Review Article

Phytochemicals – A Nutraceutical Source of Vegetables

B. Sakthinathan* and D. Udhaya Nandhini

Department of Agriculture, School of Agriculture and Bio Sciences, Karunya University, Coimbatore – 641 114

Abstract

Phytochemical literally means 'Plant chemicals'. Vegetables have immense beneficial properties for human health, because of the presence of phytochemicals which include flavones, flavonols, isoflavones, phenolic acids and glucosinolates. These phytochemicals seem to play a role against the development of different types of cancer and cardiovascular diseases, because these compounds could provide antioxidant capacity, anti-inflammation properties, lipid profile modification and antitumor effects. In addition to these beneficial properties of phytochemicals in human health, they are responsible for the color, flavor and smell of fruits and vegetables. During recent decades, many studies have examined the relationship between vegetables and health benefits. This article explores the role of phytochemicals in the diet and stresses the importance of vegetable consumption habit right from the start for the welfare of humanitarian.

Keywords: phytochemicals, vegetables, flavonols, glucosinolates, phenolic acid.

***Correspondence**

Author: B. Sakthinathan

Email: sakthinathan2020@gmail.com

Introduction

Vegetables play an important role in human diets, as they support the normal functioning of the different body systems. They provide our cells with vitamins, minerals, fibber, essential oils and phytonutrients. Vegetables contain low amounts of fat and calories. Phytochemicals are the primary source of antioxidants in the human diet and play an important role in combating the damaging effects of oxidative stress and other adverse cell responses that can lead to a wide variety of chronic and degenerative illnesses [11]. These phytochemicals typically consist of a wide array of phenolic compounds, ascorbic acid, alpha tocopherol and carotenoids, and have been shown to promote health and provide protection against a growing list of diseases including various cancers and cardiovascular and neurodegenerative diseases.

Phytochemicals are part of a plant's natural systems of defense and repair. Our bodies utilize a small fraction of these components by incorporating them into various cellular and metabolic processes that enhance cellular growth, regeneration and repair. Some phytochemicals act as antioxidants, some protect and regenerate essential nutrients, and still others work to deactivate cancer-causing substances.

Phytochemicals impart health benefits to humans in addition to those provided by vitamins and minerals alone. Phytochemicals differ from vitamins and minerals in that they are not considered "essential" nutrients, i.e., those which are critical for normal metabolism and growth. With the exception of carotenoids, they are similar to vitamins and minerals in that they are not stored in the body for later use and must be consumed consistently over time [3]. Perhaps, the most well-known phytochemicals are the antioxidant group, which protect cells from damage caused by the by-products (free radicals) of metabolism, as well as toxic substances in the environment and foods. At high levels, reactive species, such as reactive oxygen and nitrogen species, can be damaging to cells and may contribute to cellular dysfunction and disease. Antioxidants significantly decrease the adverse effects of reactive species by eliminating free radicals as they circulate throughout the body. Beta-carotene and the other carotenoids are not antioxidants, but influence the biochemical reactions involved in the oxidative process. Other phytochemicals include: sulfides (allium), indoles, phytosterols, protease inhibitors, phenols, tannins and terpenes.

The phytochemicals can play chemo preventive roles in regards to human cancer by modulation of the cancer cell cycle, proliferation inhibition, and induction of apoptosis [6]. A phytochemical is often found in the coloring agent of fruits and vegetables, so eating brighter colored varieties may have benefits. However, there are also several beneficial phytochemicals in colorless or less colorful fruits and vegetables for example, onions and corn are rich in phytochemicals. Based on their chemical structure phytochemical are classified into the ten categories; basically they are subdivided into three main categories i.e. phenolic acids, flavonoids and stilbenes or ligans; these flavonoids are further subdivided into anthocyanins, flavones, flavanones, isoflavones as well as flavonols and flavanols. The

