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Original scientific paper

APPLICATION OF HIGH HYDROSTATIC PRESSURE IN THE TECHNOLOGY OF POULTRY PRODUCTS

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The work is devoted to studying the possibility of the athermal processing application in the technology of poultry meat products. Advantages of using the high hydrostatic pressure for processing the food products in order to preserve the nutritional and organoleptic characteristics, lengthening their shelf-life are presented. Poultry meat processing was performed in the range of 200 to 700 MPa. Microbiological indexes of the samples after the high pressure processing have been investigated, and characterized by changing the organoleptic and functional-technological properties of the raw materials. The researches that allowed studying impact of the high pressure on the microstructure of poultry meat were conducted. Rational modes of athermal processing allowing extending the shelf life of fresh meat were recommended. Ranges of pressures that can be used as intensification for the raw materials salting process were determined. According to the research results, the modes that can be used instead of the heat processing for the semi-finished goods and ready products were determined.

Key words: high hydrostatic pressure; athermal processing; poultry meat; technology

ПРИМЕНА НА ВИСОК ХИДРОСТАТИЧЕН ПРИТИСОК ВО ТЕХНОЛОГИЈАТА НА ЖИВИНСКИ ПРОИЗВОДИ

Трудот е посветен на проучување на можноста за примена на атермалната обработка во технологијата на производи од живинско месо. Презентирани се предностите од користење висок хидростатичен притисок при преработка на прехранбени производи, со цел да се зачуваат нутритивните и органолептичките карактеристики, продолжувајќи го нивниот рок на траење. Обработката на месо од живина е извршена во опфат од 200 до 700 MPa. Беа испитувани микробиолошките показатели кај примероци по обработката со висок притисок, а се карактеризирале со промена на органолептички и функционално-технолошки карактеристики кај суровините. Беа следени истражувањата за дозволено влијание на високиот притисок врз микроструктурата на месото од живина. Се препорачуваат утврдени начини на атермална обработка, овозможувајќи продолжување на рокот на траење кај свежото месо. Бил утврден опсегот на притисоци кои можат да бидат користени за интензивирање на процесот на солење кај суровините. Според резултатите од истражувањето, биле утврдени начините кои можат да бидат користени наместо топлинската обработка на полуготовите и готовите производи.

Клучни зборови: висок хидростатичен притисок; атермална обработка; живинско месо; технологија

INTRODUCTION

The existing methods of the meat products conservation are intended to inhibit the action of enzymes and inactivate them as well as to suppress the activity of microorganisms [1–5]. The principles of conservation may be performed with the help of one way or other solution – conservation method, which are divided into three main groups by the principle of influence on the raw material: physical, chemical and biochemical.

The modern processing techniques should be aimed on provision of persistent high quality products while storage that can be achieved by preserving factors which can not be overcome by the microorganisms present in the product [6–7].

Considering ways of food processing, it can be concluded that till the second half of the XIX

century there was just one way of influence – temperature. Today there are more than 60 potential preserving factors. Non-thermal physical barriers are considered to be promising: use of the high hydrostatic pressure; combination of heat processing, pressure and ultrasound; impact of pulse electric current, etc [8].

The early studies on use of the high pressure were focused on the microorganisms inactivation (vegetative cells of bacteria and yeasts), today the technology is considered as important and potentially applicable [9–10].

The Fresher Under Pressure technology is acknowledged by progressive companies due to the optimal long-term, cost-effective solutions in the field of food storage aimed on meeting the customers' needs [11].

Pasteurization of food products using the high pressure – is a natural, environmentally friendly technology, which has the following advantages [12]:

– a wide variety of the processed foods: meat, fish, seafood, fruits and vegetables, fruit juices and drinks, salads, milk and dairy products, ready-to-eat food products;

– possibility cardinally (up to several stages) to reduce the content of microflora and the most dangerous pathogens (*Listeria, E. coli, Salmonella*, etc.);

– increasing in 2–3 times the shelf life of food products without changing their natural flavor and color;

– preservation of organoleptic properties and nutritional value of the product, without damaging the nutrients, vitamins, and pigments by heat processing, as well as without changing the other components of low molecular weight which are responsible for the smell and taste;

– absence of the need to use the preservation agents and additives that increase the shelf life of food products;

– possibility to pasteurize the products which can not be pasteurized by the conventional method;

– absence of food products deformation due to the even distribution of the hydrostatic pressure (irrespective of the product's volume and shape), which reduces the processing time;

– improvement or occurrence of new functional properties of the products;

– improvement of the product's texture as compared with the thermal processing mode;

– reduction of energy costs, as compared with the conventional method of pasteurization.

