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CHANGES IN CONSUMER PROPERTIES OF NEW GRAIN CRISPBREADS BASED ON SPELT DURING STORAGE

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Abstract. The changes that occur with the organoleptic, physicochemical, and microbiological performance of new grain crispbreads based on spelt with the inclusion of enriching supplements in the process of storage. Types of packing, which are used for packing grain crispbreads have been analyzed. The results of the organoleptic analysis showed that the use of biaxially oriented polypropylene film (BOPP) kept the organoleptic performance of grain crispbreads at a high level for six months, in contrast to the samples that were stored in a polyethylene film (PF). According to the physical and chemical performance (mass fraction of moisture, acidity and the acid number of fat), it was found out that it is advisable to use metalized packages of BOPP for storage of crispbreads, allowing their storage life extension up to six months with a slight decrease in physical and chemical performance. Microbiological analysis showed that the inclusion of vegetable supplements in grain crispbreads reduced the overall insemination of the initial samples and improved the stability of finished products during storage, due to the antioxidant properties of enriching supplements. On the basis of the researches carried out, we define the guaranteed storage term for expanded heifers, which is 6 months in the BOPP package.

Keywords: *grain crispbreads, spelt, vegetable supplements, storage, consumer properties, physicochemical performance.*

Introduction

Along with the development of new products, the question of the duration of their storage, that is, the possibility of bringing products to the consumer with the least loss in quality and quantity is of great importance. The storage process is usually accompanied by deterioration of the quality of food products, their organoleptic properties, nutritional and biological value, the development of the microflora, and other undesirable processes. Moreover, the duration of storage is determined by the individual composition of products, the intensity of biochemical processes therein, as well as the nature of introduced supplements, the effect of which may vary [1].

It is required to use packaging materials to weaken the influence of the environment on the quality of products and to prolong their storage life. Packaging is necessary to protect against mechanical damage, contamination, exposure to sunlight and heat, to prevent sticking, drying, and moistening, to preserve the taste and aroma of products, to reduce losses and increase storage life, and to provide products with an effective and attractive look.

The aim of the paper is to learn changes occurring with consumer properties (organoleptic, physicochemical, and microbiological performance) of grain crispbreads based on spelt with the inclusion of vegetable supplements during the storage process, in order to establish a guaranteed storage life.

Materials and Methods

Research materials used in the experiment. For the purpose of research, spelt, enriching vegetable supplements were used as objects: milk thistle powder, rose hip fruit powder, chokeberry fruit powder, and green tea extract, as well as new grain crispbreads based on these components. According to the previously calculated formulation [2], all the initial components of grain crispbreads were subjected to sieving, magnetic cleaning, and dispersing. Prepared dry ingredients were mixed with water for 5 minutes until a homogeneous mass and redistribution of surface-bound moisture were reached. The obtained mixture was fed to a special device for the production of whole-grain swollen grains of the brand, where its thermal and mechanical processing was performed. As a result, grain crispbreads in the form of round briquettes were obtained: the control is crispbreads of spelt; sample 1 is crispbreads of spelt with the inclusion of 5% of the milk thistle powder; sample 2 is crispbreads of spelt with the inclusion of 5% of rose hips powder; sample 3 is crispbreads of spelt with the inclusion of 5% of chokeberry powder; and sample 4 is crispbreads from spelt with the inclusion of 0.5% of green tea extract.

Methods for Identification the Quality of Grain Crispbreads. Identification of the moisture mass fraction in the raw materials and finished products was carried out by drying the sample of the product to a constant mass at a temperature of 100-105°C as per GOST 15113.4-77. Acidity in finished products was identified by the method of alkali titration of all acids in the product as per GOST 15113.5-77. The acid number of fat in crispbreads was identified by the titration of free fatty acids as per GOST 5476-80.

