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**SCIENTIFIC DEVELOPMENT  
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## Scientific development and achievements

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**Belinska S.**

*Doctor of Technical Sciences, Professor, Head of the Department of Commodity Studies, Safety and Quality Management, Kyiv National Trade and Economics University, Kyiv, Ukraine*

**Moroz O.**

*Doctor of Economics, Professor, Head of the Department of Entrepreneurship and Financial Activities, Vinnytsia National Technical University, Vinnytsia, Ukraine*

**Kamienieva N.**

*Candidate of Technical Sciences, Associate Professor, Department of Commodity Studies, Safety and Quality Management, Kyiv National Trade and Economics University, Kyiv, Ukraine*

**Moroz I.**

*Candidate of Economic Sciences, Associate Professor, Department of Cybernetics and Systems Analysis, Kyiv National Trade and Economics University, Kyiv, Ukraine*

**Kepko V.**

*Candidate of Economic Sciences, Associate Professor, Department of Entrepreneurship, Trade and Stock Exchanges, Bila Tserkva National Agrarian University, Bila Tserkva, Ukraine*

## METHODOLOGICAL APPROACHES TO THE PROCESS OF FORMING A QUALITY MANAGEMENT SYSTEM FOR FROZEN FRUIT AND VEGETABLE PRODUCTION

**Introduction.** The growing popularity of a healthy lifestyle is accompanied by an increase in the diet of the fruit and vegetable production the quality of which is guaranteed by the producer and undergoes minimal changes throughout the life cycle. The guaranteed quality is a fundamental feature of the products and one of the essential motivations of the potential buyers to their acquisition. The category of food quality is multifaceted. It combines safety, nutritional, biological value, organoleptic, ergonomic properties, compliance with the modern theories and dietary trends and so on. At the same time the quality generated during the production process is not stable, since the overwhelming share of food products is a multi-component system in which the physical, chemical, and biochemical processes take place. The result of these processes are changes in consumer properties whose depth determines the storage time.

**Research results.** The formation of food quality is a complex process that requires the permanent management of a number of factors of influence on the predicted quality of the product. The management features stem from the specifics of



the product as an object of management and can not be universal for a wide range of species, groups, assortment positions of the food products.

One of the peculiarities of the food quality management is that it, as a component of the production management, is not limited only to the process of its production, but also includes its commodity sales and preparation for consumption. One more feature of the food quality management is that the quality is not constant and changes throughout the life cycle, so it is only possible with a certain probability to predict it.

Considering the quality of a product, it should be noted that it is a hierarchical system of properties in which the properties of each previous level are determined by the simpler properties of the subsequent levels. Therefore, the change of a certain property can be achieved by the guided influence on the corresponding properties of the lower level of the hierarchy. A significant number of the product properties, the complexity of their interconnections, is what determine the specifics of the quality management.

The range of the products in the food market is constantly changing. This is due to the globalization and the elimination of the technical barriers to trade, the introduction of modern production technologies, the changes in consumer preferences and dietary trends. In recent years Ukraine and the world have seen an increase in demand for natural products that have a high degree of readiness for consumption or culinary use, and at the same time retain their intrinsic qualities. Such requirements correspond to frozen fruits and vegetables that for many decades have a steady demand.

Specific factors influence on the formation and preservation of the quality of the fast frozen fruit and vegetable products: specific and varietal features of the raw materials, degree of ripening, peculiarities of harvesting, conditions of transportation, duration of storage of the raw materials, freezing technology, packaging methods, storage conditions, transportation, sales of the frozen products and methods of the preparation before consumption.

The above stipulates the need for a systematic analysis of all the factors when making managerial decisions on the quality of the frozen fruit and vegetable products.

The purpose of our work was to develop methodological approaches to the process of forming a quality management system for quick-frozen fruit and vegetable products.

The quality management is an objective, logical process, which is inextricably linked with the development of the society and is based on the analysis and integration into a coherent set of factors of the formation of quality. The most common are the following methodological approaches to management: systemic, process and situational.

