

The Science of Stress and Functional Foods: A Holistic Perspective

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ABSTRACT

Stress has become a pervasive issue in modern life, significantly affecting both mental and physical health. Behavioural, hormonal, immunological, and physiological responses to stressors lead to physical expressions of fatigue and psychological expressions of tension or irritation. If not treated, it can lead to chronic problems like despair, therefore requiring effective evidence-based treatments. Current medications mainly target psychological or physical symptoms, and they often have side effects, including overuse risks. An emerging approach includes the use of functional foods, nutraceuticals, or products that are a combination of nutrition and therapy. These include dietary fiber, prebiotics, probiotics, antioxidants, and natural foods, which significantly affect stress management. This review explores the impact of nutrients and diets on managing stress. The release of cortisol during stress serves a purpose but can become harmful when elevated over time. Although practices like meditation and exercise are often recommended for stress relief, the role of functional foods is frequently overlooked. These foods offer more than basic nutrition; they contain bioactive compounds that support brain function, regulate hormones, and enhance overall well-being. By nourishing the body and mind with essential nutrients, functional foods serve as natural allies in managing stress. This literature review examines various types of functional foods and their health implications, particularly in stress management. Understanding their mechanisms and benefits can provide a path to optimal use in promoting health and resilience in our increasingly stressful world. Although the present body of research is promising in showing the potential of functional foods in managing stress, there is a need for holistic studies that consider both psychological and physiological outcomes. Future human trials to study the efficacy of nutritional interventions to reduce acute responses to stress need to pay attention to several critical aspects of study design.

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Introduction

Hans Selye, a Canadian endocrinologist, introduced the term stress in healthcare in 1949. Stress refers to the body's reaction to changes in its environment and how it responds to situations that disturb its balance. A stressor can be anything from people to events that cause stress. Stress is both a natural response to threats and a psychological way to manage that response, focusing on preparing the body for challenges. Increasing awareness of stress has led to efforts to find both medical and non-medical ways to reduce it. The body's stress response involves complex physiological and neurological changes, necessary for survival. Each person responds to stress differently based on genetics, experiences, and social factors. Stress hormones are released, prompting reactions to stressful situations, which can be short-term or long-term. Acute stress can be managed and resolved, while chronic stress leads to serious health problems (Asalak et al., 2022).

The Neurobiology of Stress

Stress activates the HPA axis, releasing norepinephrine in the brain, that may lead to stress-related problems. ACTH

produced by the anterior pituitary is stimulated by CRF, which increases the glucocorticoids released and helps relieve stress in the body. Glucocorticoids can influence cognitive functions, causing a person to forget things temporarily while they are experiencing stress. GABA is an important neurotransmitter that regulates stress disorders; stress can disrupt GABA levels, affecting behavior and physiology. Melatonin, produced in the pineal gland, also plays a role in stress response through GABA pathways. Dopamine regulates neuronal functions and is influenced by stress, which alters its pathways. Norepinephrine is tied to the central stress response, especially in relation to depression and immune responses. Serotonin is also associated with stress and psychological disorders, and its signaling in the brain is affected by stress. Stress may have an irregular effect on melatonin production; however, it could be used to treat problems associated with stress and enhance responses to vaccines. Glutamate interacts with stress in different brain regions (Rice, 2012; Eugeny and Natalia, 2019).

Functional Foods for Oxidative Defense

Functional foods are also important to combat oxidative stress that is induced by chronic tension. Oxidative stress can be defined as an imbalance of free radicals and antioxidants in the body, which induce cellular damage. Some antioxidant-rich foods, including berries, green tea, and dark chocolate, are rich in compounds like polyphenols, flavonoids, and catechins, which neutralize free radicals (Figure 1). Antioxidants are not only good at combating oxidative damage to the brain but also in reducing inflammation, which usually tends to increase with stress conditions (Rajeshwari et al., 2014). When one experiences stress, the body releases cortisol, a hormone that prepares us to deal with challenges but can cause harm if persistently elevated. Chronic stress also triggers oxidative stress, damaging cells and accelerating the aging process. Neurotransmitter imbalances, particularly a decrease in serotonin and dopamine, further exacerbate feelings of anxiety and depression. Regulation of cortisol is one of the most important ways functional foods can help in managing stress. This hormone, referred to as cortisol, or the stress hormone, is required in minimal amounts to regulate acute stress. When stress is chronic, though, high levels of cortisol over time can interfere with sleep, lower cognitive ability, and even weaken the immune system. Cortisol regulation includes some foods that contain magnesium, such as spinach, almonds, and avocados. Magnesium helps to regulate the hypothalamic-pituitary-adrenal (HPA) axis, thus dampening the excessive production of cortisol and promoting relaxation (Jacka et al., 2009). Vitamin C-rich foods, such as oranges, bell peppers, and strawberries, help to dampen the physiological effects of stress by reducing cortisol levels and boosting immune health (Brody et al., 2002).

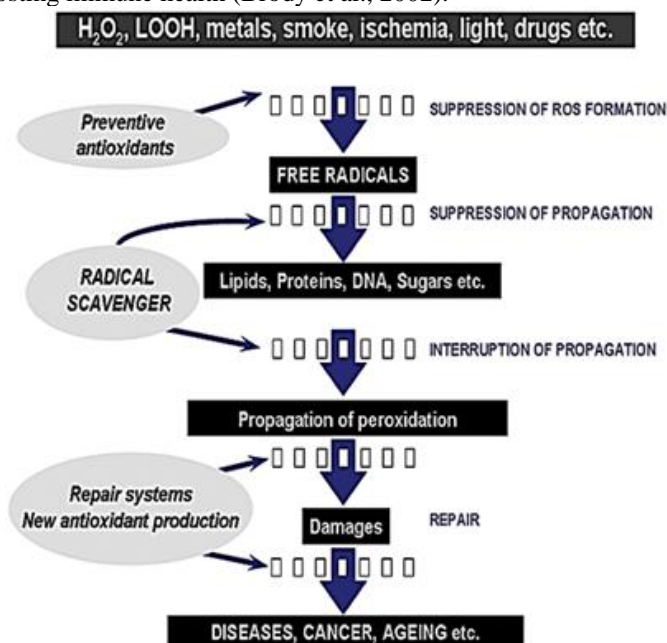


Figure 1: Mechanism of action of Nutraceuticals (Rajeshwari et al., 2014)