Microbiological studies were carried out before dispatching for storage and every 3 months of storage. To identify the qualitative and quantitative content of the microflora, both classical techniques and modern microbiological express analyzer "BacTrac 4300" (Austria), whose work is based on the registration of changes in the electrical resistance (impedance) of the nutrient medium, occurring as a result of microorganism activity have been used. Samples were taken to sterile dishes under aseptic conditions, excluding microbial contamination of samples from the environment. The qualitative and quantitative content of the microflora of samples was identified by microbiological and sanitary indicators, which include the number of mesophilic-aerobic and facultative-anaerobic microorganisms, micromycetes (mold and yeast fungi), bacteria of the intestinal bug group (coliform bacteria), followed by identification of potentially pathogenic Escherichia coli and Staphylococcus aureus, and pathogenic microorganisms, including Salmonella and sulfide-reducing clostridia. Identification was carried out by sowing on special culture media with subsequent cultivation and characterizing as per GOST 10444.9, 10444.12, and 10444.15.

The total number of bacteria was determined by sowing wipe-samples of various degrees of dilution in meat infusion agar, mold and yeast fungi, in wort agar, followed by cultivation at the temperature of (30±1)°C for 24-48 hours and (28±1)°C for 5-7 days, respectively. Spore forms of bacteria were identified in pasteurized wipe-samples that had been seeded on a complex nutrient medium of the meat infusion agar and wort agar in the (1:1) ratio; to identify clostridia, sowing was made in the liver broth and the nutrient Kitt-Tarozzi medium; to identify Staphylococci, in the milk-salt agar; to identify Salmonella, in the bismuth-sulfite agar; and to identify Proteus vulgaris, in the condensing water of the freshly-cut meat infusion agar. The presence of E.coli in the Kessler medium was analyzed by the turbidity of the medium, the appearance of gas bubbles in the floats and changes in the color of the nutrient medium, which are mandatory signs of acid and gas formation for this study and are formed when these bacteria ferment sugars. Furthermore, the identification of directly potentially pathogenic *Escherichia coli* was carried out by transplanting to the differential diagnostic Endo medium; cultivation was carried out at the temperature of (30±1)°C for 24-48 hours.

Results and Discussions

Based on the analysis of the range of grain crispbreads that are represented in the trading chain and references concerning packaging materials that use various enterprises when packing grain crispbreads, it was revealed that manufacturers most often used the following types of packaging: plain polyethylene film (PF) and biaxially oriented polypropylene film (BOPP) [2, 3].

To study changes in consumer properties of grain crispbreads based on spelt with the inclusion of vegetable supplements during the storage process, a number of experiments were conducted to study changes in organoleptic, physicochemical, and microbiological performance of the product quality depending on the storage duration and conditions. For this purpose, all samples were placed in a conventional food polyethylene film and packages of BOPP, GM-200, and stored at the temperature of (18±2)˚C and a relative humidity of 70...75% for 6 months. The quality performance was determined immediately after their manufacture, as well as after 3, 6 months of storage.

Based on organoleptic analysis, it was found that grain crispbreads with the inclusion of enriching supplements, which were stored in packages of BOPP for six months, practically did not change their look, had a pleasant pronounced taste of the supplements used, porous and crispy structure, and did not have any foreign odor (Figure 1). It should be noted that after three months of storage, the control sample, which was stored in packages of BOPP, had slightly deteriorated organoleptic performance, particularly, the sample had a slight foreign taste and not enough crispy structure. This allows assuming that the inclusion of vegetable supplements in the composition of grain crispbreads helps to prolong the preservation of acceptable organoleptic performance of products. After six months of storage, both the control and the test studied samples, which were stored in the PF, had a slightly rancid taste, an unpleasant aftertaste, and a foreign faint odor, these samples did not have a crispy structure as well. The results show the inadmissibility of the use of the PF for packaging and storage of grain crispbreads. Therefore, it is established that the metalized packages of BOPP preserve the organoleptic quality performance of grain crispbreads at a high level within six months, in contrast to the samples stored in the PF.

