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МИКРОСТРУКТУРНЫЕ ИССЛЕДОВАНИЯ УСОВЕРШЕНСТВОВАНЫХ МЯСНЫХ РУБЛЕННЫХ ПОЛУФАБРИКАТОВ

Рассмотрены усовершенствованные говяжьи фарши с заменой 5 %, 10 %, 15 % мясной доли на люпиновую муку с добавлением 0,5 % порошка корня девясила, как пряно-ароматического сырья и контрольный образец говяжьего фарша. Гистологические исследования показали за ШИК реакцией содержание в мясных разработанных полуфабрикатах мясной

и растительной части. По гематоксилину и эозину определили процентный состав фарша.

Ключевые слова: мясные рубленые полуфабрикаты, порошок корня девясила, мука люпина пищевого белого.

Paska Maria, Doctor of Veterinary Science, Professor, Department of Technology of Meat, Meat and Oil and Fat Products, Lviv National University of Veterinary Medicine and Biotechnologies named after S. Z. Gzhytskyi, Ukraine, e-mail: maria_pas@ukr.net, ORCID: <https://orcid.org/0000-0002-9208-1092>

Maslichuk Olga, Applicant, Department of Technology of Meat, Meat and Oil and Fat Products, Lviv National University of Veterinary Medicine and Biotechnologies named after S. Z. Gzhytskyi, Ukraine, e-mail: olia_maruniak@ukr.net, ORCID: <http://orcid.org/0000-0003-2045-9284>

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Serdyuk M.,
Velichko I.,
Priss O.,
Danchenko O.,
Kurcheva L.,
Baiberova S.

SUBSTANTIATION OF THE CHOICE OF OPTIMAL CONCENTRATIONS OF ACTIVE INGREDIENTS OF THE ANTIOXIDANT COMPOSITION FOR FRUIT TREATMENT BEFORE STORAGE

Розроблена антиоксидантна композиція на основі іонолу, диметилсульфоксиду та лецитину, застосування якої сприятиме подовженню терміну зберігання плодів з мінімальним рівнем щодобових втрат. Проведеною оптимізацією встановлено, що при зберіганні плодів яблуни та груші концентрація дистинолу повинна бути на рівні 0,041...0,042 %, концентрація лецитину – 2,9 %, при зберіганні плодів сливи відповідно: дистинолу – 0,022 %, лецитину – 3,4 %.

Ключові слова: обробка плодів антиоксидантною композицією, подовження терміну зберігання, щодобові втрати при зберіганні.

1. Introduction

Fruit products due to their high biological value and functional properties should be an obligatory component of the human diet throughout the year. According to some authors, the proportion of fruits in the diet is considered an indicator of the growth of the well-being of the population [1, 2].

According to the recommendations of the Food and Agriculture Organization of the United Nations (FAO) to ensure the food security of the population, the total capacity of refrigerated storage facilities in the country must correspond to the population and the balance sheet conditions of the export-import turnover. At the same time, part of the fruit and vegetable products stored should be 90...125 kg per person per year. Unfortunately, this value in Ukraine today is on the average 10.5...17.5 kg per person, and in large industrial centers does not reach the required level [3].

Among the main factors contributing to this situation in the field of fruit storage are the lack of modern production facilities for storing and use of too expensive, and sometimes very complex and unsustainable storage technologies [4–6].

In this regard, studies devoted to the search for ways to improve existing storage technologies, with the aim of providing the population with fresh and quality fruit products throughout the year, are relevant.

2. The object of research and its technological audit

The object of research is the technological process of refrigerated storage of fruit products.

The biggest problem with storage for this technology is a high level of losses (20–30 %) from microbiological diseases and physiological disorders. In addition, low positive temperatures only inhibit, but do not stop the redox processes. Therefore, when storing fruits in conventional cold rooms, a high rate of post-harvest ripening processes is noted. At the same time there is a rapid deterioration of non-quantitative indicators and biological value.

To find ways to eliminate these problems, a technological audit is conducted, which aimed to investigate the possibility of using antioxidant compositions for fruit treatment before further storage.

3. The aim and objectives of research

The aim of research is development of a new antioxidant composition and optimization of its composition. The use of this composition for post-harvest treatment of fruits contributes to the extension of their shelf life and the reduction of the level of daily loss.

