DEVELOPMENT OF FOOD CONCENTRATES TO ENSURE THE ENERGY VALUE OF MILITARY RATIONS FOR PERSONNEL OF THE ARMED FORCES OF UKRAINE

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DOI: https://doi.org/10.30525/978-9934-26-531-0-4

Abstract. During multi-day exercises and combat operations, military personnel are almost routinely exposed to moderate to severe energy deficits, which affect their body composition and weight, as well as their physical and cognitive performance. Fatigue, decreased physical performance, mood swings, and impaired immune function are considered risks associated with energy deficiency. *The purpose* of the paper is to development of food concentrates to ensure the energy and physiological and hygienic completeness of the military rations of personnel of the Armed Forces of Ukraine in conditions of conventional and combat operations. *Methodology of the study* was based on research into the nutritional and energy value of military rations for personnel produced in Ukraine, Germany, Great Britain, and France using generally accepted methods, with subsequent analysis of information and development of food concentrates. *Results.* It was established that the studied military rations are characterized by different mass fractions of protein, fat, carbohydrates and indicators of energy value. The military ration of Ukrainian production is characterized by the highest mass fraction of protein (205.6 g), the military ration of German production is characterized by the lowest (76.4 g). The studied military ration for the nutrition of military personnel of Ukraine is characterized by a fat content of 235.1 g, which is the highest value among all studied military rations, at the

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same time, the military ration of German production is characterized by the lowest mass fraction of fat (123.4 g). The mass fraction of carbohydrates in the military ration of Ukrainian production (613.7 g) is the largest indicator among other military rations, and in the military ration of French production it is the smallest (383.1 g). Among the studied military rations, the highest indicator of energy value (4369.9 kcal) is characterized by the military ration of Ukrainian production, the lowest (3226.4 kcal) is the military ration of French production. Daily military rations of Ukrainian and foreign production are characterized by a mismatch in the ratio of proteins, fats and carbohydrates. Full energy supply when consuming military rations of Ukrainian production, in addition to NATO recommendations for combat operations, occurs mainly due to excessive fat content. According to the results of the study, the developed food concentrates are characterized by high nutritional value. *Conclusions.* An imbalance in energy intake and expenditure causes a negative energy balance that can occur over days or weeks during military operations. The food format and its nutritional composition should be varied to meet the specific needs of the personnel and their activities in different climatic conditions. The developed technology of food concentrates will allow obtaining complete food products for the nutrition of military personnel. *Practical implications.* The proposed food concentrates of increased nutritional value can be included in the military rations of military personnel of the Armed Forces of Ukraine to support their activities. *Value/originality.* The technology of food concentrates involves the use of both traditional and non-traditional raw materials, which makes it possible to obtain a complete food product for the military personnel of the Armed Forces of Ukraine.

1. Introduction

The priority of the Ministry of Defense of Ukraine has been and remains the organization of high-quality nutrition for military personnel, in particular in the area of combat operations. Thus, according to the resolution "On the nutritional standards of military personnel of the Armed Forces, other military formations and the State Service for Special Communications and Information Protection, police officers, rank-and-file and command

personnel of civil defense bodies and units" [1], the issue of providing military personnel and police officers with additional nutrition, a daily set of dry food, a daily field set of food while performing assigned tasks in areas of combat operations, tasks of territorial defense and repelling armed aggression against Ukraine is regulated.

Soldiers are provided with dry dry rations in accordance with food standards No. 10 and No. 15 [1].

During multi-day training and combat operations, soldiers almost systematically encounter moderate to severe energy deficits, which affect their body composition and weight, as well as their physical and cognitive performance. Repeated observations show that soldiers eat significantly less in the field than in garrison, and are usually unable to regulate their energy balance and avoid severe energy deficits [2].

Individual rations are designed to provide food for military personnel for a 24-hour period and typically consist of two main meals and several light snacks [3].

The military personnel need for food with a long shelf life and complete nutritional value has been a key driver of technological innovation in the food industry [4].

Since military rations may be the sole source of nutrition, they must be designed to meet all the nutritional needs and organoleptic preferences of personnel. At the same time, military specifications differ significantly from national medical and sanitary recommendations [5].

