Секція 4. **ХІМІЧНІ, ФІЗИЧНІ, МАТЕМАТИЧНІ МЕТОДИ ДОСЛІДЖЕНЬ ЯКОСТІ ПРОДУКТІВ ХАРЧУВАННЯ**

УДК 519.8:637.521.473(083.12)

КІЛЬКІСНИЙ АНАЛІЗ ЗБАЛАНСОВАНОСТІ НУТРІЄНТІВ У РАЦІОНАХ ОДНОРАЗОВОГО СПОЖИВАННЯ ДРУГОГО ПОКОЛІННЯ

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Здійснено кількісний аналіз збалансованості трьох груп зв'язаних між собою нутрієнтів у 28 раціонах одноразового споживання другого покоління, призначених для довготривалих систем харчування лікувально-профілактичної дії.

Ключові слова: *кількісний аналіз, збалансованість, нутрієнти, раціони одноразового споживання, системи харчування.*

КОЛИЧЕСТВЕННЫЙ АНАЛИЗ СБАЛАНСИРОВАННОСТИ НУТРИЕНТОВ В РАЦИОНАХ РАЗОВОГО ПОТРЕБЛЕНИЯ ВТОРОГО ПОКОЛЕНИЯ

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Осуществлён количественный анализ сбалансированности трёх групп связанных между собой нутриентов в 28 рационах одноразового потребления второго поколения, предназначенных для долговременных систем питания лечебно-профилактического действия.

Ключевые слова: *количественный анализ, сбалансированность, нутриенты, рационы разового потребления, системы питания.*

QUANTITATIVE ANALYSIS OF NUTRIENTS BALANCE IN DAILY DIETS OF THE SECOND GENERATION

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In the article, the balance of the bond groups of nutrients for twenty-eight daily diets of the second generation is quantitatively analyzed with the use of the authors' technique. The specified diets differ from the similar rations of the first generation by the inclusion of purposefully designed unconventional flour products enriched in such deficient nutrients as boron, selenium, fluorine, etc.

The highest level of the nutrients balance in the created daily diets of the second generation belongs to Ca group (calcium, fat, phosphorus, magnesium). Average daily and weekly balance parameters for the specified nutrients are within the interval 78...88% that is explained by the restrictions on minimal and maximal amount of calcium, fat, phosphorus and magnesium in mathematical models of the optimization of the ingredients content in rations.

The nutrients of ten essential amino acids have mainly an average and above average balance level that is primarily explained by the presence of the second generation of unconventional floury products with high content of balanced amino acids in daily diets. Only about 10% of diets under investigation possess low indicators of the balance of this group of nutrients.

The nutrients of proteins, fats and carbohydrates group have the balance level close to the average and only about 15% have low level.

The performed investigations resulted in the concept of creating a set of daily diets as elements of the diets for durable and effective therapeutic nutrition systems. The proposed concept presupposes the enrichment of daily diets with the deficient nutrients, increase of the parameters of their balance, and biological value of proteins through the application of purposefully designed dishes and products; the increase of a number of diets of the second generation with high balance indicators of nutrients; establishment of rigid criteria for the choice of daily diets for their optimization; choice of effective optimization algorithm of daily diets within the nutrition therapeutic systems.

Keywords: *quantitative analysis, balance, nutrients, daily diets, nutritional systems.*

General formulation of the problem. Everybody knowns that a large number of human diseases are connected with their unbalanced or poorly balanced nutrition. This fact stipulates the urgency of creating both products' receipts, dishes with the predetermined properties, and diets of separate meals as basic elements of multi-day nutrition systems (NS). The nutrition system should be enriched in a large number of nutrients balanced on the level of a certain dish, expendable diets (ED) of various purposes (breakfasts, dinners, suppers, etc.) – namely daily diets – for effective influence on the disease prevention and treatment. First, it is necessary to balance the groups of nutrients connected by scientifically substantiated relations.

It is evident that the amount of nutrients can be balanced only through the optimization of the ingredients content. While designing the dishes' receipts, the number of ingredients as means of providing the necessary correlations between nutrients is rather small. At the same time, the number of correlations we have to take into account is quite large. Therefore, we have very few weigh-scales for balancing, and it is practically impossible to do it at the level of a dish receipt. There are much more ways for balancing nutrients while designing expendable diets, and even more – during the creation of daily diets (DD) because they are composed of a large number of the ingredients. Each is the method for balancing.

From what has been said it follows that the problem of integrally balanced nutrition of the consumers, balanced during each meal every day for a long time covering days, weeks, and months remains actual. A perspective way for the provision of people with a balanced nutrition is the design of nutrition systems (NS) for preventive medicine for various diseases. NS design is connected with the necessity to create the mechanism of enriching the systems in a great number of essential nutrients and the mechanism for balancing them, in particular, the development of quantitative indicators of nutrients balance at various stages.

Analysis of the recent research and publications. For many years under the guidance of the Honored worker of science and technology of Ukraine, Ukraine State Prize winner in the field of science and technology Professor Cherevko O.I. Kharkiv State University of Food Technology and Trade carry out research activities concerning the creation nutrition systems for preventive medicine various diseases caused by calcium deficiency [1–2].