To achieve this aim it is necessary:

1. To offer a new antioxidant composition based on the results of analytical studies.
2. To set optimization parameters and accept initial restrictions for them.
3. To carry out a study of the effect of the antioxidant composition on the level of daily loss of fruit raw material during storage.
4. To optimize the composition of the developed antioxidant composition.

4. Research of existing solutions of the problem

Antioxidant compounds are used in many countries around the world to enhance the positive effect of low temperatures in the storage of fruit raw materials. They inhibit oxidation-reduction processes occurring in fruits during storage, and thus inhibit the processes of post-harvest metabolism and promote the preservation of biologically active substances, as well as a significant reduction in the loss of fruit raw materials from physiological disorders. A large number of antioxidant compounds have bactericidal properties, and, accordingly, protect the raw material from damage by pathogenic microflora [7, 8].

Today, synthetic, natural or combined antioxidant compounds are actively used in production conditions. Synthetic antioxidants are the cheapest, affordable and technological, and therefore find increasing use in the food industry. The group of these substances includes synthetic analogues of natural antioxidants, as well as a large group of artificial antioxidants based on phenolic and sulfur-containing compounds [9].

The synthetic antioxidant 2,6-bis(1,1-dimethylethyl)-4-methylphenol (phenol, 2,6-bis(1,1-dimethylethyl)-4-methyl-, butylated hydroxytoluene, ionol, agidol 1, dibunol, BHT) has found wide application in the food industry. This substance is considered a food additive E321 and is actively used to prevent peroxidation in products such as vegetable oils, cereals, bakery products, crackers, potato chips and purees, meat products and canned food, beer [10]. When storing fruit products, ionol is used for post-harvest treatment of fruits of apples, apricots, mangoes and citrus fruits [11]. Positive results are obtained during storage with post-harvest treatment of ionol of fruit and gourds vegetables [12].

As synergists in ionol, some researchers recommend the use of dimethyl sulfoxide [13]. Dimethyl sulfoxide (DMSO, dimexide) is considered a powerful antioxidant. It prevents lipid peroxidation and stabilizes cell membranes. Along with this, dimexide stimulates the SOD synthesis in the cells – the main enzyme of the antioxidant system. Simultaneously with antioxidant, DMSO also has antiseptic properties. Solutions with a substance concentration of 0.15...10 % have a bacteriostatic effect, and in a concentration of 25...50 % – bactericidal. In complex preparations, DMSO can act as a solvent, as

well as ensure rapid transport of other active substances into cells [14].

In previous studies, for the treatment of fruits before long-term storage, DMSO was used at concentrations of 10 to 25 % [15]. However, it was found that at high DMSO concentrations in the fruit raw material there is an extraneous smell and taste. Consequently, in further studies of the effect of dimethyl sulfoxide on the preservation of fruit raw material, it is advisable to use significantly lower concentrations, and the enhancement of antioxidant properties can be achieved using its synergism with ionol.

Along with this, a large number of antioxidant compounds has a low solubility and is not capable of forming homogeneous solutions and suspensions. This complicates the process of applying and uniform distribution of preparation on the surface of the fruit raw material, reduces the technological effect and makes it impossible to use them in production. To eliminate these deficiencies, food coatings of various nature are introduced into the complex antioxidant preparations.

Among the protective coatings of biological origin, the most common is lecithin. It is considered a good emulsifier and a powerful antioxidant. It is considered a natural food additive (E 322), which is actively used in the food industry for the production of margarine, pasta, bread and other bakery products, in the production of chocolate and chocolate glaze, fat emulsions. The use of food additive E322 is allowed in Ukraine without restrictions [16].

For post-harvest processing of fruit products before its subsequent storage, a number of complex compositions based on lecithin were developed, the application of which contributed to the preservation of quality and biological value [17–19].

The only drawback that can limit the use of lecithin in the storage of fruit products is the propensity to microbiological spoilage and oxidation by air oxygen [20]. Stabilize lecithin from oxidation and increase its microbiological tolerance is possible due to the introduction of complex compositions of substances with high bactericidal and antioxidant properties. Such substances can be ionol and dimethyl sulfoxide.

So, according to the results of analytical studies, distinol-based antioxidant DL composition was developed, consisting of a mixture of ionol and dimethyl sulfoxide, and lecithin. But its compositional composition remains undefined.

Therefore, in order to further use the complex antioxidant DL composition in production conditions, it is necessary to optimize and determine the effective concentrations of its components.

