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A REVIEW ON HEALTH BENEFITS AND NUTRITIVE VALUE OF VEGETABLES

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ABSTRACT

For a well-balanced diet, vegetables are considered as essential source of minerals, vitamins, dietary fiber and phytochemicals. A unique combination and amount of these vitamins and minerals are present in different vegetables, which make them separate from each other. Vegetables have a strong association in improving the gastrointestinal health, vision, chronic diseases and varioustypes of cancer. Vegetables being rich in antioxidants are involved in our daily diet. A balanced diet contributes to solve many nutrition related problems and different vegetables offer distinct level of protection to humans against diseases. Now-a-days, the focus is not only on the quantity but also on the quality of vegetable products, which further coincides with the consumer demand for healthy produce. An individual must includes a diverse type of vegetable in diet to get a combination of phytonutraceuticals to lead a healthy life. This article goes through a review and discuss about the nutritive value and health benefits with respect to vegetables. Further, in future research work is to be carried out involving food scientists and biomedical researchers to know about the exact constituents of different vegetables related to phytonutraceuticals.
Keywords: Antioxidants, Dietary fiber, Minerals, Phyto chemicals, Vitamins, Vegetables

Introduction

In human nutrition, vegetables play an important role in completing daily requirements by providing a balanced diet, especially as sources of minerals, vitamins, dietary fiber and phytochemicals (Quebedeaux and Eisa 1990; Craig and Beck 1999; Wargovich 2000; Dias and Ryder, 2011). The vegetables are well known for reducing the risk of chronic diseases due to presence of strong antioxidants. It protects human body from free-radical damage, modifies metabolic activities, detoxify carcinogens and sometimes restricts the process of formation of tumor cells (Craig and Beck, 1999; Wargovich 2000; Southon 2000; Herrera *et al*., 2009). A strong association exists between our daily diet and balanced health, which includes reduced risk of cancer, good vision, gastrointestinal health cardiovascular diseases, ulcer, anaemia, diabetes, high or low blood pressure and arthritis (Prior and Cao 2000; Keatinge *et al*., 2010). Globally, due to consumption of unbalanced diets and poor intake of vegetables, 31% of cardio-vascular disease and 11% of heart stroke has been estimated. It has been estimated as per World Health Report, 2007, responsible causing approximately 2.7 million deaths annually, due to improper habit of consuming indigestible dietary fiber and carbohydrates it contributes to mortality (Dias, 2011). Although some general awareness is there that phytonutraceuticals present in vegetables are required for reducing some of these disease but still the actual mechanism of involvement of vegetable consumption needs to be understood properly.

Results from a Worldwide Survey on Vegetable revealed that 402 vegetable crops are under cultivation, involving 230 genera and 69 families (Kays and Dias 1995; Kays, 2011). Out of total vegetable consumption, includes leafy vegetable (53%), fruit vegetable (15%) and root vegetables (17%). As these are highly perishable in nature, it needs to consumed fresh and a very minimal quantity is being processed. Quality vegetable consumption is highly required now-a-days over quantity.

As far as breeding of vegetable crops is concerned, it is only confined to commercial vegetables due to their large scale production and consumption i.e. only 17%. Still production of quality seed and planting material is necessary for these vegetable crops considered as minor 13% and rare 22%(Dias, 2011). In 2010, the seed market for vegetable worldwide was estimated at 4.1 billion US $, out of which vegetables belonging to Solanaceae family contribute 36%, 21% for Cucurbits, 13% for roots and bulb crops, 11% for brassicas, 7% for leafy and minor vegetables and 12% for large seeded vegetables. In the coming years, it is expected to increase in the global market for vegetable seeds, due to rise in World population and consumption. Consumers are not only interested in consumption of high quantity of vegetable with enhanced nutritional qualities too.

Nutritive value and health benefits of vegetables

Here, we will bring out the nutritional benefits of different vegetables available throughout the World.

Solanaceous Vegetables

Vegetables belonging to Solanaceae family contain different phytonutraceuticals and hence need to be studied separately.

1. Tomato: It is one of the most widely cultivated, accepted and consumed vegetable after potato, globally. Even tomato is the most readily accepted vegetable for preparation of different processed products (for example: canned, puree, sauce, juice, soup, pickle and ketchup). It is a low energy food with zero fat content and a number of benefits for maintaining good health.

