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ТЕХНОЛОГИЧЕСКИЕ ПРОЦЕССЫ, МАШИНЫ И АППАРАТЫ ДЛЯ ПЕРЕРАБОТКИ ВОДНЫХ БИОРЕСУРСОВ

TECHNOLOGICAL PROCESSES, MACHINES AND APPARATUS FOR PROCESSING AQUATIC BIORESOURCES

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Technology and quality of dried-cured products from aquatic biological resources of polycomponent composition

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Abstract. The technology of chips production from aquatic biological resources of a polycomponent composition is considered, the formulations of minced meat and curing mixtures for their production are developed. An assessment of the quality of finished products was carried out. Chips were made from crushed tissues of hydrobionts. Recipes for minced meat for chips production were developed. It became possible to manufacture products with high nutritional value. Various salting mixtures were prepared for the processing the minced meat. The functional and technological properties of minced meat were improved. There were obtained products with a variety of organoleptic characteristics. Modes of exposure of minced meat in salted mixtures are substantiated: the ratio of minced meat and salted mixture is 2 : 1, the duration of salting is from 60 to 90 minutes (depending on the recipe of the minced mixture at a temperature of 15 °C). The modes of drying in a convection drying chamber at a temperature of 55 °C, air velocity of 0.8 m/s, air humidity of 50%, for 5-6 hours are substantiated. The chemical composition of the finished product was studied: it contained of 51.3-63.7% protein, 1.5-7.2% lipids, 0.4-2.5% carbohydrates, 15.3-19.4% minerals, 16.5-23.2% water depending on the formulation. The energy value of chips was determined: it amounted to 259.40-295.2 kcal. It is substantiated that he shelf life of chips packed in bags of polymeric materials under vacuum and without it does not exceed 6 months. The product was assessed by microbiological parameters and by the content of heavy metals, radionuclides, pesticides, and other chemical pollutants in it, which showed its compliance with the requirements and norms of the current technical regulation. The organization's standard for finished products STO 00471515-082-2020 “Dried-cured products from aquatic biological resources” was developed and approved.

Keywords: technology, fish chips, chemical composition, safety indicators

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Научная статья

Технология и качество сушено-вяленой продукции из водных биологических ресурсов поликомпонентного состава

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Аннотация. Рассмотрена технология производства чипсов из водных биологических ресурсов поликомпонентного состава, разработаны рецептуры фаршей и посолочных смесей для их производства. Проведена оценка качества готовой продукции. Чипсы изготавливали из измельченных тканей гидробионтов. В качестве сырья использованы различные виды рыб, рыбная икра, нерыбные объекты промысла (мидии, устрицы, креветка, осьминог, кальмар), морские водоросли. Разработаны рецептуры фаршей для производства чипсов, позволяющие получить продукцию с высокой пищевой ценностью. Подготовлены разные посольные смеси для обработки фаршей, позволяющие улучшить функционально-технологические свойства фаршевых систем и получить продукцию с разнообразными органолептическими показателями. Обоснованы режимы выдержки фаршей в посольных смесях: соотношение фарша и посольной смеси 2 : 1, продолжительность просаливания от 60 до 90 мин, в зависимости от рецептуры фаршевой смеси, при температуре 15 °С. Обоснованы режимы сушки в конвекционной сушильной камере при температуре 55 °С, скорости движения воздуха 0,8 м/с, влажности воздуха 50 %, в течение 5-6 ч. Исследован химический состав готовой продукции, который показал, что в ней содержится 51,3–63,7 % белка, 1,5–7,2 % липидов, 0,4–2,5 % углеводов, 15,3–19,4 % минеральных веществ, от 16,5 до 23,2 % воды в зависимости от рецептуры. Определена энергетическая ценность чипсов, которая составила 259,4–295,2 ккал. Обоснован срок годности чипсов, упакованных в пакеты из полимерных материалов, под вакуумом и без него, не превышающий более 6 мес. Проведена оценка продукции по микробиологическим показателям и по содержанию в ней тяжелых металлов, радионуклидов, пестицидов и других химических загрязнителей, которая показала ее соответствие требованиям и нормам действующего технического регламента. Разработан и утвержден стандарт организации на готовую продукцию СТО 00471515-082-2020 «Сушено-вяленая продукция из водных биологических ресурсов».