5. Methods of research

As model varieties for the study, apple fruits of Aidared, Golden Delicious, pear of varieties Victoriia, Iziumynka Krymu and plum of varieties Voloshka, Stenlei were chosen. The fruits of apple and pear were harvested when the degree of ripeness was reached, the fruits of the plum were in technical ripeness, typical in shape and color according to the requirements of GSTU 01.1-37-160:2004, GSTU 01.1-37-162:2004, GSTU 01.1-37-163:2004. Prior to the storage, an inspection, sorting and calibration of the fruit was carried out.

The treatment with antioxidant compositions (AOC) was performed in storage facilities by immersing them in pre-prepared working solutions. Exposure – 10 seconds. The fruit was dried by ventilation. Options for treatment: K – control, option 1 – DL – a mixture of dimethyl sulfoxide, inonol and lecithin. The following concentrations of active substances were studied: distinol 0–0.048 %, lecithin 0–6 %. The effectiveness of exposure to various concentrations of active substances was determined by the average level of daily loss of fruit during storage, consisting of the sum of mass losses and losses caused by microbiological diseases and functional disorders, referred to the number of days of storage. Determination of the level of development of functional disorders and microbiological diseases during storage of fruits was performed by inspection, and exposure of specimens, which are reduced commercial quality and grouping them according to the nature of the lesion. The loss of weight of the fruit was determined by the method of fixed samples [21]. The studies were carried out in two-year replication.

Storage was carried out in plastic boxes, 15 kg of fruit each. Storage temperature was 0 ± 1 °C, relative humidity was 95 %.

In the analysis and processing of experimental data, the construction of mathematical models used computer programs – the system of computer mathematics Maple.

6. Research results

To establish the effective concentrations of distinol (D) and lecithin (L) in the complex DL composition during the storage of fruit products, a scientific experiment is made and optimization of the experimental data is carried out. As a result of the optimization, a mathematical model is obtained and the response surface is constructed, which reflects the dependence of the average loss level of apple fruit g (%) on the concentrations of distinol x (%) and lecithin in (%).

The criterion of optimality in the construction of the mathematical model is the minimum average daily loss of apple fruits during storage:

$$g \rightarrow \min.$$

The initial constraints of optimization parameters (%):

$$0 \leq x \leq 0,048,$$

$$0 \leq y \leq 6.$$

The level of average daily losses during storage of fruits is determined by the sum of daily losses from damage caused by microbiological diseases, physiological disorders and mass losses (Table 1).

The data are given taking into account the mass loss. The value at the intersection of concentrations of active substances 0-0 corresponds to the number of standard products of the control variant.

Analysis of the obtained data (Table 1) shows that the minimum level of daily loss during storage of fruits of apple and pear is established in the vicinity of the point (0.036; 4), and the fruit of the plum – point (0.024; 4). Therefore, new optimization constraints are chosen for fruit of pome fruits within the rectangle $[0.024; 0.048] \times [0; 5]$, for which

this point is internal. For plum fruits, the optimization constraints are within the rectangle $[0.012; 0.048] \times [0; 5]$.

Table 1

Average daily loss during storage of apple fruits using the DL composition

Type of fruit	Daily losses (%), at appropriate concentrations of the composition components				
	D/L	0	4	5	6
Apple fruits	0	0.0698	0.0758	0.0844	0.0942
	0.012	–	0.0591	0.0706	0.0826
	0.024	–	0.0365	0.0529	0.0610
	0.036	–	0.0195	0.0397	0.0514
	0.048	–	0.0197	0.0404	0.0534
<i>LSD₀₅</i>	–	–	<i>0.003</i>	<i>0.003</i>	<i>0.002</i>
Pear fruits	0	0.0771	0.0675	0.0817	0.0886
	0.012	–	0.0618	0.0773	0.0847
	0.024	–	0.0386	0.0627	0.0705
	0.036	–	0.0116	0.0431	0.0516
	0.048	–	0.0127	0.0433	0.0524
<i>LSD₀₅</i>	–	–	<i>0.004</i>	<i>0.002</i>	<i>0.002</i>
Plum fruits	0	0.6534	0.2037	0.3159	0.3557
	0.012	–	0.1380	0.2709	0.3069
	0.024	–	0.0594	0.1779	0.2346
	0.036	–	0.0626	0.1835	0.2387
	0.048	–	0.0712	0.2009	0.2537
<i>LSD₀₅</i>	–	–	<i>0.008</i>	<i>0.008</i>	<i>0.011</i>

