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Chapter

Functional Properties of Snack Bars

Oana Emilia Constantin and Daniela Ionela Istrati

Abstract

Nowadays, people spend more time and effort to gain greater control over their health by exploring alternative or herbal medicines and natural health products to prevent disease or for a healthier life. It is known that people who consume a diet rich in natural foods, such as fruits, vegetables, nuts, whole grains, and fish, tend to lead a life free of diseases. Recent studies suggest that regular or increased consumption of fruits and vegetables can reduce the risk of chronic diseases, and these health benefits are believed to be primarily due to their natural antioxidants and dietary fiber content. At present, consumers prefer foods with health benefits and, at the same time, convenient for consumption, storage, and handling. In this sense, ready-to-eat nutritious products, such as snack bars, are highly appreciated for their convenience. Snack bars are versatile products often made, with cereals, fruits, and nuts being an ideal food format to deliver healthy nutrients, bioactive compounds, and dietary fiber to the consumers.

Keywords: snack bar, health benefits, functional food, bioactive compounds, dietary fiber

1. Introduction

Globally, a relatively substantial number of terms were used to define the natural health-developed food products. For this purpose, the names of functional foods, nutraceutical foods, pharmaceutical foods, designer foods, farmafoods, vitafoods, foodaceutical, etc. were used [1]. Other terms, often grouped separately, may be included in the same regulations: medical foods, dietary supplements, fortified foods, and botanicals.

There are definitions around the world for functional foods, but there is no official or accepted definition; the functional foods are more of a concept than a defined food product group. Therefore, a functional food can be a natural food, a food in which a component has been added or has been removed, a food in which the nature of one or more components has been altered, or any combination of these possibilities [2]. Functional foods can be those foods made up of distinct, fortified, and enriched elements that provide health benefits apart from the supply of essential nutrients (e.g., vitamins and minerals) when consumed at effective levels within a varied diet [3]. A food may be functional for all individuals or for certain population groups, which can be defined, for example, by age or genetic constitution.

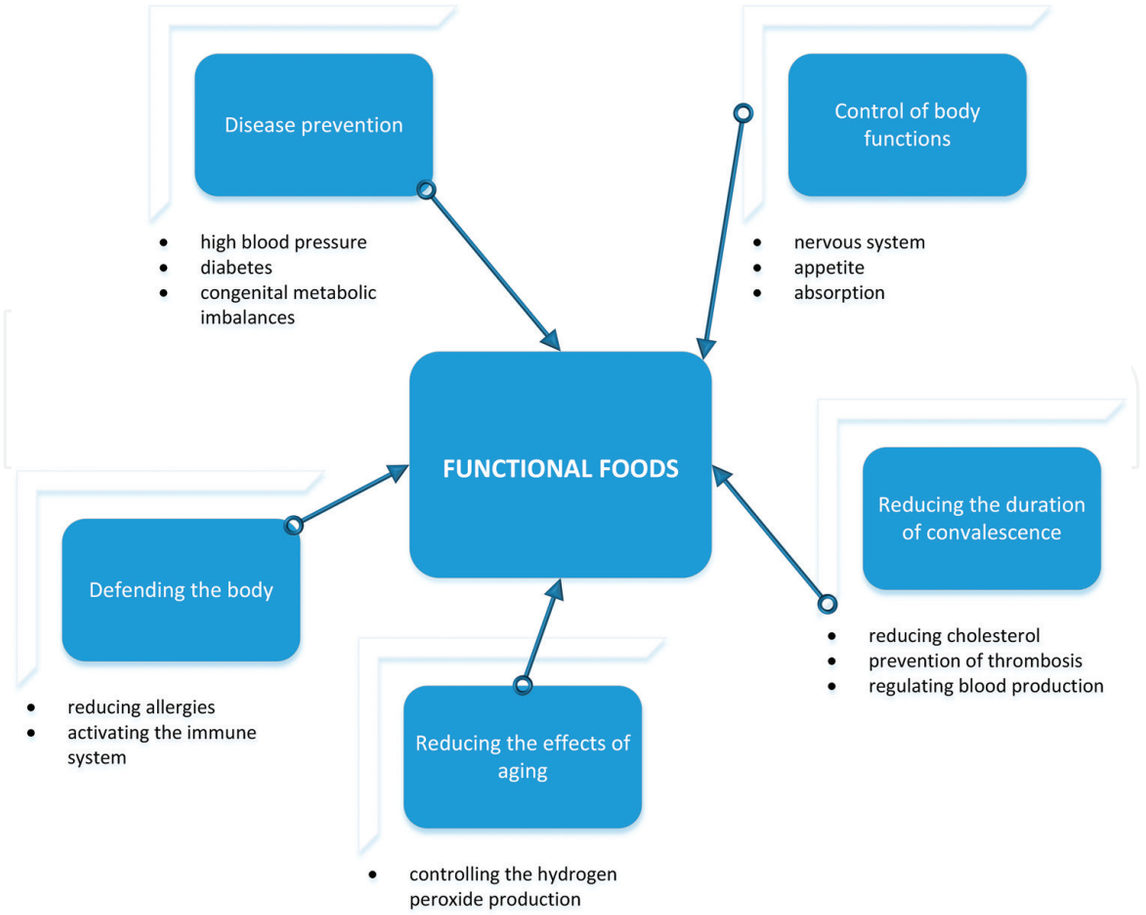


Figure 1.
The role of functional foods in regulating processes in the body.

Moreover, the functional food, besides its basic nutritional effect, has also beneficial effects on human body functions (improving the general physical state, decreasing the risk of disease evolution, etc.) [1, 4–6]. The main roles of functional foods in regulating processes in the body are presented in **Figure 1**.

