Study of composition and properties of duck meat

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Abstract. The work is devoted to the essential task of scientific justification of the use of waterfowl meat in the meat products technology. The objects of the study were the white Peking ducks, the muscovy ducks and the mulard hybrid ducks. In the comparative aspect, the gravimetric parameters of the main dressing parts of the duck carcasses, their tissue composition, total chemical composition (moisture, protein, fat, mineral substances), the fractional composition of meat proteins, the content of macroelements (potassium, calcium, magnesium, phosphorus) and microelements (Ferrum, zinc) were studied. The energy value of the duck meat, its functional and technological properties was determined, and the microstructure of the muscle tissue of the breast and thigh parts of the carcass was studied. The comparative analysis showed that the meat of the Peking duck is inferior to the meat of the muscovy duck and the mulard duck in protein content, but exceeds it in fat content. The most significant portion of the muscle tissue is concentrated in the breast and leg quarter. The meat of the Peking duck has a higher calorific content compared to that of the muscovy and the mulard duck. Duck meat is rich in potassium, calcium, magnesium, as well as Ferrum and zinc. Duck meat can be used as a functional raw material because these mineral substances are often scarce in the diet of a modern human. High functional and technological properties of duck meat provide high-quality indicators of the finished product.

1. Introduction

Currently, poultry meat farming traditionally uses grain-eating (land) birds: chickens of meat breeds and lines, turkeys, less often guinea fowls, quails, and ostriches.

The consumption of the waterfowl meat, particularly that of ducks, is considered to be quite low. In essence, only about 50 grams are consumed per year for every Russian citizen, while the overall consumption of poultry meat per person is about 32 kg [1].

Most of the duck meat is produced and consumed at personal subsidiary plots and peasant farms.
Recently, the technologies for industrial duck meat production have begun to be embraced. The industrial methods of year-round production ensure sufficient efficiency of duck meat production in various regions of the country.

This tendency is due to the high growth rate of young ducks: so for the first 7 – 8 weeks of life, the weight of ducklings increases by 5 – 6 times. Therefore, ducklings reach the slaughter age with the live weight of more than 3 kg with relatively low feed costs[2-5].

Ducks are characterized by their resistance to low temperatures, high reproductive capacity, and being undemanding to the presence of reservoirs.

Currently, raising ducks of different breeds and hybrids is typical for the Krasnodar, Perm territories, Rostov region, the republic of the Volga region and the North Caucasus.

The most common breed of duck is the white Peking duck. This breed was bred more than 300 years ago in China, a suburb of Peking (Beijing). The Peking ducks were imported to Russia from England in 1925.

The muscovy meat-type ducks were bred in South America. They differ from the Peking ones in higher viability and being undemanding to feeding and maintenance conditions. They are not loud - they hiss, so they are sometimes called "hissers". Their name is "Muscovy ducks" because they have nothing to do with turkeys: they only share corals above the beak and around the eyes. The meat of the muscovy ducks has pleasant taste and aroma of the game.

The Peking ducks and the muscovy drakes are crossed to get the mulard ducks, which are characterized by high consumer qualities.

According to the forecasts for 2020 – 2022, the supply of the duck meat products in the domestic market overgrow. It is essential to put into operation new capacities and increase those at the existing duck meat production enterprises.

Until recently, the Russian market was dominated by products imported from abroad, but the situation has begun to change. In Russia, the level of consumption of waterfowl meat has increased, the network of large and medium-sized enterprises for raising ducks is expanding, and the process of import substitution has begun.

An urgent task is to expand the production of the duck meat products, which requires expanding of the range of products based on it, including that of functional orientation, making a certain contribution to the creation of healthy food products [2, 6, 7].

Therefore, the purpose of this study was to substantiate the use of duck meat in meat products technology, ensuring the dynamic development of competitive poultry farming in Russia.

For achieving this goal, the task was defined as follows – to study the morphological and chemical composition, functional and technological properties, and energy value of the duck meat.

2. Object of research
The objects of the study were the white Peking ducks, muscovy ducks, and their hybrids - the mulards belonging to private farms in Ramonsky and Semiluksky districts of Voronezh region.

The groups of the fowl of each breed were formed according to the principle of analogues at the slaughter age. For the white Peking breed, the age of the ducks was 50 – 60 days (n=5), for the muscovy ducks 70 – 80 days (n=3), and for the mulards 60 – 70 days (n=3).

3. Method of research
The experimental studies were conducted at the research laboratory of the Department of Technology of Products of Animal Origin and the regional production veterinary laboratory. Conventional methods determined the general chemical composition of the meat, fractional composition of proteins, functional and technological properties, and energy value.