Functional foods in Stress Management

Nutraceuticals are gaining considerable attention for the safety and benefits of healthiness in supplements or processed foods; they prevent and aid in the management of diseases through containing beneficial natural source compounds of various chronic inflammatory diseases. Nutraceuticals include dietary supplements, value-added processed foods, and non-dietary supplements such as tablets, soft gels, and capsules

containing bioactive ingredients. Nutraceuticals are defined as foods or dietary components that prevent and treat disease. These contain protein, vitamins, minerals, and compounds from natural sources. As Nutraceuticals contain phytochemicals, these are useful to delay, prevent and treat chronic inflammatory diseases (Sachdeva et al., 2020; Aslak et al., 2022).

By 2030, an estimated 23.6 million people will be suffering from CVD, 40 million diabetics, and 215 million hypertensive populations. There is no denying of the fact that affluence is one of the causes of lifestyle diseases, to which nutraceuticals and dietary supplements attend. The consumption of foods such as oats, flaxseeds, soybean, green tea, citrus fruits, tomatoes, garlic, and nuts, among others, including their corresponding physiologically active constituents, have been associated with mitigating the risk of diseases. People can maximize their health-promotional potential from their diet through the use of supplementation and the development or enrichment of the foods with health-promoting factors. Nutraceuticals and functional food are at the forefront of new approaches to managing lifestyle diseases. The health claims of functional foods need to be proven scientifically with concrete and reliable data through well-designed studies that demonstrate both their safety and efficacy (Sangha, 2014; Khan et al., 2023).

Functional foods are defined as foods that offer potential health benefits beyond basic nutrition. These foods not only promote good health but also lower the risk of diseases, making them a key focus in modern nutrition and healthcare. Known by terms such as “nutraceuticals” and “designer food,” functional foods have gained global popularity (Mellentin et al., 2014). Although these functional foods contain very small quantities of bioactive compounds, the health effects of these bioactive compounds were thoroughly studied in rodent models and in clinical settings. Recent epidemiological studies have supported that the consumption of some fruits, vegetables, as well as some animal products rich in bioactive compounds decreases the risk of metabolic disorders and cancer (Karasawa and Mohan, 2018). In 1989, Dr. Stephen De Felice introduced the term nutraceutical, which is derived from merging ‘nutrition’ and ‘pharmaceutical’. He describes a nutraceutical as “any substance that is a food or a component of food that provides medical or health benefits, including disease prevention and treatment.” (Goldstein and Kopin, 2010; Chauhan et al., 2013).

Categories of Nutraceuticals

Nutraceuticals can be generally classified as products derived from natural sources (nature like) or synthesized (man-made), which supplement the normal diet and help to enhance nutritional quality and safety, besides disease prevention and treatment. Nutraceuticals are categorized as follows:

1. Based on chemical constituents (a) Nutrients: Chemical substances having definite nutritional function, namely vitamins, minerals, amino acids, and fatty acids. (b) Herbals: Herbs or botanical products as concentrates and extracts. (c) Dietary Supplement: Dietary supplements are products intended to be ingested by putting them in your mouth, that contain a dietary ingredient that is present in addition to what you normally eat. Examples include black cohosh for menopause symptoms, ginkgo biloba for memory loss, and glucosamine/chondroitin for arthritis. They also provide specific purposes: sports nutrition, weight-loss supplements,

and meal replacements. The ingredients of the supplement include the vitamins, minerals, herbs, or other botanicals, amino acids, enzymes, organ tissues, gland extracts, or other dietary substances. All these forms come in tablets, capsules, liquids, powders, extracts and concentrates (Williamson, 2001).

2. Conventional and Non-Conventional nutraceuticals

Nutraceutical foods are not just introduced on the market; there exists a vast assortment introduced that belongs to the genre of traditional food and non-traditional foods.

(a) Conventional Nutraceuticals: Under the conventional Nutraceuticals category come foods in which no alteration of the food is done; It is nothing but naturally occurring whole foods with new information about the potential health qualities. There has been no real change to the actual foods, other than the way the consumer perceives them. Many fruits, vegetables, grains, fish, dairy and meat products contain several natural components that deliver benefits beyond basic

Nutrients, be it lycopene in tomatoes, omega-3 fatty acids in salmon, or saponins in soy to even tea and chocolate, have all been touted to possess health benefits in one study or another. Tomatoes and salmon are just two such foods researchers have come across, containing benefits beyond plain, old nutrition: lycopene and omega-3s fatty acids, respectively.

(b) Non-conventional Nutraceuticals : They are the product of agricultural breeding or added nutrients and/or ingredients like orange juice fortified with calcium, cereals with added vitamins or minerals and flour with added folic acid are nonconventional nutraceutical. Agricultural scientists successfully have come up with the techniques to boost the nutritional content of certain crops. Research currently is being conducted to improve the nutritional quality of many other crops (Figure 2) (Anand and Bharadvaja, 2022; Khan et al.,2023).

Health scenario of India and Functional Foods

Diabetes in India: The number of diabetics in India is estimated to be about 40 million.

Hypertension – the silent killer: 140 million in 2008 to nearly 215 million by 2030. According to the World Health Organization (WHO), high blood pressure affects every third person above the age of 18.

Cancer Scenario in India: Cancer is the second most common disease in India responsible for maximum mortality with about 0.3 million deaths per year.

Obesity in India : Incidence : 12% males and 16% females in India 30% males and 37.5% females in Punjab

India: 'Heart disease capital of world': The estimated CVD deaths in 2008 were around 17.3 million. The percentage to global deaths stands at 30%. There are about 7.3 million deaths by CHD, and around 6.2 million by stroke (Williamson, 2001).

