Theory and practice of food combinatorial. Case: food compositions for optimal nutrition

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Abstract. The article describes the principles of the methodology of food combinatorics as a science about methods of combining the component compound of food compositions to achieve specified nutritional parameters corresponding to physiological nutritional standards of the population of different categories of nutrient needs.

We examined the problem of providing the population, as a whole, and individual consumer groups when achieving the parity of needs of multidirectional interests in the previous period, from the point of view of the theory of the possibility of achieving a stable "Nash equilibrium" for the plurality of un-cooperated stakeholders. The essence of this theory is that such an equilibrium point can always be found in the system of multiple coordinate axes in which the interests of multiple stakeholders will be taken into account to the maximum extent possible for the given conditions. In this study, stackers were: consumers and producers of functional foods, employers and government agencies monitoring the health sector, food industry.

The study developed the author's algorithm and software for optimizing the ingredient composition of food products for the functional nutrition of target consumer groups. Mathematical / cybernetic results obtained experiment to optimize versatile criteria for the subsequent modeling / design of functional food products.

1. Introduction

The practice of designing an optimal set of food products is based primarily on achieving economic efficiency. Among these factors, we take into account the reduction in the cost of food raw materials, an increase in the shelf life of ready-to-eat products, an increase in the efficiency of logistics processes, a change in the place of their production for the purpose of import substitution, etc.

These factors to a small extent meet the global challenges of the agro-economic and food industries, as well as the preservation of health and life expectancy of the population. However, the current challenge of food supply for the population requires a new approach to the development of optimal diets. The key point of food innovation is the consideration of factors that ensure the daily harmonious development of the health of the population in accordance with their group and individual needs, protect the health of consumers from harmful environmental conditions (both permanent residence and...
professional activity). Such an approach needs state support, including through the Strategy for Scientific and Technical Development of the Russian Federation until 2020.

2. Methodology

The purpose of this study is to implement this strategy through scientific justification and the development of a methodological apparatus (mathematical model and software) for constructing the food composition of combined food sets with desired functional properties, balanced in nutrient composition in accordance with the needs of certain consumer groups, as well as optimized for criteria for environmental and economic efficiency.

The goal is achieved by theoretical justification and experimental confirmation, followed by practical testing in a production conditions. In addition, such food combinations were tested through consumer tastings in target environment. Such scientifically based food compositions have nutritional balance (including individual) and economic and environmental (at micro and macro levels) efficiency.

The scientific novelty of the research results consists in the development of scientifically based methodological tools for designing innovative food compositions with specified functional properties, environmental and economic parameters.

The research results (software, algorithms, experimental data, etc.) possess patent novelty comply with copyright protection requirements and are transferred to research customers as intangible assets which helps to increase the level of innovative development of the Russian Federation.

The collection of innovative sets of optimal nutrition for various population groups was created as a part of the implementation of scientific and practical results. The main scientific and practical results and recommendations of this study are published in scientific and professional journals indexed by Russian and international scientometric systems, as well as in the format of reports at scientific and professional conferences in Russia and abroad.

The participants in of this project team have worked out in the previous period a new scientific direction "economic commodity research" developed by V.M. Kiselev and members of his scientific school of food combinatorics [1]. The principles and methodology of this new scientific approach are published in a scientific monograph [2]. An algorithm for optimizing the nutrient compound of functional food compositions has been published in scientific articles [3]. A description of the main provisions of food combinatorics as a science based on a parity methodology to meet the needs of participants is realised in scientific papers [4-7].

The possibility and expediency of optimizing the nutrient composition of food combinations with the priority of food scoring according to regulated and normalized physiological values are substantiated as a result of the experimental scientific research. These studies theoretically substantiated and experimentally confirmed the possibility of optimizing the nutrient composition of food combinations in terms of the presence of vital nutrients in food diets and optimizing their balance between themselves and energy value. Optimization is carried out due to using the mathematical equilibrium model developed by J. Nash [8].

In addition to the needs of the target consumer group for various nutrients and in the framework of the experiments to achieve parity of the needs of consumers and producers their economic interests (the price of these food compositions) and social criteria (reduction in the incidence of the target group) were also taken into account.

The last of the criteria is programmatically set as priority. This approach to the formation of the ingredient composition of food products is designated as a life concept. The life concept affirms priority among a number of needs of standardized nutrient indicators, which provide an increase in the body's resistance to the consumption of functional foods and, as a result, a decrease in the incidence of diseases (including professional ones) and an increase in working capacity, duration and quality of life. Created food diets are not only optimal, but also functional, providing consumers with specified nutrient parameters in quantitative terms and a balance in the integrated average daily energy value.
The mathematical modeling of needs parity was carried out by optimizing the total criteria for assessing the needs of the body of the target population in nutrients contained in the daily intake of food raw materials both in absolute and in relative values [9-15].

