



Importance of different functional compounds from food sources

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Abstract

“Bioactive compounds” are extra nutritional constituents that typically occur in small quantities in foods. They are being intensively studied to evaluate their effects on health. The impetus sparking this scientific inquiry was the result of many epidemiologic studies that have shown protective effects of plant-based diets on cardiovascular disease (CVD) and cancer. Many bioactive compounds have been discovered. These compounds vary widely in chemical structure and function and are grouped accordingly. Phenolic compounds, including their subcategory, flavonoids, are present in all plants and have been studied extensively in cereals, legumes, nuts, olive oil, vegetables, fruits, tea, and red wine. Many phenolic compounds have antioxidant properties, and some studies have demonstrated favorable effects on thrombosis and tumorigenesis and promotion. This review's highlight health benefits of different bioactive compounds obtained from different food sources.

Keywords: Bioactive compounds, functional compounds, health benefits, CVD

Introduction

Phytochemicals, also known as phytonutrients, include polyphenols, terpenes, and organosulfur compounds that give fruits and vegetables their unique flavors, odors, and colors. There are probably many more as-yet-unidentified phytochemicals in food. Other significant bioactive components in foods include probiotics, omega-3 fatty acids, isoflavones, sterols, and stanols. Bioactive compounds are non-essential biomolecules found in foods, spices, and beverages that can affect metabolic processes and promote health but are not necessary for growth (Liu RH. 2013) ^[7]

Bioactive compounds have multiple mechanisms of action, often acting synergistically to promote health effects. Any diet that promotes a variety of nutrient-rich whole foods

should provide a wide range of bioactive compounds, although bioavailability does vary among plant varieties and can be affected by farming practices and food preparation techniques.

Types of Bioactive Compounds

Some of the most well-researched bioactive compounds are phytonutrients, including polyphenols, carotenoids, terpenes, and organosulfur compounds. Other examples of bioactive compounds in food include omega-3 fatty acids, fibers, prebiotics, probiotics, sterols, and stanols (Table 1). This review explores some of the major bioactive compounds identified in the foods, highlights some of the scientific evidence of their potential health benefits, and discusses applications in culinary medicine.

Table1: Bioactive Compounds

Bioactive food component	Food sources	Health benefits
Phytoestrogens	Soybeans, flaxseeds, oats, beans, lentils, apples, barley	Help manage menopausal symptoms, bone health, cardiovascular health, cancer prevention
Polyphenols	Green tea, berries, cocoa, red wine, beans, nuts, vegetables, grains, herbs, fruits, potato, turmeric, ginger, olive oil	Antioxidant properties, anti-inflammatory effects, protect against cancer, stroke, diabetes Alzheimer's disease, and cardiovascular diseases.
Prebiotics	Fruits, vegetables, whole grains, legumes, garlic, onions, leeks, cocoa	Provide fuel for beneficial bacteria in the gut. Indigestible carbohydrates, soluble fibers, and resistant starches in plant-based foods increase probiotic bacteria populations.
Probiotics	Yogurt, kefir, fermented foods (e.g., miso, kimchi)	Improve gut health, enhance immune function, potential mental health benefits, metabolism improvements
Carotenoids	Yellow, orange, and red fruits and vegetables, leafy greens, herbs, carrots, melons, tomatoes	Promote eye health, antioxidant properties, prevent cancer
Omega-3 fatty acids	Fatty fish (e.g., salmon, mackerel), chia seeds, flaxseeds, enriched eggs	Cardiovascular support, brain health, relief from dry eye symptoms, help manage rheumatoid arthritis
Terpenes	Citrus fruits, herbs and spices, cannabis	Anti-inflammatory, potential anticancer properties
Sterols and stanols	Nuts, seeds, vegetable oils	Lowers cholesterol levels, immune-enhancing properties, anticancer
Sulfur compounds	Garlic, onions, cruciferous vegetables	Antioxidant properties, potential anticancer effects, immune-enhancing properties, blood pressure regulation

(Source: Casey *et.al.*, 2024) ^[12]

Over the past century, nutrition scientists have continued to investigate and debate what defines a healthy diet. In the past 25 years, the DASH and Mediterranean diets and their variations have emerged as examples of eating patterns that are beneficial in multiple areas of health and disease prevention and treatment.

