UDC 664.95.013.022–025.12:005.591.6

JUSTIFICATION OF THE INNOVATIVE METHOD OF THE FISH RAW MATERIALS PRELIMINARY PROCESSING

N. Kushnyrenko, Ph.D, Associate Professor
A. Palamarchuk, Ph.D, Associate Professor
S. Patyukov, Ph.D, Associate Professor
Department of meat, fish and seafood technology
Odessa National Academy of Food Technologies
112, Kanatnaya, Street, Odessa, Ukraine 65039

DOI: https://doi.org/10.15673/fst.v15i2.2106

Article history

Received 07.11.2020
Reviewed 18.12.2020
Revised 21.04.2021
Approved 08.06.2021

Correspondence:

A. Palamarchuk
E-mail:
anna.palamarchook@gmail.com

Cite as Vancuver style citation

Kushnyrenko N, Palamarchuk A, Patyukov S. Justification of the innovative method of preliminary processing of fish raw materials. Food science and technology. 2021;15(2):103-111. https://doi.org/10.15673/fst.v15i2.2106

Цитування згідно ДСТУ 8302:2015

Kushnyrenko N., Palamarchuk A., Patyukov S. Justification of the innovative method of preliminary processing of fish raw materials // Food science and technology. 2021. Vol. 15, Issue 2. P. 103-111 https://doi.org/10.15673/fst.v15i2.106

Abstract. The scientific article presents experimental data on the modification of the generally accepted traditional preliminary heat treatment technology of freshwater fish raw materials. The technology is applicable in the production of canned fish. To achieve this aim the innovative method – dehydration with hydrochloric acid – was developed. The object of research – silver carp is the most important object of aquaculture and industrial fish farming in Ukraine and many other countries. Technological and rheological features of silver carp muscle tissue require decrease the moisture content. Heat treatment is traditionally used for it. Required effed is achieved by denaturing proteins at a temperature rise of 95 ° C. Heat treatment is energy intensive and therefore ineffective in terms of cost. Modification of preliminary treatment of fish industry raw materials is a promising direction in the production of canned fish. It is necessary to develop and introduce a new innovative energy-saving method of processing semi-finished products at fish processing enterprises. The article presents data on the effect of hydrochloric acid solution on the properties of silver carp muscle tissue. Regulation of moisture binding capacity is possible by shifting the pH to the isoelectric point of muscle proteins. At the same time, the moisture binding capacity is reduced. The influence of the most important parameters of technological process was investigated. These parameters influence the active acidity of the muscle tissue and, therefore, the moisture binding capacity. There were established the following technological parameters: mass fraction of hydrochloric acid – 0.1%, processing temperature 20–25°C, hydromodule (raw material to solution ratio) – 1:10, processing time – 30 minutes. The implementation of the developed innovative method of pretreatment makes it possible to bring the pH of muscle tissue closer to the isoelectric point of the proteins. This, in turn, ensures the minimum values of the moisture binding capacity. Based on the obtained data, a technological process of preliminary processing of fish raw materials in the production of canned fish has been developed. The use of this method allows us completely eliminate energy-intensive thermal operation from the technological cycle and significantly increase economic efficiency.

Keywords: fish, moisture holding capacity, acid treatment, canned food.

Introduction. Formulation of the problem

Fish is one of the most important sources of human protein nutrition, constitutes the most important part in aquaculture and mariculture and can be considered as a promising source of proteins and other nutrients. Fish and seafood make up to 20% of all animal protein consumed in food. The main dietary value of fish is easily digestible protein. The protein content in the muscle tissue of fish varies from 10 to 25% [1, 2]. Fish food is digested and absorbed much easier in the human body than animal meat, which is due to the peculiarities of the structure of fish tissues. In the muscles of fish, the connective protein of the stroma – collagen, is 6 times less than in land animals [3].

The production of sterilized canned food is one of the main areas of food use of fish raw materials and seafood due to the versatility and high profitability of finished products, long shelf life, as well as the improving the taste of raw materials [4]. Despite the successive heat treatment during sterilization, semi-finished products for canned food (main raw materials, fillings and side dishes) are also subjected to preliminary heat treatment. At present, in the market of canned fish a significant part belongs to the products where the semi-finished product undergoes preliminary heat treatment (PHT). This method of preparation of the semi-finished product allows to improve the quality of raw materials and its nutritional value in the manufacture of canned food even from low-value fish species.