The systemic approach involves the construction of a complex model with the definition of external and internal connections, which can be influenced and

accordingly predict the functioning of the system in certain ranges. In this case the model must meet the requirements of the emergence, structural, interdependence, hierarchy.

The process approach is to identify many interrelated processes where each process is considered in combination with others as a sequence of the stages.

The situational approach is to manage a particular situation without taking into account the connections and relationships between the elements of the system.

The most common and effective are the systemic and process approaches. It is they that help to identify the main object of the object under study and ignore the secondary one by arranging them in the form of a set of interconnected and interrelated elements that are part of the system and form a single functional purpose intended to achieve a specific goal. In this formalization, namely the ability to describe the system through its structure, the interdependence of the elements of structure and environment, hierarchy allows you to identify the nature of the relationship between the elements of the system and ensure its effective management. However, solving specific problems of the quality assurance requires their adaptation to the specifics of the food products.

The main factors of the formation and preservation of the quality of frozen fruit and vegetable products are species and varietal characteristics of the plant raw materials, terms of harvesting, conditions, duration of transportation and storage of the fruits and vegetables before freezing, freezing technology, packaging methods, storage conditions, transportation, sales, methods of defrosting of the frozen products.

The beginning of the general chain of the formation of consumer properties is the determination of the species and varieties of the plant material suitable for freezing [1-4]. The general criterion that determines the variety of fruits and vegetables to refrigeration is the high moisture content and a dense structure after defrosting, resistance to cracking, high content of pectin substances, fiber, hemicellulose which provide the relative stability of the covering tissues and the consistency of the pulp as after freezing, and after defrosting, high content of dry substances, biologically active components (anthocyanins, carotenoids, ascorbic acid). Specifics: homogeneity of colour, density of pulp, peculiarities of separation of peduncles, sepals, bone from the pulp, dry breakage of the peduncle, etc.

The agricultural production and harvesting are important in terms of the quality of the frozen fruit and vegetable production [5]. For most crops, harvesting is optimal in the stage of consumer maturity. However, for strawberries, raspberries, apricots, intended for quick freezing, the most optimal for harvesting is the transitional stage of ripening - from the technical to the consumer.

The reason for lowering the quality of the frozen fruits and berries (relaxing their consistency after defrosting) is a long period of time between the harvesting and freezing [6, 7]. The frozen freshly harvested fruits and vegetables are of superior

quality compared to those made from raw materials even with short-term storage in optimum conditions. The strawberries, currant, cherries, apricots, peaches for freezing can be stored in refrigerating chambers for up to three days, grapes, plums - up to seven days at a temperature from 0 to 6...7°C [8]. The foreign authors recommend to freeze fruits and vegetables in 1.5 hours after they are harvested [9]. At the same time, under conditions of harvesting at high temperatures, the fruits and vegetables should be cooled to a temperature of 0 to 2° before freezing. With increasing storage temperature, the intensity of heat dissipation increases, metabolic processes are accelerated, turgor is lost, nutritional and biological value decreases, and weight loss increases. Different cooling methods are used to slow down the metabolic processes: air, hydro- and vacuum cooling. It is proved that it is expedient to carry out air cooling for small berries and vegetables with a gentle consistence, hydrocooling - for fruits and vegetables of a large size, vacuum cooling - for leafy vegetables. Air cooling is effective for all types of fruits and vegetables, hydrocooling - for 62%, vacuum cooling - for 43%.

The modern technologies and methods of pre-treatment help to reduce unwanted changes in the consumer properties of the frozen fruits and vegetables: loss of turgor, changes in organoleptic properties. The existing methods of preliminary treatment, regardless of the nature of the effect on the plant material (physical, chemical, biochemical) can be conventionally grouped into two groups: those that are aimed at inactivation of the enzymes and those that are aimed at reducing the activity of the water.

