

STUDY OF THE MAIN QUALITY INDICES OF WHEAT FLOUR-BASED CROQUETTES DURING STORAGE

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Abstract

Introduction. The research paper is devoted to the study of the main indices of croquettes quality under different storage conditions. The analysis of the modern market of formed culinary production, in particular culinary products from the croquet mass which is limited at the domestic market is carried out.

Materials and methods. Organoleptic, physical and chemical, microbiological indices were selected as the main indices of the samples quality which were determined in the experiment. Organoleptic characteristics of products were carried out by the profile method with five-point scale use (according to the average data).

The dry matter content of wheat flour-based croquet mass was determined by the arbitration method, total protein – by the Kjeldahl method, carbohydrates – by the iodometric method. The mass fraction of fat was determined by the Soxhlet method, the lipid content was determined by weight method with extraction by Bligh E., Dyer W.

Results and discussion. The main problem of production and sale of croquettes is limited storage term which is no more than 14 hours at temperature of 4 ... 8 °C. Systematic research in the interests of restaurant business enterprises isn't found in the literature for determining the technological parameters of croquettes production without food additives use. The fact that croquet mass chemical composition is diverse greatly complicates storage conditions and terms. That is why the use of preliminary hydrothermal treatment

of wheat flour during croquettes production is relevant for further storage conditions and terms.

The main quality indices of wheat flour-based croquettes during storage in the cooled and frozen state are studied. It is established that storage of cooled samples at temperature of 2...4 °C during 12 hours and frozen samples at temperature of below 18 °C during 6 months is rational from high consumer properties preservation point of view.

Physical and chemical parameters of croquettes in the form of semi-finished products and finished products have been determined and comprehensively studied. The main indices (humidity, content of fat, protein, carbohydrates, etc.) during cooling and freezing are established.

The microbiological parameters of croquettes immediately after their production and during storage were studied for products' shelf life determining.

Conclusions. The research results provide the opportunity for storage parameters rationalization of wheat flour-based croquettes (they are 2...4 °C during 12 hours for cooled products and below - 18 °C during 6 months for frozen products).

Keywords:

croquettes,
frozen semi-finished products,
hydrothermally processed wheat flour,
organoleptic, physical and chemical, microbiological indices

Introduction

Recently, the interrelationship between diet and health becomes increasingly important. The population part which suffers from malnutrition result diseases is growing every year. Currently, one of the traditional forms of diet around the world, including in Ukraine, is culinary products that are processed by deep frying and industrial production flour products. Sociological research [1, 2] find that potato chips, crackers, as well as hot fried snacks, mainly croquettes, breaded cheese, meat and fish products (nuggets, sticks, strips), chicken wings in breadcrumbs and seafood are especially popular among the population. These products composition components are starchy and fatty products that are saturated with fat and oxidized during the production and storage of culinary products.

It is established [2, 3] that formed culinary products, in particular croquettes mass products, are of special interest to consumers. Its range at the domestic market is limited, so the need is not sufficiently met.

Croquettes (fr. croquette, from croquer – to crunch, gnaw) are products which are produced from chopped meat, fish, vegetables, cereals with

structuring agent use (egg products, wheat flour, etc.), breaded and deep-fried [4].

The term of storage and sale of croquettes which are produced according to the traditional technology at temperature of 4...8 °C is no more than 14 hours. Finished products must meet the requirements of regulatory documentation according to shape, weight and humidity.

At present, there is a lot of information about storage duration increasing of culinary products that were pre-treatment processed (deep frying). Typically, these characteristics include general recommendations for their use in specific technologies. Firstly, it is the cryostabilizers use (combinations of hydrocolloids such as chemical modification starch with gums, carrageenan, etc.), which maintain stable structural and mechanical indices of the product after the «freeze-thaw» cycle. Secondly, it is the use of expensive refrigeration equipment, which is able to cool in minutes, freeze the product to -24 °C without further deformation of the product and with minimum icing.

However, the main principle in the technological process is hydrothermal processing laws of wheat flour, which is transformed by starch grains and protein swelling that are then colloiddally bounded during the «freezing-thawing» cycle.

