

Informational technologies and the prospects of personalization of food rations

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Abstract: Among the main markets of the national technological initiative there is the platform of developing competitive projects of the food industry – FoodNet. The promising line of the market development is transition to personalized nutrition which takes into account a person's genetic traits, his or her physiological and biomedical needs and creation of digital platforms for its implementation. In the context of constant growth of the number of diagnosable genetic diseases, including alimentary-dependent ones, such an approach is very modern. Medical technological scheme of constructing personalized products is presented in the article and also its implementation as exemplified by gluten-free flour confectionery articles is considered. A program module for automatic calculation of the characteristics of developed products was realized on the basis of the suggested scheme and it represents a client-server application. The optimal parameters for the biscuit manufacturing technology were set on the basis of the program module operation which allows obtaining products for special use and enriched with mineral substances.

One of the key tasks of the Russian economy is implementation of the National Technological Initiative (NTI) – a complex of measures on forming principally new markets and creating conditions for global technological leadership of Russia by 2035. NTI will include system solutions on defining key technologies necessary for making changes in the sphere of norms and regulations, the working measures of financial and professional development, mechanisms of involvement and rewarding competency bearers. The choice will be made with due consideration of the main trends of global development based on the priority of network technologies focused on the human being as the end-consumer.

9 key directions for development within the framework of NTI were chosen: one of them is developing competitive projects of food industry – FoodNet – it embraces the market of manufacturing and realization of nutritive substances and food products of final types (personalized and general, on the basis of traditional primary products and their substitutes). The document also provides for development of auxiliary IT-decisions (e. g. those which provide for services on logistics and selecting individual nutrition). FoodNet is one of three markets aimed at security of the country and its system support with resources [1].

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The strategic importance of the FoodNet market is confirmed by the provisions of

- The Food Security Doctrine of the Russian Federation approved by the Decree of the President of Russia No. 120 on January 30, 2010,
- The fundamentals of the national policy in the field of healthy nutrition for the population of the Russian Federation for the period to 2020 approved by the Russian Federation Government Executive Order No. 1873-p on October 25, 2010,
- The Concept on the Demographic Policy of the Russian Federation for the period to 2025 approved by the Decree of the President of the Russian Federation No. 1351 on October 9, 2007,
- The strategy of development of food and pharmaceutical processing industry of the Russian Federation for the period to 2020 approved by the Russian Federation Government Executive Order No. 559-p on April 17, 2012.

According to the United Nations estimates, the population of the Earth will increase up to 9-10 billion people by 2050. However, according to Yuan Tseh Lee, the President of the International Council for Science (ICSU), the Nobel prizewinner for Chemistry in 1986, food consumption will increase exceeding people's basic demands and not proportional to them; this will happen as a result of evolution of the consumption structure in the developing countries.

For example, animal protein consumption and also consumption of products with personalized properties will increase in the developed countries but consumption of the main food products will remain at a high level owing to the demand of under-privileged people. In the developing countries, the growth of income of the general public, population increase and outflow of working people into cities is expected. In those countries demand for products which have passed processing treatment and which possess healthy properties will increase [2]. Besides, individual rations which take into account physiological and biomedical needs of population will become more and more popular.

Today, in the integrated digital map of "The Common Image of Saint Petersburg in Future – 2035" we can see the prospects of developing food markets presented as "Future Nutrition: Personalization for Everyone" as one of strategic priorities. So, for example, there are services which offer preparing personal menu. For instance, services *ELEMENTAREE* and *REALFOOD* enable choosing one of the menu variants suggested on the sites according to one's goals and get a ready-made "constructor" for healthy and varied food: the menu is developed by a nutrition expert, high-quality products are thoroughly measured, the recipe is described in the manual in detail, and one has to spend some time in order to "gather" the obtained dishes. This service combines the two conceptions popular on the market: food delivery and individual selection of products [3, 4]. The idea is promising for future development in the field of creating individual menus on the basis of genetic analysis. Such an approach is based on the existing achievements in the sphere of nutrigenetics – the branch of science which task is to determine optimal variants of nutrition depending on genetic peculiarities of a person.

