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PHYSICOCHEMICAL BASIS FOR INTENSIFICATION OF THE PROCESS OF SALTING FISH

Gennady POSTNOV[*], Grigory DEYNICHENKO[*], Mykola CHEKANOV[*], Vitaliy CHERVONY[*], Oleg YAKOVLIEV[**]
[*] Kharkiv State University of Food Technology and Trade, Ukraine
[**] Kerch State Maritime Technological University, Ukraine

Abstract. The article deals with the physicochemical characteristics of the process of salting fish. A very long duration of salting large fish is the main deterrent to the mechanization and automation of salted fish, which excludes the possibility of creating machines or maintain a continuous on-going process. The transition to the accelerated methods of preservation requires the development of new technology, which would salting proceeded more rapidly, and the quality of the products remained high. These theoretical studies are the basis of the introduction of ultrasound treatment for industrial salted fish in order to reduce energy costs and improve the profitability of fish processing plants.

Keywords: ultrasonic, cavitation, salting fish, intensification of the process

1. Introduction

Salting process, as a way of preserving, widely used in the production of salted herring and salmon fish. In addition, the salting process is preceded by other methods of processing of fish, such as smoking, drying, production of food products and other products.

Process for salting the fish is exposed to the brine followed by transfer of salt brine in the muscle tissue and water from fish muscle saline. The diffusion process is a kind of complicated structure of muscle tissue, form water connection with proteins, chemical composition of the tissue and other factors [1].

2. Objects and problems

Salting process – it is a way of preserving, in which the main action has preservative salt. In contact fish and salt crystals are dissolved salts in the water, located on the surface of the fish produced brine and the process of salting.

The essence of salting is saturated with water contained in fish, common salt. The process of moving the salt in fish tissue is considered to be diffusion. Complexity diffusion associated with the fish tissue heterogeneity, through which penetrates a salt. The driving force of the process is the difference between the concentration of sodium chloride in brine and muscle juice. In the process of diffusion through the complex salt penetrates organic system fish skin is distributed to the formation of extracellular, in tissue juice, connective tissue, penetrates the muscle fibres in the sarcolemma. The rate of diffusion of sodium chloride in the muscle tissue of fish obeys the Fick which is expressed by the formula [2]:

$$\frac{dm}{dt} = -D\frac{dc}{dx}F \qquad (1)$$

D – diffusion coefficient, dc/dx – concentration gradient, i.e. drop concentration in the direction of diffusion.

It shows the amount of the substance (m), diffusing in the time interval (t) per unit of area (F) (Fick's first law).

Salting the fish is a diffusion process, ie spontaneous alignment salt concentration throughout the volume of the system under the influence of the thermal motion of ions and molecules. This process continues until uniform concentration of salt, and as a result there is maximum entropy of the system, this process is irreversible at a constant ambient conditions.

Diffusion of salt and water in the fish tissue is complicated by non-uniform permeability, which also is influenced by salt. Live fish tissue, especially skin, impervious to salt, after the death of tissue salt begins to penetrate into the body, takes a solvation shell of protein molecules.

The mechanism of sodium chloride from the brine in the tissue and its distribution in the tissues satisfactorily explained from the standpoint of the laws of diffusion processes.

It is possible that in the micro-and macro-capillaries placed in the connective tissue septa,

along with the molecular transport of sodium chloride are transported by capillary action. In the same muscle fibres and capillary vessels is sodium chloride distributed under the influence of molecular diffusion.

The higher concentration of sodium chloride in the intercellular juice compared with an average concentration of intracellular and tissue helps to explain the reason for discrepancies between the average concentration of sodium chloride in the brine and tissues in sooty salting process: large in brine and less in the tissues. Comparison of the concentrations of sodium chloride brine and intercellular juice shows that in the end they are aligned and brining there between diffusion equilibrium is established. The lack of balance between the extracellular and intracellular juice is due to the presence of sodium chloride, protein adsorption.

The main deterrent to the mechanization and automation of salted fish is a very long duration of salting large fish, which excludes the possibility of creating machines or maintain a continuous on-going process.

The transition to the accelerated methods of preservation requires the development of new technology, which would salting proceeded more rapidly, and the quality of the products remained high.

Currently, instead of the so-called interrupted salting introduced a more perfect way to complete salting, which, however, can not be used to handle large fish, since this method can not timely establish preservative salt concentration in the paravertebral tissue layer fish.