Protective foods as a source of functional food

Fruits and vegetables are highly rich in nutraceuticals, like vitamins and minerals, fibre, and phytochemicals. Key phytochemicals include flavonoids from berries and carotenoids found in carrots, in addition to phenolic acids from citrus fruits. They have antioxidant activity, anti-inflammatory properties, and provide cardioprotection. Dietary fibres in fruits of the apple family as well as vegetables of the broccoli family enhance gut health and modulate blood sugar and cholesterol levels. Specific bioactive compounds like lycopene in tomatoes, anthocyanins in blueberries, and sulforaphane in cruciferous vegetables have been shown to prevent chronic diseases, which are associated with the occurrence of cancer, cardiovascular disease, and diabetes. Many studies have been carried out to determine the role these nutraceuticals play in disease prevention. For instance, polyphenols in apples and berries activate glucose metabolism, while nitrates in leafy greens facilitate blood pressure reduction. Sulforaphane in broccoli thus regulates the activity of detoxification enzymes and inhibits tumor development, thus exerting anti-cancer effects. Other antioxidants in berries and green vegetables promote neuroprotection and prevent neurodegenerative diseases. The bioactive compounds in fruits and vegetables therefore

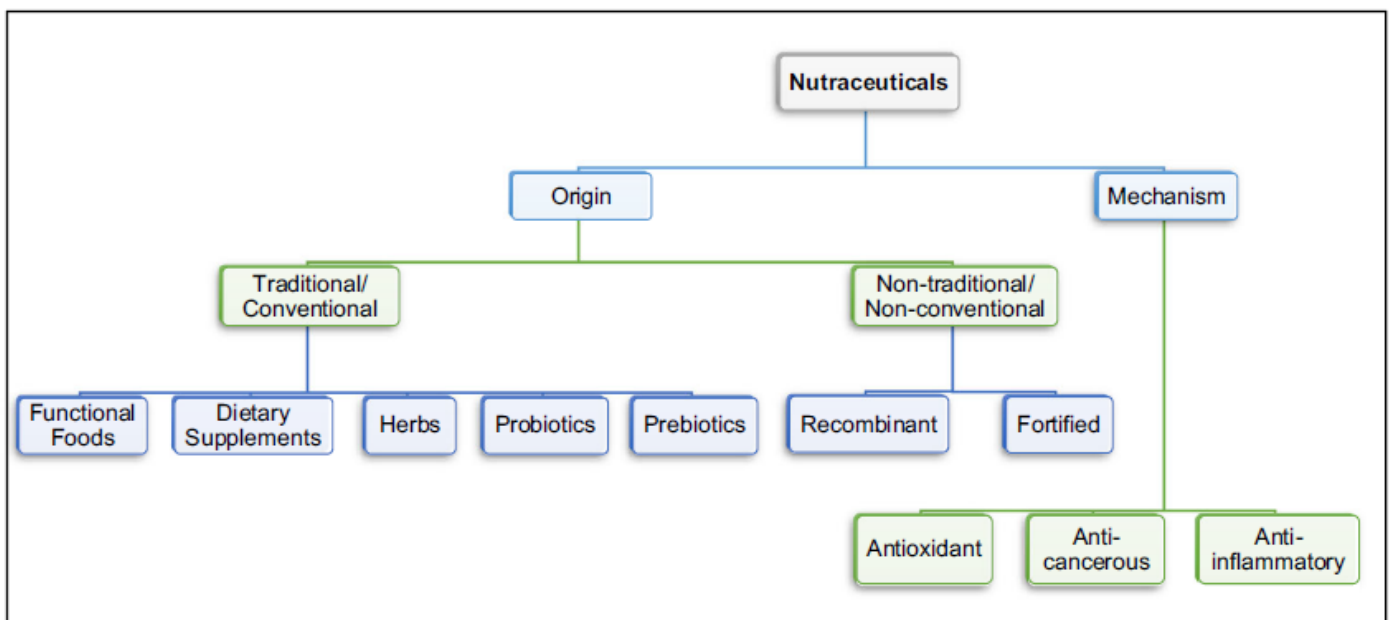


Figure 2. Different classes of nutraceuticals according to their origin and mechanism (Anand and Bharadvaja, 2022)

provide a natural and effective way of showing support for health and preventing ailments, which is why their intake is indispensable for a healthy diet (Lobo et al., 2010).

Nuts as a source of Functional food

Nuts are a good source of bioactive compounds, essential nutrients, and health-promoting properties. In addition, nuts are rich in proteins, dietary fibers, vitamins, such as vitamin E, B vitamins, and minerals, such as magnesium, potassium, and calcium, which will keep the metabolic functions, immunity, bones, and cognition working properly. Furthermore, bioactive compounds present in nuts, such as omega-3 fatty acids in walnuts, have been known to support brain health, reduce inflammation, and enhance cognitive function. Nuts also help manage weight despite their calorie-rich nature because they provide a satiating effect and regulation of hunger. This is due to the combination of healthy fats, fiber, and proteins found in nuts that works together to control appetite and reduce the total intake of calories. Moreover, research has indicated that regular consumption of nuts reduce oxidative stress, improves blood sugar control and is therefore useful for people with, or at risk of developing, type 2 diabetes. They contain healthy fats, mainly monounsaturated and polyunsaturated fatty acids, that help improve heart health by reducing bad cholesterol levels (LDL) and boosting good cholesterol (HDL). These Nuts, when consumed as part of a balanced diet, are a natural and effective way to improve overall health and prevent chronic conditions, making them functional foods with significant nutritional and therapeutic value (Basu et al., 2014).