The important constituents of tomato includes carotenoids having 60-64% lycopene, 7-9% neurosporene, 10-15% carotenes and 10-12% phytoene (Clinton, 1998). On an average, a freshly harvested tomato contains about 35 mg/kg of lycopene, which is further different for red (90mg/kg) and yellow (5mg/kg) cultivars (Scott and Hart, 1995). As compared to fresh tomatoes, processed products prepared from tomatoes contain 2 to 40 times higher lycopene (Clinton, 1998; Tonucci *et al*., 1995; Gerster, 1997). Products prepared from tomatoes are considered to be the richest source of lycopene, throughout world. Human diet should comprise of about 25 mg lycopene per day and nearly 85% is being fulfilled from raw and processed tomato (Gerster, 1997; Rao *et al*., 1998). It is also a good source of carotene ranging from 0.6 to 2.0 mg/kg (Albushita *et al*., 2000; Leonardi *et al*., 2000). In the American diet, it is considered as one of the leading contributor of Vitamins such as Provitamin A and Vitamin A, (Arab and Steck, 2000).

In addition to the American diet, in other developed countries, it is considered as the top contributors of potassium. As per the USA National Health and Nutrition Examination Survey, food intake data, 1999-2000, as a source of potassium tomatoes comes seventh after milk, potato, coffee, beef, poultry and citrus fruit juice. A recommended amount of consumption of 4700 mg potassium which helps in lowering blood pressure, minimising the risk of kidney stones, the bad effects of excess consumption of sodium and age-related bone loss. For World developed countries, increasing intake of potassium through tomato consumption is a healthful and calorically sensible strategy.

Tomato fruits are found to be a very good source of Ascorbic acid, containing about 200mg/kg and are next to citrus (Rao and Rao, 2007). Fresh tomatoes contains flavonoids and which is available in the conjugated form as Quercetin and Kaempferol (Crozier *et al*., 1997), but a significant amount of free flavonoids is found in the processed tomato products(Stewart *et al*., 2000). In comparison to greenhouse grown tomatoes, open-field cultivated fruits have higher flavonoids content (Stewart *et al*., 2000; Simon and Goldman, 2007). Some double-rich varieties are present having Vitamin C in double the amount than that of normal, 40 times than normal Vitamin A (97L97), increased level of anthocyanin (Purple tomato), 2-4 times of the normal lycopene (cultivars with high crimson gene).

In human serum and tissues, an appreciable amount of lycopene is found when tomatoes and its products are frequently consumed (Allen *et al*., 2003; Ganji and Kafai, 2005). As per some researchers, the serum or plasma lycopene concentration is inversely proportional to some cancers up to an extent (Burney *et al*., 1989; Wakai *et al*., 2005). For different Cardiovascular diseases markers, osteroporosis, cognitive function and body weight, similar association have been suggested (Foy *et al*., 1999; Yang *et al*., 2008).

About 178 research papers (original) reported that the relationship between humans and lycopene which includes tomato (both raw and processed) and cancer risk(Burton-Freeman and Reimers, 2011). Among all these investigations, cancer related to tomato intake, lycopene consumption and prostate cancer is the most widely studied. Minimised risk of prostate cancer upto 35% was observed, when there is consumption of 10 or more servings of tomato products per week and it was also found effective against more aggressive and advanced stages of cancer (Giovannucci *et al*., 1995). It can be concluded that the people consuming tomato and tomato based products in diets are less likely to go through stomach and rectal cancers as compared to those consuming less quantity of lycopene rich vegetable (Giovannucci, 1999).

Studies reported that when tomatoes and tomato products are removed from daily consumption, the antioxidant capacity of plasma decreases and when they are added back it increases (Hadley *et al*., 2003). A daily consumption of tomato products for 2-4 weeks enhances the defence mechanism by antioxidant enzyme and reduces plasma lipid peroxides activity (Briviba *et al*., 2004; Upritchard *et al*., 2000; Bub *et al*., 2005). Reports suggested that a daily intake of tomato for more than 8 weeks reduced the ultraviolet light-induced erythema as 40 gm tomato contains approximately 16 mg of lycopene (Stahl *et al*., 2001; Stahl *et al*., 2006; Stahl and Sies, 2002).