The main task that must be solved during the preliminary technological treatment is the removal of excess moisture from the raw material [5]. Since the methods of decreasing the moisture-binding capacity, generally accepted in the food and, in particular, in the canning industry, are highly energy-consuming, the search for new methods for solving this problem is highly relevant [6, 7].

Analysis of recent research and publications

The main types of preliminary heat treatment include blanching, drying, smoking, frying, for which in the industry they use a variety of heat carriers (steam, water, air, IR - energy) [8]. The tasks pursued during the PHT is to increase the nutritional value of the product; remove air and other gaseous substances from muscle tissue; inactivate enzymes; reduce the moisture content or increase the weight of the semi-finished product (when using dried raw materials); remove volatile sulfur-containing compounds (to avoid the formation of sulfide compounds on the metal of container); give the product specific taste; reduce the initial microbial contamination of the semi-finished product.

Particularly important is the PHT stage in the production of canned food from new types of fish, since it allows you to significantly adjust the natural properties of raw materials. For example, removing excess moisture from fish prevents its increased separation during sterilization, which, in turn, avoids such defects in canned food as increased sediment in oil or changes in the standard concentration of filling, as well as the normalized ratio of components. At the same time, excessive dehydration of a semi-finished product can lead to a canned product with a dry and fibrous structure.

PHT is associated with the removal of a significant amount of moisture, which is necessary, in addition to the above purposes, also to ensure high quality of canned fish in fillings. For example, in the case of canned fish in oil reduces the amount of sludge, and canned in tomato sauce will not dilute the tomato sauce.

However, despite all the positive features of PHT, it has a significant disadvantage – a fairly large expenditure of energy and time. So, much attention is paid to the development of methods and modes of preliminary heat treatment of various fish species [9-11]. Therefore, an urgent problem for fish canning production in Ukraine is the development of new methods of pre-dehydration in order to replace traditional energy-intensive methods of preliminary heat treatment.

This necessitates the development of alternative PHT methods that can replace existing ones. For this, it is important to reduce the moisture-binding capacity of proteins, reduce the moisture content in the fish muscles, soften bone tissue, and suppress the growth of pathogenic and putrefactive microflora. In this case, the chemicals used must be safe for human health. The use of food acids in combination with heat is very promising for this [12,13].

The use of food acids to regulate the moisture-binding capacity is based on the acid-base properties of proteins. Among food acids, hydrochloric acid seems to us the most promising. It is this acid that is present in human gastric juice, therefore its use in concentrations close to the concentration in gastric juice will not lead to the formation of any potentially hazardous reaction products. This acid is cheap, readily available and approved for use in the food industry [14].

Regulation of water-holding capacity (WHC) for technological purposes. Various methods are used to reduce the WHC index of muscle tissue, in particular, the effect on it of sodium chloride, sucrose, enzyme preparations, and polyphosphates [15-21].

The expansion of the raw material base and the improvement of the hydrobionts processing technology requires the development of technological methods that allow not only to stabilize, but also to correct the WHC.

Studies [22-25] of the technological features of deep-sea fish with a high WHC have shown the need to include in the technological scheme the operation of partial dehydration of their meat. For this, minced meat or fish pieces was dehydrated by draining, pressing or centrifugation. In this case, it is necessary to remove 35–40% of tissue juice. To bind the remaining moisture of minced meat or fish pieces, it is recommended to add a mixture consisting of the enzyme amilorizin (0.1% by weight of meat) and salt (1.5% by weight of meat). This method of fish processing with watered muscle tissue avoids high protein losses during processing and a decrease in the nutritional value of the product.

Calcium chloride has also been used to regulate the WHC of proteins in salted semi-finished products [15-18]. The author claims the effect of divalent metal salts on the degree of protein hydration. In addition, it proves its effectiveness in reducing the water-slurry ratio and accelerating the moisture release during drying. In a number of such studies, solutions of glucose, salts, ethanol, and anhydrous lactose were used.

