

## USE OF LINEAR OPTIMIZATION MODEL IN DEFINING THE NEW STANDARDS FOR THE PREPARATION OF FOOD FOR SERVICEMEN IN PREPARATION FOR PARTICIPATION IN PEACEKEEPING OPERATIONS

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**Abstract:** *The role of providing ready-to-use food, regarded as a multiplier of the combat force of the formations of the Bulgarian Army (BA) participating in peace keeping operations (PKO) is beyond doubt. The concept of the feeding of a battalion battle group (BBG), which is a potential participant in PKO should be sustainable under any conditions in different climatic zones and altitudes, providing for the specific needs of the personnel in accordance with their sex, age, health status, body mass index (BMI) and personal preferences. The energy needs of the servicemen in a BBG on a PKO in hot climates are equal to those in moderate climates - 3595 kcal per day. During combat operations this need rises to 4905 kcal per day.*

**Keywords:** linear optimization, product sets, standards, feeding

### 1. Introduction

The existing nutritional standards in the Ministry of Defence (MOD) are higher than the standards for the medium-sized energy needs of the population by an average of 25% for men and an average 43% for women (aged 19 to 30 years).

On the basis of a study of the actual feeding of troops in preparation for participation in PKO, covering the period from 01 January 2014 to 31 December 2014, it has been established that the actual food intake has an energy value exceeding the established standard for the country with 30 % for men and 47 % for women (6).

A better efficiency of the nutrition in the Defence Ministry could be achieved through the application of a nutrition model that complies with the national physiological standards for the feeding of the population, while at the same time sufficient financial resources are allocated for achieving it, while taking into account

the market price of food products and the possibilities for transferring services to external contractors [12].

As a result of solving such a research task, a list of food products has been drawn up and proposed for the preparation of food within the week menu for troops in preparation for participation in dispatch PKO. The contents of the drawn-up new list of food products are divided in groups of foodstuffs in accordance with the national standards (4). In summary the list of food products can be presented as follows: Cereals and potatoes - 560 gr, vegetables and fruit - 1230 gr, milk and milk products - 355 gr, foods rich in protein - 415 gr, added fats - 40 gr and sugar, honey and foods with a high content of added sugar - 80gr. In drawing up the list of food products, we have adopted an approach aimed at keeping the so-called "unhealthy foods" to a minimum (7). The latter include the following groups of

foodstuffs: foods containing partially hydrogenated vegetable oil; certain foodstuffs with a high content of salt; certain foods and drinks containing caffeine or taurine; certain foods and drinks with a high content of sugars and sweeteners.

The careful selection of the food products in the proposed list allows the nutritionists in the Defence Ministry, who draw up the weekly menu for troops in preparation for participation in the PKO, to comply with the following requirements for the nutrition of this specific group of users: The application of scientifically based nutrition standards; achievement of a balanced and rational diet; the use of food products that are generally preferred by the servicemen, which makes it possible to prepare favorite dishes and achieve a greater level of satisfaction; the application of a nutrition model that is adequate to the needs of the servicemen and economical at the same time.

The listed requirements are characteristics of the catering service for troops in preparation for participation in PKO.

Each of these five requirements has its weight in providing the service. The balance in the proportions among these characteristics is fundamental for defining the quality of the catering service.

The above list of food products does not preclude the possibility to use other food products as well, if necessary, with a view to diversifying the menu, meeting the needs of the servicemen, or using the best market prices according to the season. In this case, the "substitution" should be by types and groups of foodstuffs, ensuring the provision of the respective nutrient.

The conversion of the "list of food products" into standards for the preparation of food for the soldiers and civilians in preparation for participation in dispatch, humanitarian, and other operations is connected with the determination of the natural indicators, in this case the quantity which should be provided per person per day (recommended daily intake) [13]. Diversification, balance and the

achievement of a rational diet should be considered in preparing the weekly menu.

The use of mathematical techniques in describing the proposed new list of food products in compiling the weekly menu for soldiers and civilians preparing for participation in dispatch operations allows for the creation of a suitable mathematical model.

## 2. OPTIMIZATION MODEL IN DEFINING THE NEW STANDARDS FOR THE PREPARATION OF FOOD

The construction of a mathematical model covers the following stages [2]: the introduction of variables through which to measure in quantitative terms the different characteristics of the researched subject. Usually for this purpose the following restrictions are used  $x_1, x_2, \dots, x_n$ . The aligned set  $x = (x_1, x_2, \dots, x_n)$  represents one state of the modelled subject; specifying the subject by means of the ratios and interrelations between the values  $x_1, x_2, \dots, x_n$ . These are the equations or inequalities and are called **restrictions** of the model.