For several years now, there has been a substantial interest in fast food and snack food production, due to changes on people's lifestyles. Consumers have the tendency to look for easily prepared food, such as snacks, which are defined as alternatives to quick meals with or without substantial nutritional value. According to Bower and Whitten [7], numerous products are classified as "snacks," and in this category, mini-pizzas, cakes, popcorn, cereals, and cereal-based bars can be included.

Generally, snack bars are not recognized as functional foods, mainly due to their nutrient-poor composition. In the last years, there is an interest in making new types of snack bars with functional components. Therefore, snack bars can also be included in the functional product category and to consider consumer's acceptable and suitable ready-to-eat products.

2. Snack bar types

According to a report regarding the snack food consumption in the USA [8], the snack, cereal, and nutrition bars may be classified in three main categories: health and wellness snack, organic snack bars, and energy and nutrition bars. A complex classification of functional bars is difficult to obtain, and the focus has generally been on consumption. Therefore, snack bars can be consumed as a meal part (as part of breakfast, lunch, or dinner or as a snack between meals), as a dessert (after lunch or dinner), or as a meal replacement (breakfast, lunch, or dinner).

The consumption of the snack bars is usually influenced by the age, gender, and the nutritional knowledge of the consumers. According to the International Markets Bureau market indicator [8], the consumption of the snack bars is also influenced by the following aspects: satisfying the need for sweets; saving time; using as an energy source; using for weight loss; and using for the protein, fiber, vitamin contents, etc.

3. Snack bar processing

3.1 Snack bar production process

The simplified flowcharts of snack bar production processes are shown in **Figure 2**. For the baked bar products, dry and wet raw materials are mixed together. This mixture is portioned and subjected to baking.

The baking parameters (time and temperature) differ according to the specific characteristics of the finished product. For cold-formed bar production, the ingredients are also mixed together, and the resulting mixture is portioned in the desired shape without a baking step. For both types of snacks, there may also be additional operations, e.g., filling, coating with various glazes, drying bars, etc. Despite the bar type obtained, the final operation in the technological chart is packing.

3.2 Formulation and physicochemical evaluation of snack bar ingredients

The bars are often made using a base of cereals such as oats, rice, corn, or proteins (milk dairy proteins, soy, or whey) and fortified with vitamins, minerals, and other nutrient- or energy-rich ingredients [9, 10]. Snack bars are not just popular

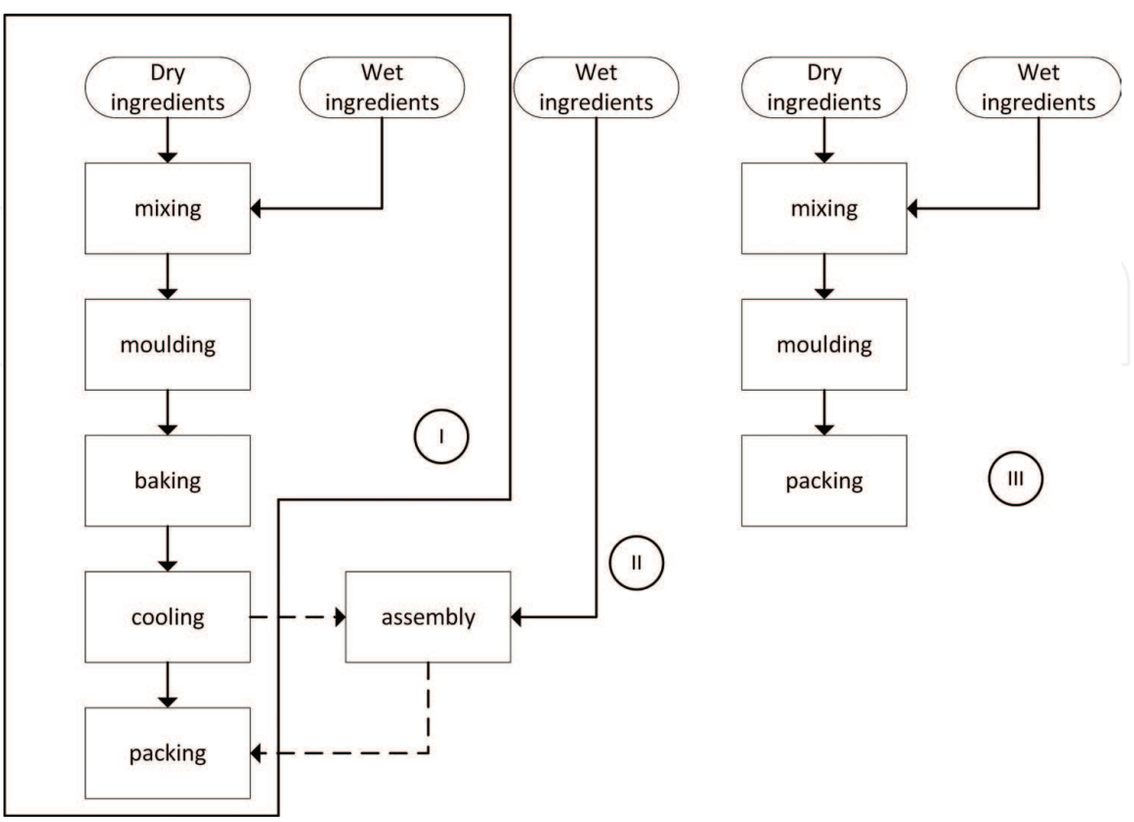


Figure 2.
Flowchart of snack bar production process (I, baked bars; II, baked bars with filling; III, cold-formed snack bar).

for their portability but also for the health implications associated with their consumption. Trends in health and wellness in food and beverages have increased more and more in recent years, as consumers are turning to less processed and more natural alternatives than regular products. Furthermore, nutritional snacks are suitable products that can provide energy and micronutrients to both healthy people and people from areas affected by famine of the world [10].