The preliminary hydrothermal processing methods of wheat flour main components change during croquet mass production on its base are studied. Therefore, the main indices of croquet mass quality during storage were studied in works [5, 6].

Under analyzing the modern market of frozen semi-finished products, it is found that frozen semi-finished products are extremely popular products: 93% of all families in Ukraine buy them at least once a year [7]. The frozen semi-finished products market is represented by: meat, fish, poultry, vegetables and mushrooms (meat dumplings, dumplings, croquettes, chebureks, pizza, crab sticks, etc.). These products are sold through the trade network, but in restaurant business enterprises (RBE), in particular of the «fast food» format, there is growing demand for culinary formed products which are made from croquet mass.

According to the analysis result [1, 4] of existing technologies the culinary formed products from croquet mass are classified by: basic raw material type, heat treatment method, recipe composition, technological purpose, type of breading and filler, production method (heat treated, frozen and production which requires additional heat treatment, frozen production, but that needs to be deep-fried after thawing, cooled) and form.

It is established that recipe components percentage is important: the main raw material is 50...60%, structure forming agents are 5...10%, raw material that forms the range of 0...30%, additional raw material is 10...15%, spices are 1...2% (fig. 1).

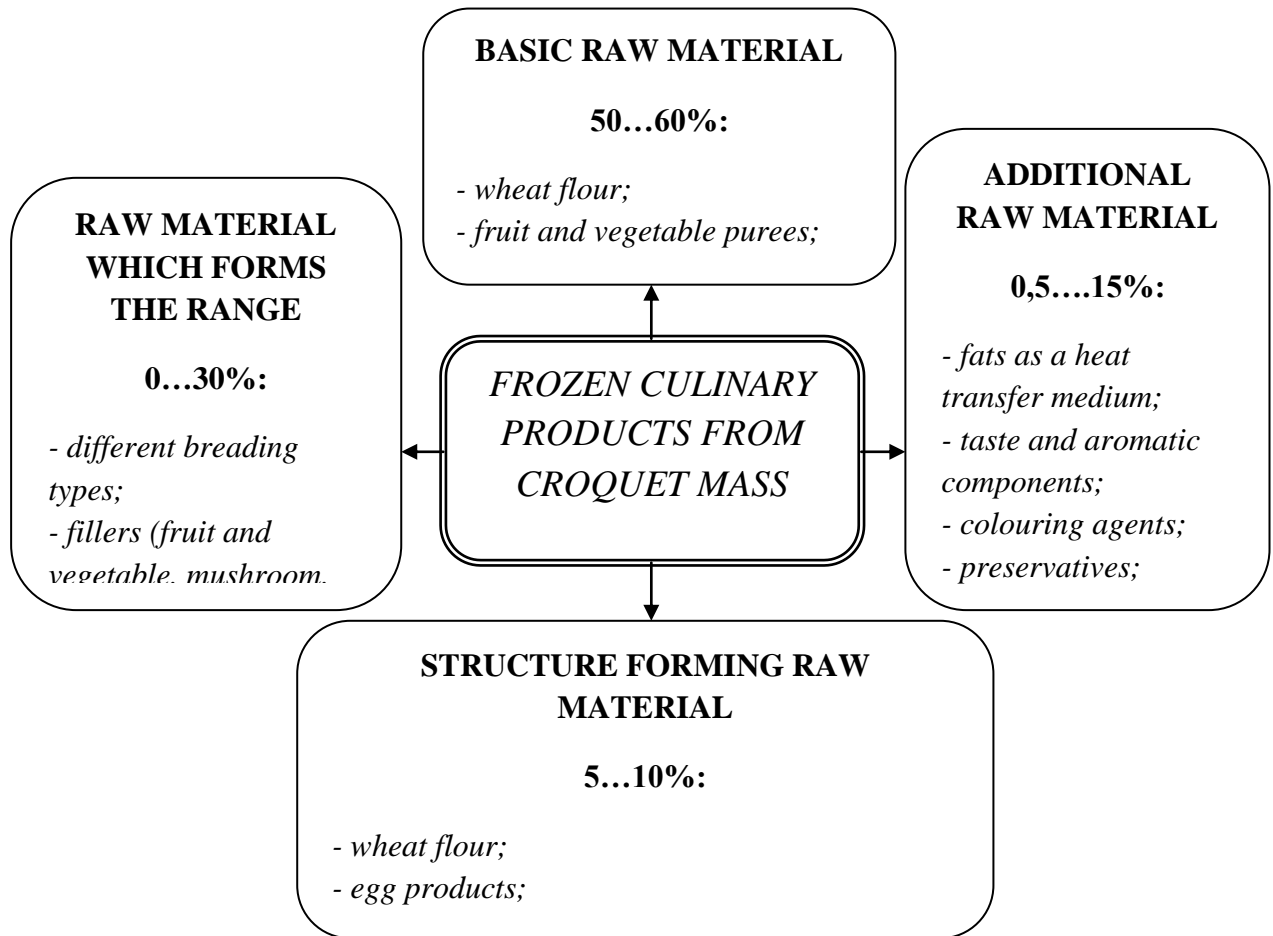


Figure 1. Model of recipe composition of frozen products from croquet mass

Scientists [5, 8] proposed the production technology of croquet masses on the base of hydrothermally treated (HTT) wheat flour. It is determined that the croquet mass in terms of rheological parameters is complex system from the technological point of view. The croquet mass quality is influenced by the conditions of freezing, storage under significant temperature differences and subsequent heat treatment of products to culinary readiness, in particular to deep frying.

The consumer wishes to get the finished product of aesthetic appearance with certain consumer properties. In addition, the rheological parameters of the croquet mass must clearly correspond to the technical characteristics of the equipment that the enterprises are equipped with.

The authors [9] noted the great potential for extending the shelf life of flour products by freezing. The freezing effect on product quality is considered. However, the results of the research were more related to the technology of flour products production. And the issue of culinary products from the croquet mass was not considered at all.