It is expected that in the nearest future, when forming rations and diets, the interconnection between the chemical food composition and the genetic profile of a person will be taken into account. This tendency in the nutrition science defines new approaches to creating specialized food products.

Currently, the growth of genetic diseases is observed, including alimentary-dependent ones, that is diseases which are precipitated by nutrition. Among these are: the entire group of cardiovascular diseases, osteoporosis, diabetes mellitus type 2, gluten enteropathy (celiac disease), obesity, some oncology diseases. A very important role for prophylaxis and treatment of such diseases is played by specialized diets which are meant for excluding precipitating factors from nutrition.

For instance, gluten enteropathy is precipitated by gluten – protein of grain varieties: wheat, rye, barley and oats. Celiac disease can be called "the disease of today". 150-200 years ago people didn't know about this disease. With regard to the human evolution, graminaceous plants have become the main part of the nutrition diet not long ago and in the course of several thousands years they contained almost no gluten. The majority of nations cultivated "gluten-free" plants such as rice, maize and panic. People began growing barley and wheat about 9000 years ago in Mesopotamia and in more than 5000 years cultivating these graminaceous plants expanded outside of the Mediterranean region and the Danube boundaries. In the course of time wheat became the most cultivated grain used for cooking dough and that significantly increased gluten "load" and the humanity didn't have enough time for adjusting to the new food and developing immune tolerance. That is why a number of people have the genetic disease – celiacia. Today approximately 1% of the Earth population suffers from this disease [5]. It is quite difficult to diagnose gluten enteropathy because there are almost no symptoms which 100% of people suffering from gluten intolerance have, and these symptoms can be expressed to different extents. Gluten-free diet for people suffering from celiacia which excludes products containing gluten from the nutrition ration is the only way to normalize the work of the digestive system without increasing the risk of oncology diseases. Gluten can be represented in two forms: distinct and hidden. Distinct gluten is contained in the products after processing wheat, rye, oats, barley, and hidden gluten can be found in sausage products, meat, fish and vegetable preserves, ice-cream, yogurts, cheese, oriental sweets, etc. [6].

The food market should take into account the demands of such a patient and provide him with the opportunity to obtain alternative food products with a modified chemical composition and given properties for forming an individual diet adjusted to the level and kind of metabolic disorders [7].

The strategy of developing such products is based on a medical technological algorithm which provides a cumulative result of monitoring nutritional status disorders and designing products with the address designation; their distinctive feature is scientifically based and proven effect aimed at complex correction of specific nutritional status disorders [8].

Successful solution of this problem is connected with two scientific approaches – digital modeling and constructing nutritional systems with the given chemical composition and properties which enables developing multicomponent products with the clearly defined complex of quality indicators.

Such methodology enables creating products with the determined (given) composition of necessary proteins, fats, carbohydrates, vitamins and dietary fibers, mineral and other substances. The selection of qualitative and quantitative composition of a product is done in three directions:

1. according to chemical composition and biological effectiveness,
2. according to stability of properties,
3. according to organoleptic indicators.

The determining step in such constructing is the selection of a product-prototype which is planned to be fully or partially modified. At this stage, the preliminary analysis of all positive and negative peculiarities of the primary product and also presupposed ways of its modification is made, main ingredients are chosen which will be probably included into the end-product, and also a system model is developed.

Then critical parameters are set for the end-product: the quantity and correlation of the key nutrients, organoleptic characteristics, ability to keep the qualitative and security factors, including biological effectiveness, throughout the entire period of consumption.

Technological compatibility of raw materials and ingredients which are planned to be used for constructing is estimated at the final stage of forming requirements to the product. As a result of the given estimation a conclusion is made about the possibility of using all the

key nutrients in one product or about the necessity for creating a group of products for forming a complete and effective ration regarding alimentary therapy.

