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STUDY OF THE QUALITY OF QUINOA GRAIN DURING STORAGE

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Abstract. The paper presents data on the useful properties of quinoa seeds, which are rapidly gaining popularity due to their rich chemical composition. The results of studying the changes in the organoleptic, chemical, and microbiological characteristics of quinoa grain during storage under different conditions are presented. The quinoa seeds considered in the research were stored for 12 months at the temperature +(5–30)°C and relative humidity 20–80%. It has been shown that after storing the quinoa seeds for 12 months at +(5–30)°C, their organoleptic characteristics changed: a noticeable rancid and unpleasant aftertaste appeared, accompanied by a foreign smell and a slight change in the colour. When the quinoa grain was stored at +5°C, its acidity remained within the standards of good grain quality throughout the whole storage period. At +15°C, the acidity remained normal for up to 9 months of storage, and at +30°C, up to 6 months. Analysis of the obtained results on the microbiological characteristics has shown that the predominant component of the bacterial microflora of quinoa grain (70.5%) is non-spore-forming bacterium *Erwinia herbicola*, a representative of the epiphytic microflora. The micromycetes found are mould fungi of the genus *Aspergillus* and field fungi of the genus *Mucor*. It has been shown that when quinoa grain is stored at +(5–30)°C, the vital activity of microorganisms is significantly reduced, the development of bacteria and even moulds is retarded, which has a positive effect on maintaining the grain quality. The studies have made it possible to recommend storing quinoa grain for up to 12 months at +5°C, up to 9 months at +15°C, and not more than 6 months at +30°C.

Key words: quinoa seeds, microbiota, quality parameters, storage, acidity, consumer properties.

Introduction. Formulation of the problem

In recent years, quinoa is rapidly gaining popularity due to its rich chemical composition. An important characteristic of the chemical composition of quinoa seeds is a high content of proteins (14–14%), of which non-essential amino acids make up 12–15%, and essential 7–8%. The amino acid content makes quinoa seeds a full-value protein product of plant origin. Its use is ideal for meat-free diets, for vegetarians, as sports nutrition, for dietetic treatment, and in the recovery period after a serious illness. Protein in quinoa grain, unlike animal protein, is assimilated very quickly and almost completely, which determines the high nutritional value of this grain [1-5].

The world's main producers of quinoa seeds are Bolivia, Peru, and Ecuador with an average gross seed yield of 34.4, 31.2, and 1.04 thousand tons a year respectively. These countries are traditionally the main exporters of seeds in the world market [6]. Quinoa has recently appeared on the shelves of Ukrainian shops, but it was all imported. In Ukraine, quinoa seeds have only recently started being cultivated, and many food companies use quinoa as a raw material to manufacture various products, so quinoa grain needs long-term storage. From harvesting to processing, losses and deterioration of quinoa grain should be prevented.

Grain quality is a set of properties and characteristics (biological, physicochemical, technological, consumer) that determine the suitability of grain for its intended use. The parameters of the quality of grain are understood as the characteristics of its properties that form the quality.

Characteristic changes in the chemical composition of the grain mass during storage depend on the storage conditions and on microorganisms that develop in it. The latter affect the raw material in different ways, causing rotting, different types of fermentation, and so on.

In this regard, it becomes important to find optimal ways of preparing quinoa grain for long-term

storage. These ways should take into account biological and chemical characteristics, quantitative and species composition of this crop's microflora, and preserve its consumer properties until further targeted processing.

Analysis of recent research and publications

An increase in consumer and industrial demand for quinoa grain has inevitably made this crop an object of increasing interest to scientists too. Most scientific research is devoted to determining the chemical composition and biological and consumer value of quinoa grain and prospects for its use in various sectors of the food industry [1,6-9].

There are also some works considering the processes that take place during storage of quinoa seeds, and presenting the findings on how the storage conditions affect the consumption properties of quinoa and how the chemical studying the technological properties of quinoa grain and consider its postharvest processing. However, in our opinion, not enough attention is paid to the preserving the quality of quinoa grain during storage and to studying the changes in its quality characteristics, namely its microbiological and chemical parameters.composition of its grain is changed with changes in the duration of storage [7]. The papers [8,9] present the results of the researches of technological properties of quinoa grain are given and the issue of its postharvest processing is considered. However, in our opinion, not enough attention is paid to the issue of preserving the quality of quinoa grain during storage and research of changes in its quality indicators, namely microbiological and chemical indicators.