The food combinatorics methodology includes a multivariate computational experiment to create innovative food combinations with desired properties. Such properties consist of both nutritional dietary organoleptic and economic as well as environmental parameters or other socially significant characteristics of food compositions as well as the loss of labile nutrients during the processing of food raw materials into finished food products [2].

The rational combination of types of food raw materials and technological materials is a special parameter of food combinatorics. Thanks to the combination of their natural nutritional properties this allows to achieve when combined such an effect that would economically combine the deficient types of food raw materials whose resources are limited by various factors with other scarce raw materials. This ensures the parity of needs of participants in the chain of integrated relations as the business owners and workers, manufacturers and consumers, sellers and buyers.

The optimal food compositions obtained by combinatorics are functional in nature and their sensory characteristics (shape, color, taste, smell, texture) can be both traditional and compare favorably with them for example exceed expectations of consumption. The functionality of innovative sets of food products will allow their consumers to lead a healthy lifestyle and protect their body from the adverse effects of the external environment, including environmental and professional factors.

The general methodology of food combinatorics involves the identification and analysis of data demonstrating the advantages and disadvantages of the formation transmission and perception of marketing messages through multi-sensory channels in which it is supposed to use all the human senses. Theoretical studies are carried out in related scientific fields such as physiology and human psychology as well as economics and communicative science. Experimental studies involve both sociological surveys and observations individual and group interviews (in-depth interviews, focus groups).

3. Main part
An in-depth study of the possibilities of correcting the diets of differentiated contingents in practice was carried out in order to implement the presented scientific hypothesis. One of the most optimistic scenarios of practical nutritional correction differentiated by categories is the scientific direction of introducing foods with specified physiological properties into the diet which ensures the maintenance of the consumption of such products by the consumer’s body and the maintenance of their health level at the optimal level.

Food combinations are a new category of food sets that is at the highest evolutionary level among traditional approaches to optimal nutrition. They help to maintain the health of those consumers who need a correction in nutrition, providing the body with the intake of the most important nutrients for them in the optimal amount and balance between them. Thus food compositions with desired nutritional properties are first of all the prophylactic importance for the population and they form the basis for the healthy development of the human body.

This new scientific direction in the formation of food compositions allows individual consumer groups to create individual protection against diseases that most often occur when exposed to the external environment. At the same time the target consumer audiences besides the population of various regions can undoubtedly be other consumer groups who need food diets with the optimal combination of nutrients for example for older people who need to provide a balanced diet.

Optimal diets include compositions that contain foods for the contribution to a more complete assimilation of nutrients by the body which contributes to a more comfortable state of the population and strengthens the weakened immune system of the body. Optimum food packages can be obtained by optimizing the assortment list of food products which consists of the following ways:

- natural products that naturally contain the required amount of functional ingredients;
- natural products, additionally enriched with any functional ingredient or group of ingredients;
• natural products from which the component has been removed, which interferes with the manifestation of the physiological activity of the functional ingredients present in them; natural products in which the original potential functional ingredients are modified so that they begin to show their biological or physiological activity or this activity is enhanced;
• natural foods in which, as a result of certain changes in the bioavailability of the functional ingredients included in them;
• natural or artificial products, which, as a result of a combination of the above technological methods, acquire the ability to maintain and improve human health and / or reduce the risk of disease.

Optimal food combinations should ensure the ability of the consumer’s body to maintain its health in case of urban or occupational air pollution other factors of aggressiveness of the environment to increase the tone of the body and reduce its susceptibility to inflammatory diseases.

Optimized food compositions possess among many others such properties as the optimal calcium content and its ratio with other mineral elements which against the background of the optimal formula of other nutrients ensure its high digestibility. This can significantly reduce injuries associated with bone fractures.

Another distinctive feature of optimal diets with desired nutrient properties is the presence of the required amount of vitamins and other biologically active components which provide high efficiency and have a preventive effect in rheumatic diseases. The regular use of such food compositions will significantly reduce the possibility of disease in the population.

The development of this scientific hypothesis gives hygienists the opportunity to use optimal food compositions with desired properties for the prophylactic effect on the whole spectrum of blood diseases by introducing into a multicomponent mixture ingredients that enrich the products with an iron source, which leads to an increase in the blood content of red blood cells - hemoglobin.

The other side of the application of optimal nutritional compositions of a new evolutionary generation is the prevention of a disease such as glycemia, which reduces the likelihood of developing diabetes.

We consider as the success of science the development by the method of food combinatorics of such foods to adapt consumers to stressful situations that arise during their work, which will significantly reduce the incidence of cardiovascular diseases in the population.

