Chapter

Fermented Functional Beverages

Daniela Ionela Istrati, Eugenia Mihaela Pricop, Alina Georgiana Profir and Camelia Vizireanu

Abstract

Functional foods are intensively studied and promoted by various organizations in the field of food and nutrition. They are foods that, by their initial, fortified, enriched, or improved composition, offer health benefits. At global level, there is a great interest in promoting fruit varieties, vegetables, and pseudocereal consumption in order to improve our health. Due to their content in essential compounds such as antioxidants, important amounts of fruits and vegetables should be included in our daily diet. New food matrixes, such as fruit and vegetable juices, have been tested for their ability to deliver probiotic microorganisms and results were promising. Technological progress made possible the use of fruits and vegetables as ideal substrates for probiotics development, due to their content in minerals, vitamins, fibers, and antioxidants. Probiotic products based on vegetables have a continuous development due to the increase in popularity of vegetarianism and the growth of lactose intolerance among the entire world population.

Keywords: functional foods, fermented juices, probiotic microorganisms, antioxidants, health benefits

1. Introduction

In the last decade, preventive medicine has made significant progress, demonstrating the crucial role of nutrition in preventing diseases, especially those related to diet. The concept that foods have health promotion effects beyond their nutritional value has been increasingly accepted in recent years, and the specific effects of nutrition prevention on disease have led to the discovery of functional foods.

Functional foods are those foods that can be eaten in the normal diet and contain biologically active compounds with potential for improving health or reducing the risk of diseases. Examples of functional foods include foods that contain minerals, vitamins, fatty acids, food fibers, and food with the addition of biologically active substances such as the antioxidants and probiotics.

2. Functional foods

The concept of functional foods emerged in the 1980s in Japan when the medical authorities in the country recognized that an increase in life expectancy and in the number of elderly people should be accompanied by an improvement in the quality of life. The main aspect that enhances the quality of life is food. Thus, the concept of foods developed especially for the purpose of promoting health and reducing the risk of disease occurrence.

Currently, many healthy products are known, defined as functional foods or nutraceuticals. Functional foods are foods that, by way of the nutrient intake, contribute to maintaining and improving the health of consumers. These foods offer the opportunity to reduce, directly or indirectly, the medical costs associated with various cortical conditions such as diabetes, coronary heart disease, cancer, etc. [1, 2].

The products in this category experienced a real expansion, now at the beginning of the twenty-first century worldwide, whereas, at the end of the last millennium, only a few countries such as USA, Canada, Japan, and some European countries developed such products. Generally, within the existing regulations in different countries, it is accepted that the term functional food can be used for products similar to conventional foods, while the term nutraceutical is intended for the concentrated form. Both forms should be considered as natural products with obvious health benefits.

There are currently no separate regulations for functional foods in the United States and other countries except for Japan. The academic scientific community in Japan used to define the food that performs three functions as a functional food in the early 1980s. The first function is nutrition. The second function is the sensory function or sensorial satisfaction. The third is a tertiary psychological function. In short, Japan back in 1984, defined ad hoc the term functional food as a food with physiological functions, including regulation of biorhythm, nervous system, immune system, and self-defense of the body beyond nutritional functions.

In 1991, the Japanese Ministry of Health, Labor and Welfare (MHLW) established the "Foods for Specified Health Uses" regulatory system (FOSHU) to approve the statements on food labels as regards the effects of food on the human body. Foods that are subject to FOSHU approval are scientifically analyzed to determine their effectiveness and safety by the Council of Pharmaceutical Affairs and Food Hygiene under MHLW leadership [3].

In 1998, in the U.S.A., there were 11 Food and Drug Administration (FDA)-approved correlations among foods or their components and diseases. These include:

- correlations between foods with high calcium content and decreased risk of osteoporosis,
- correlations between foods with low fat content, saturated fat, low cholesterol, and reduced risk of coronary heart disease, and
- correlations between products containing sugar alcohols and the risk of tooth decay reduction.

These are claims for the relationship between high calcium content foods and a reduced risk for osteoporosis; claims for low fat saturated foods, cholesterol lowering and fat lowering and the risk of coronary artery disease reduction; and a demand for sugar alcohols in relation to the reduced risk of dental cavities. The mention for diets containing soluble fiber with a potential to reduce the risk of coronary artery disease has been altered twice in order to allow recognition of the beneficial effects of soluble fiber provided by oats and psyllium bran [4].

