Fruits and Beverages as Functional Foods

Subjects: Nutrition & Dietetics

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It is largely accepted that the daily intake of fruits, vegetables, herbal products and derivatives is an added value in promoting human health, given their capacity to counteract oxidative stress markers and suppress uncontrolled pro-inflammatory responses. Given that, natural-based products seem to be a promising strategy to attenuate, or even mitigate, the development of chronic diseases, such as diabetes, and to boost the immune system.

functional foods

functional beverages

cherry blueberry

health properties

1. Introduction

Food is any substance consumed capable of providing nutrients required for several functions, such as producing energy, supporting various metabolic activities, growing processes, and promoting wellness and a healthy status ^[1] ^[2]. In recent decades, the demand for healthy foods and beverages has increased worldwide, mainly due to their nutritional values and health-promoting properties, demonstrating their ability to reduce the risk of oxidative stress-related disorders and others ^{[3][4][5]}. Given that, it is not surprising that the knowledge about the influence of nutrition on health and well-being has greatly increased, leading to the development of new and healthier foods, which are called functional foods ^[6].

The concept of functional foods was firstly described in ancient Vedic texts from India and was also an integral part of traditional Chinese medicine since early times ^[Z]. In the 1980s, it was introduced in Japan, in the face of escalating processed foods that, in addition to their nutritional function, contained ingredients with specific bodily functions and beneficial physiological effects ^[Z]. In 1984, after the increase in healthcare costs, an ad hoc group of the Ministry of Education, Science, and Culture in Japan launched a national project to explore the link between medical sciences and foods, and to legislate these products into Foods Of Specified Health Use (FOSHU) (**Table 1**) ^[B] given their biological potential ^[9]. To receive a FOSHU designation, manufacturers must complete an application that includes scientific evidence of the proposed medical or nutritional relationship, the proposed dose of the functional food, the safety of the food, and a description of the physical/chemical properties, experimental methods, and composition of the food ^[10].

Table 1. The Japanese FOSHU criteria for functional food.

- They are food (not capsules, pills, or powder) based on naturally occurring food components
- They can and should be consumed as part of the normal daily diet

- They have a defined function on the human organism:
 - To improve immune function
 - To prevent specific diseases
 - To support recovery from specific diseases
 - To control physical and physic complaints
 - To slow down the ageing process

The term "functional food" was first mentioned in 1993 in a scientific paper in Nature News Magazine entitled "*Japan explores the boundary between food and medicine*" ^[11]. There is no doubt about the interest of Japanese consumers in functional foods, and consequently, the growing awareness of functional products throughout the world. However, there is no consensus between Europe and the United States of America (USA) on a relatively concrete definition for functional foods, resulting in a variety of different terms: nutraceutical, designer food, pharmafood, and others, which contribute to increasing the confusion between professionals and consumers ^[12]. The USA prefers the term "nutraceutical", while European experts decided to adopt the term "functional food" with a consensus definition within the FUFOSE (Functional Food Science in Europe) project (**Table 2**).

 Table 2. The FUFOSE definition of functional food in Europe



Advertised by authorized claims

2. Functional Foods Definition References

Functional foods are used to increase certain physiological functions, and to prevent or even cure, diseases ^[14]. The Continue of Substantiable of Substantiable of Substantial foods, Carlina by Eliteration of Substantial foods, and dietary energy and the substantiable of Sub

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3). Sloan, A.E. Top 10 functional food trends. Food Technol. 2020, 64, 22–41.

5. Dimmito, M.P.: Stefanucci, A.: Della Valle, A.: Scioli, G.: Cichelli, A.: Mollica, A. An overview on in the USA, there is no formal definition of functional foods, interested, the terms nutraceutical, dietary supplement, or medical foods, are used (fable 4), and therefore, functional foods cannot be regulated differently from other foods. 111963.
Despite government authorities, national and international organizations have proposed their definitions of fonktional Social Bodes and a lack of clarity for scientists, governments, and consumers as to what 7. Henry, C.J. Functional foods and a lack of clarity for scientists, governments, and consumers as to what 7. Henry, C.J. Functional foods. Eur. J. Clin. Nutr. 2010, 64, 657–659.
"functional foods" actually are. There is an urgent need for researchers to rethink the meaning of functional foods in Japan. Toxicology 2006, 221, 95–111.
Although the terms "nutraceuticals" and "functional foods" are commonly used worldwide, there is no consensus on 9. Arai, S. Studies on functional foods in Japan-state of the art. Biosci. Biotechnol. Biochem. 1996, their meaning. Therefore, the Bureau of Nutritional Sciences, of the Food Directorate of Health Canada, has 60, 9–15.
proposed the following definitions: a nutraceutical is a product isolated or purified from food, generally sold in 14eMattirosyme. Governments for foods of Nutritional foods or parasite of the food Directorate of Health Canada, has 60, 9–15.
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risk of chronic disease ^[16]. According to regulation (functional food ^[16]), a functional food is a food with specific 12 López-Varela S. González-Gross, M. Marcos A, Functional foods and the immune system. A beneficial effects on one of more target functions in the body that go beyond basic nutritional functions and result in improved health status and well-being of a reduction in the risk of disease. It is consumed as part of a normal diet