Grain and products of its processing are the main source of human nutrition and animal feed. Therefore, microbiological contamination of grain is one of the main factors affecting people's health. In this regard, much attention is paid to studying methods of protecting long-stored seed yields against pests and diseases, ways of improving grain quality [10].

Grain consists mainly of starch, protein, and a small amount of fat, thus being an ideal growth medium for microorganisms. Just one gram of grain mass contains several hundred to several thousand microorganisms [11].

The development of these microorganisms is one of the possible reasons for the decline in the quality of wheat grain and other cereals during storage. Depending on the storage conditions of the grain mass, changes in the quantitative and species composition of its microflora can be of different nature [12]. Microbial contamination takes place at all stages of the life cycle of grain (in the field, during harvesting, transportation, storage, and processing), so the intensity of bacterial contamination can be quite high [12].

Up to 60% of pathogens of bacterial and fungal origin can be transmitted through seeds, which, in the end, affects their yield and quality. Economic damage caused by bacterial and viral infections and by moulds is difficult to overestimate, as the grain yield of infected plants is reduced by 35–65% on average, and crop losses can reach 90% [11]. Plants are affected by many pathogens and spores. These are bacteria of the group *Enterobacteriaceae* and mould fungi of the genera *Fusarium* (*F. nivale*, *F. culmorum*, *F. graminearum*, *F. avenaceum*), *Tilletia* (*T. caries* and *T. controversa*), *Cladosporium* (*C. herbarum herbarum*), *Claviceps* (*C. purpurea*), bacteria of the genera *Bacillus*, *Penicillium* spp., *Epicoccum* spp., *Trichothecium* spp., etc. [13]. Damage by such microorganisms prevents the normal formation of the crop, and spores of these bacteria, on entering the human body, can cause serious of the immune, gastrointestinal, respiratory, and nervous disorders [14].

Seasonality of grain production, on the one hand, and its consumption throughout the year, on the other, require long-term storage of large masses of grain.

Humidity is the most important factor influencing the nature of grain behaviour during storage. Factors that affect the quality of grain also include temperature, general condition of grain, oxygen supply, duration of storage, presence of mould (fungi) and insects. These factors affect, first of all, the reproduction and metabolic activity of moulds. Insects are not only harmful because they penetrate grains and consume endosperm, but also due to the effect they have on the activity of moulds [13].

Whether microorganisms can develop in grain during storage depends on the condition of the grain's integumentary tissues. The development of microbes, primarily on damaged grains, further facilitates their reproduction on whole and normal-looking grains. The most vulnerable part is the germ, which in the grains of many crops is less protected with a coating than other parts.

Thus, the presence of individual grains in the total grain mass that are mechanically damaged or spoilt by microorganisms dramatically reduces the stability of grain during storage. Before storage, these grains must be removed from the grain mass during the cleaning process. Spoilt grains must be removed especially thoroughly.

Processing of grain with a high microbial count results in its getting into a finished product, which reduces its quality and effectiveness of heat treatment. In some cases, the raw material becomes unusable due to the accumulation of toxic products of microorganisms.

Therefore, studies of the qualitative and quantitative composition of the microflora are important for the development and practical application of various processing methods to improve the stability and extend the shelf life of quinoa grain to be further used in food, pharmaceutical, microbiological, and animal feed industries.

Purpose and objectives of the research

The purpose of the research is studying the changes in the sensory, chemical, and microbiological

characteristics of quinoa grain during storage under different conditions, in order to determine the safe conditions and optimum duration of its storage.

The **objectives** of the study were:

– to determine sensory parameters of quinoa grain quality under different conditions and with different terms of storage;

– to study the changes in the acidity of quinoa seeds, as one of the indicators of grain quality, under different temperature conditions and with different terms of storage;

– to establish changes in the qualitative and quantitative composition of quinoa seed microbiota under different storage conditions and thus to assess the sanitary safety;

– to determine storage conditions of quinoa grain that are not accompanied with deterioration in its quality.

Research materials and methods

The research used quinoa grain of three colours (red, yellow, and black), with the moisture content 9.6%. The grain was harvested 2020 (the manufacturer PeruvianOne Superfoods).

Samples of quinoa grain weighing 0.5 kg each were stored in bags from cotton cloth for 12 months in the laboratory.