Cereal bars are very adaptable products made from processed cereals mixed with a variety of ingredients depending on the target population group [7]. Wheat and/or soy snack bars were designed as nutritional bars to provide the nutrients to consumers on the run [10]. Walnuts were successfully used in the manufacture of snack bars with good nutritional (significant amount of raw fibers and lipids) and sensory quality [11].

In recent years, the demand for high-protein snack bars has grown significantly by the people engaged in sports activities and dieting and as meal substitutes. These snack bars provide a healthy alternative to conventional snacks due to its high content of protein (15–35%, w/w) and other nutritionally beneficial ingredients [12]. In **Table 1**, different formulations for snack bars are shown.

The tendency to eat more nutritious foods instead of sweet products has led to the development of different snack bar types. Since cereal consumption extends beyond breakfast at any time of the day, these products have become an excellent vehicle for delivering ingredients to functional foods on the market. Cereals have an increasingly important role in modern lifestyle due to the convenient forms they can use such as ready-to-eat food products, snack bars, and energy bars [14].

People who are interested in getting healthier foods and maintaining good body fitness have changed their eating habits, which have promoted growth in the cereal bar market of 20% per year [18]. Therefore, snack bars can be considered as a reliable source of high-quality proteins, fibers, vitamins, and minerals. The nutritive composition of selected snack bars is presented in **Table 2**.

From the data presented in **Table 2**, the chemical composition of the snack bars varies greatly depending on their destination. The variation of snack bar composition gives the consumers the possibility to select the proper bar to purchase. Therefore, corn flake crust with fruit breakfast bar is a good source of vitamin A, thiamine, riboflavin, niacin, and vitamin B6, while formulated bar (power bar with chocolate) is a good source of protein, vitamin E (alpha-tocopherol), calcium (covers 50% of the recommended daily dose), iron, magnesium, phosphorus, zinc, and copper. Moreover, the power bar is a very good source of vitamin C (covers 154% of the recommended daily dose), thiamine (covers 537% of the recommended daily value), riboflavin, niacin, vitamin B6, folate, vitamin B12, pantothenic acid, and manganese [19].

Also, formulated bar, marathon protein performance bar and caramel nut rush, is a good source of protein (covers 50% of the recommended daily dose), calcium, iron, magnesium, zinc, copper, and manganese and a very good source of vitamin C, vitamin E (alpha-tocopherol), thiamine, riboflavin, niacin, vitamin B6, folate, vitamin B12, and pantothenic acid [19], while snack bar with soy can be considered as a good source of high-quality proteins, fibers, and B-complex vitamins [10].

Researchers reported that snack bars with a high ratio of protein/carbohydrate can improve post meal and diurnal glucose profiles in patients with type 2 diabetes and insulin resistance [20]. In addition, proteins can have a very positive effect on the human body, helping to control blood pressure, and the effect has been dependent on the type of protein [18]. Champ et al. [21] reported that the demand to increase dietary fiber content in the daily diet is justified by the positive role of fibers in health and disease prevention, especially in digestive health, energy balance, cancer, and heart and diabetes problems. According to the data presented in **Table 2**, some formulated snack bars contain higher amounts of minerals and

Snack bar type	Formulation and Functionality	References
Fruit-based snack bar	**Ingredients**: Base: rice crisps, glucose syrup, honey, vegetable oil, quick-cook rolled oats (or natural apple dietary fibre or inulin), glycerol, whey protein concentrate, maltodextrin, pectin; Filling: pectin, sugar, citric acid, glucose syrup, honey, vegetable shortening, glycerol, and apple purée. **Process:** Base: the dry and wet ingredients were mixed, moulded and baked at 130°C/15 min; Filling: ingredients were heated with stirring to 84-86% soluble solids content; Assembly: the filing was placed between base parts **Functionality:** increased polyphenols and dietary fibre contents	[13]
Wheat- or soy-based bar	**Ingredients:** water, corn syrup, glycerine, brown sugar, Arabic gum, emulsifier, puffed wheat, wheat germ, commercial coatings, shortening, soy nuggets, soy protein, soy fibre, vanilla extract **Process**: ingredients (water, corn syrup, glycerine, brown sugar, Arabic gum, emulsifier, shortening, vanilla extract) were mixed and blended in different proportions to obtain wheat bar; wheat bar with coating; wheat and soy bar with coating; soy bar with coating; wheat bar with glycerine. The puffed wheat, wheat germ, soy nuggets, soy protein, soy fibre, were heated at 85°C/4 min. All the ingredients were mixed together and moulded. The bars were cooled at room temperature. Some bars were coated and cooled supplementary. **Functionality:** high quality proteins, fibres and B-complex vitamins contents	[10]
Cereal snack bar	**Ingredients**: corn starch biscuit (or marolo flour), skimmed milk powder, rice flakes, oat flakes, corn syrup **Process**: dry ingredients were mixed and then syrup was added. The bars were manually sealed, cooled for 8 h and then cut and packed in aluminium-coated cellophane **Functionality:** the marolo flour provided an increase in dietary fibre content, vitamin C, minerals, and antioxidant activity.	[14]
Fruit and vegetable-based snack bar	**Ingredients**: Sweet: fruit and vegetable flour, rice flour, oat flakes, linseeds, sucrose syrup, brown sugar, cocoa powder Salty: fruit and vegetable flour, rice flour, oat flakes, linseeds, egg white, olive oil, condiments **Process**: Sweet: the sucrose syrup heated was mixed with dry ingredients; Salty: ingredients were mixed, moulded into bars and baked at 160°/10 min, and reposed for 6h at room temperature until cold; Both types were coated in aluminized bags, sealed **Functionality:** high fibre, protein and mineral contents	[15]
Cereal snack bar	**Ingredients**: crushed corn starch biscuit (or jerivá flour), oat, skimmed milk powder, rice flakes, corn syrup **Process:** dry ingredients were mixed, adding the syrup (corn glucose and honey) and mixing. The mixture was plastic-coated and reposed for 8h, then moulded **Functionality:** increasing in total dietary fiber, vitamin C, mineral contents and antioxidant activity	[16]
Vegetable based snack bar	**Ingredients**: bean flour, oat flakes powder, water and soy lecithin **Process**: the ingredients were mixed, and the dough obtained was coated and cut to a standard size. The snacks were baked using convection oven at 120°C/30 min, cooled at room temperature and packed in metallic bags **Functionality:** increasing in protein and dietary fiber content and the antioxidant capacity	[17]
High-protein snack bar	**Ingredients**: milk protein, high fructose corn syrup and glycerol **Process**: the ingredients were mixed, and the mixture obtained was moulded into plastic cups. **Functionality:** increasing in protein content	[12]

