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STUDY OF CRYOPROTECTORS EFFECT ON OXIDATION PROCESSES AT STORAGE OF FROZEN HALF-FINISHED PRODUCTS

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Summary. The publication presents data on the effect of polysaccharides as cryoprotectants on changes of the lipid fraction of quick-frozen semi-finished products during storage. Since the structure of minced systems is formed as a result of the destruction of the native structure of the meat and the formation of a new secondary structure, it is important to establish the effect of cryoprotectants on the key functional and technological properties of meat systems after freezing, and in the process of storage. Based on studies of the kinetics of the oxidation of fat and accumulation data on the accumulation of the primary and secondary products of oxidation inhibition of oxidative processes has been found.

Keywords: quick-frozen semi-finished products, polysaccharides, lipids, acid value, storage.

ДОСЛІДЖЕННЯ ВПЛИВУ КРІОПРОТЕКТОРІВ НА ОКИСЛЮВАЛЬНІ ПРОЦЕСИ ПРИ ЗБЕРІГАННІ ЗАМОРОЖЕНИХ НАПІВФАБРИКАТІВ

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Анотація. У статті наведено дані щодо впливу полісахаридів кріопротекторів на зміни ліпідної фракції швидкозаморожених м'ясних напівфабрикатів у процесі зберігання. Оскільки структура фаршевих систем формується в результаті руйнування нативної структури м'яса і утворення нової вторинної структури, доцільним є встановлення впливу кріопротекторів на ключові функціонально-технологічні властивості м'ясних систем після заморожування, і в процесі зберігання. На підставі досліджень кінетики окиснення жиру і даних щодо накопичення первинних і вторинних продуктів окиснення, встановлено гальмування окиснювальних процесів.

Ключові слова: швидкозаморожені напівфабрикати, полісахариди, ліпіди, кислотне число, зберігання.

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Introduction

Fast frozen meat products with extended shelf life without the preservative food additives are of great demand with consumers.

However, due to the high moisture content during freezing and storage, there appear problems associated with the preservation of structure, organoleptic characteristics and nutritional value of products.

Grain formation and recrystallization processes, causing damage to cells and proteins in muscle tissue, are the reasons for these changes.

Application of cryoprotectors of different chemical nature is one of the ways to solve the problem. Despite the fact that some types of cryoprotectors are used in frozen food products, their effect on the physical-chemical and biochemical processes at long-term storage has been studied partially and do not provide a complete picture of these changes thus requiring comprehensive survey.

Literature review

The literature review has showed that changes in tissues at freezing, storage and subsequent thawing are due to a complex set of processes. At that, the nature of changes is dependent on physical and physical-chemical phenomena of water freezing out, crystal formation and structural changes in tissues.

Changes in hydrogen ions concentration and their redistribution in volume when freezing is one of the factors that causes cell disruption. Moreover, depending on solution composition, pH can vary either towards acidic or alkaline side. These processes contribute to the strengthening of denaturation effect, dissolved substances, namely, hydrogen ions can actively destroy cell membranes [1,2].

The next group of factors damaging the cell is due to the increasing concentration of the dissolved substances in the liquid phase crystallization process. Feature of biological objects freezing, where the main component is water, is that pure water first crystallizes and the dissolved solids are concentrated between the crystals. Freezing temperature decreases in these solids, the process continues with decreasing temperature until full saturation of the solution, and then the whole mixture passes to a solid state.

In the cellular substance freezing process, its part is pushed out by ice into the nonfrozen space in

concentrated solutions. Moisture is produced in them under osmotic pressure. Henceforth, denaturation of lipoprotein complexes occurs in the presence of hyperconcentrated salt solutions in proteins, the isoelectric point of which is in the acidic environment and becomes even more acidic, and consequently leads to denaturation [3,4].

One of the explanations for the protective effect of penetrating cryoprotectors is based on the fact that they can form a strong links with water and much stronger than water with water, thereby reducing the amount of frozen out water and dehydration of cells. Cryoprotectors bind intercellular water from inside, thus contributing to the formation of crystals with more rounded edges, and reduce the solution freezing point. Generally, the crystallization process when using cryoprotectors varies considerably, and the formation of intracellular ice is inhibited [5].