Thus, use of the high hydrostatic pressure is the promising mode to produce new types of meat products, including using the poultry meat.

MATERIAL AND METHODS

The aim of our research is to establish the possibility of using the athermal processing technology of the poultry meat products.

We studied the pattern and control samples of meat obtained from chilled fillets of broiler chickens (white muscles) which were stored for not more than 24 hours after the slaughter at the temperature of 0 ... 4°C.

Processing of the samples was carried out at the pressure of 200, 300, 400, 500, 600 and 700 MPa 20 min and at the temperature of 20 ± 1°C in the high-pressure experimental unit. Control 1 – chilled meat (temperature 2 ± 1°C), control 2 – boiled meat (cooking until core temperature 70 ± 1°C).

To achieve the goal it was necessary to fulfill the following tasks:

– to determine the change in the microbiological indicators of poultry meat after the processing;

– to assess the effect of high pressure on the organoleptic characteristics;

– to investigate the change in the functional and technological parameters of poultry meat after the athermal processing;

– to determine the level of the poultry microstructure change.

Microbiological, organoleptic, physico-chemical and histological studies were performed according to standard procedures [13–14].

RESULTS AND DISCUSSIONS

a) Determination of microbiological indexes. In the study of the sanitary conditions of the meat processed with different parameters of the high pressure, we determined the overall contamination of the meat, presence of coliform bacteria, pathogenic microorganisms (including the *Salmonella bacteria group*), bacteria of the *Protea genus*, and also the coagulase-positive staphylococci (Table. 1).

Table 1

Microbiological indicators of poultry meat after high pressure treatment (n = 5, p ≤ 95)

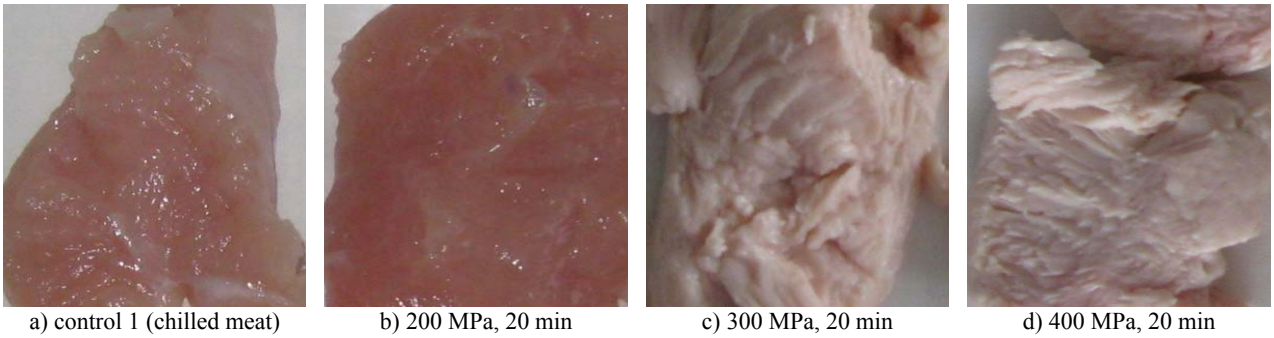
Processing mode P, MPa	τ, min	QMA&OAMO, CFU in 1 g	CGB, in 25 g	Pathogens Salmonella, Proteus)
Control 1		3,5±0,09·104	detected	not detected
200	20	2,8±0,04·104	detected	not detected
300	20	1,5±0,07·103	not detected	not detected
400	20	1,0±0,11·103	not detected	not detected
500	20	less than 1,5±0,10·10	not detected	not detected
600	20	less than 1,5±0,04·10	not detected	not detected
700	20	less than 1,5±0,02·10	not detected	not detected

As the result of the research it was established that at increasing the pressure to 300 MPa, we noticed the reduction in the total number of microorganisms for the next 1 order, and at the 500 MPa processing this rate has reduced to the 150 microbial cells per 1 g.

Bacteriological tests have shown that the inhibitory effect on the bacterial growth is shown at the pressure of 200 MPa, but these parameters do not cause the death of the Escherichia coli group bacteria (CGB). The lower limit of the high pressure at which the coliform bacteria are not detected is 300 MPa. In all the test samples there were no pathogens, including the Salmonella, of Proteus bacteria group.