Table 1.
Several snack bars formulation.

Nutrients	Unit/100g	1	2	3	4	5	6	7	8
Proteins	g	9.8	4.4	14.2	18.5	25	21.9	17.5	12.46
Lipids	g	17.6	7.5	3.1	13.2	10	10.8	17.5	14.82
Carbohydrates	g	66.7	72.9	69.6	55.1	53	50.3	52.5	62.01
Total fibers	g	3.1	2.1	5.7	2.8	10	6.7	5	20.84
Minerals									
Calcium, Ca	mg	60	41	504	953	625	754	15	~
Iron, Fe	mg	3.18	4.9	11.7	14.7	10.1	16.3	5	~
Magnesium, Mg	mg	101	27	248	255	175	317	0	~
Phosphorus, P	mg	277	103	614	455	375	455	2.5	~
Potassium, K	mg	326	197	362	~	300	351	~	~
Sodium, Na	mg	251	167	308	418	225	383	125	~
Zinc, Zn	mg	1.6	4.1	10	9.6	6.6	11.9	0	~
Vitamins									
Vitamin C, total ascorbic acid	mg	1	0	92.3	144	75	490	0	~
Thiamine	mg	0.28	1.0	8.06	2.7	1.9	29	0	~
Riboflavin	mg	0.11	1.1	1.92	3.1	2.1	3.3	0	~
Niacin	mg	1.75	13.5	32.6	36.4	25	45.2	0	~
Vitamin B-6	mg	0.35	1.4	2.2	3.6	2.5	4.5	0	~
Folate, DFE	μg	81	108	1046	727	500	816	0	~
Vitamin B-12	μg	0	0	5.6	10.9	7.5	12.2	0	~
Vitamin E (alpha-tocopherol)	mg	0.82	0.8	8.28	24.6	125	27.5	0	~
Moisture	g	4.1	14.5	9.8	8.0	9.0	14.0	~	6.8
Ash	g	1.8	0.8	3.3	3.1	3.0	3.0	~	3.89
Energy value	Kcal	464	377	363	406	402	386	450	347.9

1, breakfast bars, oats, sugar, raisins, coconut (include granola bar); 2, breakfast bar, corn flake crust with fruit; 3, formulated bar, power bar, chocolate; 4, formulated bar, marathon multi grain crunch bar; 5, formulated bar; protein performance bar, caramel nut rush; 6, formulated bar, marathon energy bar; 7, snack bar with soy; 8, snack bars with beans and oat flour; ~ n.a., not analyzed.

Table 2.
Chemical composition of selected snack bars made with cereal, fruits, nuts and/or chocolate [10, 17, 19].

vitamins. Micronutrients are necessary compounds for a proper physiological state of the body that can be administered orally in the diet, and it is necessary to maintain an adequate balance [21, 22]. Minerals must be supplied from foods because they cannot be synthesized, and given the global deficiencies in different minerals, it is worthy to offer convenient food with sufficient amounts of minerals [23].

4. Functional properties of snack bar compounds

From the compounds present in snack food, only a few, through their specific action, are essential to life and are usually known as biologically active compounds.

Proteins, polyunsaturated fatty acids, vitamins, and minerals as well as food fibers or probiotics may be included in this category.

4.1 Proteins

The importance of dietary protein, as a bioactive factor, is determined deficit terms, by decreasing of metabolic capacity, reduction of energy metabolism, inhibition of biosynthesis processes, diminution of immunity, and the body resistance to external agent's actions. Proteins are necessary to support growth, tissue repair, and protection [24]. Usually, the protein necessary is influenced by the gender, age, activity level, body health, or physiological states [25, 26]. The conventional protein sources are plants and animals, e.g., meat, milk, whey egg, fish, soy, etc. [26]. In general, protein-based snack bars contain the following proportion of ingredients: soy or dairy proteins (20–40%), carbohydrates as sugar syrups (10–50%), and fats (10–15%) [27, 28]. Protein bars in addition to basic ingredients may contain other components such as flavors and stabilizers [29].