In Europe, the interest in functional foods emerged in the second half of the 1990s. The European Commission has generated an activity entitled Functional Food Science in Europe (FuFoSE) to explore the functional concept of food based on a scientific approach. Thus, the European Commission has determined that "a food can be considered functional if, together with the basic nutritional impact, there are also beneficial effects for one or more functions of the human body either by improving the general and physical conditions or by reducing the risk of disease progression" [5, 6].

Examples of functional foods include foods containing specific minerals, vitamins, fatty acids, or dietary fibers; foods containing added biologically active substances such as phytochemicals or other antioxidants; and probiotics containing live beneficial cultures. Therefore, a functional food can be as follows:

- an unprocessed natural food product;
- a food product in which a component has been improved by special breeding, reproduction, or biotechnological means;
- a food product to which a component has been added to provide benefits;
- a food product from which a component has been removed by technological or biotechnological means;
- a food in which a component has been replaced by an alternative component with favorable properties;
- a food in which a component has been modified by enzymatic, chemical, or technological means to provide a benefit;
- a food in which the bioavailability of a component has been altered; or
- a combination of any of the above [7].

The scientific community continues to increase its understanding of the functional foods potential and their role in maintaining and optimizing health. As regards the benefits to be validated and the requirements to be met, approval from a strong and trustworthy scientific research entity is required to confirm the benefits of each food product or component. For functional foods to provide potential public health benefits, consumers should be able to rely on the scientific criteria that are used to document such health statements and claims.

3. Vegetables and fruits with functional role

Many plants or their compounds with physiologically active role have been investigated for their role in disease prevention and health assurance. The components of food products of plant origin that have been scientifically proven to bring benefits to human health are numerous. Naturally, fruits and vegetables are rich in carbohydrates, dietary fiber, mineral vitamins, polyphenols, and phytochemicals; they are designated as healthy foods as many researchers have reported the beneficial effects of juices on health [8].

Tomatoes and processed tomatoes, by their high content of lycopene and β-carotene—powerful antioxidants—can help reduce prostate cancer. According to the clinical studies conducted on patients in the Health Professionals Follow-Up Study (HPFS) during 1986–1992, it was found that administering over 10 servings/week processed tomatoes or tomatoes reduces the risk of prostate cancer by 35%, and in the case of serious forms of prostate cancer, a reduction of 53% was found [9]. The most important aspect is that out of 46 evaluated fruits and vegetables, only tomatoes have been associated with reducing the risk of prostate cancer [9]. A balanced diet containing broccoli, carrots, spinach can help reduce the risk of macular degeneration with age or cataracts [10].

Cherries, red grapes, forest fruits, and other red- and violet-colored fruits and vegetables are rich in flavonoids (anthocyanins—cyanidin, pelargonidin, and malvidin), bioactive compounds with an important role in preventing and reducing the risk of various cancers and cardiovascular diseases, considering that their consumption supports antioxidant cellular defense.

Apples and pears are an important source of phenolic compounds to support heart health. However, the pears have a smaller amount of phenolic compounds, around 30 mg/100 g, as compared to fresh apples that may contain 357 mg/100 g [11]. By their high content of insoluble fiber, especially the skin and shell, fruits and vegetables,

contribute to maintaining the health of the gastrointestinal tract, while soluble fiber in beans, apples, and citrus can reduce the risk of coronary affections [12].

Forest fruits are rich in anthocyanins and broad-spectrum antioxidants on biomedical functions. These include cardiovascular disease, oxidative stress induced by aging, inflammatory response, etc. [1].

Potassium content in bananas and beans helps lowering blood pressure when their consumption is associated with a low-fat diet. Also, in beans, salads, and spinach, there are folates—that is folic acid—which play an important role in preventing the birth of children with different spinal and cerebral disorders.

Most fruits are rich in vitamin C, predominantly the citruses, kiwi, and berries. The role of vitamin C is well known for its antioxidant action and the prevention of free radical formation in the body that can promote the emergence of different cancers. Vitamin C also helps the immune system fight different pathogenic agents.