Finally the consumption of optimal food compositions will allow for the preventive cleaning of your body from intoxications resulting due to exposure to harmful environmental factors and production activities timely and comfortable removal of heavy metal salts from consumers' bodies that accumulate in it during their production activities. The formation of the optimal nutrient composition of the diet for the population creates the best possible vitality of the body providing resistance to aggressive environmental conditions including adverse environmental conditions and industrial environment.

This ultimately leads to the preservation of the health and health of consumers. The optimal food product sets developed by the food combinatorics method for a specific contingent of consumers are intended for the prevention of nutritional-dependent diseases.

The principles of optimal nutrition formulated by academician A. A. Pokrovsky [8] are reduced to the following provisions:
• slowing down the absorption of harmful substances in the digestive system using nutrients. The absorption of toxic substances entering the stomach and intestines with a sufficient amount of food is mechanically difficult, the access of poisons to the mucous membrane is slowed down. Therefore, it is important that those who live or work in harmful environmental conditions have complete diets;
• the use of antidote properties of individual food components in order to neutralize certain toxic substances; for example, pectin substances: contained in food products: able to bind salts of heavy metals and their compounds in the digestive system;
• acceleration or deceleration with the help of food products of the neutralization of harmful substances, depending on the nutrient composition;
• the effect of the nutrient factor on accelerating the elimination of harmful substances from the body (for example, a protein with sulfur-containing amino acids);
compensation by nutrient foods for the increased costs of certain nutrients by the body (amino acids, vitamins, macro-and micronutrients, etc.);

- the effect of nutrients on the condition of the most affected organs and systems (liver, kidneys), for example, food products that are a source of animal protein, vitamins, etc.;

- increasing the body's overall resistance to occupational hazards through nutritional factors (unbalanced nutrition, especially in terms of protein and water-soluble vitamins, exacerbates the effects of toxic substances on the body).

- thus, the optimal nutrition from the point of view discussed contributes to an increase in the general resistance of the organism, improvement of well-being, working capacity, and also reduces the general and professional morbidity of consumers.

From their point of view, optimal nutrition is intended for:

- increase the protective functions of the physiological barriers of the body (skin, mucous membranes of the gastrointestinal tract, upper respiratory tract, etc.);

- regulation of biotransformation processes of various xenobiotics, including endotoxins, by oxidation, methylation, deamination and other biochemical reactions aimed at neutralizing them;

- activation of the processes of binding and elimination of poisons or their adverse metabolic products;

- improving the functional state of the affected organs and systems of the body, which are primarily affected by harmful environmental or production factors;

- increase the antitoxic function of individual organs and systems of the body;

- compensation for the arising deficiency of essential nutrients, both under the influence of adverse environmental or occupational factors, and as a result of pathological processes of the development of chronic diseases;

- a beneficial effect on the autoregulatory reactions of the body, especially the nervous and endocrine regulation of the immune system, metabolism, etc.;

- increase the overall resistance of the body and its adaptive reserves.

From the point of view of the previously considered scientific approach to the formation of an optimal set of food products from the nutritional point of view, it is advisable to take into account the empirical properties of each food product included in these optimal combinations when developing the regulation of the criteria for nutrient parameters of the developed food compositions. We believe that food should become a carrier of not only nutrient but also sensory informational and semantic properties. From this point of view in our food compositions - optimal diets not only biological but also social and spiritual needs of consumers are satisfied.

The developed food compositions take into account the levels of development of consumers, their family, national traditions, lifestyle and health status. Thus, the consumption by certain contingents of the population of optimal diets should be an integral part of their sociocultural environment, a set of social, biological, physiological ethical principles that determine human behavior in the biosphere. The justification for the formation of criteria for optimizing the composition of nutrients, as well as energy value and their ranking, was served in addition to the scientific developments of hygienists. These scientists reasonably determine the degree of significance of various nutrient factors for the body in their theories.

These scientists consider the main nutrients and energy value a universally recognized priority in the prevention of diseases. To these factors in the parity of needs, we establish the highest ranks. The second most important group of factors for the prevention of diseases of the body is polyunsaturated fatty acids and fat-soluble vitamins that are part of vegetable fats. For this group of nutrients, the rank of the second level is established. The third level of importance for the human body is a set of minerals and water-soluble vitamins. We establish the ranks of the third level for this group of factors. In addition to the nutritional factors in the formation of the parity of needs in the development of food nutritional compositions we also took into account the economic feasibility factor for which according to the previously mentioned life concept we establish the fourth-level rank.
A feature of the used method of food combinatorics is the combination of natural food products through which the maximum possible satisfaction of the “ideal” needs of the body is ensured with the greatest possible variety of taste and technological properties of ready-made food sets. When choosing the type and variety of foods included in the optimal diet both the chemical composition of the starting products and their other properties were taken into account in accordance with the principle of complexity considered earlier in the framework of the methodology for forming the parity of needs such as aesthetic, social purpose, reliability and safety of the products being developed functional products. In addition to these parameters, the need to achieve the recommended frequency of consumption, set as the consumption of a particular product no more than once every two months, is taken into account, that is, the range of optimal food sets developed should be at least 45 items for each food group.