In the work [10], croquettes were developed for restaurants business enterprises of «Fast food» format with chemical modification starch «Cold Swell» use. Starch creates the effect of rapid formation, provides the product with the appropriate structure. The starch paste is heat-resistant, does not lose its colloidal properties during the «freezing-storage-sale» cycle. However, the chemical modification starches use may have appropriate restrictions in children's and elderly people diet because of chemical reagents content.

The authors [11] developed vegetable formed snacks with new types of liquid breadings use. The liquid breadings composition includes chitin and glucan complex, which has film formation property.

Functional properties of chitin and glucan complex derivatives as thickeners and film formers can be used during frying and smokeless smoking. Complex derivatives solutions increase the liquid breading viscosity; provide them with the ability to firmly hold on the surface of the product layer of crackers or flour. The presence of strong breading layer prevents excessive evaporation of water from the product during frying, promote the formation of uniform crispy crust and maintain the amount of oil in which the frying is carried out. This technology is really innovative, but its testing has not been tested in the «freeze-thaw» cycle.

The possibility of croquettes production with soy flour use was established [14]. This raw material has positive effect on the technological process of deep frying, namely on temperature. The positive aspects of the technology are the rapid reaction of melanoid formation, frying temperature lowering, increasing the service life of frying fat. However, there are a number of negative effects of soy flour on the finished product indices. Retrograde changes occur, products deformation during storage in the frozen state is observed. But the question of microbiological indices study remains open.

The problem was partially solved by scientists [13, 14], during developing the technology of formed dough products with spelled flour use. Under samples storage at temperature of -18 ± 2 °C during 120 days, the total bacterial contamination decreased, and at the end of storage the parameters did not exceed $4,0 \times 10^3$ CFU/g. But there are open questions about the study of the effect of spelled on the rheological parameters of products and the effect of recipe components during production, storage and sale.

Systematization and analysis of literature data allow stating that the main disadvantages which may arise during production of frozen formed products from croquet mass can be:

- cracking of croquet mass during freezing and storage;
- finished products deformation during the freezing cycle;
- products deformation during heat treatment after the freezing process;

– microbiological parameters stability disorder during storage. However, the data of organoleptic, physical and chemical and microbiological parameters of the systems are not provided for this hypothesis proving.