Changes in the WHC of the muscle tissue of the lemonema range from 65.5% to 61.0%. The percentage depends on the concentration of the fixing solution and the processing time. The amount of squeezed liquid decreased most sharply when the lemonema was treated for 5 minutes in a 0.5% solution of calcium chloride. This indicates a significant increase in the WHC of the tissue. An increase in the treatment time of the samples to 10 min did not have a noticeable effect on the amount of squeezed liquid [22].

Another way to thicken meat and influence the WHC is to shift the pH of the meat to a region close to isoelectric. In IEP, muscle tissue has maximum density and minimum hydration. To reduce the pH of the lemonema meat, it was proposed to treat it with a 0.2% citric acid solution. As a result of such treatment, the

WHC of the muscle tissue of lemonema increases, but to a lesser extent than when it is treated with a solution of calcium chloride [24].

To increase the WHC of the muscle tissue of fish with an increased moisture content, it was also proposed to process it in a cold state with a 1% mixture of salt and sugar [26].

Fillet salting in a warm saline solution at ambient temperature reduced the moisture yield of saberfish and macrourus specimens by 5.4 and 3.6%, respectively. The moisture yield of muscle tissue decreased more significantly when fish was salted at a temperature of 8°C and an acetic-salt solution – by 11% – for saberfish and by 10.9% – for macrourus.

However, when processing fish with high humidity, it is not always advisable to increase the WHC of its muscle tissue.

For example, in experiments on the preparation of canned food from macrourus it was found that the greatest preservation of the integrity of the structure of muscle tissue after its blanching with steam was achieved with the maximum yield of moisture (28–30%). At the same time, the WHC of muscle tissue decreased when it was treated in a 1% citric acid solution [24].

There are a significant number of compounds that cause a change in the conformation of proteins. However, the choice of chemical modifiers for use in the manufacture of products with controlled moisture content is very limited. This is explained by the fact that the main characteristic of these compounds should be absolute harmlessness to the human body [27].

The use of chemical methods for removing moisture from raw materials excludes processing in devices that consume a significant amount of electricity. But at the same time, there are difficulties associated with the specificity of operations. This involves the installation of non-standard equipment; the need to remove a dehydrating equipment from the system, which can have an undesirable effect on the taste of the finished product.

The ratio of hydrophilic and hydrophobic radicals on the surface of a protein molecule can be varied by influencing its molecular environment. Structural changes in protein molecules also can be achieved using various chemical compounds.

When developing a technology for the production of canned fish according TINRO studies, citric acid and calcium chloride were used. The test samples had a high moisture content (over 83%) and a weakened muscle tissue structure. This makes it difficult to use them for the preparation of canned food by traditional technology [24,28].

The conformational changes of proteins under the influence of CaCl2 when obtaining fish products with controlled moisture content were studied [158]. It was found that low concentrations contribute to a slight increase in the WHC of proteins. With an increase in concentration in muscle tissue up to 0.5%, a decrease in the WHC of proteins by 8–12% occurs.

The decrease in the WHC of muscle proteins can be caused by two reasons. The first reason is the competition between the introduced ions and the protein for water molecules. The second reason is the screening of fixed charges and polar groups of macromolecules as a result of the appearance of salt-like bonds between the hydrophilic groups of the protein and inorganic ions. The authors made the following conclusion: a significant decrease in the solubility of proteins in the muscle tissue of fish is facilitated by their interaction with table salt, which occurs during the preparation of a salted semi-finished product.

The effect of alkaline and acid treatment on the functional properties and color of the meat of Monterei sardines (Sardinops sagax caerulea) has been studied [29]. A change in pH during washing of chopped sardine meat strongly affects the composition, color, and the ability to gel. The best results in terms of gelling ability were obtained at pH 6.7.

A similar method of pretreating mackerel before smoking was developed in Japan [30]. In the process of exposure to salt, mass fraction of 10%, and acetic acid, mass fraction of 4.2%, no proteolytic breakdown of muscle proteins was observed.

Research results have shown that structural changes in mackerel muscle tissue, caused by the deposition of a significant amount of sarcoplasmic proteins, lead to an increase in the shelf life of fish. In this case, the mackerel was treated with salt and vinegar.