For the selected data range, the approximations of the function are performed by a polynomial of the second degree:

$$f(x, y) = a_0 + a_1x + a_2y + a_3x^2 + a_4xy + a_5y^2.$$

The coefficients are determined by minimizing the sum of the squares of the deviations of the theoretical and experimental values at the nodes belonging to the given rectangle (for example, apple fruits):

$$F(a_0, \dots, a_5) = \sum_{i=1}^3 \sum_{j=1}^3 (f(x_i, y_j) - g(x_i, y_j))^2,$$

where $x_1 = 0.024$, $x_2 = 0.036$, $x_3 = 0.048$, $y_1 = 0$, $y_2 = 4$, $x_3 = 5$, $g(x, y)$ – experimental values of daily loss of apple fruits during storage, %.

From the linear system, which is a consequence of the necessary conditions for the extremum:

$$\left\{ \frac{\partial F}{\partial a_j} = 0, j = \overline{0, 5}, \right.$$

the values of the coefficients $a_j, j = \overline{0, 5}$ are obtained. The following mathematical dependence is obtained in the calculation results:

$$\begin{aligned} f(x, y) = & 35.99537037x^2 - 0.1244047619xy + \\ & + 0.006048333333y^2 - 2.625396825x - \\ & - 0.03085642857y + 0.1142087302. \end{aligned}$$

Notice, that:

$$\Delta = \frac{\partial^2 f}{\partial x^2} \cdot \frac{\partial^2 f}{\partial y^2} - \left(\frac{\partial^2 f}{\partial x \partial y} \right)^2 > 0, \quad \frac{\partial^2 f}{\partial x^2} > 0.$$

It follows that this function is convex, and has a single minimum illustrating the response surface (Fig. 1).

The minimum point is the solution of the system:

$$\begin{cases} \partial f / \partial x = 0, \\ \partial f / \partial y = 0. \end{cases}$$

After calculations, let's find the optimal concentrations of active substances:

$$\{x = 0.042, y = 2.9\}.$$

In this case, the minimum value of daily loss when storing apple fruits at the optimum point is 0.014 %.

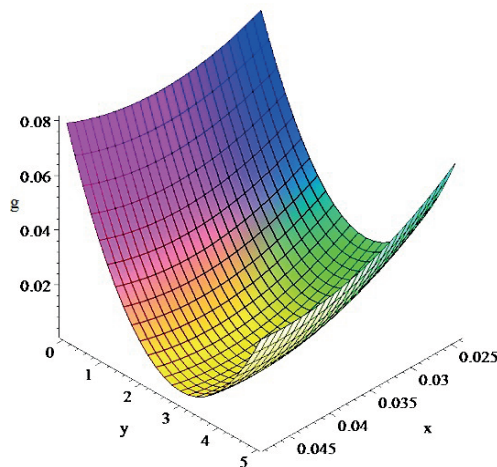


Fig. 1. The response surface for the model for optimizing the concentrations of the active substances of the DL composition when storing apple fruits

According to the above algorithm, the concentrations of the active substances of the DL composition are optimized when storing pear and plum fruits.

The mathematical dependence for establishing the optimum concentrations of the DL composition when storing the pear fruit is different from the apple fruit model. At the same time, the optimal concentrations of active substances are at the point $\{x=0.041, y=2.9\}$ with a minimum value at the optimum point of 0.002 %.

For plum fruits, the mathematical dependence has the form:

$$\begin{aligned} f(x,y) = & 19.90740741x^2 - 0.1720238095xy + \\ & + 0.05405666667y^2 - 1.466071429x - \\ & - 0.3696695238y + 0.6784674603. \end{aligned}$$

The optimal concentrations of active substances are at the point $\{x=0.022, y=3.4\}$ with a minimum value at the optimum point of 0.037 %.

The response surfaces illustrating the optimization process are shown in Fig. 2, 3.