Functional foods of Animal origin

Fish products are rich in polyunsaturated fatty acids, primarily eicosapentaenoic acid and docosahexaenoic acid (DHA). DHA is essential for the structure and function of brain and retinal cell membranes, and it plays a crucial role in the developmental needs of children. Extensive research indicates that fatty acids like DHA can positively influence inflammatory diseases, including arthritis and psoriasis, as well as more chronic conditions such as cancer and heart disease. Additionally, DHA may offer protective benefits against neurological disorders. Probiotics, which are live microorganisms, enhance gut health and have been recognized for their anticarcinogenic and cholesterol-lowering properties, along with combating intestinal pathogens. Commonly found in milk and various food products, probiotics play a significant role in the functional food market. They inhibit pathogen growth through several mechanisms, including altering pH and stimulating immune responses. Studies show a gut microbiota imbalance in autistic children, revealing lower *Bifidobacterium* and higher *Clostridium* spp. levels. Probiotics may help in mitigating these imbalances, proving beneficial for conditions like autism and Alzheimer's disease (Wergeland et al., 2012; Begum et al., 2017).

Potential of Herbs and Spices as Functional food

Herbs have become a key player in the functional food category because of their bioactive compounds that promote health. Examples include rosemary, oregano, turmeric, and garlic, which are high in phytochemicals such as flavonoids and phenolic acids. These compounds reduce oxidative stress and inflammation, contribute to heart health, and aid in the prevention of diseases. Herbs have specific benefits for different health areas (Shahidi and Ambigaipalan, 2023). Herbs and spices have been valued not just for culinary uses but for their health benefits due to bioactive compounds like

antioxidants and phytochemicals. Common herbs such as basil, rosemary, and oregano, alongside spices like turmeric, ginger, cinnamon, and garlic, are known for their roles in preventing chronic diseases. For example, curcumin in turmeric acts as a powerful anti-inflammatory and antioxidant, while gingerol in ginger aids digestion. Cinnamon can improve blood sugar control (Figure 3), and garlic supports cardiovascular health by reducing blood pressure and cholesterol levels. These natural substances may also influence biological processes related to disease prevention, demonstrating anti-inflammatory, antimicrobial, and anticancer properties. Herbs like rosemary and oregano showcase significant health benefits, potentially enhancing cognitive function and protecting against neurodegenerative diseases, thus reinforcing their role as functional foods that promote overall well-being (Rajeshwari et al., 2014; Bohn et al., 2015). Garlic reduces blood pressure and cholesterol, and ginger and peppermint improve digestive health by reducing symptoms such as nausea and indigestion. Immune-supportive herbs, such as echinacea, reduce the severity of infections and boost immune function. These properties make herbs versatile ingredients in teas, supplements, and fortified foods that cater to diverse dietary and health needs (Sharma et al., 2023).

Health Benefits of Functional Foods and Nutraceuticals

The core content of functional foods for health benefits comes from natural bioactive molecules: curcumin, resveratrol, quercetin, sulforaphane, epigallocatechin, lycopene, and ellagic acid (Figure 1). Curcumin is a well-studied bioactive compound within the *Curcuma longa*, also known as turmeric. This compound possesses many antioxidant and anti-inflammatory effects (Sneharani, 2019). Resveratrol found in grapes and pomegranates has beneficial effects on vascular function, immunity, and gut microbiota modulation (Chaplin et al., 2018). Similarly, the neuroprotective ability and the capability to prevent neurodegenerative diseases have been accredited to quercetin, the most abundant flavonoid of apples (Elumalai and Lakshmi, 2016). Sulforaphane, a compound in cruciferous vegetables such as broccoli, cabbage, and kale, activates the Nrf2-ARE pathway, promoting redox balance and protection against oxidative stress. Sulforaphane also modulates xenobiotic-metabolizing enzymes, thereby reducing the risk of carcinogen-induced DNA damage (Figure 4 and 5) (Juengel et al., 2017; Essa et al., 2024).

Epigallocatechins, a group of polyphenols in tea leaves, have been recognized for their pharmacological properties. These compounds have shown potential in inhibiting various harmful cellular pathways, contributing to their therapeutic effects. These findings reflect the importance that functional foods play within modern diets: their bioactive components interact.

Role of Functional foods in mitigating Stress

Functional foods are essential in stress management as they provide crucial nutrients and bioactive compounds that help regulate the body's stress response. Stress triggers the release of hormones such as cortisol and adrenaline, which, if sustained, can lead to adverse health effects like anxiety, depression, heart disease, and immune dysfunction. Certain functional foods-including specific fruits, vegetables, nuts, seeds, and herbs-possess therapeutic properties that promote relaxation, reduce inflammation, and enhance overall well-being.

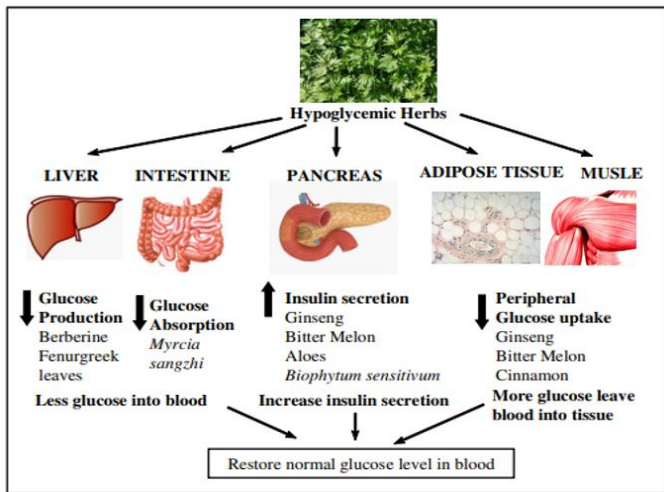


Figure 3. Action sites of herbs in diabetes treatment (Hui et al., 2009; Rajeshwari et al., 2013)