The mechanism of the high pressure influence on the poultry meat microflora is associated with damage to the cell membranes of microorganisms without heat. The exponentially growing cultures are majorly compression sensitive, damage to their membranes are nonconvertible. Mechanism of the microorganisms destruction by the high pressure is based on the microbial degradation of cell membranes by changes in the cell volume [12].

b) Determination of the organoleptic characteristics. During the tasting of the investigated samples it was established that the samples which passed the processing of 500, 600 and 700 MPa in the color and appearance resemble the boiled poultry products (Fig. 1). The color of these specimens was uniform, the surface was gloss, the texture was dense, elastic, delicate, and the slight separation of meat juice was observed only at the sample processed with the pressure of 500 MPa.



a) control 1 (chilled meat) b) 200 MPa, 20 min c) 300 MPa, 20 min d) 400 MPa, 20 min

e) 500 MPa, 20 min f) 600 MPa, 20 min g) 700 MPa, 20 min

Fig. 1. Organoleptic characteristics of poultry meat after high pressure treatment

When processing from 200 to 500 MPa the residual odor and taste of fresh meat is noted, and from 600 to 700 MPa the samples are tasted like the boiled meat.

c) Determination of functional and technological parameters. The water-binding power (WBP) is a major functional and technological properties (FTC), affecting the output of the finished products, the juiciness, etc., so we conducted a study aimed at exploring the dependence of the WBP on the modes of the high pressure processing. The results are shown in the Fig. 2.

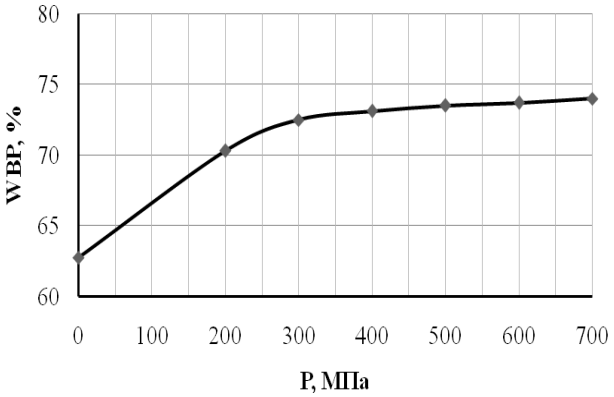


Fig. 2. Dependence of the water-binding power (WBP) after high pressure treatment

Value of the WBP for the control sample was 76.4%. When using the pressure of 200 MPa, the figure was not significantly changed (77.3%), but at processing with the pressure of 300 MPa, the water binding power rate increased by 6.1% compared to the control sample. It was found that the WBP depends on the processing mode. So when the pressure is increased from 300 to 700 MPa, the value of the researched index has increased for 6.5%. The value of WBP made 89.0% at the pressure of 700 MPa

Increase of the WBP, in our opinion, is caused by the following changes in the protein molecules: at mechanical influence of the upper range value on the muscle fibers of the poultry, destruction of myofibrils with the release of myofibrillar proteins occurs. This is followed by rupture of the electrostatic bonds and formation of the ionized groups which bind the water.

Based on these data it can be concluded that occurrence of the additional centers available to water after the pressure processing increases the water-binding capacity of the poultry meat.

When studying the effect of the hydrostatic pressure on the hydrogen ion concentration, it was observed that this processing does not lead to significant changes in the pH, which was within the range of 5.78 ± 0.22 for all samples.

Structural and mechanical properties are characterized by such indicators as the texture and juiciness of meat and meat products. Therefore, we investigated the effect of the high pressure on the ultimate cut stress. The results are shown in the Fig. 3.

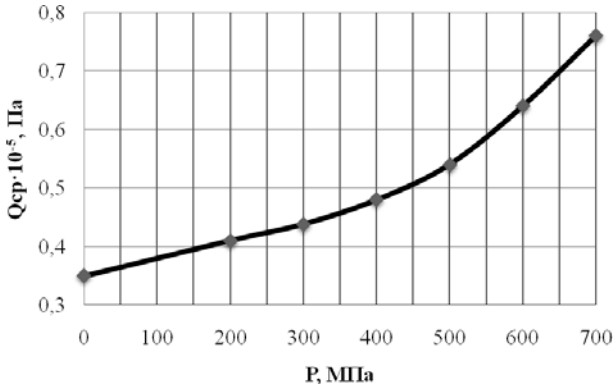
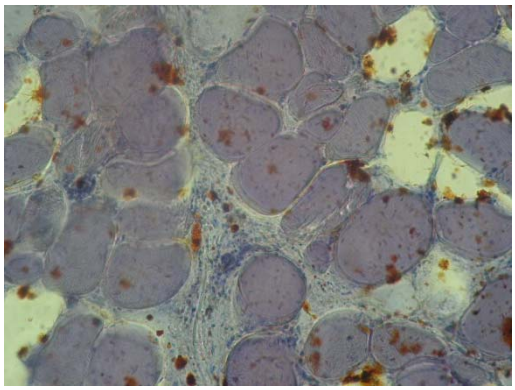


