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Nutraceuticals Role of Vegetables in Human Diet as Immunity Booster

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SUMMARY

Improper diets and unbalanced nutrition contribute significantly to the malnutrition of approximately 3 billion people worldwide. Vegetables, rich in nutraceuticals and phytonutrients, play a crucial role in human nutrition and health, earning the title of "protective foods." They provide essential nutrients such as vitamins, minerals, dietary fiber, antioxidants, proteins, and flavonoids that are effective against various chronic diseases. A healthy diet should include all the necessary nutritional compounds for proper growth and development, and fresh vegetables, being an affordable source of numerous nutrients, should be a key component of such a diet. Each vegetable offers a unique combination of phytonutrients, with colored vegetables being particularly rich in antioxidants like Vitamins C, E, and K, as well as minerals such as calcium, magnesium, potassium, iron, beta-carotene, and the B-complex vitamins. Phytonutrients are plant-derived compounds with promising health benefits, while nutraceuticals are food components or additives that provide nutritional value and health benefits, including the prevention or treatment of diseases. They play a vital role in future therapeutic developments.

INTRODUCTION

Vegetables are abundant in vitamins, minerals, carbohydrates, proteins, and fats, which offer various medicinal properties. With the rise of diseases globally, there is an increasing focus on health, driving demand for foods rich in antioxidants, proteins, and vitamins. Fresh vegetables, with their diverse range of nutrients, should be a major part of a healthy diet. Many vegetables contain high levels of immune-boosting amino acids that combat infections and diseases. Additionally, they are rich in carotenoids, flavonoids, and Vitamin C, which enhance immune function (Webb and Villamor, 2007).

Nutraceutical Role of Vegetables:

Different vegetables offer various combinations of nutraceutical compounds. Colored vegetables, in particular, are excellent sources of antioxidants like Vitamins C, E, and K, along with essential minerals such as calcium, magnesium, potassium, iron, and beta-carotene. Phytonutrients, which are plant-derived compounds with health-promising properties, play a critical role in disease prevention and treatment. In India, over 60 types of vegetables are grown across diverse climates, making the country the second-largest vegetable producer globally after China, accounting for 15% of global production. Increasing vegetable consumption is a cornerstone of a healthy diet. Vegetables and fruits rich in natural antioxidants, such as phenolics, flavonoids, ascorbic acid, and carotenoids, can help mitigate the harmful effects of reactive oxygen species (ROS) on human health (Macedo et al., 2013). Different horticultural crops vary in their biochemical, morphological, and quality parameters based on their variety, climate, and diversity (Prasad et al., 2016).

Among horticultural crops, vegetables hold a special place in dietary guidelines due to their high concentration of phytochemicals like vitamins (C, E, and A), minerals, fiber, and antioxidants, which act as phytoestrogens, anti-inflammatory agents, and provide other protective mechanisms (Joanne et al., 2012). For example, cruciferous vegetables like broccoli, cauliflower, and Brussels sprouts, as well as alliaceous vegetables like onions and garlic, contain high levels of organosulfur compounds, which are beneficial for cancer chemoprevention (Bianchini et al., 2001). Leafy vegetables are also rich in carbohydrates, proteins, vitamins, and minerals, while salad crops play a significant role in combating chronic and cardiovascular diseases (Azadbakht et al., 2012).

Vegetables from the Crucifer (broccoli, cauliflower, Brussels sprouts) and Alliaceae (onion and garlic) families contain high levels of organosulfur compounds, which have been shown to have cancer chemopreventive effects (Bianchini et al., 2001). Phenolic acids and flavonoids in vegetables act as reducing agents and free radical

scavengers due to their antioxidant properties, providing protection against damage caused by reactive oxygen species (ROS), which are linked to various health issues. Carotenoids, the second most abundant pigments in nature, are responsible for the orange and yellow hues in vegetables such as carrots, pumpkins, sweet potatoes, winter squash, cantaloupes, and red peppers. Cruciferous vegetables are also rich in glucosinolates, which activate liver detoxification and protect against the toxicity of electrophiles, reactive oxygen species, carcinogenesis, and mutagenesis (Fahey et al., 1997).