The quality of quinoa grain was determined by organoleptic parameters, acidity, and microbiological indicators. The quinoa grain samples were studied every 3 months of storage. The samples were stored at different temperatures: in a refrigerator at the temperature varying +5±1°C and the relative humidity 18–20%, in a laboratory environment at the temperature +15±1°C and relative humidity 40–60%, and in a thermostat at the temperature +30±1°C and relative humidity 75–80%.

Sensory evaluation of the quinoa seed samples was carried out before storage, and after 3 and 6 months of storage, in accordance with DSTU 1055:2006. To assess the sensory parameters, a score scale was developed taking into account the weighting factors (Table 1).

The scoring system allows evaluating quinoa seed samples organoleptically and labelling them as belonging to one of the following categories: excellent (the overall score 4.5–5.0 points), good (4.0–4.5 points), satisfactory (3.5–4.0 points) and unsatisfactory (below 3.5 points).

According to DSTU ISO 6658:2005 "Sensory research. Methodology. General guidelines," sensory analysis was performed using methods of analytical assessment by the descriptive method (profiling method) and the scale-and-category method (scoring).

The acidity was determined according to DSTU 4250:2003. The method is based on using sodium hydroxide solution for potentiometric titration of the total amount of free fatty acids, organic acids, and end groups of proteins contained in grain and products of its processing and able to pass into the extractant.

Microbiological studies of the quinoa seed samples were performed using both modern determination methods (microbiological analyser BakTrak 4300, the operation of which is based on recording changes in the electrical resistance of the nutrient medium resulting from the activity of microorganisms) and classical methods [15].

Table 1 – Scale for assessing the quality of quinoa seed samples

Quality parameters	Weighting factor	Characteristics of a parameter, points				
		5	4	3	2	1
Colour	0.2	Pleasant, corresponding to the colour of this type of seeds	Quite pleasant, corresponding to the colour of this type of seeds	Not pleasant enough, the colour of the products slightly deviates from the colour of this type of seeds	Unpleasant, of different shades	Not typical of this type of seed
Taste	0.5	Pleasant, corresponding to the taste of this type of seeds, strongly pronounced, without off-flavours	Pleasant, corresponding to the taste of this type of seeds, pronounced, without off-flavours	Feebly marked	Nonmarked, flat taste	Inappropriate, with an off-flavour
Smell	0.3	Pleasant, appropriate, strongly pronounced, without off-odours	Pleasant, appropriate, pronounced, without off-odours	Weak smell	Nonmarked smell	Inappropriate, with an off-odour

Samples were placed into sterile containers under aseptic conditions, which exclude contamination of the product with microbes from the environment. The composition of the microbiota of quinoa grain was determined by microbiological and sanitary indicators, which include the quantity of mesophilic aerobic and facultative anaerobic microorganisms (QMAFAnM), the count of micromycetes (moulds and yeasts) and coliform bacteria (with the following identification of opportunistic *Escherichia coli* and *Staphylococcus aureus*).

The total bacterial count was determined by inoculating wipe samples, with varying degrees of dilution, onto meat-and-peptone agar (MPA), and that of moulds and yeast by inoculating onto wort agar (WA), followed by culturing at (30±1)°C for 24–48 hours and at (28±1)°C for 5–7 days respectively. Spore forms of bacteria were determined in pasteurised wipe samples from quinoa grain which were inoculated onto a combined growth medium MPA + WA (1:1) [15].

The presence of coliform bacteria was established by inoculating a wipe sample of grain onto a Kessler medium using the method of fermentation tests, and evaluated by the gas formation and turbidity of the medium [16].

The presence of potentially pathogenic staphylococci was established by accumulating them in the meat-and-peptone broth with NaCl 6% and reoculating onto milk-and-salt agar. Culturing of both inoculations lasted 24 hours at (37±1)C [15].

The quinoa grain was also analysed for the presence of mycotoxins (aflatoxins B1, zearalenone, deoxynivalenol) using the test system Veratox [17].

During the research, the experiments were performed in triplicate. The regularities were reproduced in each of the parallel studies. To determine the true values of the experimental parameters and to perform correlation analysis, mathematical and statistical processing of experimental data was performed, which were processed by Fisher and Student's method at a reliability level of at least 0.95. The results were processed using standard methods and the ones developed in Odesa National Academy of Food Technologies [18].