A new method of hot smoked fish cooking in production conditions was developed and tested [20,21]. Based on the proposed data, it was established that acetic acid has a positive effect on the rheological properties of herring muscular tissue.

Thus, for different types of fish, it is necessary to apply different methods of pretreatment, reducing or increasing the WHC. This is due to the specificity of the biochemical properties of muscle tissue proteins.

Thus, the problem of dehydration of fish raw materials without high-temperature processing has not yet been resolved. The method of chemical treatment with the use of hydrochloric acid seems to be promising for pre-dehydration of fish semi-finished products in canned fish production.

The purpose of the research is to develop a method of pre-dehydration of fish raw materials by investigating the effect of acid treatment on the properties of fish muscle tissue for canned fish production.

In accordance with the goal, it is necessary to solve the following objectives:

- to investigate the influence of technological parameters on the active acidity (pH) of fish muscle tissue;

- to investigate the technological parameters that affect the water holding capacity (WHC) of muscle tissue of fish;
- to develop technological methods for removing moisture.

Research materials and methods

The object of the study was the bighead carp (Hypophthalmichthys nobilis) with mass in the range 1,5-2,0 kg. The fish was in a chilled state with a temperature of +2–+4°C, the period elapsed from the moment of catch was 24–36 hours. For the experiment, the fish was gutted, scales, head, tail, and fins were removed. From fish carcasses, pieces weighing 80-90 g were cut out for further research.

Hydrochloric acid of chemically pure grade produced by Merck Life Science LLC was used as a chemical acid.

The moisture content was determined by drying at 105°C to constant weight [31].

The pH was determined by a potentiometric method using glass electrodes using standard method (GOST 7636-85 Ryiba, morskie mlekopitayuschie, morskie bespozvonochnyie i produktyi ih pererabotki. Metodyi analiza).

For experimental studies, the samples were prepared as follows. A chilled specimen of silver carp was washed, cut, entrails and bone tissue were removed, the prepared fillet was portioned into pieces of sizes that corresponded to the geometric dimensions of a can. Portioned fillet pieces were treated in a model environment with acid solutions.

The water holding capacity (WHC) was determined by the Grau-Hamm pressing method [32].

In this work, we used mathematical processing of the experimental data obtained for each experimental samples 3 replicates (n = 3), with a relative experimental error (Ɛ = 0.5%).

Results of the research and their discussion

During developing a method of pre-dehydration of fish raw materials, the main attention was paid to the possibility of changing the moisture loss of muscle tissue at different pH values.

Numerous studies have shown that the maximum moisture loss is observed at the pH of isoelectric point, which for most fish proteins is in the range from 5.1 to 5.6 [14,20]. The point of minimum moisture retention corresponds to the point of maximum moisture loss. It is also located at the isoelectric point. It confirms that pH value is the important factor that can contribute to dehydration of fish muscle tissue.

Therefore, the first stage of research was to determine the effect of pH on the change in the moisture holding capacity of muscle tissue.

Due to the peculiarity of the muscle tissue of fish to lower the pH when treated with acid solutions, it was essential to determine the processing time, which will reduce the pH, and ideally – to reach its isoelectric point.

During the experiment, 0,007 N hydrochloric acid was used (the pH of the solution was 2,3), the hydromodule was 1:10, the treatment time was 10, 20 and 30 minutes, temperature was 20°C. Such a concentration of hydrochloric acid solution is close to the average concentration of this acid in the human stomach. This ensures the safety of the reaction products. With a hydromodule of 1:10, complete coverage of fish pieces with a solution is ensured and at the same time rational use of the volume of technological equipment is provided.

At these points, the pH value of the solution and muscle tissue was recorded. The results of the experiment are shown on the Fig. 1.

The data presented on the Fig. 1 shows that the minimum and maximum pH of the active solution was observed for 10 and 30 minutes, respectively, and was equal to 3.0 and 3.6. At the same time, the pH value of muscle tissue was maximum after 10 minutes of treatment (5.9) and minimum - after 30 minutes (5.5). The decrease in the pH of fish muscle tissue occurs most dramatically at the beginning of the process. Then the rate of decline slows down, since the buffering properties of sarcoplasmic proteins of fish muscle tissue begin to appear. As hydrochloric acid is consumed to acidify the muscle tissue of the fish, the pH of the solution increases. The pH increased by 1.3 over the acid treatment period of 30 minutes (Fig. 1).