Mass composition of the dressing parts was determined by the gravimetric method. The microstructure of the muscle tissue of the duck meat was studied using histological preparations prepared from the tissue samples taken in the similar places of the carcasses and cuts fixed in 10% formalin and stained with hematoxylin-eosin [8].
The content of macro- and microelements were determined by atomic absorption spectroscopy. The statistical processing of the results was performed on a computer running Microsoft Office Excel 2010 (11.5612.56.06). Reliability was assumed at a reliability threshold of $B=0.95$ (significance level $P \leq 0.05$).

4. Research result

4.1 Mass characteristics of the dressing parts and tissue composition of the duck cuts.

The manual dressing of the carcass detaches the anatomical parts of the ducks, makes it possible to adjust the level of protein and fat in the formulation of the meat products.

The dressing of the eviscerated duck carcasses was performed by detaching the following parts: wings, breast part, lumbosacral section, leg quarter (Table 1).

Table 1. Mass properties of dressing parts of eviscerated duck carcasses

| Carcass parts                | Weight of carcass dressing parts, in % of the mass of the whole muscovy duck carcass | Weight of carcass dressing parts, in % of the mass of the whole Peking duck carcass | Weight of carcass dressing parts, in % of the mass of the whole mulard duck carcass |
|-----------------------------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| Whole carcass               | 2745 ± 130.4                                                                      | 3743 ± 183.8                                                                     | 3900 ± 203.4                                                                    |
| Wings                       | 8.3 ± 0.9 *                                                                       | 6.4 ± 0.35                                                                       | 6.2 ± 0.74                                                                       |
| Breast part                 | 36.2 ± 4.60 *                                                                     | 38.4 ± 2.4                                                                       | 39.2 ± 3.01                                                                     |
| Lumbosacral section         | 35.0 ± 4.6                                                                        | 33.4 ± 2.96                                                                      | 38.4 ± 1.77 *                                                                   |
| Leg quarter                 | 22.0 ± 4.03, *                                                                    | 22.01 ± 6.82                                                                     | 22.4 ± 1.88                                                                     |

* - $P \leq 0.05$ for Peking ducks

The research results have shown that all the breeds of ducks are characterized by similar ratios of mass characteristics of the main parts of the eviscerated duck carcasses.

However, the muscovy ducks, in contrast to the Peking ducks, have a more significant yield of wings, but a smaller yield of the breast part ($P \leq 0.05$). For the mulard ducks, the weight of the lumbosacral part is 1.6 – 3.4% higher ($P \leq 0.05$) compared to the Peking and the muscovy ducks.

The results of studying the mass composition of the duck meat tissues are presented in Table 2. The three main dressing parts of the carcass were examined: leg quarter, breast part, and lumbosacral section. It was found that the content of the muscle tissue in the leg quarter of the mulard and the muscovy duck is higher than in the leg quarter of the Peking ducks ($P \leq 0.05$) by 12.1 and 11.3%, respectively.

It was found that the bones in the leg quarter of the mulard hybrid duck are significantly less numerous than in the leg quarter of the Peking and the muscovy ducks: by 9.6 and 9.0, respectively. The leg quarter of the muscovy duck has much less skin (21.3±0.61%) compared to the Peking duck (32.2±0.64%) and the mulard duck (29.4±0.89%).

The breast part of the carcass in the mulard ducks and the muscovy ducks exceeds the Peking ducks in the content of muscle tissue: by 20.1% and 12.6%, respectively ($P \leq 0.05$). The mass fraction
in the breast part of the muscovy ducks is significantly less than that of the Peking ducks and the mulard ducks.

### Table 2. Tissue composition of dressing parts in ducks of different breeds, %

| Type of tissues | Peking duck | Muscovy duck | Mulard duck |
|----------------|-------------|--------------|-------------|
| **Leg quarter** |             |              |             |
| Muscular       | 43.5±0.91   | 55.0±0.92*   | 55.8±2.71*  |
| Skin           | 32.2±0.64   | 21.3±0.61*   | 29.4±0.89   |
| Bones          | 24.3±0.70   | 23.7±0.76    | 14.8±0.60*  |
| **Breast part**|             |              |             |
| Muscular       | 32.4±0.82   | 44.0±0.81*   | 52.5±0.52*  |
| Skin           | 32.0±0.66   | 21.3±0.74*   | 28.2±0.48   |
| Bones          | 35.6±0.83   | 34.7±0.73    | 19.3±0.09*  |
| **Lumbosacral section** | |           |            |
| Muscular       | 26.4±0.53   | 38.0±0.53*   | 26.8±0.78   |
| Skin           | 29.7±0.61   | 19.5±0.67*   | 44.8±0.63*  |
| Bones          | 43.9±2.90   | 42.5±0.76    | 28.4±0.24*  |

* P≤0.05 for Peking ducks

4.2. Chemical composition of duck meat.

For determine the overall chemical composition, the duck meat was ground, the minced meat was mixed, and the meat samples were used in the experiment in three repetitions. The content of protein, fat, moisture, and mineral substances was studied. The results are given in Table 3.

