Original article
UDK 664.953
https://doi.org/10.24143/2073-5529-2023-3-113-118
EDN DREQPZ

Functional and technological properties of dry fish vegetable concentrates

Ibrahim Koroma, Svetlana V. Zolotokopova✉, Bogdan E. Kovenkin, Elizaveta S. Pyanova

Astrakhan State Technical University,
Astrakhan, Russia, zotokopova@mail.ru✉

Abstract. The studies of the functional and technological properties of dry fish-vegetable concentrates (DFVC) justifing the technology of their use in food products are presented in the article. The important functional and technological properties that determine the consistency of products obtained by using dry concentrates are the degree of swelling and the kinematic viscosity of the mixtures. The samples for the study were dry fish vegetable concentrates from Sardinella (*S. maderensis*) based on minced fish fillet, minced fish fillet with carrots, minced fish fillet with corn flour and minced fish fillet with powdered okra. We studied the process of swelling of dry fish vegetable concentrate samples. According to the type of kinetic curves it was found that dry fish vegetables are characterized by limited swelling, which ends with the absorption of the solvent by natural biopolymers. In the course of the experiment it was found that the highest degree of swelling in dry fish vegetable concentrate was with okra (180%), the smallest – in dry concentrate from minced fish without herbal additives (140%). The degree of swelling of samples of dry fish and vegetable concentrate with okra and cornmeal is higher than that of dry fish vegetable concentrate with carrots. The highest kinematic viscosity was observed in solutions of DFVC with corn flour (3.03 mm^2/s and okra (2.86 mm^2/s), the lowest in the control sample without vegetable ingredients (2.21 mm^2/s). Thus dry fish concentrates with okra and cornmeal are recommended for use in the preparation of sauces, pureed soups and molded culinary products.

Keywords: sardinella (*Sardinella maderensis*), dry fish concentrate, cornmeal, okra, carrot, swelling, kinematic viscosity

For citation: Koroma Ibrahim, Zolotokopova S. V., Kovenkin B. E., Pyanova E. S. Functional and technological properties of dry fish vegetable concentrates. *Vestnik of Astrakhan State Technical University. Series: Fishing Industry*. 2023;3:113-118. (In Russ.). https://doi.org/10.24143/2073-5529-2023-3-113-118. EDN DREQPZ.

Научная статья

Функционально-технологические свойства сухих рыборастительных концентратов

Ибрахим Корома, Светлана Васильевна Золотокопова✉,
Богдан Евгеньевич Ковенькин, Елизавета Сергеевна Пьянова

Астраханский государственный технический университет,
Астрахань, Россия, zotokopova@mail.ru✉

Аннотация. Представлены исследования по определению функционально-технологических свойств сухих рыборастительных концентратов (СРК) с целью обоснования технологии их использования в пищевых продуктах. Важными функционально-технологическими свойствами, определяющими консистенцию продуктов, получаемых с использованием сухих концентратов, являются степень набухания и кинематическая вязкость растворов. В качестве образцов для исследования были выбраны сухие рыборастительные концентраты из сардинеллы (*Sardinella maderensis*) на основе фарша из филе рыбы, фарша из филе рыбы с морковью, фарша из филе рыбы с мукой кукурузной, фарша из филе рыбы с бамией. Изучен процесс набухания образцов сухого рыборастительного концентрата. По типу кинетических кривых установлено, что для сухих рыборастительных концентратов характерно ограниченное набухание, которое заканчивается поглощением растворителя природными биополимерами. В ходе эксперимента установлено, что наибольшая степень набухания у сухого рыборастительного концентрата с бамией (180 %), наименьшая – у сухого концентрата из рыбного фарша без растительных добавок (140 %). Степень набухания образцов сухого рыборастительного концентрата с бамией и кукурузной мукой выше, чем у сухого рыборастительного концентрата с морковью. Наибольшая кинематическая вязкость наблюдается у растворов СКР с кукурузной мукой (3,03 мм^2/с) и бамией (2,86 мм^2/с), наименьшая – у контрольного образца без растительных ингредиентов (2,21 мм^2/с). Таким образом, сухие рыборастительные концентраты с бамией и кукурузной мукой рекомендуются для использования при приготовлении соусов, супов-пюре и формованных кулинарных изделий.