The effective methods of inactivating enzymes of the plant tissues include blanching (water or steam) and the treatment with chemical reagents. However, along with the positive sides of blanching, namely, inactivation of the enzymes, partial destruction of the vegetative forms of microorganisms, displacement of air from the intercellular space and increased intensity of colour expression, decrease in the content of pesticides and nitrates, it also should be noted disadvantages the main of which is the loss of the valuable water-soluble substances, adsorption of water by the product, the loss of tissue elasticity. Adding citric acid to water for blanching contributes to a more intense decrease in the activity of the enzymes, as the pH and the threshold of thermal denaturation of the enzymes are reduced. The colour stabilization is achieved under condition of blanching in milk whey, addition to water for blasting of bisulfite, metabisulfite, sodium carbonate, consistency - sugar and pectin with a low degree of esterification [10].

In recent years studies have been conducted on the inactivation of the enzymes by electroconductive method, infrared rays, high frequency currents.

The positive influence on the consumer properties of the fruits and berries has been confirmed by preliminary treatment in solutions that have antioxidant properties:

extracts of oak, birch, St. John's wort; infusion of green tea; solutions of sugar and ascorbic acid; ascorbic acid and sodium chloride.

The pre-treatment methods aimed at reducing the activity of the water include dehydration, osmotic dehydration, freezing in concentrated solutions. Pre-drying at temperatures of 100°C and above ensures the inactivation of the oxidative-reducing enzymes, promotes the preservation of the biologically valuable components, accelerates the freezing process, prevents lacing of the products during storage.

The aerial dehydration is sometimes replaced by osmotic. This changes the ratio of the free and osmotically absorbed moisture which contributes to the preservation of the microstructure of the tissues and stabilization of the consistency. However, despite the benefits of osmotic dehydration, namely, increasing the content of the dry matter, preserving the vitamin value, colour and structure of the tissues of the fruits, from a technological point of view, the osmotic dehydration is a rather costly process.

In order to reduce the activity of water, the fruits are frozen in sugars or in its solutions of different concentrations. Adding to a solution of starch sugar helps to soften the sweet taste of the fruits at high concentrations of the first; the addition of ascorbic acid, citric acid and their mixture guarantees the preservation of the colour; and the addition of gelatin, pectin, agar - ensures the stability of the consistency.

A significant factor in the formation and preservation of the consumer properties of frozen foods is the detection of an optimal method of freezing and its method - contact or non-contact. The choice of freezing methods is determined by the economic and technological aspects. The most used is air freezing. Along with its significant advantages, it has significant disadvantages: low thermal conductivity of air which slows down the heat transfer intensity and activates oxidation processes under the condition of free access of oxygen to air; massive loss of mass.

When freezing fruits and vegetables in solutions (calcium and sodium chlorides, propylene glycol, ethyl alcohol, mixtures of salts and alcohols), the process of freezing is intensified. This is due to higher thermal conductivity of the solutions compared with air, reducing mass losses during freezing. In addition, rapid immersion freezing, compared with air, reduces the dehydration of the product. A significant drawback is the negative influence of the solution on the taste properties of some types of plant material (except eggplant, pepper, potato) and the need for special waterproof film and rapid corrosion of equipment.

The use of low-boiling cryogenic liquids, in particular, liquefied nitrogen, carbon dioxide, reduces the product temperature from plus 21°C to minus 18°C, depending on the size of the product for 1 to 5 minutes. However, the high freezing rate, the intense increase in the internal volume of the product can cause cracking of the fruits. The advantages of freezing in vapors of liquefied nitrogen include the lack of drying. The passive nitrogen atmosphere formed on the surface of the product helps to slow down

the oxidation processes, maximally preserve sensory, the properties and biological value. The advantages of the cryogenic freezing are minimally changing the nutritional and biological value of the fruits and vegetables, maximizing the mass of the product and the possibility of organizing the production in confined areas with the use of simple technological equipment. The main disadvantage of this freezing method is the high cost of the liquefied nitrogen. A new method of the cryogenic contact freezing in conventional type cells using granular carbon dioxide is characterized by a reduction in production costs [11].