It was found that the meat of the muscovy ducks and the mulard ducks has slightly more protein than that of the Peking ducks: 18.5±2.73% and 17.3±3.11%, respectively, against 15.0±1.82%.

But the meat of the Peking ducks has a significantly higher fat content (35.0±1.63%) than the meat of the muscovy ducks and the mulard ducks. The high-fat content as a hydrophobic component, in the
meat of the Peking ducks, causes a lower moisture level. It is noteworthy that the meat of the muscovy ducks and the mulard ducks has a higher level of mineral substances than the Peking ducks ($P \leq 0.05$).

The high-fat level in the meat of the Peking ducks determines the high caloric content of the duck meat of this breed: 375.0 kcal per 100 g of meat.

### Table 3. Chemical composition of duck meat.

| Duck breed | Protein, % | Fat, % | Moisture, % | Mineral substances, +% | Calorific value, kcal |
|------------|------------|--------|-------------|------------------------|----------------------|
| the Peking | 15.0±1.82  | 35.0±1.63 | 49.4±3.94  | 0.6±0.07               | 375.0                |
| the muscovy| 18.5±2.73  | 23.4±1.42 | 56.6±3.26  | 1.5±0.03               | 284.6                |
| the mulard | 17.3±3.11  | 24.3±3.71  | 55.8±4.48  | 2.6±0.70               | 287.9                |

* - $P \leq 0.05$ for Peking ducks

The duck meat of the original dressing parts: breast part, leg quarter, and lumbosacral section differ significantly in chemical composition.

It is confirmed by the study of the general chemical composition of the primary dressing parts of the Peking ducks (Table 4).

### Table 4. Chemical composition of the Peking duck meat in the main dressing parts

| Name of the cut       | Mass fraction, % | Energy value of 100 g of product, kcal |
|-----------------------|-------------------|---------------------------------------|
|                       | Protein | Fat    | Moisture | Mineral substances |                                      |
| Leg quarter            | 14.8±1.2 | 40.0±2.33 | 44.6±3.46 | 0.6±0.15            | 419.2                               |
| Breast part            | 18.9±2.02 | 36.4±1.61 | 43.9±2.33 | 0.6±0.28            | 403.2                               |
| Lumbosacral section    | 14.3±1.66 | 40.1±1.62 | 44.2±2.47 | 1.4±0.30            | 418.1                               |

The results show that the protein content in the meat of the breast part is higher than that in the leg quarter and the lumbosacral section.

The analysis of the fractional composition of the duck meat proteins showed that the salt-soluble fraction, which mainly determines the functional and technological properties of the raw materials, is more pronounced in the meat protein of the duck breeds studied.

In the level of water- and alkaline-soluble protein fractions, the ducks of different breeds do not differ much. But the water-soluble protein fraction of the duck meat significantly (more than by twice) exceeds the alkaline-soluble one (Table 5).

The study of the content of mineral substances in the duck meat showed that the duck meat is rich in potassium, phosphorus, Ferrum, and zinc (Table 6).
Table 5. Fractional composition of duck meat proteins

| Name of the ducks | Water-soluble | Salt-soluble | Alkaline-soluble |
|------------------|--------------|-------------|-----------------|
| The Peking       | 38.3±4.18    | 46.7±5.03   | 15.0±3.14       |
| The muscovy      | 35.1±2.33    | 48.3±4.02   | 16.6±4.25       |
| The mulard       | 35.0±1.86    | 50.4±6.81   | 14.6±3.54       |

* - P≤0.05 for Peking ducks

Table 6. Content of mineral substances in duck meat

| Minerals | The Peking ducks | The muscovy ducks | The mulard ducks |
|---------|-----------------|------------------|-----------------|
| Potassium  | 148.0±16.33     | 156.3±8.45       | 152.4±11.07     |
| Sodium   | 84.6±15.7       | 68.4±8.93*       | 70.3±14.22*     |
| Calcium  | 21.3±2.03       | 24.8±3.44        | 23.4±9.83       |
| Phosphorus | 140.4±16.22     | 142.3±25.6       | 139.6±12.44     |
| Ferrum   | 1.7±0.21        | 3.26±0.27*       | 2.7±0.45*       |
| Zinc     | 3.28±0.04       | 3.0±0.12         | 3.6±0.73        |
| Magnesium | 13.4±0.21      | 14.6±0.33        | 15.4±3.06       |

* - P≤0.05 for Peking ducks

It was found that the sodium level in the meat of the muscovy ducks and the mulard ducks is significantly lower than that in the meat of the Peking ducks, but the meat of the muscovy duck and the mulard duck contains a higher level of Ferrum (P≤0.05).