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of functional foods in Europe: Consensus document. Br. J. Nutr. 1999, 81, S1–S27.

Functional foods are clearly in a different category than nutraceuticals, pharmafood, or dietary supplements. They 14 Roberfroid, M.B. Prebiotics and probiotics: Are they functional foods? Am J. Clin, Nutr. 2000. 71 are considered food, not a pharmaceutical drug because they have health-promoting properties, which are usually disease-preventive, rather than therapeutic properties (**Table 3** and **Table 4**).

1	Scioli, G.; Della, A.; Zengin, Tabitel 30 Gateelial Mefiliai dag batu Actional tellida.; Stefanucci, A.; Mollica, A.			
	Artisanal fortified beers: Brewing, enrichment, HPLC-DAD analysis and preliminary screening of			
	Reference	Definition		
1	FOSHAN [18]	Foods for specified health use. The FOSHU can be foods that exhibit health effect, used as foods in a diet, and are in the form of foods, not as supplements	the	

			html
1	Health Canada, Ontario, Canada [<u>19</u>]	A functional food to be similar in appearance to conventional food, to be consumed as part of the usual diet, to demonstrate physiologic benefits, and/or to reduce the risk of chronic disease beyond basic nutritional functions.	Maciuk,
1	International Food Information Council, Washington, USA	Foods or dietary components may provide a health benefit beyond basic nutrition.	nal
1			e online:
	International Life Sciences Institute	Foods that by physiologically active food components provide health benefits beyond	⁻ ebruary
2	of North America (ILSI North America) ^[21]	basic nutrition.	d the
2		Euroctional food is a food with cortain bonoficial offorts on one or more target functions in	Foods,
2	Regulation (EC) No 1924/2006 ^[17]	the body beyond the basic nutritional effects with a result of the improved health state and well-being or reduction of risk of diseases. It is consumed as a part of a normal diet and is not used in the form of a pill or capsule or any other form of dietary supplement.	2003,
2	[7]		
		A food product can be made functional by using any of the five approaches listed below:	;821–
2		(1) Eliminating a component known to cause or identified as causing a deleterious effect when consumed (for example, an allergenic protein). (2) Increasing the concentration of a component naturally present in food to a point at which it will induce predicted effects (for	cil of 10
2		example, fortification with a micronutrient to reach a daily intake higher than the recommended daily intake). (3) Adding a component that is not normally present in most foods and is not necessarily a macronutrient or a micronutrient, but for which beneficial	USA.
2		effects have been shown (for example, non-vitamin antioxidant or prebiotic fructans). (4)	
	Canada. Regul.	Funct. Foods Nutraceuticals A Glob. Perspect. 2007, 79, 213–226.	

2	Reference	Definition	ctive;
2		Replacing a component, usually a macronutrient (for example, fats), intake of which is usually excessive and replacing it with a component for which beneficial effects have been shown (for example, modified starch). (5) Increasing bioavailability or stability of a component known to produce a functional effect or to reduce the disease-risk potential of the food.	nd avier- e of in Food
(r) (r)	Functional Food Center (FFC) ^[10]	Natural or processed foods that contain known or unknown biologically-active compounds; which, in defined, effective non-toxic amounts, provide a clinically proven and documented health benefit for the prevention, management, or treatment of chronic disease. In this definition, first functional foods can be natural or processed. Second, bioactive compounds, which are considered to be the source of the functionality of the foods, are secondary metabolites that occur in food usually in small amounts that act synergistically to benefit health. Specifically, bioactive compounds may exert antioxidant, cardio-protective and chemo-preventive effects.	lucans: 6-year roval for
(J)	Food and Nutrition Board (FNB) of the National Academy of Sciences, Washington, USA) [22]	Functional food is one that encompasses potentially healthful products, including any modified food or food ingredient that may provide a health benefit beyond that of the traditional nutrient it contains.	support- 2022). 97, 14,
3		Bioactive Compounds:	slation.
(1) (1)	The Office of Dieta dietary supplements,	ry Supplements at the NIH has defined bioactive compounds as constituents in foods or other than those needed to meet basic human nutritional needs, which are responsible for changes in health status ^[23] .	of EFSA
		Dietary Supplements:	IS.
(1) (1)	Dietary supplements mean foodstuffs, the purpose of which is to supplement the normal diet, and which are concentrated sources of nutrients or other substances with a nutritional or physiological effect, alone or in combination, marketed in dose form, namely forms such as capsules, pastilles, tablets, pills and other similar forms, and sachets of powder, ampoules of liquids, drop dispensing bottles, and other similar forms of liquids and powders designed to be taken in measured small unit quantities ^[24] .		olics in . Anal. nds and 2019,
		Functional Ingredients:	
4	and phytochemi	cal composition of 23 Portuguese sweet cherries as conditioned by variet	ysical v (or
	1. 7		

