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Review Article

Functional Foods: Exploring the Health Benefits of Bioactive Compounds from Plant and Animal Sources

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"Let food be the medicine" (Hippocrates) is a historic quote that became the basis of food science and nutraceuticals. Due to their possible therapeutic advantages, extracts from food have attracted much interest in the medical community. These extracts are abundant in bioactive compounds, which are natural molecules that may be found in various foods and have been demonstrated to affect health positively. Food components have lots of bioactive components, including primary and secondary metabolites and nutritional components, for example, carbohydrates, proteins, vitamins, minerals, fatty acids, antioxidants, phenolics, and flavonoids. This study's primary focus is on the make-up and purpose of these bioactive components found in food extracts. This review aims to give readers a thorough grasp of the bioactive substances found in food extracts and their possible physiological uses. These bioactive substances' functional traits, such as their antioxidant, anti-inflammatory, antibacterial, anticancer, and neuroprotective actions, are also studied. Further research is required to create new functional foods, nutraceuticals, and dietary supplements with specific health advantages that can benefit from understanding these molecules' structure and function.

1. Introduction

Foods possessing medicinal properties are a category of specific foods that are thought to offer particular health advantages beyond their fundamental nutritional worth. These foods have been utilized in traditional medicine practices worldwide and have undergone comprehensive examination by modern science to explore their therapeutic potential. Various foods possess medicinal properties that can benefit our health. For example, garlic contains antimicrobial, antiviral, and anticancer properties [1]. Turmeric, frequently used in the Indian style of food, has curcumin that possesses anti-inflammatory properties and is able to prevent immedicable diseases such as Alzheimer's and cancer [2]. Berries, including blueberries and strawberries, are rich in antioxidants and may enhance cognitive function and reduce the liability of heart disease [3]. Ginger was investigated for its anti-inflammatory properties and potential to relieve nausea and pain [4]. Honey has been traditionally used for its antimicrobial properties and is believed to facilitate wound healing [5]. Green tea is recognized for its antioxidant and anti-inflammatory properties and is associated with lower risks of diseases such as cancer, heart disease, and diabetes [6].

The concept of food having medicinal properties has been introduced previously. For centuries, various cultures

have used food to prevent and treat illnesses. With advances in science and medicine, researchers have identified the specific compounds in certain foods that contribute to their health benefits. Bioactive components are organic or inorganic molecules that are naturally available in food and have the power to alter more than one metabolic pathway or process, thereby improving health and promoting well-being. Research has demonstrated a link between functional dietary ingredients, health, and well-being. Therefore, functional components support health at different phases of illness control, which are connected to several advancing steps, from commencement to development. Therefore, they can be used to treat and prevent diseases efficiently. Phytochemicals are nutrient-free, physiologically active compounds obtained from plants that work in the human body to delay the initiation of several chronic ailments. Foods contain more than 900 phytochemicals. A fruit or vegetable serving (120 g) may contain up to 100 different phytochemicals [7].

Garlic, for example, contains a compound called allicin, which gives it its distinct aroma and flavor. Allicin has been found to have antimicrobial, antiviral, and anticancer properties, making garlic a popular choice that boosts the body's immunity and prevents certain types of cancer [1, 8]. Turmeric, another commonly used spice, contains curcumin, which has potent anti-inflammatory properties. Chronic inflammation has been linked to a variety of diseases, including cancer and Alzheimer's disease. Therefore, incorporating turmeric into your diet may help prevent or lessen inflammation and potentially reduce the risk of developing these immedicable diseases [2]. Berries, including strawberries and blueberries, are known for their lofty antioxidant content. Antioxidants protect cells from free radicals, which can harm cells and cause conditions like cancer and heart disease. In addition, some studies have shown that consuming berries may improve cognitive function and memory [3]. Ginger is a root used for its medicinal properties for centuries. It has important compounds, namely, gingerols and shogaols, which have anti-inflammatory effects and may help relieve pain and nausea [4]. Ginger is often used as a natural remedy for motion sickness, morning sickness during pregnancy, and other types of nausea. Honey has been used for its medicinal properties for thousands of years. It has antibacterial properties and has been proven impactful in treating wounds and preventing infection [5]. It can also be used to soothe a sore throat and cough. Finally, green tea is a popular beverage that has been shown to have numerous health benefits. It contains compounds called catechins, which have been connected to reducing cancer risks, heart disorders, and diabetes. Green tea also has anti-inflammatory effects and may improve brain function [6].

Phytochemicals and nutrients are abundant in the large variety of plants that make up vegetables. This food group's primary edible components can be broken down into the root, leaf, stem, fruit, and immature flower bud. The bioactive compounds (BACs) in leafy vegetables, sometimes referred to as "greens," "vegetable greens," or "leafy greens," have a complicated character. These metabolites are present in small amounts, but they play a significant part in the process of secondary metabolism in vegetables. In addition, these offer various well-being and nutraceutical advantages, leading to strong demand from customers who are more concerned with their well-being. In actuality, recent years have seen a marked rise in vegetable intake [9].

Overall, incorporating these foods into your diet can have numerous health benefits. However, the fact that they are not a substitute for medical treatment or advice is prominent. If you have a medical condition, always check with your healthcare provider before changing your diet. Incorporating these foods into our diets can have various health benefits, but it is essential to note that they are not a replacement for medical treatment and advice (see Table 1).

2. Bioactive Compounds from Food Extracts

Bioactive chemicals are "extra nutritional" components often seen in trace amounts in lipid-rich foods and plant products [20]. Bioactive substances especially favorably impact the human body or particular cells or tissues. Several bioactive compounds are studied from both plant and animal origin that positively affect human health. Vitamins, carotenoids, polyphenols, peptides, and long-chain polyunsaturated fatty acids (PUFA) are only a few examples of bioactive substances. Docosahexaenoic acid (DHA), arachidonic acid, and eicosapentaenoic acid (EPA) are three important long-chain PUFA [21]. Fruits are a fantastic source of bioactive substances. Some classes of the numerous compounds included in these sources, such as polyphenols, betalains, and terpenes, stand out because of their favorable effects on health and their function in food preservation [22]. Excellent sources of BACs are vegetables. Depending on the plant portion (fruits, peels, seeds, stems, or leaves) from which they were extracted, these phytochemicals vary in composition and concentration. Studies have shown that compared to other sections such as fruits or stems, leaves typically exhibit a wider variety and higher concentration of these BACs. The primary class of secondary metabolites found in vegetable leaves, flavonoids, and phenolic acids is known as polyphenols [9].

2.1. Carbohydrates. Carbohydrates, normally called carbs, are the most prominent and significant components of the human diet, along with other top macronutrients, which are fats and proteins. Carbohydrates comprise three atoms in their structure: carbon, oxygen, and hydrogen [23]. Carbs are divided into different types based on their structure: monosaccharides (glucose, galactose, and fructose) which have the chemical formula $C_6H_{12}O_6$; disaccharides (sucrose and lactose) with the chemical formula $C_{12}H_{22}O_{11}$; oligosaccharides (maltodextrins and raffinose) which have three to ten monosaccharide units; and polysaccharides (amylose, cellulose) which are long chains of monosaccharides linked with glycosidic bonds [24].