Calculation of composition of the personalized product is made on the basis of comparing its chemical composition with the correlation of separate nutrients with the values of the daily demand for nutrient materials and energy.

Then, using standard approaches, compliance of the product consumer properties with the primary prototype is estimated. In case it is necessary, the recipe is corrected for achieving the most acceptable consumer characteristics.

The task-oriented personalized approach to the development of new alternative products is universal, it doesn't depend on the nature of nutritional status disorders being corrected and the type of designed products, and it can be used for alimentary therapy of various alimentary-dependent diseases.

A program module was implemented on the basis of the suggested algorithm; this module automatizes calculation of characteristics of designed products. The program module is represented by a client-server application. The architecture of the developed program module is in Fig. 1:

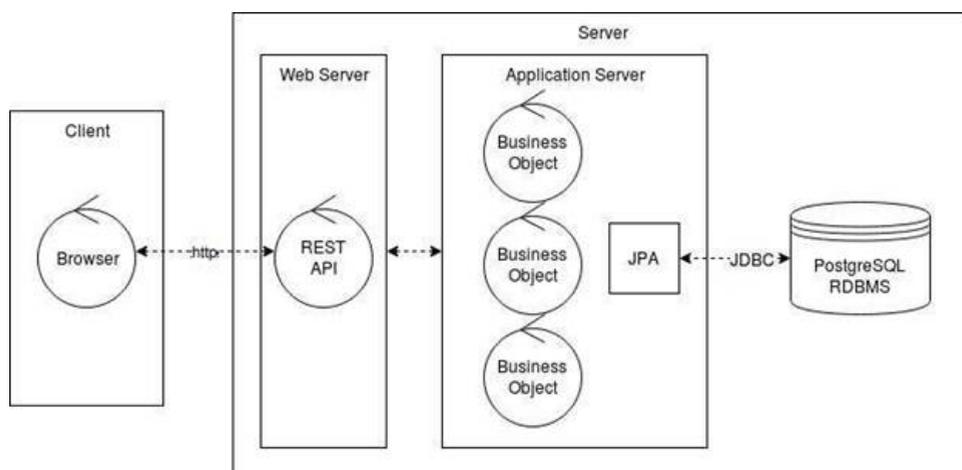


Fig. 2. The architecture of the developed program module.

As a repository for storing information on products, their characteristics, components and production technologies a relational database is used under the control of DBMS PostgreSQL 9.4. The server part of the module is a set of business-components EJB for Java EE platform operating under the control of the application server WildFly 11. Cooperation of the system with the database is carried out via JDBC with the use of Java Persistence API (JPA) 2.0 technology.

The user can cooperate with the developed module with the help of the web-interface built on the React+Redux platform. Cooperation with the server part of the system is carried out via REST API.

The suggested architecture of the program module has the following advantages:

1. All the applied program products and libraries are distributed under a license with the open source code which excludes any license restrictions including those for commercial use of the product.
2. The client part imposes minimum requirements on the client device (it can be, for example, a personal computer, a pad or a smart phone) and it doesn't require installing any additional program software: any modern web-browser is quite sufficient.
3. The server part is cross-platform and can be started in the infrastructure on the basis

of virtually any modern environment, for example, under the control of the Windows Server, Linux or FreeBSD.

4. If necessary, any modern relational DBMS of the enterprise level (for example, Oracle) can be used as a repository for storing information instead of PostgreSQL. At that, no changes in the architecture of application will be necessary.

The evaluation of the suggested approach and the developed module was carried out in the process of developing the assortment of new food products for alimentary therapy of gluten enteropathy patients [9-11]. As an example, the use of the program module in the process of constructing gluten-free biscuit on the basis of secondary products of processing pumpkin – pumpkin flour – will be considered.