Results of the research and their discussion

Organoleptic assessment of grain quality is of great practical importance, because it gives a preliminary idea of the benefits of the grain mass. Besides, it is of paramount importance to the consumer, as quickly, without any physico-chemical studies, it gives a general idea of a product's quality. These parameters are the ones that have the psychological effect on consumers and make them choose a certain product [19]. Sensory parameters of grain quality include colour, smell, taste.

To study such important components of a product's consumer properties as "taste," "smell," and "color," the profiling method was used. It consists in representing the complex concept of a sensory property as a set of simple components that tasters assess by the quality, intensity, and order of manifestation [19]. This method is the most informative, because it covers all aspects of the sensory quality of food and allows identifying which components of the taste, smell, colour, and texture are the most responsible for a product's consumer properties.

At the first stage of the research on the quality of quinoa grain before storage, the organoleptic characteristics were determined: taste, colour, and smell.

Panels of the descriptors of taste, colour, and smell were presented for tasting, and the tasters gave their scores on a conditional five-point scale. The research results are shown in Fig. 1–3.

The following descriptors were taken into account during the study of taste by profiling:

– positive: general impression, harmonious, characteristic of grain;

– negative: bland, rancid, unpleasant aftertaste.

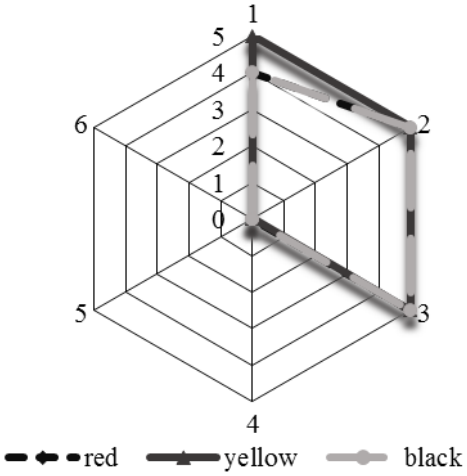

Fig.1. Profilogram of the taste of the quinoa seed samples: 1 – general impression; 2 – harmonious; 3 – characteristic of grain; 4 – bland; 5 – rancid; 6 – unpleasant aftertaste

As can be seen from the profilogram, all types of quinoa seeds were characterized by a harmonious taste, pleasant aftertaste characteristic of grain.

To evaluate the samples of quinoa seeds by the colour and smell, profilograms were constructed, which are shown in Fig. 2, 3.

As can be seen from the profilograms presented in Fig. 2, 3, the quinoa seed samples, regardless of their colour and smell, have an attractive, pleasant colour and a pronounced grain smell.

The Taste Panel also evaluated the quinoa seed samples according to the specially developed score system at the beginning of storage and every 3 months of storage. The organoleptic parameters of the quinoa seed samples did not change after 3, 6, and 9 months of storage. That is why Table 2 shows the Taste Panel's data on the sensory characteristics of the samples determined at the beginning of storage and after 12 months of storage.

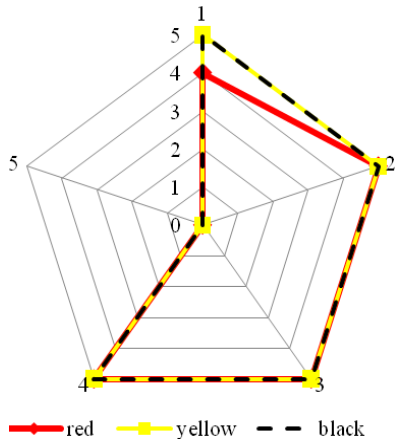

Fig. 2. Profilogram of the colour of the quinoa seed samples:
1 – attractive; 2 – pleasant; 3 – corresponding to the type of seeds; 4 – non-uniform; 5 – not corresponding to the type of seeds

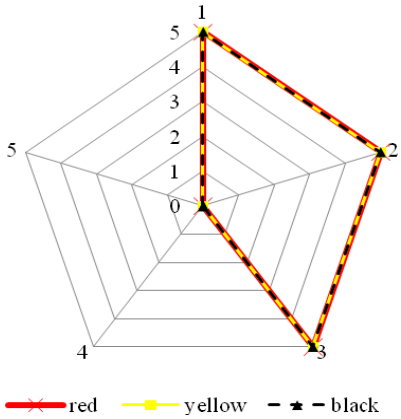

Fig. 3. Prophylogram of the smell of the quinoa seed samples:
1 – pronounced; 2 – characteristic of grain; 3 – pleasant; 4 – weak; 5 – foreign