At the same time, described in works [3, 4, 10] scientific and practical bases of quality indices changes during storage concern mainly production of flour culinary and confectionery products.

Therefore, there is reason to believe that the lack of certainty of changes in the quality indices of wheat flour-based croquettes necessitates research in this direction.

Materials and methods

Subjects and materials of research:

– freshly made wheat flour-based croquettes (cooled semi-finished product and heat-treated in deep fryer at temperature of 170...180 ° C croquettes);

– wheat flour-based croquettes, which were stored at temperature of -18 °C during 6 months (cooled semi-finished product and heat-treated in deep fryer at temperature of 170... 180 °C croquettes).

Organoleptic, physical and chemical, microbiological indices were selected as the main indices of the samples quality which were determined in the experiment.

Organoleptic characteristics of products were carried out by the profile method with five-point scale use (according to the average data) [15].

The dry matter content of wheat flour-based croquet mass was determined by the arbitration method, total protein – by the Kjeldahl method [16, 17], carbohydrates – by the iodometric method [16]. The mass fraction of fat was determined by the Soxhlet method [16], the lipid content was determined by weight method with extraction by Bligh E., Dyer W. [18].

The ash content in the samples was determined by sample weight burning in muffler at temperature of 450...500°C [16].

Indices of titrated and active acidity of wheat flour-based croquettes were determined according to the methods of food research [16].

The light reflection spectrum of model systems «sautéed wheat flour – fat component – drinking water» samples was determined on the device «Specol» («Carl Zeitz Jena», Germany). The test samples were placed in the cuvette of the device, through which light of certain wavelength from 420 to 540 nm was transmitted. The degree of light reflection of the sample was recorded for each wavelength.

Statistical processing of research results, graphing and charting were performed with the software Statistics and MS Office Excel use.

Results and discussion

The study results of the main quality indices of wheat flour-based croquettes during storage

The technology of hydrothermally processed wheat flour-based croquettes was developed according to experimental studies [6–8]. Wheat flour-based croquettes are formed culinary products with the addition of flavoring components and fillers and deep-fried.

Study of organoleptic characteristics of croquettes during storage

Croquettes on the base of hydrothermally processed wheat flour are new products at the food market and technology implementation can lead to products with different levels of quality. The quantitative scale of general organoleptic assessment of new product was developed with the help of experts. Organoleptic indices of products that correspond to those which are specified in the regulatory documentation are presented in table 1.

Table 1
Organoleptic indices of culinary products from croquet mass on the base of wheat flour

Index	Product characteristics		
	control sample which is produced according to the traditional recipe	semi-finished croquettes (cooled, frozen)	finished product – croquettes (cooled, frozen)
Form	products in the form of balls, round-oblong, in the form of barrels, sausages		
Surface	damage of breading integrity, cracks	without significant damage, cracks; evenly covered with breadcrumbs	without significant damage, cracks; evenly covered with crust
View on the cut	the mass is inhomogeneous, with particles of raw material	homogeneous mass without extraneous additives	
Consistence	soft, dry, uneven	soft, tender, juicy; with filler particles, extraneous inclusions are not allowed	
Colour	surface is brown, cut is light cream, inhomogeneous	surface corresponds to the breading, cut is yellow-cream	surface is golden, without burns, cut is yellow-cream
Smell and taste	inherent in potatoes	creamy, tender, saturated, inherent in the fillers which are art of it, without extraneous smell and taste	

On the results base (table 1), it can be stated that wheat flour-based croquettes (semi-finished and finished products) both in the cooled and frozen state are characterized by high organoleptic characteristics.

Organoleptic parameters were assessed according to the sensory scale for cooled samples (non-heat-treated and heat-treated) immediately produced and

12 hours after production, for frozen samples – during 6 months of storage. Organoleptic profiles of cooled samples of culinary products are presented in fig. 2.