From a hygienic point of view, it is important to identify those types of food that are significant sources of essential nutrients, such as proteins, fats, carbohydrates. When choosing ingredients, their chemical composition is taken into account based on reference books. These data are recommended by official medical authorities to calculate the chemical composition of food rations.

The most important process of food combinatorics is the formation of the boundaries of the intervals of the specific gravity of individual food products. The size of the interval is justified by the influence of these food products on the perception of taste and other parameters of consumer properties of optimal diets. If an increase in the proportion of a food product is advisable from the point of view of achieving an optimal balance of nutrients, then there is a need to use the technological methods of its preparation to balance organoleptic properties. As you know, the historical practice of food consumption is more conservative in comparison with the variety of types and varieties of food products.

Taking into account the food habits of the target group of consumers takes into account the presence of a certain conservatism in the combination of food products, appearance, taste, aroma of food to the detriment of the balance of their nutritional composition. To some extent, these restrictions concern economic indicators, for example, the cost of an optimal set of food products. As you know, consumers tend to correlate the high price of food with their high quality and, conversely, tend to perceive the low price of food as a symbol of their low quality. In those cases when economic indicators are priority over hygienic, it is impossible to achieve parity of needs based on a life concept.

4. Conclusions
Based on the above theory of food combinatorics, we can conclude that this science shapes the future, and the practice of applying this science determines a healthy lifestyle for citizens of Russian regions.

References
[1] Kiselev V M 2008 Combinatorial Calculus of Ingredients Achieving Commodity & Service Excellence. IGWT (Korea: Suwon) 392-396
[2] Kiselev V M, Astrakov S N 2005 Methodology of the formation of functional foods Storage and processing of agricultural raw materials 2: 43-46 (In Russ.)
[3] Kiselev V M, Poznyakovsky V M 2004 Power miners. Scientific basis and practical recommendations (monograph) (Novosibirsk: Siberian University Press) (In Russ.)
[4] Alekseev G V, Aksenova O I, Derkanosova A A 2015 Optimization of feed for unproductive animals with the help of mathematical modeling. Proceedings of the Voronezh State University of Engineering Technologies (Voronezh) 1:28-35 (In Russ.) https://doi.org/10.20914/2310-1202-2015-1-28-35
[5] Sergazieva O D, Pershina E V, Krivonos O N 2019 Application of the principles of healthy nutrition in the network of fast food service enterprises of Astrakhan. Proceedings of the Voronezh State University of Engineering Technologies (Voronezh) 81(1):247-251. (In Russ.) https://doi.org/10.20914/2310-1202-2019-1-247-251
[6] Ren H, Zentek J, Vahjen W 2019 Optimization of production parameters for probiotic Lactobacillus strains as feed additive Molecules 24 (18) 3286 DOI: 10.3390/molecules24183286
[7] Gaal S, Kerr MA, Ward M, McNulty H, Livingstone M B E. 2018 Breakfast consumption in the UK: Patterns, nutrient intake and diet quality. a study from the international breakfast research initiative group Nutrients 10 (8) 999 DOI: 10.3390/nu10080999

[8] Nash J F 1951 Non-cooperative games Annals of Mathematics 54 (2) 286–295. doi: 10.2307/1969529.

[9] Skurikhin I M (Ed), Volgarev M N (Ed) 1994 The chemical composition of dishes and culinary products. Reference tables of the content of basic nutrients and energy value of dishes and culinary products: in 2 volumes 1 (Moscow: VINITI) (In Russ.)

[10] Skurikhin I M (Ed), Volgarev M N (Ed) 1994 The Chemical composition, food and culinary products. Reference tables of the content of basic nutrients and energy value of dishes and culinary products: in 2 volumes 2 (Moscow: VINITI) (In Russ.)

[11] Pokrovsky A A (Ed) 1976 The chemical composition of food: in 3 volumes 1 (Moscow: Food industry) (In Russ.)

[12] Nesterin M F (Ed), Skurikhin I M (Ed) 1979 The chemical composition of food: in 3 volumes 2 (Moscow: Food industry) (In Russ.)

[13] Skurikhin I M (Ed), Shaternikov V A (Ed) 1984 The chemical composition of food: in 3 volumes 3 (Moscow: Food industry) (In Russ.)

[14] Skurikhin I M (Ed), Tuteljan V A (Ed) 2002 The chemical composition of Russian food products: Handbook (Moscow: DeLi) (In Russ.)

[15] Hulshof P, Doets E, Seyha S and others 2019 Food Composition Tables in Southeast Asia: The Contribution of the SMILING Project Maternal and Child Health Journal 23:46-54 DOI: 10.1007/s10995-018-2528-8