



# Functional Foods and Food Supplements

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**Abstract:** This Special Issue aims to provide new findings and information with respect to healthy foods and biologically active food ingredients. Studies on the chemical, technological, and nutritional characteristics of healthy food ingredients will be taken into consideration as well as analytical methods for monitoring their quality. New findings on the bioavailability and the mechanism of action of food bioactive compounds will be considered. Moreover, studies on the rational design of potential new formulations, both of functional foods and of food supplements, have been taken into account.

**Keywords:** functional foods; dietary supplements; food bioactive compounds; formulations; bioavailability; biological activities; quality control

It is well known that a clear relationship exists between the food that we eat and our well-being. Nowadays, foods are not intended to only satisfy hunger and to provide necessary nutrients, but they can confer additional health benefits to human, preventing nutrition-related diseases, and improving physical and mental well-being [1].

The recent technological advancement, the socio-economic trends, and the population lifestyle modifications throughout the world indicate the need for foods with increased health benefits [2]. In this view, the demand for functional foods and dietary food supplements in the global market have increased rapidly, according also to the popular belief, although sometimes wrong, that ‘natural’ is healthier and safer than synthetic drugs.

Functional foods are foods that, consumed as an integral part of the normal diet, can provide, in addition to nutrients, one or more bioactive compounds, adding beneficial health effects to the traditional nutritional ones [3]. Recent trends in the food industry show that functional foods have become increasingly popular around the world and they are becoming a part of the daily diet of developed countries [3]. The health benefit of functional foods derives from their composition of bioactive compounds, which can occur naturally, form during industrial processing or be extracted from other sources and added [4]. Examples include phytochemicals such as vitamins, peptides, polyphenolic compounds, carotenoids, and isoflavones, which provide health benefits, mainly on development and growth, regulation of metabolic processes, defence against oxidative stress, cardiovascular and gastrointestinal physiology, and physical and cognitive performances [5]. These products, aimed at the maintenance of well-being, should present the highest quality standards if compared to the corresponding conventional products [6]. Japan, United States, and Europe have the highest amount of functional food consumers [5].

Food supplements are concentrated sources of bioactive compounds (i.e., minerals, amino acids, vitamins, herbs or other botanicals, and other dietary ingredients) to supplement the normal diet by increasing the total intake of these substances, but they are not intended to treat disease [7].

Nowadays, dietary food supplements are widespread, and they play an increasingly important role in the consumer’s awareness. According to Euromonitor International, the current sales of these

food products in the European Union are close to 7 billion Euros annually, and they are constantly growing [8].

Food supplements are used by the population for many different purposes including health maintenance, preventing diseases, balancing diets, improving appearance and wellness as well as to increase sport performance [8]. Unlike functional foods, they are marketed in dosage forms (i.e., pills, tablets, capsules, or liquids in measured doses) [9].

This Special Issue provides a good overview of the status and the developments in the field of functional foods and food supplements. It includes papers focused on different food matrices as innovative natural sources of bioactive compounds endowed with health-promoting properties.

Colombo et al. [10] presented an overview on botanicals as ingredients in functional foods and food supplements. In recent decades, the interest in botanicals has grown exponentially and, consequently, the relative market increased all over the world [11,12]. Botanicals have become among the most popular in the food supplements category, due to the general belief that “natural” is better, healthier, and safer than synthetic drugs. The availability of these relatively new products can positively influence the well-being of the population, but it is essential to provide the consumers with the necessary recommendations to guide them in their purchase and use. This review discusses some open points, such as: the definitions and regulation of products containing botanicals; the difficulty in obtaining nutritional and functional claims (botanical ingredients obtaining claims in the European Union are listed and summarized); the safety aspects of these products; and the poor harmonization between international legislations.

Zuccari et al. [13] present a review on different formulation strategies to improve the oral bioavailability of ellagic acid. This is a polyphenolic compound contained in many fruit and berries, endowed with antioxidant activity, which might be potentially useful for the prevention and treatment of cancer, cardiovascular pathologies, and neurodegenerative disorders. However, ellagic acid has poor bioavailability associated with low solubility, limited permeability, first pass effect, and inter-individual variability in gut microbial transformations. This review described several strategies, including micro and nano formulations, to overcome this problem and which can be exploited to produce nutritional supplements or to include it in functional foods.