The carbohydrates are further divided into four groups based on their types: simple carbohydrates, complex carbohydrates, starches, and fibers. Simple carbohydrates have one to two sugars and are directly utilized for energy; they

Table 1: List of some plants, its bioactive compounds, and some important pharmaceutical activities.

Plant sources	Bioactive compounds	Pharmacological properties	Reference
Garlic	Allicin, S-allyl cysteine	Antimicrobial, anti-inflammatory, anticancer, and properties, reducing blood pressure and cholesterol levels	[10]
Blueberries	Antioxidants	Improve cognitive function, as well as reduce the risk of cardiovascular disease	[11]
Turmeric	Curcumin	Antioxidant and anti-inflammatory agent that has been associated with improved symptoms in arthritis and other inflammatory conditions	[12]
Salmon	Omega-3 fatty acids	Anti-inflammatory properties and improved heart health	[13]
Ginger	Gingerol, β-sesquiphellandrene, zingiberene, β-bisabolene, α-farnesene, and α-curcumene, shogao, and paradols	Anti-inflammatory and anticancer properties, and reduce nausea and vomiting	[14]
Kale	Vitamins and antioxidants, prebiotic carbohydrates, and unsaturated fatty acids	Anticancer properties, anti-inflammatory activity, antigenotoxic ability, and less chance of heart disease	[15]
Green tea	Catechins	Anti-inflammatory antioxidant and properties, and prevents chance of some cancers	[16]
Walnuts	Omega-3 fatty acids and antioxidants	Antidiabetics, weight management, anti-inflammatory, antioxidant, and antibacterial qualities. Antiaging, antioxidant, protein biosynthesis, fertility boosters, prevention of miscarriages, anticancer, and promotion of a healthy heart, immunological booster, and decrease of low-density lipoprotein	[17]
Dark chocolate	Flavonoids	Anti-inflammatory antioxidant properties and decrease the possibility of cardiovascular disease	[18]
Fermented foods (yogurt, kefir, and sauerkraut)	Probiotics	It improves the health of the gut and strengthens the immune system	[19]

tend to produce a spike in insulin production as blood sugar is shot up. Common simple carbohydrates are ribose, glucose, lactose, and maltose. The foods that contain these are candies, table sugar, honey, corn syrup, and fruit juice [25]. Complex carbohydrates have three or more sugar molecules and are linked to each other more complexly. They tend to digest slowly and hence get gradually released into the bloodstream with a slower pace of rise in blood sugar. These comprise cellobiose, dextrin, cellulose, amylose, and rutinulose. Starches are the many complex carbohydrates that contain many glucose molecules and are usually produced by plants. The foods that contain these are potatoes, wheat, pasta, etc [26]. Fibers are the nondigestible complex form of carbs mainly made of cellulose, pectin, and hemicellulose. They are further divided into soluble and insoluble fibers. These are found in whole grains, beans, nuts, vegetables, and fruits [27].

2.2. Dietary Fibers. Dietary fibers are foods made from the parts of plants that the human body cannot absorb or digest. Contrary to food materials, the human body does not digest fibers. These are generally composed of plant cell walls and include components obtained from cell walls like cellulose, pectin, and lignin and nonstarch polysaccharides NSP from other sources like seaweeds and microorganisms [28].

These can be divided based on the sources, solubility, physiological effects, and fermentability [29]. These fibers are mainly of two types based on their solubility factor: soluble and insoluble; the soluble are those that attract water and turn into a gel form during digestion which is a slow process. Examples are inulin, pectin, β-glucan, galactomannan, glucomannan, polydextrose, psyllium, fructooligosaccharides, and dextrin. These solubles are again divided into two types based on the kind of viscous gel they form after getting dissolved in water, which are viscous fibers and nonviscous fibers. The insoluble fibers mostly add bulk mass to the stool and help with the faster movement of food through the stomach and intestines. Examples are cellulose, hemicellulose, lignins, resistant starches, nonstarch polysaccharides, resistant starches, arabinoxylans, and so on [30].

Soluble fibers are found in oat bran, vegetables, peas, seeds, barley, nuts, lentils, and fruits. Insoluble fiber is found in wheat bran, vegetables, and whole grains. Some examples are whole grain foods like wheat and corn bran, legumes such as beans and peas, nuts and seeds, potato skins, and some fruits like unripe bananas and avocados [31]. The major role of dietary fibers involves the gastrointestinal-absorptive and digestive processes, motility and its control, and immune function [32].

2.3. Vitamins. Vitamins are a prominent cluster of compounds required for regular cell function, growth, and development. The vitamins are classified into two categories: fat-soluble and water-soluble vitamins. Fat-soluble vitamins are stored in the liver, fatty tissues, and muscles. The main fat-soluble vitamins are A, D, E, and K (Table 2). Water-soluble vitamins are not stored in the body; they are vitamin C and vitamin B. Excess vitamins in the body are left out through urine, except vitamin B12. All others should be taken through the diet on a regular basis [47]. The studies on biotin say that the oral intake of it in animals and humans is significantly lower. According to the US IOM, 2.5 mg/day of biotin is necessary, but the upper limit needs to be set due to insufficient data [48], and vitamin B12 has a high limit of 2000 μg/day. EVM suggests the upper intake level of pantothenic acid as 200 mg/day whereas for riboflavin, the guidance level for intake was set at 43.3 mg/day without having any adverse effects [49].

2.4. Fatty Acids. Fatty acids are lipid biomolecules that can be seen in all beings and are responsible for several functions. Fatty acids are generally divided into saturated fatty acids (SAFA) and unsaturated fatty acids. Unsaturated fatty acids are further divided into monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) [50]. SAFA is a chain structure with no double bond; this length will usually be 14–24 carbons. PUFA will have nearly 2–6 double bonds and a chain of 16–22 carbons. Highly unsaturated fatty acids (HUFA) are polymers with 20 or more carbons in a chain and with 3 or more double bonds [51]. Based on the carbon number, they are divided into medium-chain fatty acids (MCFA) and long-chain fatty acids (LCFA). The MCFA will have better absorption in the intestinal mucosa when compared to the LCFA [52]. The unsaturated fats usually are in a liquid state at room temperature, which is generally beneficial in many ways. The MUFA are usually found in foods like olive, peanut, canola oils, avocado, almonds, pecans, and pumpkin seeds. PUFA are found in sunflower, corn, flaxseed oil, walnut, and fish [53] (see Table 3)

2.5. Plant Sterols. Plant sterols or phytosterols, or stanols, are the natural compounds present in the plant, and they are helpful in lowering cholesterol levels in the human body. These compounds compete with cholesterol for absorption by the digestive system and make the body remove some of the cholesterol as waste. Thus, it helps in minimizing cholesterol content in the body and improves health [58]. These plant sterols are present in most plant-based foods but are in maximum quantity in unrefined plant oils such as vegetables, olives, sesame, and nut oils. They can also be found in mayonnaise, pistachio nuts, sage, oregano, thyme, paprika, and macadamia nuts [59].

