Functional and technological properties of fish farce with added amaranth and chickpea flour

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Abstract. The purpose of this work is to research the functional and technological properties of Alaska Pollock farce systems with added amaranth and chickpea flour, which improve their structure. As a principal object of our research, we used frozen Alaska Pollock (Theragra chalcogramma), as well as amaranth and chickpea flour as structure forming additives. The article explores the influence of amaranth and chickpea-seed flour added in the proportion of 10.0% to the total raw mass input on the functional and technological properties of Alaska Pollock farce. We discovered that adding amaranth and chickpea flour is reasonable for increasing viscosity, water-binding and water-retaining capacity of farce systems. As a result, we found out that the farce compositions we developed are characterized by improved structural, mechanical, and rheological properties and sensory parameters as compared with the Alaska Pollock’s ground muscular tissue. Combined farce systems have a dense and elastic texture, good structure and high capacity to bind and retain water. The article substantiates the use of structure-forming additives from domestically produced raw to manufacture fish farce. The research conducted makes it possible to consider Alaska Pollock farce with amaranth or chickpea flour added in the proportion of 10.0% to the total raw mass input as a raw material to manufacture shaped products with improved functional and technological properties.

1. Introduction

Among the most important public policy objectives in Russia, of special importance is rational and efficient use of fish resources. One of the possible solutions to this problem is manufacture of fish farce with the use of fish raw, which is poorly suitable for manufacture of high-quality food products as far as technology is concerned, and with reduced commercial value.

The most massively caught finfish in Russia is Pollock [1]. Pollock meat is characterized by high water content (81.8-85.2%) resulting in appearance of excessive water, which is poorly bound and poorly retained by macromolecules of protein chain [2]. Pollock’s ground muscular tissue has an excessive wateriness and low water-retaining capacity (less than 50%), as a result of which any mechanical impact (centrifugation, pressing etc.) and heat treatment lead to intensive dewatering accompanied by degradation of its functional and technological properties [2-5].

Practical methods of manufacturing shaped products with desired structure include use of food additives, such as stabilizers, thickening agents, gelling agents, and emulsifying agents. Structure-forming additives change techno-chemical, rheological, physico-chemical properties of farce systems and improve organoleptic parameters, in particular, succulence and output of finished products [6,7]. Flour, isolate, starch and other components are used as thickening agents for production of fish farce.
systems from fish raw with low functional and technological properties, including highly-watered fish raw, which makes it possible to bind free water and improve the structure of fish farces [2, 3, 7].

Amaranth and chickpea flour may become perspective non-conventional structure-forming agents produced from domestic raw materials. The advantages of amaranth and chickpea flour are their high functional and technological properties (water-binding, water-retaining, gel-forming capacity) [8-13]. Amaranth and chickpea flour contain comparatively large quantity of proteins (19 to 30%) and carbohydrates (48 to 65%), which is mainly starch [10, 11]. It is commonly known that starch, while reacting with water, swells and turns into gel, while the products made with added starch have the highest water-binding and water-retaining capacity, as well as improved gel-forming capability [14-15].

Amaranth and chickpea-seed flour is used to manufacture bread and flour products, flour confectionery products, macaroni products, milk desserts, mayonnaise and prefabricated meat products [8-13]. At the same time, manufacture of fish farce, which functional and technological properties are regulated by way of adding amaranth and chickpea flour, still remains unresearched.

The objective of this work is comparative investigation of functional and technological properties of Alaska Pollock’s ground muscular tissue and Alaska Pollock-based farce systems with added amaranth and chickpea flour.

2. Materials and methods
The objects of research are: frozen Alaska Pollock (Theraqra chalcoqramma), which quality parameters are in accordance with GOST 32366-2013. Frozen fish; amaranth flour manufactured under IS (Industry Standards, STO) 53548590-044-2016; chickpea flour manufactured under TS (Technical Specifications, TU) ТУ 9293-009-89751414-10.

When cooking the farce systems, frozen Alaska Pollock is defrosted to the temperature from 0 to minus 2°C within the fish body; then filleted, rinsed with water, cut into pieces and shredded with the meat shredder with a screen hole diameter of 3-4 mm. The quantity of amaranth and chickpea flour to be added was determined according to the structural and mechanical, rheological properties and sensory evaluation of combined farce systems. As a result of research conducted, we found out that the reasonable proportion of amaranth or chickpea flour should be not more than 10.0% of the total raw mass input.

