The kombucha infusion use prospects in as an environmentally friendly food product

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Abstract. The Medusomyces gisevi (combucha) culture has long been widely used by the population for food purposes, as well as a natural prophylactic and medicinal agent. The detoxification, antioxidant, anti-inflammatory, immunostimulating, hypolipidemic properties etc. are among the proven properties of kombucha. Researches by a number of authors have proven a pronounced bacteriostatic and bactericidal effect of kombucha metabolites against a wide range of pathogenic microorganisms. In this work we conducted research on the fish pickling technology on the basis of vinegar obtained from the cultural liquid of the kombucha. We studied the organoleptic and physicochemical indicators of the experimental pickled fish batches, according to the results of which it was noted that in the course of autoleptic changes when pickling by the proposed method, the proteins undergo a stronger denaturation.

1. Introduction

The problem of nutrition has been and remains one of the most important for human society. There is a shortage of food products with a high content of complete protein rich in essential amino acids. It is known that a simple increase in food consumption cannot solve the problem of rational nutrition and effective assimilation of various products by human body. Therefore, the development of food and processing industries should be based not only on the knowledge of the chemical composition of the raw materials used, but also on the patterns of their formation, transformation and modification during technological processing and storage, as well as the degree of assimilation of finished products and their physiological value. Fish and fish products derived from it are one of the most important components of the protein nutrition of most people.

In this regard, particular attention is paid to the species composition of fish, their fishing, storage, delivery and processing methods. The priority direction of the fish processing industry in our country and abroad is the improvement of classical methods and techinics of its processing, the development and use of modern equipment, the purposeful regulation of biological and physicochemical processes in fish occurring at different stages of its technological cycle of processing [1]. The main volume of commercial fish (over 60%) consists of three fish families - codfish, herring and anchovy, among which: pollack, hake, saury, mackerel, tuna, capelin, herring, anchovy and others. Among the pond commercial fish priority is given to carp, silver carp, trout, sturgeon, pikeperch, etc.

The chemical composition is characterized by the content of complete proteins - 14-22% on average, easily digestible biologically active fats - 0.2-33%, mineral substances - 1-2%, extractive
substances - 1.5-3.9%, fat- and water-soluble vitamins, and other substances. Water accounts for 52–85% of the fish mass.

2. Materials and methods
The purpose of our research was to study the possibility of the fish pickling technology improving using vinegar obtained on the basis of a kombucha solution instead of acetic acid.

To study the vinegar application obtained from a kombucha solution in the technology of fish products pickling, such fishing mass objects were used as the white amur, the carp family (Ctenopharyngodon idella), which is famous for its taste and nutritional qualities, and the mackerel - Scomber family (Scomber scombrus), which range is widely represented in the commodity markets. The kombucha (Medusomyces gisevii) is a symbiotic culture in which various forms of acetic acid bacteria and yeast fungi co-exist [2]. This is a multilayer elastic lamellar structure, the nutrient medium for which, as a rule, is a sweetened tea solution. In the process of the microorganisms’ vital activity that make up the kombucha in the presence of oxygen, enzymatic fermentation of the tea solution occurs with the formation of a specific product that can be consumed as a drink [3, 4]. The chemical composition of the kombucha drink has been studied several times, however, as noted in the research works of Danielyan [5], the published results often differ from each other, which may be due to the different microbiological composition of the Medusomyces gisevii samples, the concentration of the nutrient tea solution or other modifications of the nutrient medium, the methods and the time of enzymatic fermentation used [5, 6]. According to the data of Konovalov and Semenova [7], Hauser [8], Bauer-Petrovska and Petrushevska-Tozi [9], Danielyan [5], Velicanski [10], Vitas [11], the kombucha drink contains:

- phenolic compounds, polyphenols;
- flavonoids;
- organic acids (acetic, gluconic, glucuronic, citric, succinic, malic, vinic, malonic, oxalic, L-lactic, D-saccharic, pyroracemic and also usnic);
- sucrose, glucose and fructose;
- vitamins B1, B2, B6, B12, C;
- 14 amino acids, biogenic amines, purines, pigments, lipids, proteins, some hydrolytic enzymes;
- substances with antibacterial activity;
- carbon dioxide CO2;
- ethyl alcohol;
- manganese, iron, nickel, copper, zinc, lead, cobalt, chromium, cadmium.