These reviews suggest that the benefits due to consumption of tomato products or tomato are not solely because of presence of lycopene content, but due to the combinations of nutrients and bioactive constituents in the whole fruit.

2. Brinjal (Eggplant): It is the most widely adapted vegetable crop grown throughout the tropics, subtropics and Mediterranean region. A comparatively long warm weather is required for its proper growth and development and to give higher yields. It does not only have a number of vitamins and minerals but also contains important phytochemicals having anti-oxidant activity. The major phytochemical content is delphinidin-3-(coumaroylrutinoside)-5-glucoside. The purple pigment is due to presence of anthocyanin (Noda *et al*., 1998; Noda *et al*., 2000). But the purple colour gets fade away on cooing without losing its properties. Daily consumption of brinjal lessens formation of free radicals and protects blood cholesterol from peroxidation, prevents from active cancer cells and rheumatoid arthritis. It also has anti-mutagenic properties, anti-microbial, anti-low density lipoproteins and antiviral activities. Along with the most predominant phenolic compound known as chlorogenic acid, 13 other phenolic acid are also present significantly at varying levels. The phenolic acids are not only responsible for their nutritive potential but also for the bitter taste and browning of the flesh when cut open. It produces the brown pigments due to the phenolic reaction caused by polyphenol oxidase. Now-a-days, research work has been carried out to develop cultivars

with balanced phenolics to maintain optimum nutritional value and appealing taste.

It is a rich source of dietary fiber and manganese. It also posses a good amount of Molybdenum, potassium, Vitamin K, Magnesium, Vitamin C, B6, folate and niacin (Ensminger *et al*., 1986; Wood, 1988). Regular consumption of brinjal proves to be effective in treating high blood cholesterol (Jorge *et al*., 1998). As reported from the research conducted by (Guimares *et al.*, 2000) by feeding human beings with brinjal powder results in a significant decrease in low-density lipoproteins level and total cholesterol level.

It is considered to be a very good source of nicotine having a concentration of 0.01mg/100g, as compared to other vegetables. However, the presence of nicotine is negligible compared to passive smoking (Domino *et al*., 1993). Studies confirmed that, the amount of nicotine present in a cigarette is equal to 9kg of brinjal. It also contains some amount of oxalates, hence recommended not to consume excessive quantity of brinjal as the oxalates when get too concentrated in body fluids leads to kidney calcium oxalate stones. Therefore, as a general recommendation, patients suffering from gall bladder problems or kidney problems should avoid eating brinjal on regular basis (Parivar *et al*., 1996; Assimos and Holmes, 2000). Reports also suggested that oxalates may interfere in absorption of calcium from the body (Kikunaga *et al*., 1988).

3. Chilli and Capsicum: It is also known as Hot and Sweet peppers. A wide variability is present in the colours, shape and size of peppers. It is very well accepted for adding flavours, crunch and pungency to a number of dishes. It is an excellent source of Vitamin C, K, carotenoids and flavonoids when consumed fresh (Bosland, 1996). It is very effective against cell damage, diseases related to old age and strengthen immune system, due to presence of antioxidant, Vitamin A and C. Its adequate consumption helps in reducing inflammation; presence of Vitamin K protects cells from oxidative damage, strengthens bones and promotes blood clotting. It is also effective against cancer due to presence of lycopene especially in red peppers. It is not only high in phyto chemicals, but also contains a good proportion of fiber. Studies confirmed a significant variation in Vitamin C content among cultivars but not among species. Fresh pepper fruits contain 200-300% of RDA of vitamin C for adults (Howard *et al*., 2000). The presence of α and β-carotene level varies as per the varieties. Some specific cultivars of chilli contain about 12 mg/kg total carotenoids, as compared to others which are below the traceable level (Howard *et al*., 2000; Howard *et al*., 1994). Reports suggested that red bell peppers contain significantly higher amount of nutrients as compared to green one. Capsicum proves to be protective against cataracts due to presence of high vitamin C and β-carotene. Besides having powerful phytochemicals, it also contains Capsaicin and flavonoids which reduces the risk of heart attack and stroke to a great extent. As compared to chilli, capsicum outstands in controlling the cholesterol levels.