Ключевые слова: сардинелла (*Sardinella maderensis*), сухой рыборастительный концентрат, кукурузная мука, бамия, морковь, набухание, кинематическая вязкость

Для цитирования: *Корома Ибрахим, Золотокопова С. В., Ковенькин Б. Е., Пьянова Е. С.* Функционально-технологические свойства сухих рыборастительных концентратов // Вестник Астраханского государственного технического университета. Серия: Рыбное хозяйство. 2023. № 3. С. 113–118. https://doi.org/10.24143/2073-5529-2023-3-113-118. EDN DREQPZ.

Introduction

According to national nutrition studies in Sierra Leone, there is a lack of protein consumption by the population [1-3], which necessitates improvement of raw material processing technologies and the expansion of the range of food products from low-value fish species [4, 5]. The priority direction of the state policy of Sierra Leone in the field of healthy nutrition of the population is the creation of a range of new food products that have the properties to improve human health in modern conditions [4]. One of the promising directions for solving these problems is the development of technologies based on the principles of food combinations for obtaining highly nutritious dry fish and vegetable concentrates intended for use in pasta, sauces and soups.

The most common fish caught in Sierra Leone rich in protein and available to the general population is the sardinella (*Sardinella maderensis*), and there is need to develop a processing technologies for which will ensure the food security of the country. Sardinella (*Sardinella maderensis*) refers to a high-protein raw material capable of forming thick plastic mixtures when crushed into minced meat [6].

The most common foods consumed in Sierra Leone on a daily basis and everywhere by all groups of children and adults include cereal products: corn, rice, bread, etc. In this group, cereal-based foods are most common, including soup concentrates, plassa (first and second lunch courses) [2]. Taking into account the traditions of Sierra Leone, in the consumption of soups and cereals, the use of dry fish vegetable concentrates enriched with micronutrients can make a significant impact to the deterrence of macro- and micronutrient deficiencies in children and adults [1, 7]. An important technological point in this case is to ensure the optimal distribution of ingredients of animal and vegetable origin to enrich the mass of the product and improve its organoleptic properties [8].

Okra, a readily available nutritious vegetable crop in Sierra Leone rich in various trace elements and polysaccharides, capable of forming viscous aqueous suspensions due to the content of mucous substances which is important in the preparation of soups and sauces.

Solving the problem of rational use of low-value fish raw materials involves the development of technologies for its complex processing into food products; in particular, dry fish vegetable concentrates that are stored for a long time and have a small weight, which allow them to be used by various groups of the population in areas with a lack of food resources and long trips.

There are no systematic studies of the functional and technological properties of dry fish and vegetable concentrates in literatures. The combination of fish raw materials and vegetable fiber in the composition of dry fish and vegetable concentrates pursues several important tasks:

– improving the organoleptic properties of the dry concentrate;

– formation of specified technological properties;

– increase in nutritional value, ensuring the physiological content of dietary fiber necessary to maintain the normal functioning of the digestive system [9].

Thus, the study of the functional and technological properties of dry fish concentrates to substantiate the directions of their use in food technology is an urgent and timely task.

Goal of the work – to study the functional and technological properties of dry fish vegetable concentrates in order to justify their use in food products. To achieve this goal, it is necessary to solve certain tasks:

– to substantiate the effect of vegetable raw materials in dietary fibers of fish raw materials in the composition of dry fish vegetable concentrates of various dispersions on their swelling in aqueous solutions;

– to investigate the kinematic viscosity of solutions of dry fish vegetable concentrates;

– to substantiate the promising directions for the use of the developed dry fish vegetable concentrate in the preparation and production of food products.