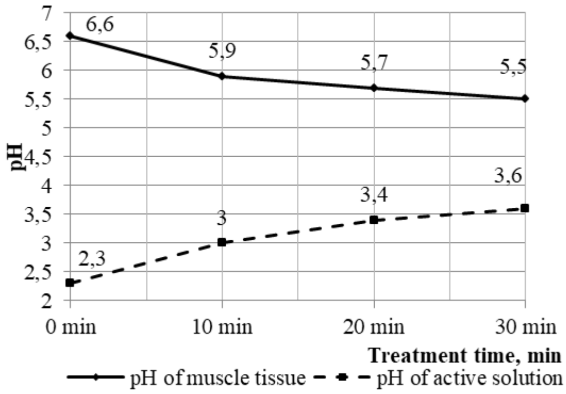

Fig. 1. The effect of treatment time on pH of muscle tissue and active solution

Temperature significantly affects the course of chemical reactions. According to Van't Hoff's rule, rate constant of homogeneous elementary reaction increases two to four times when the temperature rises for each 10 degrees.

In addition to the abovementioned, in the production of various fish products it is necessary to control the temperature of the processes, because the raw material is perishable, and is subject to intense exposure to various microorganisms, as well as due to physicochemical characteristics of fish muscle tissue.

The intensity of treatment of fish with acid solutions should also depend on temperature.

Therefore, the influence of temperature in combination with other technological parameters was studied. As a result, the hydromodule was taken into account, which was 1:10, the pH of the acid was 2.3, the acting time was 10, 20 and 30 minutes. At these parameters, the pH value of the solution and of muscle tissue was recorded. The results of the experiment are shown on the Fig. 2 and Fig. 3.

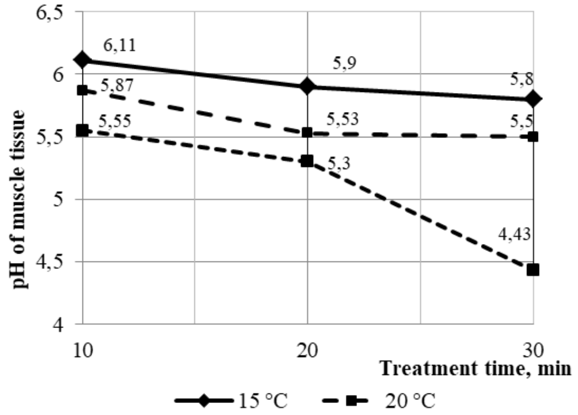

Fig. 2. The effect of treatment time on pH of muscle tissue at different temperatures

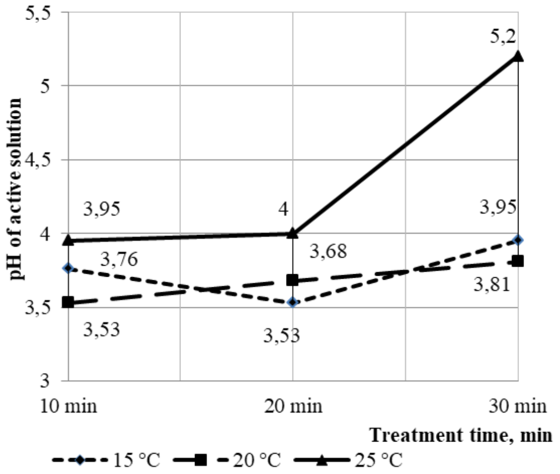

Fig. 3. The effect of treatment time on pH of active solution at different temperatures

The data presented on the Fig. 2 and Fig. 3 shows that the minimum pH value of muscle tissue was reached at 25°C for 30 minutes and was 4.43, the maximum at 10°C for 10 minutes; at the same time, the smallest (3.24) and largest (5.2) pH values of the active solution were reached at 15°C for 30 minutes and at 25°C for 30 minutes, respectively.

Hydromodule - the mass ratio of solid and liquid fraction is important in the processing of food in different solutions. This is due to physico-chemical and economic aspects. Therefore, the effect of the hydraulic module in combination with other technological parameters on the change in pH was studied.

