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Influence of biochemical properties of raw materials on the change of quality of salted fish products

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Abstract. According to the state of development of the fishery industry of Ukraine and increasing requirements for the quality of food products, it is relevant to address issues of preventing losses of fish products from spoilage of microbial origin, protecting them from oxidation, ensuring proper quality, safety and competitiveness of finished products sold on the Ukrainian market**.** The purpose of the work is to study the influence of the biochemical properties of raw materials on the change in the quality of salted fish products. The research explores the influence of the biochemical properties of raw materials on the change of quality of salted fish products packed in a modified environment. The main reasons for the deterioration of the quality of salted fish products are described. Possible areas for increasing the stability of salted fish products during storage are presented. The level of activity of tissue proteolytic enzymes is one of the main factors that characterise the maturation rate of salted fish, and the mass fraction of fat can determine the degree of influence of carbon dioxide on muscle tissue during storage. Accordingly, the results of the study of the initial fish raw materials, namely the mass fraction of fat and enzymatic activity of muscle tissue are presented. It was established that fish raw materials had significant differences in both the mass fraction of fat and enzyme activity. The results of studies of the physical and chemical parameters of salted fish

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products packed in a modified environment are presented. Initial composition of the gas mixture: 40% CO_2 and 60% N_2. High-barrier bags were used for packaging. The results of the experimental studies demonstrated that in terms of changes in quality indicators, the packaging of salted fish in a modified environment is most effective for products from non-fat raw materials with low total acidity and proteolytic enzyme activity. The practical value of the scientific work is to develop promising areas for improving the sustainability of salted fish products by using modified environments. Despite a significant amount of scientific research in the field of packaging, systematic studies of such products have not been conducted, thus, the practical application of modified environments raises the greatest number of questions for manufacturers regarding the reliable sustainability of products

Keywords: fish raw materials, salted fish products, biochemical parameters, modified environment

Introduction

The deterioration of the quality of salted fish products can be considered based on several compositional and environmental factors (Ivaniuta *et al*., 2021; Mazur *et al*., 2013).

Environmental factors include temperature, presence of packaging and modified environment, including modified gas environment (O_2, CO_2, N_2) and vacuum. Compositional factors (Kolyanovska *et al*., 2019; Zheplinska *et al*., 2021) include salt concentration, preservative, number of microorganisms, pH, and water activity.

One of the promising areas for increasing the sustainability of salted fish products is using modified environments during packaging and storage. Despite a significant amount of scientific research in the field of packaging, systematic studies of such products have not been performed, thus the practical application of modified environments and the influence of biochemical properties of raw materials on the change in the quality of salted fish products is an urgent subject of scientific research.

Analysis of recent studies and publications. The following scientists made a significant contribution to the study of technological factors affecting the change in the quality of salted fish products during storage: V.I. Shenderiuk, V.P. Lisova *et al.* (Golembovskaya, 2019).

The packaging process is of great significance in the production of salted fish products, which significantly affects the preservation of quality and economic indicators of production. Research in the field of packaging in modified environments of fish products was performed by the following foreign scientists: S. Knoechel, N. Huss, L. Gram, P. Masniyom and others (Holembovska *et al*., 2021; Sukhenko *et al*., 2019).

In the works of Devlighere, it was demonstrated that the degree of inhibition of microorganisms growth in the atmosphere of MGE is determined by the concentration of solubility in the product of CO_2. The concentration of CO_2 in food depends on the fat and water content and the partial pressure of CO_2 in the atmosphere. However, at high concentrations of oxygen dioxide in the package, and higher water content in the product, the appearance of a sour taste in the surface layer of meat is possible (Eveleva & Cherpalova, 2019).

Numerous studies have demonstrated the efficiency of packaging fish products in a vacuum and modified atmosphere (Palamarchuk *et al*., 2020; da Silva *et al*. 2019; Lansing *et al*. 2018).

Studies by V.P. Lisova demonstrated that using synthetic films for packaging salted herring under a vacuum significantly delayed

the process of fat oxidation (Fernandez *et al.*, 2019; Zheplinska *et al.*, 2020).

Thus, the results of the review of scientific literature demonstrate the prospects of using a modified environment in the technology of production of salted fish products.

The purpose – explore the influence of biochemical properties of raw materials on the change in the quality of salted fish products packed in modified environments during storage.

Material and Methods

The following fish species were used for the study: Baltic cod (Gadus morhua callarias), Atlantic herring (Clupea harengus), Baltic herring (herring) (Clupea harengus membras), Baltic sprat (Sprattus sprattus balticus), pink salmon (Oncorhynchus gorbuscha), Atlantic mackerel (Scomber scombrus), Atlantic salmon (Salmo salar). To obtain a given mass fraction of salt (4.2-4.5%), mixed salting of fish divided into fillets (except sprat and herring) and carcasses (sprat, herring) was performed. The mass fraction of preservative in the products was 0.02%. A mixture of sodium benzoate and potassium sorbate in a ratio of 1:1 was used. After salting, the skin was removed from the fish (except for sprat and herring) and packed in the form of fillets in high-barrier bags. After packing, the bags were filled with a modified gas environment on a vacuum machine. Initial composition of the gas mixture: 40% CO_2 and 60% N_2. High-barrier bags were used for packaging.