Objects and methods of research

The object of the study is dry fish vegetable concentrates (DFVC) from sardinella (*Sardinella maderensis*) based on minced fish fillet, minced fish fillet with carrots, minced fish fillet with corn flour, minced fish fillet with okra. To obtain dry fish vegetable concentrates, the fish was cut into fillets, which were then crushed on a cutter and mixed with corn flour or okra powder in a ratio of 3 : 1. Peeled carrots were passed through a cutter along with minced meat in a ratio of 1 : 3. Then the minced meat with vegetable components were dried at a temperature of 100 °C for 60 minutes.

In order to determine the ways of further use of dry fish vegetable concentrates, their functional and technological properties (swelling and kinematic viscosity) were studied. Experimental studies were carried out in the research laboratory of the department "Technology of goods and commodity science" of the Astrakhan State Technical University. The swelling of dry test samples was determined by the following method: identical weighed portions of the product (3 g) were placed in chemical beakers with a capacity of 100 cm^3, poured with distilled water in a ratio of 1 : 10 and kept at a temperature of 20 °C. At regular intervals of 20 minutes, the contents of the beakers were transferred to funnels with a folded filter and the solvents were allowed to drain to the last drop. The swollen samples were transferred to pre-weighed bottles and weighed. The degree of swelling of the samples were calculated using the following formula:

$$\alpha = (m - m_0) / m_0,$$

where α – degree of swelling; m – is the mass after swelling; m_0 – dry weight; or by the formula:

$$\alpha = (m - m_0) / m_0 \cdot 100,$$

where α – swelling percentage, %.

To determine the kinematic viscosity of the liquid a capillary glass viscometer type. VPZh-2 was used; the study was carried out in accordance with GOST 33768-2015 "Method for determining the kinematic viscosity and calculating the dynamic viscosity of transparent and opaque liquids" [10]. To obtain the necessary solutions for the study, all samples were crushed to 0.01 mm, weighed in 3 grams, mixed with 30 ml of water at a temperature of 100 ± 50 °C. The samples were infused for 10 minutes. To determine the kinematic viscosity of a liquid, the solutions were filtered through filter paper. Based on GOST, the essence of the method for determining the kinematic viscosity of a liquid is to measure the time of expiration of a certain volume of the test product under the influence of gravity with a glass capillary viscometer. The kinematic viscosity is calculated as the product of the measured product flow time and the viscometer constant. The kinematic viscosity of liquids show how easily a given substance is able to flow. The calculation of the kinematic viscosity of the liquid was carried out according to the formula:

$$V = (g / 9.807) \cdot T \cdot K,$$

where V – is the kinematic viscosity of the fluid in mm^2/s; g – is the acceleration due to gravity at the place of measurement in m/s; T – is the liquid outflow time in seconds; K – viscometer constant, 1.025 mm^2/s.

Research results and discussion

As a result of multifaceted research, the authors have developed a DFVC technology based on the complex processing of low-fat small fish raw material Sardinella in combination with vegetables. The study of the technological properties of DFVC and possible directions for their use in the food industry is an urgent task. It is necessary to provide a wide range of various high-quality products that retain the beneficial properties of natural products to the maximum, the nutrients of which are in an easily digestible form [11].

Table 1 according to the literature [12] shows the content of starch and dietary fiber in vegetables and cereals.

Table 1

The content of soluble and insoluble dietary fiber and starch in cereals and vegetables, g per 100 g products

Name of products	Dietary fiber				Starch
	Hemicellulose	Cellulose	Pectin	Total	
Corn flour	4.2	2.1	–	6.3	56.9
Okra	1.2	3.2	0.4	4.8	0.3
Carrot	0.3	1.2	0.6	2.1	0.2

Table 1 shows that corn flour contains the largest amount of starch, while okra contains more fiber. Considering that, a promising field of application of dry fish vegetable concentrates is the preparation of puree soups, sauces, pates, salad dressings, and mould culinary products. The functional and technological properties of the ingredients used have a great influence on the quality and organoleptic desirability of the finished products. The ability of dry fish vegetable concentrates to swell, regulate hydration, viscoelastic and adhesive properties play the role in solving certain technological problems, which affect the consistency and organoleptic characteristics of the finished product.