4.2 Fat and fatty acids

In addition to their role as a source of high calories, as a biomembrane construction material, or as a vehicle of fat-soluble vitamins, lipids are important by their intake in polyunsaturated fatty acids, phosphatide, and substances physiologically active, such as prostaglandin, prostacyclin, etc. [30]. The omega-3 (n-3) and omega-6 (n-6) polyunsaturated fatty acids are essential for human health and are obtained exclusively from the nutrition [31]. In recent years, emphasis has been placed on obtaining functional foods supplemented with n – 3 fatty acids. At present, there is a wide range of omega-3-enriched food products such as bakery products, dairy products, juices and soft drinks, meat products, etc. [32]. Usually, the natural sources of n-3 fatty acids are seed and fish oils [31, 33]. Snack bars with a high content of essential fatty acids are generally those that contain crop seeds and vegetable oils (canola, soybeans, corn, and sunflower oils); these are the major sources of linoleic acid (LA, C18: 2) but with a low proportion of α-linolenic acid (ALA, C18: 3) [34]. ALA sources are chia and flaxseed [34, 35]. The flaxseeds have a high antioxidant potential and omega-3 α-linolenic acid content [36, 37]. The addition of milled flaxseed in snack products, such as bars, is explained by their preventive and functional properties, such as vascular function improvement [38], anti-arrhythmic, anti-atherogenic, and anti-inflammatory functions [38–40].

4.3 Minerals

Mineral elements have a biological key role because they participate in all the vital processes of the body. Mineral substances can have different roles in vitamins and enzyme functionality, having either an activating role (calcium, magnesium, etc.) or an inhibitor (copper), and can be a part of enzyme structure as specific (sulfur, iron, copper, zinc, etc.) or unspecific (magnesium, zinc, cobalt, etc.) elements [41]. The commercial snack bars usually contain the following minerals in different intakes (**Table 2**): calcium, iron, magnesium, phosphorus, potassium, sodium, and zinc.

4.4 Vitamins

Vitamins are biologically active compounds of organic nature, with variable and complex structure. Vitamins are needed in very small quantities for the normal

development of many metabolic processes, including assimilation and the use of nutrients brought by food, growth, and tissue restoration.

Usually, snack bars commercialized on the market are rich in vitamins such as vitamin B1 (thiamine), vitamin B2 (riboflavin), vitamin B5 (pantothenic acid), vitamin B3 (niacin), vitamin B6 (pyridoxine, pyridoxal, pyridoxamine), folic acid (pteroylglutamic acid, vitamin B9), vitamin B12, vitamin C, vitamin A, and vitamin E (alpha-tocopherol).

Vitamin B1 is found in the outer layers and germ of cereals, nuts, whole grains, brewer's yeast, etc. Vitamin B1 exhibits several functions within the body, such as essential for maintaining appetite and normal digestion and necessary for growth, fertility, and lactation [42], as well as for the normal functioning of the nervous tissue [43]. According to the nutrition data [19], the bars with the highest content in thiamine are formulated bar, power bar, chocolate (8 mg/100 g), and formulated bar, marathon types: honey nut oat bar; energy bar, all flavors; chewy chocolate peanut bar; and multigrain crunch bar (~3 mg/100 g), with high daily values for adults between 197 and 537%.

Vitamin B2 is widely found in food products. Sources rich in B2 are beer and bakery yeast, meat, eggs, fish, and dairy products. In the body, vitamin B2 fulfills certain metabolic functions, as phosphorus esters are part of the flavin enzyme structure involved in biological oxidation–reduction reactions [44]and together with pyridoxine is involved in the conversion of tryptophan to nicotinic acid.

Vitamin B5, in the form of coenzyme A, is vital in the metabolism of lipids, carbohydrates, and nitrogen compounds [44]. Sources rich in pantothenic acid that are used in snack bar composition are wheat germ, mushrooms, broccoli, cauliflower, oats, dried peas, soybean, etc.

Vitamin B6 is found in large quantities in beer and bakery yeast and raw cereals. Fruits and vegetables have a lower content of vitamin B6. Pyridoxal phosphate and pyridoxamine phosphate are coenzymes involved in transamination, decarboxylation, deamination, etc. [45].

In the body, folic acid as a coenzyme is involved in accepting and transferring one carbon, from a metabolite to another [46], interfering with the synthesis of purines and pyrimidines necessary for nucleic acid formation [47]. Folic acid is mainly found in green leaves, whole grains, soybeans, wheat germ, soybeans, oranges, avocado, etc. [47, 48].

Vitamins E performs several functions in the body such as Krebs cycle regulator, a regulator of nucleic acid metabolism with implications for cell maturation and differentiation, a regulator of porphyrin and heme biosynthesis, a regulator of protein and amino acid metabolism, etc. The main nutritional function is a biological antioxidant for oxidizable vitamins and lipids [44]. Tocopherols are found in almost all foods, the richest sources usually used for bar production being vegetable oils (corn germ oil, wheat germ oil), cereal products, and eggs.

Vitamin C is acting as biochemical antioxidant and as enzyme cosubstrate [44], interfering with numerous processes, including formation of stromal proteins (collagen, elastin), maintaining capillary integrity, etc. Sources rich in vitamin C are rosehips, white sea buckthorn, citrus fruits, tomatoes and tomato juice, cabbage, parsley, nettle, spinach, cauliflower, red and green pepper, red cabbage, eggplant, broccoli, strawberries, etc. [45, 49]. In a study conducted by Sung et al. [50], a cereal bar with welsh onion extracts was obtained, rich in vitamins C, B2, B3, and B9 and with high-protein content. The study also demonstrated the nutraceutical potential of the bars for the obesity and metabolic disorder's control.

Description	Thiamine (mg/100 g)	Riboflavin (mg/100 g)	Vitamin C (mg/100 g)
Formulated bar, power bar, chocolate	8.06	1.92	92.3
Formulated bar, snickers marathon			
Honey nut oat bar	3.394	3.846	176.4
Energy bar, all flavors	2.949	3.343	489.9
Chewy chocolate peanut bar	2.727	3.091	144.4
Multigrain crunch bar	2.727	3.091	144.3
Protein performance bar, caramel nut rush	1.875	2.125	75
Formulated bar, meal bar, milk chocolate peanut	1.7	1.9	96.6
Snack, balance, original bar	1.628	1.708	11.2
Snacks, crisped rice bar, almond	1.323	1.499	11.5
Snacks, nutri-grain cereal bars, fruit	1.153	2.067	7.8
Breakfast bar, corn flake crust with fruit	1	1.1	0
Snacks, granola bar, with yogurt coating	0.905	0.542	0
Formulated bar, mixed flavors	0.75	1.7	120

Table 3.
Classification of snack bars according to the content of thiamine, riboflavin and vitamin C [51].

