

A REVIEW OF PLANT-BASED, HIGH PROTEIN SNACK BARS: COMPOSITION, NUTRITIONAL VALUE AND HEALTH BENEFITS

**Mihaela Cristina DRĂGHICI, Mihaela GEICU-CRISTEA, Elisabeta Elena POPA,
Paul-Alexandru POPESCU, Amalia Carmen MITELUȚ, Mona Elena POPA**

University of Agronomic Sciences and Veterinary Medicine of Bucharest, Faculty of
Biotechnologies, 59 Mărăști Blvd, District 1, Bucharest, Romania

Corresponding author email: paul.alex.popescu@gmail.com

Abstract

In present days, consumers tend to spend more effort and time in order to find a well-balanced diet for maintaining a healthy life-style despite the daily-life problems that occur because of the current life and work style. Alternative food products such as functional foods or nutraceutical are gaining more sympathy from the general consumers because they can prevent diseases and uphold a healthier life. Food products that are convenient for consumption, storage, and handling are being sought after by consumers. Snack-bars are ready-to-eat nutritious products, that can contain different vitamins, proteins and other components that are of value for the human nutrition, and are also easy to eat. Snack-bars can be used as a meal replacement, as desserts or as salty snacks throughout the day, and their consumption is influenced by different factors such as protein content, sugar content, protein and fibre content or vitamin content. This review aims to highlight the current researches in the development of plant-based, high protein snack bars, and their composition, nutritional value and health benefits.

Key words: *plant-based snack bar, health benefits, functional food, protein content.*

INTRODUCTION

The current work style and the increasing number of families where both partners work have led to a decrease in the time available for cooking and therefore a greater demand for convenience and ready-to-eat food products foods, which should be fresh, natural, minimally processed and without additives (Eldesouky & Mesias, 2014). Snack-type meals, with or without substantial nutritional value, have become an alternative to fast meals, being popular among consumers of all ages (Constantin & Istrati, 2018). Recent changes in the way of shopping preferences and consuming food products have led consumers to give greater importance to aspects such as convenience, sustainability and the health impact of the food products bought. This represents a challenge for the food industry, especially in regard to perishable foods such as fresh fruits and vegetables (Mesías et al., 2021). Therefore, current research directions are directed towards the full use of harvested fruits and vegetables, minimizing the amount of waste resulting from processing them. Food products are recommended to be consumed in

their integral form. The more processed a product is, the more it can lose vitamins, minerals or fiber from its composition (Richter et al., 2015). So, achieving a nutritionally balanced protein snack is a scientifically and technologically advanced goal.

The main characteristics of food bars are that they have enough nutritional benefits for the health of the consumer and are also easy to consume. Foods bars are found in the markets in different forms, the main ones being: salty and sweet cereal bars, sweet fruit bars and unsweetened cereal and fruit bars. Because of their main ingredients, they are a good source of fibres (Paiva et al., 2012), energy (Jabeen et al., 2022) and protein.

Although the term functional food is being used for some time in the food industry, there is no official or accepted current definition for it. Functional foods are products that are naturally beneficial for the health of the consumer or have distinct, fortified, and enriched elements that provide health benefits besides those that come from the supply of essential nutrients (Wang & Li, 2015; Sharanya & Penchalaraju, 2016). The main roles of functional foods in

promoting human health are presented in Figure 1.

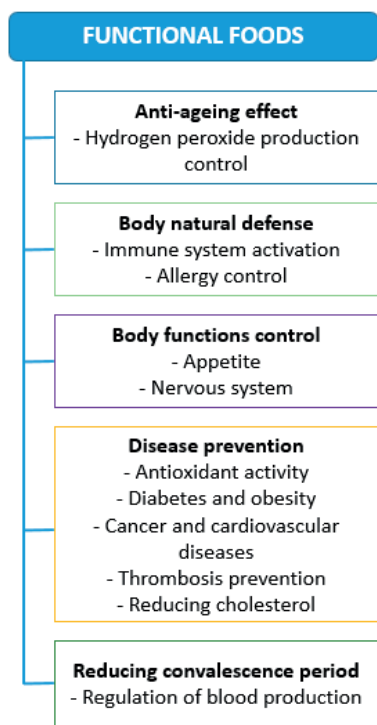


Figure 1. The role of functional foods in regulating processes in the body (source: Constantin & Istrati, 2018)