The experiment used hydrochloric acid, the pH of the solution of which was 2.3, the processing temperature was fixed at 25°C, the treatment was carried out for 30 minutes. The research results are shown in Table 1.

Table 1 – Changes in the pH of bighead carp muscle depending on the hydromodule (n=3, $p \leq 0.05$)

Hydromodule	pH of acid	τ, min	t, °C	pH of muscle tissue
1:8	2.3	30	25	5.95±0.05
1: 9	2.3	30	25	5.7±0.05
1:10	2.3	30	25	5.1±0.05

The acid added to the pieces of fish is used to dissolve bone minerals and to neutralize alkaline radicals of protein polypeptide chains. After that, the protons of the acid cause a decrease in pH. Table 1 shows that the pH of muscle tissue has the highest value of 5.95, at the hydromodule 1: 8, which is far from the isoelectric point of most fish proteins, and the lowest, which is as close as possible to the isoelectric point, and equal to 5.1 – with a hydromodule1:10. As you can see, the pH of the fish muscle tissue decreases with the growth of the hydromodule. Nevertheless, we made a decision not to increase the hydromodule above 1:10, since this will require an increase in the volume of reaction tanks and an increase in the need for the working area of the enterprise. All this would inevitably lead to a decrease in the economic efficiency of the projected enterprise.

It is well known that with increasing of acid concentration, the pH of the solution decreases, so, studying the effect of pH on the water holding capacity, it was necessary to monitor how the acid concentration affects the pH change.

Hydrochloric acid with a mass fraction of 0.03, 0.07 and 0.1% was used in the studies, the processing time was 30 minutes, the processing temperature was 25°C, the hydromodule was 1:10. The results of the experiment are shown on Fig.4. Such a range of acid concentrations is selected based on the concentration of hydrochloric acid in the human stomach under various physiological conditions. The maximum value corresponds to the concentration of acid on an empty stomach, the minimum value - after eating. We decided not to exceed the concentration above the physiological value in order to guarantee the safety of the reaction products.

As can be seen from Fig. 4, the pH of muscle tissue after acid treatment corresponds to the literature data of the electrical point of most fish proteins at a mass fraction of hydrochloric acid in the range from 0.07 to 0.1%.

Thus, as it can be seen from the above data, the pH of bighead carp muscle tissue corresponds to the isoelectric point of fish proteins in the temperature range of 20–25°C, at a hydromodule 1:10, time of treatment – 30 minutes, with a mass fraction of hydrochloric acid of 0.1%, and to a lesser extent 0.07%.

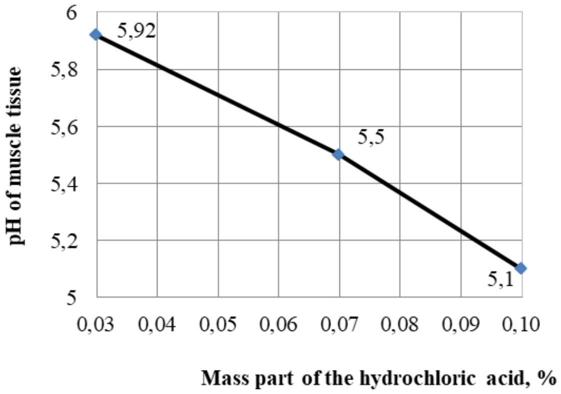

Fig 4. Changes in the pH of muscle tissue of bigheah carp depending on the mass fraction of hydrochloric acid in acting solution

Since the main purpose of this work is to develop a method of pre-dehydration of fish raw materials and optimize the process, after the stage of preliminary research it was necessary to determine the influence of various technological parameters affecting the WHC of muscle tissue of fish during acid treatment. Thus, the purpose of research at this stage was to study the influence of technological parameters of acid treatment, at which the WHC will have a minimum value. At acid dehydration of fish semi-finished product it was necessary to regulate the following parameters: temperature of acid solution, duration of processing and hydromodule. Three series of experiments were performed, each of which used hydrochloric acid of different concentrations - 0.03%, 0.1% and 1%. The hydromodule in all experiments was 1:10, because the results of previous studies showed that these values are optimal for achieving muscle tissue isoelectric point, and, consequently, maximum moisture losses. The semi-finished product was treated in an acid solution at a temperature of 15, 20 and 25°C. The treatment time was 10, 20 and 30 minutes. The WHC of fresh fish was previously measured, which was 78.0%. In the first series of experiments, hydrochloric acid with a mass fraction of 0.03% was used. The research results are shown in Fig. 5.

