An assessment of a nutritionally appropriate diet for adolescents' nutrition

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Abstract. A modern human is exposed to numerous stresses associated with an intensive lifestyle, the impact of aggressive factors of man-made habitat, high rates of urbanization, etc. This led to the need to correct a considerable part of the lifestyle, as well as approaches to nutrition. It is especially topical for children and youth, since during this period all the body systems are initiated and formed, ensuring its normal operation throughout the rest of life. One of the key tasks of preserving and improving the health of the population, especially in childhood and adolescence, is the need for balanced nutrition in terms of the proportion of nutrients consumed. These include proteins, fats and carbohydrates, as well as the number of macro- and microelements, such as iron, copper, zinc, etc. We will present an example of calculating the optimal food ration from the point of view of material costs, satisfying the required balanced nutrition of children and adolescents. It is studied by algorithmic means from the standpoint of a statistical approach to the task of the initial physico-chemical data on the composition of the product.

1. Introduction
A modern human is exposed to numerous stresses associated with an intensive lifestyle, the impact of aggressive factors of man-made habitat [1–6], high rates of urbanization, etc. This led to the need to correct a considerable part of the lifestyle, as well as approaches to nutrition. It is especially topical for children and youth, since during this period all the body systems are initiated and formed, ensuring its normal operation throughout the rest of life.

The considerable changes in living conditions have been taking place since the second half of the XX century already during the lifetime of one generation. This fact inevitably forms conflicts between the anthropologically conditioned physiological tradition and the need to adapt to a rapidly changing environment.

A “food revolution”, which took place in the world in the 50s of the last century and consisted in the widespread transition to industrial food supply, can serve as an example of such changes.

An economic prerequisite of this social technology is the priority of the interests of the food distribution system (retail) and industry at the expense of the consumer’s interests.
The implementation of intensive technologies for the production and distribution of food resources focuses on increasing the shelf life, the “manufacturability” of food in the process of its receipt, delivery, storage and distribution [7–8].

There is a key role played by information technologies. An advertising, first of all, is aimed at forming a given “psychological profile” of the products being sold. In the XXI century, this trend is intensifying and becoming total.

Without a doubt, such an approach in the food supply system is a path to the stressful conditions of consumers, which often result in a disorder of the homeostasis of the human body, expressed in a pathological change in metabolism, the growth of inherited diseases and their “rejuvenation” [9–12].

Since the useful substances are usually received by the young man in the form of components consumed with food products, then naturally, in social conditions, parents of children and adolescents face the challenge of providing the recommended scientifically based rates of rational nutrition [13–16].

Alternatively, the consumer is faced with the problem of buying groceries in a supermarket or at a market at an affordable price for the family. From the standpoint of the concept of economic and mathematical modeling, in order to meet the requirements for the nutrient composition and minerals in the grocery basket for a teenager, parents try to spend minimal money on purchased products. Meanwhile, they try to consider the rates of rational nutrition and get the opportunity to design food products with programmed functional and specialized characteristics [17–22].

2. Materials and method

The mathematical formalization of such a challenge, within the framework of the linear formulation of the problem called the linear programming problem, has the form:

Objective function

$$F(x) = \sum_{i=1}^{n} c_i x_i \rightarrow \text{min},$$

where \(c_i\) – unit value,

$$\sum_{i=1}^{n} a_{ij} x_i \geq a_j,$$

where \(a_{ij}\) – the content of nutrients and mineral elements in 100 g of the product, \(x_i\) – quantity of the purchased product, \(i\) – sequence number of summations, \(j\) – serial number of the nutrient or mineral substance in the product.

The ideal goal (1), (2) is usually solved using the simplex method. Microsoft Excel is often recommended for this purpose. Nevertheless, an easier-to-use Minimize software product developed for the simplex method in the MATHCAD environment is suitable for this issue.

Like others, including challenges of the form (1), (2) defined in a linear formulation by the objective function (1) and constraints (2), a mathematical problem in a non-degenerate form has a single optimal solution. Therefore, from the didactic point of view, it is obviously impractical to apply the dependencies connected with the nonlinearity in (1), (2) the issue of optimizing the food ration when solving the task.

That is attributed mainly to the fact that the ingredients of food raw materials used in public catering, for many reasons, vary in a fairly wide dimensional range of physico-chemical parameters.

Thus, while studying the optimal linear programming problem about the diet, it is meaningless to subject the applied scientific provisions, resorting, usually, to more complex iterative procedures.