Research has focused on the underlying mechanisms of these dietary patterns, which include lipid-lowering, anti-inflammatory, and metabolic effects on the gut microbiota. The DASH and Mediterranean diet patterns are based on a variety of nutrient-rich whole foods and reduction of more highly processed foods, simple sugars, and saturated fats. The Mediterranean diet also emphasizes the intake of fish, olive oil, fresh herbs, and wine.

It is being increasingly recognized that the multiple bioactive compounds in these diet patterns are likely a main contributing factor in the many demonstrated health benefits (Estruch *et.al.*, 2018)^[4]

Polyphenols

Polyphenols are naturally occurring plant phytochemicals that have health-promoting properties, including acting as a free radical scavenger and reactive oxygen species that counters oxidative damage that contributes to inflammation and associated diseases such as cancer, cardiovascular disease (CVD), and type 2 diabetes. Polyphenols comprise several categories, including flavonoids, lignans, stilbenes, and phenolic acids. Each type has numerous subcategories

Table 2: Polyphenol Categories and Health Benefits

Polyphenol type	Food sources	Facts and health benefits
Flavonoids	Citrus, grapes, berries, cherries, apples, currents, buckwheat, nuts, seeds, onions, broccoli, purple cabbage, blue potatoes, parsley, red peppers, mint, tea, cocoa	Two-thirds of polyphenols and most bioactive; antioxidant properties; anti-inflammatory effects; protect against cardiovascular disease (CVD), cancer, stroke, type 2 diabetes, Alzheimer's disease.
Phenolic acids	Fruits, vegetables, whole grains	Combat free radicals and protect against cancer, arthritis, autoimmune disorders, CVD, and neurodegenerative disease
Other polyphenols	Ginger	Health effects are mainly attributed to gingerol, a phenolic compound used for antinausea, antioxidant, and anti-inflammatory properties.
Lignans	Extra-virgin olive oil, garlic, onions, vegetables, grains, fruits, seeds	Reduced risk of CVD and stroke
Stilbenes	Grapes, berries, peanuts, red wine	Anti-inflammatory, promote cardiovascular health antioxidant properties

There is an extensive amount of research on individual polyphenols, but it's often unclear how it applies to habitual intakes of mixed diets. Diets rich in polyphenols are associated with a reduced risk of type 2 diabetes. Studies exploring their impact on CVD risk are ongoing, and findings have been largely positive. (Woodward *et.al.*, 2018)

Flavonoids

Flavonoids account for most of the dietary phenolic compounds and are the most bioactive. Flavonoids can be further divided into 6 structural groups or families. Some of the most researched types include quercetin, catechins, and anthocyanins, which are present in fruits, vegetables, tea, and cocoa. The flavonoids found in berries and citrus fruits are potent antioxidants and anti-inflammatory agents, which may protect against oxidative stress, chronic inflammation, and Alzheimer's disease. (Panche *et.al.*, 2016)^[8]

Flavonoids Subtypes

- **Quercetin:** is contained in fruits, especially citrus, berries, cherries, and apples, and in buckwheat, nuts, seeds, onions, broccoli, olive oil, and green tea. Exhibits a strong potential for reducing the risk of CVD and certain cancers and preventing tissue injury. (Perez-Vizcaino *et.al.*, 2018)^[9]

- **Curcumin:** is contained in the spice turmeric, which has been used in Eastern medicine for centuries, curcumin has anti-inflammatory and antioxidant mechanisms still being defined. Some research findings have been positive, whereas others have been inconclusive. One theory being investigated is that differences in the gut microbiome profile may influence the bioavailability and pharmacological activity of curcumin. It has been discovered that adding an alkaloid agent in black pepper called piperine increases bioavailability of curcumin. (Hewlings & Kalman 2017)^[5]

