



Original research

The Perspective of Using Bioactive Compounds in Functional Beverages -Review

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A B S T R A C T

The use of bioactive ingredients in various functional food products is increasing due to the demand for food-drug formulations that contain natural ingredients. This goal can be achieved by including vegetable essential oils (V-EOs) in these industries are among the most popular ingredients used to enrich/fortified various food products to increase their functional properties. However, these oils are sensitive to harsh conditions such as oxidation stress and high temperature. Recently, various micro/nano-encapsulation systems have been employed to produce suitable carriers for V-EOs to be incorporated into food formulations, which can overcome the limitation of their pure application in foods. The approach of controlled release and high stability against harsh conditions can enhance the functional properties of V-EOs, thus facilitating their potential use in food products. The production of functional products, especially based on medicinal plants, has been the main focus of recent developments in the food industry. The top functional benefit consumers seek out from functional products are immune support and general weight management, digestive/gut health and heart health, muscle recovery, energy support, endurance, and bone health. The functional drink industry is the largest market and the fastest growing in the food sector. This issue has led to the production of several new drinks that are designed to address specific health concerns. Functional drinks such as probiotic, energy and sports drinks, meal replacements, and vegetable, and fruit drinks are now popular among consumers. In addition, declining health due to busy lifestyles, high consumption of prepared/fast foods, insufficient exercise, and increased self-medication are all known as important factors that lead to increased demand for the production of functional foods. The upcoming review article refers to the applications of bioactive compounds in the food industry and especially the production of functional drinks.

Keywords: Functional Foods, Beverage, Bioactive Compounds, Nutraceutical, Health

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1. Introduction

Functional foods can be considered to be those whole, fortified, enriched or enhanced foods that provide health benefits beyond the provision of essential nutrients (e.g., vitamins and minerals). Functional foods include conventional foods, modified foods (i.e., fortified, enriched, or enhanced), medical foods, and foods for special dietary use (Granato et al., 2020). Due to growing consumer interest in fitness and well-being, functional beverages with therapeutic and functional qualities are in higher demand. The vast majority of consumers (96%) who purchase functional and fortified

products reported they're proactive about their health. A whopping 95% of consumers who purchase functional and fortified products said foods and beverages with extra health benefits help them achieve their health goals. The top functional benefit consumers seek out from functional and fortified products, per the report, is skin support, which was considered important to more than half (51%) of consumers. Immune support and hair support followed, each considered important by 44% of consumers. Other functional benefits considered important by respondents include general weight management (43%), digestive/gut health and heart health (42%), muscle recovery (39%), energy support (39%), endurance, and bone

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health (38%). Nowadays, manufacturers need to create products that support top concerns such as immune, digestive, cognitive, and heart health, and include science-backed functional ingredients to increase credibility.

2- Bioactive Compounds(BCs)

Bioactive compounds (BCs) including polyphenols, carotenoids, vitamins, omega-3 fatty acids, organic acids, nucleosides and nucleotides, and phytosterols have attracted great attention due to their role in the prevention of several chronic diseases. (Kamiloglu et al. 2021)

Nowadays, natural products play an important role to improve the quality of life. In recent decades, researchers around the world have been working to extract and identify chemically active molecules in plants that can replace chemical drugs or be the basis for new drugs or additives. Essential oils are an important source of biological molecules that are potentially used in various industries, including food industry. These valuable compounds are formed in the secondary metabolism of plants and are responsible for the protection of plants. Considering that the concentration of the main compounds in essential oils can directly influence their biological activities, understanding the chemical composition of essential oils is crucial. (Matera, et al. 2023) Volatile compounds in essential oils have various uses in the food industry, including food preservation, due to their properties such as antioxidant and antimicrobial potential. Plant essential oils have been used since ancient times as flavors and preservatives in food and also as medicine to treat various diseases. These ingredients increase the shelf-life of food by delaying the oxidation of fats through antioxidant activity or by controlling the growth of microorganisms through bacteriostatic and bactericidal properties. (Karimlar et al. 2019) Essential oils obtained from plants are considered as healthy and low-risk ingredients due to their low toxicity and rare side effects. In short, the use of plant essential oils can be mentioned in several groups: Natural preservatives, flavoring and fragrance agents in the food industry, Aromatic agents in the cosmetics production industry, Pre-material needed by many chemical industries such as making insecticides, preparation of various medical drugs, application in medicine (aromatherapy knowledge) (Pereira, et al. 2022).

