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Phytonutrients: Potential Health Benefits

S.K. Kachhot[1*] and B.G. Patel[2]
[1]Ph.D. Scholar, Department of Food Science and Nutrition,
ACN&CS, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar (Gujarat), India.
[2]Professor and Head, Department of Food Science and Nutrition,
ACN&CS, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar (Gujarat), India.

(Corresponding author: S.K. Kachhot)*
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ABSTRACT: Plant foods contain a variety of nutrients (carbohydrates, proteins, lipids, etc.) that can cover almost all of our nutritional needs. In addition, plant foods contain rich biologically active ingredients called "phytonutrients" that have many benefits for human health; these include, among others, polyphenols, flavonoids, carotenoids, limonoids, phytosterols and anthocyanins. Certain health benefits that these active compounds provide to people include lipid-lowering, anti-aging, anti-diabetic, anti-allergic, and anti-inflammatory properties. The body uses phytonutrients to maintain and modulate immunological function, which helps to prevent certain diseases. These "functional foods," often known as "medical foods", are rich in phytonutrients or phytomedicines that enhance health, prevent disease, and positively maintain well-being. The scientific study of healing with a class of natural compounds, such as certain herbs and their derivatives that are controlled as foods and used as dietary supplements, is referred to by the more recent titles "phytonutrients" and "phytotherapy". An overview of phytonutrients' recent advancements in health benefits is provided in this review article.

Keywords: Phytonutrients, Plant-based foods, Phytotherapy, Health.

INTRODUCTION

- Phytonutrients or phytochemicals are natural compounds found in all plant foods. They represent a complex group of bioactive and non-nutritive compounds in the plant kingdom and are an essential part of the human diet.
- As stated by Zaynab *et al*. (2018), phytonutrients serve as pollination attractants, protective agents against parasite and insect attacks, and shield plants from various stresses like UV light. Furthermore, phytonutrients are thought to have potential benefits for human health and nutrition and can affect the color, taste, and perfume of plants. In actuality, we frequently find them in our diets when we eat whole grains, beans, nuts, fruits, vegetables, tea, coffee, and fragrant herbs (Maggini *et al.,* 2018).
- In order to prevent disease and maintain maximum health, phytonutrients are thought to be anti-inflammatory, detoxifying, antioxidant, and hormone-balancing substances that should be consumed on a regular basis. The body receives a variety of advantageous substances from a balanced diet that includes fruits and vegetables in a range of forms and colors. According to Liu (2003), "Phytochemicals have antioxidant effects that protect cells from rheumatoid arthritis, cancer, cardiovascular disease, and immune system suppression".
- Eating is essential to preserving the human body's healthy operation. Natural products are gaining a lot of attention from consumers and medical professionals as foods that promote health as a result of recent developments in nutrition and medicine. Nutraceuticals and bioactive foods have demonstrated promise as natural food sources for illness prevention and as supplements for the treatment of a variety of ailments.
- Nutraceuticals can be used by consumers as a dietary supplement, to enhance general health, post-illness, for stress relief, during pregnancy and weight reduction, to improve athletic performance, and to alleviate symptoms (colds, coughs, arthritis, etc.). These functional foods, sometimes referred to as medical foods, are rich in phytonutrients or phytomedicines that support good health, enhance well-being, and alter immune response to fend off disease. The phrases "phytonutrients" and "phytotherapy", which are more recent, describe the science of treating illnesses using a variety of natural substances, such as certain plants and their derivatives that are classified as foods and used as dietary supplements.
- The human body requires nutrients other than nutrients such as proteins, vitamins and minerals. Phytonutrients have the unique ability to fight free radicals that circulate in the body in search of electrons. By providing electrons, phytonutrients prevent free radicals from stealing electrons from proteins or other

nutrients, which is the “theft” that leads to oxidative stress.

Phytonutrients and Health:

• In addition to serving as a source of phytonutrients, colors serve as a defense mechanism for plants. Phytonutrients are the foundation of almost forty percent of medications, along with herbs and spices. Their defense mechanisms can be utilized to maximize bodily functioning, and they have a restorative effect on our bodies (Hyman, 2013).