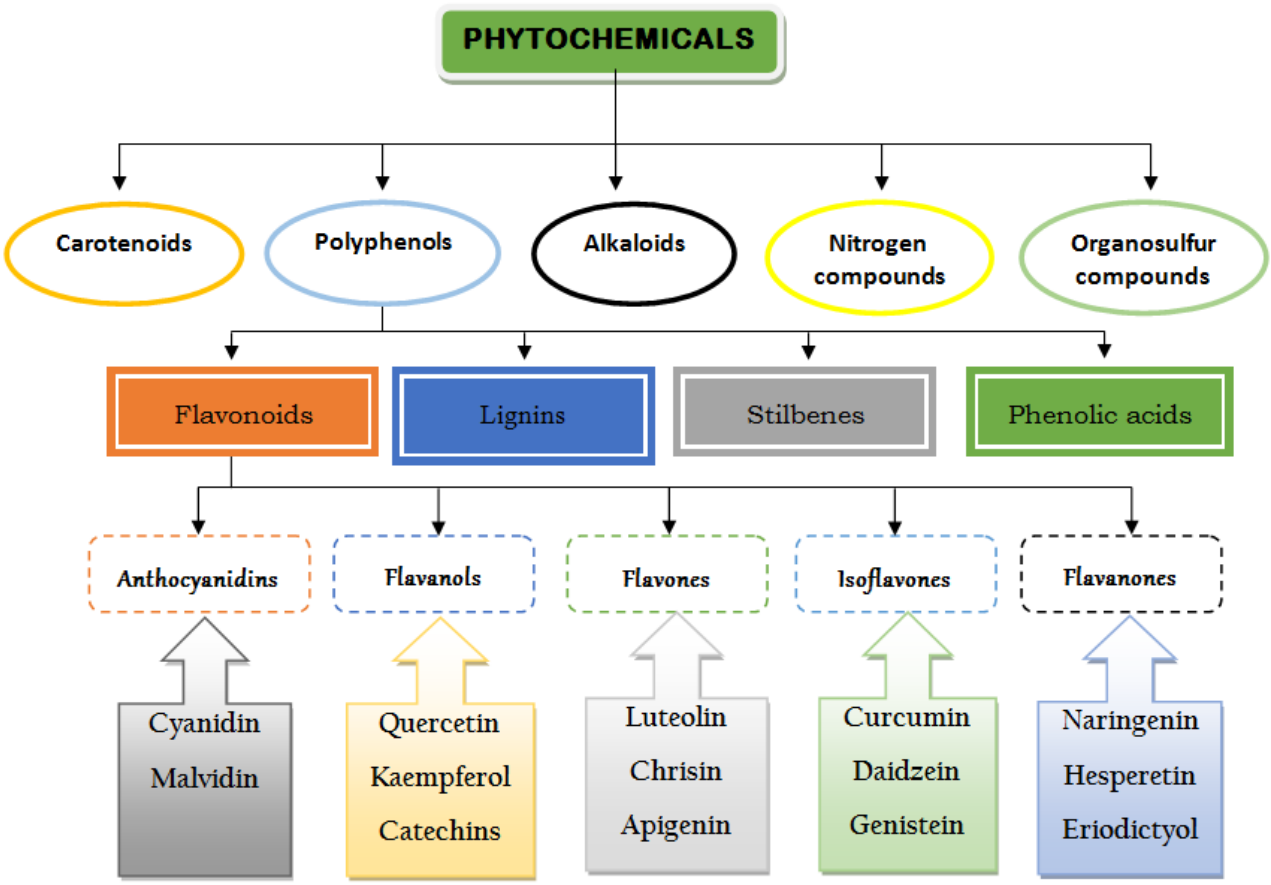
flavanols are further divided into catechins and epicatechins as well as proanthocyanidins and proanthocyanidins are further subdivided into procyanidins as well as prodelphinidins [3].