Shaped products manufacturing technology includes the following operations: preparing fish farce; adding amaranth or chickpea flour without hydration in the proportion of 10.0% to the total raw mass input; mixing with the fish farce mixer at a rotation speed of 1,500 rpm for 2-3 minutes; swelling of amaranth or chickpea flour within 20 minutes; making shaped products.

Research of mass fraction of total nitrogen, lipids, water, mineral substances, water-retaining capacity was performed with the help of common methods according to GOST 7636-85 Fish, marine mammals, marine invertebrates and products produced from the same. Analysis methods.

Viscosity and adhesiveness parameters of farce systems were researched with the help of Rheolograph-Sol (Toyo Seiki Seisaku-Sho, Tokyo, Japan).

The content of water-soluble and salt-soluble proteins was determined by method of proteins extraction with water and 7% NaCl solution with further determining of nitrogen content by Kjeldahl procedure [16].

Water Content Ratio (WCR0) was calculated as relation of total water quantity to the sum of water-soluble and salt-soluble proteins in the farce system [17].

\[
WCR = \frac{B}{N_{salt} + N_{water}}
\]  

where \(B\) is water content, %; \(N_{salt}\) is content of nitrogen of salt-soluble protein fraction, g/100g of farce; \(N_{water}\) is content of nitrogen of water-soluble protein fraction, g/100g of farce.

Lipid-Protein Ratio (LPR), which characterizes the tenderness of farce systems was determined as the quantitative relation of lipids and proteins [18]:

\[
LPR = \frac{L}{P},
\]  

where \(L\) is content of lipids, g/100g of farce; \(P\) is content of proteins, g/100g of farce.
where $L$ is lipid content, $\%$; $P$ is protein content, $\%$.

Protein-Water-Lipid Ratio (PWLR) was determined according to the following formula [18]:

$$\text{PWLR} = \frac{P+L}{W},$$

(3)

where $P$ is protein content, $\%$; $L$ is lipid content, $\%$; $W$ is water content, $\%$.

To determine the protein quantity (g) per 100 g of water, Protein-Water Ratio (PWR) was applied, which is relation of protein content to water content [18]:

$$\text{PWR} = \frac{P}{W},$$

(4)

where $P$ is protein content, $\%$; $W$ is water content, $\%$.

Lipid-Water Ratio (LWR), which characterizes the succulence of farce systems, was calculated under the formula [16]:

$$\text{LWR} = \frac{L}{W},$$

(5)

where $L$ is lipid content, $\%$; $W$ is water content, $\%$.

To characterize texture and forming capability of ground muscular tissue, the Protein Ratio (PR) was used, which is a relation of salt-soluble proteins content to water-soluble proteins content [19]:

$$\text{PR} = \frac{N_{\text{salt}}}{N_{\text{water}}},$$

(6)

where $N_{\text{salt}}$ is salt-soluble proteins content; $N_{\text{water}}$ is water-soluble proteins content.

Structure Formation Ratio (SFR) characterizes structural and mechanical properties of fish raw and is determined by the relation of salt-soluble proteins content to total proteins content in the farce system [17]:

$$\text{SFR} = \frac{N_{\text{salt}}}{N_{\text{total}}},$$

(7)

where $N_{\text{salt}}$ is salt-soluble proteins content; $N_{\text{total}}$ is total nitrogen content.

Organoleptic parameters of samples under research were brought into compliance with GOST 7631-2008. Fin-fish, non-finfish, and products from the same. Methods to determine organoleptic and physical parameters, according to which their texture, taste, smell, color, and appearance were assessed.

3. Results of Research and Their Discussion
We researched chemical composition of Alaska Pollock farce systems with amaranth and chickpea flour added in the proportion of 10.0% to the total raw mass input (Figure 1). As a control sample, we used Alaska Pollock’s ground muscular tissue.