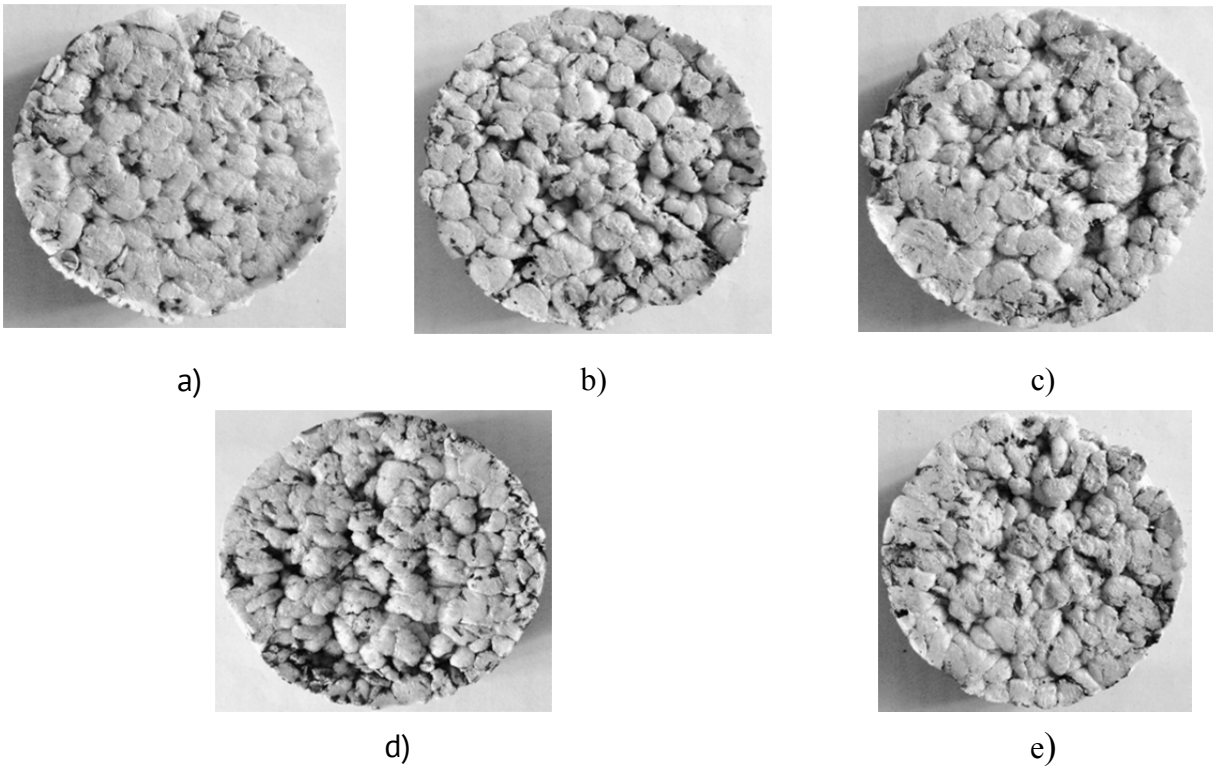

Figure 1. Samples of grain crispbreads: control (a), sample 1 (b), sample 2 (c), sample 3 (d), sample 4 (e).

In addition to organoleptic performance during the storage of grain crispbreads, changes in such physical and chemical quality indicators as the mass fraction of moisture, acidity, and the acid number of fat were also controlled. The results of the change in the mass fraction of moisture of the samples are shown in Figure 2. In the samples that were