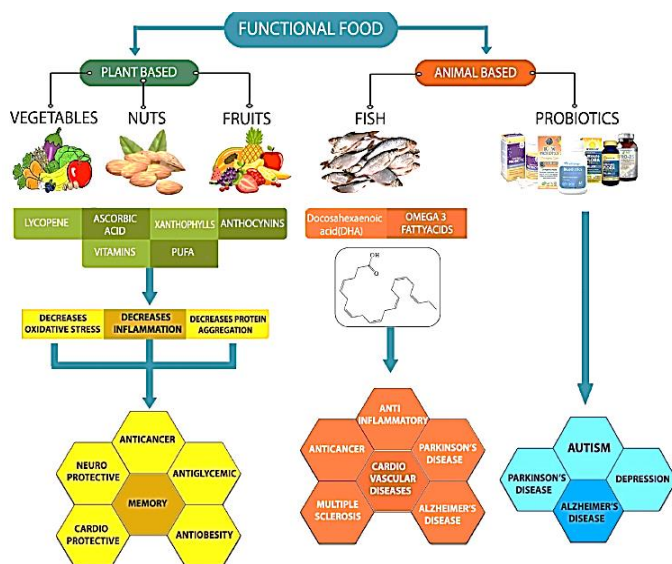


Figure 4: Health benefits of Functional Foods (Essa et al., 2024)

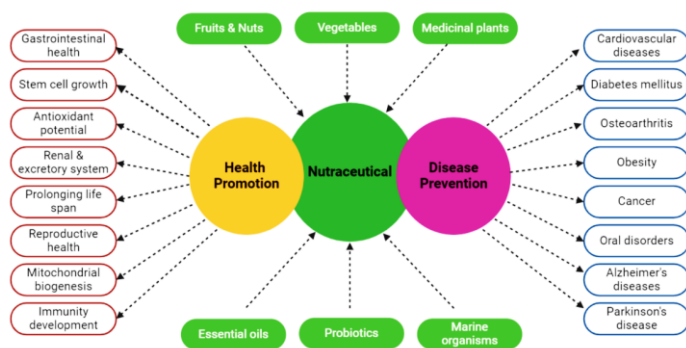


Figure 5: Health benefits of various nutraceuticals in Functional Foods (Rajeshwari and Varsha, 2024; Vighnesh et al., 2024)

Key nutritional components in these foods, such as omega-3 fatty acids, magnesium, B vitamins, and antioxidants, are particularly effective in stress management. Omega-3 fatty acids, available in fatty fish and walnuts, can decrease inflammation and lower cortisol levels. Foods rich in magnesium, like dark leafy greens, help regulate the nervous system and ease muscle tension. B vitamins found in whole grains are crucial for neurotransmitter synthesis, affecting mood. Moreover, antioxidants from berries and green tea

combat oxidative stress (Kris-Etherton et al., 2004). Herbs like ashwagandha, chamomile, and lavender further support stress relief, making a diet rich in these functional foods vital for enhancing resilience to daily challenges (Table 1) (Sharma et al., 2023).

Another significant mechanism is that it promotes neurotransmitter balance, especially serotonin and dopamine. Functional foods tackle the root causes of stress such as hormonal regulation, reduction of oxidative stress, and neurotransmitter balance, these foods manage short-term and long-term stress (Khan et al., 2023). These neurotransmitters play a crucial role in mood regulation and emotional stability. Tryptophan is an amino acid in turkey, eggs, and cheese, which acts as a precursor to serotonin synthesis. Tryptophan intake into the body elevates serotonin levels in the brain, causing people to feel calmer and reducing anxiety (Markus et al., 2000). Of course, omega-3 fatty acids also enhance neurotransmitter function by reducing neuroinflammation and enhancing dopamine signaling, an important mediator for motivation and pleasure (Hibbeln, 2002).

The gut-brain axis is another critical pathway through which functional foods influence stress. The gut microbiome consists of a complex community that lives in the digestive tract. Communication with the brain is mediated through neural, hormonal, and immune pathways. Foods high in probiotics, like yogurt and kefir, introduce good bacteria to the gut, while prebiotics in garlic and onions serve as fuel for these micro-organisms and bananas are a good source. A healthy gut microbiome is associated with good mood, lower anxiety, and greater resilience to stress (Cryan and Dinan, 2012). This shows why functional foods that support gut health are important. Among the functional foods, adaptogenic herbs are quite powerful in terms of enhancing resilience in the body to stress. Ashwagandha, ginseng, and Rhodiola rosea are a few examples of adaptogens that have been proven to modulate the HPA axis, stabilize cortisol levels, and boost energy without overstimulating the system. In clinical studies, ashwagandha supplementation has significantly reduced cortisol levels and improved self-perceived stress levels, thereby providing a natural alternative to conventional stress-relief methods (Chandrasekhar et al., 2012). Functional foods also contribute to sleep quality. Stress can only be added to this by poor sleep; conversely, many people suffer from sleep-wake cycles impairment due to stress. Foods rich in melatonin include tart cherries and walnuts. Melatonin is the hormone that regulates sleep quality; hence, foods rich in magnesium and tryptophan should be among the best. Better-quality sleep would help the body recover faster from stress-related impacts and balance its emotions (Pandi-Perumal et al., 2006; Rondanelli et al., 2013).

Practicality and enjoyment follow the incorporation of functional foods in diets. Spinach, yogurt, berries, and flaxseeds can be mixed for a smoothie at the start of the day, which fills the meal with nutrients, ensuring resilience under stress. Fatty fish, whole grains, and colorful vegetables constitute lunch and dinner, thereby ensuring sufficient intake of essential nutrients. Some of these snacks will be small handfuls of nuts or small pieces of dark chocolate, which satisfy the sweet tooth and help reduce stress. Another potential evening ritual could be the sipping of herbal teas such as chamomile or green tea to calm the day to a close. Therefore, functional foods can be considered an integral and science-based approach toward stress management. They

reduce the immediate impact of stress by attacking its physiological and biochemical underpinnings and build resilience over time. With research continuing to uncover the intricate relationships between diet, the brain, and stress, functional foods become an integral component of a healthy and balanced lifestyle (Khan et al., 2023).