It is seen that with increasing temperature of the active solution and the duration of incubation, the value of the WHC decreases and reaches its minimum value (61%) after 30 minutes at 25 °C.

In the second series of experiments, the mass fraction of hydrochloric acid was equal to 0.1%. The research results are shown in Fig. 6.

From Fig. 6 it is seen that value of the WHC decreases with increasing of the temperature of the active solution and the duration of treatment time and reaches its minimum value (59.8%) in 30 minutes at 25°C.

A further increase in the time of treatment of muscle tissue is not reasonable, since the experimental value of WHC correlates with the values of a semi-finished product obtained when using traditional preliminary heat treatment. It allows to obtain finished products - canned fish with quality indicators in complying to standard requirements. In addition, an increase in time will lead to a decrease in the economic efficiency of the process.

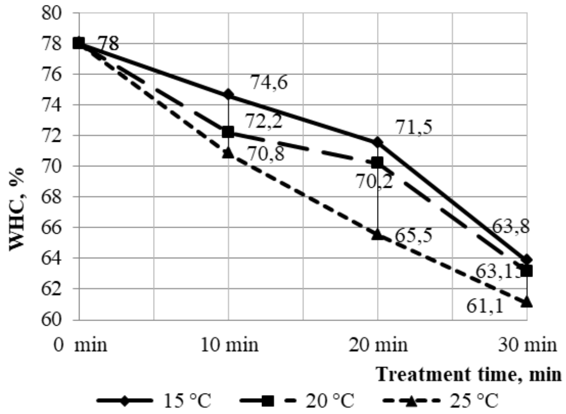

Fig. 5. Changes in water holding capacity as function of treatment time (C_{HCl} = 0.03%)

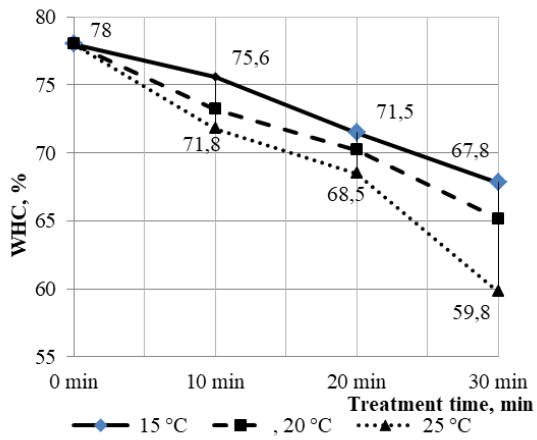

Fig. 6. Changes in water holding capacity as function of treatment time (C_{HCl} = 0.1%)

In the third stage of the experiment the concentration of hydrochloric acid was 1%. The results are shown at Fig. 7.

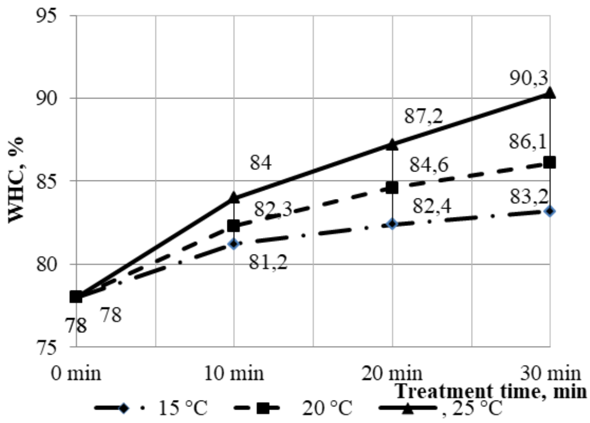

Fig. 7. Changes in water holding capacity as function of treatment time (C_{HCl} = 1%)

The value of the WHC is increasing wit increase of treatment time and temperature and reaches its maximum (90.3%) in 30 minutes at 25°C.