In a consistent manner, we realize mathematical and computerized approach to the formulation and solution of a number of interrelated actual problems.

In the work [1], the principles of designing medical and preventive nutrition systems are formulated, and they are structured. A number of mathematical models for multi-purpose expendable diets are elaborated and the included ingredients are optimized. A mathematical model for daily diets optimization is developed, the projects of three types of standard nutrition systems are proposed.

In works [3–9], results of the research activities in the field of standard nutrition systems improvement, namely the application of unconventional floury products enriched in deficient nutrients, are presented.

The work [8] formulates the totality of problems related to the creation and study of medicinal nutrition systems of the second generation at various stages.

The work [9] suggests quantitative indicators of nutrients balance at different stages of nutrition systems creation.

At the same time, the problems of quantitative analysis of nutrients balance both in EDs of the second generation designed with the use of floury products enriched in deficient nutrients and in daily diets.

The purpose of the article is to specify the totality of indicators, which would be capable to feature the balance level in certain groups of nutrients. It is necessary to perform quantitative analysis of the balance in the following groups of the related nutrients:

a) calcium, fat, phosphorus and magnesium;
b) proteins, fats and carbohydrates;
c) essential amino acids.

The main material of the research. Expendable diets of the second generation created at the current stage of the research, and the ones, which will be created in the future, differ from similar diets of the first generation by the application of unconventional floury products enriched in such deficient nutrients as selenium, fluorine, boron, etc. In perspective, it is possible to use purposely designed first or other dishes to enrich daily diets in the essential groups of nutrients, to improve their balance indices, to raise biological value of proteins and general functional efficiency of durable medical-preventive nutrition systems. At this, overwhelmingly important is the problem of quantitative analysis of the balance level of the related nutrients.

In the work [9] the authors substantiated and proposed the totality of quantitative balance indicators for the related groups of nutrients.

We designed a number of EDs of the second generation. Let's use the earlier developed balance indices [9] in three groups of nutrients in the created expedient diets.

$$K = 100 - 3\sqrt{\frac{1}{l-1}\sum_{i=1}^{l}(Z_i - \overline{Z})^2}, \quad (1)$$

where

$$Z_i = \frac{Y_i}{Y_i^{\partial.n.}} \cdot 10^2, \quad i = \overline{1,l} \quad (2)$$

$$\overline{Z} = \frac{1}{l}\sum_{i=1}^{l} Z_i. \quad (3)$$

Here Y_1, Y_2, … Y_l mark the values of the related l nutrients (g) at a certain stage of creating NS, namely designing ED;

$Y_1^{\partial.n.}, Y_2^{\partial.n.} \ldots Y_l^{\partial.n.}$ mark the values of scientifically substantiated daily needs in nutrients of a group for a certain group of consumers;

Z_i is the value of relative enrichment if i nutrient (% per daily need) at the stage of designing ED;

$\overline{Z}$ is an average value of relative enrichment of l nutrients.

Let us notice that at a large dissipation of Z_j, and as a conclusion, – very low balance level, the value of K, calculated by the formula (1), can theoretically be more than 100%. In this case, the balance index of a group of nutrients is to become zero. With the account of the above mentioned, let us write down

$$K \approx \begin{cases} 100 - R & \text{при} \quad 0 \le R \le 100 \\ 0 & \text{при} \quad R > 100. \end{cases} \quad (4)$$

K index may be used for quantitative evaluation of balance quality of the following groups in EDs of the second generation:

a) calcium, fat, phosphorus and magnesium;
b) proteins, fats and carbohydrates;
c) ten essential amino acids.

At the previous stage of the research, we designed 28 multi-purpose EDs (per seven breakfasts and lunches, dinners and suppers) with the use of unconventional floury products enriched in deficient nutrients.

Table 1

Quantitative indices (%) of nutrients balance for the group of calcium (fat, calcium, phosphorus, magnesium)

№ of the day	Type of ED				Average index for a day
	breakfasts	lunches	dinners	suppers	
1	76,6	86,5	88,8	77,2	82,3
2	92,3	73,8	78,5	68,7	78,3
3	91,5	83,5	86,1	89,6	87,7
4	89,6	87,6	81,4	89,0	86,9
5	83,3	91,0	75,0	86,2	83,9
6	87,5	89,0	76,1	92,0	86,2
7	85,3	83,5	68,7	84,7	80,6
An average weekly index	86,6	85,0	79,2	83,9	

Table 2

Quantitative indices (%) of nutrients balance for the group of proteins, fats and carbohydrates

№ of the day	Type of ED				Average index for a day
	breakfasts	lunches	dinners	suppers	
1	45,2	76,1	31,5	32,4	46,3
2	38,4	48,5	33,5	27,9	37,1
3	42,3	46,9	42,8	50,3	45,6
4	54,5	39,3	93,7	41,1	57,2
5	42,0	41,3	33,5	39,2	39,0
6	57,5	40,7	33,5	97,6	57,3
7	57,5	19,6	61,8	80,0	54,7
An average weekly index	48,2	44,6	47,2	52,6	

In tables 1–3 we present the results of calculations by the formulas (1)–(4) of quantitative indices of balance for four groups of nutrients in the created totality of the diets of the second generation.