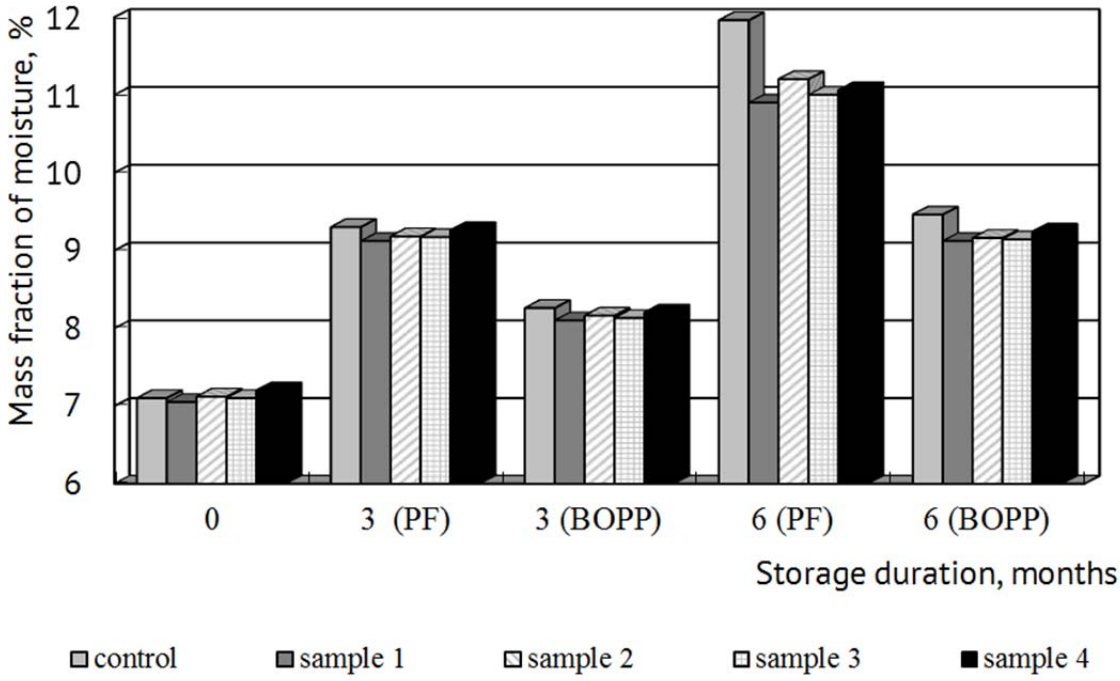

Figure 2. Change in the mass fraction of moisture of grain crispbreads during storage, depending on the package.

stored in the polyethylene film, the mass fraction of moisture increased significantly compared to the samples that were stored in BOPP. In our opinion, the reason is the properties of the package, particularly, BOOP has high moisture-proof properties in relation to the PF [3, 4]. In this regard, the mass fraction of moisture in the studied samples that were stored in BOPP increased by an average of 1.3 times during six months of storage, while in products that were stored in the polyethylene film, by an average of 1.6 times. At the end of the sixth month of storage, the mass fraction of moisture in the samples that were stored in the PF exceeded the standard allowed by the designed specifications for the product (under 9.5%) by an average of 1.2 times. The results also indicate that the inclusion of supplements in the composition of crispbreads may reduce the intensity of the process of moisture loss during storage. Probably, this may be explained by the fact that the supplements that were included in the composition of crispbreads had a higher moisture-retaining capacity, which was also confirmed in a number of papers [5].

This allows reducing the loss of moisture and positively affecting the storage life of products.

During the process of storage of crispbreads, the change in acidity was also identified (Figure 3).

