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Properties of Compact Food Bars: A Review Study

Vahid Hadi[1], Abdolreza Norouzy[2*], Mostafa Mazaheri Tehrani[3], Mohsen Nematy[2], Saeid Hadi[4]

1. Ph.D. student, Department of Nutrition, Faculty of medicine, Mashhad University of Medical Sciences, Mashhad, Iran
2. AssociateProfessor, Department of Nutrition, Faculty of medicine, Mashhad University of Medical Sciences, Mashhad, Iran
3. Professor, Department of Food Science and Technology Ferdowsi University of Mashhad, Mashhad, Iran
4. Ph.D. student, Department of Nutrition, Faculty of Nutrition and Food Sciences, Isfahan University of Medical Sciences, Isfahan, Iran

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ABSTRACT

Compact food Bars (CFBs) are used in meals ready-to-eat (MRE) diets during maneuvers and military operations and as emergency food products (EFPs) in emergencies and crises, such as natural disasters and warfare, in order to promote crisis management. Ready-to-use therapeutic food (RUTF) is used for therapeutic purposes in malnourished individuals and patients with acquired immune deficiency syndrome (AIDS). Some of the properties of CFBs include high nutritional value, high nutrient content, high energy density, no need for preparation, readiness to use, long-lasting preservation, low spoilage due to the low moisture content, low volume and weight, and ease of transportation and distribution. The energy level and type and amount of fat, protein, carbohydrates, fiber, and micronutrients should be considered in the formulation of CFBs. The main ingredients of these dietary products are cereal, skimmed milk, soy and its products, vegetable oil, sugar, and plant nutrients. Such food products are remarkably valuable to individuals in crisis. CFBs play a key role in the survival of victims of war and natural disasters. The present study aimed to review the properties and production of CFBs.

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Introduction

Compact food Bars (CFBs) are an element of the diets used in crises, maneuvers, and military operations (1, 2). The term 'compact foods' encompasses a large category of dietary products, such as enriched biscuits, chocolate bars, and nutrient-dense pastes (1, 2). CFBs are durable and ready to consume, while they are logistically low in volume and weight. This is important since soldiers must be able to adhere to their diet independently (3). Compact foods should provide all the nutrients required for 7-15 days in crises and up to 21 days in military operations. Another important issue in the case of CFBs is their consumption in the event of natural disasters, such as hurricanes and earthquakes (4).

Attention to the nutritional needs of the individuals in emergency conditions (e.g., floods, earthquakes, and war) is a vital concern, which has led countries to prioritize the production of a wide variety of these dietary products on their agenda, especially industrialized and developed countries (4). In addition to military consumptions, the production of these food products for various purposes is common in these countries.

Compact foods have long been used in the conditions of food supply constraint (5). Studies in this regard have been conducted since 1901 focusing on the foods provided for a

* *Corresponding author:* Abdolreza Norouzy, Associate professor in Clinical Nutrition. Tel: 00985138002382; Email: Norouzya@mums.ac.ir

single individual for unpredictable conditions. Compact foods were first added to the diets of the US army soldiers in 1980 and have been promoted constantly ever since (5).

Today, every country produces its own special diets depending on their scientific advancement and food technology, as well as the climate and taste of the populations. The armies of developed countries have procured special formulas for CFBs so as to supply the food sources of their militia (6). Proper nutrition is of paramount importance for the militants in difficult circumstances (e.g., operations and enemy siege), as well as the victims of natural disasters or disease outbreak in a region (7). Compact foods are optimal for such situations owing to properties such as no need for preparation, long-lasting preservation, low humidity, low spoilage rate, high energy and nutrient density, and easy transportation and distribution.

The CFBs used in crises include emergency food products (EFPs), meal ready-to-eat (MRE), and ready-to-use therapeutic food (RUTF). CFBs could be formulated and produced in three modes. The present study aimed to review the properties, types, and applications of CFBs in various situations, such as crises, wars, and treatments.