This doesn't mean that chilli aren't important, rather the major phytochemical present is capsaicinoides. Nelson 1846, discovered capsaicin and its structure as an acid amide (Suzuki and Iwai, 1984). The pungency is contributed by capsaicin (70%) and its analogue dihydrocapsaicin (30%), (Thomas *et al*., 1998). A significant difference has been found between and within the chilli species for capsaicinoides content, which ranges from about 200ppm in *Capsicum annum* to 20,000 ppm in *Capsicum chinense* (Thomas *et al*., 1998).

Studies reflect that the pungency we feel due to consumption of chilli is because the capsaicin acts on pain receptors and not taste buds. The concentration of capsaicin is more in the white membranes and seeds as compared to the flesh of fruits. A daily consumption of raw chilli has been found effective against high blood cholesterol and triglycerides boost immunity and decrease the risk of stomach ulcers. Myth exist that chilli aggravates ulcers, by killing the beneficial bacteria present in stomach.

Capsaicin acts as a major constituent in pharmaceutical formulation for the treatment of pain, ache, burn and rheumatoid arthritis. It also possesses analgesic, antibacterial and antidiabetic properties. It is found to be beneficial for bladder hypersensitivity, vasomotor rhinitis and hyperreflexia of spinal origin (Szallasi and Blumberg, 1999). Fresh chilli of 100 gm contains 240% of vitamin C, 32% of vitamin A, 39% of vitamin B6, 14% of copper, 13% of iron and 7% of potassium (Frei and Lawson, 2008). 100 gm fresh chilli contributes about 240% of recommended daily allowance. Chilli contains an adequate amount of vitamins and minerals like vitamin B6, B1, potassium, manganese, iron and magnesium.

Studies shown that there is an increase in body's heat production and oxygen consumption for about 20 minutes after consuming chilli and capsicum, which also means that our body is burning extra calories that helps in weight loss.

4. Potato: It is considered to be the third most important staple food after rice and wheat. On per-day basis, potato yields more energy as compared to cassava and cereals. It isn't only an important source of carbohydrates but also amino acids. The carbohydrates are available in the form of starch, which is slightly difficult on the part of our small intestine to digest and so it reaches the large intestine intact. The resistant starch is considered as the dietary fiber which is associated with a member of health benefits like protection against cancer, increase in insulin sensitivity, lowers cholesterol and triglyceride levels and even reduces fat storage (Raben *et al*., 1994; Hylla *et al*., 1998). The residual starch content (resistant) depends upon the method of preparation as cooked potato contains 7% resistant starch, which further increases to 13% upon cooling (Englyst *et al*., 1992). A daily consumption of more than RDA of carbohydrates makes the individual obese. Although potato contains a less amount of protein (less than 6%), but it is considered as the best among other vegetables having protein and even comparable to cow's milk. It is because the protein content in potato is of very high quality as it is rich in amino acid, lysine and other metabolites (McCay *et al*., 1987; Okeyo and Kushad, 1995; Friedman, 1996).

Besides that it is a rich source of vitamins, minerals and phytochemicals including phenolics, phytoalexins and protease inhibitors. A potato of medium size (150g) with skin intact provides 27 mg of vitamin C, 0.2 mg vitamin B6, 620 mg potassium and small amount of folate, niacin, P, Fe, Zn, thiamine, riboflavin, Mg and fiber (2g). The phytochemical content of potato varies with the flesh colour, like yellow, white, red and purple. The purple coloured potato turns blue on cooking which is the result of mutation in those cultivars,

P locus leads to production of antioxidant anthocyanin (Jung *et al*., 2005). In potato, total phenol content varies from 0.5 to 1.7g/kg, (Reeve *et al*., 1969; Thomas and Joshi, 1977). Studies reported that the concentration of total phenolic compounds is high in the peel and nearby tissues and it decreases towards the centre of tuber (Bosland 1996; Howard *et al*., 2000).

The vitamin C content is moderate about 10 to 104 mg/kg in tubers, which depends upon the growing season and cultivars and it decreases rapidly during cooking and storage (Okeyo and Kushad, 1995); Cieslik 1994; Hagg *et al*., 1998).

