The effect of plant components on the rheological properties of chopped semi-finished products from mulard meat

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Abstract. This article presents the results of an analysis to assess the effect of plant components on the rheological properties of chopped semi-finished products from mulard meat. Flour-ground talkan oatmeal, pea flour, white sesame flour and kelp algae were used as vegetable components. During the experiment, the analysis of changes in general deformation, plastic deformation, elastic deformation and modulus of elasticity was carried out. The nature of the change in the criterion of stickiness (adhesion) and consistency according to its five descriptors describing the consumer properties of products was also considered. The results of the study indicate a positive dynamics of changes in rheological parameters when plant components are introduced into the recipe. The analysis of the data obtained allows to establish 4% white sesame flour and 5% kelp as the recommended dosage for adding to the recipe of chopped semi-finished products from mulard meat.

1. Introduction

In the modern world, one of the most important issues is the preservation of life and health of the world population. Today, more and more people are concerned about aspects of healthy and rational diet. Scientists around the world are working on the problems of creating products considering the metabolic aspects of pharmacology, as well as the toxicology of food components. Researchers identify correlations between the state of health and the content of certain biologically active substances in products, as well as micronutrients. The main condition for the development of modern innovative products is to maintain and improve people's health, minimize the risk of pathologies and diseases of the body directly related to nutrition. To ensure an optimal ratio of the structure of food systems, maximum and adequate limits of consumption of biologically and physiologically active substances are established in accordance with the necessary norms. At the same time, age, gender, physiological state, level and frequency of physical activity of a person are necessarily considered [1].

To date, the main consumer demand is for products that have a positive physiological effect on the human immune system as a whole or a selective effect on individual organs and systems, due to the presence of a functional food component or a combination of several components in the product recipe that make it possible to compensate for the deficiency of certain substances in the body. The most common substances in the food industry are substances with increased biological value and physiological activity, these include natural ingredients or complexes of systems of plant, animal, mineral, microbiological origin, substances identical to natural, as well as living microorganisms [2, 3].
Among the components of animal origin, poultry meat is of the greatest scientific and practical interest. This type of raw material is the most balanced in amino acid and fatty acid composition, contains a high amount of extractive substances, macro and microelements, which makes it an indispensable material for the production of various types of food and culinary products. Considering the entire range of poultry meat products, it should be noted that the main share of the entire production of the modern meat products market falls on the meat of broiler chickens and chickens. Nevertheless, it is also necessary to emphasize the importance of alternative raw materials, for example, such as waterfowl meat, and in particular duck meat. Duck meat is characterized by increased taste and nutritional properties, it has a positive effect on the general immune system, the body digestive system, and also helps to cleanse the blood system of cholesterol plaques, wastes and toxins. It has a unique set of chemical components and acts as a good antioxidant. Duck meat is characterized by a high content of selenium, which makes it possible to maintain the protection of organ cells and tissues from the adverse effects of various environmental factors. The composition of waterfowl tissue is characterized by a large amount of ω-3 unsaturated fatty acids that strengthens the circulatory system of the human body, and the combination of a set of fat-soluble vitamins A, E, K and water soluble vitamins has a positive effect on metabolic processes in the body, allowing to improve skin condition and vision [4, 5].

At the same time, scientists are carrying out purposeful work on the breeding selection of crosses of ducks with reduced fat content of carcasses. The most successful studies are considered to be the breeding of mulards obtained during the crossing of Peking ducks with Muscovy cock-ducks. In conditions of an extended fattening period and systematic breeding work to improve the quality indicators of duck meat while maintaining their productivity and viability, mulards can be considered an excellent raw material for the production of meat and culinary products with a reduced fat content [6-10].

To create functional, dietary, and therapeutic and preventive food products, research has been conducted in recent years to develop recipes for products and dishes that combine raw materials of plant and animal origin. Also a popular topic of study is the use of photoautotrophic organisms in the production of semi-finished meat products with partial replacement of animal raw materials with vegetable ones or enrichment of products. At the same time, to date, special attention is paid to the analysis of the structures of meat and fat emulsions, since they directly form the qualitative and consumer characteristics of products [11, 12].