Material and methods

This review was conducted via searching in databases such as Pub Med, Science Direct, Google Scholar, SID, and Scopus, as well as credible reference books using keywords such as emergency food product, meal ready-to-eat, ready-to-use therapeutic, emergency ration bar, emergency food product, high-energy and nutrient-dense food products. The articles published in English and Persian were collected in August 2018.

Results

1. Types of Compact Foods

1-1 Emergency Food Products (EFPs)

EFPs are used to reduce morbidity and mortality in the victims of natural disasters or human incidents through adequately meeting the human nutritional needs for a maximum of 15 days since the onset of the event. EFPs should provide the required nutrients in individuals from the onset of the incident to the usual meal (3, 5). Most often, EFPs are used as the only food source in the early stages of natural disasters (e.g., earthquakes and hurricanes) or in emergencies (e.g., evacuation of the combat zone in military operations) (9).

The energy amount, nutritional composition, and sensitivity of EFPs play a key role in meeting the nutritional needs of victims (9, 10). These food products were also distributed in bulks in ancient times and developing countries. Some of the main EFPs in these situations included wheat, corn, and cereals, which were used to help the victims of emergencies and required preparation before consumption (4). In addition to emergency use, new EFPs are consumed as food supplements and are rich sources of various nutrients (4).

In the formulation of EFPs, several factors must be considered, including the nutrient contents that are needed for the human body, safety and health, pleasance, easy transportation and distribution, and ready-to-eat diets. The predicted time for the consumption of these foods by victims as the only consumed food is 3-7 days, while it may take up to 15 days as the only food source for these individuals (4). Moreover, EFPs should be cost-effective and provide the required amounts of energy (Kcal), protein, vitamins, and other essential nutrients for short-term survival. EFPs should also be organoleptically and culturally acceptable and easily transported (3, 8).

1-2 Meal Ready-to-Eat (MRE)

CFBs are part of MRE, which is used in harsh conditions and military operations. MRE should have three main parameters, including product acceptability, suitable packaging and shelf-life, and high nutrient levels (11, 12). Compressed diets should nutritionally meet the established standards, including the presence of macronutrients (carbohydrates, proteins, and lipids) and micronutrients (vitamins and minerals) to guarantee the health and efficiency of military personnel (Army Defense Branch, 2015). With regard to the use of compact foods by the militia, lack of access to fresh food must be considered for almost 21 days, and each serving should contain about 1,200 kilocalories to provide the required energy in three servings (13).

1-3 Ready-to-Use Therapeutic Food (RUTF)

RUTFs are the foods that are designed to serve therapeutic purposes and meet the nutritional requirements of the individuals in need, which are most commonly consumed in the form of supplementary diets.

One of the main applications of RUTFs is to provide the nutritional supplement of children with malnutrition in emergencies (14, 15). Severe malnutrition is a significant concern regarding inadequate energy and nutrients and is considered to be a major cause of mortality among children and other populations across the world (14, 16). The treatment of severe malnutrition often requires referral to nutrition therapy centers or hospitals, which may be impossible in deprived, borderline, and rural regions. To overcome this issue, the provision of products such as RUTFs has proven effective in many countries within the past decade (17, 18).

In this regard, various studies were carried out until a commercial product known as Plumpy'Nut® was produced in 1997 by a research institution in France for the treatment of acute malnutrition (19). This product is a semi-solid paste or cream consisting of skimmed milk, vegetable oil, sugar, peanuts, minerals, and vitamins (micronutrients) and is considered to be a standard RUTF (19). The product is packaged in 92-gram single packages (20). This type of RUTF mainly contains peanut butter enriched with other ingredients (20). The main features of Plumpy'Nut® are high energy density (approximately 500 kcal/92 g), complete nutrient combination with mineral salts, vitamins, amino acids, and essential fatty acids, and more durability compared to other products (up to 24 months). Furthermore, the product could promptly compensate for underweight individuals (up to 500 grams per week) (20).