Fenech et al. [13] have demonstrated the positive effect of eating nine micronutrients easily found in fruits, namely, calcium, retinol, vitamin E, folic acid, nicotinic acid, riboflavin, pantothenic acid, β-carotene, and biotin on the damage and the repair of the genome.

The above listed are just a few functional features of some vegetables and fruits: scientific studies in this field being very diverse and elaborate.

4. Microorganisms used in producing fermented beverages of plant origin with a functional role

The gastrointestinal microflora is made up of a complex of microorganisms that form a particularly important part of the organism. These microorganisms interfere with each other and with the host organism in the intestinal tract where they exist. The normal intestinal microflora may undergo changes by way of diet, medication and/or environmental factors. These imbalances can be remedied by two methods:

- Oral administration of live microorganisms (probiotics)
- Oral administration of some bacterial stimulants for certain indigenous (prebiotic) microflora components

According to FAO/WHO (2001), probiotics are living microorganisms (mainly bacteria and certain yeast strains) that influence the host organism by improving microbial intestinal balance. Probiotics have numerous beneficial effects on the body of which we can mention:

- increased lactose tolerance and digestion,
- positive influence on intestinal microflora,
- reduction of intestinal pH,
- improvement of intestinal functions,
- reduction of cholesterol,
- reducing the level of ammonia and other toxic compounds,
- production of folic acid,
- restoring normal intestinal microflora after antibiotic treatments,
- treatment and prevention of diarrheal seizures due to rotaviruses, and
- stimulating the immune system response.

Fruit, cereals, vegetables, and soy beverages have been reported as a suitable medium for probiotic cultures due to the essential nutrient content [14]. Fruit, grain, vegetable, and soy beverages have been proposed as novel products containing probiotic strains; essentially, fruit and vegetable juices have been reported as a new suitable support for probiotics. Nevertheless, maintaining viability (the recent trend is to have 1 billion viable cells/100 g of product) and maintaining the activity of probiotics in these products by the end of the product shelf-life are two important criteria to be met in juices where low pH is a disadvantage [15].

At present, there are numerous studies on the production of functional beverages, with researchers in the field tackling many variants to obtain them. Different approaches could be grouped as follows:

- Exploiting the functionality of microorganisms
- Optimizing the production and formation of new functional beverages
- The use of prebiotics and symbiotics
- The use and processing of natural ingredients
- The use of the by-products from the fruits and food industry as functional ingredients

In addition to that, some works focus and propose the application of new technologies to improve the production of functional beverages without compromising their sensory and functional properties [5].

Many researchers have investigated the possibility of using various fruit and vegetable juices such as tomatoes, mangoes, oranges, apples, grapes, peaches, pomegranates, watermelons, carrots, beetroot, and cabbage as raw materials for the production of probiotic juices or drinks. The most commonly used probiotics include different strains of *Lactobacillus* spp. (*Lb. acidophilus, Lb. helveticus, Lb. casei, Lb. paracasei, Lb. johnsonii, Lb. plantarum, Lb. gasseri, Lb. reuteri, Lb. delbrueckii* subsp. *bulgaricus, Lb. crispatus, Lb. fermentum, Lb. rhamnosus); Bifidobacterium* spp. *(B. bifidum, B. longum, B. adolescentis, B. infantis, B. breve, B. lactis, B. laterosporus);* and other species such as *Escherichia coli Nissle, Streptococcus thermophilus, Weissella* spp., *Propionibacterium* spp., *Pediococcus* spp., *Enterococcus faecium, Leuconostoc* spp. și *Saccharomyces cerevisiae* var. *Boulardii* [14, 16, 17]. Most probiotic microorganisms are lactic bacteria belonging to *Lactobacillus* spp. and bifidobacteria. Nevertheless, other types of microorganisms are used as probiotics: *Enterococcus faecalis, Lactococcus lactis*, and *Saccharomyces boulardii* [18].

5. Functional beverages based on fruits and vegetables

5.1 General aspects

The probiotics market is currently dominated by fermented dairy products. These are the best environment for developing and maintaining the viability of probiotic microorganisms. However, there is a trend of increasing demand for probiotic vegetable products due to negative aspects of dairy consumption. Lactose intolerance, proteins with allergenic potential, and cholesterol content may adversely affect human health [19].

