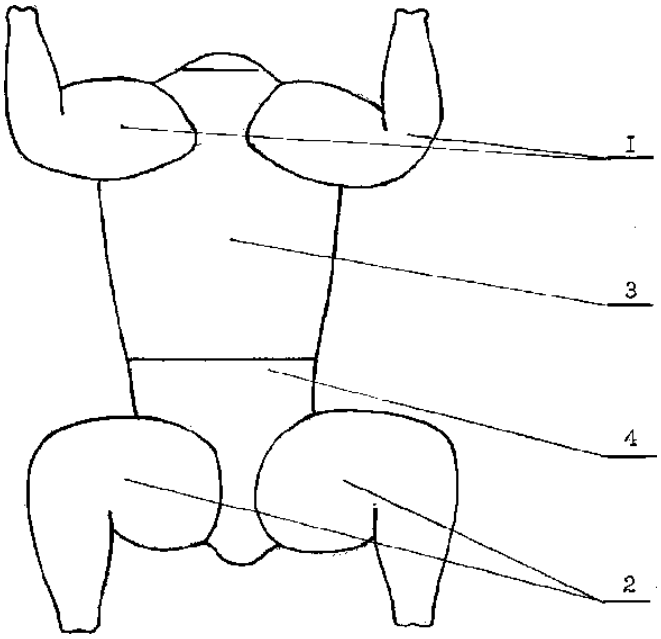

Fig. 1. Scheme of cutting carcass of nutria into culinary parts: 1 — scapular part; 2 — ham; 3 — spinal chest part; 4 — lumbar-flank part.

When boning the culinary parts, three types of tissue were distinguished: pulp, bone-cartilage, and adipose tissue (Fig. 2). Analyzing the research data on the morphological composition of the nutria carcass shown in Fig. 2, it was found that the ratio of the main tissues: muscle, fat and bone is on average 68.6:17.1:12.3. The yield of adipose tissue of carcasses of females was 1.25% higher compared to carcasses of males. Nutria flesh meat index was 4.9 ± 0.7. The largest value for this indicator was in males.

When deboning nutria carcasses rather large parts were separated: the shoulder blade 360–454 g, the ham 730–980 g, the lumbar-flank part 420–620 g, and the dorsal-chest part 590–857 g (Table 2).

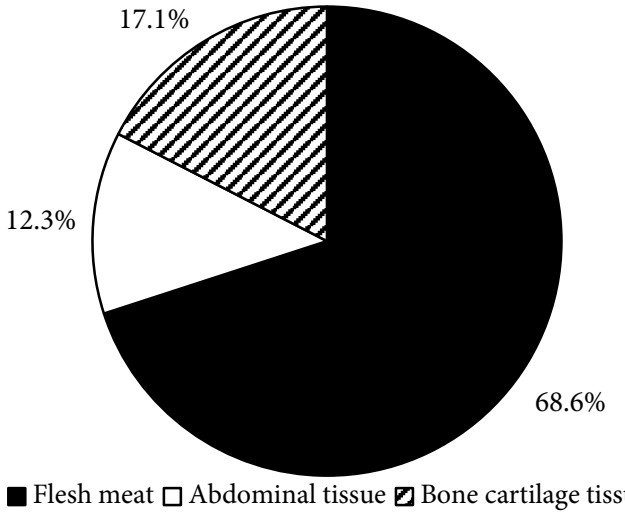

Figure 2. Morphological composition of nutria meat

Table 2 — The ratio of some parts of the nutria carcass, % of the total mass (M ± m, n = 15)

Carcass part	The yield of culinary parts when cutting nutria carcass, %	The yield of flesh meat during boning of carcass parts,%
Shoulder blade	16.3 ± 1.2	10.7 ± 2.1
Ham	36.4 ± 2.4	23.8 ± 2.3
Lumbar flank	20.2 ± 2.1	22.5 ± 1.5
Dorsal-chest	29.8 ± 1.6	13.1 ± 2.1

The largest amount of meat flesh was separated during boning of ham and lumbar flank, which is 23.8 ± 2.3% and 22.5 ± 1.5% of the carcass weight, respectively. At the same time, the largest culinary parts when cutting the carcasses of nutria were ham and dorsal-chest part — 36.4 ± 2.4 and 29.8 ± 1.6% of the total weight of the carcass, respectively.