High-molecular cryoprotectors do not penetrate into cells, so the osmotic forces constantly maintain the newly formed by them moisture and salt balance inside and at the intercellular space. Therefore, both addition and removal of cryoprotectors is associated with the osmotic loads on the cell.

Thus, the introduction of cryoprotectors improves the durability of products in the freezing and thawing cycle, inhibiting the formation of ice crystals aggregates in the intermediate phase [6,7].

Formulation of the problem

Meat for processing has a complex chemical composition due to the meat morphological structure, including muscle, fat, chain and other tissues.

Numerous chemical, physica – chemical and microbiological processes occur in such systems at freezing and storage, thus specifying the quality of frozen meat products.

Careful selection of substances with cryoprotective effect is of great importance in respect of meat for processing. Studies carried out earlier in this direction [4] allowed identifying some types of hydrocolloids [8], insoluble polysaccharides and cereals as the most promising for application in the technologies of fast-frozen meat products.

Given the long shelf life of these products, the final conclusion on the cryoprotectors' positive impact can be obtained only after a comprehensive survey of all changes during storage. The lipid fraction of meat products is the least persistent to storage, which has determined the direction of survey [9,10].

Changes in lipid fraction of frozen meat products at storage

Samples of half-finished products with the cryoprotectors were produced for tests. Basic recipes without the polysaccharide additives served as control. Experimental and control samples, packed in polymeric materials, were frozen at the temperature of -30 °C and stored at temperature -18 ºC for 3 to 6 months.

The following half-finished products have been produced: 1 – patties (control); 2 – patties with the introduction of 1.0 % –carob bean gum by weight of the meat; 3 – patties with the introduction of 0.25 % – carob bean gum and 0.25 % -guar gum by weight of the meat; 4 – meatballs (control); 5 – meatballs with the introduction of 5 % -pumpkin meal by weight of the meat; 6 – meatballs with the introduction of 5 % - wheat germ by weight of the meat; 7 –croquettes (control); 8 – croquettes with the introduction of 10 %- cereal additive by weight of the meat.

Peroxide, acid and thiobarbiturate indexes were determined to monitor the dynamics of oxidation processes in the lipid fraction of control and pilot samples of half-finished products during the storage period. The studies were carried out in samples after freezing and every month within 6 months.

The dynamics of oxidation processes shown on Fig. 1-3, indicates the behavior of hydrolytic and oxidation processes in lipid fraction at storage of frozen products. Changes occur in both the control and experimental samples. Fat splitting occurs under the tissue lipase influence with the accumulation of free fatty acids, thereby increasing the acid-degree value (Fig. 1). Free fatty acids are first subjected to oxidation, which is accompanied by formation and accumulation of peroxide compounds.

The data obtained shows that the process of fat tissue destruction occurs with varying intensity throughout the storage period, as well as depending on the recipe composition and the inclusion of polysaccharides.

Accumulation of free fatty acids occurs with greater intensity in all samples of half-finished products without additives. Introduction of both hydrocolloids and insoluble polysaccharides reduces the hydrolytic processes rate.

Results of studies of fatty acids oxidation and accumulation of peroxides are shown in (Fig. 2)

Initially, the accumulation of primary fat oxidation products occurs in test samples without additives, and then, after reaching a maximum, some disintegration occurs with the formation of low molecular weight carbonyl compounds. These processes occur to the fullest extent in half-finished products with a higher fat content, i.e in patties and meatballs.

A decrease of peroxide indexes compared to control is observed in samples containing soluble and insoluble polysaccharides. This trend has continued throughout 6 months of storage. It may be noted that insoluble polysaccharides more effectively inhibit oxidation processes when comparing data on the influence of separate polysaccharide additives groups.

The studies of accumulation of by-products of oxidative fat damage, reacting with the thiobarbituric acid, have been presented in (Fig. 3). Oxidation by-products, in contrast to the primary ones, affect the organoleptic indicators of finished products.