MATERIALS AND METHODS

This state of the art study is a literature review that investigated reviews and research articles that have been published in the last decade regarding high interest topics such as functional foods products and plant based high protein snack bars.

The content analysed and presented in this review article is focused on highlighting the developments, ingredients, nutritional values and health benefits of ready-to-eat salty snack-bars, which are gaining more and more popularity between food product consumers because of their advantages, such as ease of consumption or high protein values. Several international databases such as, Web of Science, Wiley, Scopus, Elsevier and Springer and Google Academic were electronically scanned for study articles and reviews and the main keywords were: “ready-to-eat snack

bars”, “high protein content vegetables”, “health benefits of vegetables protein”.

RESULTS AND DISCUSSIONS

Nowadays, diets that promote the consumption of high amounts of carbohydrates and sugars are linked with higher disease incidence and mortality rates. In opposition, plant based-diets which consist of legumes, vegetables, fruits and whole grains are generally considered to promote human health (Herpich, 2022). Plant-based diets are not only environmentally sustainable, but play a major role in the prevention of several diseases, such as metabolic syndrome (McGrath & Fernandez, 2022) chronic kidney disease (Bernstein, 2007), hypertension, acidosis, diabetes (Betz, 2021), and cardiovascular disease (Herpich, 2022). High-protein bars are popular food products, that contain 20-50% protein and can provide in a quick way the energy that the human body needs at a certain point (Jiang, 2021), thus being consumed all over the world but the manufacturing process can be difficult for the producers because processing issues such as clogging, sticking and cold flow.

An important part of the human diet are proteins, that contribute directly to human health and are usually found in plants (soy, beans, chickpeas, buckwheat) and animals (meat, milk, egg, fish). (Fox et al., 2015; Kumar et al., 2022; Jin et al., 2022; Grasso et al., 2022; Qin et al., 2022). Protein based snack bars usually contain proteins from cereals and dairy, carbohydrates in different quantities, fats and other auxiliary ingredients such as preservatives, flavors and stabilizers (Constantin & Istrati, 2018).

Vitamins, as proteins, serve a critical role in the human nutrition, being needed in order to maintain a healthy life and to guide several metabolic processes (Sá et al., 2022). Vitamins such as B1, B2, B5, E and C can be found in several kinds of snack-bars on the market, the proportions of each vitamin depending on the ingredients of the snack bar (Constantin & Istrati, 2018). Vitamin B1 is usually found in cereals, nuts and whole grains, thus this vitamin is present in higher quantities in oats, peanut, multigrain snack-bars (Mikkelsen & Apostolopoulos, 2019). Snack-bars rich in oats,

soybean, mushrooms and cauliflower are a good source of vitamin B5 (Yadav & Negi, 2021). Vitamin C is found in food products like tomatoes, cabbage, parsley, spinach, red and green pepper, red cabbage, eggplant and broccoli, all of which can be found in snack-bar type of products (Tylewicz et al., 2020). Currently, their industry is developing testing methods, such as wear testing, which will help the problems that occur in the formulation development stage (Sparkman et al., 2019).

Mushrooms

The use of mushrooms as a functional ingredient has increased over the years because of their high protein and fiber content as well as the low fat content. Moreover, they contain valuable constituents such as polyphenols, terpene and terpenoids, mannitol and trehalose which are beneficial for human consumption and health (You et al., 2022). González et al., 2021 studied the possibility of obtaining and characterizing a protein concentrate from a *Pleurotus ostreatus* flour. Nutritional and functional proprieties were evaluated and the parameters for extraction, such as pH and flour-solvent ratio were optimized. The results showed that the protein density increased to 78% and the protein digestibility increased by the decrease of total phenolic compounds in the protein concentrate.