The recommended β-sitosterol dosage is 60 mg at the maximum based on the condition that it can be used at 30 mg twice daily [60] (see Table 4).

2.6. Polyols. Polyols are the aldoses and ketosis, which are transformed into sugar alcohols by the process of hydrogenation. These are considered a better choice of sweeteners because of their slow absorption in the body; mostly, these polyols can be found in protein bars [64]. However, overconsumption of these polyols has its side effects, such as a laxative effect; it can cause bloating,

Table 2: List of vitamins and their health benefits.

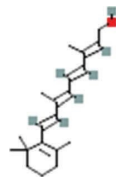
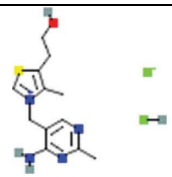
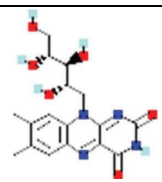
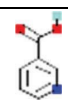
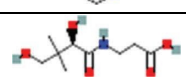
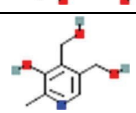
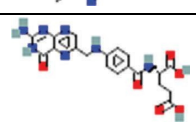
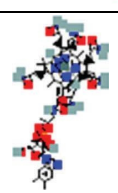
Names of vitamin	Molecular weights	Molecular structures	Source foods	Benefits	References
Vitamin A	286.5 g/mol		Fruits, carrots, sweet potato, milk, eggs, spinach, liver, and organ meat	It helps in improving eye health, immunity, bone, and skin contributes to cell integrity	[33]
Vitamin B1 (thiamine)	337.3 g/mol		Legumes, cereals, meat, grains	It helps improve mental function, regulates metabolism, and keeps the nervous system healthy	[34]
Vitamin B2 (riboflavin)	376.4 g/mol		Fish, meat, legumes, and dairy products	It helps in the increase of cell growth	[35]
Vitamin B3 (niacin)	123.11 g/mol		Fish, egg, meat, nuts, peaches, and dales	It helps in promoting a healthy nervous system and energy metabolism and regularisation	[36]
Vitamin B5 (pantothenic acid)	219.23 g/mol		Peanuts, liver, and yolks	It helps in stabilizing metabolism and hormone synthesis	[37]
Vitamin B6 (pyridoxine)	169.18 g/mol		Bananas, fish, potatoes, nuts, beef liver, meat, and chickpea	It helps improve immune health, maintain a healthy metabolism, and boost the energy level	[38]
Vitamin B9 (folic acid)	441.4 g/mol		Broccoli, asparagus, citrus, beans, green leafy vegetables, carrots, celery, and okra	It helps in the reduction of defects in the neural tubes and helps against anemia, indigestion, abnormal brain growth, and skin disorders	[39]
Vitamin B12 (cyanocobalamin)	1355.4 g/mol		Milk, poultry, eggs, meat, shellfish, etc	It helps in the metabolism regularisation and also increases the formation of blood cells	[40]

Table 2: Continued.

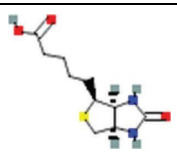
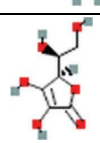
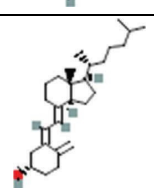
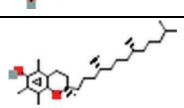
Names of vitamin	Molecular weights	Molecular structures	Source foods	Benefits	References
Biotin	244.31 g/mol		Almonds, legumes, nuts, eggs, salmon, dairy products, and oysters,	It helps in treating skin disorders, regulates metabolism, and boosts hair growth	[41]
Vitamin C	176.12 g/mol		Citrus, kiwi, guava, papaya, broccoli, parsley, pineapple, Brussels, and sprouts	It helps to treat eye disorders, scurvy, and diabetes and helps to neutralize the free radicals	[42]
Vitamin D	384.6 g/mol		Sunlight, fatty fish, egg yolks, and milk	It helps in preventing osteoporosis, arthritis, and tooth decay, boosts immunity, and lowers blood pressure	[43]
Vitamin E	430.7 g/mol		Dandelion greens, almonds, hazelnuts, sunflower seeds, avocado, and spinach	It helps in improving blood circulation, skincare, and heart health and boosts immunity	[44]
Choline	104.17 g/mol			It helps the brain and nervous system functioning	[45]
Carnitine	161.20 g/mol			It helps to change fatty acids into energy	[46]

Table 3: List of fatty acids and their health benefits.

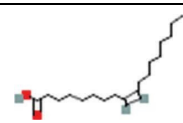
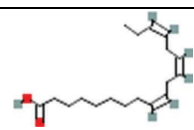
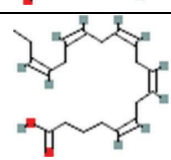
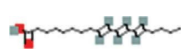
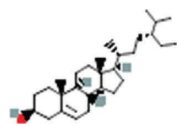
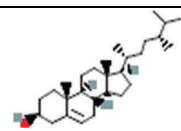
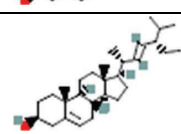
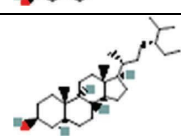
Names	Molecular weights	Molecular structures	Sources	Benefits	References
Monounsaturated fatty acids (MUFAs) Example: oleic acid	282.5 g/mol		Olive oil, avocados, grapeseed oil, red meat, tree nuts, and canola oil	Helps in reducing the risk of cardiovascular disorders and also provides a healthier serum lipid profile	[54]
Omega-3 fatty acids (linolenic acid)	278.4 g/mol		Flaxseed oil, walnuts, and hemp oil,	Helps in the anti-inflammatory and anticlotting effects, improves eye and heart health, and maintains mental functions	[55]
Long-chain omega-3 fatty acids Example: Eicosapentaenoic acid	302.5 g/mol		Fish oil, salmon, tuna, and algal oil	Helps in providing protection against CHD and autoimmune diseases such as rheumatoid arthritis and also improves infant visual and cognitive development, reducing the risk of cardiovascular diseases	[56]
Conjugated linolenic acid Example: β-Eleostearic acid	278.4 g/mol		Meat items, including beef, some mushroom species, and cheese	Helps in bodybuilding and improves immunity along with body composition, decreasing the risk of certain cancers	[57]

Table 4: List of plant sterols with their health benefits.

Names	Molecular weights	Molecular structures	Sources	Benefits	Reference
β-Sitosterol	414.7 g/mol		Rice bran oil, wheat germ oil, peanuts, corn oil, and soybeans	Helps in treating benign prostrate hyperplasia, lowers cholesterol	[61]
Campesterol	400.7 g/mol		Banana, pomegranate, pepper, coffee, cucumber, and lemongrass	Helps in reducing cholesterol levels and has anticarcinogenic effects	[61]
Stigmasterol	412.7 g/mol		Soybean, rapeseed, and calabar beans oil	Important in the development of drugs for cancer therapy	[62]
Sitostanol	416.7 g/mol		Rice bran, whole grains, rye, nuts, and lentils	It helps in lowering cholesterol and improves symptoms of an enlarged prostate (BPH)	[63]

diarrhea, and flatulence. Commonly observed polyols are sorbitol, maltitol, xylitol, isomalt, lactitol, and mannitol [65].