The restrictions of the model allow for all possible states of the subject to be defined. In our case the subject is the new list of food products and the aim is to identify the best state among all the possibilities, taking into consideration the pre-formulated criteria. In this sense, through the inclusion of a target function in the model, it becomes possible to compare the individual states and select the best one of them.

The presence of the target function converts a mathematical model into an optimization model. The target function of the following type is linear and when using linear equations and/or inequalities for restrictions, it gives the nature of linear optimization model:

$$Z = \sum_j C_j X_j \rightarrow \min \quad (1)$$

where  $C_j$  = the value (cost) of expenses [1] for one weight unit  $j$  of the food product that is part of the "nutritional set" and  $X_j$  = the quantity of  $j$  of the food product that is part of the "nutritional set".

The mathematical model of the task makes it possible to identify the minimum or maximum of the target function.

The definition of the economic task for optimal compounding of mixtures with the aid of linear programming, in this particular case, looks as follows:

1. A starting point for our task is the fact that soldiers and civilians in preparation for participation in dispatch operations are in need of energy and nutrients in accordance with the physiological nutrition norms for feeding the population.

2. The optimal diet for this special category of staff in the Ministry of Defence is connected with the drawing-up of a weekly menu that includes a variety of dishes prepared from food products with different biological value, subject to the requirement for the provision of a specific quantity of macro- and micro-nutrients at the highest economic efficiency - the lowest cost of the menu. The prices of the used food products are known - they are defined in the contracts signed between the Ministry of Defence and the supplier.

3. In the optimization model, the unknown variables are the quantities of food products in the new list, which shall be denoted as  $x_1$ ,  $x_2$  and so on (in grams). Through the main restrictive conditions, we shall determine the limits of the quantities of the total protein, total fats, fatty acids, total carbohydrates, cholesterol, food fiber, mineral substances, vitamins, electrolytes and food products. These restrictions may be two - for the lower and upper limits, and the exact quantity can also be fixed.

4. In order to ensure the diversity of dishes and the availability of food products for their preparation, we fix certain values for some of them.

5. No restrictions are placed for essential and non-essential amino acids, carotene and oxalates as the physiological norms for the feeding of the population do not specify any requirements for them.

6. As for food fibre (in its full content), there are no restrictions, as its full content per 100 gr net food product is not listed in

the Tables on the composition of the Bulgarian food products, edited by Academician Tashev [9].

The solution of the task is carried out through the use of the application "Solver" of the Windows 10" software product" by Microsoft Corporation. For this purpose, all food products from the new list of food products are entered into the Microsoft Excel application, as well as the cost per unit and the content of macro- and micro-nutrients in 100 gr gross product.

After entering the restrictions into the Solver application, a solution is proposed for the quantity of food products which satisfies the restrictive conditions and the special requirements of the task, and the lowest value is given, i.e. the target function tends towards a minimum.

The resulting ratio of proteins to fats to carbohydrates (P:F:C) is 1:0,76:3,23. Balanced in this way, the macro-nutrients in the food of soldiers and civilians - men, preparing for participation in PKO, is close to the recommended P:F:C ratio = 1:0,8:3 – 3,5 for people performing mental labour [5]. In defining the linear restrictions for macro- and micro-nutrients, the specific conditions in the preparation of the troops involved in dispatch operations are taken into account, which are characterised as requiring mental labour and are usually performed in the conditions of greater psychological tension and physical adversity, such as noise and vibration.

Studies show that one of the characteristics of the metabolism of the mental worker is the more intensive protein exchange, which is expressed through the more intensive release of nitrogen from the body. In addition to this, the great mental and emotional stress is indicated as the main factor which impacts their health and performance [5].

Under the conditions of mental strain or adversity (physical, chemical), it is necessary to increase the total protein intake by 15 - 20% [8]. In this sense, the total protein intake for servicemen shall be increased as follows: Total protein from

83,66 - 125,61 grams to 100 - 150 grams; animal protein from 59 grams to 70 - 75 grams and vegetable protein from 24,6 - 66,6 grams to 29,5 - 75 grams.