Ключевые слова: технология, рыбные чипсы, химический состав, показатели безопасности

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Introduction

The fishing industry produces a fairly diverse range of products from aquatic organisms which is constantly expanding. The innovations are being introduced into production, the quality of products is improving, which helps to increase consumer demand [1-3].

Undoubtedly purchasing capacity for dried-cured products from aquatic biological resources is growing. For its production the different types of fish, mollusks, crustaceans, and other aquatic organisms are used. There are dried-cured products of different shapes: in the form of sticks, medallions, plastics, straws, etc.

Drying is an ancient method of raw materials preserving in aquatic industries, which occurs as a result of contained moisture transfer in the semi-finished product into steam and its removal into the external environment. This operation makes it difficult for microorganisms to develop and the products get preserved for a long time. Dried products are made from chilled, frozen or salted raw materials, have a small amount of water and are characterized by a certain food specificity and taste, determined by pre-processing methods (salting, boiling, and baking).

Non-traditional types of finished products of this type include fish chips [4]. For their production the crushed raw materials are used which are the base to obtain minced fish intended for chips production. To do this different hydrobionts (in their chemical composition and the content of biologically active components) are combined [5]. The raw materials for the production of dried-cured products are mainly skinny fish species and other non-fish species that have a low fat content [6].

For the production of dried-cured products of a multicomponent composition based on minced meat compositions (in order to enrich this type of product with high-value proteins and polyunsaturated fatty acids) it is possible to obtain minced meat with minimal inclusion of raw materials with a high lipid content. For the rational use of hydrobionts, secondary food waste from cutting of various types of seafood (shrimp, mussels, squid, etc.) can also be added to the recipes [7]. Aquatic organisms modeling in formulations will contribute to the production of finished products with varied taste characteristics and high nutritional value [8-10].

In the process of chips production to pre-process the combined minced meat it is necessary to develop com-

positions for salting the semi-finished product, including natural flavoring and aromatic substances. There is also a need to improve and adjust the drying regime. Fulfillment of the assigned tasks will make it possible to obtain products with new organoleptic characteristics and will help to improve their quality and shelf life.

The goal of the study was to improve the technology of dried products of multicomponent composition and to evaluate their quality.

Objects and methods of study

For chips production the different types of raw materials were used in accordance with AUSS (all-Union State Standard) 32366-2013 "Frozen fish. Technical specifications"; Frozen Pacific herring according to AUSS 32910-2014 "Frozen herring. Technical specifications"; frozen Pacific salmon with spawning changes according to AUSS 32342-2013; Frozen Pacific squid according to AUSS 20414-2011 "Frozen squid and cuttlefish"; shrimp according to AUSS 20845-2017 "Frozen shrimp. Technical specifications"; mussels according to AUSS 32005-2012 "Boiled and frozen mussel meat. Technical specifications"; frozen octopus according to TS (Technical specifications) 15-01-212-80; oysters – raw according to TS 9253-044-33620410-04; frozen sea cabbage according to AUSS 31583-2012; frozen caviar according to TS 10.20.26-015-37676459-2019; Frozen salmon caviar according to AUSS 31793-2012; Frozen pollock caviar according to TS 9264-021-26191641-06.

In addition to the main raw materials the following auxiliary materials were used: table salt according to AUSS R 51574-2000 "Table salt. Technical specifications"; granulated sugar according to AUSS 33222-2015 "White sugar. Technical specifications"; ground paprika according to AUSS R ISO 7540-2008 "Ground paprika. Technical specifications"; dried ground coriander according to AUSS 29055-91 "Spices. Coriander. Technical specifications"; soy sauce according to AUSS R58434-2019 "Soy sauces. Technical specifications"; rice and apple cider vinegar according to AUSS 32097-2013 "Vinegars from food raw materials. Technical specifications"; Linden honey according to AUSS R 54644-2011 "Natural honey. Technical specifications"; lemon according to AUSS 4429-82 "Lemons. Technical specifications"; garlic according to AUSS R 55909-2013 "Fresh garlic. Technical /specifications"; ground red pepper according to STO 23613946-002-2009; dried parsley according to TS 10.39.13-710-37676459-2014 "Dried parsley (greens). Technical specifications"; curry seasoning according to AUSS ISO 2253-2015 "Curry powder. Technical specifications"; fresh onions according to AUSS 34306-2017 "Fresh onions. Technical specifications"; frozen lingonberries according to AUSS 33823-2016, AUSS 29187-91 "Quick-frozen fruits and berries. General technical specifications"; ginger according to AUSS ISO 1003-2016 "Spices. Ginger. Technical specifications".