One of the most important indicators for assessing the quality of a dried product (material) is its reducibility, i. e. the ability to bind moisture and swell during cooking (soaking). This ability depends on the difference in the structure of the material, the content of hydrophilic colloids, osmotic active substances and a number of other reasons. With various methods and modes of preliminary heat treatment of raw materials, as well as with various methods and modes of drying, phenomena can occur that leads to denaturation of colloidal systems, changes in the structure of the material, its porosity (shrinkage), which changes the conditions for the penetration and binding of moisture inside a piece of dried product.

It is known that one of the most important indicators of quality assessment is the juiciness and consistency of reconstituted dry products which depend on swelling. In the course of the research the degree of dry fish swelling and vegetable concentrates were studied. Minced fish fillet (sardinella) without vegetable additives was taken as a control sample. The changes in the dry fish concentrate (DFC) and dry fish vegetable concentrates (DFVC) during swelling depending on time are shown in Table 2.

Table 2

Mass of samples of DFC and DFVC during swelling

Swelling duration, min	Mass of samples, g			
	DFC minced fish	DFVC from minced fish with corn flour	DFVC minced fish with carrots	DFVC minced fish with okra
0	1.0 ± 0.01	1.0 ± 0.01	1.0 ± 0.01	1.0 ± 0.01
20	2.2 ± 0.01	2.6 ± 0.02	2.5 ± 0.02	2.7 ± 0.01
40	2.3 ± 0.02	2.8 ± 0.01	2.6 ± 0.01	2.8 ± 0.02
60	2.5 ± 0.01	3.0 ± 0.02	2.8 ± 0.02	3.1 ± 0.01
80	2.5 ± 0.02	2.7 ± 0.01	2.6 ± 0.01	2.9 ± 0.02
100	2.4 ± 0.01	2.7 ± 0.02	2.5 ± 0.02	2.8 ± 0.01

Table 2 shows that the maximum change in mass occurs after 60 min of the experiment. The greatest change in mass is observed in samples with corn flour and okra. The lowest value is for the control sample of dry fish concentrate from minced fish without vegetable additives. The process of swelling of dry samples take place in two stages: penetration of the solvent into the product and direct swelling of the polymers [6, 8]. Native starch is practically insoluble in cold water and forms a suspension. However, it is hydrophilic and can absorb up to 30% of moisture by weight due to adsorption. Since the starch contained in corn flour and the fiber contained in okra are biopolymers, the mass of samples of dry fish concentrate with corn flour and okra changed more significantly than in the control sample from minced dry fish concentrate.

Table 3 shows the calculated degree of swelling of samples of dry minced fish and dry minced fish vegetable concentrates respectively.

Table 3

The degree of swelling of minced dry fish and minced dry fish vegetable concentrates

Sample	Sample weight before swelling, m_0, g	Sample weight after swelling, m, g	Swelling degree, α, g	Swelling percentage, α, %
DFC minced fish	1.0 ± 0.1	2.5 ± 0.1	1.4	140
DFVC minced fish with carrots		2.8 ± 0.2	1.5	150
DFVC from minced fish with corn flour		3.0 ± 0.2	1.7	170
DFVC minced fish with okra		3.1 ± 0.1	1.8	180

Table 3 shows that the highest degree of swelling of dry fish vegetable concentrate with okra (180%), the smallest in dry concentrate from minced fish without herbal additives (140%). The degree of swelling of samples of dry fish vegetable concentrate with okra and cornmeal is higher than that of dry fish vegetable concentrate with carrots. Since it is known that corn flour contains a large amount of starch and at high temperature starch is able to absorb water through adsorption and form structured systems. Okra contains a large amount of fiber and mucous substances represented by glycosaminoglycans which increase in volume when exposed to hot water.