In this regard, it is of great scientific and practical interest to study the effect of a combination of vegetable components of flour-ground oatmeal talkan, pea flour, white sesame flour and kelp on the rheological properties of chopped semi-finished products from mulard meat. The introduction of these ingredients will further enrich meat products with amino acids (including essential ones), poly- and monounsaturated fatty acids, vitamins B, D, E, folic acid, carotinoids, pectins, phytosterols, phytoestrogens, micro- and macroelements, mineral salts.

2. Materials and Methods
The research was carried out on the basis of scientific laboratories of the Center for Organic and Functional Nutrition of the FSBEI HE Bashkir State Agrarian University (city of Ufa). To study the rheological properties of chopped meat semi-finished products, the development of control and experimental groups of products was carried out. Analyses of qualitative indicators were carried out in two stages. At the first stage, according to the results of comprehensive studies, the preferred dosage of the kelp algae component and a set of vegetable components of flour-ground oatmeal talkan, pea flour and white sesame flour were determined. As a result of the study of organoleptic indicators, the study of the functional and technological properties of semi-finished products, their optimal dosage was established, which was 5% kelp and 6% oatmeal talkan, 6% pea flour, 6% white sesame flour per 100 g of semi-finished product weight. At the second stage, experiments were conducted to assess the rheological properties of the products under study. The 1st group consisted of products developed according to TU 9214-302-23476484-98. In the recipe of the 2 experimental group, 6% of ground-
flour oatmeal talkan and 5% of kelp per 100 g of product weight were added. The samples of group 3 contained 6% of pea flour and 5% of kelp. For group 4, the dosage of vegetable components was 6% of white sesame flour and 5% of kelp.

The rheological properties of semi-finished products were evaluated on the ST-2 structure meter by means of compression of the indenter (Cylinder Ø36), while the total, plastic and elastic deformation was determined. The study of indenter mechanical stress parameters during its contact with the product was carried out at a deformation rate of 0.5 mm/s, a touch force of 7 g, up to the maximum force of the indenter insertion into the product of 500 g. The determination of the stickiness (adhesion) was carried out using a dynamometer, by the method of tearing a polished metal plate from minced meat samples. The consistency criterion was evaluated by sensory analysis of its five descriptors (juiciness, friability, tenderness, chewability, uniformity) according to ISO 11035:1994 "Sensory analysis. Identification and selection of descriptors for establishing a sensory profile with a comprehensive approach" during the tasting. The results of the tasting were described on a 5-point scale.

3. Results and discussion

Chopped meat semi-finished products are based on minced systems consisting of complex combinations of complexes of myofibrils, hydrated muscle proteins, fat balls, water droplets, salts, phosphates, etc. The structural proteins of muscle tissue included in the minced meat are able to bind fat and free moisture, while forming a branched matrix with a solid spatial carcass in the solution. Thus, the rheological properties of minced meat directly depend on the amount of moisture and fat content, the particle size of fat balls and water droplets, as well as on the physical and chemical properties of meat.

The analysis of deformation characteristics showed that the introduction of a combination of vegetable components of oatmeal talkan – kelp, pea flour – kelp, white sesame flour - kelp into the composition of minced meat systems contributes to the formation of a plastic structure of the product (Table 1).

| Indicator                  | Control sample (1 group) | Experiment samples |
|----------------------------|--------------------------|--------------------|
|                            | 2 group                  | 3 group            | 4 group             |
| Total deformation, mm      | 2.018±0.021              | 2.369±0.065        | 3.805±0.138         | 3.389±0.124         |
| Plastic deformation, mm    | 0.594±0.041              | 0.910±0.005        | 1.530±0.028         | 1.254±0.021         |
| Elastic deformation, mm    | 1.398±0.088              | 1.441±0.067        | 2.635±0.154         | 2.190±0.107         |
| Modulus of elasticity, Δh  | 0.277                    | 0.371              | 0.394               | 0.359               |

It was found that the samples of the 3 experimental group differed in terms of the overall deformation by the best characteristics. The level of their deformation was 3.805 mm, which indicates their advantage, compared with groups 1, 2, and 4, by 1.787 mm, 1.436 mm, and 0.416 mm, respectively. Similar dynamics were observed in the analysis of the criteria of plastic, elastic deformation, and modulus of elasticity. The index of plastic deformation of the control group samples is almost twice lower than that of the samples of group 3, and the elastic deformation of group 2 is more than 1.5 times lower than 3 (Figure 1).
Figure 1. Change of the deformation characteristics of chopped semi-finished products from mulard meat, with the addition of oatmeal talkan, pea flour, white sesame flour and kelp.