The wide accessibility, the large volumes, and the low costs make agri-food and by-products a considerable source of BCs that can be isolated through sustainable methodologies. Most of by-products deriving from agro-industrial transformation such as grain, legumes, fruits, and vegetables bio-residues are rich sources of macronutrients (carbohydrates, protein, and fatty acids) and micronutrients (vitamins, iron, calcium, and potassium) (Messinese, et al. 2023)

Today more than ever, technologists and scientists in the food industry are formulating essential oils (EOs) to produce functional foods. The antibacterial, antifungal, antioxidant and anticarcinogenic properties of EOs have been proven by several researchers. Health-conscious consumers prefer natural additives, so these essential oils can be safely used as an alternative to artificial preservatives due to their green image. The shelf -life of useful foods can be improved by antimicrobial packaging containing EOs and their derivatives in edible films and coatings. EOs can be easily produced in the form of microcapsules and nanoparticles, which increases their stability and solubility. Therefore, EOs are considered as the most useful additives in future functional foods. (Matera et al. 2023).

3- Functional Foods

3.1 Physicochemical properties of whey

Many foods are defined as "Functional foods", a common definition being that functional foods contain ingredients that have positive effects on health, beyond nutrition. However, there are several problems with this definition. A new definition that has recently been proposed is: functional foods are novel foods formulated to contain ingredients or living microorganisms that have potential health-promoting or disease-preventing value, in a concentration that is both safe and achieves the desired benefits is high. Added ingredients may include nutrients, dietary fiber, phytochemicals, or other ingredients or probiotics. New food products such as nutrients, pharmaceutical foods, and vitamins; Collectively, they are called functional foods, which are included in the diets of health-conscious consumers. Useful foods containing probiotics and prebiotics can be used in the prevention and treatment of many diseases such as cardiovascular diseases, cancer, diabetes, and high blood pressure (Temple, 2022).

Plant-based functional foods are receiving more attention now than ever because, they have the potential to provide countless benefits to society, or indeed to humanity as a whole, especially in the fields of nutrition, medicine, and pharmaceuticals. The medicinal value of these plant foods lies in their bioactive compounds, such as phytochemicals and proteins, which produce specific physiological effects on the human body. In addition, these desirable nutrients and bioactive compounds can be found in functional drinks, such as antioxidants, dietary fibers, probiotics, proteins, peptides, unsaturated fatty acids, minerals and combined vitamins. The functionality of functional drinks can be directly affected by various factors such as process conditions, protein sources, sequence and amino acid composition, molecular weight and charge distribution, pH and certain chemical treatments (Khamidah et al., 2023).

4. .Examples of functional foods

Examples of foods that can be classified as functional include: 1. Orange juice with added calcium and margarine with increased levels of omega fatty acids 2. A body of evidence shows that omega-3 fatty acid supplements may protect the human body against heart diseases (Shen, et al. 2023), memory impairment and Alzheimer's disease. (Wood, et al. 2022) 4. Studies on the microbiome and its relationship with health have received a lot of attention in recent years. The focus has been on the gut microbiome. Probiotics are products that contain potentially beneficial microorganisms. Some evidence suggests that probiotics may improve immune function and help with weight loss (Perna, et al. 2022). Depending on the production method, yogurt and kefir may contain probiotics. Other fermented foods contain fungi instead of bacteria. Examples include tempeh (from Indonesia) and miso (from Japan), both of which are made from soybeans. Since the above four foods have been eaten for centuries, they are not new and therefore should not be considered functional foods. However, innovative food manufacturers can formulate new foods that are made from fermented foods and contain good live microorganisms that are likely to be beneficial to health. 3 Foods with added prebiotics are another potential type of functional food. Prebiotics are ingredients that can have a favorable effect on the colon microbiome. In this sense, they are comparable to probiotics. Beta-glucans (from oats) (Joyce, et al. 2019) and fructans (Hughes, et al. 2021) are examples of prebiotics. 4. Margarine and other foods containing plant sterols and stanols reduce the level of