Since the beginning of the war, more than 1.5 million military rations of domestic and foreign production have been purchased to provide the Armed Forces of Ukraine. Also, more than 1 million military rations have been received as aid from partner countries (Great Britain, Germany, Slovakia, Finland, Sweden, the Netherlands, Denmark, Canada, USA, France, Croatia and others).

The Armed Forces have specifications for storing food for long periods of time in hot climates without refrigeration or with periodic freezing. These specifications also make military rations and the technologies behind them very useful in other areas of their application [6].

Food products must not only remain complete in terms of nutrients, but also have appropriate organoleptic indicators, support the physical and

cognitive performance of personnel, provide a sufficient level of macro- and microelements, vitamins, minerals and fiber.

In modern conditions, the diet corresponds to the scientific foundations of organizing healthy nutrition for military personnel of the Armed Forces of Ukraine.

In connection with the above, there is a need for a more detailed study of military rations and the impact of energy deficiency on the body of military personnel and the development of complete food products that are convenient for use in nutrition, such as food concentrates.

The purpose of the paper is to development of food concentrates to ensure the energy and physiological and hygienic completeness of the military rations of personnel of the Armed Forces of Ukraine in conditions of conventional and combat operations.

Methodology of the study was based on a study of the nutritional and energy value of military rations for military personnel produced in Ukraine, Germany, Great Britain and France using generally accepted methods with subsequent analysis of the information. We do not provide the names of the ration manufacturers we studied in order to prevent and ethically promote advertising in the conditions of socio-political life in Ukraine. The mass fraction of fat, protein, carbohydrates in food concentrates was determined using generally accepted methods.

2. Nutritional and energy value of military rations

The results of the study of the nutritional and energy value of military rations for military personnel produced in Ukraine, Germany, Great Britain, and France are shown in Table 1.

The degree of provision of proteins, fats, carbohydrates and energy value of the studied military rations for the nutrition of military personnel according to NATO recommendations and Order of the Ministry of Health of Ukraine No. 1073 is shown in Table 2-4.

According to the results presented in Table 1, it should be noted that the daily rations of domestic and foreign production are characterized by different mass fractions of protein, fat, carbohydrates and energy value indicators. Thus, the largest mass fraction of protein (205.6 g) is characterized by the military rations for the nutrition of Ukrainian military personnel (No. 3), the smallest (76.4 g) is the individual combat ration of German military personnel.

Table 1

Nutritional and energy value of military rations of domestic and foreign production for the nutrition of military personnel

Indicator	Country producing					
	Ukraine			Germany	United Kingdom	France
	No. 1	No. 2	No. 3			
Mass fraction of proteins, g	144.9	155.3	205.6	76.4	116.9	121.6
Mass fraction of fats, g	235.1	197.9	141.3	123.4	134.2	130.2
Mass fraction of carbohydrates, g	420.1	439.6	613.7	503.4	486.1	383.1
Energy value, kcal	4324.2	4196.0	4369.9	3470.1	3547.9	3226.4

Table 2

Degree of meeting the daily nutrient needs of military personnel when consuming military rations of domestic and foreign production according to NATO recommendations

Country of production	Conventional Operations			Combat Operations		
	Mass fraction, g					
	proteins	fats	carbohydrates	proteins	fats	carbohydrates
Daily rate	180	110	494	246	150	675
Degree of provision, %						
Ukraine (No. 1)	81	214	85	59	157	62
Ukraine (No. 2)	86	180	89	63	132	65
Ukraine (No. 3)	114	128	124	84	94	91
Germany	42	112	102	31	82	75
United Kingdom	65	122	98	48	89	72
France	68	118	78	49	87	57

Table 3

Degree of meeting the daily nutrient needs of military personnel when consuming military rations of domestic and foreign production according to the recommendations of the Order of the Ministry of Health of Ukraine No. 1073

Country of production	Age								
	18-29	30-39	40-59	18-29	30-39	40-59	18-29	30-39	40-59
	Mass fraction, g								
	proteins			fats			carbohydrates		
Daily rate	117	111	104	154	144	137	586	550	524
Degree of provision, %									
Ukraine (No. 1)	124	130	139	153	163	172	72	76	80
Ukraine (No. 2)	133	140	149	129	137	144	75	80	84
Ukraine (No. 3)	176	185	198	92	98	103	105	112	117
Germany	65	69	73	80	85	91	86	92	97
United Kingdom	99	105	112	87	93	98	83	88	93
France	104	109	117	85	90	95	65	70	73