As a prototype, general biscuit (recipe No. 1) [12] was chosen in the database; the biscuit is cooked according to the main method without heating. The given product can't be consumed by celiacia patients because it contains wheat flour rich in gluten. As modifying the given product, it is suggested to completely replace wheat flour with pumpkin seeds flour. Organoleptic indicators of the examined samples are the key characteristics according to which the product is chosen by the consumer. The combination of these indicators was determined according to GOST 50763 taking into account the weight coefficient [13]. All the characteristics of the examined samples are also stored in the common database; this enables making recalculation of the characteristics of the developed product in real-time mode.

As critical parameters of the end-product several organoleptic indicators were chosen in the database; they are represented in Table 1.

Table 1. Critical parameters for the end-product.

Indicator name	Characteristics
Surface appearance:	
form	Corresponding to the form in which bakery food is made, with a slightly raised up upper crust
surface	smooth, without large cracks and ripping
Crumb condition:	
baking thoroughly	well-baked, not wet by touch, elastic. After slight pressing the crumb must take the primary form
kneading	free of lumps and traces of improper kneading
crumb grain	developed, without cavities and firming

A prototype was created on the basis of the data from the base, and organoleptic analysis was carried out. As it follows from the analysis of the prototype and the biscuit based on pumpkin flour the examined sample was unsatisfying according to such indicators as texture, taste, shape and appearance at the cutting place. Consequently, the technology and recipe of biscuit production was changed on the basis of calculations made in the developed module:

- 1 Pumpkin seed flour was partially replaced by rice flour;
- 2 When whipping eggs sugar was added in the form of a syrup at a temperature of 114 °C thus providing a more stable and fine-pored foam.

For validating the parameters of biscuit technology with the use of pumpkin seeds flour and rice flour a central compositional plan of a complete factorial experiment with the use of additional points in the form of a "star" was realized. As particular factors of optimization, the correlation of pumpkin seeds flour and rice flour varying them from 0 to 100 % as output parameters – organoleptic qualitative indicators – were chosen. All the results of the experiments were introduced into the database of the developed module and that allowed to significantly reducing the cost of constructing regression plots and it also will enable reusing the obtained data in future.

Regression equations are received on the basis of experimental data, they characterize the dependence of the total organoleptic indicator (Y_1) of biscuit on the content of flour made from pumpkin seeds (x_1 , %) and rice flour (x_2 , %). The regression equation is represented as follows:

$$Y_1 = -284 + 9.81x_1 - 0.97x_2 - 0.06x_1^2 - 0.03x_1x_2 + 0.11x_2^2, \tag{1}$$

The coefficient of determination of the obtained regression equation R^2 is 0.96 which allows considering functional dependence of the total organoleptic indicator of biscuit on the content of flour made from pumpkin seeds and rice flour. The adjusted coefficient of determination R^2_{adj} is 0.91 which confirms the importance of the chosen factors.

The graphical interpretations of the equation (1) formed in the developed program module as represented by the value curves and response surface are shown in Fig. 2 and 3.

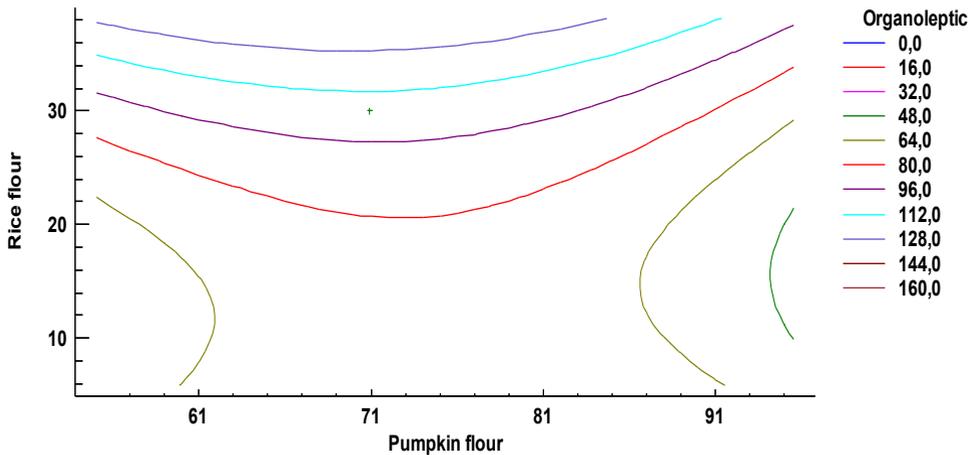


Fig. 2. The diagram of value curves of the total organoleptic indicator of biscuit semi finished product on the content of flour made from pumpkin seeds and rice flour.