Cruciferous Vegetables

Crucifers are considered as the largest family of vegetables which provide the richest sources of glucosinolates in the human diet. As per the research work carried out by World Cancer Research Fund in USA, World Cancer Research Fund, "Food, Nutrition and the Prevention of Cancer: A Global Perspective (1997), they reported that the diet rich in crucifers proves to be beneficial against cancers. Vegetables rich in glucosinolates include broccoli, Brussels sprouts, cabbage and kale (Verhoeven *et al*., 1996; Ambrosone *et al*., 2004; Brennan *et al*., 2005; Kirsh *et al*., 2007; Traka, 2010). Studies reported that a daily intake of 10g crucifers can decrease the risk of cancers significantly (Verhoeven *et al*., 1996; Ambrosone *et al*., 2004; Kirsh *et al*., 2007; Traka 2010; Kohlmeier and Su, 1997; Seow *et al*., 2002). As compared to all forms of Cancers, consumption of broccoli in daily diet can reduce the incidence of prostate cancer to a large extent (Kirsh *et al*., 2007; Traka, 2010). Hence, they are considered to have the anti-carcinogenic properties.

A significant qualitative and quantitative difference exist among the cultivars within each crucifers for glucosinolates levels, which also varies as per the stage of development, management practices and climatic conditions (VanEtten *et al*., 1976; Cartea *et al*., 2008). Comparative studies of glucoraphanin suggested that, red cabbage have higher concentrations than white cabbage (Goodrich *et al*., 1989). The white cabbage has significantly higher concentration of glucoiberin than red cabbage (Goodrich *et al*., 1989). The concentration of gluconasturtiin was found significantly higher in red cabbage than white ones.

The most important glucosinolates present in broccoli are glucoraphanin, progoitrin, gluconasturtiin and glucobrassicin (Carlson *et al*., 1987; Kushad *et al*., 1999; Vallejo *et al*., 2002; Vallejo *et al*., 2003; Borkowski *et al*., 2008; Assimos and Holmes, 2000). The glucosinolates predominantly present in kale, cabbage, cauliflower, brussels sprouts and collard are sinigrin, progoitrin and glucobassicin (VanEtten *et al*., 1976; Carlson *et al*., 1987; Kushad *et al*., 1999; Cartea *et al*., 2008; Hansen *et al*., 2010; Kusznierewics *et al*., 2008). The radish and turnip possess glucoraphanin, glucobrassicin and glucoerucin to a great extent (Carlson *et al*., 1981; Carlson *et al*., 1985; Carlson *et al*., 1987; Ciska, 2000). Due to involvement of the environmental factors, a difference in indol glucosinolates and aliphatic glucosinolates exists and the effect of genotypes is found to be greater than that of the environment (Farnham *et al*., 2000).

In a research containing 22 different vegetables, kale found to be the second highest in vitamin content (Cao *et al*., 1996). A significantly high quantity of vitamin C and E and β-carotene is found in Brussels sprouts and broccoli (Kurilich *et al*., 1999). A wide variation in the vitamin C and tocopherols content is being observed within the crucifers (Kushad *et al*., 1999; Kurilich *et al*., 1999). In a study for determining vitamin C content, kale had the highest amount followed by broccoli, Brussels sprouts, cabbage and cauliflower (Kurilich *et al*., 1999). Variability in broccoli was also associated with genetic factors for 79% of β-carotene, 55% of vitamin C and 82% of α-tocopherol (Kurilich *et al*., 1999). Apart from these, Broccoli and Brussels sprout are found to contain highest amount of folate which contributes about 110 to 135µg/100g and 70 to 90µg/100g respectively (Konings *et al*., 2001).

A significant amount of dietary fiber is also present in crucifers. For example, cauliflowers have dietary fiber content of 5% of total fresh weight and have 40% of non-starch polysaccharides (Fermenia *et al*., 1999). Studies confirmed that in Brussels sprouts the concentrations of cellulose and lignin is about 36% and 14.5% as compared to cauliflower having 16% and 13% of total dry matter respectively (Rahn *et al*., 1999).