In domestic and foreign meat industry in recent years has developed rapidly progressive direction associated with the use of multi-needle jet injection and extrusion for diffusion-osmotic processes [3].

Duration is determined by the rate of penetration of salting salt in the thickness of fish, as well as the speed to achieve the desired concentration, the appearance of specific taste and aroma of delicious product. Accelerating the process of salting the big fish it is advisable, as the process of post-mortem changes in the fish's body, accompanied by the appearance of signs of damaging the product, ahead of the formation of preserving salt concentrations in the muscle of fish juice. The process of salting fish marinated in technology is seen as a diffusion and osmosis.

The possibilities of intensification process and improve product quality through the diffusion of dependencies under the influence of natural forces nearly exhausted. In this regard, are becoming increasingly important intensive mechanical and electrical processes: extrusion, injection jet, massing, electrical stimulation, high pressure treatment and sonication [4, 5].

The number of accumulated substances increases curing mainly due the mechanical filtration process and the sponge effect and only their final allocation is performed by diffusion. Therefore, the salting process, which is usually a physical-chemical point of view, it is a diffusion-osmotic should be considered as a process of filtration and diffusion. This approach allows the process opening up new possibilities for its improvement.

One of the most effective and efficient is a multi-needle stuffing – a way of curing the accumulation of substances (mostly inorganic), which is widely used in the meat industry.

Needle-free method of introduction of curing agents - jet injection - is very different from the others. Instead can be used a liquid jet needle with a diameter of 0.1…0.2 mm deriving from the holes under pressure (10…30) · 10 Pa. When injected brine, partially fed directly into the muscle fibres, it is speed up the salting process. The destruction of the jet in contact with the bone during injection contributes to the accumulation of salt in the most unfavourable zone - about bones and joints.

One method of distribution of the solution is the intensification of massaging raw materials in rotating containers or paddle mixers. When massaging salted with violated the integrity of the membrane structures tissue swell and disintegrate myofibrillar proteins, the communication between actin and myosin appear free bonds in the structure of proteins capable of holding more water, partial movement of release and into the intercellular space of intracellular enzymes. Speed salting increases the duration of salting decreased by 5 … 7 times by applying massage to boneless raw materials. Treatment of bone material reduces the quality of the finished product due to violation of the integrity of the macrostructure.

With the application of the method of vacuum salting can reduce the time required for the production of salting, by 30-40% compared with the traditional method of salting. From scientific publications it is known that for the salting of fish accelerating attempts were made to introduce the salt solution using a syringe, but in this way able to enter into the fish only small amounts of brine, preservative effect is negligible.

According to A. Yuditskaya at the very least change the salt content of the paravertebral muscle tissue of fish, making it the most vulnerable in terms of maintaining the quality of fish during the production of salted products [6]. Obviously, for this reason, the production of salted Chinook salmon by salting vat existing technology is often the case the appearance of spreadable meat deep in the back and caudal peduncle.

Today, one of the least explored areas intensification of salting is ultrasonic processing. Domestic and foreign research scientists devoted to the issue of the use of ultrasound based on the properties and specificity of action of ultrasonic waves on biological objects, it is proved that the basis of ultrasound treatment is the influence of ultrasonic energy on their cell structure.

Studies conducted Elpiner showed that the effect of ultrasonic vibrations on different media due to the effects of cavitation, ultrasound and ultrasonic wind pressure, and the maximum effect is caused by ultrasonic cavitation. Virtually all physicochemical and technological processes occur at the boundary of division phase (interfacial surface) where the molecules of different substances collide.

As the literature data [7, 8], near the surface of the solid formed diffusion boundary layer of fluid, which contains the bulk resistance of the bear molecules of the reactants through the boundary phases. Moreover, the main resistance of the diffusion layer, which is directly adjacent to the solid. In this region, transfer is carried out by molecular diffusion. The speed of technological processes can be increased by reducing the thickness or eliminate the diffusion boundary layer.

In the case of the passage of ultrasonic waves through the liquid ultrasonic cavitation occurs and due to its powerful micro showers liquid and ultrasonic wind and pressure affect the boundary layer and "wash" it. Thus, resistance of reactants bear molecules is significantly reduced and the rate of mass transfer and mass transfer processes due to this increase.

Also the thickness of the diffusion boundary layer, the speed of mass transfer and mass transfer process depends on the contact surface of the reactants. Therefore, the increase of the contact surface of the reactants also increases the speed of the processes of mass transfer and mass transfer.