The kombucha cultivation at home and the use of the fermentation product of its cultural liquid as a drink is widespread among the population. Many people believe that this drink is a valuable prophylactic and therapeutic agent for various diseases and they regularly consume it [12, 13]. Considering the above, it should be recognized that the study of the Medusomyces gisevii fermented culture fluid effect and its other metabolites on the body internal environment, as well as the systematization of materials, are relevant.

Danielyan conducted a long-term study of the kombucha biological characteristics. According to the data obtained the Medusomyces gisevii cultural liquid, firstly, has a pronounced antimicrobial activity, which is associated with the presence in the studied liquid composition of antibacterial substances of a wide spectrum of action, which have both bacteriostatic and bactericidal properties. Secondly, under conditions of exposure to cultural fluid, there is an increase in the size and volume of bacterial cells, a change in their shape, vacuolization of the hyaloplasm, the appearance of granular inclusions in it. Thirdly, under the influence of the kombucha cultural fluid, there is a decrease in the intensity of redox processes in microbial cells, a decrease in their virulence and an increase in immunogenicity. Danielyan also showed that the kombucha cultural liquid at its oral intake does not have any toxic effect on the body. In addition, the author notes the presence of hypotensive activity in the studied fluid, the ability to regulate secretion and motility of the stomach and intestines [5].
Steinkraus et al linked the kombucha antimicrobial activity with the effect on acetic acid microorganisms, the main fermentation product of the cultural liquid [14]. The composition of acetic acid bacteria varies, so the substances they produce are heterogeneous. Some of them oxidise the ethyl alcohol produced by yeast into acetic acid, others convert sucrose into glucose and fructose and oxidise monosaccharides into gluconic acids. The formed acids are used by the yeast to synthesize vitamins required for the development of acetic acid bacteria. As a result of the combined vital activity of yeast fungi and acetic acid bacteria, the finished kombucha infusion has a sour taste and effervescence.

The body is positively affected by glucuronic acid, which has a detoxifying effect, while lactic acid destroys harmful intestinal microflora and normalizes its functions. Preparations made from the kombucha infusion have anti-bacterial activity, which they do not lose during long-term storage, as well as antibiotic properties. They can be successfully used as growth stimulators for animals, inhibitors of various microorganisms’ vital functions and for many diseases treatment.

The preparation of vinegar based on kombucha is as follows: the kombucha is placed in a solution of not too strong tea in which sugar was previously diluted (sugar syrup) and left for 2-3 months, and not for 7 days, as in the case of obtaining a medicinal drink. After this period, the solution is poured into an enamel bowl and boiled for 30-40 minutes. Then the infusion is cooled and filtered through gauze folded in several layers. Filtered vinegar is poured into bottles. Bottles are sealed tightly and placed in a cool place. It is used when needed.

In the standard sense, pickling is a method of fish preserving using cooking salt, acetic acid and a set of spices. Products obtained by pickling are called marinades. There are two types of marinades: cold and hot. Hot marinades are prepared from previously cooked, fried or smoked fish; cold marinades are from fresh or salted fish. Cold marinades are the most widespread in the industry.

For the production of pickled goods are sent mainly salted semi-finished products. There are two methods of cold pickling: with pre-cooking of fish in a vinegar-salt solution and without pre-cooking.

The pickled fish becomes soft, the bones are easily separated, and the fish turns white and gets a sour taste.

To obtain control and experimental samples, white amur and mackerel were pre-salted with cooking salt.

The salting process is quite long. The salting rate in different periods is not the same. At first, when the difference in osmotic pressure is large, salting goes faster, then it slows down and stops altogether when the osmotic pressure drops to zero (the concentration of the salt solution in pickled brine and fish tissues is equalized.