Table 2 – Assessment of the sensory quality parameters of the quinoa seed samples, scores (P≥0.95, n=3)

Type of quinoa seeds	Name of parameters without/with the weighting factor			Overall quality assessment	Quality category
	Colour	Taste	Smell		
At the beginning of storage					
Red	5.0/1.0	5.0/2.5	5.0/1.5	5.0	excellent
Yellow	5.0/1.0	5.0/2.5	5.0/1.5	5.0	
Black	5.0/1.0	4.9/2.45	5.0/1.5	4.95	
After 12 months of storage, at the temperature +15±1°C					
Red	4.0/0.8	3.0/1.5	4.0/1.2	3.5	satisfactory
Yellow	4.0/0.8	3.0/1.5	4.0/1.2	3.5	
Black	4.0/0.8	3.0/1.5	4.0/1.2	3.5	

The results of the sensory analysis confirm the high results of the quinoa seed samples at the beginning of storage. They were characterised by a harmonious taste, with a pleasant, slightly grainy shade, and a pleasant colour. According to the results of the tasting evaluation, the samples received the highest number of points, which corresponds to the quality category "excellent."

However, after 12 months of storage, there were changes in the taste, smell, and colour: a rancid and unpleasant aftertaste, a slightly changed colour, a foreign smell. According to the results of the tasting evaluation, the samples received the number of points corresponding to the quality category "satisfactory."

The acidity of grain is an important parameter of its quality. Acidity can testify to the quality, or rather the freshness of grain or products of its processing.

Grain acidity depends, firstly, on proteins that are known to contain alkali-binding carboxyl groups. Secondly, the acidity of grain also depends on fatty acids that are released as a result of the cleavage of fats by lipase. Thirdly, the acidity of grain and flour depends on phosphoric acid, which is contained in grain in the form of various compounds in significant quantities. Fourthly,

the acidity of grain also depends on acetic, lactic, malic, and other organic acids (including the Krebs cycle), which are usually contained in grain in small quantities. The content of acetic and lactic acids increases significantly if the grain, groats, or flour has got spoilt as a result of self-heating or acidification [20]. As a result of the experiments, the following acidity values have been obtained for the quinoa grain depending on the duration of storage (Table 3).

Table 3 – Change in the acidity of the yellow quinoa grain during storage (P≥0.95, n=3)

Storage temperature	Storage duration, months	Acidity, degrees
+5°C	0	1.8
	3	2.1
	6	2.4
	9	3.8
	12	3.0
+15°C	0	1.8
	3	2.3
	6	2.8
	9	3.0
	12	3.8
+30°C	0	1.8
	3	2.8
	6	4.4
	9	4.8
	12	5.4

During storage of the quinoa grain, there is a gradual increase in its acidity. This is due to the activity of enzymes (phytase, phosphatase), which cleave phosphoric acid off organic compounds. Oxidation of the fatty component of seeds, too, can be a significant acidity-increasing factor. The acidity of quinoa grain increases with an increase in the storage duration and temperature [20].

The microflora of any grain mass includes various bacteria and fungi. Sometimes, grain is inhabited by actinomycetes and related organisms, and with yeast, too. According to their way of life, microorganisms are divided into three groups: saprophytic, phytopathogenic, and pathogenic for animals and humans. The vast majority of microorganisms in the grain mass are saprophytes, which feed on the organic matter of grain. As a result, it is partially or completely destroyed, changing its physical properties and chemical composition [15]. Depending on the storage conditions of the grain mass, the quantitative and species composition of the microflora changes. If the grain mass is stored under conditions when the active development of microorganisms is impossible, then with increasing storage duration, part of them die, and the ratio of individual species of microbes changes. This happens because different types of microbes, under conditions unfavourable for their development, have different degrees of survival. However, even long-term storage (for several years) does not deprive the grain mass of its constant component, microorganisms.

Under conditions when the development of microorganisms is possible, both in freshly harvested grain and during long-term storage, it is mould fungi that first develop in the grain (or seeds) of all crops. They are more adapted to living in the grain mass than bacteria, yeast, and actinomycetes are [21].