USDA Food Composition Databases [51] provides the selection of snack bars according to deficiency in one or more vitamins or any nutrient that must be reintroduced into the diet. As an example, a selection of the snack bar products according to the content of thiamine, riboflavin, and vitamin C is shown in **Table 3**.

4.5 Food fiber

In the food industry, fiber plays a significant role in preventing obesity, diabetes, and cardiovascular disease [52]. Fiber is incorporated into different foods for both nutritional benefits and functional properties, as well as low-cost and noncaloric partial replacements for fat and/or sugar flour [52, 53]. Cereals contain quantities of insoluble fiber, except for oats, whereas fruit and, in particular, citrus fruit and apples contain substantial amounts of soluble fiber. Lentils are also used in snack bar development, especially for their dietary fiber and the essential amino acid contents and for the folic acid and iron addition [54].

Lately, emphasis has been placed on the use of resistant starch (RS) in products as a potential functional ingredient. RS may increase the dietary fiber content [55] and promote the probiotic bacteria activity [56]. Aigster et al. [57] studied the addition of RS in granola and cereal bars, to determine the RS health significance and also the consumer acceptability. The study concluded the increasing of dietary fiber intake by the addition of RS.

5. Conclusions

In recent years, consumers are constantly changing their eating habits, wanting to improve their diet with nutritious and safe food products that are easy to

consume but, at the same time, improving health and well-being. Therefore, food industry specialists have continuously changed formulations and ingredients, and thus, new technologies to produce foods with increasing nutritional value and safety that fully meet consumers' requirements. Due to their versatility, snack bars can be used by wide categories of individuals: athletes, people dieting or with nutritional problems, or irregular meals. Snack bars allow the consumers to get necessary energy and the nutritional benefits (high-quality proteins, polyunsaturated fatty acids, minerals, vitamins, and fibers) in one convenient and easy to store package.

Conflict of interest

The authors declare no conflict of interest.

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References

[1] Roberfroid MB. Defining functional foods. In: Gibson GR, Williams CM, editors. Functional foods, 9. Cambridge England: Woodhead Publishing Limited; 2000

[2] Wang C, Li S. Functional foods and nutraceuticals potential role in human health. In: Clinical aspects of functional foods and nutraceuticals. 1st ed. Vol. 2015. Boca Raton: CRC Press. pp. 51-76

[3] Sharanya Rani D, Penchalaraju M. A review different types of functional foods and their health benefits. International Journal of Applied and Natural Sciences. 2016;**5**(3):19-28

[4] Howlett J. Functional Foods: From Science to Health and Claims. Brussel: ILSI Europe; 2008 http://ilsi.org/publication/functional-foods-from-science-to-health-and-claims/

[5] Hasler CM, Brown AC. Position of the American Dietetic Association: Functional Foods. Journal of the American Dietetic Association. 2009;**109**(4):735-746. DOI: 10.1016/j.jada.2009.02.023

[6] Ozen AE, Pons A, Tur JA. Worldwide consumption of functional foods: A systematic review. Nutrition Reviews. 2012;**70**(8):472-481. DOI: 10.1111/j.1753-4887.2012.00492.x

[7] Bower JA, Whitten R. Sensory characteristics and consumer linking for cereal bar snack foods. Journal of Sensory Studies. 2000;**15**:327-345. DOI: 10.1111/j.1745-459X.2000.tb00274.x

[8] International Markets Bureau Market Indicator. Snack, Cereal and Nutrition Bars in the United States; September 2013. Report http://www.agr.gc.ca/eng/industry-markets-and-trade/international-agri-food-market-intelligence/united-states-and-mexico/market-intelligence/snack-cereal-and-nutrition-bars-in-the-united-states/?id=1421353894973 [Accessed: 2018-06-05]

[9] Gonzales E, Draganchuk M. Flavoring nutrition bars. Cereal Foods World. 2003;**48**:250-251

[10] Aramouni FM, Abu-Ghoush MH. Physicochemical and sensory characteristics of no-bake wheat–soy snack bars. Journal of the Science of Food and Agriculture. 2011;**91**:44-51. DOI: 10.10002/jsfa.4134

[11] Estévez AM, Escobar B, Vásquez M, Castillo E, Araya E, Zacarías I. Cereal and nut bars, nutritional quality and storage stability. Plant Foods for Human Nutrition. 1995;**47**:309-317. DOI: 10.1007/BF01088268

[12] Hogan SA, Chaurin V, O'Kennedy BT, Kelly PM. Influence of dairy proteins on textural changes in high-protein bars. International Dairy Journal. 2012;**26**:58-65. DOI: 10.1016/j.idairyj.2012.02.006

[13] Sun-Waterhouse D, Teoh A, Massarotto C, Wibisono R, Wadhwa S. Comparative analysis of fruit-based functional snack bars. Food Chemistry. 2010;**119**(4):1369-1379. DOI: 10.1016/j.foodchem.2009.09.016

[14] da Silva EP, Siqueira HH, Do Lago RC, Rosell CM, Boas V, De Barros EV. Developing fruit-based nutritious snack bars. Journal of the Science of Food and Agriculture. 2014;**94**(1):52-56. DOI: 10.1002/jsfa.6282