The most common and typical synthetically produced polyols include erythritol, a derivative of fermented glucose, or xylitol from hardwood trees [66]. These polyols are also used in gums, sugar-free candies, ice creams, jams, jellies, beverages, and lozenges. Erythritol, chemically called 1,2,3,4-butanediol, is generally found in vegetables, fruits, mushrooms, and fermented foods such as soy sauce. Isomalt is the mixture of two disaccharide alcohols which are glucose-mannitol and glucose-sorbitol. It is resistant to high temperatures and is being used in many products, which are termed sugar-free products. Lactitol is a disaccharide, and it is made up of galactose and sorbitol. Maltitol, chemically called 4-*O*-α-D-glucopyranosyl-D-glucitol, is made of glucose and sorbitol and is of great use in commercial products, namely, sweet pear and malty sweet [67, 68]. According to the European Commission, the proposed caloric value of polyol is 2.4 kcal/g, whereas FASEB reported calorific values ranging from 1.6 to 3.0 kcal/g [69].

2.7. Phytoestrogens. Phytoestrogens are compounds produced in plants that act similar to the estrogen produced by the human body. The foods that consist of these phytoestrogens include soy, legumes, some grains, fruits, and vegetables. They are also called dietary estrogens because of the effect they produce in the body [70]. The phytoestrogens are classified depending on their biosynthesis patterns and structures. They are grouped into chalcones, lignans, flavonoids, and various classes. The most important of these is isoflavonoids which include among many groups of chemicals including coumestans, isoflavones, pterocarpenes, and isoflavones [71]. The human body has many different functions in many processes, such as reproduction, skin, bone, cardiovascular system, metabolism, nervous system, immune system, and cancer [72].

Phytoestrogens are also considered endocrine-disrupting agents, saying they can also cause major problems in health. Nowadays, these are widely used in the hormone replacement therapy including estrogen replacement therapy in numerous dietary supplements [73]. These compounds are most beneficial for women in their perimenopause, as their hormonal levels will rapidly change [74]. They also help relieve hot flashes, prevent osteoporosis, treat acne, fight breast cancer, and promote heart health [75, 76]. The drug genistein in a dosage of 200 mg per day can reduce total cholesterol [77].

2.8. Soy Protein. Soy protein is the primary protein that is seen in soy products; this is mostly preferred as an alternative source to meat products. The essential types of these soy proteins fall under 3 major categories: soy protein concentrate, soy protein isolate, and texture soy protein [78]. This can be commonly found in products such as tofu, soy milk, and tempeh. For people who use plant-based protein in place of dairy products, these are significant sources of minerals, proteins, and vitamins [79]. The products obtained from soy protein are of many types, such as minimally processed soy, including tofu, natto, tempeh, and miso. More processed soy protein includes soybeans, some ingredients used by various companies, and soy milk [80]. Soy is a perfect source of fiber, proteins, and minerals, including zinc, calcium, magnesium, and iron. This is one of the important foods used for bodybuilding as a source of protein [81]. The isolated soy protein ISP helps in the normal development of children and even infants; it is less fat-containing and has no cholesterol or saturated fat [82].

Soy protein has all essential amino acids, making it a good diet choice [83]. They have some excellent health benefits, such as protecting heart health, offering anticancer benefits, and supporting blood sugar control [84–86]. Soy protein can aid in the weight loss process when used as a protein supplement [87]. There are some downsides to soy protein as well which go with their acting as antinutrients, phytoestrogens, and sometimes genetic modification agents [88, 89].

2.9. Sulfides/Thiols. Sulfides are chemicals used to preserve foods and beverages to prevent discoloration and slow down the browning of food items. Even in some medications, these sulfides are used. The foods that have sulfides are baked foods, soup mixes, canned vegetables and fruits, pickled foods, beer, and wine. The sulfides in sulfur dioxide are mainly helpful in preventing the growth of unwanted microbes in fruits, meat, and pickles [90]. SO_2 is considered a broad-spectrum antimicrobial that prevents the growth of bacteria, fungi, etc. Also, it is a vital ingredient to prevent malolactic fermentation in wine production [91]. Diallyl sulfide and allyl methyl trisulfide are the naturally occurring sulfides found in foods such as garlic, scallions, leeks, and onions. These are proven to have the detox and purification properties of unnecessary compounds and reduce the chance of blood clots, heart disease, and cholesterol [92]. Sulfide sensitivity is when a person gets triggered by sulfide-containing foods, and it is similar to that of food allergies. These are mostly observed in people with asthma or who are immunocompromised. There are various symptoms, including digestive, skin, respiratory, anxiety, paleness, and weakness, and in severe cases, it might lead to anaphylactic shock also [93].

Thiols are basically a kind of mercaptans that have a sulfhydryl functional group, and naturally formed thiols are very important and valuable antioxidants that are useful for the protection of cells from oxidative damage [94]. Thiols are electron donors, making them good antioxidant and anticancer agents. They avoid the carcinogenic effects of aflatoxin B1 (AFB1) [95]. Protein thiols play an essential role in the intramitochondrial antioxidant defense of mammals specific to their ROS and RNS [96]. Examples of thiols are glutathione (GSH), which protects cells against oxidative stress [97]. Dithiolethiones are naturally occurring thiols found in cruciferous vegetables, and they act as chemopreventive agents in cancer and as immune boosters [92].

2.10. Minerals. Minerals are the earth's crust originating inorganic elements present in plant and animal cells in a small ratio of the body. Most minerals play important roles in the growth and regulation of various physiological processes such as muscle contraction, oxygen transport, and maintenance of osmotic pressure, bones, and tissues [98]. It is necessary that, from all the nutrients, 0.2-0.3% of minerals should be consumed in the total daily diet. Minerals are commonly categorized into two groups based on their proportions in the human body, i.e., macroelements and microelements. Minerals or elements that occur in relatively large proportions and are required in 100 mg or more per day are known as macrominerals or macroelements. Examples of macroelements include sodium, magnesium, calcium, chloride, phosphorus, and potassium. Minerals or elements which occur in small proportions and are required in very few milligrams or less than that per day are known as microminerals, microelements, or trace elements. Zinc, iron, cobalt, copper, fluorine, manganese, selenium, silicon, boron, chromium, and nickel are examples of microelements. Recently, strontium and lithium have been appraised as potentially essential elements [99]. The recommended daily intake (RDA) of all these minerals shows a nutrition standard set by the Food and Nutrition Board of the U.S. National Academy of Sciences in milligrams per person [98]. The daily intake of these minerals depends on various internal and external factors such as nutritional habits, age, weight, and sex; the chemical form of the minerals; their consumption in food; their presence; and their absorption percentage from the gastrointestinal tract. The table shows data on the average daily intake, minerals absorption percentage, and RDA (Table 5) [100, 101].