Crucifers are a good source of calcium, protein, fiber and sulphur too. They are also capable of accumulating selenium when grown on selenium rich soil (Banuelos and Meek, 1989). Studies revealed that cabbage sprouts and fully grown heads also have the selenium content and the concentration was higher in the sprouts as compared to mature heads (Bibak *et al*., 1999).

Some other antioxidants present in crucifers are flavonoids, quercetin, luteolin, myricetin, apigenin and kalian (Miean and Mohamed, 2001).

Alliums Vegetables

Alliums include onion, garlic, leek, chive and welsh onion. They are considered to be the richest source of thiosulfides and are helpful in reducing chronic diseases. Studies reported that, a significant difference exists among alliums, for the concentration of thiosulfides. The non-protein sulphur compounds content varies from 1% to 5% on dry weight basis (Kubee *et al*., 2000). Results also confirmed a significant variation in the total thiosulfide content (0.02% to 1.3% fresh weight) between and within alliums, even when grown under same environmental conditions(Kubee *et al*., 2000).It has also been concluded that in leaves (green onion), chive and bulb (onion), the complete amount of thiosulfide were 0.2, 0.72 and 1.02g/kg fresh weight, respectively. Onion bulb contains methiin (34%), ethiin (5%), alliin (5%), isoalliin (49%) and propiin (6%), (Yang *et. al*., 2008), whereas garlic cloves contains methiin (8%), alliin (92%) and some amount of propiin, ethiin and isoalliin (Kubee *et al*., 1999).

Onion bulbs also contain anthocyanins in red cultivars and quercetin and kaempferol in yellow cultivars. It has been observed that onion leaves possess the highest total flavonoid content (2.7g/kg) followed by garlic (1.0g/kg) on dry weight basis (Hertog *et. al*., 1992). In a comparative study of onion bulb and leaves, for flavonoids content, reveals that onion leaves have quercetin (55%), kaempferol (31%) and luteolin (14%), whereas onion bulb have quercetin (95%) and traceable amount of kaempferol (Hertog *et al*., 1992). The quercetin content in white cultivars is significantly less as compared to red ones and is mostly present in the outer

scales (Herrmann, 1976). The flavonoids kaempferol is predominantly present in chive, garlic and leek (Bilyk and Sapers, 1985).

Besides that alliums are an excellent source of potassium, calcium and manganese and can fulfil up to 10% of human daily requirements. If grown in selenium-rich soil, they are capable of accumulating selenium and can efficiently deliver it to human body, which provides prevention against cancer (IP and Lisk, 1994; EI-Bayoumy, 1991).

Recently, it has been found that onion also contain chromium and can meet up to 20% of its daily requirement, which is very beneficial for diabetic patients (Kruse *et al*., 1999). Onion is found to be a good source of dietary fibers and has prebiotic properties, as it activates the beneficial bacterial myco-flora present in intestine (Dorant *et al*., 1996). Studies concluded a strong association between the consumption of onion and reduced risk of intestine and stomach cancers (You *et al*., 2005; Galeone *et al*., 2006). Similarly, consumption of one to seven portion of garlic per week is inversely proportional to colorectal and prostate cancers (Salem *et al*., 2011; Fleischauer *et al*., 2000; Hsing *et al*., 2002; Osmont *et al*., 2003). By adding onion and garlic to our daily diet, prevention against cardiovascular diseases can be achieved, (Clinton, 1998).

Conclusion

Consumption of vegetables can provide protection against a number of chronic diseases in human due to the presence of phytoneutraceuticals. Although the actual mechanism behind providing protection against diseases is still unknown, but a proper and balanced diet can contribute to overall healthy life. The presence of different antioxidants and anti-carcinogenic properties directly or indirectly proves to be beneficial. Vegetables not only provides nutrients, vitamins and minerals but also contain dietary fiber which improves bowel movement, manage glucose levels and lowers cholesterol levels. Instead of consuming foods with high saturated fats, high caloric value, we can choose relatively healthier diet. As each vegetable possess a different and unique combination of nutrients, so we need to ensure the involvement of each and every vegetable in an adequate amount in our daily diet. But this isn't enough and we need to carry out research on the health benefits of vegetables from breeding perspective in near future to make the availability of quality vegetables to the consumers at a cheaper and affordable price with surplus quantity too.

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