Table 3

Quantitative indices (%) of nutrients balance for the group of essential acids

№ of the day	Type of ED				Average index for a day
	breakfasts	lunches	dinners	suppers	
1	75,8	52,8	79,9	47,3	64,0
2	64,3	72,0	60,0	51,1	61,9
3	64,3	49,0	49,1	59,3	55,4
4	77,6	53,8	48,6	0,0	45,0
5	62,3	22,8	40,6	56,7	45,6
6	72,5	77,0	0,0	37,2	46,7
7	43,7	0,1	9,7	57,3	36,9
An average weekly index	65,8	54,6	41,1	44,1	

Analysis of the results of calculating indices of nutrients balance presented in Tables 1–3 demonstrates the following.

The highest level of the nutrients balance in the created EDs of the second generation is characteristic feature for calcium group (calcium, fat, phosphorous, magnesium). Average indices of the nutrients balance per day and average weekly indices range within the interval 78...88%. So high results are explained by the presence in mathematical models of the optimization of the ingredients content of the restrictions like

$$A_1^{'} \le \frac{Y_2}{Y_1} \le A_2^{''} \tag{5}$$

$$A_2^{'} \le \frac{Y_1}{Y_3} \le A_2^{''} \tag{6}$$

$$A_3^{'} \le \frac{Y_1}{Y_4} \le A_3^{''}, \tag{7}$$

where Y_1, Y_2, Y_3, Y_4 are the content of nutrients of calcium, fat, phosphorus and magnesium in EDs respectively.

Moreover, rather small differences of the numbers $A_i'' - A_i'$, i=1, 2, 3 characterize double inequalities (5)–(7). They predetermine high level of nutrients balance for the noted group.

The nutrients of the group of ten essential amino acids possess middle and higher levels. The presence of unconventional floury products with a high balanced content of the indicated acids in EDs of the second generation explain the obtained results. Only about 15% of the researched EDs have relatively low parameters of the balance of this group's nutrients.

The nutrients of the group of proteins, fats, carbohydrates have balance level close to an average, and about 30% have low level.

It is worth mentioning that EDs including those of the second generation are being designed for the creation of balanced daily diets (DD) for durable effective nutrition systems. It is possible to raise the balance level of nutrients in DD through:

a) the increase of a set of EDs of the second generation;

b) avoid attracting expendable diets of the second generation with low indices of nutrients balance, simultaneously attracting (in case of expediency) EDs of the first generation to the totality of EDs, which will participate in DD optimization;

c) the corresponding choice of the algorithm for the optimization of the totality of daily diets.

Conclusion. The results of the performed research.

1. The balance parameters of the related groups of nutrients are specified:

a) calcium, fat, phosphorus and magnesium;

b) proteins, fats and carbohydrates;

c) ten essential amino acids.

Quantitative indices, the values of which change from zero to 100% can be used for the evaluation of the level of nutrients balance in expendable diets (EDs) for breakfast and lunch, dinner, supper, etc.

2. Quantitative analysis of the balance of the specified groups of nutrients in 28 EDs of the second generation is performed.

3. The concept of the creation of EDs totality as elements for the optimization of balanced daily diets for durable and effective medical and preventive nutrition systems is formulated.

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Рекомендовано до публікації д-ром техн. наук, проф. В.М. Михайловим.
Отримано 1.08.2015. ХДУХТ, Харків.

УДК 519.8:637.521.473(083.12)

ДОВГОТРИВАЛІ ЦИКЛОВІ РАЦІОНИ В СИСТЕМАХ ХАРЧУВАННЯ: ЗАБЕЗПЕЧЕННЯ ДОБОВИХ ПОТРЕБ У ДЕФІЦИТНИХ НУТРІЄНТАХ

О.І. Черевко, Ж.А. Крутовий, Г.В. Запаренко, А.О. Борисова

Для циклових раціонів тривалістю до двадцяти однієї доби в системах лікувально-профілактичного харчування запропоновано спосіб забезпечення добових потреб у таких дефіцитних нутрієнтах: селен, фтор, бор, цинк, марганець та ін.

Ключові слова: *циклові раціони, системи харчування, дефіцитні нутрієнти, нетрадиційні борошняні вироби.*

ДЛИТЕЛЬНЫЕ ЦИКЛОВЫЕ РАЦИОНЫ В СИСТЕМАХ ПИТАНИЯ: ОБЕСПЕЧЕНИЕ СУТОЧНЫХ ПОТРЕБНОСТЕЙ В ДЕФИЦИТНЫХ НУТРИЕНТАХ

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Для цикловых рационов продолжительностью до двадцати одних суток в системах лечебно-профилактического назначения предложен способ обеспечения