Vegetables are a suitable substrate for the development of probiotic microorganisms because they contain vitamins, minerals, and fibers, but the development of a probiotic drink having a vegetal substrate involves many stages. The factors that may have a negative influence on the viability of microorganisms in vegetable

products are as follows: organic acids, pH, compounds with antimicrobial activity, temperature, and the storage time of the fermented food product. The optimal storage temperature of fermented products is 4–5°C [20].

Also, another important challenge is to obtain a product with sensory properties acceptable to the consumer. The combination of substrate with probiotic microorganisms can lead to undesirable volatile compounds.

5.2 Nondairy fermented beverages: from traditional to commercial foods

Since ancient times, fermentation has been used to preserve vegetables as well as to improve their nutritional and sensorial qualities. Most products are fermented at ambient temperature with the existing microflora, with no strict control of fermentation and microorganism development (**Table 1**).

These are mainly consumed due to sensory characteristics. There are few researches on the composition and safety of these beverages. Starting from traditional beverages, many researches focused on the development of vegetarian probiotic beverages (**Table 2**). In order to improve the stability of the products obtained and their nutritional value, prebiotics are added in their composition. The applicability of laboratory studies led to the development of commercial products (**Table 3**). Although their cost is high, companies selling such products are on the rise.

In order to maintain the innocuity and the functional value of vegetal probiotic products, special packaging was created to meet the challenges posed during storage in the shelves of the shops. Most manufacturers recommend storing at 4°C, with the indication that packaging deformities may occur due to the high CO_2 content resulting from the fermentation process. After unpacking, the product should be stored, refrigerated, and consumed in the shortest possible time.

Beverage name	Origin	Substrate	Microorganisms isolated
Boza	Bulgaria, Albania, Turkey and Romania	Wheat, rye, millet, maize, and other cereals mixed with sugar or saccharine	*Lactobacillus plantarum, L. acidophilus, L. fermentum, L. coprophilus, L. brevis, Leuconostoc reffinolactis, Leuconostoc mesenteroides, Saccharomyces cerevisiae*
Bushera	Uganda	Sorghum	*Lactobacillus* spp., *Lactococcus* spp., *Leuconostoc* spp., *Enterococcus* spp., *Streptococcus* spp.
Mahewu	Africa and some Arabian Gulf countries	Maize	*Lactococcus lactis*
Togwa	Africa	Maize, millet	*Lactobacillus* spp., *Streptococcus* spp.
Hardaliye	Turkey	Red grapes	*Lactobacillus paracasei, L. casei, L. brevis, L. pontis, L. acetotolerans, L. sanfrancisco. L. vaccinostercus*
Kombucha	China	Tea	*Gluconacetobacter* spp. *(G. xylinus), Acetobacter* spp., *Lactobacillus* spp., *Zygosaccharomyces* spp., *Hanseniaspora* spp., *Torulaspora* spp., *Pichia* spp., *Dekkera* spp., *Saccharomyces* spp.
Water Kefir	Mexico	Water, sucrose	*Lactobacillus* spp. (*L. lactis), Leuconostoc mesenteroides, Zymomonas* spp., *Dekkera* spp., *Hanseniaspora* spp., *Saccharomyces cerevisiae, Lachancea fermentati*, *Zygosaccharomyces* spp.

Table 1.
Traditional probiotic beverages [19, 21].

Substrate	Probiotic microorganisms	References
Tomato juice	*Lactobacillus acidophilus* LA39, *Lactobacillus casei* A4, *Lactobacillus delbrueckii* D7, *Lactobacillus plantarum* C3	[22]
Beet juice	*Lactobacillus acidophilus* LA39, *Lactobacillus casei* A4, *Lactobacillus delbrueckii* D7, *Lactobacillus plantarum* C3	[23]
Cabbage juice	*Lactobacillus casei* A4, *Lactobacillus delbrueckii* D7, *Lactobacillus plantarum* C3	[24]
Carrot, celery, and apple cocktail	*L. acidophilus* LA-5	[25]
Olives	*L. paracasei* IMPC2.1	[26]
Honeydew melon juice	*L. casei* NCIMB 4114	[27]
Cereals and grape juice	*L. plantarum* 6E și M6	[28]
Malț	*L. plantarum* NCIMB 8826, *L. acidophilus* NCIMB 8821	[29]
Herbal mate	*L. acidophilus* ATCC 4356	[30]
Sapodilla, grapes, orange, and watermelon juice	*L. acidophilus*	[31]
Pineapple juice	*Lactobacillus casei* NRRL B442	[32]
Peach juice	*Lactobacillus plantarum* DSMZ 20179, *L. delbrueckii* DSMZ 15996, *L. casei* DSMZ 20011	[33]
Germinated seeds and sprouts of lentil and cowpea,	*Lactobacillus plantarum* VISBYVAC	[34]
Cereals, vegetables, and soymilk	*Lactobacillus acidophilus* NCDC14	[35]
Cereals	*Lactobacillus acidophilus* NCIMB 8821, *Lactobacillus plantarum* NCIMB 8826, *Lactobacillus reuteri* NCIMB 11951	[36]
Soymilk, almonds, and peanuts	*Lactobacillus rhamnosus* GR-1	[37]
Rice	*Lactobacillus fermentum* KKL1	[38]