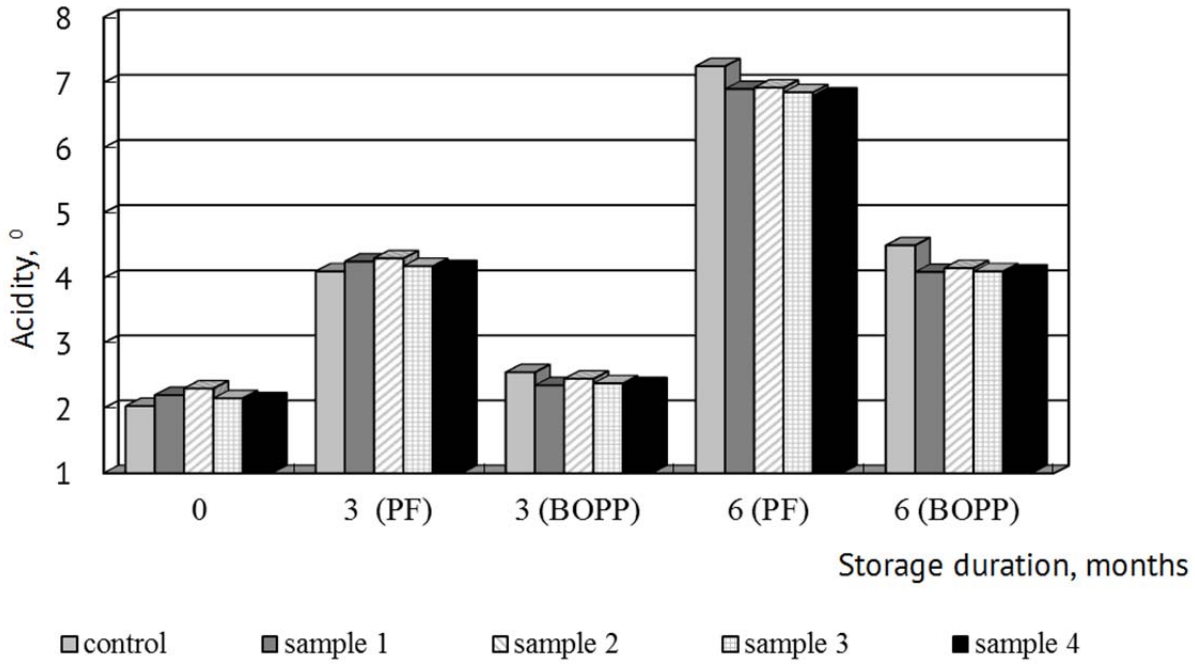

Figure 3. Change in the acidity of grain crispbreads depending on the packaging during storage.

As it is known [6], the index of titrated acidity indicates the freshness of grain products, and an increase in its value during storage is a consequence of changes in the constituent chemicals of grain products under the impact of enzymes or microorganisms. The results of studies showed that the inclusion of supplements in the composition of grain crispbreads led to an increase in the initial value of acidity. In our opinion, this is due to the chemical composition of supplements, particularly, to the presence of organic and fatty acids [7, 8]. It was also found that the acidity of the samples that were stored in BOPP packages for six months increased slightly compared to the samples that were stored in the

PF. Thus, after 6 months of storage, the studied samples that were stored in BOOP had the average acidity value of 4.1 ^{0} N, which corresponded to the requirements of the designed regulatory documentation for grain crispbreads. After 6 months of storage, the samples that were stored in the PF had the average acidity value of 6,9 ^{0} N, which is much higher compared to the samples that were stored in BOPP. The results indicate the feasibility of storage of enriched grain crispbreads in BOPP for six months.

The accumulation of fatty acids, which occurs due to the preservation of fat, may be controlled by measuring the acid number. As it is known [1], the intensity of fatty acid accumulation is due to the formulation of products, storage conditions, and storage life, as well as protective properties of the packaging material. If the packaging is not sealed during storage, it will increase the humidity and temperature of products, and as a result, activate all processes leading to faster spoilage of products [3].

The results of studies of changes in the acid number of fat during storage of grain crispbreads showed in Figure 4. The acid number increases with an increase in storage life, but it should be noted that with each measurement, the amount of free fatty acids was greater in the control sample, compared to the test ones, which contained supplements with bioantioxidants.

In addition, during the studies, protective functions of BOPP were found, which are manifested in the inhibition of the accumulation of free fatty acids, that is, during the final storage period, the difference between the values of the acid number of the fat component of grain crispbreads stored in BOPP and those stored in the PF accounted for up to 70% on average (in favor of BOPP).