2. Properties of CFBs

Given the importance of CFB in the nutrition of militia and civilians in response to the increased incidence of natural disasters (e.g., floods and earthquakes) and human incidents (e.g., warfare), there has been a growing need for relief supplies. The Food and Nutrition Board of the Institute of Medicine (IOM) has attempted to describe the properties of these food products (3, 4). In addition, the Food and Nutrition Board of the Medical Association (under the supervision of the US Committee on Military Nutrition Research) has determined the technical properties of CFBs (8).

The recommended fat content for the CFBs has been determined to be 35-45% (39-50 grams per 1,000 calories) of the calories. Determining the type and amount of fats in the preparation of CFBs is of utmost importance and should include stable and resistant oils containing minimal unsaturated bands. Furthermore, use of animal fats is not recommended, and only hydrogenated oils are added to these products (8, 21). On the other hand, use of fats with a higher melting point has been recommended in the formulation of CFBs in tropical regions (8, 22). Therefore, some of the main properties of fats in CFBs include ensuring energy needs, low weight, good taste of food, stability against oxidation, ensuring the adequate absorption of fat-soluble vitamins, presence of essential fatty acids, and non-degradation during transportation and storage (3).

Proteins could affect the sensory properties of food products (appearance, color, aroma, and taste). According to the findings of Yang et al., high levels of protein adversely affect the edibility of products. The essential amino acids should be considered as proteins rather than free dietary elements since free amino acids are not recommended due to their adverse effects on the taste of food. In addition, they increase the costs of food products (8). Furthermore, the addition of meat to CFBs as a source of protein is not recommended, and the protein in these dietary products should be supplied by high-quality milk and plant proteins (8). Plant proteins are preferred in this regard, and the deficiency of some amino acids in their composition could be eliminated by using a combination of cereals and legumes, which in turn enhance the quality of protein (8).

On the same note, using dairy protein in CFBs should be with caution. The level of lactose in the product should not exceed 12 grams per day due to lactose intolerance in many individuals (23). To prevent kidney strain and thirst, a maximum of 10-15% (34 grams per 1,000 kcal) of the total dietary energy should be provided through protein substances (3). These diets are accompanied by vitamins and minerals, supplying nutritional demands for a

maximum of 21 days (23). It is notable that the nutritional requirements of the general population are determined based on the RDA or RDI tables. Military personnel also have specific tables entitled the Military Dietary Reference Intakes (Table 1) (3, 24).

Table 1. Levels of Energy, Macronutrients, and Micronutrients in Emergency Ration Bar and Operational Diets Based on RDA and MRDA

Variables	RDA	MRDA
Energy (kcal. d^{-1})	2100	3200-3600
CHO (g. d^{-1})	230	400
Protein (g. d^{-1})	70	63-100
Fat (g. d^{-1})	100	Maximum 160 (35-45%)
Vitamin A (IU. d^{-1})	900	1000
Vitamin C (mg. d^{-1})	60	90
Vitamin D(IU. d^{-1})	200	200
Vitamin E (mg. d^{-1})	15	15
Vitamin K (µg. d^{-1})	120	120
Thiamine (mg. d^{-1})	1.2	1.2
Riboflavin (mg. d^{-1})	1.3	2.1
Niacin (mg. d^{-1})	16	24
Vitamin B6(mg. d^{-1})	1.7	2.2
Folic Acid (µg. d^{-1})	400	400
Vitamin B12 (µg. d^{-1})	2.4	3
Biotin (µg. d^{-1})	30	30
Pantothenic Acid (mg. d^{-1})	5	6
Calcium (mg. d^{-1})	1200	1200
Iron (mg. d^{-1})	8	9
Phosphorus (mg. d^{-1})	700	800
Iodine (µg. d^{-1})	150	150
Magnesium (mg. d^{-1})	400	800
Zinc (mg. d^{-1})	11	11
Selenium (µg. d^{-1})	50	77
Copper (mg. d^{-1})	0.9	1.8
Manganese (mg. d^{-1})	2.3	5.5
Chromium (µg. d^{-1})	30	35
Molybdenum (µg. d^{-1})	45	45
Potassium (mg. d^{-1})	4700	5600
Sodium (mg. d^{-1})	1500	2300-5000