The content of total nitrogen, minerals, and table salt was determined according to AUSS 7636-85 "Fish, marine mammals, marine invertebrates and their processed products (methods of analysis)". Determination of the mass fraction of lipids was carried out using the express method according to AUSS 28829-86. An ML-50 moisture meter was used to determine the mass fraction of water.

Chips were dried in convection dryer Tabai PERFECT OVEN – ORIGINAL PV-110.

Determination of microbiological parameters was carried out according to AUSS 10444.15-94, AUSS R 52816-2007, AUSS R 52815-2007, AUSS 29185-2014, AUSS R 52814-2007, AUSS R 51921-2002, AUSS 10444.12-2013.

The content of toxic elements was determined according to AUSS 26927-86, AUSS 26930-86, AUSS 26932-86, AUSS 26933-86, AUSS 30178-96, AUSS 30538-97, AUSS R 51301-99, AUSS R 51766-2001, AUSS R 51962-2002.

The content of nitrosamines was carried out according to MUK 4.4.1.011-93, the content of pesticides was according to MUK No. 2142-80 and MU 2482-81. The content of polychlorinated biphenyls was carried out according to MUK 4.1.1023-2001. Radionuclide content was carried out according to MUK 2.6.1.1194-2003. Determination of microbiological parameters – according to AUSS 10444.15-94, AUSS R 52816-2007, AUSS R 52815-2007, AUSS 29185-2014, AUSS R 52814-2007, AUSS R 51921-2002, AUSS 10444.12-2013.

Results and discussion

A technology for the production of chips from aquatic organisms was developed in the previous research. The technological process was carried out as follows: raw ice cream was defrosted in water (temperature was not higher than 20 °C) with a raw material to water ratio of 1 : 2. Then the raw materials were washed with clean, fresh water. The washed raw materials were kept in containers with perforated bottoms to allow dripping moisture to drain off. Thawed raw fish was cut up, non-food parts of the body, waste, entrails, blood clots, and black film were removed. The fish was cut into fillets without skin. Seafood and seaweed were cleaned of sand and foreign matter and washed with water.

The washed raw materials were sent for grinding on a grinding grinder with a grid diameter of 2-3 mm. It was experimentally determined that grinding raw materials less than 2 mm led to weight losses of the order of 8-11%. If the grating diameter was more than 3 mm, then acquiring the necessary structure for the product was difficult and the resulting finished product acquired a non-uniform structure.

Minced meat from raw materials for the production of chips was prepared according to the developed recipes (Table 1).

Table 1

Minced meat recipes for the production of chips

Components	Recipes, kg per 100 kg of raw materials														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Pollok	70	35	–	75	–	65	–	70	10	45	70	–	–	–	–
Cod	–	35	15	–	–	–	50	–	–	10	–	40	–	15	–
Mackerel	–	10	–	–	–	–	10	–	15	–	–	–	–	–	10
Saffron cod	–	–	15	–	–	–	10	–	–	–	–	10	–	15	–
Perch – greenling	–	–	15	–	–	–	10	–	–	15	–	–	–	–	–
Pacific herring	15	–	–	15	15	15	–	15	–	–	–	15	–	–	10
Pink salmon	–	–	10		10	–	–	–	20	–	–	10	10	15	–
Char	–	–	–	–	–	–	–	–	10	–	–	–	10	–	–
Chum salmon	–	–	–	–	10	–	–	–		–	–	5	10	–	15
Coha salmon	–	–	–	–	–	–	–	–	10	–	–	–	10	–	–
Red salmon	–	–	–	–	10	–	–	–		–	–	5	–	–	–
Squid	–	10	10	10	–	–	5	5	–	–	10	5	10	–	–
Shrimp	15	–	10	–	–	–	–	5	–	–	10	5	–	15	–
Mussel	–	–	5	–	10	20	–	5	–	–	10	–	10		–
Octopus	–	–	–	–	15	–	5	–	–	–	–	–	10	10	–
Oyster	–	–	–	–	–	–	10	–	10	10	–	–	–	–	10
Japanese kelp	–	10	10	–	10	–	–	–	5	–	–	5	–	15	10
Fucus	–	–	–	–	10	–	–	–		–	–	–	–	–	5
Nori	–	–	–	–	–	–	–	–	5	–	–	–	–	–	5
Chuka	–	–	–	–	–	–	–	–	5	–	–	–	–	5	5
Substandard salmon caviar	–	–	5	–	–	–	–	–	5	10	–	–	–	–	–
Pollock caviar	–	–	5	–	–	–	–	–	5	–	–	–	15	5	–
Herring caviar	–	–	–	–	5	–	–	–	–	–	–	–	15		–
Cod caviar	–	–	–	–	5	–	–	–	–	10	–	–	–	5	–