![Figure 1. Chemical composition of Alaska Pollock farce systems](image-url)
Analysis of chemical composition of face systems we developed (Figure 1) showed that adding amaranth and chickpea flour results in increase of mass fraction of protein by 3.4%; of lipids, by 42.8%; of mineral substances, by 18.2 and 9.1%; carbohydrates, by 6.5% and 4.8% respectively as compared with Alaska Pollock’s ground muscular tissue. In combined farces, we detected at the same time decrease of water content by 9.0% and 6.8% respectively as compared with the control sample. Therefore, analysis of chemical composition of Alaska Pollock farce systems demonstrates that amaranth and chickpea flour improve their nutritional value.

To characterize the structural and mechanical properties of ground muscular tissue, a number of parameters were established: Protein-Water Ratio (PWR); Protein-Water-Lipid Ratio (PWLR); Lipid-Water Ratio (LWR); Lipid Ratio (LR); Structure Formation Ratio (SFR); Protein Ratio (PR); Water Content Ratio (WCR).

Based on the data of the chemical composition of Alaska Pollock farce systems, we calculated PWR (P/W), PWLR (P+L/W), LWR (L/W), LR (L/B) (Figure 2).

Protein-Water Ratio (PWR) of farce systems with added amaranth and chickpea flour is 0.2 (Figure 2), which is 1.2 times higher as compared with Alaska Pollock’s ground muscular tissue. According to the data from literature sources [18], the higher the PWR, the greater the plastic viscosity of farce systems. The comparative analysis shows that farces with plant-based additives are the best source among the samples available to obtain fish systems with good forming capability and better density.

Assessment of Protein-Water-Lipid Ratio (PWLR) showed (Figure 2) that is higher for the farces with added chickpea and amaranth flour 1.2 times on the average as compared with the control sample. Density and succulence of ground muscular tissue of fishes depends on PWLR; the higher the lipids content, the higher the succulence [18]; therefore, experimental samples have a more dense and succulent texture as compared with Alaska Pollock farce.

Lipid-Protein Ratio (LPR) (0.07) and Lipid Water Ratio (LWR) (0.013) of the combined farce systems are 1.4 times and 1.6 times higher respectively than that of Alaska Pollock’s ground muscular tissue. Lipid-Protein Ratio (LPR) and Lipid Water Ratio (LWR) are the parameters demonstrating the muscular tissue succulence and tenderness: the higher these parameters, the more tender and succulent the ground meat [16, 18].

![Figure 2](image_url)
During the experiments, we researched the fractional composition of proteins (salt-soluble, water-soluble proteins), as well as total nitrogen; we also calculated the Water Content Ratio (WCR), Structure Formation Ratio (SFR), Protein Ratio (PR) (Table 1).

| Farce systems                | \( N_{\text{total}} \) | Protein fractions content, % | PR          | SFR | WCR  |
|-----------------------------|-------------------------|-----------------------------|-------------|-----|------|
| Alaska Pollock farce        | 2.4                     | \( N_{\text{salt}} = 0.38 \) | 0.86        | 0.4 | 0.16 | 10.6 |
| Alaska Pollock farce + 10%  | 2.4                     | \( N_{\text{water}} = 0.98 \) | 0.75        | 1.3 | 0.4  | 7.2  |
| chickpea flour              |                         |                             |             |     |      |      |
| Alaska Pollock farce + 10%  | 2.4                     |                             | 1.0         | 0.73| 1.4  | 7.0  |
| amaranth flour              |                         |                             |             |     |      |      |

Structure Formation Ratio (SFR) and Protein Ratio (PR) demonstrate (Table 1) that their maximum values are observed for the farces with added amaranth and chickpea flour, being on the average 0.4 and 1.4 respectively. According to classification of L. Abramova (2005), E. Rambez, N.I. Rekhina (1980), ground muscular tissue with Structure Formation Ratio (SFR) over 0.2 and Protein Ratio (PR) over 1 is characterized by high structural and mechanical parameters, as well as good texture. According to this classification, by their Structure Formation Ratio (SFR>0.2) and Protein Ratio (PR>1), experimental samples belong to the group of raw materials used for production of fish farce; they possess good structure and forming capability as compared with the control sample.