Table 2.
Studies regarding the production of probiotic beverages.

5.3 Current trends in the development of probiotic beverages based on vegetable products

The industry of probiotic vegetable products is in its early stages, as the first commercial product appeared on the market in 1994. Increasing the availability of these products on the market, improving the existing technologies, and increasing the consumer's interest make this segment a promising one [21].

Probiotics can be inoculated directly into fruit or vegetables juices due to existing aseptic dosing technologies. In order to maintain the viability of probiotics throughout the life of products, microencapsulation, vacuum impregnation, and prebiotics are used [19]. Of a high importance is the relationship between different probiotic cultures, especially yeasts and bacteria.

A possible solution to the increase in probiotic resistance in new food matrices is their genetic modification, although in many countries, there is a low acceptability of these microorganisms [39]. Lactic fermentation is often used for preserving vegetables, so the best approach at this time is to develop probiotic products using known strains [40].

An important aspect in the development of new products is the acceptability from the sensorial point of view. Consumers want nutritious and tasty products for an affordable price. Traditional fermented products are a basis for developing

Beverage name	Origin	Substrate	Probiotic microorganisms
Proviva	Sweden	Orange, strawberry, or blackcurrant juice	*Lactobacillus plantarum 299v*
GoodBelly	U.S.A.	Mango, blueberry acai, pomegranate, blackberry, tropical green, cranberry, watermelon, tropical orange, and coconut water juices	*Lactobacillus plantarum* 299v
Biola	Norway	Orange-mango and apple-pear flavors	*Lactobacillus rhamnosus GG*
Biola	Finland	Seven varieties of juices	*Lactobacillus rhamnosus* GG
Gefilus	Finland	Fruit juice	*Lactobacillus rhamnosus GG, Propionibacterium freudenreichii ssp. shermanii JS*
Good Belly	U.S.A.	Fruit juice	*Lactobacillus plantarum* 299v
Kevika	U.S.A.	Sparkling lemon ginger probiotic drink	*Bacillus coagulans, L. rhamnosus, L. plantarum, L. paracasei*
Rela	Sweden	Fruit juice	*Lactobacillus reuteri* MM53
Healthy life probiotic	Australia	Apple and mango juice	*Lactobacillus paracasei* and *Lb. plantarum*
Malee probiotic juices	Thailand	White grape and orange juice	*Lactobacillus paracasei*

Table 3.
Commercial probiotic vegetable and fruit beverages [5, 14, 15].

new probiotic products in a manner that ensures their innocuity and stability. For the future, new research is needed in order to understand the microbiological and nutritional potential of traditional products [41].

Due to the high costs involved in the development of probiotic products, a collaboration between academia and the industry partners could lead to a much faster development of new products [42]. The use of vegetable residues and by-products resulting from different technological processes (e.g., vegetable pulp) would have beneficial effects on the environment and add value to finished products. Although they have shown good viability in new food matrices, clinical studies are required to demonstrate adherence to the intestine and viability of probiotics following the consumption of probiotic-based vegetable products.

