Methods of air-cured and dried fish storage technique improvement

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Abstract The article gives the review of production and consumption of air-cured and dried fish in Russia. While storing there may be prominent mass losses because of shrinking caused by different factors. To reduce air-cured and dried fish shrinking there may be used different methods of creating and supporting the temperature and humidity conditions, different kinds of packaging, solutions for fish surface treatment. Refrigerated counters, used for fish storage and sales, have some drawbacks. The major drawbacks of the traditional methods of fish storage are changes of relative humidity in a holding room, of fish humidity, and of temperature, which leads to shortening of storage time and to fish shrinking. The use of different adsorbents allows to reach the necessary air humidity in refrigerated counters, and a fat substitute allows to reduce food shrinking. The investigation shows that the use of monoglyceride helps to increase fish storage period, but at the same time the taste of sea- or river-fish changes. Carbon dioxide considerably slows different microorganisms development, and consequently, increases a storage period. The use of carbon dioxide does not substantially influence the taste of fish. Though carbon dioxide increases the humidity in a holding room, its chemical properties sustain considerable lessening of oxygen concentration in a holding room, thus slowing the process of outer and inner changes in fish tissues, which results in a longer storage period. In the course of investigation the advantages and disadvantages of each method have been developed and their efficiency has been estimated.

1. Introduction
Nowadays there is increase in demand for air-cured and dried fish because it is easily digested, it also has a delicious pungent flavor, and because of vitamins and proteins it has, it can compete meat. Air-cured / dried fish can help to avoid the problem of putting on weight owing to its lower carbohydrate content and lack of redundant fat. Everyone knows health properties of cod-liver oil, the main of which are full digestibility and a number of unique vitamins not found in other products.

The most perspective direction of home market development is the production of food with high nutritional qualities. To do it, it is necessary to improve prominently fish processing techniques, including filleting, processing and, the most important, storing of air-cured and dried fish.

For the past two decades, we can see that Russian fishing fleet has considerably lowered sea fishing-out volume. As the result, Russian fish canneries extensively use freshwater fish to produce salty, smoked, dried fish, which is traditionally widely used in our country. That is why to carry out our experiments we have chosen a freshwater bream.

To store and sale air-cured and dried fish refrigerated counters are used. The temperature in them is from 0 °C to 4 °C below zero, besides, conditioning systems indoors overdry the air. Relative
humidity in counters is often lower than 20 % (the standard is 40-60 %), especially in winter. Insufficient air humidity in a counter results in natural fish shrinking.

Fish consists of water for more than 70%, that is why it quickly loses its attractiveness, initial weight, freshness and quality in a dry atmosphere.

Table 1 shows rates of fish shrinking.

**Table 1.** Rates of natural loss of fish and fishery products when stored at stocks, retailers and public catering enterprises.

| Product list | Storage life, 24-hour period | Rates of natural loss, % (the year round) |
|--------------|-------------------------------|------------------------------------------|
| Fish and fishery products, non-fish marine products, salty-dried and cured | The first climatic group | The second climatic group | The third climatic group |
| 1            | 0.03                          | 0.03                                     | 0.06 |
| 2            | 0.04                          | 0.04                                     | 0.07 |
| 3            | 0.05                          | 0.05                                     | 0.08 |
| More than 3 up to 30 inclusively | Rates increase every following 24-hour period on: | 0.005 | 0.005 | 0.006 |

According to the table the natural loss should not exceed 0.08 %.

But really enterprises selling air-cured and dried fish lose up to 2.5% of total weight of product a day.

To store air-cured and dried fish different types of packaging are used, all of them are in accord with sanitary standards. Investigations are being conducted on how to use alternative types of packaging. There were investigated the properties of polyethylene film of low density (thickness 100–130 micron), polyethylene – cellophane, kraft-paper with one-sided polyethylene coating, aluminum foil laminated with polyethylene. The use of these types of packaging aims at preventing possible changes, such as shrinking, moisturization, vegetation of salt, mold deterioration, putrefactive spoilage, fat oxidization, consistence changing, vermin damage.