RDA: recommended dietary allowance; MRDA: military recommended dietary allowance

The production potentials of the consumers' region and culture should be considered in selecting the raw materials for CFBs (3, 8). The formulation of these diets is based on the materials and guidelines recommended by the American Medical Association, including carbohydrate sources (e.g., wheat flour, corn, barley, barley flour, and rice flour), protein sources (e.g., soybean products such as condensed and isolated soybean, skimmed milk, casein, and other dairy products), lipid sources (e.g., soybean, cottonseed oil, hydrogenated sunflower seed oil, and cocoa butter oil), simple sugars (e.g., granulated sugar, sucrose, glucose, maltodextrin, and corn syrup with high quantities of fructose), cooking factors, yeasts (if necessary), vitamins, and minerals. Furthermore, use of allergenic foods, such as peanuts and livestock products (with the exception of milk), should be avoided in the formulation of CFBs (3, 8). Examples of CFBs are presented in Table 2.

Table 2. Examples of Compact Food Rations

Product(reference)	Specifications (manufacturer, country, features, durability, and packaging)	Kcal/100g
Military Chocolate Bar (25)	- Formulated by the Hershy's Company (USA) - High-energy content, ease of transport, resistance to high temperature, temperature tolerance of 60°C, no change in texture or taste. - Packed in aluminum foil layers, five-year lifespan	452
Huawei Chocolate (25)	- Produced by the US Defense Forces Studies Center to increase the energy of the militia during operations - High shelf-life (three years minimum) at the temperature of 80°F - The formula of this chocolate and its appropriate packaging reduce the volume of	430

		the MRE diet package.	
	-	Total weight of 65 grams, containing 280kilocalories, 9 grams of fat, 40 grams of carbohydrates (18grams of simple sugars), 1% fiber, 10grams of protein, and multivitamin minerals	
	-	For military and civilian use	
	-	Packed in aluminum foil layers, five-year lifespan	
Mainstay	-	Formulated by the US Department of Defense	517
Emergency Ration	-	High-energy diet containing vitamins, minerals, and proteins	
(24)	-	Each ration bar is calibrated with 400 kilocalories and its nine bars are packed with3600 kilocalories.	
	-	Rationbarsare packed in aluminum foil layers and have a five-year lifespan.	
	-	Resistant at temperatures of 22-149°F	
	-	Suitable for land and sea emergency situations, floods, earthquakes, and wars	
Seven Ocean	-	Formulated by the United States	500
Compact Rations	-	Seven Ocean compressed rations have improved over time in terms of nutrients, packaging, and prolonged shelf-life.	
(25)	-	Each pack contains nine compressed food bars with the energy of 2500 kilocalories and weight of 500 grams.	
Emergency	-	Formulated by the United States	512
Survival Ration	-	The bars are packed in aluminum foil layers and have a five-year lifespan.	
Pack	-	A package of nine compact bars with 3600 kilocalories, which eliminates the need for military operations.	
(25)			
S.O.S Rations	-	Formulated by the United States	450
(25)	-	Contains nine templates in a package, and each template contains 400 calories of energy.	
	-	Ingredients include wheat flour, hydrogenated vegetable oils, sugar, coconut, corn starch, corn syrup, vitamins, and minerals.	
	-	Strong polyethylene package	
Bp-5	-	Made in Norway	458
(26)	-	Initially, emergency rescue boats were used by the ship crew during accidents. In the droughts in Sudan (1985-1986), they were used in the battle of Balkan.	
	-	Each packet weighs500 grams and contains nine compact mushrooms, each with 100 grams of 458 kilocalories.	
	-	The package is a vacuum and regular bag composed of aluminum foil with a five-year shelf-life and minimum reduction in the amount of vitamins.	
	-	This diet provides healthy foods for malnourished individuals.	
	-	These compressed food formulations contain all essential nutrients (with the exception of water) for the restoration and maintenance of the body.	
BP100	-	Made in Norway	458
(26)	-	A nutritious wheat and barley meal	
	-	Each packs weighs510 grams and contains nine compressed food bars.	
	-	Military applications (e.g., rehabilitation of malnourished individuals)	
	-	This diet is effective in the treatment of tuberculosis and AIDS patients.	
AFYA	-	Made in Norway	480
(27)	-	A high-energy diet with vitamins and minerals to enhance the immune system	
	-	It could be used at home and in hospitals for the treatment of tuberculosis and AIDS.	
	-	The ingredients include wheat flour, barley flour, vegetable oils, sugar, concentrates, soy protein, malt extract, amino acids, vitamins, and salts.	
	-	The package is a vacuum and regular bag composed of aluminum foil.	
Plumpy'Nut(28)	-	Made in France	545
	-	The package is a vacuum bag composed of aluminum foil and lasts12 months.	
	-	Plumpy'Nut has been referred to in scientific literature as a Ready-to-Use Therapeutic Food (RUTF) alongside other RUTFs (e.g., BP100).	
	-	Plumpy'Nut is used as a treatment for the emergency cases of malnutrition.	
MR8	-	Approved by NATO for emergencies	452
(29)	-	Contains high-quality protein, fat, and carbohydrate B, enriched with nutrients	
	-	The package is a vacuum bag composed of aluminum for waterproofing with a five-year shelf-life.	
SF-7 and SF-9	-	Approved by NATO for emergencies	452
(30)	-	Similar to MR8, the product is focused on the taste.	
	-	Added dried fruits	
	-	Mostly used in the army	
	-	The package is composed of strong polyethylene and lasts five years.	
Datrex Emergency	-	Designed for the US Coast Guard	526
Food Bars	-	Each package has 18 compact foods weighing 38 grams with 200 kilocalories,	