Spim et al., 2021, evaluated the consumer preferences and nutritional value of four different kinds of snack bars, two sweet and two salty one, made from *Lentinula edodes* (shiitake) and other vegetable ingredients. The sensorial tests were performed by hedonic scale analysis of texture, aroma, taste and appearance, and the nutritional values analyzed were moisture content, lipids, fibers, proteins, glucans and phenolic compounds. The results showed that the sweet bars had better sensory acceptance, and as for the nutritional values, the shiitake bars showed high concentrations of calcium, iron, phosphorus, potassium, zinc, manganese, phenolic compounds and glucans.

Peas and beans

Peas and beans are currently used as the main ingredients in vegetables based snacks because of their high protein content. Several studies have been made to study the protein content

and the factors affecting this parameter. Walters et al., 2022, studied the changes in the protein content of Field peas (*Pisum sativum*) and Faba beans (*Vicia faba*) cultivated under different ecophysiological factors. Soil composition, meteorological parameters and cultivar conditions were evaluated and the protein content was evaluated. The results showed that the protein content of the analyzed peas and beans was influenced directly by the cultivar and the period of cultivation. In terms of the ecophysiological factors, higher temperatures and low rainfall were associated with a high protein content.

A snack bar from bean and oat flour was developed by Ramírez-Jiménez et al., 2018, and the consumer acceptance and nutritional values (lipids, fibers, carbohydrates, protein, total flavonoids and antioxidant activity) were assessed. In order to carry out the experiments, 27 different samples where the main ingredients varied in percentage were tested and ranked accordingly to the most desired formulations. The results showed that the snack bars made from bean and oat flour had better values in protein content, total flavonoids and antioxidant capacity compared to a control samples that no bean or oat flour added. Also, the carbohydrates and lipid content was lower.

Soy

Soy protein and its by-products are used in the food industry as raw materials in different kinds of salty snacks and food products because of their high-protein content. As soy protein is easily digestible, having a corrected amino acid score of 1.00, almost the same as animal proteins and from a sensory point of view a desirable texture, it can be successfully used as a good source of vegetable proteins by the food industry (Qin et al., 2022).

Lobato et al., 2012, developed a snack bar rich in isoflavones and soy protein as a functional food product in order to help control people with dyslipidaemia. The analysis carries out in the studies focused on the shelf-life of the snack-bars and on the health benefits. The results showed that the water activity and hardness of the developed snack bars increased over the shelf-life analysis. In order to see the health benefits of the snack bars over the high-density lipoprotein cholesterol and triglycerides

levels, a clinical trial was carried out by testing lipid profiles of 22 dyslipidaemic subjects for a period of 45 days. An increase in high-density lipoprotein cholesterol (HDL-c) (+8%) and a decrease in the triglycerides levels (-20%) was observed when compared to baselines values.

Other ingredients

da Silva et al., 2014, carried out a study in which marolo (*Annona crassiflora* Mart) flour was used as a functional ingredient in the composition of a snack bar in order to valorise the nutritional proprieties of this fruit. The results showed that the addition of up to 20% of marolo flour in the snack bars increased the dietary fiber, minerals and vitamin C content and also the antioxidant activity. The addition

of up to 10% of this flour into the snack bar, improved its organoleptic proprieties such as texture, taste, appearance and overall acceptance.

Rawat & Darappa, 2015, carried out a study in which they created a novel energy bar by replacing brown flour with a fibre rich mixture (banana, coconut and oats flour, psyllium husk) and a protein rich mixture (sesame, chickpea flour, soya and whey protein isolates). The authors analysed the during a 3 months' period the nutritional proprieties (protein and fibre content), rheological and quality characteristics of the energy bars. The results showed that the protein and dietary fibres showed 9 times increase values over the analysis period.