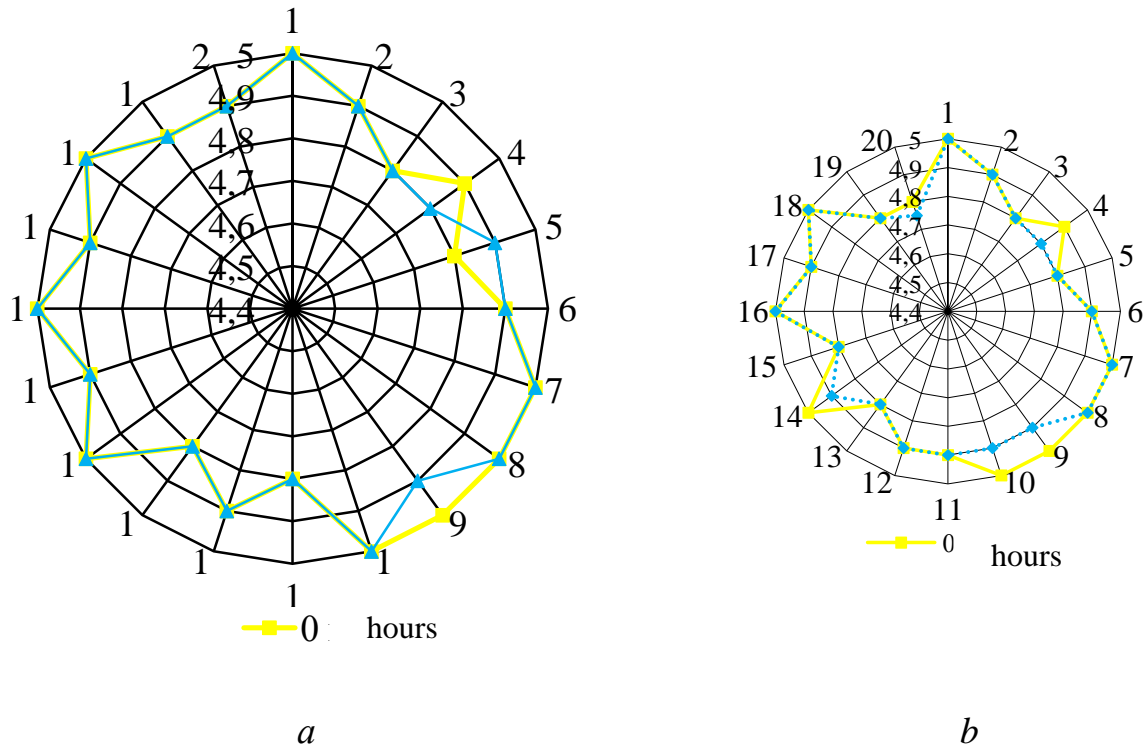


Figure 2. Organoleptic profiles of cooled wheat flour-based croquettes after 12 hours of storage (at temperature of 0...+2 °C):

a – non-heat-treated, b – heat-treated

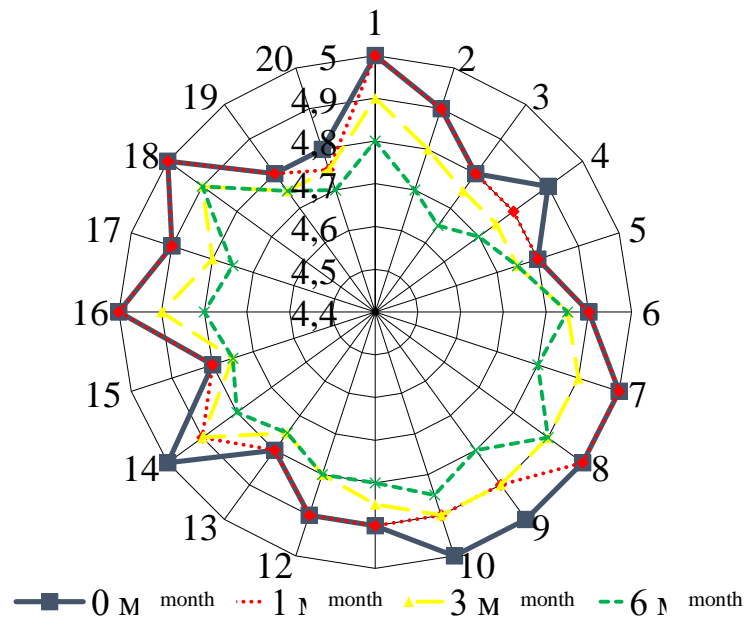
appearance: 1 – conformity with the set form, 2 – integrity of breading, 3 – presence on cut of homogeneous mass with filler inclusions, 4 – clearly marked border of section between breading and product; **consistency:** 5 – resilient, 6 – elastic, 7 – homogeneous, 8 – tender; **color:** 9 – homogeneous on the surface, 10 – natural, 11 – breading is golden and brown, the cut is pale yellow with inclusions in the form of fillers, 12 – uneven color of product parts; **smell:** 13 – pure, 14 – natural, 15 – expressive, 16 – without extraneous odors; **taste:** 17 – pure, 18 – natural, 19 – without bitter taste, 20 – expressive.