The major reason of refusal to use packaging material for air-cured and dried fish is its low resistance to mechanical damage because of sharp parts of fish.

Air-cured and dried fish storage is characterized by processes connected with fat oxidization and changing of fish flesh colour. To store such kind of fish it is recommended to maintain relative air humidity in refrigerated enclosure on the level of not more than 70 %. At about 75% humidity fungus start developing on the dried fish surface, if humidity is 90 % or more bacteria start developing. The basic parameter of air-cured and dried fish quality in storage is consistence changing. This parameter is estimated by fish muscle tissue moisture absorption. To keep high moisture absorption of packed fish aiming at preventing fish from shrinking, the fish is wrapped in polymer film, thus heavy bod of fish flesh won’t change, the product is easily chewed and fully preserves its flavor and wet.

One of the ways of effective protection of food products and food raw materials not only from shrinking while storage but also from air oxygen exposure is creation and usage of biopolymer films. Polymer compounds contain modified gelling biopolymers such as gelatin, pectin, collagen, chitosan, carboxymethyl cellulose, sodium alginate.

There has been developed a certain method of fish and fish products storage by means of putting a biodegradable film-forming compound on the surface of fish products. The main component of the compound is chitosan or solution of chitosan and vinylpyrrolidone-co-crotonic acid with or without pre-processing of a fish product surface by pectin solution or sodium alginate solution.

Biopolymer gelatin coatings have the capacity for thermoreversible gellation. By modification of gelatin we can get gel-forming and water-retaining complexes for alimentary systems. The authors have investigated the properties of polyelectrolyte complexes obtained in the mixture of gelatin and κ-carrageenan.
To keep moisture in protein foods of animal origin it is possible to use not only film-type and gelating coatings but also chemical processing of raw material by different agents, such as polyphosphates, starch, gums, carrageenans. Processing of muscle tissues by water-retaining nutrient additives can provide stability of a food system in freeze-thaw cycles. Effectiveness of such additives usage depends on many factors: structure, pH medium, hydrophilic-lipophilic balance, degree of hydration, degree of swelling, etc. Hydrocolloids can act because a polymeric network is created as the result of polysaccharide molecules and proteins interaction. Spatial cross-linking prevents weeping. Owing to negative hydration polyphosphates contribute to the increase of destructured water content which results in the increase of protein tissue volume.

2. The work objective

Having analysed existing traditional and innovative methods of fish storage we have made a number of studies so as to define the most effective and promising one.

For making the experiments to study the process of cured fish shrinking we used a refrigerated counter equipped with facilities, and equipment allowing to control all necessary characteristics: the temperature and humidity in the room, the temperature and humidity in the product, the product mass loss, a storage period [10].

3. Results and discussion

The control of temperature in the room was exercised with the help of the electronic temperature controller ID 974 lx. The thermo relay of ID 974 lx has a temperature range from +50 to -50 °C. The sensor organ was thermocouples with the junction point diameter 0,3·10⁻³m.

To keep an even temperature field in the room the ventilator was set, its functioning was regulated by the thermo relay ID 974. The apparatus design allowed it to be fitted into acting processing lines.

The control of humidity in the refrigerated counter was exercised with the help of a hygrometer with its sensor organ set in the holding room.

The samples under investigation were two kinds of fish: sea-fish (plaice) and freshwater fish (bream).

To keep moisture-retaining capacity we suggested processing fish muscle issues with the help of inorganic electrolyte alkaline silicate by way of immersion, injection, pickling. The time available for contact of the food product with the solution of sodium silicate or potassium silicate while immersing varies from 5 to 30 minutes.