- **Anthocyanins:** are water-soluble pigments responsible for red, purple, and blue fruits and vegetables such as berries, acai, currants, grapes, purple cabbage, and blue potatoes. Anthocyanins possess antioxidant, vasorelaxation, free radical scavenging, and antimicrobial activities that improve visual and neurological health and help prevent cancer and CVD. Mild heat, such as blanching, is recommended when trying to preserve the bioactivity of foods high in anthocyanins (Khoo *et.al.*, 2017)^[6]

- **Flavones:** are considered some of the most powerful antioxidants and protect against reactive oxygen species.³⁶ Food sources include celery, parsley, red peppers, chamomile, mint, peels of citrus fruits, onions, and tea. (Panche *et.al.*, 2016)^[8]



Fig 1: Berries are rich in flavonoids.

Phenolic Acids

Subtypes of phenolic acids include caffeic acid and ferulic acid, which are widely distributed in fruits, vegetables, and whole grains. Health benefits of ferulic acid include the ability to combat free radicals related to oxidative damage associated with chronic diseases such as cancer, arthritis, autoimmune disorders, CVD, and neurogenerative diseases. (Rudrapal *et. al.*, 2022)^[12]

Phytosterols and Stanols



Fig 2: Nuts are a source of phytosterols.

Phytosterols are plant counterparts of cholesterol in animals. The most common bioactive phytosterols are beta-sitosterol, campesterol, and stigmasterol. Plant stanols are similar in structure but much less common in the diet, representing approximately 10% of phytosterol dietary intake. (Delage *et.al.*, 2024)

The main food sources are nuts, seeds, unrefined plant oils, and legumes, which are sometimes referred to as pulses and beans. It is believed that early human diets were rich in phytosterols, but the typical Western diet is relatively low in these compounds. After phytosterols are absorbed in the small intestine, where they interfere with the absorption of dietary cholesterol by displacing cholesterol and by facilitating excretion of cholesterol in the feces

(Noakes *et.al.*, 2002)^[11]

Probiotics and Prebiotics



Fig 3: Yogurt is rich in probiotics.

Probiotics are a unique category of essential bioactive food components that mainly arise from various fermented foods, including yogurt, kefir, sauerkraut, and kimchi, or can be added to foods such as juices, protein bars, dairy products, cereals, and prunes. Fermentation techniques create various textures and flavors and also result in populations of beneficial bacteria that enhance the amount and diversity of intestinal bacteria that compose the microbiota (Valdes *et.al.*, 2018)^[13]

Prebiotics are indigestible carbohydrates (types of dietary fiber) that are fermented in the colon and stimulate the growth or activity of specific types of beneficial bacteria. Dietary fibers in foods cannot be digested by human enzymes, but they can serve as fuel for gut bacteria and lead to both improvements in nutrient absorption and enhancement of the bacterial environment in the gut. Food sources of prebiotics include cocoa, garlic, onions, leeks, whole grains, seeds, nuts, pulses, and other fruits and vegetables. Much is still being investigated about the role and mechanism of prebiotics before specific recommendations can be made. (Maldonado-Contreras *et.al.*, 2020)^[10]

Omega-3 Fatty Acid



Fig 4. Eat salmon to boost omega-3 fatty acids in diet.

Our diets contain a mixture of lipids with fatty acids (FAs) as their fundamental building blocks. The fate of FAs in the diet includes using them for energy production, storage in adipose tissue, or integration into other lipid species such as phospholipids, which form the major structural components of cellular membranes. (Blasbalg *et.al.*, 2011)^[1] In this role at the membrane level, the different forms of essential FAs—omega-3 and omega-6—are precursors to eicosanoids, which can be used for inflammatory or anti-inflammatory pathways in the body,

with omega-3 favoring anti-inflammatory pathways and omega-6 being associated with risk of blood clots, pain, and inflammation (Figure.5). Omega-3 FAs act as precursors to less inflammatory versions of bioactive molecules such as eicosanoids, which positively influence health. For example, eicosanoids act as powerful hormones that control many other hormones and essential body functions, such as the immune system, central nervous system, cardiac cell health, and blood pressure regulation. (Duan *et.al.*, 2021)^[3]