As a result of research conducted, we revealed (Table 1) that Protein-Water-Content Ratio (PWCR) in the experimental samples (7.0 and 7.2) is on the average 1.5 times lower as compared with Alaska Pollock ground muscular tissue (PWCR=10.6). As it is known from literature [20], the lower the Protein-Water-Content Ratio (PWCR), the higher the content of bound water in the farce, as well as its elastoplastic properties, therefore, the samples with plant-based additives are characterized by a denser texture and elastic structure.

As a result of analysis of above ratios, it is worth noting that Alaska Pollock farces with added amaranth and chickpea flour demonstrate high structure-forming capabilities as compared with the control sample.

We researched the quality parameters characterizing rheological properties and water-retaining capacity of Alaska Pollock farce systems (Figure 3).
Analysis of rheological properties of Alaska Pollock farce systems (Figure 3) shows that maximum values of viscosity (55.1 and 54.8 Pa•s respectively) and adhesiveness (43.1·10^2 and 41.8·10^2 Pa respectively) are characteristic of farces with added amaranth and chickpea flour, in contrast to viscosity and adhesiveness values of Alaska Pollock ground muscular tissue (42.3 Pa•s and 31.8·10^2 Pa respectively). Increase of values of rheological properties in combined fish farces is due to the presence of protein-polysaccharide mixture in amaranth and chickpea flour, which takes part in formation of respective structure of food systems [11].

According to recommendations of E. Rambez, N. Rekhina (1980), farce systems with WRC over 55% may be applied to manufacture high quality food products. Fish farces with added amaranth and chickpea flour have WRC 63.3 and 61.9% respectively, which is 1.4 times higher as compared with the control sample (45.0%), which makes them suitable for wide use to manufacture various fish products.

Sensory evaluation is one of important components of functional and technological properties of farces. Experimental and analytical data characterizing high structural and mechanical properties of Alaska Pollock farce systems with added amaranth or chickpea flour are coherent with sensory parameters (Tables 2, 3).

Table 2. Sensory evaluation of farce systems from Alaska Pollock with added amaranth and chickpea flour

| Farce systems                  | Texture       | Appearance         | Color                     | Taste and smell                  |
|--------------------------------|---------------|--------------------|---------------------------|----------------------------------|
| Ground muscular tissue         | Watery mass   | Smooth ground mass | Light gray                | Typical of fish product          |
| with added 10.0% amaranth flour| Moderately dense, smooth ground mass | Light gray with yellowish shade | Typical of fish product with light nut flavor |
| with added 10.0% chickpea flour| Moderately dense, smooth ground mass | Light gray with yellowish shade | Typical of fish product with light nut flavor |

Table 3. Sensory evaluation of fish patties from Alaska Pollock with added amaranth and chickpea flour

| Farce systems                  | Texture       | Appearance         | Color                     | Taste and smell                  |
|--------------------------------|---------------|--------------------|---------------------------|----------------------------------|
| Ground muscular tissue         | Fluffy, crumbly | Surface cracked    | Light gray                | Typical of fish product          |
| with added 10.0% amaranth flour| Elastic, succulent, soft | Surface intact, oval shape | Light gray with yellowish shade with light nut flavor |
| with added 10.0% chickpea flour| Elastic, succulent, soft | Surface intact, oval shape | Light gray with yellowish shade with light nut flavor |

Summing up the above said, adding amaranth or chickpea flour in the proportion of 10.0% of raw mass input as part of Alaska Pollock farces production technology improves their sensory parameters. The sensory analysis (Table 2, 3) demonstrated that the farces we developed have a good forming capability, and the finished products have elastic, succulent, and soft texture, good appearance and nice fish aroma with light nut flavor.
4. Conclusion
As a result of scientific and technological research conducted, we managed to define a solid rationale for adding chickpea or amaranth-seed flour to the fish farce. Farce compositions from Alaska Pollock with added amaranth or chickpea flour in the proportion of 10.0% to the total raw mass input possess higher structural and mechanical properties, rheological properties and sensory parameters as compared to the control sample. We did not find any significant difference in the functional and technological properties of farce systems with structure-forming additives, which makes it possible to recommend both chickpea-seed and amaranth-seed flour. Manufacture of combined Alaska Pollock farces is reasonable and practicable, since it helps to enhance functional and technological properties of fish systems and make use of structure-forming additives of Russian origin.

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