Fig. 3. Dependence of the ultimate cut stress after high pressure treatment

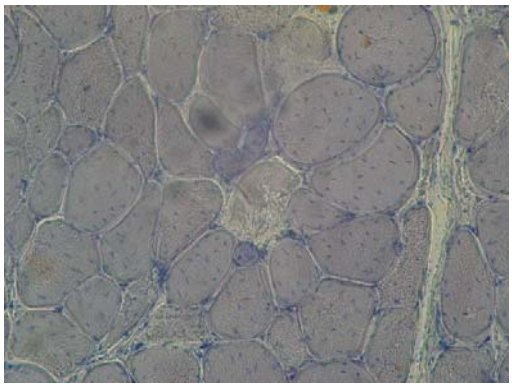
The studies have shown that at the pressure of 200 MPa, the ultimate cut stress is $0.41 \cdot 10^{-5}$ Pa, and gradually increases to the value of $0.54 \cdot 10^{-5}$ Pa, which corresponds to the processing of samples at 500 MPa. In the pressure range from 500 to 700 MPa, there is a significant increase in the limit cut-off voltage: value of the investigated index increases within the specified test pressure conditions for 40.74%.

We believe that the observed increase in the value of the ultimate cut stress in the model samples is due to the densifying the meat structure under the pressure and pressing off the moisture. You can also assume that the elasticity of the muscle fibers is increased due to the additional interaction of the dipoles formed in the protein structure under the influence of the high pressure on the water molecules. Such hydration of protein molecules has an ordered structure which density is significantly higher than normal.

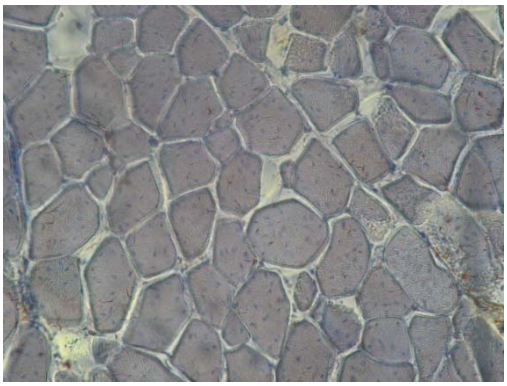
d) Microstructural analysis. Histological studies were performed for the following samples: chilled poultry meat, boiled poultry meat and poultry meat processed under the specific regimes of high pressure. The results are shown in the Fig. 4.



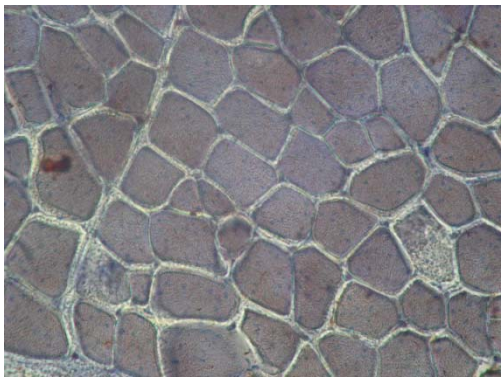
a) control 1 (chilled meat)



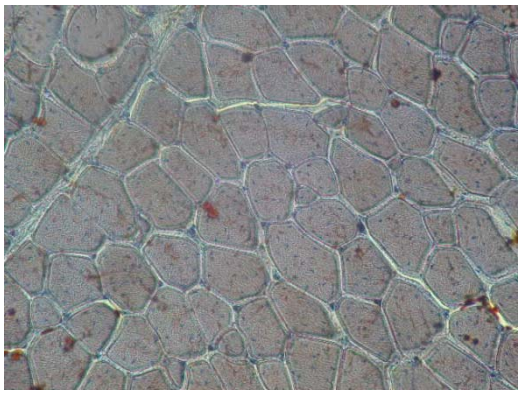
b) 300 MPa, 20 min (200×)



c) 500 MPa, 20 min (200×)



d) 700 MPa, 20 min (200×)



e) control 2 (boiled meat) (200×)

Fig. 4. Histological structure of poultry meat after different treatments

Muscle fibers of the control sample (frozen meat) are generally arranged in a straight line. In the cross-sections occurrence of local cracks and discontinuities muscle fibers are marked. Connective layers are presented in form of tortuous bands.