As it can be seen, after 12 hours of storage of cooled non-heat-treated and heat-treated samples, their organoleptic characteristics remained almost unchanged.

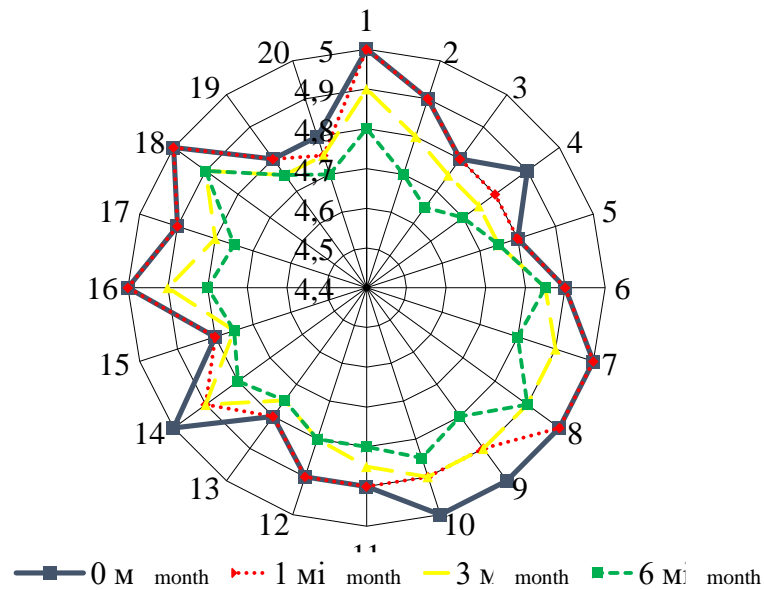
Organoleptic profiles of frozen samples are presented in fig. 3.

It should be noted that in the process of product storage its appearance does not change: the shape of the product remains almost unchanged (this index

decreases from 5 in freshly made samples and after 1 month of storage to 4,8 in samples after 6 months of storage). After 6 months of storage, there is slight separation of the breadding from the product, but the interface between the breadding and the product remains unchanged. There is partial compaction of the structure, increasing the elasticity of the samples after 3 and 6 months of storage. It is also possible to note insignificant weakening of smell and taste in comparison with freshly made samples, but naturalness and expressiveness of smell and taste remains inherent in all samples of products.



a



b

Figure 3. Organoleptic profiles of frozen wheat flour-based croquettes during storage (at temperature of -18 °C): a – non-heat-treated, b – heat-treated

Study of physical and chemical parameters of croquettes

The nutritional value of products is determined by the content of proteins, fats, carbohydrates, minerals and vitamins. Under wide range of wheat flour-based croquettes, the nutrients content in each case will be individual; however, the absolute values fluctuations will be small.

Physical and chemical parameters of finished products and semi-finished products are presented in table 2.

Table 2.