Thus, the high content of flesh meat on the dorsal-chest part and ham allows you to use these parts not only for the production of sausages, but also for the preparation of portioned semi-finished products.

To ground the use of nutria meat in the meat industry, we studied its chemical composition in comparison with the meat of the rabbit. For this, we performed a control slaughter of nutria to study the physicochemical parameters of meat and to compare with rabbit meat. The samples of muscular tissue for further researches we took in the area of ham and shoulder-blade. The results of physical and chemical researches are presented in Table 3.

Having analyzed the data of Table 3, it was found that the nutria meat is characterized by a high moisture content (90.27 ± 2.18%), high protein content (20.82 ± 1.15%), and low fat content (8.34 ± 0.71%), which allows us to attribute this type of meat to dietary. The energy value of nutria meat is 252.92 kJ/100 g more compared to rabbit meat.

Table 3 — Physico-chemical characteristics of nutria meat (M ± m, n = 15)

Researched index	Nutria meat	Rabbit meat
pH	5.76 ± 0.02	5.95 ± 0.03
Mass concentration of moisture, %	90.27 ± 2.18	74.40 ± 0.53
Mass concentration of protein, %	20.82 ± 1.15	17.40 ± 0.29
Mass concentration of fat, %	8.34 ± 0.71	8.10 ± 0.36
Mass concentration of carbohydrates, %	0.37 ± 0.05	0
Mass concentration of ash, %	0.96 ± 0.01	1.03 ± 0.04
Mineral substance, %	1.0 ± 0.15	1.0 ± 0.12
Energy value of product, kJ/100 g	674.42 ± 2.35	421.5 ± 3.99
Protein:Fat	1:2.5	1:2.2

Thus, the chemical composition of nutria meat is not inferior to rabbit meat, and by such an indicator as the mass fraction of protein is even 3.42% higher than rabbit meat. Therefore, nutria meat can be used as an alternative meat raw material in the production of cooked sausages in accordance with DSTU 4529:2006 'Cooked Sausages of Poultry and Rabbits Meat. General Specifications' (DSSU, 2007).

According to the results of toxicological and radiological studies, there were no deviations from normalized indicators. Thus, having a high slaughter yield, meatiness index, high flesh content on the dorsal-thoracic part and ham, as well as the optimal chemical composition, nutria meat can be used in meat processing industry as an alternative raw material in the production of sausages and semi-finished meat products.

Conclusions. 1. During the realization of specific authentication of carcasses of nutrias it is necessary to pay attention to the next anatomic features: form and structure of kidneys, presence of lipoma of the rounded form, developed depot fats in area of withers.

2. It was established that nutria has a rather high slaughter yield (to live weight): males — 59.8 ± 1.6%, females — 55.2 ± 2.1%. Correlation of muscular, fatty, and bone tissue of nutria carcass is 68.6:17.1:12.3, which allows using the meat of nutria in sausage production.

3. The chemical composition of nutria meat is not inferior to rabbit meat, and, therefore, can be used as an alternative meat raw material in the production of cooked sausage products in accordance with DSTU 4529:2006 'Cooked Sausages of Poultry and Rabbits Meat. General Specifications' (DSSU, 2007).

4. However, today in Ukraine and other countries of the world there is no standard DSTU 'Nutria Meat. Technical Conditions'. This is a huge obstacle to the use of nutria on an industrial scale. This standard will introduce requirements for nutria meat, as a high-grade raw material for the manufacture of sausages.

Research prospects: Based on DSTU 4529:2006 'Cooked Sausages of Poultry and Rabbits Meat. General Specifications' (DSSU, 2007) to develop recipes of sausages using nutria meat.

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