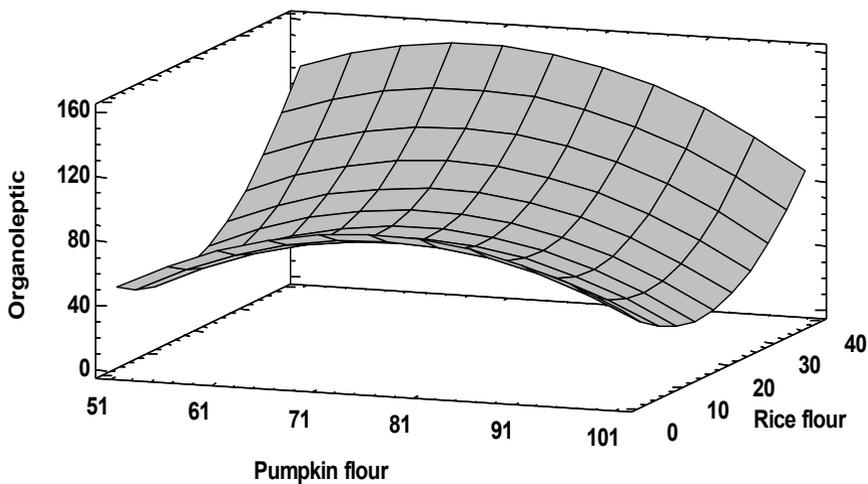


Fig. 3. The diagram of response surface of the total organoleptic indicator of biscuit semi finished product on the content of flour made from pumpkin seeds and rice flour.

The optimal content of flour made from pumpkin seeds and rice flour for producing biscuit with the best organoleptic indicators is 70±1% and 30±1% respectively of the mass of flour mixture.

The chemical composition of the worked out biscuit has been compared with the values of the daily demand of a person for food substances and energy (Table 3).

Table 3. Chemical composition of the worked out biscuit

Indicators	Indicator values in 100 g of the semi finished product in % of the daily intake		
	made of wheat flour	made of pumpkin flour	deviation
Carbohydrates	36.96	31.69	-5.28
Proteins	9.54	12.80	3.26
Fats	8.76	10.16	1.40
Dietary fibers	8.84	1.35	-7.49
Mineral substances, mg%			
Magnesium	6.86	20.79	13.93
Ferrum	9.73	6.93	-0.23
Zinc	3.57	9.24	8.98
Selenium	17.45	2.18	-15.27
Cuprum	0.68	1.92	1.25
Phosphorus	18.68	33.43	14.75
Manganese	32.80	36.30	3.50
Calcium	3.36	2.88	0.29
Potassium	4.62	2.59	3.11
Sodium	4.76	4.74	0.17

Conclusions

Modern conditions necessitate transition to personalization of nutrition which is based on medical technological scheme. The algorithm and the program module – which form the basis for the digital platform for optimizing the process of working out "clever" food rations – were developed by the authors within the framework of the given investigation. The considered principle of constructing food systems is successfully implemented for working out gluten-free flour confectionery. The obtained product made of pumpkin flour differs from its prototype product made of wheat flour in that it has higher concentration of protein and fat and besides it is enriched with such mineral substances as magnesium, phosphorus and manganese. Thus, we can speak of creating a "clever" product which provides up to 30% of the daily intake of important microelements and forms the basis of the balanced ration.

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