We also use CaCl2 as adsorbent. The experiments, studying the changes in the shrinking process when the fish is unpacked but this adsorbent is used demonstrate positive changes in mass losses during the first 24 hours of the experiment compared with that when the fish was packed. Packaging creates the medium in which we can observe inner shrinking, as the result of sweating wet remains on the inner surface of package, but it is worth noticing that the unpacked fish had considerable shrinking just during the first 24 hours, while packed fish had mass losses during the following days of storing.

In order to reduce shrinking and to increase the storage period for air-cured and dried fish we suggest putting monoglyceride on the surface layer. Analyzing the data we can say that the monoglyceride chemical composition makes it possible to combine fat and water creating a protective coat on the fish surface layer, which prevents water evaporation. It results in noticeable reduction of shrinking, but at the same time we can observe changing of eating qualities and taste of fish because monoglyceride serves as fat substitute and complement in meat of animal origin. Also, marketable appearance of fish becomes much worse if it is dressed by such composition.

The research results of using monoglyceride for fish processing are given on figure 1.

The temperature in the room was 0°C, humidity 65%. The bream weighed 69,7 g, the flounder weighed 64,5, humidity was 46% and 53% respectively. The surface layer was covered by monoglyceride.
Analyzing these data we can say that under the maximum permissible temperature of 0 °C and room humidity of 75% with monoglyceride used, the changes of fish mass losses because of shrinking during the first 24 hours was 4g of bream and 3g of flounder. The reason of it is the following – the chemical composition of monoglyceride makes it possible to combine fat and water, thus creating a protective coating on the fish surface layer, which prevents water evaporation. As the result, during the following days of the experiment the fish shrinking was about 3 g. per 24 hours for each sample in spite of the maximum permissible temperature. During the experiment the fish preserved its marketable condition, there were not any signs of the fish being spoilt, but fish gustatory qualities changed because monoglyceride is a fat substitute in meat of animal origin.

From our point of view the most progressive and promising method is the one which is based on the use of carbon dioxide. The method implies that in the holding room there will be located a special container with solid carbon dioxide. During the process of CO2 sublimation in the room there was kept an air and gas medium with the definite concentration of carbon dioxide. The experimental data of the studies of the changes in fish shrinking process with carbon dioxide used are shown in figure 2.

The temperature in the room was 0°C, humidity was 65%. The amount of CO2 in a special container located in the room was 150 g.
For the experiment we used two samples, bream and flounder, the humidity in the room was 65%. The bream weighed 93.2 g, and the humidity was 41.4%, the flounder weighed 91.6 g, the humidity was 46.5%.

Analyzing these data we can say that shrinking is of regular and low-level rate in spite of fatness and rather high humidity rate of fish flesh. Daily mass loss did not exceed 3 g during four periods of 24 hours of the experiment. These data are similar to the data of the experiment when monoglyceride was used.

High concentration of carbon dioxide on the fish surface allows considerably reduce residual oxygen in water, interacting with outer and inner layers of fish, reducing oxygen content in preformed as well as releasable water. Carbon dioxide dissolves in water and fat, that is why interacting with inner layers of fish CO2 reduces fat viscosity and increases water viscosity while dissolving, reducing water mobility in relation to fish flesh. Despite direct contact with fish, carbon dioxide does not influence gustatory qualities of fish flesh, which is very important.

4. Conclusion

According to the conducted research, we can come to the conclusion that the traditional storage method makes air-cured and dried fish lose weight during the process of storing because of shrinking, and lose its health properties, thus enterprises involved in sales of this kind of food product suffer losses. Trying to find the solution of the problem, we have investigated different methods of shrinking reduction, and we have found the most promising one. This method is based on the use of carbon dioxide, which practically does not change gustatory qualities of fish, though it causes increase of humidity in the room. Carbon dioxide helps considerably reduce oxygen concentration in the room, which results in reduction of product acidity and retardation of outer and inner changes in fish tissues. As the result, fish can be stored by 15-20% longer, mass losses are reduced by 10-15%. Using this storage method, it is possible to get minimal and uniform shrinking for different kinds of fish.

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