total blood cholesterol and low-density lipoprotein cholesterol (LDL-C) (Fumeron, et al. 2017).

functional foods with plant sterols/stanols may be considered 1) in individuals with high cholesterol levels at intermediate or low global cardiovascular risk who do not qualify for pharmacotherapy, 2) as an adjunct to pharmacologic therapy in high and very high risk patients who fail to achieve LDL-C targets on statins or are statin-intolerant, 3) and in adults and children (>6 years) with familial hypercholesterolaemia, in line with current guidance.

5. The findings of many studies show that tea has a beneficial effect on health. Specifically, it appears to protect the body against obesity, metabolic syndrome, type 2 diabetes, cardiovascular disease, cancer, and possibly some neurological diseases.

A group of ingredients that are believed to be responsible for this benefit are catechins. Catechins belong to a group of phenolics called flavonoids. In general, phenolics are plant chemicals. In fact, there are non-vitamin organic ingredients in food and it is believed that they have beneficial effects on health. (Isemura, et al. 2022) 6. Many evidences show that berries are beneficial for health and protect the body against various diseases. Anthocyanins are widely distributed in berries and they are believed to be responsible for the health benefits. Therefore, anthocyanins can potentially be used in the production of functional foods. Like catechin, anthocyanins are also flavonoids. (Wilken, et al. 2022, Panchal, et al. 2022).

5.What Are Functional Beverages?

Functional beverages are defined as drinks that offer additional health and diet benefits. These benefits may include added energy, vitamins, protein, and mental enhancement. They may also increase the ability to focus, reduce stress, and promote better sleep. In other words, these beverages improve body function. According to the book *Functional and Medicinal Beverages* by Alexandru Grumezescu and Alina Marie Holban, a functional beverage, contains unconventional ingredients (i.e. probiotics, vitamins, minerals); ranges throughout dairy, probiotic, energy, sports, meal replacement, and fruit-based drinks; provides both physical and mental health benefits. The functional beverages market is one of the fastest growing industries and is mainly targeting different demographic groups such as children, the elderly, athletes, immune-compromised people, and fitness enthusiasts are focused. Nowadays, functional drinks may be divided into 7 main categories such as energy drinks, performance enhancers, weight control drinks, and drinks for digestive health, immunity, cardiovascular, and health-oriented. Typically containing additives such as vitamins, minerals, herbs, or other bioactive compounds intended to support specific performance or improve health, this includes sports drinks, energy drinks, and vitamin-enriched waters, on the other hand, Functional Drinks is a larger category that includes any beverage that provides a specific function or benefit beyond basic hydration, including herbal teas, juices, and smoothies. These beverages may or may not contain additives, and their primary function may be to support general health rather than a specific targeted benefit. (Gupta et al., 2023).

6. Bioactive compounds in functional beverages

Bioactive compounds make useful foods and drinks healthier and more attractive. Phenolic compounds, dietary fibers, prebiotics, peptides, unsaturated fatty acids, minerals, and vitamins are the main ingredients used to develop functional drinks. (Raman et al., 2019)

These bioactive compounds are prepared from plants, spices, animals, seafood, and microorganisms. Some of the popular medicinal plants that are used to produce functional drinks are lemon balm, peppermint, sea buckthorn, rosemary, lavender, sage, thyme, sweet fennel, lemon grass, and ginger. functional drinks often contain a range of phenolic compounds and simple molecules to complex polymers, Flavonoids, phenolic acids, tannins, stilbenes, lignans, and other phenols are the most abundant and widespread group. In particular, preferred compounds are quercetin, kaempferol, myristin, isoramanthine, rutin, apigenin, luteolin, naringin, and hesperetin (Farooq, et al. 2021).