Table 1. Nutraceuticals and their role in managing Stress (Sharma et al., 2023)

S.No	Phytochemicals	Mechanism of action
Polyphenols		
1	Resveratrol	Activates the SIRT1 pathway, enhancing mitochondrial function and reducing oxidative stress.
2.	Epigallocatechingallate	Modulates NF-KB pathway, reducing pro-inflammatory cytokine production and enhancing antioxidant enzyme expression through Nrt2 pathway activation.
Flavonoids		
3	Quercetin	Scavenges ROS inhibits NF-KB pathway and enhances antioxidant defences through Nrf2 pathway activation.
4	Luteolin	Modulates NF-KB and MAPK pathways, inhibiting pro-inflammatory cytokine production and enhancing antioxidant defences through Nrf2 pathway activation.
Adaptogens		
5	<i>Rhodiola rosea</i>	Modulates cortisol levels, and enhances mood and cognitive function by HPA axis modulation.
6	Ashwagandha	Modulates HPA axis, reduces cortisol levels, and bolsters antioxidant defences.
Triterpenoid Saponins		
7	<i>Ginkgo biloba</i>	Enhances cerebral blood flow, reduces oxidative stress, and improves cognitive function.
8	Astragalus	Bolsters immune function, reduces inflammation, and supports stress resilience.
Other nutraceuticals		
9	Omega-3 Fatty acids	Modulate neurotransmitter systems, reduce inflammation, and promote cognitive health.
10	B-vitamins	Support cognitive health and alleviate stress by modulating neurotransmitter systems

For instance, omega-3 fatty acids, found abundantly in fatty fish such as salmon and mackerel, as well as plant-based sources like chia seeds and walnuts, play a vital role in

maintaining brain health. These healthy fats reduce inflammation in the brain and promote the proper functioning of neurotransmitters like serotonin and dopamine, which are crucial for maintaining a positive mood. Studies have consistently shown that regular consumption of omega-3-rich foods is linked to reduced symptoms of anxiety and depression (Logan, 2004; Hibbeln, 2002). The connection between gut health and mental well-being is another fascinating area where functional foods excel. Probiotic-rich foods such as yogurt, kefir, and fermented vegetables like kimchi and sauerkraut introduce beneficial bacteria to the gut, while prebiotics, found in garlic, onions, and bananas, serve as food for these microbes. This dynamic duo improves gut health, which is closely tied to the brain through the gut-brain axis. Research has demonstrated that a healthy gut microbiome can reduce anxiety, improve mood, and enhance resilience to stress (Cryan and Dinan, 2012; Mayer et al., 2014).

Magnesium, often referred to as the "anti-stress mineral," is another key nutrient found in functional foods. Dark chocolate, spinach, almonds, and avocados are rich in magnesium, which helps regulate cortisol levels and relax the nervous system. A deficiency in magnesium is often linked to heightened feelings of stress and anxiety, making it an essential mineral for emotional balance (Jacka et al., 2009). Similarly, foods rich in antioxidants, such as berries, green tea, and nuts, protect the body from oxidative stress caused by chronic tension. Antioxidants neutralize free radicals, reduce inflammation, and support cognitive function. For individuals seeking natural relaxation, adaptogens like ashwagandha and *Rhodiola rosea* are invaluable. These herbs have been used for centuries to help the body adapt to stress, regulate cortisol, and improve energy levels without overstimulating the system. Clinical trials have shown that ashwagandha supplementation significantly reduces cortisol levels and stress symptoms (Chandrasekhar et al., 2012).

Another important group of functional foods includes those high in vitamin C, such as oranges, kiwi, and bell peppers. Vitamin C not only boosts the immune system but also lowers cortisol levels, helping the body recover from stressful events. Similarly, foods containing tryptophan, an amino acid found in turkey, eggs, and cheese, contribute to the production of serotonin, the "feel-good" neurotransmitter. This promotes relaxation, improves sleep quality, and enhances overall emotional stability (Markus et al., 2000).

Incorporating these functional foods into daily life is both simple and rewarding. Starting the day with a smoothie made from spinach, berries, yogurt, and flaxseeds provides a nutrient-rich foundation. For snacks, a handful of nuts or a piece of dark chocolate can be both satisfying and beneficial. Meals that include fatty fish, whole grains, and colorful vegetables offer a delicious way to nourish the mind and body. In the evenings, a warm cup of herbal tea, such as chamomile or green tea, can help unwind after a long day (Khan et al., 2023). Scientific research continues to validate the impact of diet on stress management. Studies have shown that fermented foods reduce social anxiety (Hilimire et al., 2015), while omega-3s and adaptogens effectively lower cortisol levels (Hibbeln, 2002; Chandrasekhar et al., 2012). This growing body of evidence underscores the profound influence of what we eat on our mental health.

Challenges to overcome

Despite the promise of various functional foods, challenges abound in standardizing their bioactive content,

with differences in cultivation, processing, and formulation. The proper dose is critical for ensuring health benefits without adverse effects. Traditional knowledge supports the efficacy of herbs; however, the scientific validation that comes through clinical trials will give a strong footing to their health claims. However, optimization of their use in functional food systems requires proper standardization and safety evaluation together with continued research. The research efforts of academic, government, and private research institutes around the world are now being focused on identifying how functional foods and food ingredients might be useful in preventing chronic diseases or optimizing health and thereby reducing healthcare costs and improving the quality of life for many consumers (Sharma et al., 2023).

Present status and Future prospects

Future foods enhanced with other nutritive or non-nutritive substances might even help to prevent chronic diseases such as heart disease, osteoporosis, or cancer. Functional foods are more than just sustenance; they are powerful tools in the fight against stress. By incorporating these foods into a balanced and mindful diet, it becomes possible to build resilience, elevate mood, and achieve a greater sense of calm. In a world that often feels overwhelming, the right nutrition can be a cornerstone of a healthier, more balanced life. Individuals are now more interested in a healthy diet so that they can prevent the onset of the disease through the food they intake rather than depending on medicines for treatment. This belief and the help of internet regarding the benefits of various nutraceuticals have increased their demand in the last 20 years. Although self-medication sometimes becomes fatal, with the detailed information on the internet and with experts' help it is a trend now (Shahidi and Ambigaipalan, 2023).