4	Functional ingredients are a diverse group of compounds; health benefits have been attributed, for example, to allyl compounds found in garlic, carotenoids, and flavonoids, found in fruits and vegetables, glucosinolates, found in cruciferous vegetables, hypericin and pseudohypericin found in St. John's wort, peptides such as epidermal growth factor, opioid peptides, and lactoferrin, found in milk, and arachidonic and docosahexaenoic acids, found in human milk and derived for use in infant formulas from various algal, bacteria, and fish sources. Functional ingredients can be marketed as part of dietary supplements, food additives, or generally recognized as safe (GRAS) ingredients included in functional foods ^[22] .	tamin C
4	Medical Foods:	a lint
4	A Medical Food is a food that is "formulated to be consumed or administered under the supervision of a physician and which is intended for the specific dietary management of a disease or condition for which distinctive nutritional requirements are established by medical evaluation ^[25] .	unds: try; -78.
	Natural health products:	
4	Natural health products (NHPs) include homoeopathic preparations, substances used in traditional medicine, a mineral or trace element, a vitamin, an amino acid, an essential fatty acid, or other botanical-, animal-, or microorganism-derived substance ^[26] .	ristics of
4	Nutraceutical:	berry '169.
4	The term nutraceutical is a substance that may be considered a food or part of a food that provides medical or health benefits, encompassing prevention and treatment of disease. Products as diverse as isolated nutrients, dietary supplements, and diets, to genetically engineered "designer" foods, herbal products, and processed foods (cereals, soups, beverages) may be included under the umbrella of nutraceuticals ^[27] .	rcaloric .3,

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 Table 5. Categories of functional foods.

Category	Example
Basic food	Carrots (containing the antioxidant β -carotene); Turmeric (containing curcumin); Grapes (containing resveratrol)
Processed foods	Oat bran cereal
Processed foods with added ingredients	Calcium-enriched fruit juice; margarine enriched in phytosterols; Beverages enriched with vitamins and minerals
Food enhanced to have more of a functional component	Tomatoes with a higher level of lycopene
	Isoflavones from soy
Isolated, purified preparations of active food ingredients (dosage form)	eta-Glucan from oat bran
	Anthocyanins from red fruits

Several dairy products have also been explored, such as yogurts with live cultures and lactose-free cheeses. The addition of margarine is another commonly available functional food product. Examples of functional beverages are energy drinks and those enriched with vitamins and minerals or lactose-free milk (**Table 5**) ^[7].

In conclusion, there is a consensus about the term functional which is used to enhance certain physiological functions in order or even cure medical conditions; however, some control exists about the fact that capsules, pills, and powders might be included ^[14]. A functional food can be (i) a natural food, (ii) a food to which a component has been added, (iii) a food from which a component has been removed, (iv) a food where one or more components has been modified, (v) a food in which the bioavailability has been modified, or (vi) any combination of these ^[Z]. There is no EU legislation on functional foods, so this definition has legal force. It is only a current working definition: functional foods are not pills, capsules, or any form of food supplement, but in any case, they must retain the character of a food, and their consumption must be part of a normal diet.

3. Fruits and Beverages as Functional Foods

The global consumption of fruit beverages reached 95.69 billion liters in 2018, representing 0.78% less compared to 2017, accounting for 37.23 billion juice drinks, 10.92 billion liters for nectar, and 30.55 billion for powdered and concentrated juice ^[31], revealing its great importance in the world economy. Consumers demonstrated an

increased interest in juices with innovative and functional juice ingredients that help improve health. With the pandemic coronavirus in 2020, demand for juice in Europe rapidly increased. It is common to see orange juice consumption increase during the flu season in Europe. However, COVID-19 completely changed consumption patterns. Until 2019, European juice consumption decreased at an annual rate of 1% for almost a decade. But in 2020/2021, consumption increased again in several European markets. After the COVID-19 pandemic began, consumers regained some interest in citrus juices and red fruits. They also became more interested in functional ingredients in drinks ^[32].