In an organism, microelements such as copper, manganese, iron, zinc, nickel, and chromium commonly function as cations merged with chelators or ligands, i.e., porphyrins, proteins, pterins, and flavones [98]. Generally, the function of minerals can be classified into two categories, i.e., bodybuilding tissues and regulating processes. Phosphorus, potassium, iron, sulfur, and various minerals are important structural elements of soft tissues [98]. Essential minerals act as catalysts. Calcium is an example of a catalyst that helps in blood clotting. Few minerals help in the absorption of nutrients, the metabolism of carbohydrates, protein, and fat, and the usage of nutrients by the body cell [98]. Dissolved bodily fluids minerals are supervised for nerve impulses, muscle contraction, and acid-base balance. These minerals are vital for maintaining blood pressure, respiration, and heart rate. Details of various micronutrients and macronutrients are listed in Table 6.

2.11. Omega-3 Fatty Acid. Omega-3 fatty acid is a polyunsaturated, crucial nutrient known as healthy fat, which benefits human health. It is mainly made up of eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA), and alpha-linolenic acid (ALA), which help decrease the level of triglycerides in the human body. It protects the heart from many diseases by reducing the presence of arrhythmias [103]. They provide energy to the human body and support the health system. Fish, seafood, dairy products, chia seeds, walnuts, and flax seeds are good sources of omega-3 fatty acids. Flax seeds are a combination of lignin, protein hydrolysates, and ALA. Conjugated linoleic acid (CLA) decreases the development of adipose fat. Besides CLA, gamma-linolenic acid is helpful for premenstrual pain and skin-related diseases. Intake of omega-3 fatty acids is beneficial, but it should be taken in recommended amounts only, which are dominant for average growth and homeostasis. For the intake of omega-3 fatty acids, different health agencies have recommended daily intake doses, as mentioned in Table 7 [103, 104].

2.12. Probiotics and Prebiotics. Probiotics are a beneficiary group of live microorganisms that play a crucial role in the human digestive system. Bifidobacterium and lactobacillus (LAB) are common examples of probiotics [105]. Dietary foods, yogurt, candy bars, cereal juice, and fermented foods are good sources of probiotics. It helps bind relations between harmful and good microorganisms in the gut. A balanced digestive system helps to avoid infections such as urinary tract, diarrhea, fatigue, and muscle pain [7]. Along with this, probiotics help in building the immune system in human beings. It prevents humans from suffering autoimmune disorders such as Cronh's disease, ulcerative colitis, allergic reactions, rheumatoid arthritis, and various infections. It prevents humans from suffering from autoimmune disorders such as Cronh's disease, ulcerative colitis, allergic reactions, rheumatoid arthritis, and various infections [105].

Prebiotics come under nondigestible components that promote probiotics' activity and growth in the human digestive system. It provides a beneficial role for good bacteria to flourish and grow in the gut [106]. Nonstarchy carbohydrates such as inulin, beta-glucan, soluble dietary fiber, galactooligosaccharides, and fructooligosaccharide are the most common examples of prebiotics. It is also important to know that all prebiotics are not fiber, and all fiber is not prebiotics. A very common thing about prebiotics and fiber is that they are not at all digestible by human enzymes [103, 107]. Garlic, onion, asparagus, raw oats, soybeans, unrefined barley, and wheat are familiar sources of prebiotics [7]. Natural oligosaccharides such as breast milk are crucial in building an active immune system in newborns [7].

3. Antioxidants

A group of substances called antioxidants work to counteract reactive oxygen species (ROS) and free radicals in the cell. An unpaired electron on a carbon or oxygen atom qualifies as a free radical which is a highly charged and unstable electron. Lipids, proteins, and carbohydrates can produce free radicals [7]. They can be found as minerals, vitamins, carotenoids, and polyphenols in the diet. Antioxidants are mainly identified by their distinctive color [92].

Examples of antioxidants are as follows:

(1) Carotenoids (e.g., β-carotene, lycopene, and lutein)

(2) Polyphenols

(3) Phytosterols

Table 5: List of DI, RDA, and PA for various micronutrients and macronutrients.

Elements	Sodium	Phosphorus	Calcium	Magnesium	Potassium	Zinc	Iron	Copper	Manganese	Cobalt	Iodine	Reference
Daily intake (DI)	3000–7000	1760–2130	960–1200	150–350	3300	12	15	2.4	5.6	0.003–0.012	Up to 1.0	[100]
Recommended daily intake (RDA)	500	800–1200	800–1200	280–350	500	12–15	10–15	1.5–3	2-3	0.002	0.15	[100]
Absorption percent (PA)	High	High	10–50	20–60	High	30–70	10–40	25–60	40	30–50	100	[100]

Table 6: List of various micronutrients and macronutrients with their functions.

Minerals	Sources	Functions	Deficiency	References
Sodium	Milk, meat, eggs, table salt, salted food, fish, and bread	Cell permeability, water balance, nerve stimulation, osmotic pressure, and muscle contraction	Rare: vomiting, nausea, cramps, exhaustion	[98]
Phosphorus	Milk, whole grains, fish, meats, cheese, legumes, poultry, and eggs	Enzyme formation, tooth and bone formation, RNA and DNA components, energy metabolism, and fat transport	Stunted growth	[98]
Calcium	Hard cheese, legumes, dark green vegetables, milk, fish, and salmon	Blood clotting, enzyme activation, cell permeability, tooth and bone formation, and nerve stimulation	Osteomalacia, stunted growth, tetany, and osteoporosis	[102]
Potassium	Fish, whole grains, legumes, vegetables, fruits, and meat	Water balance, muscle contraction, protein synthesis, nerve stimulation, osmotic pressure, and acid-base balance	Muscular weakness, vomiting, heart failure, and nausea	[102]
Magnesium	Green leafy vegetables, milk, whole grains, nuts, meat, and seafood	Nerve stimulation, enzyme activation, muscle contraction, and teeth and bone components	Renal diseases or alcoholism	[98, 102]
Zinc	Fish, meat, milk, nuts, whole grains, oysters, and legumes	Vit A utilization and transport of carbon dioxide	Dwarfism, serve deficiency, delayed wound healing, and tooth decay in young children	[102]
Iron	Legumes, green leafy vegetables, liver, dry fruits, and meat	Formation of various enzymes' essential components, myoglobin, and hemoglobin formation	Muscle weakness, anemia, reduction in cellular immunity, and oxygen transport system	[102]
Manganese	Green vegetables, fruits, whole grain, tea, and meat	Important cofactor in many enzymes, helpful for normal brain function, bone structure, and reproduction	In animal studies: reproductive difficulties and abnormal bone development	[98]
Cobalt	Dairy products, fish, eggs, and liver	Plays an essential role in immunity, cofactor of vit B12	Rarely observed: vit B12 deficiency and pernicious anemia	[102]
Iodine	Seafood and iodized salt	Thyroid hormones synthesis, which regulates metabolic rate	Cretinism, goiter if deficiency is more	[98]
Copper	Fruits, dried legumes, kidneys, liver, nuts, and oysters	Essential for the formation of hemoglobin, utilization of iron, elastic tissue, and bone development	Leucopenia, anemia, skeletal demineralization, and neutropenia	[102]
Boron	Plant-originated foods	Helpful in arthritis treatment, muscle building, and arrest of osteoporosis	Damage growth and development	[102]

Table 7: List of different health agencies with recommended daily intake dose of omega-3 fatty acids.