Flavonoids:

• Flavonoids, which include flavonols, flavones, flavanols, flavanones, and isoflavonoids, are members of the polyphenol family. Flavonoids are the ubiquitous yellow, red, and purple pigments that are present in a wide variety of plants. The compounds that give plants their "colorful hues" are called flavonoids, and they are found in a wide range of plants, but in comparatively little amounts. Flavonoids are mostly found in tea, onions, and apples, but they are also present in a wide variety of other vibrant plants. Herbs, citrus fruits, and tomatoes all contain flavanones. Lettuce, olives, onions, and cabbage all contain flavonols. Olives and celery both contain flavones. Red wine, tea, and pears are excellent sources of flavonols. Ultimately, soy products contain the majority of isoflavones (King and Young 1999).

• Broccoli, cabbage, blueberries, grapes, and many other fruits and vegetables contain flavonoids. Flavonoids have antimicrobial properties, blood pressure-lowering effects, and the ability to prevent cancer and heart disease (Reader's Digest, 2013).

• Flavonoids are found in whole wheat, wine, berries, black tea, celery, citrus fruits, olives, onions, purple grapes, purple grape juice, seeds, and fruit products from soy. They also function as antioxidants, get rid of carcinogens, bind nitrates in the stomach, stop them from turning into nitrosamines, stop cell division, stop platelet aggregation, and prevent arteriosclerosis.

• Mastroiacovo *et al.* (2015) conducted a randomized controlled experiment with ninety-nine older adults in 2015 to investigate the impact of daily flavanol consumption on cognitive function. According to their study's findings, consuming a flavonoid-rich drink (993 mg/day) every day for eight weeks greatly enhanced participants' performance on cognitive function tests, especially the verbal fluency and course exam.

• A study conducted lately by Law *et al.* (2016) validated the effects of flavonoids. Following a two-month course of daily administration of 100 milliliters of onion juice, abundant in flavonoids and phenolic acids, individuals suffering from osteoporosis exhibited noteworthy enhancements in oxidation indicators and favorable regulation of bone loss. The mechanisms of action were associated with the antioxidant characteristics of flavonoids and their capacity to inhibit progenitor cell development into osteoclasts (Law *et al.*, 2016).

Isoflavones:

• Isoflavones, or the flavonoids included in soy, have the potential to act as an estrogen substitute, alleviate menopausal symptoms, and offer protection against some hormone-dependent malignancies.

• Hachul *et al.* (2011) investigated how postmenopausal women with insomnia fared in terms of the quality of their sleep when exposed to flavonoids, especially isoflavones. For four months, the subjects were given either a placebo or 80 mg of isoflavones every day. Questionnaires and polysomnography were used to analyze sleep. The outcomes demonstrate both an improvement in sleep efficiency and a significant reduction in the frequency of insomnia episodes at the conclusion of treatment in patients treated with isoflavones compared to placebo.

• Isoflavones have been shown to be therapeutically beneficial in the management of bone loss during menopause, according to a systematic literature review that included 26 randomized clinical studies and 2652 patients. The medication significantly increased bone density in the lumbar spine and femoral neck (Lambert *et al.,* 2017).

Carotenoids:

• Another group of phytochemicals that are frequently addressed is called carotenoids, and it include compounds like lutein, zeaxanthin, lycopene, and beta-carotene. They have potent antioxidant properties and are present in carrots, tomatoes, and melons. They may help lower the chance of developing some cancers.

• Age-related macular degeneration and night blindness may be avoided with beta-carotene. Additionally, it might prevent certain malignancies and maintain the health of your bones, teeth, gums, skin, hair, nails, and glands.

• Orange, yellow, and dark green fruits and vegetables, such as carrots, sweet potatoes, pumpkin, broccoli, kale, spinach, apricots, peaches, and melons, are the richest sources of beta-carotene. According to Reader's Digest (2013), lutein and zeaxanthin may offer protection against age-related macular degeneration and cataracts.

• Positive benefits on stress management have also been demonstrated by carotenoids. The therapeutic effects of saffron, namely its crocin (carotenoid) content, were investigated by Kell *et al.* (2017) in relation to the treatment of anxiety, stress, and mood disorders. Patients reported significantly improved mood and reduced levels of stress and anxiety after 4 weeks of therapy with saffron at a dose of 28 mg/day, as compared to placebo. Stringham *et al.* (2018) made an additional effort to prove the advantageous effects of long-term carotenoid supplementation on stress reduction.