Phytochemicals as natural preservatives and antimicrobials

Natural preservatives derived from plant extracts such as phytochemicals and essential oils are used against fungal development in many fruits and vegetables after harvest [5]. The efficiency of an antimicrobial treatment depends on many factors, such as type, genus, species and strain of the main microorganism, in addition to environmental factors such as pH, water activity, temperature, atmospheric composition and an initial microbial load of the food material. Therefore, other important subject to know is type of the microorganisms owing to usually combinations of antimicrobials is more effective than adding just one. The natural antimicrobial preservative activity is not clear since there are many influencing factors, one of the most important being the interaction between phytochemicals and growth of microorganisms. Processing of foods containing phytochemicals is expected to result in some changes in their phytochemical content. Phytochemicals present in many food stuffs are lost by heat processing such as sterilization, pasteurization and dehydration [13]. Many investigations have evaluated phytochemical effects on antifungal activity. The potential use of plant extracts as natural antimicrobial agents in food preservation forms the basis for many applications such as grape seed or rosemary extracts that have been used as food preservatives.

Flavonoids usually occur as glycosides and aglycones in plant tissue which have significant antioxidant properties and antimicrobial and insect-repellent properties as well. Flavonoids and their antimicrobial effect are useful as a food preservative to extend the shelf life and safety of foods. Flavonoids play important roles in biological activities, including antiallergenic, antiviral and antifungal effects. It is also present in various common fruits and vegetables (apples, grapes, lemons, tomatoes, onions, lettuce and broccoli). The following flavonoids are antifungal agents in plants: isoflavonoids, flavans flavanones [7]. However, the antifungal activity of flavonoid compounds plays an important role between plant-microorganism and host plant's defensive systems.

Saponin and flavonoids are found in fruits and vegetables and in general they form a soapy lather after extracted from parts of plants. Thiosulfinates come from hydrolysis products of garlic and onion. They have a strong potential of producing antimicrobial effects against pathogenic microorganisms. Broccoli, Brussels' sprouts, cabbage mustard and horseradish have glucosinolates that also have a wide range of antibacterial effects [7].



Phytochemical extraction and determination

All the reagents used were with the analytical grade from Sigma Aldrich, Germany. UV spectrophotometer UV-1800 (Shimadzu Corporation, Japan) was used for the absorbance measurements. The chlorophylls, carotenoides and xantophylls were extracted with ethanol according to the methods described by [10] with some modifications. For extraction a representative portion of sample (0.1±0.001 g) (mass) was accurately weighted, grinded and quantitavely transmit in a glass test tube. Then ethanol was added till 5 mL to it and the test tubes were held in dark for 15 min with occasional shaking at room temperature and finally centrifuged. The chlorophylls, carotenoids and xantophylls content were analyzed spectrophotometrically by absorption measurements (A) at 350 to 700 nm with 1 nm interval and calculated according to the following equations:

$$\text{Chlorophyll a (mg g}^{-1}) = 13.7\ A_{665} - 5.76\ A_{649} / \text{mass} \cdot 200$$

$$\text{Chlorophyll b (mg g}^{-1}) = 25.8\ A_{649} - 7.6\ A_{665} / \text{mass} \cdot 200$$

$$\text{Carotenoid (mg g}^{-1}) = 4.7\ A_{440} - 0.263\ C_{chla + chlb} / \text{mass} \cdot 200$$

$$\text{Xanthophyll – Lutein (mg g}^{-1}) = 11.51\ A_{480} - 20.61\ A_{495} / \text{mass} \cdot 200$$

The content of vitamin C was determined titrimetrically using 2.6- dichlorphenolindophenol [1]. For determination 2±0.001 g of sample was accurately weighted, grinded in porcelain mortar, than quantitatively transfer in 100 mL tubes, added 50 mL of 1% HCl and 5% HPO3 mixture (v : v=1 : 1) and mix thoroughly [4]. After 30 minutes solution was filtered through a filter paper No. 89th. For determination 10 mL (Vanal) of filtrate was titrated with 0.0005 molar solution of 2.6 dichlorphenolindophenol (Vtitr). The content of vitamin C was calculating according to the equation:

$$\text{Vitamin C (mg 100 g}^{-1}) = V_{titr}^{.0.044 \cdot} V_{total} . .100 / V_{anal} . .\text{mass}$$