Table 4

Degree of meeting the daily nutrient needs of military personnel when consuming military rations of domestic and foreign production according to recommendations of the NATO and Order of the Ministry of Health of Ukraine No. 1073

Country of production	Recommendations of the NATO Research Task Group-154		Order of the Ministry of Health of Ukraine No. 1073		
	Conventional Operations	Combat Operations	Age		
			18-29	30-39	40-59
	Energy value, kcal				
Daily rate	3600	4900	4100	3900	3700
Degree of provision, %					
Ukraine (No. 1)	120	88	105	111	117
Ukraine (No. 2)	117	86	102	108	113
Ukraine (No. 3)	121	89	107	112	118
Germany	96	71	85	89	94
United Kingdom	99	72	86	91	96
France	90	66	79	83	87

The studied military rations for the nutrition of Ukrainian military personnel (No. 1) is characterized by a fat content of 235.1 g, which is the largest value among all rations, at the same time, the smallest mass fraction of fat (123.4 g) is noted in the individual combat ration of German military personnel. The mass fraction of carbohydrates in the ration for the nutrition of Ukrainian military personnel (No. 3) (613.7 g) is the largest indicator among other samples, and in the individual military rations of French military personnel it is the smallest and amounts to 383.1 g.

Among the studied samples, the highest energy value (4369.9 kcal) is characterized by the military rations for the nutrition of Ukrainian military personnel (No. 3), the lowest (3226.4 kcal) is the individual military rations of French military personnel.

Analysis of the degree of provision of the daily needs of military personnel in proteins, fats, carbohydrates and energy value (Table 2 and 3) when consuming military rations of domestic and foreign production shows the following. Military rations of domestic production according to NATO recommendations for energy during conventional operations and recommendations of the Order of the Ministry of Health No. 1073 for all age categories have a degree of provision of more than 100%. At the same time, these military rations do not correspond to the provision of energy according to NATO recommendations during combat operations – the degree of provision is 86-89 %. The military rations for the military personnel of Germany, Great Britain, and France do not meet the energy requirements according to NATO recommendations and Ministry of Health Order No. 1073 – the level of provision is less than 100 %.

Energy deficit, sleep deprivation combined with mental stress of soldiers in harsh climate conditions significantly impair hormonal regulation and physical performance [7]. Hormones that stimulate appetite include leptin and ghrelin, and their indicators change significantly in the event of acute calorie deficit and body weight loss. Cortisol content increases and anabolic testosterone decreases, but these hormonal changes are restored when energy balance increases [8]. In addition, researchers [9] claim that energy deficit changes the efficiency and effectiveness of shooting weapons during training, especially in a standing position.

Domestically produced military rations (No. 1 and No. 2) according to the recommendations of the Order of the Ministry of Health No. 1073 in

terms of the degree of provision of daily needs in proteins and fats have an indicator of more than 100 %, domestic ration No. 3 has a degree of provision (for the age category 18-39 years) in fats of 92 % and 98 %, and the degree of provision in carbohydrates is 72-84 % for domestic rations No. 1 and No. 2, for No. 3 – more than 100 %. The above results of the analysis of domestically produced military rations No. 1 and No. 2 correlate with the indicators of the degree of provision in daily needs in proteins, fats and carbohydrates according to NATO recommendations for conventional and combat operations, but it should be noted that domestic ration No. 3 meets the recommendations for conventional operations.

Military rations of foreign production do not meet the full level of provision in proteins, fats and carbohydrates according to NATO recommendations for conventional and combat operations and the recommendations of the Ministry of Health Order No. 1073. It should be noted that the level of provision in proteins for the military rations of German military personnel according to NATO recommendations for conventional and combat operations is too low – 42 % and 31 %, respectively, and for the military rations of British and French military personnel according to NATO recommendations for conventional operations – 48 % and 49 %, respectively.

Thus, military rations of domestic and foreign production are characterized by a mismatch in the ratio of proteins, fats and carbohydrates. Full energy supply when consuming rations of domestic production, in addition to NATO recommendations during combat operations, occurs mainly due to the excessive fat content.