Functional beverages occupied over half (USD 99 billion) ^[13] of the total market value (USD 168 billion) of functional foods in 2019 ^[33], with approximately 1/3 of the market value (USD 36 billion) being contributed by the Asia Pacific region ^[13].

The growth of functional beverages and novel ingredients has led to improved legislation (Regulation No. 258/97) ^[34] from the European Commission (EC), which now requires the submission of a comprehensive safety document before novel ingredients can be used in foods. The EC is willing to grant approval and support the industry provided their development is based on scientific evidence and validated in human populations ^[32]. Within the emerging paradigm of functional foods, functional beverages may help increase the consumption of fruits and vegetables to restore the balance between recommendations and actual consumption, although consumption of juices is not equivalent to the consumption of whole fruits or vegetables.

In 2007, the regulation regarding nutrition and health claims made on foods was introduced in the European Union. This regulation provides opportunities for the use of health claims on foods in Europe, including claims to reduce the risk of disease. Nutrition and health claims must be based on and substantiated by generally accepted scientific evidence; EFSA requires RCT (Randomized Control to demonstrate the beneficial physiological effects on a healthy population ^{[35][36]}.

Consumers around the world are looking for healthier, more natural, and functional products, looking for relaxation, energy, performance, and memory, as well as the addition of exotic ingredients and vegetables ^[28]. The consumption of low-sugar options has already been consolidated in the market by natural substitutes ^[31]. Beverages are commonly used to deliver high concentrations of functional ingredients (e.g., sports and performance drinks, ready-to-drink teas, vitamin-enriched water, soy, and energy beverages) ^[28].

Functional beverages have been reported as the most active and popular among consumers, taking into account meeting consumer demands for desirable nutrients and bioactive compounds, easiness in distribution and storage, size, shape, and appearance ^[37]. Beverages have been used habitually to deliver high concentrations of functional ingredients, associated with their easy delivery and human body need. Beverages represent an appropriate solution for the dissolution of functional ingredients, but also a convenient and widely accepted method of consumption. The processing of beverages can contribute to some sensory barriers (e.g., bitter taste, grainy texture, etc.), and they provide a proper method of ingestion ^[28]. The different types of commercially available

beverages could be grouped into: (i) dairy-based beverages including probiotics and minerals/ ω -3 enriched drinks, (ii) vegetable and fruit beverages, and (iii) sports and energy drinks ^[37].

As far as the study of fruit juice is concerned, two major groups have been focused on: (i) juices high in antioxidants, or (ii) juices relatively low in antioxidants, but widely consumed by the general public. However, there are also mixed juices with high antioxidant activity that are consumed in relatively large quantities ^[28]. The first group of juices includes pomegranate, cranberry, and blueberry, as well as other dark fruits, such as cherry and blackcurrant, which have higher levels of phenolic compounds (e.g., phenolic acids, flavonoids, anthocyanins, and tannins) ^{[38][39][40]} In the other category, research focused on orange, grape, and apple juices, which contain mainly hydroxycinnamic acids and vitamins ^{[28][41][42]}.

Berries, such as blueberries and sweet cherries, are usually consumed as fresh fruits, however, but various technological products are also widely available. They are usually processed into juices, concentrate, and jams/purees; additionally, their oils can be extracted from seeds ^[29]. Interest in beverages has increased significantly in recent years. Studies have demonstrated more beneficial effects of berries phytochemicals, which has led to an increase in consumption associated with increased health awareness among consumers ^{[29][39][40][43]}. ^[44]

Red fruits such as berries are an important component of a healthy diet due to their high content of phenolic acids and flavonoids, especially anthocyanins ^{[29][40][43][44]}. Blueberries (*Vaccinium* spp.) and cherries (*Prunus* spp.) are considered one of the five healthy foods certified by the International Food and Agriculture Organization (FAO) because they are rich in phenolic compounds, anthocyanins, and other nutrients ^[45]. Their consumption has increased in recent years, partially due to the health benefits attributed to their phenolic content. Blueberries are composed of high levels of anthocyanins, flavonols, and flavan-3-ols, as well as benzoic and cinnamic acids ^{[43][46]}. ^[47]. Several health benefits were reported for blueberries and cherries given their capacity to offer protection against metabolic disorders thanks to their remarkable antioxidant, anti-inflammatory anti-diabetic properties ^{[48][49]}.