After the traditional cooking of the poultry meat the muscle fibers became tighter to each other, there is an increase of microcracks, fine-grained protein mass in spaced between the ends of the muscle fibers and separate beams is noted. Connective septum is deformed.

In the samples that passed the high pressure processing, the swelling and indurations of muscle fibers, local destructions and sarcolemma detachment, loosening of connective tissue layers were noted due to the pressure increase.

When exposed to the pressure of 300 MPa the sample muscle tissue is characterized by uneven swelling of fibers, presence of micro-cracks, tears and emergence of a fine-grained protein mass in places of destruction and in the inter-fiber spaces. Also a slight fibers separation is noted in the connective tissue layers.

The deeper changes are marked in the pressure range from 500 to 700 MPa. At processing the upper range value at 700 MPa, there is a significant fragmentation of muscle fibers, emergence of sarcoplasmic proteins in the interfiber space with formation of a fine-cellular mesh. The connective layers are swelled and disintegrated.

Thus, the microstructurals studies have shown that the effects at using the heat processing and the high pressure processing are similar, however differed by the depth and character.

CONCLUSIONS

Resulting from the obtained data, we came to the following conclusion:

– based on microbiological and organoleptic characteristics, the range of pressures from 200 to 300 MPa with the processing time of 20 min can be used for to extend the shelf life of the chilled poultry meat;

– considering the functional and technological figures, it is believed that the pressure treatment of 200 to 250 MPa, at which the structural changes in muscle tissue are started, can be used to intensify the process of meat salting for production of ham products;

– the pressure range from 300 to 500 MPa starts the reduction of microflora without achieving the culinary readiness that can give the possibility of getting the semi-finished goods with a long shelf life;

– by the results of microbiological, organoleptic and functional and technological research is could be recommended to use the pressure range from 500 to 700 MPa to obtain the poultry product of the complete culinary readiness.

REFERENCES

[1] Антипова, Л., Полянских, С., Калачев, А.: *Технология и оборудование птице-перерабатывающего производства*, ГИОРД, Санкт-Петербург, 2009.

[2] Митрофанов, Н.: *Технология продуктов из мяса птицы,* КолосС*,* Москва, 2011.

[3] Сэмс, Р. А.: *Переработка мяса птицы*, Профессия*,* Санкт-Петербург, 2007.

[4] Стеле, Р.: *Срок годности пищевых продуктов: Расчет и испытание*, Профессия, Санкт-Петербург, 2006.

[5] Баль-Прилипко, Л.: *Технологія зберігання, консервування та переробки м'яса*, Підручник, Київ, 2010.

[6] Лузина, Н.: *Микробиология мяса и мясных продуктов*, Кемеровский технологический институт пищевой промышленности*,* Кемерово, 2004.

[7] Винникова, Л.: *Технология мяса и мясных продуктов*, ИНКОС, Киев, 2006.

[8] Сукманов, В., Хазипов, В.: *Сверхвысокое давление в пищевых технологиях. Состояние проблемы*, Дон ГУЭТ, Донецк, 2003.

[9] Крисс, А.: *Жизненные процессы и гидростатическое давление*, Наука, Москва, 1973.

[10] Schlüter, O.: *Impact of High Pressure – Low Temperature Processes on Cellular Materials Related to Foods*: genehmigte Dissertation, Berlin, 2003.

[11] Cheftel, J., Culioli, J.: Effects of high pressure on meat: a review. *J. Meat Science*, **46**, 211–236 (1997).

[12] Knorr, D.: Effects of high-hydrostatic-pressure processes on food safety and quality, *J. Trends in Food Science and Technology*, 4, 370–375 (1993).

[13] ДСТУ 3143-95 *М`ясо птиці (тушки курей, качок, гусей, индиків, цесарок). Технічні умови,* Держспоживстандарт, Київ, 2005.

[14] Антипова, Л., Глотова, И., Рогов, И.: *Методы исследования мяса и мясных продуктов*, КолосС, Москва, 2004.