While solving the optimization problem under study on the basis of algorithmic linear programming tools, as a result, it is essential to consider the correction coefficients in the initial data of the problem with the help of statistically determined (or expert) correction coefficients. For example, if the variability parameters are used as multipliers in the right-hand sides of inequalities (2) \(\varepsilon_j\):
\[
\sum_{i=1}^{n} a_i x_i \geq a_j \varepsilon_j,
\]

where
\[\varepsilon_j = (100 \pm \eta_j)/100,\]

\[\eta_j\] – error in %.

3. Results and Discussion

It is anticipated that it is essential to calculate the optimal diet for a certain adolescent contingent according to the nutrient composition and minerals in the product, choosing as components of the diet: white bread, meat, and buckwheat.

In return, bearing in mind that iron (Fe), copper (Cu), zinc (Zn), iodine (I) are essential (vital for the body, but rarely found in deficit) micronutrients, then Fe, Cu, Zn were taken as basic parameters for micronutrients (see Table 1).

| Table 1. The nutrient content in food products and their consumption rates. |
|-----------------------------|-----------|-----------|-----------|-----------|
|                             | X₁        | X₂        | X₃        |
| Nutrients, micronutrients   | Goods     | White bread, g/kg | Meat, g/kg | Buckwheat, g/kg | Consumption rate, g |
| Basic nutrients             | Proteins, g/kg | 81       | 190       | 130       | 90          |
|                            | Fats, g/kg   | 12       | 124       | 26        | 90          |
|                            | Carbohydrates, g/kg | 468  | 0         | 680       | 620         |
| Micronutrients             | Fe, mg/kg   | 3.9      | 2.7       | 6.65      | 10×10⁻³     |
|                            | Cu, mg/kg   | 0        | 182×10⁻³  | 640×10⁻³  | 10×10⁻³     |
|                            | Zn, mg/kg   | 2.5      | 3.24      | 2.65      | 1.25×10⁻³   |
|                            | Price, rub/kg | 80      | 350       | 80        |             |

Based on (1) and the data in Table 1, the ninth row - the objective function takes the form (n = 3)

\[F(x) = 80x₁ + 350x₂ + 80x₃ \rightarrow \min\]

In turn, according to the data of columns 3-6 and in connection with (1), the system of inequalities (2) is written as (j = 1,2…6):

\[81x₁ + 190x₂ + 139x₃ \geq 90 \varepsilon₁,
12x₁ + 124x₂ + 26x₃ \geq 90 \varepsilon₂,
468x₁ + 680x₃ \geq 620 \varepsilon₃,
3.9x₁ + 2.7x₂ + 6.65x₃ \geq 10 \varepsilon₄ \times 10⁻³,
0.182\times10⁻³x₁ + 640\times10⁻³x₃ \geq 10 \varepsilon₅ \times 10⁻³,
x₂ + 6.65x₃ \geq 1.25 \times 10⁻³ \varepsilon₅,
2.5x₁ + 3.24x₂ + 2.65x₃ \geq 1.25 \varepsilon₆ \times 10⁻³,
\]

with additional constraints on non-negative values of variables \(x_i\)

\[x_i \geq 0, i = 1,2,3.\]

While performing the calculation in the MATHCAD, based on the Minimize software product, the inequalities (5) were considered (expertly):

\[\varepsilon₁ = \varepsilon₄ = (0.95;1.05), \varepsilon₂ = \varepsilon₅ = (0.90;1.10), \varepsilon₃ = \varepsilon₆ = (0.85;1.15).\]
The estimation findings in accordance with (4)-(7) and the data in Table 1 are summarized in Table 2.

| Goods             | $\varepsilon_{\text{min}}$ (85 %) | $\varepsilon_{\text{opt}}$ (100 %) | $\varepsilon_{\text{max}}$ (115 %) |
|-------------------|----------------------------------|----------------------------------|----------------------------------|
| $X_1$ (white bread), g | 0                                | 0                                | 0                                |
| $X_2$ (meat), g    | 50                               | 54                               | 59                               |
| $X_3$ (buckwheat), g | 74                               | 87                               | 100                              |
| $F$ (purchase costs), rub. | 23.4                            | 26                               | 28.6                             |

4. Conclusion
For satisfying, in accordance with the daily regulatory requirements for nutrients (proteins, fats, carbohydrates) and trace elements (Fe, Cu, Zn) of the adolescent population, it is essential (with minimal consumption of bakery products) in a favorable case to limit the purchase of 50 g of meat and 74 g of buckwheat. The costs are: 23.4 rubles. If unfavorable - the purchase of 59 g of meat and 100 g of buckwheat (costs: 28.6 rubles).

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