Physical and chemical parameters of culinary products from croquet mass on wheat flour base

Index	Study results			
	semi-finished product		finished product	
	cooled	frozen	cooled	frozen
Mass fraction of moisture, %	60,0±0,5	58,0±0,5	58,0±0,5	55,0±0,5
Mass fraction of fat, %	13,5±0,3	13,9±0,3	15,0±0,3	15,7±0,3
Mass fraction of protein, %	8,5±0,05	8,9±0,05	8,5±0,05	8,9±0,05
Mass fraction of carbohydrates, %	14,0±0,3	14,9±0,3	14,5±0,3	15,1±0,3
Ash, %	2,5±0,01	2,8±0,01	2,5±0,01	2,8±0,01
Temperature inside the product, °C	+6±1	-18±1	+6±1	-18±1

On the base of results (table 2), it can be stated that the mass fraction of moisture in the product is in the range of 55,0...60,0±0,5%, depends on the thermal state of the product and heat treatment: for the semi-finished product under freezing it decreases by 2±0,5%, for the finished product it decreases by

$9 \pm 0,5\%$. The fat content of the semi-finished product is $13,5 \dots 13,9 \pm 0,3\%$, of the finished product it is $15,0 \dots 15,7 \pm 0,3\%$. The protein content in the product is $8,5 \dots 8,9 \pm 0,05\%$.

Study of microbiological indices of wheat flour-based croquettes

Wheat flour-based croquettes as well as other products, which contain liquid and fatty components, animal origin fillers and/or vegetable origin, are perishable. Quantitative and qualitative composition of the microflora is one of the important criteria for product's quality assessing and together with technological indices characterizes possible disorders that may occur in the technological process of its production, storage and sale.

Pathogenic microorganisms of the genus *Salmonella*, *Listeria monocytogenes*, bacteria of the *Escherichia coli* group, which cause food poisoning, various types of yeast, which give the products yeasty taste and mouldy fungi develop in wheat flour-based croquettes in the process of storage. These culinary products must be stored at low temperatures for rapid spoilage preventing and also for microorganisms' growth slowing down. From the data [19, 20] it is known that for cooled food products the recommended storage temperature is $2 \pm 2^\circ\text{C}$ at relative humidity of 80...85%, and for frozen food products it is below 18°C . It is temperature that has depressing effect on the growth of microorganisms and bacteria.

Microbiological indices were studied immediately after products manufacture and during storage for products shelf life determining.

The microbiological studies results are presented in table 3.

Table 3.

Change of microbiological parameters of wheat flour-based croquettes during storage

Terms and conditions of storage	Microbiological indices					
	The number of MAFAM, CFU, in 1g, not more	Bacteria of the Escherichia coli group (coliforms), in 0,001 g	Pathogenic microorganisms, including Salmonella, in 25 g	Listeria monocytogenes, in 25 g	Yeast, CFU, in 1 g, not more	Mouldy fungi, CFU, in 1 g, not more
Permissible level (according to MBR)	$1,0 \times 10^4$	It isn't allowed	It isn't allowed	It isn't allowed	$1,0 \times 10^4$	$1,0 \times 10^2$
0×60^2 s/ 12×60^2 s $t=1 \dots 4^\circ\text{C}$	$3,0 \times 10^2 / 3,2 \times 10^2$	It isn't found	It isn't found	It isn't found	$4,0 \times 10^1 / 4,3 \times 10^1$	It isn't found
30 days $t \leq -18^\circ\text{C}$, W=80...85 %	$2,0 \times 10^2$	It isn't found	It isn't found	It isn't found	$3,0 \times 10^1$	It isn't found
60 days $t \leq -18^\circ\text{C}$, W=80...85 %	$1,5 \times 10^2$	It isn't found	It isn't found	It isn't found	$2,0 \times 10^1$	It isn't found
60 days $t \leq -18^\circ\text{C}$, W=80...85 %	$1,4 \times 10^2$	It isn't found	It isn't found	It isn't found	$2,0 \times 10^1$	It isn't found
90 days $t \leq -18^\circ\text{C}$, W=80...85 %	$1,4 \times 10^2$	It isn't found	It isn't found	It isn't found	$2,0 \times 10^1$	It isn't found