[15] Ferreira MS, Santos MC, Moro TM, Basto GJ, Andrade RM, Gonçalves ÉC. Formulation and characterization of functional foods based on fruit and vegetable residue flour. Journal of Food Science and Technology. 2015;**52**(2):822-830. DOI: 10.1007/s13197-013-1061-4

[16] da Silva EPD, Siqueira HH, Damiani C, Boas V, de Barros EV. Physicochemical and sensory characteristics of snack bars added of jerivá flour (*Syagrus romanzoffiana*). Food Science and Technology (Campinas). 2016;**36**(3):421-425. DOI: 10.1590/1678-457X.08115

[17] Ramírez-Jiménez AK, Gaytán-Martínez M, Morales-Sánchez E, Loarca-Piña G. Functional properties and sensory value of snack bars added with common bean flour as a source of bioactive compounds. LWT- Food Science and Technology. 2018;**89**:674-680. DOI: 10.1016/j.lwt.2017.11.043

[18] Lin PH, Miwa S, Li YJ, Wang Y, Levy E, Lastor K, et al. Factors influencing dietary protein sources in the premier trial population. Journal of the American Dietetic Association. 2010;**110**:291-295. DOI: 10.1016/j.jada.2009.10.041

[19] Nutrition Data. Bars Nutrition Information in Snacks; 2018. http://nutritiondata.self.com. [Accessed: 2018-06-20]

[20] Williams G, Noakes M, Keogh J, Foster P, Clifton P. High protein high fibre snack bars reduce food intake and improve short term glucose and insulin profiles compared with high fat snack bars. Asia Pacific Journal of Clinical Nutrition. 2006;**15**(4):443-450

[21] Champ M, Langkilde AM, Brouns F, Kettlitz B, Collet Y, Le B. Advances in dietary fiber characterization. 1. Definition of dietary fiber, physiological relevance, health benefits and analytical aspects. Nutrition Research Reviews. 2003;**16**. DOI: 71.82 DOI:10.1079/NRR200254

[22] Davidi A, Reynolds J, Njike VY, Ma Y, Doughty K, Katz DL. The effect of the addition of daily fruit and nut bars to diet on weight, and cardiac risk profile, in overweight adults. Journal of Human Nutrition and Dietetics. 2011;**24**:543-551. DOI: 10.1111/j.1365-277X.2011.01201.x

[23] Rosell CM. Vitamin and mineral fortification of bread. In: Hamaker B, editor. Technology of Functional Cereal Products. Cambridge, UK: Woodhead Publishing Ltd; 2007. pp. 336-361

[24] Shang N, Chaplot S, Wu J. Food proteins for health and nutrition. In: Yada RY, editor. Proteins in Food Processing. 2nd ed. Woodhead Publishing; 2018. pp. 301-336

[25] Wolfe RR, Cifelli AM, Kostas G, Kim IY. Optimizing Protein Intake in Adults: Interpretation and Application of the Recommended Dietary Allowance Compared with the Acceptable Macronutrient Distribution Range. Advances in Nutrition. 2017;**8**(2):266-275. DOI: 10.3945/an.116.013821

[26] Dullius A, Goettert MI, De Souza CFV. Whey protein hydrolysates as a source of bioactive peptides for functional foods–Biotechnological facilitation of industrial scale-up. Journal of Functional Foods. 2018;**42**:58-74. DOI: 10.1016/j.jff.2017.12.063

[27] Li Y, Szlachetka K, Chen P, Lin X, Ruan R. Ingredient characterization and hardening of high protein food bars: An NMR state diagram approach. Cereal Chemistry. 2008;**85**(6):780-786. DOI: 10.1094/CCHEM-85-6-0780

[28] Dan Z, Labuza TP. Effect of cysteine on lowering protein aggregation and subsequent hardening of whey protein isolate (WPI) protein bars in WPI/buffer model systems. Journal of Agricultural and Food Chemistry. 2010;**58**(13):7970-7979. DOI: 10.1021/jf100743z

[29] McMahon DJ, Adams SL, Mcmanus WR. Hardening of high-protein nutrition bars

and sugar/polyol-protein phase separation. Journal of Food Science. 2009;**74**(6):312-321. DOI: 10.1111/j.1750-3841.2009.01225.x

[30] Hansen HS. New Biological and Clinical Roles for the n–6 and n–3 Fatty Acids. Nutrition Reviews. 1994;**52**(5):162-167. DOI: 10.1111/j.1753-4887.1994.tb01412.x

[31] Rubio-Rodríguez N, Beltrán S, Jaime I, Sara M, Sanz MT, Carballido JR. Production of omega-3 polyunsaturated fatty acid concentrates: a review. Innovative Food Science & Emerging Technologies. 2010;**11**(1):1-12. DOI: 10.1016/j.ifset.2009.10.006

[32] Kolanowski W, Laufenberg G. Enrichment of food products with polyunsaturated fatty acids by fish oil addition. European Food Research and Technology. 2006;**222**(3-4):472-477. DOI: 10.1007/s00217-005-0089-8

[33] Jiménez-Colmenero F. Healthier lipid formulation approaches in meat-based functional foods. Technological options for replacement of meat fats by non-meat fats. Trends in Food Science and Technology. 2007;**18**(11):567-578. DOI: 10.1016/j.tifs.2007.05.006

[34] Saini RK, Keum YS. Omega-3 and omega-6 polyunsaturated fatty acids: Dietary sources, metabolism, and significance: A review. Life Sciences. 2018;**15, 203**:255-267. DOI: 10.1016/j.lfs.2018.04.049

[35] Goyal A, Sharma V, Upadhyay N, Gill S, Sihag M. Flax and flaxseed oil: An ancient medicine & modern functional food. Journal of Food Science and Technology. 2014;**51**(9):1633-1653. DOI: 10.1007/s13197-013-1247-9