The minced meat was mixed for 10 minutes to give the minced meat mixture a uniform consistency.

The prepared minced meat was immediately sent for treatment with a salting mixture (Table 2) in order to increase water-binding capacity, viscosity, and stickiness.

Table 2

Recipes for salting mixtures for processing the minced meat intended for the production of chips

Components	Recipes, kg per 100 kg of raw materials			
	Recipe			
	No. 1	**No. 2**	**No. 3**	**No. 4**
Coriander	2.0	3.1	–	–
Ground red pepper	0.6	–	1.0	–
Paprika	3.1	–	2.5	2.0
Curry	–	4.0	–	–
Ginger	–	–	3.0	–
Dried parsley	–	0.4	–	–
Table salt	20.0	20.0	20.0	20.0
Sugar – sand	–	28.0	–	15.0
Fresh onion	–	–	–	8.0
Fresh garlic	–	9.5	5.5	–
Linden honey	26.5	–	27.0	–
Lemon juice	–	10.0	9.0	–
Frozen lingonberries	–	–	–	17.0
Soy sauce	48.0	–	32.0	25.0
Rice vinegar (4%)	–	25.0	–	–
Apple vinegar	–	–	–	13.0

The ratio of minced meat and salting mixture was 2 : 1.

To speed up salting, the minced meat was stirred periodically. Processing of minced meat with the salting mixture was carried out at a temperature of 15 °C. The duration of salting ranged from 60 to 90 minutes, depending on the recipe of the minced meat mixture. As a result of this processing, the forming ability of minced meat and the consistency of the finished product improved.

The prepared minced meat was sent for molding. The minced meat mixture was laid out on a layer of 0.3-0.5 cm thick, shaped into various shapes (triangular, oval, square, round, etc.) in the form of chips measuring of 2.0-5.0 cm in width, 3.0-6.0 cm in length and sent to the dryer. The duration of the drying process depended on the thickness of the semi-finished product layer; a thickness of more than 0.5 cm increased the drying process by 1.5-2 times.

Drying was carried out in a convection drying chamber at a temperature of 55 °C, air speed of 0.8 m/s, air humidity of 50%, for 5-6 hours. Removing the moisture at a given temperature contributed to the preservation of vitamins, preservation of the natural color, taste, and aroma of drying products. Properly dried products had a clean surface, a hard, dense, but not crumbly or hard consistency and a pleasant taste and smell characteristic of dried fish products.

After drying, the chips were kept in a chamber at a temperature of 15-20 °C for 1 hour to cool. The temperature of the chips after cooling was 20-25 °C. Then they were sorted, non-standard products were removed and sent for packaging.

The chemical composition and caloric content of the finished products were determined. Depending on the recipe, they contained 51.3-63.7% of protein, 1.5-7.2% of lipids, 0.4-2.5% of carbohydrates, 15.3-19.4% of minerals, 16.5-23.2% of water. The energy value of the chips varied from 259.4 to 295.2 kcal. Studies have shown that they can be classified as high-protein foods with low lipid content.

The development of regulatory documentation for finished products was carried out, and the organization standard STO 00471515-082-2020 “Dried products from aquatic biological resources” was approved.

The organoleptic and physicochemical characteristics of the chips met the requirements of the standard (Table 3).