120 days t _≤ - 18 °C, W=80...85 %	1,4×10 ²	It isn't found	It isn't found	It isn't found	2,0×10 ¹	It isn't found
150 days t _≤ - 18 °C, W=80...85 %	1,4×10 ²	It isn't found	It isn't found	It isn't found	2,0×10 ¹	It isn't found
180 days t _≤ - 18 °C, W=80...85 %	1,4×10 ²	It isn't found	It isn't found	It isn't found	2,0×10 ¹	It isn't found

As it can be seen (table 3), freshly made wheat flour-based croquettes, as well as during storage at temperature of 2...4 °C during 12 hours have microbiological parameters that correspond to the product's quality. During storage of products at temperatures below - 18°C during 6 months, the indices of total microbiological contamination and the amount of yeast are within the established norms. They even decrease slightly by $0,6 \times 10^2$ CFU in 1 g, which is probably due to the effect of low temperatures on microorganisms. Pathogenic microflora (microorganisms of the genus Salmonella, Listeria monocytogenes and bacteria of the Escherichia coli group) during this period in the experimental samples was not identified. Also, fungi were not found in the samples of this volume.

Research of other quality indices of wheat flour-based croquettes during storage

Also, researchers of study the change in the mass fraction of moisture, active and titratable acidity during storage were conducted for the choice of storage rational terms of wheat flour-based croquettes.

According to the research data, the active and titratable acidity of the samples varies insignificantly in the range of 6,54...6,60 pH units and 3,20...3,28 degrees, respectively. There is a slight decrease in the amount of moisture in both frozen and cooled samples during samples storage. Thus, during storage, the mass fraction of moisture in cooled and frozen non-heat-treated and heat-treated samples decreases by 0,02 and 0,03%, respectively.

During long-term storage as well as during heat treatment, chemical transformations of substances are possible, which can lead to change in the color of the product. In this regard, one of the tasks are set in this work is determining

the degree of discoloration of wheat flour-based non-heat-treated and heat-treated croquettes during storage.

Organoleptic assessment (table 1) of the color of wheat flour-based croquettes during storage, before and after heat treatment shows that samples color does not change when the storage conditions are observed. The value of the light reflection coefficient of all wavelengths of the studied samples during 6 months of storage changes by 11...16% for non-heat-treated, by 5...8% for heat-treated products.

Conclusion

Under determining the organoleptic characteristics of croquettes during storage, which follows from the data in table 1 and fig. 1, 2, it is seen that products appearance does not change in the process of storage. It is due to the processes that occur during croquet mass for croquettes production. In particular, it is also substantiated by proteins destruction and starch dextrinization of wheat flour during sautéing. Obviously, such mechanism of sautéing temperature effect is regulating factor of the process of structural and mechanical and physical and chemical parameters of the finished product.

According to the table 2 data, it can be stated that the mass fraction of moisture, protein and fat in the product depends on the thermal state of the product and heat treatment.

Of particular interest is the study results interpretation of microbiological parameters of wheat flour-based croquettes, which are presented in table 3. It proves the fact of microbiological parameters stability.

Product's color study results are important; under adherence to storage conditions the color of the samples does not change.

The obtained data of the study of croquettes quality basic indices during storage allow stating the following:

- freezing process use of wheat flour-based croquettes during storage will expand the possibilities of obtaining products with specified consumer properties and will prolong their shelf life;
- identified technological parameters of products freezing can be considered as expedient.

Such conclusions can be considered reasonable from the practical point of view, because they allow substantiated approach to the process of freezing and storage of wheat flour-based croquettes. From the theoretical point of view, they allow stating about the consumer indices change determining; they are certain advantages of this study.

However, it isn't impossible to note that there are open questions about the study of breeding materials types for croquettes. Such uncertainty imposes certain restrictions on the obtained results use, which can be interpreted as

shortcomings of this study. The inability to remove these limitations in this study creates potentially interesting direction for further research. In particular, they can be focused on determining the effect of breading materials on the change of organoleptic and physical and chemical parameters of croquettes during freezing and storage. Such identification will allow researching the possibility of breading materials new types use and determining the factors that can regulate the croquettes quality.

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