Keeping this trend in mind and the fact that drug development is a costlier venture, companies will shift to producing new and cost-effective nutraceutical products. Just like personalized medicine, nutrigenetics can be developed to analyze the difference in. This might be due to the difference between two genetically diverse individuals' response to the administered nutraceutical to propose a customized nutraceutical. A greater domain of nutrigenomics could also be opened to recognize the nutraceutical's action on transcription and translation after genomics interaction for the best preventive measure. Much interest has recently been triggered regarding nutrigenomics as there have been statements and announcements stating that an almost complete rough draft of the human genome was available for general access and viewing. Nutrigenomics (a discipline concerned with the investigation of interactions between diet and development of diseases based on a person's genetic profile) will deeply impact future work in disease prevention, including the future of the functional foods industry (Falk et al, 2002).

Meanwhile, an increased government funding can be expected for quality and safety assurance of nutraceuticals and research to check their efficiency against life-threatening diseases. Another technology that will profoundly impact the future of functional foods is biotechnology. Recent examples of biotechnology-derived crops, which have huge potential to benefit the health of millions around the world, are golden rice and iron-enriched rice. These grains have been genetically engineered to provide elevated levels of iron and β -carotene that could prevent iron deficiency anaemia and vitamin A

deficiency-related blindness worldwide. Further research will need to identify and establish critical bottlenecks in production systems and, for example, point out opportunities that will provide rural employment as well as a competitive advantage to small-scale farmers as producers of nutraceuticals (Williamson, 2001; Falk et al, 2002).

Conclusion

In conclusion, functional foods significantly aid in managing stress by supplying essential nutrients and bioactive compounds that support the body's stress response. Through the inclusion of foods rich in omega-3 fatty acids, antioxidants, vitamins, and minerals, functional foods can help modulate the effects of stress, reduce inflammation, and improve overall emotional well-being. However, while functional foods hold significant potential for enhancing public health, concerns arise regarding the scientific basis for their promotion. Health benefits should be grounded in rigorous safety and efficacy studies, including understanding interactions with other dietary components and pharmaceutical agents. Consumers should recognize that functional foods are not miraculous solutions for poor health habits; a holistic lifestyle approach encompassing diet, exercise, and stress management is essential. Effective utilization of functional foods requires a collective effort from academia, industry, government, and research institutions to combat lifestyle diseases through education and promotion of healthful eating practices.

References

- Anand, S and Bharadvaja N (2022). Potential Benefits of Nutraceuticals for Oxidative Stress Management, *Revista Brasileira de Farmacognosia*, 32:211-220.
- Asalak A, Raut S, Bidkar M, Shingote P and Bedse A: Review on role of nutraceuticals in stress management. *Int J Pharm Sci & Res* 2022; 13(8): 3028-35.
- Basu, A., Rhone, M., and Rhone, D. (2014). Walnuts and heart health: A review. *Nutrition Reviews*, 72(9), 513–521.
- Begum PS, Madhavi G, Rajagopal S, Viswanath B, Razak MA, Venkataratnam V (2017) Probiotics as functional foods: potential effects on human health and its impact on neurological diseases. *Int J Nutr Pharmacol Neurol Dis* 7:23. https://doi.org/10.4103/ijnpnd.ijnpnd_90_16
- Bohn, T., Borge, G. I. A., and Carlsen, H. (2015). Herbs and spices as functional foods. *Functional Foods in Health and Disease*, 5(6), 225–237.
- Brody S, Preut R, Schommer K & Schurmeyer TH (2002) A randomized controlled trial of high dose ascorbic acid for reduction of blood pressure, cortisol, and subjective responses to psychological stress. *Psychopharmacology* 159, 319–324.
- Chandrasekhar, K., Kapoor, J., & Anishetty, S. (2012). A prospective, randomized double-blind, placebo-controlled study of safety and efficacy of a high-concentration full-spectrum extract of Ashwagandha root in reducing stress and anxiety in adults. *Indian Journal of Psychological Medicine*, 34(3), 255-262.
- Chaplin A, Carpe'ne' C, Mercader J (2018) Resveratrol, metabolic syndrome, and gut microbiota. *Nutrients*. <https://doi.org/10.3390/nu10111651>
- Chauhan B, Kumar G, Kalam N and Ansari S H: Current concepts and prospects of herbal nutraceutical: A review. *Journal of Advanced Pharmaceutical Technology & Research* 2013; 4(1): 4.