Table 1. List of nutraceutical compound isolated from vegetables

S. No.	Nutraceuticals	Vegetables	Properties
1.	Glucosinolates, Sulforaphane	Cruciferous crops	Having antioxidant properties thus provide protection against free radicals and also against breast cancer
2.	Lycopene	Tomato and other Solanaceous vegetables, Watermelon	Reduce the risk of cancer and scavenge harmful free-radicals, enhance resistance against total body x-rays irradiation.
3.	Silymarin	Artichoke	Reduce the risk of chronic liver diseases caused by oxidative stress.
4.	Vitamin C	Cabbage, Broccoli, Green Leafy vegetables(GLV)	Most important source of antioxidant thus provide protection to body tissue from oxidative damage and also from free radicals.
5.	Vitamin E (Tocopherol)	Green Leafy vegetables (GLV)	Provide protection against oxidative damage.
6.	Allyl Sulphides	Onion and garlic	Prevention/treatment of cancer, inhibit toxicities caused by alcohol and drug and regulate HIV protein and diabetes-mediated toxicities (Rao et al., 2015).
7.	Vit A (Retinol)	Carrot, Pumpkin, Cantaloupe, Spinach, Amaranth, Broccoli	It helps in cell reproduction, improve immunity, vision, bone growth and development of tooth and also maintain skin and hair.
8.	Alliin, Methiin	Alliums	Antiviral,antibacterial,antihypertensive
9.	Quercetin	Onion and Garlic	Treatment of Alzheimer's disease; used in cancer and heart disease
10.	Kaempferol, Myricetin, Fisetin	Onion, lettuce, Endive, Horse Radish	Reducing the risk of chronic diseases, especially cancer (Chen and Chen, 2012). Fisetin- Neurotrophic, anticarcinogenic, anti-inflammatory (Khan et al., 2013).
11.	Luteolin	Celery, Broccoli, sweet pepper	A carotenoid which shows eye benefits.
12.	Apigenin	Celery, Cabbage and Lettuce	4,5,7-trihydroxyflavone is a flavones that is aglycone of several glycosides.
13.	Isoflavonoids	Legume vegetables, Broccoli, Okra	Act against cancer, skin diseases, obesity, osteoporosis.
14.	Glucoraphanin	Red cabbage,	Provide protection against cancer and other Broccoli and Brussels sprout oxidative and degenerative diseases.
15.	Glucobrassicin, Progoitrin, Gluconasturtiin	Broccoli	Anticancer, reduce the risk of cardiovascular disease and also have antithyroid effects.
16.	Glucoerucin, Glucoraphanin	Turnip and Rutabaga	Have tumor prevention properties
17.	Lysine, Chlorgenic Acid	Potato	Inhibit formation of DMBA-initiated/TPA promoted, skin tumors also reduced serum complement activity in normal human serum.
18.	Caffeic acid, Chlorgenic Acid	Egg plant, Carrot	Inhibitor of the lipoxygenase enzyme that forms leukotrienes from arachidonic acid

19.	Nasunin	Egg plant	Important antioxidant provide protection to brain cell membranes from free radical damage and facilitate flow of blood in the brain.
20.	Angelicin, Xanthotoxin	Parsnip	Used to treat psoriasis and cancer and also used in skin disorders.
21.	Ferulic Acid	Turnip	Having properties of anti-oxidizing that moisturize our skin and provide protection against light and weather damage.
22.	Anthocyanin and Chlorgenic Acid	Sweet potato	Prevent cancer, cardiovascular problems and also have microbial activities.
23.	Rutin	Asparagus, Green chilli	Cytoprotective, vasoprotective, anticarcinogenic, neuroprotective and cardioprotective activities (Ganeshpurkar and Saluja, 2017).
24.	Patuletin, Spinacetin	Spinach	Scavenge reactive oxygen species and prevent macromolecular oxidative damage (Roberts and Moreau, 2016).
25.	Zeaxanthin	Carrot , celery, kale, lettuce	Used for eye health and in agerelated macular degeneration.
26.	Betanin	Beet root, chard	Natural colourant used in ice creams.
27.	Capsaicin or trans-8-methyl N-vanillyl-5 nonenamide	Red chilli	Act as a pain killer, antioxidant and antiallergic.
28.	Hesperitin	Green vegetables	Anti-inflammtory property.
29.	Lignan	Soybean and Broccoli	Reduce cellular destructions and aging etc.
30.	Allicin (organosulphur compound)	Garlic, Onion, parsnip	Antifungal; antibacterial, antioxidant; used to treat arteriosclerosis.
31.	Beta carotene	Carrots, pumpkin, sweet potatoes, winter squash	Anti aging, anti cancerous, improve lung function, reduce complications associated with diabetes.
32.	Glutathione (GSH)	Cruciferous vegetables	Provide protection against oxidative damage which is caused by free radicals.
33.	Saponin	Soybeans, beans, other legumes	Reduces blood cholesterol levels and the risk of cancer.
34.	Proanthocyanin	Red cabbage, egg plant	Help in urinary tract infections by inhibiting adhesion of microorganisms like E. coli to the urinary tract wall.
35.	Butylphthalide	Celery	Used to control high blood pressure.

Source: Singh and Devi (2015); Rai et al. (2012).

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