To reduce the negative physical and chemical changes that occur during the freezing and storage of the plant material, namely drying and oxidation, the packaging of products in containers of different types of packaging materials is used [12-14]. The optimum packaging of the frozen fruits and vegetables in terms of preserving their consumer properties is the packaging of polymer materials. It is proved that the degree of weight loss of fruits and vegetables is directly proportional to the vapor permeability of the packaging material. However, if the seal is impermeable, the evaporating moisture will settle in the form of frost on the inner surface of the packaging material which makes it impossible to visualize the product.

One of the factors of preservation of the quality of the products formed during freezing is the observance of the optimum conditions for its storage. According to the recommendations of the scientists the storage temperature should not exceed minus 18°C. However, the studies of the recent years have established that this temperature does not guarantee the complete crystallization of the moisture.

The high level of the frozen production formed during the production process, during its life cycle can not be preserved without the integrity of the refrigeration chain and the corresponding temperature regimes on each of its components. The failure to comply with the requirements for the integrity of the refrigeration chain at any of the units is accompanied by recrystallization, defrosting, laceration, loss of cellular juice and soluble dry matter, including vitamins. At the same time the enzymatic activity increases, the oxidation processes are intensified, and the consumer properties of the fruits and vegetables decrease.

The final link in the complex chain of the formation and preservation of the quality of the frozen fruit and vegetable products is its preparation for consumption. In case of violation of the recommended methods of defrosting (with the use of surface or internal heating), or unsatisfactory performance of the product the quality can significantly deteriorate.

In view of the above, we have developed a functional model of production as a control system (Fig. 1). Its elements are subsystems of the market, science, production with internal and external coordination and subordination relations.

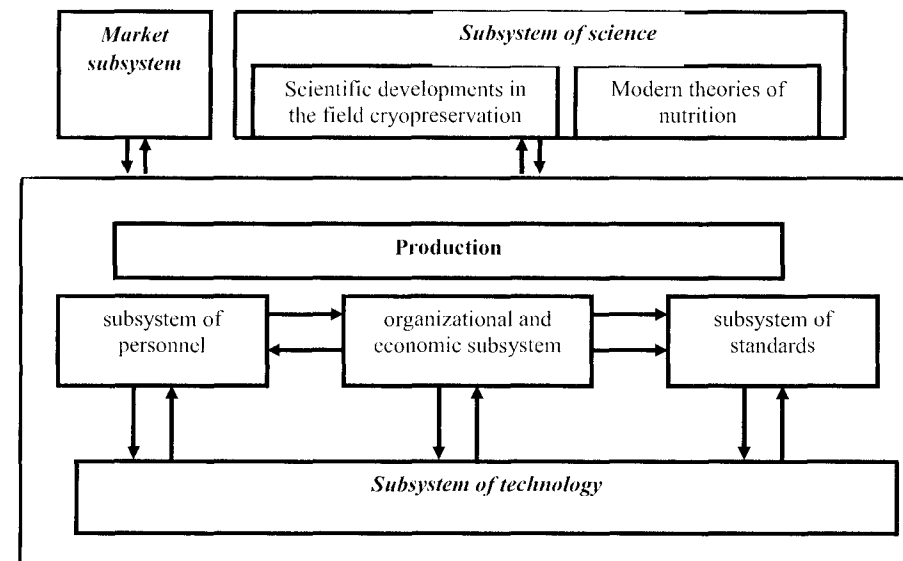


Figure 1. Functional model of the production as a quality management system

The management of the external and internal communications which can be direct and inverse, the detection of causation among them, ensures the efficiency of the functioning of the system by reducing the risk of the probability of occurrence of the inconsistencies during its operation.

Due to the existing horizontal and vertical connections, the subsystem of technology in the production system can not be considered separately from other subsystems. Given its complexity, it is expedient to decompose and consider it as a separate integral system with internal connections.

The developed model of the subsystem of technology of the frozen fruit and vegetable products (Figure 2) indicates that it is not a set of its components, but is a qualitatively new organization with straight and inverse links.