Different storage conditions significantly affect the composition of grain and grain processing products and more developed microbiota [22]. Contamination of products with microorganisms averages tens of thousands of bacteria per 1 g [21]. The bacteria that prevail in products are *Erwinia herbicola*, the number of which can be 70–90% of the total bacterial count, while spore-forming microorganisms and cocci make up 5–15%. The content of fungal spores ranges from fractions of one percent to 1–5% of the total number of microorganisms. The fungal flora of the seeds is represented mainly by species of *Penicillium* [16]. During long-term storage under conditions when the humidity and temperature of a product make it impossible for microbiota to develop, there is a gradual decrease in the total bacterial count due to the death of non-sporophorous forms [21].

That is why studying the qualitative and quantitative composition of microflora is important for the development and practical application of various processing methods to improve the stability and extend the storage time of quinoa grain intended for further use in food, pharmaceutical, microbiological, and animal feed industries.

The indicator of the quantity of mesophilic aerobic and facultative anaerobic microorganisms (QMAFAnM) is the most common microbiological parameter. It is used in the food industry to show the sanitary condition of production. It was determined the qualitative composition of the microflora as an indicator of safety, because the presence of pathogenic microorganisms or an increased content of opportunistic pathogens (compared with the permissible norm) can be the cause of poisoning. The results of microbiological study of the quinoa grain are given in Table 4.

Studies have shown that during storage, regardless of the temperature, the number of bacteria decreased. These data are consistent with the data found in the literature on the storage of different types of natural groats [20,23]. The most significant decrease was observed at the storage temperature +5°C. Micromycetes practically did not develop, but there was a change in their qualitative composition. The quantity of field fungi decreased significantly. Mould fungi of the genus *Aspergillus* were permanent representatives of the fungal microflora. This means that the seeds complied with the sanitary and hygienic standards [21].

Table 4 – Results of microbiological examination of the yellow quinoa seed samples (P≥0.95, n=3)

Temperature, °C	Duration of storage, months	QMAFAnM, CFU/g 10^3				Micromycetes, CFU/g 10^3		
		Total	including			Total	including	
			Ervinia herbicola	*Coliform bacteria*	*Subtilis licheniformis*		*Mucor*	*Aspergillus*
5	0	110.0	77.5	24.5	8.0	0.9	0.02	0.04
	3	92.2	66.2	18.2	7.8	0.9	0.02	0.09
	6	72.8	53.4	14.2	5.2	0.83	0.02	0.14
	9	53.1	40.6	10.8	4.7	0.75	–	0.19
	12	40.1	25.5	8.4	3.2	0.52	0.02	0.24
15	0	110.0	77.5	24.5	8.0	0.9	–	0.04
	3	98.5	68.4	22.1	8.0	0.83	0.02	0.10
	6	84.5	57.8	20.2	6.5	0.78	0.02	0.15
	9	69.0	46.4	16.8	5.8	0.56	0.01	0.2
	12	45.4	29.6	12.4	3.4	0.48	0.01	0.22
30	0	110.0	77.5	24.5	8.0	0.9	0.02	0.04
	3	107.0	72.3	22.8	8.0	0.76	0.02	0.11
	6	93.0	65.5	20.7	6.8	0.7	0.02	0.18
	9	72.8	52.6	16.2	6.0	0.53	–	0.25
	12	49.1	33.4	12.1	4.6	0.44	–	0.30

In all samples tested, the content of aflatoxins, zearalenone, and deoxynivalenol did not exceed the permissible limits. It should be noted that in all samples and under different storage conditions, *Escherichia coli*, staphylococcus, salmonella, proteus, sulphite-reducing clostridia were not detected. The presence of micromycetes was within normal limits. This indicates the compliance of the storage conditions with the sanitary and hygienic standards [21].

Analysis of the results obtained has shown that the predominant component of the bacterial microflora of quinoa grain is the non-sporopherous bacillus *Ervinia herbicola* (representative of the epiphytic microflora), which is normally present in grain stored under standard conditions. It is believed that the number of these bacteria is an indicator of grain freshness. The percentage of *Ervinia herbicola* of the total bacterial count is 70.5%. The share of coliform bacteria in the quinoa grain was 22.2%. Of the spore-forming bacteria, the ones of the *Subtilis licheniformis* group were detected. Their quantity on the quinoa grain was 7.3% of the total bacterial count. The micromycetes detected before storage were fungi of the genus *Aspergillus*, field fungi of the genus *Mucor*, and some unidentified fungi.