The fish salting rate, i.e. the time required to obtain fish with a certain content (concentration) of salt, depends on the salt concentration in pickled brine (brine), the presence and nature of the skin cover, the chemical composition of fish tissue and salt, ambient temperature, the method of salting and the speed of mixing the solution and fish. Fish with tissues containing little moisture and a lot of fat is salted more slowly than nonfat fish, because salt and moisture are poorly soluble in fat [1].

The salt crystal size (grind) affects the dissolution rate and therefore the maintenance of a high salt concentration in the pickled brine. Usually, salt is used for salting so that its dissolution rate is faster than the salting rate of the fish. However, in some cases, salting is slower if the salt consists of only large crystals or, conversely, only small crystals. Salt of too fine grinding can delay fish salting due to strong dehydration and hardening of its surface, which can lead to fish spoilage. Salt grading No. 2 and No. 3 and less often №1 are used for salting, the best No. 2 is 3-4 mm [15].

For the production of control and experimental samples we used cooking salt containing 39.34% sodium and 60.66% chlorine and grinding size No. 2.

Two experimental and two control fish samples were washed, dried, and then cut into 3-4 cm pieces. Then we salted the experimental and control batches and left them for 12 hours, after receiving a salty semi-finished product we washed it and poured cold water for 1 hour (to soak and remove unnecessary salinity of the samples), then we drained the water. After that, we proceeded to the pickling itself.
To give the marinades a piquant taste, spices were used, namely: allspice and whole black pepper, cloves, bay leaves, coriander. Each of the experimental and control batches were placed in a container in layers: spices, salted semi-finished product, which was laid loosely, without tamping. Subsequent layers were alternated in the same way. Further, according to the standard technology of pickled fish production, the control batches were poured into the spiciy vinegar-salt solution with the acetic acid content of 3-4% at the ratio of the solution amount to the fish weight 2:1. In the experimental batches, we replaced acetic acid with vinegar obtained on the basis of kombucha solution.

Further, we placed the control and experimental fish batches in the refrigerating chamber with the temperature of +1…+4 °C for 8 hours. In industrial conditions with large batches the ripening of pickled fish should be carried out at a temperature of about 0 °C for 10-30 days depending on the salt and vinegar concentration.

The concentration of cooking salt was determined by argentometric method.

3. Results and discussion

After receiving the finished product, an organoleptic and physicochemical analysis of control and experimental batches was carried out (Table 1).

| Table 1 - Organoleptic and physico-chemical indicators of control and experimental batches of pickled fish. |
|---|---|---|---|---|
| Indicators | Control batch | Experimental batch | Control batch | Experimental batch |
| | Mackerel | White amur | Mackerel | White amur |
| Appearance | The surface is clean with a color typical of pickled mackerel. | The surface is clean with a color typical of white amur. There is slight sediment of protein substances in the marinade. | The surface is clean with a color typical of pickled Mackerel. | The surface is clean with a color typical of white amur. There is slight sediment of protein substances in the marinade. |
| Consistency | Tender, juicy Mackerel fish tastes moderately salty and sour. The smell is characteristic of spices and marinade. | Dense, juicy The taste of white amur is salty and sour. The smell is characteristic of spices and marinade. | Tender, juicy The taste of salted mackerel fish is peculiar, moderately salty and slightly sweet. The smell is characteristic of spices and marinade. | Dense, juicy The taste of salted white amur fish is peculiar, moderately salty and slightly sweet. The smell is characteristic of spices and marinade. |
| Taste and smell | Mass fraction of cooking salt, % | 5.6 | 7.1 | 5.5 | 7.2 |

4. Conclusion

Analyzing the results of the conducted research we can say that the fish pickled in this way (using kombucha vinegar) turns out to be tenderer, juicy, acquires a peculiar aroma and taste. Pickled mackerel, in comparison with pickled white amur, has a delicate texture and a moderately salty taste. The cooking salt content in white amur is 1.5-1.7% higher than in mackerel, while the fish was salted with the same amount of salt per 1 kg of raw material.
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