[36] Aliani M, Ryland D, Pierce GN. Effect of flax addition on the flavor profile of muffins and snack bars. Foodservice Research International. 2011;**44**(8):2489-2496

[37] Martinchik AN, Baturin AK, Zubtsov VV, Molofeev V. Nutritional value and functional properties of flaxseed. Voprosy Pitaniia. 2012;**81**(3):4-10

[38] Dupasquier CM, Weber AM, Ander BP, Rampersad PP, Steigerwald S, Wigle JT, et al. Effects of dietary flaxseed on vascular contractile function and atherosclerosis during prolonged hypercholesterolemia in rabbits. American Journal of Physiology. Heart and Circulatory Physiology. 2006;**291**(6):2987-2996. DOI: 10.1152/ajpheart.01104.2006

[39] Ander BP, Weber AR, Rampersad PP, Gilchrist JS, Pierce GN, Lukas A. Dietary flaxseed protects against ventricular fibrillation induced by ischemia-reperfusion in normal and hypercholesterolemic rabbits. The Journal of Nutrition. 2004;**134**(12):3250-3256. DOI: 10.1093/jn/134.12.3250

[40] Dupasquier CMC, Dibrov E, Kostenuk AL, Yeganeh B, Moghadasian MH, Pierce GN. The beneficial effects of dietary flaxseed on atherosclerosis in the LDL receptor deficient mouse occur in part through anti-proliferative and anti-inflammatory actions. American Journal of Physiology. Heart and Circulatory Physiology. 2007;**293**:2394-2402. DOI: 10.1152/ajpheart.01104.2006

[41] Hathcock JN. Vitamins and minerals: efficacy and safety. The American Journal of Clinical Nutrition. 1997;**66**(2):427-437

[42] Gould WA. Glossary for the Food Industries. 1st ed. Woodhead Publishing; 1995

[43] Martel JL, Franklin DS. Vitamin, B1 (Thiamine). 2017. https://www.ncbi.nlm.nih.gov/books/NBK482360/

[44] Combs GF Jr, McClung JP. The vitamins: fundamental aspects in nutrition and health. Academic press; 2016

[45] Saghiri MA, Asatourian A, Ershadifar S, Moghadam MM, Sheibani N. Vitamins and regulation of angiogenesis:[A, B1, B2, B3, B6, B9, B12, C, D, E, K]. Journal of Functional Foods. 2017;**38**:180-196. DOI: 10.1016/j.jff.2017.09.005

[46] Stover PJ. one-carbon metabolism–genome interactions in folate-associated pathologies. The Journal of Nutrition. 2009;**139**(12):2402-2405. DOI: 10.3945/jn.109.113670

[47] Mahmood L. The metabolic processes of folic acid and Vitamin B12 deficiency. Journal of Health Research and Reviews. 2014;**1**(1):5. DOI: 10.4103/2394-2010.143318

[48] Abularrage CJ, Sidawy AN, White PW, Aidinian G, Dezee KJ, Weiswasser JM, et al. Effect of folic Acid and vitamins B6 and B12 on microcirculatory vasoreactivity in patients with hyperhomocysteinemia. Vascular and Endovascular Surgery. 2007;**41**:339-345. DOI: 10.1177/1538574407301692

[49] Sinha R, Patterson BH, Mangels AR, Levander OA, Gibson T, Taylor PR, et al. Determinants of plasma vitamin E in healthy males. Cancer Epidemiology and Prevention Biomarkers. 1993;**2**(5):473-479

[50] Sung YY, Kim SH, Kim DS, Park SH, Yoo BW, Kim HK. Nutritional composition and anti-obesity effects of cereal bar containing *Allium fistulosum* (welsh onion) extract. Journal of Functional Foods. 2014;**6**:428-437. DOI: 10.1016/j.jff.2013.11.009

[51] USDA Food Composition Databases; 2018. https://ndb.nal.usda.gov/ndb/nutrients/report/nutrientsfrm?max=25&offset=0&totCount=0&nutrient1=404&nutrient2=405&nutrient3=401&fg=23&subset=0&sort=c&measureby=g [Accessed: 2018-06-11]

[52] Spotti MJ, Campanella OH. Functional Modifications by Physical Treatments of Dietary Fibers used in Food Formulations. Current Opinion in Food Science. 2017;**15**:70-78. DOI: 10.1016/j.cofs.2017.10.003

[53] Elleuch M, Bedigian D, Roiseux O, Besbes S, Blecker C, Attia H. Dietary fibre and fibre-rich by-products of food processing: Characterisation, technological functionality and commercial applications: A review. Food Chemistry. 2011;**124**(2):411-421. DOI: 10.1016/j.foodchem.2010.06.077

[54] Ryland D, Vaisey-Genser M, Arntfield SD, Malcolmson LJ. Development of a nutritious acceptable snack bar using micronized flaked lentils. Foodservice Research International. 2010;**43**(2):642-649. DOI: 10.1016/j.foodres.2009.07.032

[55] Kendall CW, Emam A, Augustin LS, Jenkins DJ. Resistant starches and health. Journal of AOAC International. 2004;**87**(3):769-774

[56] Topping DL, Fukushima M, Bird AR. Resistant starch as a prebiotic and symbiotic: state of the art. Proceedings of the Nutrition Society. 2003;**62**(1):171-176. DOI: 10.1079/PNS2002224

[57] Aigster A, Duncan SE, Conforti FD, Barbeau WE. Physicochemical properties and sensory attributes of resistant starch-supplemented granola bars and cereals. LWT- Food Science and Technology. 2011;**44**(10):2159-2165. DOI: 10.1016/j.lwt.2011.07.018