Health organizations/agencies	Daily recommended dose	References
Indian Council of Medical Research	Female (1.1 g/day), male (1.6 g/day)	[104]
World Health Organization	0.7 g/day	[103]
The U.K. Health Department	0.2 g/day	[104]
American Heart Association	Up to 1 g/day	[104]
British Nutrition Foundation Task Force	Up to 1.5 g/day	[103]
European Academy of Nutritional Science	0.2 g/day	[103, 104]

(4) Tocopherols and tocotrienols

(5) Organosulphur compounds

3.1. Carotenoids. Carotenoids are colorful pigments that are soluble in lipids and are extensively present in plants which help in photoprotection. Carotenoids are oxygenated or nonoxygenated hydrocarbon molecules with at least 40 carbon atoms and are primarily found in conjugated double-bond systems. Various studies have shown a relationship between a rich carotenoid diet and decreased cases of cancer. Lycopene, alpha-carotene, and β-carotene are nonpolar functional carotenoids, whereas lutein is a dominant polar functional carotenoid [7] (Table 8). Lutein belongs to the xanthophyll group and is usually present with zeaxanthin. Commercially available lutein is a mixture of 5% zeaxanthin and 90% lutein extracted from *Tagetes erecta* [109]. Spinach, kale, beans, grapes, kiwi, oranges, and corn are significant sources of carotenoids [110]. The amount of carotenoid present in vegetables and fruits varies with storage and age. Lycopene shows chemopreventive ability with the help of its mobile oxygen-neutralizer potential.

3.2. Polyphenols. The most prevalent and numerous classes of valuable chemicals are polyphenols. Polyphenols are numerous classes of plant compounds with variable numbers of hydroxyl (OH), carbonyl (CO), and carboxylic acid (COOH) groups, as well as one or more benzene rings. They frequently appear in conjugated models with more than one sugar residue attached. Flavonoids are the highly prevalent class of polyphenols. There are about 8000 different varieties of polyphenols, including the arubigins, catechins, isoflavones, and theaflavins [111].

According to the research gathered [112], eating fruits high in phenolic compounds boosts the blood's antioxidant capacity. Fruits may counteract the detrimental effects of prooxidant and proinflammatory meals that are heavy in fat and carbohydrates. According to a survey, the oxidation process of the cholesterol-rich LDL-C particles is one of the prominent risk factors for the initiation of atherosclerosis. LDL-C oxidation makes it more atherogenic and easier for lipids to penetrate the arterial wall, leading to the blockage of arteries in general and coronary arteries in particular. Thus, it is understood that nutritional antioxidants, mainly phenolic compounds, can inhibit the oxidation of lipids. Numerous phenols, including myricetin, gallic acid, the flavan-3-ols (1)-catechin and (2)-epicatechin, and others, have been demonstrated to exhibit antioxidant properties in some studies [113].

3.3. Phytosterols. The plant version of cholesterol is known as phytosterol/plant sterol. They both share the same structures. However, plant sterols side chains have comparatively more double bonds and methyl and ethyl groups. Stigmasterol, β-sitosterol, and campesterol are the three most prevalent bioactive plant sterols [7].

3.4. Tocotrienols and Tocopherols. The phenol-chromanol ring is connected to the isoprenoid side chain that is either saturated (in the case of tocopherols) or unsaturated (in the case of tocotrienols) by a lipid-soluble functional component known as a-tocopherol or tocotrienol. The quantity and placement of the methyl groups on the phenol-chromanol ring vary across the four primary types of tocopherols and tocotrienols, alpha, beta, gamma, and delta [111, 114].

Antioxidant-rich meals may reduce the incidence of chronic disease, according to epidemiological research, but interventional treatments have had mixed results. As an illustration, epidemiological research has demonstrated the protective impact of fruits and vegetables. Many intervention trials using high doses of carotene, a potent antioxidant present in abundance in vegetables and fruits, were sparked by this information; nevertheless, these trials revealed no clear proof of benefit and showed an enhanced chance for lung cancer. It has been found that other sets of antioxidants, such as vitamins C and E, produce comparable outcomes [115].

3.5. Organosulfur Substances. Organosulfur compounds are typically found in allium-class vegetables (vegetables in the same class as onions and garlic), such as leeks, or cruciferous vegetables such as broccoli, cauliflower, and brussels sprouts. Sulfur atoms attached to a carbon atom or a cyanate group in a noncyclic or cyclic configuration make up organosulfur compounds [7].

3.6. Phenolic Acids. Secondary plant metabolites are phenolic chemicals. More than 8000 phenolic compounds have been discovered in naturally occurring sources, divided into phenolic acids, flavonoids, coumarins, lignins, stilbenes, and tannins. Phenolics are essential to plants because they are an internal physiological regulator in managing growth. For instance, when apigenin, kaempferol, and quercetin interact with cytoplasmic membrane proteins (receptors), they limit the movement of polar auxin molecules across the membrane, impacting plant growth. Numerous phenolic and polyphenolic substances exist, including phenolic acids,

Table 8: Different functional components of carotenoids with their sources and health benefits.

Functional components	Molecular weights	Molecular structures	Sources	Benefits	References
β-Carotene	536.9 g/mol		Carrots, spinach, kale, fruits, and vegetables	(i) Protects the human body from free radicals and prevents the chance of developing heart disease and cancer	[108]
Lycopene	536.9 g/mol		Tomatoes, guava, watermelon, and mango	(i) Lower neuropathic pain (ii) Protect human eyes from stress (iii) Helps to reduce the possibility of cancer (prostate and breast cancer)	[108]
Lutein	568.9 g/mol		Broccoli, spinach, carrots, corn, citrus fruits, and green peas	(i) Lowers the chance of muscular degeneration (ii) Lowers the chance of severe eye diseases	[108]

stilbenes, coumarins, lignins, flavonoids, and tannins. In plant sources such as cereals, leguminous plants, and other seeds, phenolic acids are a primary phenolic class of compounds that function as the main constituent of cell wall matrices by forming bridges with macromolecules like cellulose, hemicellulose, and pectin to support the development of compact cell wall composition. They, therefore, typically exist in different conjugated forms in addition to the free type. Hydroxycinnamic acids and hydroxybenzoic acids are the two categories of phenolic acids. P-coumaric, ferulic, caffeic, and sinapic acids are hydroxycinnamic, while syringic, protocatechuic, vanillic, and gallic acids are hydroxybenzoic [116]. There are soluble and insoluble-bound forms of phenolic chemicals. The vacuoles of plant cells are where most soluble phenolics are concentrated and trapped. The increased concentration of organic acids inside a vacuole causes a low pH, which causes phenolics to localize when integrated. Alternatively, insoluble-bound phenolics are concentrated in the matrix of the plant cells' cell walls. Legumes also contain large amounts of bound phenolic acids. Oilseeds also contain bound phenolic acids. Gallic, ferulic, protocatechuic, caffeic, p-coumaric, and sinapic acids were found in sunflower seeds, and their concentrations ranged from 2.5 to 50.8 g/g of dry weight [117]. Most phytochemicals in fruits and vegetables are in free or soluble conjugate forms. 24% of the total phenolics found in these dietary matrices are bound phenolics. The insoluble-bound phenolic concentrations of ripe medlar and oil palm fruits are 20.7% and 33.2%, respectively [117].