• Carotenoids are therapeutically important in the prevention of chronic joint illnesses, particularly because of their anti-inflammatory properties. Pattison *et al.* (2015) conducted a prospective study involving over 25,000 participants examined the impact of carotenoid intake on the likelihood of developing rheumatoid arthritis. The findings indicated that consuming β-cryptoxanthin at a level comparable to one glass of orange juice decreased the likelihood of this pathology developing and also diminished the antioxidant activity properties of this phytonutrient.

• In the realm of health, carotenoids are also interesting, especially when it comes to issues with fatigue and recuperation. Imai *et al.* (2018) carried out a randomized, controlled clinical experiment to investigate the potential benefits of carotenoids' antioxidant properties in the treatment of fatigue. Their task was to assess the impact on mental tiredness of a 4-week supplementation regimen including 3 mg of astaxanthin and 5 mg of sesamin. At the end of the treatment, they saw a reduced increase in circulating levels of *Phosphatidylcholine hydroperoxide*, an indicator of oxidative stress, and a substantial decrease in mental weariness when compared to placebo.

Lycopene

• Additionally, lycopene may offer protection against stomach, lung, and prostate cancer. Watermelon, pink guava, pink grapefruit, and tomatoes are examples of food sources.

• Ghavipour *et al.* (2013) randomly assigned 106 female students at Tehran Medical University who were overweight or obese to drink 330 milliliters of tomato juice or water daily for 20 days. The serum concentrations of TNF-α and IL-8 were considerably lower in overweight and obese women when compared to the baseline and control group.

• Tsitsimpikou *et al.* (2014) conducted another investigation on tomato juice. Compared to a control group, the study revealed that individuals with metabolic syndrome experienced notable reductions in endothelial dysfunction and inflammation after consuming tomato juice four times a week for two months.

Caffeine:

• One member of the alkaloid family of molecules is caffeine. On the other hand, due to its well-established health advantages and significant role in your daily intake of phytonutrients, caffeine is regarded as a member of its own family.

• The most widely used psychoactive drug worldwide is caffeine. It can be found in tea, mate leaves, coffee, and kola nuts.

• White *et al.* (1980) looked at how caffeine affected anxiety and tense muscles. Their research demonstrated that caffeine use had these effects, with heavy coffee drinkers experiencing considerably higher levels of muscle tension and anxiety after a three-hour caffeine-free period compared to moderate coffee drinkers.

• The effects of caffeine consumption, which included 12 clinical observational studies on depression were also looked at in the Grosso *et al.* (2016) literature review. Based on a nonlinear dose-response relationship, the analysis's findings indicate that regular ingestion of caffeinated coffee may mitigate depressive symptoms; a daily intake of 400 ml of coffee is associated with the most benefit. The authors speculate that caffeine's enhancement of dopaminergic neurotransmission and stimulation of the central nervous system may be the cause of this effect.

• Welsh *et al.* (2010) conducted a Cochrane study to investigate the impact of coffee on respiratory parameters in individuals with asthma. Even at dosages lower than 5 mg/kg, a substantial improvement in respiratory parameters was observed for up to 4 hours in seven randomized clinical studies with 75 participants.

Anthocyanins:

• The general metabolism of flavonoids produces anthocyanins, a subfamily of flavonoids. Fruits and vegetables that are red, pink, blue, or purple contain the most common anthocyanins.

• The main sources of anthocyanins include plums, berries (including blueberries, elderberries, and black currants), and cherries. Additionally, they can be found in red onion bulbs, beets, and radishes, as well as in beverages like red wine and fruit juices (Lin *et al.*, 2017).

• According to Biedermann *et al.* (2013), anthocyanins appear to be effective in treating ulcerative colitis by lowering the endoscopic Mayo score and a few other symptoms. This impact could be explained by the anti-inflammatory properties of anthocyanins, which cause the levels of IFNγ and tumor necrosis factor α (TNF-α) in mesenteric lymph nodes to decrease.