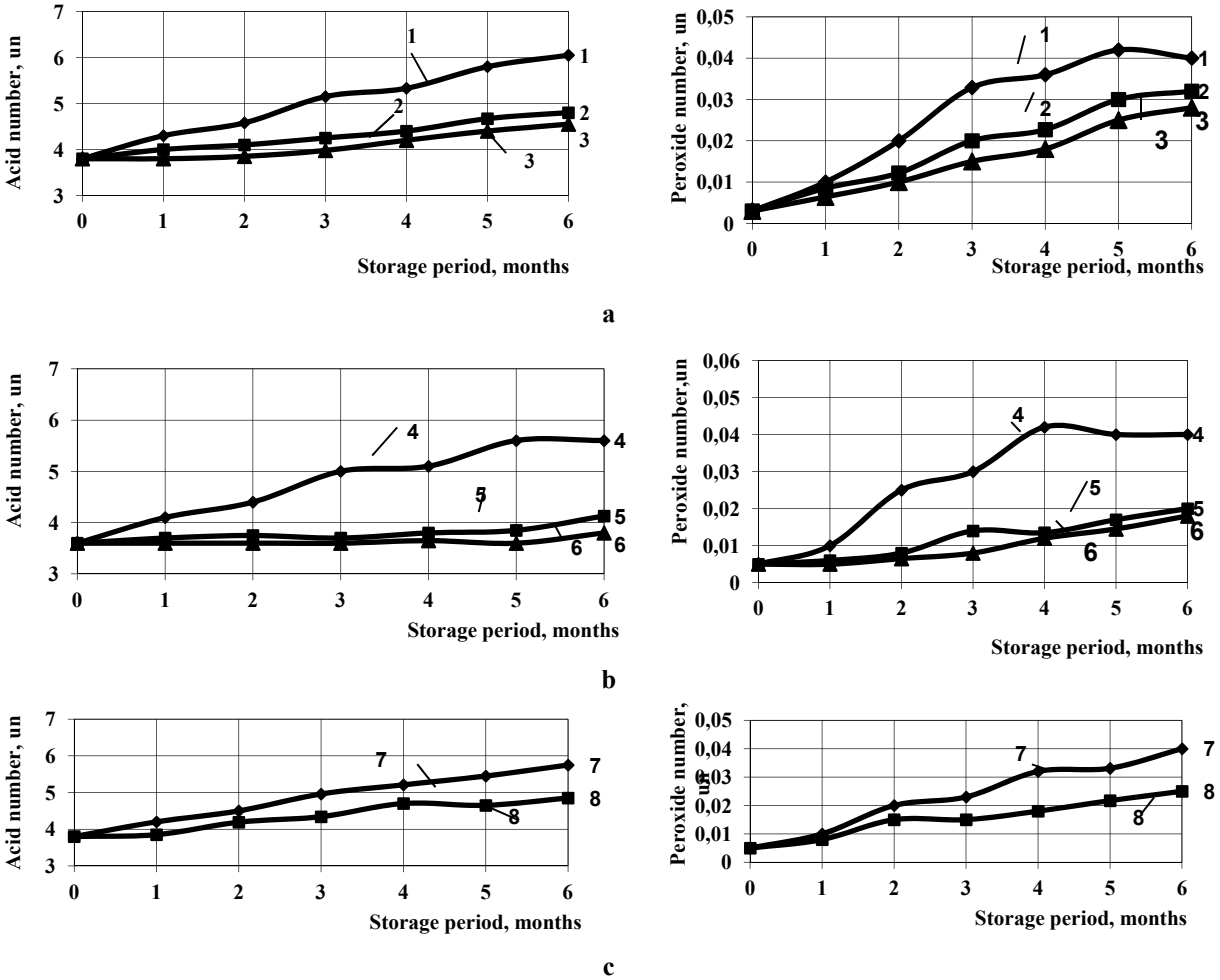

Fig. 1 The acid number changes during the storage of frozen semifinished products:
a – patties; b – meatballs; c – croquettes

Fig. 2 The peroxide number changes during the storage of frozen semifinished products