Hydroxycinnamic acids, hydroxybenzoic acids, quinic acid, chlorogenic acid, rosmarinic acid and caffeic acid are the most common phenolic acids that are used as functional ingredients. Another abundant and structurally diverse class of natural chemicals is terpene, also known as terpenoids or isoprenoids. Beverages produced with natural, mineral or spring water may contain essential minerals. Water hardness can change acidity and pH, and this can lead to changes in microbial stability and taste. In addition, the calcium content of the water should be checked for fruit drinks because when the fruit pectin breaks down, the free calcium may form a stable gel that can have an unpleasant appearance. Adaptogens, nootropics, and allergen-free plant proteins are predicted to be some of the exceptionally functional ingredients of the future. (Tireki 2021).

Recent studies on the production of functional dairy, fruit, and vegetable beverages with added polyunsaturated fatty acids such as ω -3 - alinoleic acid (C18:3n-3, ALA), reports eicosatetraenoic acid (C20:5n-3, EPA), and docosahexaenoic acid (C22:6n-3, DHA) (Saini et al. 2021). Additionally, research-based evidence has shown that fibers, vitamins, and minerals added to functional drinks also have the potential to reduce diseases. Calcium, magnesium, and iron are the most common minerals added to dairy drinks due to their central role in the human body. However, the bioavailability of these active ingredients is highly questionable because the amount consumed and the amount absorbed in the blood after consumption are not always the same. The total amount of micronutrients and macronutrients produced in a drink it is not bioavailable because a large part of it is confined in food matrices. Other factors that prevent the bioavailability of active ingredients include the presence of any form of inhibitors, forms of micronutrients, interactions with other nutrients, and the influence of external factors such as temperature, light, humidity, or oxygen (Maurya, et al. 2020). Various in-vivo studies have reported the potential mechanism of bioactive ingredients to produce health benefits such as the effectiveness of genetic linkage, membrane disruption, and reduction of intracellular ATP. Another common mechanism is the modulation of specific biological pathways in the body. (Ahmad et al., 2014).

7- Functional beverages and their health benefits

The most popular functional drinks available in the market are: yogurt-based drinks (probiotic-enriched drinks), functional milk (extra calcium, omega-3 and vitamin-enriched drinks), fruit juice. (drinks enriched with vitamins and omega 3) and functional waters (beverages enriched with vitamins and minerals, sports and energy drinks, herbal drinks and health-oriented drinks. These functional drinks reduce the risk of cancer, improve physical and mental

conditions and act as an anti-stress, anti-aging, antioxidant and anti-inflammatory booster (Tolun & Altintas, 2019)

7-1 Phyto-active enriched/fortified beverages

The composition of drinks enriched with phytoactives Munekeata includes macronutrients and micronutrients along with various bioactive compounds that originate from different materials. For example, soy-based bioactive components such as phytosterols and isoflavones, almond bioactive extracts containing arabinose and α -tocopherol, oat extract containing β -glucan and sea buckthorn extract with beta-sitosterol and vitamins (R'evillion, et al. 2020).

7-2 Pre and probiotic beverages

Probiotics are foods or supplements that contain live microorganisms intended to maintain or improve the "good" bacteria (normal microflora) in the body. Prebiotics are foods (typically high-fiber foods) that act as food for human microflora. Prebiotics are used with the intention of improving the balance of these microorganisms. Prebiotics act like neutral oligosaccharides of milk because they stimulate or suppress the growth and proliferation of intestinal microbes. In addition, fructo-oligosaccharide (FOS) and gluco-oligosaccharide (GOS) from plant sources also play a dominant role as probiotics in reducing harmful microflora and increasing beneficial microflora in the intestine. FOS together with maltodextrin has shown its role in increasing the division and utilization of soy oligosaccharides and other simple sugars such as fructose and glucose in soy milk (Raman et al. 2019). Prebiotic supplements such as maltodextrin, pectin and mannitol it was observed to improve the survival and development of probiotics. (Rivas et al., 2021), reported that the viability of probiotics increased by adding inulin to almond milk. Also, the fermentation process using *Lactobacillus roteri*, *Lactobacillus acidophilus*, *bifidobacterium*, and other microbial species have been reported to produce prebiotic mannitol, which not only increases the viscosity of the drink, but is also a non-metabolic sweetener, antioxidant, and antibiotic properties.