With the passage of ultrasonic waves in the ultrasonic wind occurs that causes intense mixing and powerful micro showers from the collapse of cavitation bubbles leads to mutual friction of the particles of the liquid phase. Similar physical processes occur in systems which consist of two or more liquid phases.

Thus the ultrasonic vibrations, which are distributed in a liquid environment, lead to an increase in the specific surface area of interaction and decrease in the value of the diffusion boundary layer, thus providing a reusable acceleration of mass transfer and mass transfer. In addition to these two main factors ultrasonic wave have different secondary effects (electrical discharges in cavitation bubbles, huge temperature in very small amounts of processed materials, shock waves, etc.). Under consideration are acoustic cavitation generation and the activation of gas or steam voids (bubbles) in an environment which is subjected to sonication.

Modern technology often based on the realization heterogeneous processes which occur between two or more systems in heterogeneous environments "liquid-liquid" and "liquid-solid". Cavitation and powerful micro showers that accompany it, the sound pressure and sound wind affect the marginal layer and debarred resistance transference of the reactants and intensify the process.

Basic research regarding mass exchange was made by many authors. Many researchers reported positive effect of ultrasonic vibrations on the processes mass exchange in the "solid-liquid". During the course of the process increases the speed of ultrasound in 3 ... 20 times. Step ultrasound accelerates 30 ... 40% in comparison with mechanical stirring.

For evenly salted fish is recommended to subject all its tissue action of ultrasonic vibrations. To achieve this goal, it is necessary to consider differences between fish species, oscillation frequency, and transmitter power, the volume of the working chamber and the position of the fish relative to the ultrasonic transducer. Generally, the higher the frequency of the waves, the smaller the depth of penetration, i.e., when the frequency of the oscillation energy of the radiation is distributed over short distances within the fish, and at low frequencies, radiation, ultrasonic waves penetrate deeper into the fish before you lose energy. One of the major obstacles encountered in the application of ultrasonic vibrations for salting fish has the ability to fish as a solid body to reflect most of the compression waves or energy from the surface of the emitter to the environment generating these waves. The reflection of sound energy from the

interface of two media is a well-known phenomenon.

The ratio of the energy flux to the incident energy transferred to another medium, the coefficient is a function of the specific acoustic impedance of the two media. The closer the ratio of the specific acoustic impedance to unity is, the more the transferred energy to the energy of the incident flow. Since the surface of different types of fish and divers and has a geometrically irregular shape, it is impossible to ensure continuous contact between the fish and the surface of the emitter.

To reduce the energy losses due to reflection at the generation of ultrasonic waves in an environment which is not in direct contact with the fish, the intermediate medium is used for direct communication with the emitter of ultrasonic vibrations, which must have specific acoustic impedance close to the resistance of fish, such as water or brine.

According to references [2, 7], in most cases the fish treated with ultrasonic waves 1do duration of 30 minutes. During this process the fish muscle tissue permeability can increase the pressure rapid change regardless of the fish (fresh, chilled or frozen). Permeability can regulate the intensity and duration of the ultrasonic vibration ultrasonic treatment. The frequency, intensity and time of ultrasonic treatment are determined for each species of fish and its geometrical dimensions experimentally. According to the literature [4, 6], there are devices which use ultrasonic vibrational energy for processing fish. The use of ultrasonic waves of high intensity, their acoustic and mechanical action can cause a change in membrane permeability of cell membranes, accelerates the mass transfer processes occurring in fish in salt, causes a change in the rheological characteristics of the treated fish, and with increasing intensity distribution rate curing agents increases in the volume of fish.

3. Conclusion

From the above it can be concluded that the effect of ultrasonic vibrations on the environment due to different effects of cavitation ultrasonic wind pressure and ultrasound. In the processes that occur at the boundary of the phase distribution of the ultrasonic vibrations, which are distributed in a liquid environment, lead to an increase in the specific surface interaction and the decrease of the diffusion boundary layer, thus providing a reusable mass exchange acceleration and mass transfer processes. Theory of propagation of ultrasonic waves used by us to analyse the mechanism of influence of ultrasonic vibrations on the intensification of the process of salting fish and characterization of ultrasonic transducer implements this process. The main reasons that prevent the use of ultrasound technology in the food industry is limited, and in some cases, the lack of scientific studies of the effect of ultrasonic waves with a flat front for heterogeneous objects such as "liquid-solid" for fish and practical recommendations for their use.

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