Recent studies in the USA military, who consumed military rations for more than 21 days in harsh conditions, leads to changes in the composition of the intestinal microbiota and the content of metabolites associated with the microbiota in feces, and as a result, an increase in intestinal permeability and inflammatory processes [10]. The use of military rations for 3-34 days leads to a decrease in body weight and changes in body composition, which significantly affects the health and performance of personnel [11].

3. Development technology of food concentrate

A recipe for a dry mix for instant green borscht has been developed, which is shown in Table 5.

Table 5

Recipe for dry mix for quick-cooking green borscht

Name of raw materials	Content, %
Dried beets	10.00
Potato flakes	19.30
Dried fried onions	2.00
Dried green onions	4.00
Dried parsley	3.50
Dried carrots	3.00
Dried sorrel	15.00
Spelt flour	15.00
Vegetable oil	6.00
Sugar	9.00
Egg powder	1.20
Sea salt	6.00

The developed technology of a dry mix for quick-cooking green borscht includes the following. At the first stage, a vegetable mixture is prepared, the components of which are dried beets, dried fried onions, dried green onions, dried parsley, dried carrots, dried sorrel, dried spinach, which are dosed, crushed, potato flakes are added, and mixed.

At the second stage, a flavor mixture is prepared, the components of which are sugar and sea salt, which are dosed, mixed.

A flavor mixture, spelt flour, egg powder, and vegetable oil are added to the vegetable mixture.

The chemical composition of the dry mix for quick-cooking green borscht is shown in Table 6.

Table 6

Chemical composition of dry mix for quick-cooking green borscht

Title	Mass fraction, g/100 g
Proteins	11.28
Fats	10.23
Carbohydrates, including dietary fiber	47.4 9.94

The proposed technology involves producing green borscht with high protein, fat, and dietary fiber content.

A recipe for a dry mix for instant borscht with meat has been developed, which is shown in Table 7.

Table 7

Recipe for dry mix for instant borscht with meat

Name of raw materials	Content, %
Potato flakes	19.30
Dried beets	13.65
Dried cabbage	16.00
Dried meat	16.00
Dried tomatoes	1.10
Dried fried onions	2.00
Dried green onions	0.40
Dried parsley	0.15
Dried carrots	3.00
Dried bay leaves	0.10
Spelt flour	6.00
Vegetable oil	9.00
Ground black pepper	0.30
Sugar	7.00
Sea salt	6.00

The developed technology of a dry mix for instant borscht with meat includes the following. At the first stage, a vegetable mixture is prepared, the components of which are dried beets, dried cabbage, dried tomatoes, dried fried onions, dried green onions, dried parsley, dried carrots, which are dosed, crushed, potato flakes are added, and mixed.

At the second stage, a flavoring mixture is prepared, the components of which are sea salt, ground black pepper, dried bay leaf, sugar, which are dosed, mixed.

After that, a flavoring mixture, dried meat, spelt flour, and vegetable oil are added to the vegetable mixture.

The chemical composition of the dry mix for instant borscht with meat is shown in Table 8.

Table 8

Chemical composition of dry mix for instant borscht with meat

Title	Mass fraction, g/100 g
Proteins	16.28
Fats	10.76
Carbohydrates, including dietary fiber	44.87 8.29

The proposed technology involves obtaining borscht with meat with high protein, fat and dietary fiber content.

A recipe for a dry mix for quick-cooking vegetable borscht has been developed, which is shown in Table 9.

Table 9

Recipe for dry mix for instant vegetable borscht

Name of raw materials	Content, %
Potato flakes	19.30
Dried beets	15.65
Dried cabbage	19.00
Textured soy concentrate	11.00
Dried tomatoes	1.10
Dried fried onions	2.00
Dried green onions	0.40
Dried parsley	0.15
Dried carrots	3.00
Dried bay leaf	0.10
Spelt flour	6.00
Vegetable oil	9.00
Ground black pepper	0.30
Sugar	7.00
Sea salt	6.00

The developed technology of a dry mix for instant vegetable borscht includes the following. At the first stage, a vegetable mix is prepared, the components of which are dried beets, dried cabbage, dried tomatoes, dried fried onions, dried green onions, dried parsley, dried carrots, which are dosed, crushed, potato flakes are added, and mixed.