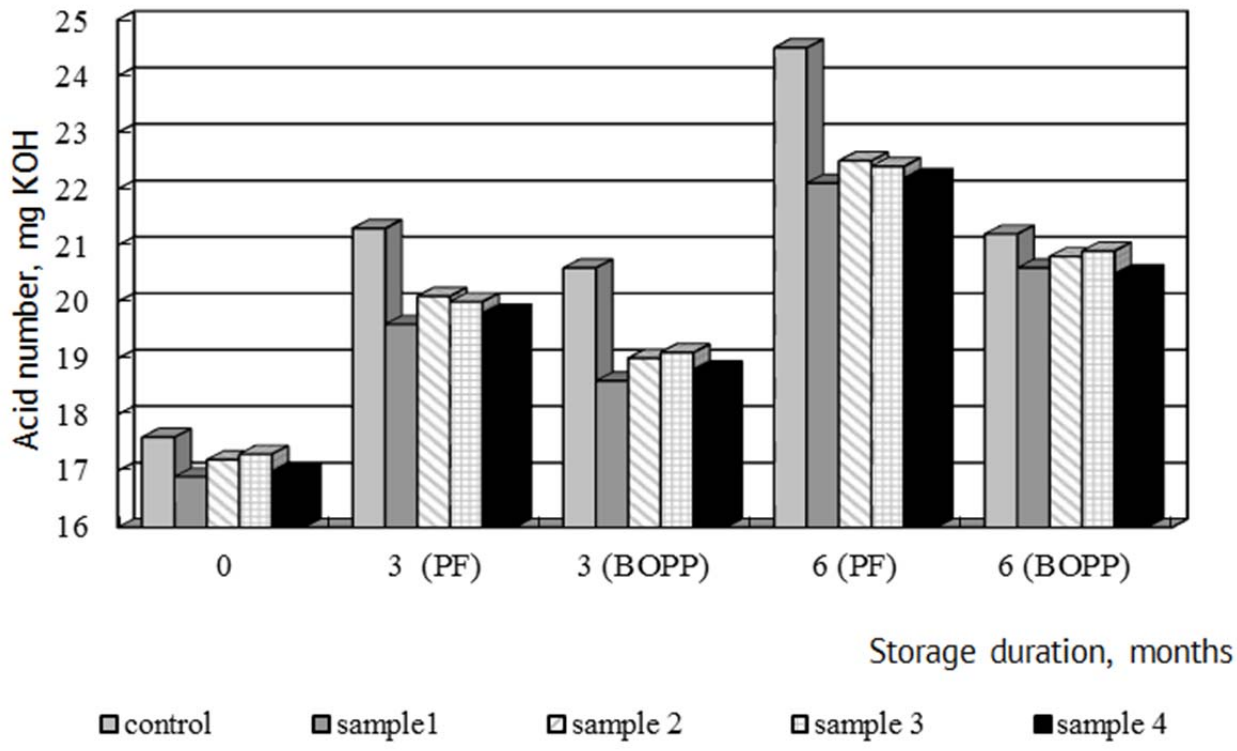

Figure 4. Change in the acid number of fat of grain crisp breads depending on the packaging during storage.

Based on the conducted studies, the following is found out: it is expedient to use BOPP for storage of enriched grain crispbreads, which will allow prolonging their storage life to six months, with an insignificant decrease in physical and chemical performance.

One of the most important indicators of the quality of any food product especially obtained on the basis of a multicomponent vegetable system and its microbiological performance. The number of mesophilic-aerobic and facultative-anaerobic microorganisms is a mandatory indicator of quality and persistence of any product during storage, and this indicator is widely used in the food industry.

Determination and identification of pathogenic, potentially pathogenic microorganisms, mold and yeast fungi are necessary in terms of safety since the presence or increase of their content compared to the permissible standard may cause food poisoning [9]. During the study of the control sample microflora content, it was found out that the dominant representative is the non-sporogenous rod-shaped bacteria, Erwinia herbicola (representative of the epiphytic the microflora of grain). It is believed that the number of these bacteria is an indicator of grain freshness. The content of Erwinia herbicola in relation to the total number was 65-70%.

A group of Bacillus subtilis-licheniformis was found as a representative of sporogenous bacteria, their relative content was 12-17% of the total number of microorganisms, and the number of coliform bacteria was 10...16%.

Representatives of micromycetes identified before dispatch for storage were field mold fungi of the Cladosporium, Alternaria species and a negligible number of unidentified fungi. If the total number of microorganisms, including Erwinia herbicola, coliform bacteria, Bacillus subtilis-licheniformis, micromycetes are taken as 100%, each of them amounts to 67.4%, 13.05%, 15.21%, and 4.34%, respectively.

Changes in the content of the microflora of finished crispbreads during storage are shown in Table 1. As it may be seen from the data obtained, the presence of yeast fungi is identified in none of the samples.

For non-sporogenous the microflora in grain crispbreads, their presence is probably conditioned by a heat shock, which is received by cells during the process of swelling, followed by the resumption of cell activity after a certain storage time.

During the storage for 6 months, the total number of bacteria decreased in the control sample by 16.2...23.8%, regardless the type of packaging.