When preparing soups, purees, sauces, molded culinary products, the ability of the system to gelatinization and the formation of viscous solutions is of great importance for the consistency of the product. Viscosity is the desired parameter, which is one of the fundamental qualities that characterize the flow behaviour. It is a measure of a fluid's ability to resist movement when shear stress is applied. The results of determining the fluid outflow time and kinematic viscosity are presented in Table 4.

Table 4

Kinematic viscosity of solutions of DFC and DFVC

Name of solutions	Liquid outflow time, s	Kinematic viscosity of liquid, mm^2/s
DFVC minced fish with okra	2.96 ± 0.02	2.86 ± 0.02
DFC minced fish	2.27 ± 0.02	2.21 ± 0.02
DFVC minced fish with carrots	2.41 ± 0.02	2.36 ± 0.02
DFVC from minced fish with corn flour	3.08 ± 0.02	3.03 ± 0.02

Table 4 shows that the kinematic viscosity of solutions of dry fish vegetable concentrates is higher than that of the control sample without vegetable additives. The highest kinematic viscosity is observed in solutions of DFVC with corn flour (3.03 mm^2/s) and okra (2.86 mm^2/s), the lowest in the control sample without vegetable ingredients (2.21 mm^2/s). Thus, dry fish concentrates with okra and cornmeal are recommended for use in the preparation of sauces, pureed soups and moulded culinary products.

Conclusion

Thus in the course of the research of the functional and technological properties of dry fish vegetable concentrates it was found that the process of DFVC swelling occurs in two stages: the penetration of the solvent into the product and the direct swelling of polymers, the largest mass of dry fish vegetable concentrate placed in an aqueous solution is achieved after 60 minutes of infusion. The use of vegetable raw materials increases the degree of swelling of the dry fish concentrate and the kinematic viscosity of its solutions. It has been confirmed that plant polysaccharides affect the kinematic viscosity of DFVC solutions, corn flour and okra have the greatest influence. The obtained research results can be used in the development of food production technologies using DFVC and allows developing the optimal parameters of the manufacturing process.

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The article was submitted 05.07.2023; approved after reviewing 20.08.2023; accepted for publication 11.09.2023
Статья поступила в редакцию 05.07.2023; одобрена после рецензирования 20.08.2023; принята к публикации 11.09.2023

Information about the authors / Информация об авторах

Ibrahim Koroma – Lecturer at the Department of Technology of Goods and Commodity Science; Astrakhan State Technical University; ibrahimkoroma@yandex.ru

Svetlana V. Zolotokopova – Doctor of Technical Sciences, Professor; Head of the Department of Technology of Goods and Commodity Science; Astrakhan State Technical University; zolotokopova@mail.ru

Bogdan E. Kovenkin – Postgraduate Student of the Department of Technology of Goods and Commodity Science; Astrakhan State Technical University; zotokopova@mail.ru

Elizaveta S. Pyanova – Master's Course Student of the Department of Technology of Goods and Commodity Science; Astrakhan State Technical University; Lizka.17102000@gmail.com

Ибрахим Корома – ассистент кафедры технологии товаров и товароведения; Астраханский государственный технический университет; ibrahimkoroma@yandex.ru

Светлана Васильевна Золотокопова – доктор технических наук, профессор; заведующий кафедрой технологии товаров и товароведения; Астраханский государственный технический университет; zolotokopova@mail.ru

Богдан Евгеньевич Ковенькин – аспирант кафедры технологии товаров и товароведения; Астраханский государственный технический университет; zotokopova@mail.ru

Елизавета Сергеевна Пьянова – магистрант кафедры технологии товаров и товароведения; Астраханский государственный технический университет; Lizka.17102000@gmail.com