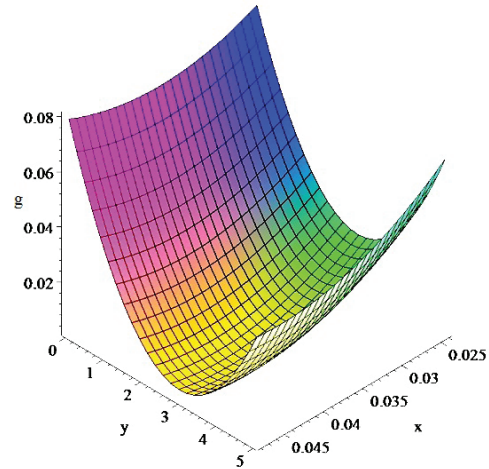


Fig. 2. The response surface for the model for optimizing the concentrations of the active substances of the DL composition when storing pear fruits

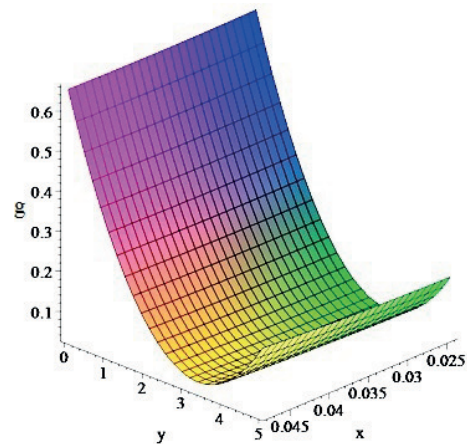


Fig. 3. The response surface for the model for optimizing the concentrations of the active substances of the DL composition when storing plum fruits

So, the following concentrations of active substances in the antioxidant DL composition are established by the optimization: apple and pear fruits storage – distinol concentration is 0.041...0.042 %, the lecithin concentration is 2.9 %. Plum fruits storage, respectively: distinol – 0.022 %, lecithin – 3.4 %.

7. SWOT analysis of research results

Strengths. The use of the antioxidant composition developed with the optimized composition for the processing of fruit products before further storage ensures maximum preservation of its non-quantitative indices and high biological value. In modern market conditions, the introduction of such technology is very relevant and may become a priority direction for the development of the storage industry in Ukraine.

The main social effect of research results can be considered an extension of the period of consumption of fresh fruit products against the background of maximum preservation of non-quantitative indicators and biological value. Realization of such products at reasonable prices in winter will have a positive effect on the health of a person, providing body with the necessary carbohydrates, vitamins, minerals and other biologically active substances.

Weaknesses. The weaknesses of this research are related to the lack of a ready-made formulation of the DL composition in the commercial network. This composition should be prepared according to the following technology: a mixture of ionol and dimethyl sulfoxide in a ratio of 1.4:1 by weight should be heated to 60 °C and kept until the ionol is completely dissolved. As a result, a complex preparation – distinol (D) is obtained. Shelf life of the form of the preparation distinol is 1 year at a temperature of 0...5 °C. The required amount of lecithin is dissolved in a small amount of distilled water at a temperature of 40...50 °C. The resulting suspension is heated to a temperature of 80...90 °C and mixed with the right amount of distinol. To the necessary concentration of active substances, the mixture is made up with warm distilled water. The resulting emulsion is homogenized, so that it can be stored without delamination for 2–3 weeks. This is quite a sufficient time for the processing of fruits and laying them for further storage.

Opportunities. The use of the proposed technology of fruit storage during treatment with DL composition promoted an increase in the yield of the standard production of 1st grade, a decrease in costs for normal and reported losses. This allowed to obtain better indicators in comparison with storage using traditional technology, despite the additional cash costs for the preparation. At the same time, the increase in the level of profitability in 3...6 times is noted, and the economic effect is at the level of 3691...12456 UAH/t, depending on the type of fruit.

Threats. The threats in implementing the results are related to the absence of modern lines of preparation of fruits for storage in Ukraine. The existing foreign equipment is of high cost, which adversely affects the technical and economic performance of the storage process. Therefore, further research will be devoted to the development of recommendations for selection of technological equipment for the line of preparation of fruits to storage using antioxidant compositions.

8. Conclusions

1. Based on the results of analytical studies, distinol-based antioxidant DL composition base is developed, consisting of a mixture of ionol, dimethyl sulfoxide and lecithin.

2. The influence of the developed antioxidant composition on the level of daily loss of fruit production during storage in the following concentration range of active substances is studied by experiment: 0–0.048 % of distinol, 0–6 % of lecithin.

3. Research results establish that the minimum level of daily loss during storage of fruits is found at distinol concentrations of 0.024...0.036 %, lecithin – 2...4 %.

4. The following concentrations of the active substances in the antioxidant DL composition are optimized: apple and pear fruits storage – distinol concentration is 0.041...0.042 %, the lecithin concentration is 2.9 %. Plum fruits storage, respectively: distinol – 0.022 %, lecithin – 3.4 %.