In the technology subsystem the factors of influence are grouped into groups: controlled, random, and restrictive.

The controlled factors include those that can be traced, monitored and effective to achieve the ultimate goal of ensuring the quality of the finished products. These are: variety, quality, safety of the raw materials, duration of its storage prior to freezing, storage conditions, methods of processing the raw materials (chemical processing, blanching, cleaning and cutting), temperature parameters of freezing, kind of packing materials, storage conditions.



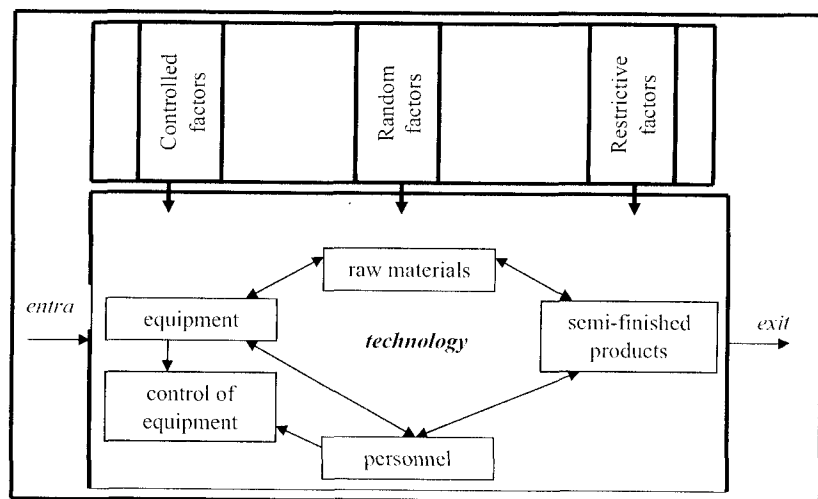


Figure 2. Model of the technology subsystem

The random factors (chemical composition) do not depend on specific conditions, they are difficult to predict, but they also affect the end result.

The restrictive factors (technical and economic possibilities of the enterprise concerning the use of modern equipment, the ability to implement the results of scientific research, the possibility of ensuring the continuity of the technological process and staff qualification) are related to the activities of a specific enterprise.

The management of the above-mentioned factors ensures a reduction of the risk of the production of the products of inadequate quality. This approach to product quality management involves a comprehensive analysis of all the factors of influence and the development of measures aimed at preventing the potential problems of the quality preservation.

In order to minimize the risks associated with the use of unfit for freezing of the varieties of vegetables, we conducted a study on the influence of broccoli cabbage variety and the duration of its storage prior to freezing on the predicted quality of the frozen cabbage. The value of broccoli is due to the content of ascorbic acid, chlorophyll, glucosinolates, amino acids and other biologically active substances important for the human body.

The fulfillment of the task was carried out through comprehensive research on the chemical composition and organoleptic properties. According to the results of the tasting evaluation, the variety Parthenon broccoli cabbage was of excellent quality (4.81 points), Monaco F1, Belstar F1 and Quinta F1 - good (4.57, 4.33 and 4.31 points,

respectively). It has been established that in the composition of the moisture, the total content of which is in the range from 87.11 to 88.07%, about 40% belongs to the colloid-bound which is retained by the forces of surface molecules of colloidal substances: proteins and carbohydrates on the fringe of the "solid body - water". The broccoli cabbage contains a small amount of sugars: from 2.97% to 3.34%.