(31)	producing a total of 3600 kilocalories. - Each packet is designed to provide the required energy by an individual in an emergency situation for three days. - Ingredients include wheat flour, vegetable oils, sugar, coconut, salt, and no preservatives.

Conclusion

CFBs were first considered due to the paramount importance of nutrition in the performance of military personnel, and its significance has persisted for the militia. Specialist troops in the armed forces of developed countries have been studying, modifying, and optimizing the military rations that are more diverse compared to civilian and emergency diets (1, 2).

Some of the key benefits of CFBs have made the diets in crisis and emergency situations to be a good response to the needs of the victims (13, 16). Given the importance of CFBs in the nutrition of military personnel and civilians, they are widely used in the development of functional foods, therapeutic foods, sports supplements, and military foods (e.g., MRE). Therefore, in response to the increased incidence of natural and human disasters and complex humanitarian emergencies, a committee appointed by the IOM of the National Academies of Science released a report outlining the specifications of CFBs (1, 13). Moreover, the IOM has determined the required composition (macronutrients and micronutrients) and sensory and physical properties in the design of CFBs and the associated diets (3, 4). According to the IOM report, the energy level, type, and amounts of fat, protein, carbohydrates, fiber, and micronutrients should be meticulously considered in the formulation of compact foods (4, 3, 8). To minimize microbiological spoilage, the nutrient degradation, oxidation, and moisture content of CFBs should be less than 9.5%, with the maximum water activity of 0.6 (4, 3, 8). Ideally, the final EFP should have a minimum shelf life of 36 months at the temperature of 21°C (4, 3, 8).

The main ingredients of EFP diets include cereals, milk, vegetable oil, sugar, and plant products, which are lightweight and have a low volume for easy transportation and storage (3, 4). Since nutritional requirements are among the most essential human needs (especially in crises and warfare), planning to produce foods with special properties (e.g., low volume), meeting all human nutritional needs, and ease of use are of great significance and should be incorporated into the agenda of national authorities, particularly in the field of crisis management.

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