When placing the restrictions in resolving the linear optimisation model, certain specific characteristics need to be taken into account. For example, linolenic acid belongs to the group of poly-saturated fatty acids and the body needs of 3,66 to 7.42 grams per day should be supplied. As for vitamin D, the intake should be between 200 and 2000 IU [3]. To achieve these values, it is necessary to use certain foods which are rich in these nutrients in in disproportionately big quantities. The market value of such foods is high and the use of expensive food products in large quantities can upset the balance of the remaining nutrients and raise the cost of the daily menu to unreasonable levels. Despite the above-mentioned, the list of food products is made up of traditional foods rich of these macro-nutrients, which gives us grounds to determine a norm for intake of linolenic acid  $\geq 1$  gram, and vitamin D  $\geq 50$  grams per day. The solution of the linear optimisation model shows that the aim of 1 gram of linolenic acid and 97,16

IU of vitamin D per day is achieved. To compensate for the shortage of micro-nutrients, 1 tablet of Fish oil + vitamin D<sub>3</sub> additive should be included on a daily basis in the menu of the servicemen. This makes it possible to secure the intake of additional 3 grams of linolenic acid and 1000 IU of Vitamin D at the cost of BGN 0,58, which will compensate for the shortage in the menu. A similar practice can be found in the existing nutrition standards in the leading armies. For example in Russia all applications defining the nutrition standards for the different categories of servicemen and for many different cases envisage 1 tablet multi-vitamin formulation Hexavit [10]. In the ready-to-eat foods, as well as in the group diets in the US, a total of 12 (twelve vitamins and minerals) are added to the dishes constituting the daily menu [11]. The solution of the task and the factors additionally taken into consideration for the specific target group gives us grounds to propose the resulting quantities of the food products for new standards in the preparation of meals for servicemen in preparation for participation in PKO. The latter are shown in Table 1.

*Table 1 New standards for the preparation of meals for soldiers and civilians in preparation for participation in dispatch operations*

Name of the food product	Quantity, g/ml
Wholewheat bread	360
Flour type 1850	10
White flour type 500	20
Wheat semolina	5
Pastry	20
Wheat starch	5
Oat flakes	20
Beans	40
Lentils	10
Soybeans	8
Rice polished	20
Almonds	20
Walnuts	10
Peanuts	5
Olives	10

Name of the food product	Quantity, g/ml
Dairy incl:	
- cow's milk skimmed	150
- low-fat yoghurt	150
Butter	10
Cow's cheese - white brined	20
Curd salt-free	15
Yellow cow's cheese	20
Pork meat - silverside	30
Lean veal	20
Lean lamb	20
Pork liver	20
Poultry meat	100
Durable sausages	7
Salami	7
Flat sausage Panagyurishte	5

Name of the food product	Quantity, g/ml
Pork fillet	5
Poultry frankfurters	13
Mackerel	30
Trout	15
Carp	15
Egg	24
Quail eggs	11
Sunflower oil	25
Olive oil	5
Refined sugar	35
Honey	20
Jam from peaches	15
Tahini khalva	10
Fresh fruit including:	
- apples	150
- bananas	60
- oranges	140
- pumpkin	60
- table grapes	50
- compote peaches	60
Fresh vegetables including:	

Name of the food product	Quantity, g/ml
- tomatoes	100
- cucumbers	45
- carrots	60
- fresh cabbage	150
- green peppers	45
- parsley leaves	5
- field mushroom	10
- onion	40
- Lyutenitsa chutney	15
- canned tomatoes	80
- hotchpotch	40
- canned green beans	40
- frozen peas	60
Autumn potatoes	100
Tomato puree	2
Red pepper	0,5
Tea	0,4
Salt	5
Vinegar	3
Essence	0.03
Black pepper	0.07

The quantity of food products in the proposed new standards for the preparation of meals for servicemen in preparation for participation in PKO, shown in Table 1, makes it possible to draw up a balanced and rational menu.

### 3. Conclusion

The proposed 69 (sixty-nine) food products allow for the preparation of a variety of dishes, in a variety of combinations, and preclude the repeated serving of the same main courses and soups, and also provide an opportunity to make maximum use of seasonal fruits and vegetables in the fourth

quarter of the year. It should be noted that the composition of the proposed new standards for the preparation of meals is only recommendable in nature, and, in the case of reasonable necessity, food products can be replaced with others from the same group on the basis of the principle for preserving the biological value and especially the protein content of the replaced product. The tables with the composition of the Bulgarian food products [9] or other similar tables, which have been validated by the Ministry of Defence can be used for this purpose.

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