Table 1 Chemical composition of varieties of broccoli cabbage, %

$n=5; P \geq 0,95; \epsilon \leq 5$

Indexes	Varieties			
	Parthenon	Belstar F1	Monaco F1	Quinta F1
Mass fraction of moisture	87,42 ± 4,33	87,93 ± 4,39	88,07 ± 4,41	87,11 ± 4,35
Soluble dry matter	9,3 ± 0,28	8,9 ± 0,27	9,0 ± 0,27	8,6 ± 0,26
Bulk protein	3,97 ± 0,19	3,86 ± 0,18	3,92 ± 0,19	3,81 ± 0,18
Total sugar content including:	3,34 ± 0,17	3,22 ± 0,16	2,97 ± 0,15	3,14 ± 0,16
reducing sugars	1,83 ± 0,09	1,71 ± 0,09	1,52 ± 0,08	1,71 ± 0,09
saccharose	1,43 ± 0,07	1,43 ± 0,07	1,37 ± 0,06	1,36 ± 0,06
Titrated acids	0,39 ± 0,02	0,43 ± 0,02	0,34 ± 0,02	0,38 ± 0,02
Cellulose	0,76 ± 0,04	0,78 ± 0,04	0,81 ± 0,05	0,74 ± 0,03

The content of protein varieties of broccoli cabbage are not significantly different. The studies of the amino acid composition of the protein allowed the identification and quantification of 8 essential and 8 amino acid substitutions: glutamine, aspartic acid, arginine, sulfur, glycine, alanine, proline, histidine. The highest biological value is the protein of broccoli cabbage of the Quinta F1 variety (64.2%).

The elemental composition of the experimental varieties of broccoli cabbage is represented predominantly by potassium (from 402.34 to 428.41 mg/100 g) and sulfurous (from 93.25 to 106.02 mg/100 g).

The varieties of broccoli cabbage differ significantly in content of ascorbic acid and isothiocyanates (Table 2).

Table 2 Content of biologically active substances in varieties of broccoli cabbage, mg/100 g

$n=5; P \geq 0,95; \epsilon \leq 5$

Indexes	Varieties			
	Parthenon	Belstar F1	Monaco F1	Quinta F1
Ascorbic acid	116,4 ± 5,83	96,2 ± 4,87	104,5 ± 5,26	88,6 ± 4,48
Chlorophyll	49,0 ± 2,45	48,8 ± 2,44	53,7 ± 2,69	49,8 ± 2,49
$\beta$ carotene	4,6 ± 0,23	3,8 ± 0,19	4,1 ± 0,21	3,1 ± 0,16
Isothiocyanates	590,4 ± 29,52	510,6 ± 25,53	530,8 ± 26,54	550,4 ± 27,52

The intensity of respiration in different varieties of broccoli cabbage is also different. It varied in the range from 14.7 mg per kg for 60 × 60 s in the Parthenon variety to 20.8 mg per kg for 60 × 60 s in the Monaco F1 variety.

The application of the method of multicriteria optimization, the correlation-regression analysis on the complex of organoleptic and physico-chemical indices made it possible to rank the varieties: Parthenon, Monaco F1, Belstar F1, Quinta F1 and determine the most important influencing factors (respiratory intensity, organoleptic properties, soluble solids content, titrated acids, total sugars content, ascorbic acid) on the value of the target function, a composite quality index. It is these factors that are chosen to establish the preservation quality of the cabbage of various varieties. The obtained data confirm that the freshly picked cabbage broccoli of all grades on the scale of Harrington's desirability is characterized by a level of "good quality" (Fig. 4). However, after 5 days of storage only the Parthenon variety retains "good quality", while in all the other varieties the quality is reduced to "satisfactory".