6. The benefits of drinking functional vegetable and fruit beverages

Beverages are the most active category of functional foods because of the convenience and the ability to meet consumers' demands in terms of content, size, shape, and appearance of the packaging, as well as, the ease in distribution and better storage for the refrigerated products. Beverages represent also an excellent medium to incorporate necessary nutrients and bioactive compounds [43–45]. Therefore, beverages based on fruits and vegetables have been proposed as a novel suitable carrier for probiotics delivery. Since fruits and vegetables are naturally rich in essential macro- and micronutrients (carbohydrates, dietary fibers, vitamins, minerals, polyphenols, and phytochemicals), the incorporation of probiotics into

juices makes them healthier [8]. Juices fortification with probiotic is a challenge and a frontier objective, because juices can combine nutritional effects with health benefits by way of adding probiotic strains.

Fruits and vegetables are the key component of a healthy diet, and if consumed in sufficient quantities every day, it could help prevent major diseases [46]. Instead, low fruit and vegetable consumption is a risk factor for chronic diseases such as cancer, coronary artery disease, stroke, and cataract formation [47]. Fruits and vegetables are important sources of vitamin C, thiamine, niacin, pyridoxine, folic acid, magnesium, iron, riboflavin, zinc, calcium, potassium, and phosphorus [48]. Some components of fruits and vegetables (polyphenols and phytochemicals) are strong antioxidants. The antioxidants act as radical scavengers and help turn the radicals into a less reactive species. Antioxidants represent the first line of defense against damage caused by free radicals and are essential for maintaining an optimal health and well-being. Antioxidants modify the metabolic activation and detoxification/disposition of carcinogens and may even influence processes that may change the course of the tumor cells [48]. Regular consumption of fruits and vegetables has been recognized as reducing the risk of chronic diseases [49]. Ranadheera et al. [50] reported on the beneficial health effects of fruit juices. According to experimental data obtained, the berries, such as blueberry, blackberry, and raspberry, have shown negative effects on some pathogenic microorganisms, improving, instead, the growth of beneficial bacteria.

Fruit and vegetable intake has been shown to have positive effects in terms of weight management and obesity prevention [51, 52]. Several studies reported a reverse relationship between the intake of fibers from fruits and vegetables and the risk of developing coronary heart disease [52, 53]. Also, diets rich in fruits and vegetables, which improved blood glucose control and lowered the risk of developing type-2 diabetes [54], have a strong protective effect against several types of cancer (oropharynx, esophagus, stomach, colon, and rectum) [55, 56] and promote detoxification of the human body [57].

Our digestive system is made up of beneficial bacteria that are responsible for assisting our digestive system to digest food, absorb nutrients, fight against harmful bacteria, and eliminate toxins. When these bacteria are killed, intestinal health is impaired. Consumption of fermented food and avoiding unhealthy food that feeds bad bacteria can help nourish healthy intestinal bacteria and balance the relationship between beneficial and bad bacteria, which will be reflected ultimately in our health and wellness.

The health benefits of probiotic bacteria depend on their viability. According to International Federation for Dairy (IDF), at least 107 probiotic bacterial cells should be alive at the time of consumption per gram or milliliter of product [58]. Beneficial effects attributed to probiotics are the enhancement and maintenance of well-balanced intestinal microbiota. The probiotics can be used in prevention and treating diseases and health disorders such as lactose intolerance, serum cholesterol, high blood pressure [59], irritable bowel syndrome, Crohn's disease, peptic ulcers, antibiotic-associated diarrhea [60–63], and cancer [64, 65]. Also, probiotics offer higher immune protection [66, 67].

7. Conclusion

As consumer awareness grows, fermented foods are becoming more and more popular and tend to be one of the largest functional food markets. The most important reason for the development and acceptance of fermented foods as probiotic fruit and vegetable beverages are related to preservation, improved nutritional properties (vitamins, minerals, fibers, and antioxidants), better taste, flavor and

aroma, food products with high biological value, and improved health benefits. Also, probiotic fruit and vegetable beverages do not have allergens as lactose or casein and are cholesterol free. However, the development of probiotic fruit and vegetable beverages is still in the early stages nowadays.

Conflict of interest

The authors declare no conflict of interest.

Author details

Daniela Ionela Istrati, Eugenia Mihaela Pricop, Alina Georgiana Profir and Camelia Vizireanu*
Department of Food Science, Food Engineering, Biotechnology and Aquaculture, Faculty of Food Science and Engineering, "Dunarea de Jos" University, Galati, Romania

*Address all correspondence to: cameliavizireanu@gmail.com

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