The data characterizing the dynamics of changes in the microflora of the test samples of grain crispbreads indicates that in all samples during storage, the number of bacteria decreased, regardless of the type of packaging. The most significant decrease was observed when using BOPP with grain crispbreads that included rose hip fruit powder, by 60%, and green tea extract, by 39%, which may be explained by the antioxidant properties of enriching supplements [8]. The decrease in the number of bacteria in all the studied samples was due to the die-off of bacteria mainly of the Erwinia herbicola species, which is natural for grain products during storage.

For sporogenous bacteria, their qualitative content in all the studied samples remained unchanged, and the quantitative one decreased.

The total number of microorganisms before 6 months of storage. For sporogenous bacteria, their qualitative content in all the studied samples remained unchanged, and the quantitative one decreased.

Table 1

Change in the microbiological performance of grain crispbreads during storage, mesophilic-aerobic and facultative-anaerobic microorganisms (thd/g)

Type of packaging	Duration of storage, months	The content of the microflora (CFU/g * 10^3)						
		Mesophilic-aerobic and facultative-anaerobic microorganisms			Micromycetes			
			including					
		Total	B.subtilis-licheniformis	Erwinia herbicola	Total	Aspergillus	Penicillium	Others
Control, grain crispbreads without supplements								
PF	0	1.05	0.62	0.12	0.04	0.00	0.00	0.04
	3	0.94	0.48	0.06	0.03	0.00	0.01	0.02
	6	0.80	0.33	0.01	0.02	0.01	0.01	0.00
BOPP	0	1.05	0.62	0.12	0.04	0.00	0.00	0.04
	3	0.99	0.38	0.09	0.03	0.00	0.01	0.02
	6	0.88	0.24	0.05	0.02	0.01	0.01	0.00
Grain crispbreads with rose hips (sample 1)								
PF	0	0.50	0.38	0.03	0.02	0.00	0.00	0.02
	3	0.42	0.29	0.01	0.01	0.00	0.01	0.01
	6	0.20	0.02	0.00	0.01	0.00	0.01	0.00
BOPP	0	0.50	0.42	0.03	0.02	0.00	0.00	0.02
	3	0.44	0.11	0.01	0.02	0.00	0.01	0.01
	6	0.38	0.02	0.00	0.01	0.00	0.01	0.00
Grain crispbreads with chokeberry (sample 2)								
PF	0	0.80	0.58	0.10	0.03	0.00	0.00	0.03
	3	0.68	0.17	0.09	0.03	0.00	0.01	0.01
	6	0.60	0.01	0.07	0.03	0.01	0.02	0.00
BOPP	0	0.80	0.58	0.10	0.03	0.00	0.00	0.03
	3	0.74	0.09	0.09	0.03	0.00	0.01	0.01
	6	0,69	0.01	0.07	0.03	0.01	0.02	0.00
Grain crispbreads with milk thistle (sample 3)								
PF	0	0.72	0.53	0.08	0.03	0.00	0.00	0.03
	3	0.61	0.15	0.04	0.02	0.00	0.01	0.02
	6	0.55	0.02	0.02	0.01	0.00	0.01	0.00
BOPP	0	0.72	0.53	0.08	0.03	0.00	0.00	0.03
	3	0.66	0.14	0.06	0.03	0.01	0.01	0.01
	6	0.60	0.02	0.03	0.03	0.01	0.02	0.00
Grain crispbreads with green tea extract (sample 4)								
PF	0	0.66	0.49	0.07	0.02	0.00	0.00	0.02
	3	0.50	0.15	0.04	0.01	0.00	0.01	0.01
	6	0.40	0.01	0.00	0.01	0.00	0.01	0.00
BOPP	0	0.66	0.49	0.07	0.02	0.00	0.00	0.02
	3	0.57	0.15	0.05	0.02	0.00	0.01	0.01
	6	0.48	0.08	0.02	0.02	0.01	0.01	0.00

The total number of microorganisms before 6 months of storage decreased in all the samples: in the control, by 1.2 times, in crispbreads with vegetable supplements, by an average of 1.5 times. Micromycetes did not develop practically, but there was a change in their species composition.