The use of the 1% solution of hydrochloric acid is not rational, as it significantly increases the WHC of muscle tissue, because muscle tissue swells and retains a significant amount of water. An increase in the concentration of hydrochloric acid in the active solution leads to a shift in the pH of the fish muscle tissue far from the isoelectric point, while the protein molecules are flooded and the moisture-binding capacity of the muscle tissue increases. This makes it much more difficult to dehydrate fish pieces, so this acid concentration is not in line with our goals.

Conclusions

1. The influence of technological parameters on the active acidity of the bighead carp muscle tissue is studied;
2. Technological parameters that affect the WHC of the muscle tissue of bighead carp are identified
3. The ability of hydrochloric acid to induce changes in proteins has been confirmed. The acid causes changes in the structure of fish proteins, which lead to a change in moisture binding capacity and loss of moisture.
4. The mechanism of the influence of acid on the water content can be used to control this indicator in the process of technological processing.
5. It has been shown that the needed value of WHC of bighead carp muscle tissue is achieved with a mass fraction of hydrochloric acid of 0.1%, the processing temperature 20–25°C, the hydromodule 1:10, the duration of the treatment – 30 minutes.

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ОБҐРУНТУВАННЯ ІННОВАЦІЙНОГО СПОСОБУ ПОПЕРЕДНЬОЇ ОБРОБКИ СИРОВИНИ РИБОПЕРЕРОБНОЇ ПРОМИСЛОВОСТІ

Н.М. Кушніренко, к.т.н., доцент, *E-mail:* kushnirenkonadia@gmail.com
А.С. Паламарчук, к.т.н., доцент, *E-mail:* anna.palamarchook @ gmail.com
С.Д. Патюков, к.т.н., доцент, *E-mail:* spatyukov@gmail.com
Кафедра технології м´яса, риби і морепродуктів
Одеська національна академія харчових технологій, вул. Канатна, 112, Одеса, Україна 65039

Анотація. У статті наведено експериментальні дані щодо можливості модифікації загальноприйнятої традиційної технології попередньої теплової обробки прісноводної рибної сировини при виробництві рибних консервів шляхом розробки інноваційного способу – зневоднення хлороводневою кислотою. Технологічні та реологічні особливості м’язової тканини об’єкту дослідження – товстолобика строкатого, який є найважливішим об'єктом аквакультури та товарного рибництва як в Україні, так і в багатьох інших країнах, потребують застосування попередньої теплової обробки. Такий технологічний прийом потрібен для забезпечення видалення вологи з м’язової тканини за рахунок денатурації саркоплазматичних білків за умови підвищення температури вище 95ºC. Внаслідок високої питомої теплоємності м’язової тканини риби, теплова обробка є енергоємною та, як наслідок, економічно не ефективною. У роботі наведено дані щодо впливу хлороводневої кислоти на властивості м'язової тканини товстолобика строкатого. Таке спрямоване регулювання вологоутримувальної здатності в бік її зниження можливе при зміщенні pH до ізоелектричної точки білків м'язової тканини. Встановлено вплив таких технологічних параметрів, як масова частка хлороводневої кислоти у розчині для обробки, гідромодуль(розчин : сировина), температура та тривалість процесу на зміну активної кислотності м’язової тканини рибної сировини, та, відповідно вологозвязувальну здатність. Визначено наступні технологічні параметри процесу: масова частка хлороводневої кислоти – 0,1%, температура обробки 20–25°С, гідромодуль – 1:10, тривалість обробки – 30 хвилин. Впровадження розроблених технологічних параметрів інноваційного способу попередньої обробки створює умови при яких активна кислотність м'язової тканини максимально наближається до значення ізоелектричної точки більшості білків рибної сировини, що у свою чергу, забезпечує мінімальні значення вологозв’язувальної здатності. На підставі отриманих даних розроблено технологічний спосіб попередньої обробки сировини при виробництві рибних консервів, застосування якого дозволяє повністю виключити з технологічного циклу енерговитратну теплову операцію, та відповідно значно підвищити економічну ефективність.

Ключові слова: риба, вологозвязувальна здатність, кислотна обробка, консервовані харчові продукти.

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