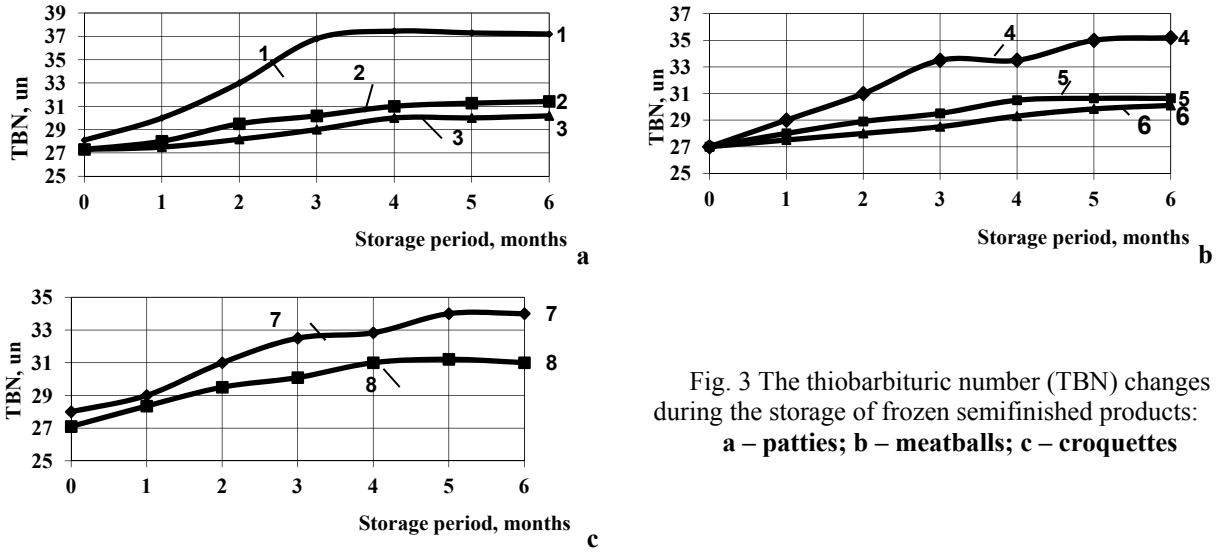

Fig. 3 The thiobarbituric number (TBN) changes during the storage of frozen semifinished products:
a – patties; b – meatballs; c – croquettes

The data obtained fully correlate with the results of peroxide and acid indexes study.

Thus, it is a good case to talk of the fact, that the introduction of all kinds of polysaccharide additives inhibits oxidation processes at the storage of frozen food.

Most likely, this is due to the following. The integrity of cell membranes, including lysosomes, is impaired when storing fat and muscle tissue. It leads to the release of hydrolytic enzymes, lipase in particular. As it has been shown earlier, with the polysaccharides introduction the degree of damage to meat tissues is significantly less due to the formation of smaller ice crystals, the output of lipase is less than in the control samples.

We may assume the inhibition of oxidation processes due to the stronger binding of water and the consequently reduction of water activity. It is peculiar to the insoluble polysaccharides fully, the fact that our findings confirm.

Conclusions

The results of studies of fat oxidation kinetics and data on the accumulation of primary and secondary oxidation products indicate that the introduction of above mentioned polysaccharide additives as cryoprotectors contributes to the inhibition of oxidation processes at the storage of frozen products.

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ИССЛЕДОВАНИЕ ВЛИЯНИЯ КРИОПРОТЕКТОРОВ НА ОКИСЛИТЕЛЬНЫЕ ПРОЦЕССЫ ПРИ ХРАНЕНИИ ЗАМОРОЖЕННЫХ ПОЛУФАБРИКАТОВ

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Аннотация. В публикации приведены данные по влиянию полисахаридов криопротекторов на изменения липидной фракции быстрозамороженных полуфабрикатов в процессе хранения. Так как структура фаршевых систем формируется в результате разрушения нативной структуры мяса и образования новой вторичной структуры, важным является установить влияние криопротекторов на ключевые функционально-технологичекие свойства мясных систем после замораживания, и в процессе хранении. На основании исследований кинетики окисления жира и данных по накоплению первичных и вторичных продуктов окисления установлено торможение окислительных процессов.

Ключевые слова: быстрозамороженные полуфабрикаты, полисахариды, липиды, кислотное число, хранение.

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