Epidemiological studies parameters related to Phytochemicals

Epidemiological studies suggest that consumption of a diet high in vegetables is associated with reduced risk of chronic disease. Unfortunately, there is not yet enough evidence to support the concept that phytochemicals are responsible for these effects. Vegetables are important sources of a variety of beneficial agents including vitamins, minerals, fiber, and phytochemicals. More research is needed to fully explain the actions of phytochemical compounds in the human body. Hundreds of phytochemical compounds, with several different biological functions, have been identified in plantbased foods [14]. Therefore, consuming a variety of plantbased foods helps ensure that individuals receive the optimum benefits from the vegetables they consume.

Table Potential health benefits from some phytochemical compounds

Vegetable type	List of Vegetables	Phytochemicals present
Dark green	Lettuce, spinach, chard, leafy greens	Carotenoids (lutein and zeaxanthin), Chlorophyll, fibres
Yellow and Orange	Pumpkin, carrot, squash, sweet potato	Carotenoids
Leguminous	Peas, lentils, soy and dried beans	Flavonoids (isoflavones), fibre, phytosterols
Allium	Onoin, shallot, garlic, chives, leeks	Flavonoids (flavonols), fibre, organosulfur compounds
Cruciferous	Cabbage, Cauliflower, Broccoli, Kale, Brussel sprouts, radish, rutabaga, turnip.	Carotenoids, chlorophylls, indoles, lignins, fibre, phytosterol.

Disease prevention by Phytochemicals

- Stimulate the immune system, the body's defense against viruses, bacteria and other disease causing agents.
- Block the potential for carcinogens to be formed in the body from substances we eat, drink and absorb from the environment.

- Reduce the oxidation, the damage to cells that occurs with aging and exposure to pollution, which causes abnormalities in cells that may eventually lead to cancer.
- Reduce the inflammation that prevents cancer growth.
- Prevent DNA damage and help with DNA repair mechanism.
- Helps in regulation of hormones, such as estrogen and insulin

Beneficial properties of plant phytochemicals

In the last decade, the results of many researches have shown the positive effects of phytochemicals in human health. There is a strong correlation of antioxidant consumption with lower risk of many diseases such as cardiovascular cancer, diabetes and hypertension diseases as well as other medical conditions. Vegetables have phenolic compounds, pigments and natural antioxidants; these compounds protect many diseases like cancer and heart diseases [9]. The importance of antioxidant effects on cardiovascular diseases and cancer is especially important and these antioxidants can be found in various fruits, vegetables and herbs. Phenolics as flavonoids have important effects such as antimicrobial, anti-inflammatory, antioxidant, antiviral, antiallergic, anticancer, antiulcer, antidiabetic, antiplasmodial, antihypertensive, anticonvulsant and all reducing risks for severe human diseases [8]. Antioxidants in fruits and vegetables have defensive effects and are three main groups: vitamins, phenolics and carotenoids. Vitamin C (ascorbic acid, AA) and the oxidized form (dehydroascorbic acid, DHAA), carotenoids and phenolic compounds prevent cardiovascular disease, cancer and cataracts which are associated with the oxidative damage of lipids, DNA and proteins. Moreover, some carotenoids also have antioxidant activity (AOA) and shown beneficial effects on the reduction of cardiovascular diseases. The vegetables that have phytochemicals are also not only low in fat and saturated fat, cholesterol and calories but also are rich in potassium and sodium, fiber, folic acid and AA. One of the most important flavonols is quercetin, which is higher in onion (red and yellow), broccoli, kale, French beans, apple, red grapes and cherries. Quercetin is anticarcinogenic and inhibits low-density lipoprotein (LDL) oxidation activities [12].