4.3 Functional and technological properties of duck meat.

The indicators that determine the quality and yield of the products in the meat products technology are moisture-binding capacity (MBC), moisture-retaining capacity (MRC), fat-retaining capacity (FRC), emulsifying capacity (EC), and emulsion stability (ES). The evaluation of these indicators in the duck meat showed that the Peking duck meat is inferior to the muscovy duck meat and the mulard duck meat by the level of MBC, MRC (P≥0.05) and practically does not differ by level of EC and ES (Table 7).

Table 7. Functional and technological properties of duck meat, %

| Duck breeds | MBC | MRC | FRC | EC | ES |
|-------------|-----|-----|-----|----|----|
| The Peking  | 78.3±4.18 | 79.1±3.83 | 76.3±2.93 | 96.3±16.48 | 98.2±9.18 |
| The muscovy | 82.0±11.34 | 81.3±6.78 | 73.2±4.77 | 94.2±16.34 | 98.2±7.22 |
| The mulard  | 80.3±7.93 | 82.5±4.67 | 74.3±3.80 | 94.6±9.53 | 98.4±8.75 |

* - P≤0.05 for Peking ducks
4.4 Microstructure of duck muscle tissue.

The features of the muscle tissue morphology were studied on histological preparations using a light microscope with an x40 lens and x10 eyepiece magnification.

The muscle tissue samples were taken from similar areas of the breast and thigh parts.

The analysis of the muscle tissue sample microstructure showed that the muscle tissue of the breast part is represented by the muscle fibres tightly located to each other. The endomysium of the muscle fibres reveals an insignificant number of cells of the loose connective tissue. The nuclei of these cells are rounded in comparison with the oval rod-shaped nuclei of the muscle fibres (Figures 1).

![Figure 1](image1.png)

**Figure 1.** The microstructure of breast muscle tissue of a) – Peking duck; b) – muscovy duck; c) – mulard duck. Staining with hematoxylin-eosin, x10 eyepiece, x40 lens magnification.

The microstructure of the thigh muscle fibres is characterized by greater disunity of the location of the muscle fibres. Between the bundles of the muscle fibres, not only the areas of the loose connective tissue are found, but the fat tissue as well (Figures 2).

![Figure 2](image2.png)

**Figure 2.** The microstructure of thigh muscle tissue: a) – Peking duck; b) – muscovy duck; c) – mulard duck. It is staining with hematoxylin-eosin, x10 eyepiece, x40 lens magnification.

The analysis of the structural organization of the muscle tissue showed that the muscle tissue in the Peking ducks includes more extensive areas of the loose connective tissue and fat tissue. To a greater extent, this was typical for the thigh muscle tissue.

The tighter arrangement of muscle fibres characterizes the structure of the muscle tissue in the muscovy ducks compared to the Peking ducks.

Its structure of the similar samples of the muscle tissue in the mulard ducks was characterized by looser allocation of the muscle fibres not only in the thigh part but also in the breast part.

5. Discussion

Thus, the experiment found that the mass composition of the main dressing parts, as well as their tissue composition in the mulard duck hybrids, differs significantly from those in the Peking and the muscovy ducks. The use of the hybrids is of particular interest for expanding the range of the meat products, which is an urgent task in the conditions of the increasing volume of the ducks grown. In this
regard, it can be asserted that in the future, it can compete with the more widely used Peking ducks. The results obtained justify the possibility of producing a more extensive range of both whole products and chopped semi-finished products.

The study of the chemical composition showed that the meat of the Peking ducks contains much more fat, which causes its more significant caloric content. In contrast, the meat of the muscovy ducks and the mulard ducks is characterized by a higher level of protein and mineral substances.

The meat of the ducks studied has a high level of potassium, which determines, first of all, the state of the cardiovascular system.

It was also found that the meat of the muscovy ducks and the mulard ducks is superior to that of the Peking ducks by the level of Ferrum. This causes its use in the formulations of anti-anaemic products.

Of particular interest is the presence of connective tissue inclusions in the duck meat, which can be considered dietary fibres of animal origin. It is confirmed by the level of alkaline-soluble meat proteins and the histological picture of the muscle tissue.

The possibility and feasibility of using the duck meat in the meat products technology are also determined by high functional and technological properties that determine the high quality of the products and high yield of the finished products.

6. Conclusion
The chemical composition, the functional and technological properties, and the microstructure of the meat of the Peking ducks, the muscovy ducks, and their hybrids were studied. The results obtained determine the feasibility of using this raw material in the meat products technology, including that of the practical orientation.

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