At the second stage, a flavoring mixture is prepared, the components of which are sea salt, ground black pepper, dried bay leaf, sugar, which are dosed, mixed.

After that, a flavoring mixture, textured soy concentrate, spelt flour, and vegetable oil are added to the vegetable mix.

The chemical composition of the dry mix for instant vegetable borscht is shown in Table 10.

Table 10

Chemical composition of dry mix for instant vegetable borscht

Title	Mass fraction, g/100 g
Proteins	17.12
Fats	10.72
Carbohydrates, including dietary fiber	46.99 8.24

The proposed technology involves obtaining vegetable borscht with high protein, fat and dietary fiber content.

A recipe for a dry mix for instant pea soup with meat has been developed, which is shown in Table 11.

Table 11

Recipe for dry mix for instant pea soup with meat

Name of raw materials	Content, %
Pea flakes	58.90
Dried meat	16.00
Spelt flour	3.95
Dried fried onion	3.50
Dried carrots	3.00
Dried dill	1.10
Vegetable oil	8.00
Black pepper	0.05
Sea salt	5.50

The developed technology of a dry mix for instant pea soup with meat includes the following. At the first stage, a bean mixture is prepared, the components of which are pea flakes and spelt flour, which are dosed and

mixed. At the second stage, a flavoring mixture is prepared, the components of which are fried dried onions, dried carrots, dried dill, black pepper, which are pre-crushed, sea salt, which are dosed and mixed.

The flavoring mixture, dried meat, vegetable oil are added to the bean mixture and mixed.

The chemical composition of the dry mix for instant pea soup with meat is shown in Table 12.

Table 12

Chemical composition of dry mix for instant pea soup with meat

Title	Mass fraction, g/100 g
Proteins	24.12
Fats	11.12
Carbohydrates, including dietary fiber	41.8 17.28

The proposed technology involves obtaining pea soup with meat with high protein and dietary fiber content.

A dry mix recipe for instant milk soup with spelt has been developed, which is shown in Table 13.

Table 13

Recipe for dry mix for instant milk soup with spelt

Name of raw materials	Content, %
Whole grain spelt flakes	53.80
Milk powder	28.00
Cream powder	10.00
Sugar	6.00
Inulin	1.50
Sea salt	0.70

The developed technology of a dry mix for instant milk soup with spelt includes the following. At the first stage, a milk mixture is prepared, the components of which are milk powder, cream powder, inulin, which are dosed and mixed. At the second stage, a flavor mixture is prepared, the components of which are sugar and sea salt, which are dosed and mixed.

The flavor mixture and whole grain spelt flakes are added to the milk mixture, mixed.

The chemical composition of the dry mix for instant milk soup with spelt is shown in the Table 14.

Table 14

Chemical composition of dry mix for instant milk soup with spelt

Title	Mass fraction, g/100 g
Proteins	16.52
Fats	12.55
Carbohydrates, including dietary fiber	55.67 8.49

The proposed technology involves obtaining milk soup with spelt with high protein and dietary fiber content.

A recipe for a dry mix for instant milk spelt porridge has been developed, which is shownin Table 15.

Table 15

Recipe for dry mix for quick-cooking spelt milk porridge

Name of raw materials	Content, %
Flakes Whole grain spelt	60.37
Milk powder	28.13
Inulin	3.00
White flax seeds	9.00
Sea salt	1.50

The developed technology of a dry mix for instant milk spelt porridge includes the following. Prepare dry milk and sea salt. Grind white flax seeds to a particle size of no more than 2.0 mm. Mix whole-grain rolled spelt with dry milk, inulin, ground flax seeds, and sea salt.

The chemical composition of the dry mix for instant milk spelt porridge is shown in Table 16.

Table 16

Chemical composition of dry mix for instant milk spelt porridge

Title	Mass fraction, g/100 g
Proteins	16.93
Fats	12.31
Carbohydrates, including dietary fiber	51.68 12.67

The proposed technology involves obtaining milk spelt porridge with high protein and dietary fiber content.

4. Conclusions

An imbalance in energy intake and expenditure causes a negative energy balance, which can occur over several days or weeks during military operations.

The format of food and its nutritional composition should be varied to meet the specific needs of personnel and their activities in different climatic conditions.