The data on the dynamics of changes in the state of the microflora of quinoa grain during storage show that during storage, the number of bacteria decreases, and the number of mould fungi varies depending on the storage conditions.

The studies have shown that during storage of the quinoa grain at +5°C, +15°C, and +30°C, the initial number of bacteria decreased after 12 months of storage by 36.4% at the storage temperature +5°C, by 41.27% at the storage temperature +15°C, and by 44.6% at the storage temperature +30°C. As for micromycetes, their number during storage decreased by 57.7%, 53.3%, and 48.8% at the respective temperatures.

The largest reduction was observed at the storage temperature +5°C, and the smallest at the storage temperature +30°C. The decrease in the number of bacteria, mainly of those of the species *Ervinia herbicola*, was due to their dying, which is natural.

The absolute number of coliform bacteria decreased throughout the storage period with all storage conditions.

Micromycetes did not develop, but there was a change in their species composition. The number of field fungi of the genus *Mucor* and of other field fungi, which were unidentified, decreased compared with their initial number, while the total number of fungi increased due to the genera *Aspergillus*.

Conclusion

Based on the results of the research, it has been established that:

– after storage of the quinoa seeds for 12 months at +(5–30)°C, the organoleptic parameters changed: there was a noticeable rancid and unpleasant aftertaste and a slight change in the colour, and an off-odour appeared.

– the acidity of the grain during storage for 12 months gradually increased, which is typical. When the quinoa grain was stored at +5°C, its acidity remained within the standard of good quality grain during the whole storage period. At the storage temperature +15°C, the acidity remained normal for up to 9 months of storage, and at +30°C, for up to 6 months;

– analysis of the results obtained has shown that the predominant component of the bacterial microflora of quinoa grain (70.5%) is the non-spore-forming bacillus *Erwinia herbicola*, a representative of epiphytic microflora. Of the micromycetes, fungi of the genus *Aspergillus* and field fungi of the genus *Mucor* were found;

– during storage of the quinoa grain at +(5–30)°C, the activity of microorganisms significantly reduces, the development of bacteria and even mould fungi slows down, which has a positive effect on maintaining the grain quality.

The studies have made it possible to recommend storing quinoa grain for up to 12 months at +5°C, up to 9 months at +15°C, and not more than 6 months at +30°C.

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ДОСЛІДЖЕННЯ ЯКОСТІ ЗЕРНА КІНОА В ПРОЦЕСІ ЗБЕРІГАННЯ

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Анотація. У статті наведено дані про корисні властивості зерен насіння кіноа, яке завдяки багатому хімічному складу, набирає стрімкої популярності. Представлено результати досліджень змін органолептичних, хімічних та мікробіологічних характеристик зерна кіноа під час зберігання в різних умовах. Для досліджень використовували насіння кіноа, яке зберігали протягом 12 місяців при температурі +(5–30)°С та відносній вологості середовища 20–80%. Показано, що після зберігання насіння кіноа протягом 12 місяців при температурі +(5–30)°С відбулась зміна органолептичних показників – було відчутно прогірклий та неприємний післясмак та дещо змінився колір і з'явився сторонній запах. При зберіганні зерна кіноа при +5°С увесь період зберігання кислотність зерна залишалась в межах норми доброякісного зерна. При температури зберігання +15°С кислотність залишалася нормальною до 9 місяців зберігання, а при температурі +30 °С – до 6 місяців. Аналіз отриманих результатів за мікробіологічними характеристиками показав, що переважною складовою бактеріальної мікрофлори зерна кіноа є неспороутворювальна паличка *Erwinia herbicola* – представник епіфітної мікрофлори, її частка складає 70,5%. Із мікроміцетів виявлено плісеневі гриби роду *Aspergillus* та польові гриби родів *Mucor*. Показано, що при зберіганні зерна кіноа при температурі +(5–30)°С суттєво знижується життєдіяльність мікроорганізмів, затримується розвиток бактерій і навіть плісневих грибів, що позитивно впливає на збереження якості зерна. В ході досліджень встановлено, що зерно кіноа рекомендовано зберігати до 12 місяців при температурі +5°С, до 9 місяців при температурі +15°С та не більше 6 місяців при температурі +30°С.

Ключові слова: насіння кіноа, мікробіота, показники якості, зберігання, кислотність, споживні властивості.