- Cryan, J. F., and Dinan, T. G. (2012). Mind-altering microorganisms: The impact of the gut microbiota on brain and behavior. *Nature Reviews Neuroscience*, 13(10), 701-712.
- Elumalai P and Lakshmi S (2016) Role of Quercetin benefits in neurodegeneration. *Adv Neurobiol* 12:229–245. https://doi.org/10.1007/978-3-319-28383-8_12
- Essa MM, Bishir M, Bhat A, Chidambaram SB, Al-Balushi B, Hamdan H, Govindarajan N, Freidland RP, Qoronfleh MW. Functional foods and their impact on health. *J Food Sci Technol*. 2023 Mar;60(3):820-834.
- Eugeny, Y. G. and Natalia, V. Z. (2019). Cellular stress and general pathological processes. *Curr. Pharm. Des.*, 25(3):251-297.
- Falk, M. C., Chassy, B. M., Harlander, S. K., Hoban, T. J., McGloughlin, M. N., and Akhlaghi, A. R. (2002). Food biotechnology: Benefits and concerns. *The Journal of Nutrition*, 132(6), 1384-1390.
- Goldstein, D. S. and Kopin, I. J. (2010). Evolution of concepts of stress. *Stress*, 13(2):175-185.
- Hibbeln, J. R. (2002). Seafood consumption, the DHA content of mothers' milk, and prevalence rates of postpartum depression: A cross-national, ecological analysis. *Journal of Affective Disorders*, 69(1-3), 15-29.
- Hilimire, M. R., DeVlyder, J. E., and Forestell, C. A. (2015). Fermented foods, neuroticism, and social anxiety: An interaction model. *Psychiatry Research*, 228(2), 203-208.
- Hui, H.; Tang, G. and Go, V.L. (2009). Hypoglycemic herbs and their action mechanisms. *Chinese Med.*, 4(11):1-11.
- Jacka, F. N., Mykletun, A., Berk, M., Bjelland, I., and Pasco, J. A. (2009). The association between habitual diet quality and the common mental disorders in community-dwelling adults: The Hordaland Health Study. *Psychosomatic Medicine*, 71(5), 483-490.
- Juengel E, Euler S, Maxeiner S, Rutz J, Justin S, Roos F, Khoder W, Nelson BWO, Blaheta RA (2017) Sulforaphane as an adjunctive to everolimus counteracts everolimus resistance in renal cancer cell lines. *Phytomedicine Int J Phytother Phytopharm*, 27:1–7. <https://doi.org/10.1016/j.phymed.2017.01.016>
- Karasawa MMG, Mohan C (2018) Fruits as prospective reserves of bioactive compounds: a review. *Nat Prod Bioprospecting* 8:335–346. <https://doi.org/10.1007/s13659-018-0186-6>
- Kris-Etherton PM, Harris WS & Appel LJ (2003) Omega-3 fatty acids and cardiovascular disease: new recommendations from the American Heart Association. *Arteriosclerosis, Thrombosis and Vascular Biology* 23, 151–152.
- Kris-Etherton PM, Hecker KD, Bonanome A, Coval SM, Binkoski AE, Hilpert KF, Griel AE and Etherton TD (2002) Bioactive compounds in foods: their role in the prevention of cardiovascular disease and cancer. *American Journal of Medicine* 113, 71S–88S.
- Kris-Etherton PM, Lefevre LM, Beecher GR, Gross MD, Keen CL and Etherton TD (2004). Bioactive compounds in nutrition and health-research methodologies for establishing biological function: The antioxidant and anti-inflammatory effects of flavonoids in atherosclerosis. *Ann Rev Nutr*, 24:511–538.
- Lobo, V., Patil, A., Phatak, A., and Chandra, N. (2010). Free radicals, antioxidants, and functional foods: Impact on human health. *Pharmacognosy Reviews*, 4(8), 118–126.
- Logan, A. C. (2004). Omega-3 fatty acids and major depression: A primer for the mental health professional. *Lipids in Health and Disease*, 3(1), 25.
- Markus, C. R., Olivier, B., & de Haan, E. H. F. (2000). Whey protein rich in α -lactalbumin increases the ratio of plasma tryptophan to the sum of the other large neutral amino acids and improves cognitive performance in stress-vulnerable subjects. *American Journal of Clinical Nutrition*, 71(6), 1536-1544.
- Mayer, E. A., Tillisch, K., and Gupta, A. (2014). Gut/brain axis and the microbiota. *The Journal of Clinical Investigation*, 124(10), 4139-4146.
- Mellentini J, Heasman M, Heasman M (2014) The functional foods revolution : healthy people. Routledge, Healthy Profits. <https://doi.org/10.4324/9781849776165>
- Pandi-Perumal, S. R., Srinivasan, V., Spence, D. W., & Cardinali, D. P. (2006). Role of melatonin in the regulation of human circadian rhythms and sleep. *Journal of Neuroendocrinology*, 18(2), 91-98.
- Rajeshwari Ullagaddi and Varsha Murkhandi (2024). Role of functional foods in health promotion and disease prevention: An overview. *Ann. Phytomed.*, 13(2):384-393.
- Rajeshwari, C.U.; Shobha, R. I. and Andallu, B. (2014). Phytochemicals in diet and human health with special reference to polyphenols. *Ann. Phytomed.*, 3:70-76.
- Rajeshwari, C.U.; Shobha, R.I. and Andallu, B. (2013). Oxidative stress and antioxidant effects of herbs and spices in diabetes. *Ann. Phytomed.*, 2(2):13-27.
- Rice VH (2012): Theories of stress and its relationship to health. In V. H. Rice (Ed.), *Handbook of stress, coping and health: Implications for nursing research*. Theory and Practice Sage Publications Inc; 22.
- Rondanelli, M., Opizzi, A., Monteferrario, F., Antonello, N., Manni, R., & Klersy, C. (2013). The effect of melatonin, magnesium, and zinc on primary insomnia in long-term care facility residents in Italy: A double-blind, placebo-controlled clinical trial. *Journal of the American Geriatrics Society*, 59(1), 82-90.
- Sachdeva V, Roy A and Bharadvaja N: Current prospects of nutraceuticals: a review. *Current Pharmaceutical Biotechnology* 2020; 21(10): 88.
- Sangha V K (2014). Nutraceuticals and functional foods: an innovative approach for management of lifestyle diseases. *Pak J Food Sci*, 24(2):91-100.
- Sara Khan, Mohammad Irfan Khan, Badruddeen, Juber Akhtar, Mohammad Ahmad, Nitin Ranjan Gupta, Anas Islam and Asad Ahmad (2023). Stress: Pathological pathways and role of nutraceuticals in its management. *J. Phytonanotech. Pharmaceut. Sci.*, 4(2):9-15. <http://dx.doi.org/10.54085/jpps.2024.4.2.2>.
- Shahidi, F., and Ambigaipalan, P. (2023). Bioactive compounds in herbs and spices. *Current Research in Food Science*, 6(1), 1-10.
- Sharma, K., et al. (2023). Standardization challenges in herbal medicine. *Journal of Herbal Pharmacotherapy*, 15(1), 85-97.
- Sneharani Sneharani AH (2019) Curcumin-sunflower protein nanoparticles-a potential antiinflammatory agent. *J Food Biochem* 43:e12909. <https://doi.org/10.1111/jfbc.12909>
- Wergeland S, Torkildsen, Bø L, Myhr KM (2012) Polyunsaturated fatty acids in multiple sclerosis therapy. *Acta Neurol Scand Suppl*. <https://doi.org/10.1111/ane.12034>.