7-3 Sports performance beverages

Drinks for athletes, known as carbohydrate-electrolyte drinks, are produced to hydrate the body and supply electrolytes and necessary carbohydrates (Alexandru Mihai Grumezescu, 2019). Alkaloid caffeine and flavonoid catechin are the most used compounds used in sports drinks. Ginseng, vitamin B, guarana, acai, ginkgo, inositol, yerba mate, carnitine, taurine, glucuronolactone, creatine, and methylxanthines are other functional ingredients that are often found in sports drinks. Evidence shows that milk-based drinks can act as an effective alternative to regular sports drinks as a source of hydration. (Berry, et al. 2022) showed that sports drinks with high concentrations of digestible carbohydrates (CHO), which increase the risk of digestive problems in athletes, may be more tolerable if gelling polysaccharides are added.

7-4 Energy beverages

While electrolytes and carbohydrates are mostly found in sports drinks, to increase energy further, energy drinks are produced as a combination of stimulants and energy boosters. The main ingredients in energy drinks are amino acids, caffeine and vitamins. many plant

compounds such as guarana, yerba mate and ginkgo are also used as functional ingredients for the production of energy drinks - in addition, (Cao et al., 2021) adverse electrophysiological and ischemia consequences associated with consumption evaluated energy drinks and suggested that patients with electrocardiographic abnormalities need a thorough examination related to energy drink consumption (Masengo et al., 2020).

8. Conclusion

The demand for herbal beverages has increased in the past few years. It has increased on natural bioactive molecules and plant extracts with promising functional properties. (Khasanov et al., 2021) However, Consumers' growing interest in organic food and their concern about synthetic chemicals, such as food colors and sweeteners, are two key factors that are now influencing the market for functional beverages (Yuan et al., 2022) For example, sales of coconut water, long popular in the tropics and now widely available in bottled and canned varieties, have recently increased in developed countries. Polyphenols, anthocyanins, and procyanidins, provide tangible health benefits and have the potential to be used as key ingredients in functional, nutraceutical foods. Probiotics, omega-3 fatty acids, bioactive peptides, plant sterols, and vitamins are added to functional dairy-based beverages, but soy milk is increasingly being used instead of animal milk (Male's et al. 2022).

Additionally, manufacturers can use Consumers' interest behavior trends to differentiate their products from competitors by using natural ingredients with proven health benefits. Agriculture and food industries are adapting to these new trends and developing their products to meet different consumer needs. It is difficult to assess the knowledge that consumers have gained from reading nutrition information labels. In addition, predicting customers' motivations to buy or not to buy a product is challenging. With the increasing demand for natural ingredients and low-calorie and healthy drinks, extensive research is being done on the optimization of new ingredients for different categories of these drinks. In addition, the combination of suitable ingredients with an efficient processing method has become a major trend in the development of such beverages.

The performance of functional beverages may provide new opportunities for manufacturers to offer customized value-added products that meet the specific needs of more health-conscious consumers who want to reduce their healthcare costs. Some of the areas of focus for research in functional drinks are technical analysis and production cycle of new drinks with new ingredients, consumer safety including sensitizing and toxicology, bioavailability of target nutrients, investigating the mechanism of action of ingredients using animal models and Human intervention studies and sustainable production techniques. Therefore, with more research and development, the potential of functional drinks can be discovered and used, thereby improving their commercial scalability in the food and pharmaceutical industries.

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