The number of field fungi of the *Alternaria, Cladosporium* species and other unidentified field fungi decreased, compared to the beginning of storage and up to 6 months of storage, they completely vanished in all samples of grain crispbreads. Permanent representatives of the fungal microflora of grain crispbreads are *Penicillium* fungi, and only before 6 months of storage, *Aspergillusin* fungi were found in all samples, except for grain crispbreads with the inclusion of rose hip fruit powder, green tea extract, and milk thistle powder in the polyethylene film. However, it should be noted that in the same samples, the content of micromycetes before 6 months of storage decreased by 50%.

In all the studied samples, regardless of the type of packaging and the inclusion of supplements, Salmonella, E.coli, sulfite-reducing clostridia are not detected. The presence of micromycetes is within regular limits. This indicates the provision of appropriate sanitary and hygienic conditions in the production of grain crispbreads.

Studies of the qualitative and quantitative composition of the microflora of grain crispbreads showed that the inclusion of vegetable supplements in grain crispbreads reduced the overall insemination of the output samples and improved the persistence of finished crispbreads during storage.

This is probably because these vegetable supplements, especially rose hips powders and green tea extract, are of a high content of vitamin C and bioflavonoids, which exhibit a bactericidal effect on microorganisms.

The samples stored in BOPP are characterized by lower microbial insemination than those in the conventional food film. Thus, according to the results of microbiological studies, it was found out that the presence of vegetable supplements in grain crispbreads not only improves the nutritional and biological value but also increases the storage life due to the content of substances with bacteriostatic effect therein.

Conclusions

The results of studies of organoleptic and physicochemical performance showed that the use of BOPP preserves the organoleptic quality performance of grain crispbreads at a high level within six months, in contrast to the samples stored in the PF.

The packaging of crispbreads in metalized packages of BOPP also allows prolonging their storage life up to six months with a slight decrease in physical and chemical performance. It is found out that the inclusion of vegetable supplements in the composition of grain crispbreads helps to prolong the preservation of acceptable organoleptic performance of products. Studies of the qualitative and quantitative composition of the microflora showed that the inclusion of vegetable supplements in grain crispbreads reduced the overall insemination of the output samples and improved the persistence of finished crispbreads during storage.

Based on studies, it is found out that the samples stored in BOOP are characterized by lower microbial insemination than those in the conventional food film.

Based on the studies, it was found out that the guaranteed storage life of grain crispbreads in the package of BOPP at the temperature of 18±2˚C and a relative humidity of 70...75% is 6 months.

References:

1. Vankevich, V.P., Milyutina, L.M., Rezgo G.Ya. *Storage of Food Products*. Moscow: Economics, 1983.
2. Mardar, M., Tkachenko N., Znachek R., Leonardi S. Optimization of formulation composition of the crispbread with improved consumer properties. In: *Process Audit and Reserves of Production*, 2017, 2/3 (34). P. 22-29.
3. Sirokhman, I.V., Zavgorodnya, V.M. *Merchandizing of Packaging Materials and Containers*. Kyiv: Center of Science Literature, 2005.
4. Kontominas, M. G. *Food Packaging: Procedures, Management and Trends*. New York: Nova Science Publishers, Inc., 2012.
5. Lukina, S.I., Zhuravlev, A.A., Sadykova, M.K. Non-Conventional Types of Flour in Cupcake Production Technology. In: *Bakery Products*, 2013, 10. P. 44-45.
6. Kozmina, N.P. *Biochemistry of Grain and Products of Its Processing*. Moscow: Kolos, 1976.
7. Volynsky, V.G., Bender, K.I. *Plants in Medicine*. Saratov: Publishing House of the Saratov University, 1988.
8. Mardar M., Vikul S., Znachek R., Bordun T. Analysis of quality of grain shortbread for biological activity and medical-biological assessment in: East.-Europeans'. journal. advanced technology, 2018, Vol. 6, 11 (96). P. 69 to 76.
9. Smirnova, T.A., Kostrova, Ye.I. *Microbiology of Grain and Products of Its Processing*. Moscow: Agropromizdat, 1989