Table 3

Organoleptic and physicochemical characteristics of the chips

Indicator	Characteristics
Appearance	The surface is dry, clean, without external damage and signs of mold
Color	From brown to straw in various shades or to light brown in various shades or to greenish brown
Consistency	Dense, firm, but not harsh
Smell and taste	Characteristic of this type of product, moderately salty with a pronounced aroma of spices, without the damaging odors of dampness and mustiness
Dimensions, mm	2.0-5.0 in width, 3.0-6.0 in length
Mass fraction of table salt, % no more	6
Mass fraction of moisture, % no more	30

The chips were packaged in polymer bags under vacuum and stored for 6 months at a temperature of 0-6 °C, humidity of 65-75%. Microbiological parameters were determined every month. Studies have shown that during the entire storage period in chips, the quantity of mesophilic aerobic and facultative anaerobic microorganisms (QMAFAnM) did not exceed the maximum permissible level ($5.0 \cdot 10^4$ CFU/g) and ranged from $2.7 \cdot 10^3$ to $1.5 \cdot 10^4$. Tests of chips for the content of coliform bacteria (coliforms), *S. aureus*, sulfide-reducing clostridia, Salmonella yeast, and mold fungi showed a negative result (Table 4).

Table 4

Microbiological indicators of chips

Indicator	Acceptable indicators	Determined indicators
Qualntity of mesophilic aerobic and facultative anaerobic microorganisms (QMAFAnM), CFU/g, no more	$5 \cdot 10^4$	from $2.7 \cdot 10^3$ to $1.5 \cdot 10^4$
Coliform bacteria (coliforms), not allowed in the product mass, g	0.1	Not detected
Staphylococcus aureus (*S. aureus*), not allowed in the product mass, g	1.0	
Sulfite-reducing clostridia, not allowed in the product mass, g	1.0	
Pathogenic agents, including salmonella and *L. monocytogenes*, not allowed in the mass of products, g	2.0	
Mold, CFU/g, no more	50	
Yeast, CFU/g, no more	100	

The presence of chemical contaminants such as heavy metals, polychlorinated biphenyls, nitrosamines, pesticides, and radionuclides was determined in the chips. All indicators did not exceed the maximum permissible standards (Table 5).

Table 5

Chips safety indicators

Indicator	Permissible content level, mg/kg, (for radionuclides – Bq/kg), no more	Determined content level, mg/kg, (for radionuclides – Bq/kg), no more
Toxic elements: lead; arsenic; cadmium; mercury	 1.0 5.0 0.2 0.5	 0.16 ± 0.05 0.014 ± 0.01 not detected not detected
Histamine	100 (mackerel, salmon, herring)	30 (mackerel, salmon, herring)
Nitrosamines: sum of NDMA and NDEA	 0.003	 0.001
Dioxins	0.000004	–
Pesticides: hexachlorocyclohexane (α, β, γ-isomers); DDT and its metabolites	 0.2 0.4 2.0 (salmon, fatty herring)	 not detected not detected
Polychlorinated biphenyls	2.0	not detected
Radionuclides: cesium-137; strontium-90	 260 –	 not detected not detected

The shelf life of chips packaged in bags made of polymer materials has been determined. In months, no more than: 1 – at a temperature from 0 to +6 °C; 4 – at temperatures from 0 to –8 °C; 5 – at a temperature not higher than –18 °C.

Shelf life of chips packed in polymer bags under vacuum, in months: no more than: 3 – at a temperature from +2 to +20 °C; 6 – at temperatures from 0 to +6 °C.

Shelf life is recommended for storing the finished products at a relative air humidity of 65-75%.

Conclusion

Thus the technology of hydrobiont chips based on combined minced meat has been improved. Kinds of minced meat have been developed for the production of dried-cured products, which provide for the combination of several types of aquatic organisms, which makes it possible to increase the nutritional value and diversify of the organoleptic characteristics of the finished product. New compositions of salting media have been developed for pre-processing minced meat, helping to improve the rheological and organoleptic characteristics of the minced meat system. The duration of preliminary exposure of minced meat in salting media before molding was experimentally determined to be 60-90 minutes at a temperature of 15 °C.

The modes of drying chips were substantiated. Based on research results the following drying regime for dried-cured products from aquatic biological resources is recommended: air speed – 0.8 m/s, humidity – 50%, temperature – 55 °C, at which the average drying time for chips is 5-6 hours.

The shelf life of chips packed under vacuum and without it has been experimentally determined not more than 6 months.

An assessment of the quality and safety of the finished product showed its compliance with the requirements and norms of the current standard and technical regulations.

STO 00471515-082-2020 “Dried products from aquatic biological resources” has been developed and approved.

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