Our recommendations for reducing or eliminating energy deficits in military personnel:

– improve commanders knowledge of military nutrition;
– make nutrition a top priority;
– encourage eating and drinking, especially during “safe” phases;
– provide drinking water in sufficient quantities and consume it even in cold and moderate climates;
– involve soldiers in planning and preparing rations;
– increase the size of products that have high palatability;
– favor a diverse range of food products in rations;
– favor a large number of menus;
– offer the easiest to prepare and/or consume dishes and drinks;
– offer food products adapted to the expected climate;
– focus on packaging similar to commercial, rather than special for military nutrition;
– three meals a day;
– consume food at the same time every day (if possible);
– give preference to long meals;

– encourage eating in pairs or groups.

The developed technology of food concentrates – green borscht, vegetable borscht, borscht with meat, pea soup, milk porridge with spelt, milk soup with spelt will allow obtaining complete food products for the nutrition of military personnel.

References:

1. Resolution of the Cabinet of Ministers of Ukraine dated March 29, 2002, № 426. "On food standards for servicemen of the Armed Forces, other military formations and the State Service for Special Communications and Information Protection, police officers, rank-and-file members, senior members of civil defense agencies and units." Available from: https://zakon.rada.gov.ua/laws/show/426-2002-%D0%BF#Text

2. Deputat Yu. M., Hulich M. P., Savytskyi V. L., Ivanko O. M., Levit Y. R., Bohomolets O. V. (2021) Zastosuvannia informatsiinoi modeli rozrakhunku ratsionu kharchuvannia dlia kompensatsii enerhetychnykh vytrat viiskovosluzhbovtsiv zbroinykh syl Ukrainy [Application of the information model for calculating food rations for compensation of energy costs of servicemen of the armed forces of Ukraine]. *Medychni perspektyvy*, vol. 26, no. 3, pp. 161–168. (in Ukrainian)

3. Tassone E. C., Baker B. A. (2017) Body weight and composition changes in military personnel consuming combat rations: A systematic review. *Br J Nutr*, vol. 117(6), pp. 897–910.

4. Bal-Prylypko L. V., Nikolayenko M. S., Tkach G. F. (2022) *Naukove obhruntuvannia udoskonalennia tekhnolohii kharchovykh produktiv spetsialnoho pryznachennia: monohrafiia* [Scientific rationale for improving the technology of special purpose food products: monograph]. Kyiv: Vydavnytstvo "NUBiP", 436 p. (in Ukrainian)

5. Stanley R., Forbes-Ewan C., McLaughlin T. (2019) Foods for the Military. *Encyclopedia of Food Chemistry*. Amsterdam: Elsevier, pp. 188–195.

6. Nau A., Fröhlich J., Lauck C., Dorn-In S., Guldimann C. (2023) Impact of the Revision of European Food Hygiene Legislation and the Introduction of Convenience-based Food on Food Safety in the German Military. *Journal of Food Protection*, vol. 26(5), 100073.

7. Nykänen T., Ojanen T., Vaara J. P., Pihlainen K., Heikkinen R., Kyröläinen H., Fogelholm M. (2023) Energy Balance, Hormonal Status, and Military Performance in Strenuous Winter Training. *International Journal Environmental Research and Public Health, vol. 20(5),* 4086.

8. Pasiakos S. M., Caruso C. M., Kellogg M. D., Kramer F. M., Lieberman H. R. (2011) Appetite and endocrine regulators of energy balance after 2 days of energy restriction: Insulin, leptin, ghrelin, and DHEA-S. *Obesity*, vol. 19(6), pp. 1124–1130.

9. Ojanen T., Kyröläinen H., Igendia M., Häkkinen K. (2018) Effect of prolonged military field training on neuromuscular and hormonal responses

and shooting performance in warfighters. *Military Medicine, vol.* 183(11–12), pp. 705–712.

10. Karl J. P., Armstrong N. J., McClung H. L., Player R. A., Rood J. C., Racicot K., Soares J. W., Montain S. J. (2019) A diet of U.S. military food rations alters gut microbiota composition and does not increase intestinal permeability. *The Journal of Nutritional Biochemistry*, vol. 72, 108217.

11. Charlot K. (2021). Negative energy balance during military training: The role of contextual limitations. *Appetite*, vol. 164, 105263.