Phenolic compounds are regarded as one of the most significant types of natural antioxidants. Within polyphenols, bioavailability varies greatly. Some substances also depend on how they are presented in the relevant dietary sources. They serve as a plant's primary defense against ultraviolet light and diseases. Plant growth, reproduction, and pigmentation play additional functions [118]. The structure of phenolic compounds, particularly the benzene ring and the amount and position of OH groups, determines their capacity or potency for antioxidant activity. Antioxidant molecules are stabilized when they react with free radicals, thanks to the benzene ring. Three hydroxyls and one carboxylic acid group are present in gallic acid, a phenolic acid. The hydroxyl group, however, forms the gallic acid-free radical, which performs the antioxidant role [119]. Phenolic extracts from plants have emerged as desirable nonsynthetic antioxidants in prepared lipid meals. Under many circumstances, it has been demonstrated that phenolic extracts from various herbal foods and waste products, such as skins, stems, and seeds, exhibit equivalent or even higher antioxidant activity than traditional antioxidants such as ascorbic acid and tocopherols. It has been demonstrated that pure phenolic chemicals can prevent oxidation and discoloration in bulk oils, meat products, and lipid dispersions. The same may be said for plant phenolic extracts, which have also been shown to be potent food antioxidants [120]. Phenolic compounds, which are classified as primary antioxidants and are primarily free radical scavengers (FRS) that delay or inhibit the initiation step of lipid oxidation or interrupt the propagation step of lipid oxidation, reduce the production of volatile decomposition products that cause rancidity (such as aldehydes and ketones) [121].

3.7. Flavonoids. Flavonoids are polyphenolic plant biochemical chemicals that comprise flavonols (found in tea, onions, broccoli, and different fruits), flavones (found in chamomile tea, parsley, and celery), flavanones (found in citrus fruits), flavonols (found in apples, grapes, red wine, cocoa, and tea), anthocyanidins (found in colored berries and red wine), and isoflavones (found in soy) (Table 9). Flavonoids' varied structural makeup relates to variations in how well they can alter particular biochemical pathways. Following consumption, variations in assimilation, administration, metabolism, and excretion further alter their bioavailability, location of the activity, and production of bioactive metabolites [133]. Soy isoflavones (daidzein, biochanin A, and genistein), flavonols (myricetin, quercetin, and kaempferol), and flavones (apigenin and luteolin) are the flavonoids that are available in the human diet in the highest concentrations. Environmental elements like light and ripeness, genetic factors like species, and postharvest practices like processing all impact the levels of particular and total flavonoid content in the food. Although catechins are present in most fruits and some legumes, their concentrations vary, ranging from 4.5 mg/kg in kiwifruit to 610 mg/kg in black chocolate. Vegetables' edible sections often contain less quercetin than 10 mg/kg. Myricetin and Kaempferol have 2 to 5 mg/l and 7 to 17 mg/l, respectively, while quercetin ranges from 10 to 25 mg/l in black tea infusions. Only tea, in addition to catechin and epicatechin (EC), includes gallocatechin (GC), epigallocatechin (EGC), epicatechin gallate (ECG), and epigallocatechin gallate (EGCG) [134].

In terms of food science, flavonoids are considered nonnutrients. Due to their nature to impede digestive enzymes, exhibit astringency and bitterness, and have inconsistent absorption after consumption, flavonoids are historically usually taken out of crops used for food. However, the demonstration of numerous therapeutic effects became recognized due to being included in regular meals, including antioxidant capabilities in animal trials, a decrease in cardiovascular disease, antiallergic, anti-inflammatory, antidiabetic effects, and high blood pressure. The review of flavonoids as third-order functional components (food factors) with biological regulatory properties thus came forth. For example, the functioning of soy isoflavones, red wine polyphenols, and green tea flavanols in relation to lowering the probability of lifestyle-related disease or metabolic disorder is particularly interesting [135]. In the human diet, flavonoids are phenolic antioxidants that are naturally occurring. Green vegetables, fruits, olive and soybean oils, red wine, chocolate, and teas all benefit from their antioxidant characteristics. Some flavonoids have been shown to exhibit a range of biological properties, including impacts on mammalian metabolism and antiallergic, anti-inflammatory, antiviral, antiproliferative, and anticarcinogenic activity [134]. Numerous

Table 9: List of categories of flavonoids, compounds, and food source.

Compound subclasses	Compounds	Sources	References
Anthocyanin	Cyanidin 3,5-diglucoside	Pulp of red pitaya	[22]
Anthocyanin	Cyanidin 3-O-galactoside	Cranberry fruit	[122]
Anthocyanin	Cyanidin 3-O-glucoside	Jabuticaba seed and peel	[123]
Anthocyanin	Delphinidin 3-O-glucoside	Seed and peel of grape pomace and jabuticaba	[123, 124]
Anthocyanin	Malvidin 3-O-glucose and malvidin 3-O-p-coumaroylglucoside	Seed and peel of grape pomace	[124, 125]
Anthocyanin	Peonidin 3-O-glucoside	Seed and peel of grape pomace	[124, 125]
Anthocyanin	Peonidin 3-O-galactoside	Cranberry fruit	[122]
Anthocyanin	Petunidin 3-O-glucose	Peel and seed of grape pomace	[125]
Flavones	Chrysin	Pomegranate peel	[126]
Flavones	Luteolin, apigenin, and chysin	Fruits, vegetables, and cereals	[127]
Flavonols	Myricetin	Cranberry fruit	[122]
Flavonols	Quercetin	Apple peel and cranberry fruit	[128]
Flavonols	Quercetin 3-O-glucoside and quercetin 3-O-glucuronide	Peel and seed of grape pomace	[124]
Flavonols	Quercetin 3-O-rhamnoside	Kiwifruit pomace	[125]
Flavonols	Quercetin 3-glucoside	Apple fruit peel	[128]
Flavonols	Quercetin 3-O-rutinoside	Jabuticaba peel and seed	[129]
Flavonols	Rutin	Apple peel	[128, 130]
Flavonols	Kaempferol and galandin	Apple, cherries, berries, onion, tomato, broccoli, tea and red wine	[127]
Dihydrochalcones	Phloretin, phloridzin, and phlorizin	Apple and apple peel	[131]
Tyrosols	Hydroxy tyrosol, oleuropein, oleuroside and tyrosol	Olive pulp	[132]
Isoflavone	Genistein, daidzein, and glycitein	Legumes (soyabean)	[127]
Flavanone	Naringenin, hesperetin, and eriodictyol	Citrus fruits	[127]
Flavanol	Catechin, epicatechin, and gallocatechin	Apple, red grapes and tea	[127]