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ОБОСНОВАНИЕ ВЫБОРА ОПТИМАЛЬНЫХ КОНЦЕНТРАЦИЙ ДЕЙСТВУЮЩИХ ВЕЩЕСТВ АНТИОКСИДАНТНОЙ КОМПОЗИЦИИ ДЛЯ ОБРАБОТКИ ПЛОДОВ ПЕРЕД ХРАНЕНИЕМ

Разработана антиоксидантная композиция на основе ионола, диметилсульфоксида и лецитина, применение которой будет способствовать продлению срока хранения плодов с минимальным уровнем ежесуточных потерь. Проведенной оптимизацией установлено, что при хранении плодов яблони и груши концентрация дистинола должна быть на уровне 0,041...0,042 %, концентрация лецитина – 2,9 %, при хранении плодов сливы соответственно: дистинола – 0,022 %, лецитина – 3,4 %.

Ключевые слова: обработка плодов антиоксидантным композицией, продления срока хранения, ежесуточные потери при хранении.

Serdyuk Marina, PhD, Associate Professor, Department of Technology of Processing and Storage of Agricultural Products, Tavia

State Agrotechnological University, Melitopol, Ukraine, e-mail: kowtun.marina2013@gmail.com, ORCID: http://orcid.org/0000-0002-6504-4093

Velichko Igor, PhD, Associate Professor, e-mail: velichkoig@gmail.com, ORCID: http://orcid.org/0000-0003-1249-774X

Priss Olesia, Doctor of Technical Sciences, Associate Professor, Department of Technology of Processing and Storage of Agricultural Products, Tavria State Agrotechnological University, Melitopol, Ukraine, e-mail: olesyapriss@gmail.com, ORCID: http://orcid.org/0000-0002-6395-4202

Danchenko Olena, Doctor of Agricultural Sciences, Professor, Department of Technology of Processing and Storage of Agricultural Products, Melitopol State Pedagogical University named after Bogdan Khmelnytsky, Ukraine, e-mail: nndea@ukr.net, ORCID: http://orcid.org/0000-0001-7041-3706

Kurcheva Luidmila, PhD, Associate Professor, Department of Technology of Processing and Storage of Agricultural Products, Tavria State Agrotechnological University, Melitopol, Ukraine, e-mail: lyidmila2007@ukr.net, ORCID: http://orcid.org/0000-0002-8225-3399

Svitlana Baiberoва, PhD, Assistant, Department of Technology of Processing and Storage of Agricultural Products, Tavria State Agrotechnological University, Melitopol, Ukraine, ORCID: https://orcid.org/0000-0003-1875-6458

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**Zhulinska O.,
Svidlo K.**

DETERMINING QUALITY PARAMETERS OF ALCOHOL-FREE FUNCTIONAL BEVERAGE BY THE PROCEDURE THAT EMPLOYS AFFINE TRANSFORMATIONS

Проведені розрахунки якості безалкогольних напоїв функціонального призначення, згідно методики оцінки із застосуванням афінних перетворень, яка може бути застосована при будь-якому ідеальному значенні. Експериментальні дослідження виконувалися на прикладі процесів виробництва безалкогольних напоїв з м'якотною текстурою, застосовуючи розроблену методику, показники фізико-хімічних та органолептичних властивостей продукту, математичні методи обробки результатів вимірювань.

Ключові слова: функціональні харчові продукти, управління якістю та безпечністю, середнє квадратичне відхилення.

1. Introduction

Activities on the creation of a modern system of control over safety and quality of functional products, market surveillance, adapted to the requirements of the World Trade Organization (WTO) and the European Union (EU) have been intensified over recent years.

According to the law of Ukraine «On safety and quality of food products», quality of a food product is the combination of perfection of its properties and characteristic attributes that are able to satisfy the needs (requirements)

and wishes those who consumes or uses this product. Among the variety of factors that affect the human health, one of the most essential is quality of nutrition [1].

Quality of the soft drinks with functional purpose is assessed by organoleptic and physical-chemical indicators. Among the physical-chemical indicators, most commonly determined are density (by saccharimeter), acidity, content of carbon dioxide and salts of heavy metals. Density and acidity are established by a standard for each particular beverage. Organoleptic assessment of drinks is conducted by a 100-point system by five indicators: transparence,