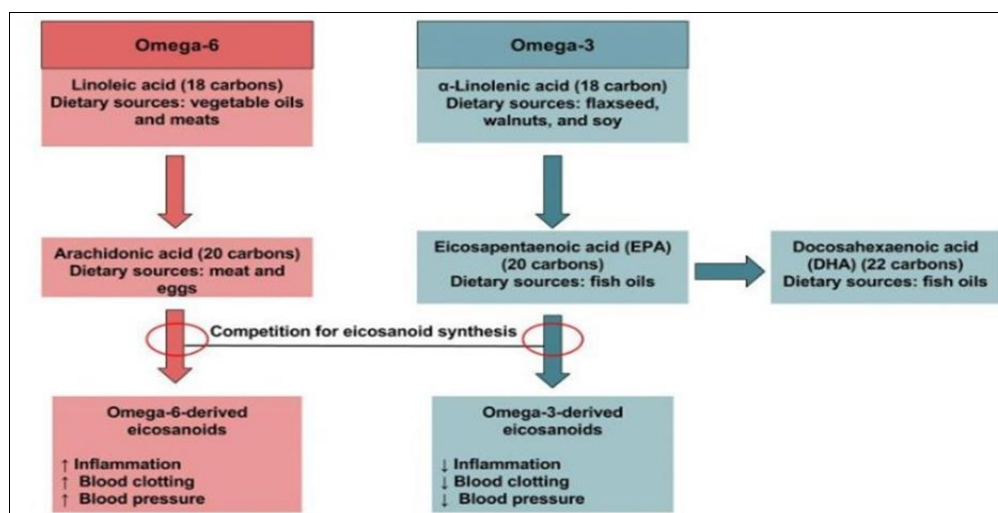


Fig 5: Essential fatty acids must be obtained from food. They fall into 2 categories: omega-3 and omega-6.

Carotenoids



Figure 6. Cruciferous vegetables include green cauliflower, white cauliflower, and cabbage.

Carotenoids belong to the terpene family and are important and widely distributed pigments determining the various colors of plants. For example, dietary sources rich in beta-

carotene are typically in the form of yellow, red, orange, and green leafy fruits and vegetables. A review of carotenoid food sources is found in Table.3.

Table 3: Carotenoid Food Sources

Carotenoid	Food sources
Beta-carotene	Carrots, sweet potatoes, squash, pumpkin, spinach, kale, mangoes, apricots, red bell peppers
Lutein	Spinach, kale, parsley, collard greens, Swiss chard, broccoli, peas, corn, eggs, raspberries, okra, basil
Lycopene	Tomatoes, watermelon, pink grapefruit, guava, papaya, red cabbage, asparagus, persimmon
Zeaxanthin	Corn, spinach, kale, collard greens, Swiss chard, beet greens, peas, eggs, oranges, pumpkin, brussels sprouts, pistachios
Cryptoxanthin	Butternut squash, red bell peppers, papaya, mangoes, oranges, tangerines, peaches, apricots, persimmon, nectarines, watermelon, paprika

(Source: Maiani *et.al.*, 2009)

It is believed that additional bioactive compounds have yet to be discovered. When considering culinary applications to promote health and well-being, incorporating foods with bioactive compounds can elevate the nutritional value and health impact of the meal beyond its basic nutrient composition.

Conclusion

Amazing advance is being made in characterizing the part of bioactive compounds in lessening the chance of major unremitting infections and the basic natural components that account for these impacts. An ever-expanding list of bioactive compounds is being deductively assessed. As examined in this, various bioactive compounds show up to have useful wellbeing impacts. On the premise of a huge populace database, there's adequate prove to suggest a count calories tall in nourishment sources wealthy in bioactive compounds/functional compounds.

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