• Calapai *et al.* (2017) reported on the impact of anthocyanins on the cognitive parameters of the older population. Using a battery of cognitive tests, this randomized, double-blind, placebo-controlled trial assessed the impact of anthocyanin supplementation at a level of 250 mg/day for 12 weeks. Anthocyanins were found to significantly increase attention, language, and memory when compared to a placebo. They also exhibited decreased frequencies of anxiety and sadness, which may be related to their anti-inflammatory, anti-apoptotic, and antioxidant qualities.

Organicsulfur compounds

• Numerous kinds of molecules with comparable fundamental chemical structures are included in organic sulfur compounds. Isothiocyanates, indoles, chemicals generated from allyl sulfides, and sulforaphanes are members of the organosulfur compound family. The two most prevalent organosulfur compounds found in plant-based diets are garlic sulfur derivatives and glucosinolates. Mustard seeds contain isothiocyanate, while cruciferous vegetables (broccoli and cabbage) are the main sources of sulforaphane. Another excellent source of sulfur compounds is garlic.

• Therapeutic significance of organic sulfur compounds for antiviral defense is also present. Muller *et al.* (2016) investigated how giving broccoli high in sulforaphane affected the immune system's reaction to an influenza vaccination. In comparison to the placebo group, their findings show a significant decrease in the number of T, N, and natural killer T cells (NKT), as well as a significant increase in the production of granzyme B, an antiviral protein, indicating that sulforaphanes improve the body's ability to fight off viral infections.

• After four months of treatment, the antioxidant activity of organosulfur compounds, especially glucophanes, has been shown to improve liver function in patients with fatty livers. This is likely because of their antioxidant qualities and their capacity to activate the transcription factor NRF2, which in turn stimulates detoxification enzymes (Kikuchi *et al.*, 2015).

• Yanaka (2018) found that using broccoli sprouts' glucosinolates, particularly sulforaphanes, at a daily dose of 20 g/day significantly reduced constipation when compared to a placebo (4.4 mg/day sulforaphane, for instance) during a 21-day period. The authors claim that this impact is the consequence of sulforaphanes' gastrointestinal tract antioxidant action.

• According to Kaczmarek *et al.* (2019), a direct impact on the intestinal flora is responsible for the beneficial effects of organosulfur compounds in the gastrointestinal system.

Tannins

• Tannins are members of the phenolic chemical family, just like flavonoids. Large levels of tannins can be found in pomegranate peels, sorghum, barley seeds, tea, wine, and cocoa beans.

• Tannins can be found in red and white wine, black-eyed peas, lentils, grapes, and tea. They can also act as antioxidants and prevent the activation of carcinogens.

• Moreover, studies on the therapeutic use of tannins in the management of digestive issues have showed promise. Venancio *et al.* (2018) investigated the advantages of giving volunteers with chronic constipation 300g of mango, which is high in gallotannins, per day. Following a 4-week course of treatment, improvements were seen in both the inflammatory and functional measures (frequency and regularity of bowel movements).

• Tannins, in particular crofelemer, were also studied by Mangel and Chaturvedi (2008) in a major randomized controlled experiment to treat symptoms related to irritable bowel syndrome. Functional metrics did not change after three months of treatment, although women taking 500 mg of the medicine reported a considerable improvement in their pain and discomfort in the abdomen.

• Tannins have been demonstrated to lessen weariness and enhance physical performance, making them therapeutically significant in the areas of energy and vitality. Compared to a placebo, daily intake of a tannin-rich extract (1,200 mg) for eight days enhanced resistance to exercise-induced fatigue in a randomized controlled experiment conducted by Ataka *et al.* (2007). This improvement was observed without affecting cardiovascular measures.

Phenolic acids

• Plant phenolic chemicals that are not flavonoid are called phenolic acids or phenolcarboxylic acids. They are members of the polyphenol family. Numerous foods, including cereals, wheat flour, onions, coffee, kiwis, berries, apples, and citrus fruits, contain phenolic acids. Phenolic acids can originate from dietary sources as well as the intestinal microflora's secondary metabolism of other polyphenols.

• Law *et al.* (2016) conducted a study that revealed the impact of flavonoids. Following a two-month course of daily administration of 100 milliliters of onion juice, abundant in flavonoids and phenolic acids, individuals suffering from osteoporosis exhibited noteworthy enhancements in oxidation indicators and favorable regulation of bone loss. The antioxidant qualities of flavonoids and their capacity to inhibit progenitor cell development into osteoclasts were identified as the mechanisms of action.