Table 1. Protein bar composition

Protein bar composition	Protein and fibre content (%)	Advantages	References
Dried shiitake, oats, quinoa, rice flakes, flaxseed and sesame seeds, dried tomatoes, peanut butter, parmesan cheese and condiments parsley, garlic, onion, oregano, thyme, bay leaf, pepper and salt	Proteins: 2.27 ± 0.23 Fibres: 9.99 ± 2.00	Health benefits, higher protein and fibre content, low-cost production and food consumer acceptance	Spim et al., 2021
Rice crisps, glucose syrup, honey, vegetable oil, quickcook rolled oats, glycerol, whey protein concentrate, maltodextrin, pectin, sugar, citric acid, glucose syrup, honey, vegetable shortening, glycerol, and apple purée.	Proteins: 2.01 ± 0.07	Health benefits, good source of dietary fibres and polyphenols	Sun-Waterhouse et al., 2010
Water, corn syrup, glycerine, brown sugar, Arabic gum, emulsifier, puffed wheat, wheat germ, commercial coatings, shortening, soy nuggets, soy protein, soy fibre, vanilla extract	Proteins: 3.00 % Fibres: 13 %	High protein and fibre content and B-complex vitamins	Aramouni & Abu-Ghoush, 2011
Sugar, glucose syrup, palm oil, glycerol, pastry flour, oats, golden raisins, apricot, apple, pear	For pear enriched samples: Proteins: 5.07 ± 0.03 / Fibres: 8.06 ± 0.50 For apple enriched samples: Proteins: 5.19 ± 0.09 / Fibres: 7.59 ± 0.55	High fibre content, good sensory proprieties	Bchir et al., 2018
Cooked bean flour, oat flour, water and soy lecithin as emulsifier in different proportions	Proteins: 12.46 ± 0.05 Dietary fibres: 20.84 ± 0.08	Improved the nutritional and bioactive profile; Protein, dietary fibre and antioxidant capacity increased values	Ramírez-Jiménez et al., 2018
Dates, cheddar cheese, whey protein isolate), roasted chickpea flour, and rice flour in different proportions	Proteins: 22.3% to 23.6% Crude fiber: 5.81 to 7.16	Improved the total protein content and diversity of proteins	Jabeen et al., 2022

A high protein content snack bar made from modified sweet potato flour, mung beans flour and whey protein concentrate was developed by Sunyoto et al., 2019. The scope of the study was to develop a snack bar with a protein content of at least 10-15% in order to meet emergency food requirements. The best formulation was 55:45 ratios of sweet potato flour:mung beans flour, thus obtaining a product with a protein content of 13.96% and raw fiber content of 3.45%. Also the sensory analysis showed that the consumer acceptance was good, the color, flavor and aroma being accepted.

Several research articles studied the potential use of different cereals and vegetables in obtaining high nutritional value snack bars, such as: corn bran (de Sousa et al., 2019), jerivá flour (Silva et al., 2016), date (Ibrahim et al., 2021), sorghum flakes (Ribanar et al., 2015), banana flour (Umme et al., 2021), jackfruit seed flour (Meethal et al., 2017)

CONCLUSIONS

In recent years, the food industry is slowly leaning towards developing food products that are rich in nutrients, easy-to-eat and possess health promoting ingredients. One category of foods that cover all these aspects and they also have a long shelf-life are snack-bars, which can be found on the market in different forms: sweet and salty snack-bars. Usually, snack-bars are consumed throughout the day and because of their nutritional benefits (high content of proteins, fibers, minerals or vitamins) they can be considered good meal replacements. There has been a lot of research studies that showed that snack bars can be classified as functional foods with good promoting health properties, as functional ingredients such as bean flour, dried shiitake mushroom and quinoa flour or fibre rich mixtures (banana, coconut and oats flour, psyllium husk), protein rich mixture (sesame, chickpea flour, soya and whey protein isolates), are incorporated in the recipe.

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