Conclusion

The potential great number of phytochemicals including some of the vitamins, flavonoids, terpenoids, carotenoids, phenolics, phytoestrogens, minerals and antioxidants in vegetables are used as alternative preservative agents for controlling postharvest physiological disorders or microbial pathogen injuries of vegetables in the food industry [2]. Many publications have focused on the potential protective nature of these natural phytochemical compounds against fungal and bacterial attacks. Moreover, these natural compounds have become interesting candidates not only for plant protection but also human and animal health protection from fungal and bacterial diseases because of their lower toxicity or absence of toxicity.

References

[1] AOAC, (1990), Official methods of analysis of the Association of Official Analytical Chemists. Fifteen edition. Arlington VA, Association of Official Analytical Chemists, Pp. 1058 – 1059.
[2] Lyimo, Nyagwegwe & Mnkeni, (1990), Investigations on the effect of traditional food processing, preservation and storage methods on vegetable nutrients: A case study in Tanzania. Plant Foods for Human Nutrition, 41, Pp. 53 – 57.
[3] Krishnaswamy and Raghuramulu, (1998), Bioactive phytochemicals with emphasis on dietary practices. Indian Journal of Medical Research, No. 108, Pp. 167 – 181.
[4] Staugaitis and P. Viskelis, (2001), Quality assessment of leaf vegetables, vitamin C and nitrates. Sodininkysteir Dazininkyste, Lithuanian Institute of Horticulture, Vol. 20 (4), Pp. 61 – 69.
[5] Kaur, C. & Kapoor, (2001), Antioxidants in fruits and vegetables-The millennium's health. International Journal of Food Science and Technology, 36, Pp703 – 725.
[6] Martin, (2003), Antioxidant vitamins E and C and risk of Alzheimer`s disease. Nutrition Reviews, No. 61, Pp. 69 – 79.
[7] Ismail, Marjan, & W. Foong, (2004), Total antioxidant activity and phenolic content in selected vegetables. Food Chemistry, 87, Pp581 – 586.
[8] Zhang and Hamauzu, (2004), Phenolics, ascorbic acid, carotenoids and antioxidant activity of broccoli and their changes during conventional and microwave cooking. Food Chemistry, 88, Pp. 503 – 509.

[9] Kopsell, Kopsell and Curran-Celentano, (2005), Carotenoid and chlorophyll pigments in sweet basil grown in the field and greenhouse. HortScience, Vol. 40 (5), Pp. 1230 –1233.
[10] Krumbein, Schonhof and Schreiner, (2005), Composition and content of phytochemicals (glucosinolates, carotenoids and chlorophylls) and ascorbic acid in selected Brassica species (B.juncea, B.rapa subsp. nipposinica var. chinoleifera, B.rapa subsp. chinesis and B.rapa subsp. rapa). Journal of Applied Botany and Food Quality, No. 79 (3), Pp. 168 – 174.
[11] Danesi & Bardoni, (2008), Effect of home freezing and Italian style of cooking on antioxidant activity of edible vegetables. Journal of Food Science, 73(6), Pp109 –1 12.
[12] Pellegrini, Chiavaro, Gardana, Mazzeo, Contino and Gallo et al. (2010), Effect of different cooking methods on colour, phytochemical concentration and antioxidant capacity of raw and frozen brassica vegetables. Journal of Agricultural and food chemistry, 58, Pp. 4310 – 4321.
[13] Banerjee, Datta and N. K. Mondal, (2012), Biochemical changes in leaves of mustard under the influence of different fertilizers and cycocel. Journal of Agricultural Technology, Vol. 8(4), Pp.1397 – 1411.
[14] Singh, Beloy, McInerney and Day, (2012), Impact of boron, calcium and genetic factors on vitamin C, carotenoids, phenolic acids, anthocyanins and antioxidant capacity of carrots. Food Chemistry, Vol. 132, Pp. 1161 – 1170.

Publication History
Received 06th Sep 2017
Revised 25th Sep 2017
Accepted 04th Oct 2017
Online 30th Oct 2017