Salehi et al. [14] present an overview on habitat, cultivation, phytochemical composition, and 14 food preservative abilities of Cucurbita plants. Cucurbita species are a natural source of carotenoids, tocopherols, phenols, terpenoids, saponins, sterols, fatty acids, functional carbohydrates, and polysaccharides that exert remarkable biological effects. For this reason, they have been used for centuries in the folk medicine of many cultures and recently they have been increasingly exploited for biotechnological applications.

Some authors also evaluated the possibility to extract functional ingredients from the by-products of different agro-industrial chains. The development of sustainable solutions for the management of food waste and by-products is currently one of the main challenges of our society. Indeed, in the developing countries, the food production and processing generate large amounts of waste and by-products, with a significant environmental, economic, and social impact [15]. On the other hand, many of these products could represent a potential source of valuable compounds, such as proteins, amino acids, starch, oligosaccharides, lipids (i.e., fatty acids, sterols), micronutrients (i.e., vitamins, minerals), bioactive compounds (i.e., polyphenols, carotenoids, glucosinolates, and terpenes), and dietary fibers [15].

Turrini et al. [16] investigated the in-vitro anti-tyrosinase activity of different aqueous extracts obtained from pomegranate juice processing by-products. One drawback in pomegranate juice industrial production is the large amount of waste, in particular, external peels which represent a promising source of phenolic compounds for exploitation (such as ellagic acid and ellagitannins) [17]. Different conventional and innovative eco-compatible extraction methods (such as ultrasound-assisted extraction) are considered, and the obtained extracts have been tested in-vitro as low-cost lightening and/or anti-browning agents.

Fraga et al. [18] propose the use of mushroom (*Agaricus bisporus*) by-products as a source of chitin–glucan complex enriched dietary fiber, as a good strategy to reduce wastes generated in the mushroom agro-industry. In this work, a simple and environmentally friendly procedure using only food-grade reagents was developed and optimized by Design of Experiments (DoE) to produce a dietary fiber-based ingredient.

Some authors considered some underrated species as potential sources of components with an important impact in health promotion. Gamba et al. [19] presented a phytochemical characterization and a bioactivity evaluation of autumn olive (*Elaeagnus umbellata* Thunb.) fruits, a deciduous shrub tree widely distributed in Asia and Southern Europe, whose fruits are locally used for human consumption. The aim of the study was to evaluate the main bioactive compounds and nutraceutical properties of these fruits, using high-performance liquid chromatography fingerprint and spectrophotometric analysis, to promote their potential applications as a food supplement.

Ziaja-Softys et al. [20] investigated the influence of different processing methods (such as boiling, blanching, and fermenting) on the content and the biological activity of the water-soluble polysaccharides extracted from a Japanese mushroom (*Lentinus edodes*). Indeed, among all mushroom-derived bioactive compounds, polysaccharides are known to have the most potent antitumor, antioxidative, and immunomodulating properties. However, the biological activities of polysaccharides differ greatly depending on the processing applied before the consumption.

Ferro et al. [21] studied the maturation evolution of olive fruits from two major traditional Portuguese cultivars (such as ‘*Galega Vulgar*’ and ‘*Cobrançosa*’), regarding their phenolic profile. Particularly, oleuropein and verbascoside are the most common phenolic glucoside found in considerably high amounts in the Oleaceae family. These bioactive compounds are shown to exert great health benefits if regularly ingested, such as the prevention of atherosclerosis and by scavenging several reactive oxygen species in the vascular wall.

Zhang et al. [22] investigated the potential dietary supplementation with pioglitazone hydrochloride and resveratrol on the quality of yellow-feathered broiler chickens. The study confirmed that the combined dietary supplementation of chickens improved the meat quality prolonging its shelf life, the growth performance, the muscle intramuscular fat content, and the antioxidant ability.

Zhao et al. [23] investigated the effect of Chinese ginseng (*Panax ginseng* C.A. Meyer) and *Polygonatum sibiricum* on the properties of Lactobacilli effervescent tablets. The research demonstrates that it is possible to develop an optimal formulation of lactobacilli effervescent tablets supplemented with Chinese ginseng and *P. sibiricum*, combining functional benefits of lactobacilli and both herbs.

Boukhatem et al. [24] describe the potential application of *Eucalyptus globulus* essential oil as a natural preservative in beverages like fruit juices. This essential oil could be used as a possible antifungal and antibacterial agent against foodborne and food spoilage microorganisms. The chemical composition showed the predominance of oxygenated terpenes responsible for the microbial inhibitory effect against pathogens.

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