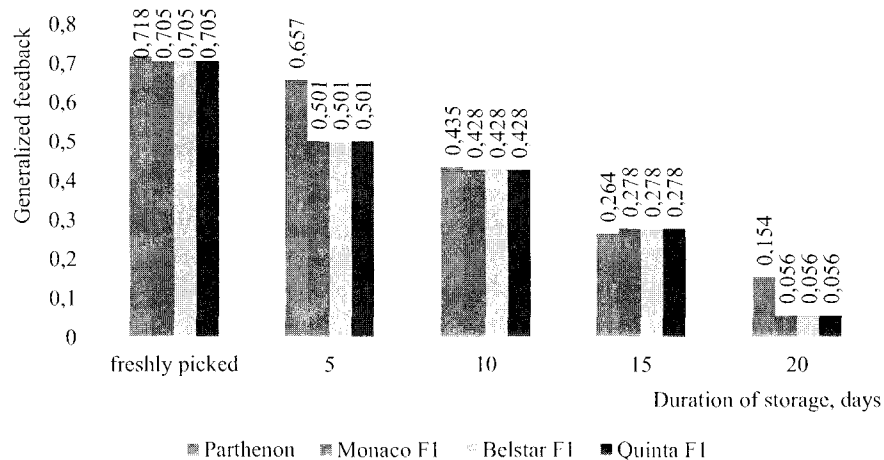


Figure 4. Summary of Harrington's desirability scale

A prognostic model of the quality preservation of broccoli cabbage is developed depending on the storage duration:  $y = 4.41 - 0.72x$   $R^2 = 0.889$ , where  $y$  is a complex quality index,  $x$  - duration of storage (days).

The conducted researches make it possible to state the following. The comprehensive commodity research of broccoli cabbage of Partenon, Monaco F1, Belstar F1, and Quinta F1 varieties zoned in Ukraine has confirmed its high organoleptic properties and biological value. In the variety section no significant differences in the chemical composition have been established except for the content of ascorbic acid, isothiocyanates, and the intensity of respiration. The method of multicriteria optimization has carried out a ranking of grades in quality: Parthenon, Monaco F1, Belstar F1, Quinta F1. This confirms the possibility of using all the varieties for canning at low temperatures.

## CONCLUSION

According to Harrington's desirability scale it has been determined that only Parthenon varieties have a "good quality" quality during the 5 days of storage. In all other varieties the quality is reduced to "satisfactory". That is what makes the Parthenon variety of domestic products best recommended for freezing.

Prospects for further research in the development of predictive models of the quality of frozen products on the basis of establishing dependencies between all the identified controlled and random factors of quality formation.

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**Berezina O.**

*PhD (Economics), Professor, Professor of the Finance Department, Cherkasy State Technological University, Cherkasy, Ukraine*

**Servatinska I.**

*PhD (Economics), Senior Lecturer of the Finance Department, Cherkasy State Technological University, Cherkasy, Ukraine*

## CONTEMPORARY CHALLENGES OF HOUSEHOLD INCOME DIFFERENCES IN UKRAINE

**Introduction.** Valid formation and distribution of household income have traditionally been the basis for a stable development of any country in the course of mankind evolution. The founders of classical Economics A. Smith, D. Ricardo believed the income distribution to be the basis for theoretical research in political economy and significant disparities to be the main obstacle for the economic development. In the early twentieth century due to the rapid development of the economy this problem needed a theoretical background and relevant practical solutions. Throughout this century western economists H. Dalton (1920) [1], A. Atkinson (1970) [2], A. Dayton (1997) [3] et al suggested substantiated theoretical constructs. Modern scholars, such as E. Libanov, [4], V. Libanova, [4], V. Mandybura [4], V. Semenov [6], N. Kholod [7] also investigated this issue.

Having learnt foreign experience of many countries regarding the dynamics of incomes, we come to the conclusion that a slight disparity contributes to the development by stimulating employees to provide real results for the corresponding wages and vice versa, a significant separation between social groups forms a depressive mood, causes social tension. The latter is a situation occurring in Ukraine.

In Ukraine the European integration vector of development influenced complex transformational changes which significantly affect the income formation and difference to detect the reasons of shadow aspects, the mentality role and are not studied enough, hence they are of great importance.

Currently there is a significant amount of research directions for the differentiation of incomes ranging from small analytical and statistical reviews to the fundamental monographs. A complex research was done by such foreign scholars as E. Tanzi [8], F. Schneider [9.10], and Sh. Chandra, J. Iado [11], G. Bosch, T. Kalina [12.13], Azarenkova [14], Yu. Pasichnyk [15], P. Shubina, O. Miroshnyk [16]. However, the studies of foreign and domestic scientists do not discuss all the existing problems that have arisen in Ukraine in the current circumstances, therefore, there is a need for further scientific substantiation of theoretical and practical bases of household income differences.

## Scientific development and achievements

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