laboratory research studies and randomized clinical trials have shown that foods high in flavonoids, such as tea, cocoa, and berries, positively affect the heart and metabolism. The effects of flavonoid-rich cocoa on blood pressure (BP), endothelial function, insulin resistance, and blood lipids are modest but noticeable [133]. Flavonoids have anti-inflammatory activities through various processes, including the suppression of regulatory enzymes and transcription factors that play a significant role in the modulation of mediators incriminating in inflammation. Potent antioxidants and flavonoids may both scavenge free radicals and prevent their production. As a result, flavonoids profoundly affect several immune cells and immunological systems crucial to inflammatory processes [127].

4. Bioactive Compounds in the Indian Market and Their Future Perspective

One billion individuals over the age of 60 lived in the world in 2020, with 70% of them residing in developed nations, driving up demand for antiaging products. The revenue from the global market for functional foods and nutraceuticals in 2013 was over $175 billion. The elderly population and a healthy retail market in various nations are predicted to cause the market to increase from $221.58 billion in 2014 to $424 billion by 2017. The market for nutraceutical beverages alone is anticipated to develop at the fastest rate, with an 8.8% average annual rate of growth. The 2016 cost estimate for the nutraceuticals sector was $87 billion. The second-largest market is for nutraceutical foods, which are anticipated to grow at an annual average growth rate of 6.4% and extend to $67 billion in 2016 [136]. Consumers' increased awareness of their physical well-being and willingness to pay for healthy meals and additives has led to a rapid increase in the demand for nutrient-rich food and the food industries in India. The Indian nutraceuticals industry can be roughly divided into healthy food and beverage (68%) and dietary supplements (32%). An increasing number of people in India's middle class believe in and rely on Ayurveda and traditional knowledge, accelerating the expansion of the country's functional food and beverage business. The nutraceutical market is estimated to be worth USD 2.2 billion. The country's southern regions dominate the nutraceutical market, including Tamil Nadu and Andhra Pradesh, as well as West Bengal and the eastern states [92]. In India, the market for food and drinks had grown by 70.74% by 2017 compared to the market for dietary supplements. The Indian nutraceuticals market has shown remarkable growth during the past seven years. The market is reportedly driven by a rise in health consciousness, increased consumer knowledge of the numerous categories of nutraceuticals on the market, and consumers' inclination to spend money on food and additives that promote good health [137].

The rising prevalence of obesity, diabetes, eye disorders, and cardiovascular diseases, shifting food consumption patterns in developing markets, rising preference for preventive medicine, rising demand for multivitamins, and ingredients such as omega-3s and astaxanthin are the main components of the market for nutraceuticals and functional foods [138]. Conjugated linoleic acid (CLA), soy, whey, and dietary fibers are added to many popular nutraceuticals because they help with weight control, cardiac care, immunity, and digestive health. Consumer knowledge of goods with high bioavailable health-beneficial elements is consistently rising. We are putting more effort into better research to understand the need for nutraceuticals and functional foods.

Government organizations, food scientists, and private research organizations work in this area. In general, efforts are focused on identifying various functional foods and their mechanisms that aid in the treatment of chronic health conditions, the prevention of these diseases, the improvement of health, and ultimately the reduction of healthcare expenses [92]. Because obtaining country legislation and creative, health-claim-proof food items from food firms is challenging, developing nutraceuticals and functional foods involves an expensive, time-consuming process. Food corporations have always supported the development of new and innovative products, but the risks associated with functional foods are more significant for both food firms and consumers. Exclusive ingredients may be used to create functional and nutrient-rich products whose rights can be recorded in patents, but "free" ingredients are present in most products. They can be easily copied, which results in limited competitive advantages for the company that invented the product [136]. The functional food and nutraceutical industries have existed for some time. However, it is impossible to predict where it will go in the future due to challenges like national restrictions, the difficulty of proving health claims, and a lack of innovation among food producers. Functional meals are not widely accepted anywhere in the world. Even though many countries have legislation permitting the use of and regulating health claims, the process has yet to result in the claim's authorization [139]. Getting a functional food's health claims approved in the USA and Japan is challenging. The European Food Safety Authority (EFSA) has proposed standards for substantiating health claims to the European community although they still seem unattainable in Europe. In these areas, the criteria for supporting a health claim, such as the length of clinical studies, the verification of biological markers, and dose-response curves that show the optimal dosage and side effects, need to be clearly defined [136].

5. Safety Concerns and Ethical Issues in the Development of Food Extracts

Functional foods and nutraceuticals play a dominant role in intercepting various diseases and stimulating health benefits in human beings. It is important to follow all safety standards from consumers in all conditions. Manufacturers often process functional foods for particular groups of consumers, i.e., high cholesterol and in specific quantities, and other family members can also be served the same. However, maintaining safety minimizes the risk. Putting components into functional foods that are unsafe for other associations is erroneous. Adding herbal ingredients to

functional foods is a typical example of this issue. It is necessary to understand that safety assessment will modify depending on the ingredients, amounts, and levels (micronutrient or macronutrient) [92].

6. Conclusion

In conclusion, functional foods are beneficial for human health due to their rich content of physiologically active substances derived from both plant and animal sources. Plant-based bioactive compounds, including carbohydrates, vitamins, minerals, polyols, and phytosterols, play a crucial role in initiating various biochemical processes within the body. By prioritizing prevention rather than treatment, the consumption of functional foods and nutraceuticals can collectively alleviate the strain on healthcare systems. When consumed in appropriate amounts and at the right time, functional foods have the potential to act as effective agents in preventing numerous health ailments and aiding in the treatment of certain disorders. However, the identification and understanding of appropriate bioactive compounds and their specific functions in disease prevention can be challenging. It is essential to scientifically establish the health-diet relationships of foods and demonstrate their prospective health benefits. Foods lacking well-established scientific evidence regarding their health benefits must undergo rigorous investigation. Functional foods not only contribute to a balanced diet but also play a vital role in maintaining various metabolic functions within the human body. Their potential to enhance a healthy lifestyle holds significant implications for the food processing industry.

In summary, functional foods, with their abundant bioactive compounds, have the potential to support human health and prevent diseases. Further research and exploration are necessary to fully comprehend their mechanisms of action and unlock their maximum benefits. By incorporating these foods into daily life, individuals can make significant strides towards achieving a healthier lifestyle, ultimately benefiting both their personal well-being and the food processing industry.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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