The mass fraction of lipids by the Soxhlet method, which consists in weighing the fat after its solvent extraction from a dry sample in a Soxhlet apparatus, is based on the determination of the change in the mass of the sample after the extraction of fat with a solvent.

Water activity (aw) was determined on the LabMaster-aw device by the hygrometric electrolytic method. Active acidity (pH) was determined according to GOST 28972-91 (1991). Canned and processed fish and non-fish products.

The mass fraction of sodium chloride was determined by the argentometric method according to GOST 7636-85 (1985). Fish, marine mammals, marine invertebrates and their products.

The activity of proteolytic enzymes of muscle tissue was determined by the intensity of amine nitrogen accumulation (mg/100 g of tissue per min).

Results

The method of establishing an oxygen-free environment in the package with salted fish (vacuum or modified gas environment consisting of carbon dioxide and nitrogen) affects the biochemical processes that occur in the experimental salted fish during storage. Table 1 presents data on fat content and activity of tissue proteolytic enzymes in the feedstock.

Table 1. *Characteristics of raw materials*

Fish species	Mass fraction of fat, %	Enzymatic activity, μg of nitrogen per 1 g of muscle tissue, min
Mackerel	25.3 ± 0.12	0.23 ± 0.01
Salmon	14.2 ± 0.14	0.11 ± 0.02
Herring	12.3 ± 0.05	0.22 ± 0.03
Salaca	6.3 ± 0.04	0.08 ± 0.01
Sprat	4.9 ± 0.02	0.37 ± 0.02
Pink salmon	4.1 ± 0.06	0.07 ± 0.01
Cod	0.6 ± 0.04	0.06 ± 0.01

As Table 1 demonstrates, the fish raw materials used for the studies had significant differences in both the mass fraction of fat (0.6-25.23%) and enzyme activity (0.07-0.37 μg nitrogen/g/min). The highest activity was observed in muscle tissue enzymes of sprat, mackerel and herring, and the lowest – was in cod and pink salmon.

The physicochemical characteristics of fish after posting are presented in Table 2.

Despite the close values of the mass fraction of salt, the differences in water activity for the investigated fish species are quite significant, due to their different fat content and, consequently, different moisture content. It is essential to consider a wide range of active acidity (pH).

Table 2. *Physicochemical parameters of salted fish products*

Fish species	Mass fraction of sodium chloride, % in muscle tissue	Concentration of sodium chloride, % in the water phase	pH, unit			aw, unit
			0-day	40th day		
				v/p	MGE	
Salmon	4.3 ± 0.1	6.2 ± 0.1	6.20 ± 0.01	6.1	6.07	0.946 ± 0.003
Mackerel	4.2 ± 0.3	7.2 ± 0.3	6.18 ± 0.03	6.16	6.15	0.946 ± 0.002
Pink salmon	4.3 ± 0.2	5.4 ± 0.2	6.16 ± 0.02	6.1	6.15	0.959 ± 0.003
Herring	4.4 ± 0.3	6.1 ± 0.3	6.21 ± 0.01	6.2	6.26	0.953 ± 0.001
Salaca	4.2 ± 0.1	5.4 ± 0.1	6.60 ± 0.03	6.39	6.42	0.961 ± 0.002
Sprat	4.1 ± 0.2	5.3 ± 0.2	6.60 ± 0.01	6.34	6.36	0.963 ± 0.001
Cod	4.2 ± 0.2	5.5 ± 0.2	7.10 ± 0.02	7.02	7.01	0.969 ± 0.001

On the 40th day of storage, the pH values of muscle tissue of most types of products (except pink salmon and salmon) packed in modified media were lower, and the total acidity was higher than in samples in vacuum packaging. Such data along with the dynamics of oxygen changes in the package can explain the specific biochemical and microbiological processes of pink salmon and salmon. Perhaps the increased pH value of raw materials was one of the reasons for the earlier onset of organoleptic spoilage of salted fish in vacuum packaging.

Thus, considering the results of the conducted research, packaging of salted fish in MGE (CO_2 – 40%, N_2 – 60%) is the most effective in terms of changing the quality indicators for products from non-fat raw materials with low total acidity and low activity of proteolytic enzymes, which in this research includes herring and cod.

Conclusions

As a result of the research, the highest activity of muscle tissue enzymes was established in sprat (0.37), mackerel (0.23) and herring (0.22), the lowest – in cod (0.06) and pink salmon (0.06).

It was established that the lowest fat content was detected in cod (0.6), and the lowest – in mackerel (25.3).

It has been proved that packaging in modified media is most suitable for herring and cod, as they are the least fatty and have low indicators of total acidity of proteolytic enzyme activity.

Based on the results obtained, the ways of further research were determined: to explore the influence of the mass fraction of salt on the change in the quality of salted herring packed in modified environments during storage.

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