• In a randomized controlled clinical trial, Wattanathorn *et al.* (2018) found that taking 1.5 g of a phenolic acid-rich extract daily for 8 weeks significantly increased the number of markers (osteocalcin, alkaline phosphatase) involved in bone formation and decreased resorption cross-links (collagen's β-terminated carboxyl) compared to the basic value.

Curcuminoids:

• Curcumin is the most significant of the curcuminoids. Curcumin, which constitutes around 5% of the rhizome, is thought to be the most significant bioactive phytochemical found in turmeric. Some additional bioactive substances found in essential oils of turmeric.

• The Indian subcontinent and Southeast Asia are major producers of turmeric, which is mostly utilized in food preparation, medicine, and supplements. The rhizome, which is found in the plant's roots, is the most significant part of turmeric, which is used as a spice and herbal supplement. Because of the curcuminoid pigments and phytochemicals found in the rhizome, turmeric powder has a strong flavor and a distinctive yellow-orange hue (Hossain and Ishimine 2005).

• Using CT26, HT29, and HCT116 colon cancer cells, Li *et al.* (2018) demonstrated that curcumin extracts (200 mg/kg) produced tumor growth suppression and anti-metastatic effects in vivo. Moreover, it works synergistically with the phytochemical quercetin to combat breast, colon, lung, and skin cancer cells.

• Because of their anti-inflammatory and cytokine storm-inhibiting qualities, curcumin and other spices may be able to help fight SARS-COV-2, according to a fairly recent systematic study by Kunnumakkara *et al.* (2021). These findings imply that turmeric extracts might be a viable therapeutic option as well as a different approach to warding off viral infections.

• Turmeric's antifungal properties are another significant consequence. According to Chen *et al.* (2018), turmeric extracts have a potent antifungal effect on 20 pathogenic fungi, including *Fusarium verticillioides, Curvularia pallescens, Colletotrichum falcatum, Aspergillus niger, Aspergillus terreus, Fusarium oxysporum, Fusarium moniliforme, Fusarium graminearum, Phoma wasabiae, Alternaria alterna, Botrytis cinere, Chaetomium oliviceum, Peniconium, chaetomium oblilivios, and Verticillium dahlia*. Additionally, the synthesis of protein is disrupted and the main components of the fungal cell wall are interrupted. The results of this study indicate that the combined antifungal effects of turmeric phytochemicals are superior to those of individual components.

Allicin:

• The primary bioactive phytochemical in aqueous garlic extract, allicin, is also the source of garlic's distinctive odor. Consequently, when garlic cloves are chopped or crushed, the enzyme alliinase changes allicin into alliin. Because of this, numerous studies have demonstrated that fresh garlic, when minced, can supply the highest concentration of phytochemicals.

• Alkaloids, saponins, flavonoids, tannins, phenols, terpenoids, and organic sulfides are some of the phytonutrients found in garlic. Garlic is also thought to be a good source of minerals and vitamins, such as calcium, phosphorus, selenium, manganese, copper, B1, B6, and C (Saif *et al*., 2020).

• Garlic's compounds have an antioxidant impact as well. 900 mg of raw or cooked garlic were prepared by Bhatt and Patel (2013), who then incubated the samples with stomach enzymes. These findings demonstrated that, in comparison to raw garlic, cooked garlic lost 90% of its phenolic content, which led to decreased antioxidant activity from heat-induced active component evaporation.

• In a double-blind clinical trial, Zare *et al.* (2019) gave garlic extract twice a day for eight weeks to 40 peritoneal dialysis patients in order to investigate the anti-inflammatory effect. Garlic was shown to lower inflammatory markers, specifically interleukin-6, C-reactive protein, and erythrocyte sedimentation rate in the therapy group, in patients with end-stage renal disease.

CONCLUSIONS

In conclusion, there is a clear correlation between the regular consumption of foods high in phytochemicals, including fruits, vegetables, whole grains, etc., and a lower risk of chronic illnesses like cancer and cardiovascular disease. For this reason, eating a diet high in vibrant fruits and vegetables is essential for overall health, happiness, and potential illness prevention.

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