The formation of high rheological characteristics can be explained by the presence in the composition of plant components, pectins, colloidal polymers (agar, alginic acids), manitol and coarse fiber introduced into the recipe of chopped semi-finished products from mulard meat. The capillary system, which is part of colloidal polymers and dietary fiber, is able to bind and retain moisture and fat particles well, while increasing the moisture-binding, moisture-retaining and fat-retaining ability of the minced meat system. Nevertheless, it is known that binding level of the water-fat fraction directly depends on the length of the capillaries, which means that it varies depending on the type of vegetable raw materials. In this regard, in samples with the addition of oatmeal talkan and white sesame flour, there is a compaction of minced meat structure, which negatively affects the rheological properties of semi-finished products.

Another important rheological characteristic of meat systems is the index of stickiness (adhesion) of the product. This property makes it possible to describe the behavior of the minced meat emulsion during processing, and to evaluate the quality of the molding operation of the semi-finished product. Stickiness directly depends on the strength of the bond between the dispersed particles of minced meat, which are represented by muscle, fat and connective tissue, as well as other components provided by the recipe. The parameters for changing this criterion are shown in Figure 2.
Figure 2. Dynamics of changes in the stickiness (adhesion) of minced meat from the exposure time.

The introduction of vegetable components into the composition of chopped meat semi-finished products generally has a positive effect on adhesion level. During exposure for five hours, the indicators of this criterion first increased proportionally, then stabilized at the same level. Similar dynamics was observed in the analysis of all experimental groups of products. Nevertheless, the advantage was characterized by the samples of group 3, so already at the second hour of the experiment, the difference between group 1, 2, and 4 was 0.38 N/cm², 0.09 N/cm², and 0.05 N/cm², respectively. Subsequently, at the fifth hour of the experiment, the advantage increased to 0.71 N/cm², 0.24 N/cm², and 0.15 N/cm². The nature of the change in this rheological property is explained by an increase in the level of moisture binding capacity of semi-finished products over time. Nevertheless, the introduction of oatmeal talkan and white sesame flour into the formulation leads to an increase in the strength characteristics of the minced meat systems and a certain decrease in the stickiness criterion, which negatively affects the consumer properties of the products.

To comprehensively assess the rheological characteristics of chopped semi-finished products from mulard meat, consistency descriptors were analyzed that most fully form an idea of the consumer qualities of the studied products (Figure 3).

Figure 3. Sensory profile of samples of chopped semi-finished products with the addition of oatmeal talkan, pea flour, white sesame flour, and kelp.
During the study, it was found that the samples with the addition of 5% kelp and 6% pea flour had the best consistency indicators. Thus, according to the juiciness descriptor, the tasting score of the third experimental group was higher, compared with the control, the first and fourth groups by 0.5 points, 0.3 and 0.1 points, respectively. The least advantage is noted by the tenderness descriptor. The distribution of points according to this criterion was as follows: group 1 (control) - 4.3 points, group 2 - 4.4 points, group 3 - 4.5 points, group 4 - 4.4 points. For the rest of the descriptors, a trend similar to the previous indicators was observed.

4. Conclusions
The study of rheological properties of chopped semi-finished products from mulard meat with the addition of vegetable components showed that when oatmeal talkan, pea flour, white sesame flour, and kelp are introduced into the recipe, the quality of products increases. The minced meat system becomes more plastic and elastic. The adhesive characteristics of the products are also changing in a positive direction, and the uniformity and chewability of the samples are also improving. The products are characterized by increased juiciness and tenderness of the structure. Based on the analysis of the main rheological properties of minced meat semi-finished products, it can be concluded that the best characteristics were semi-finished products with the introduction of 5% of kelp and 6% of pea flour per 100 g of the product. These studies confirm the importance of the use of plant components in the production of chopped semi-finished products. In addition to enriching the chemical composition, the products acquire high technological qualities, which proves the attractiveness of using plant components in the production of meat products.

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