



CITRUS FRUITS AND CRUCIFEROUS VEGETABLES: BOON FOR IMMUNITY

Priya Singla¹ and Gurpreet Kaur¹

¹Research Scholar, Department of Food and Nutrition, Punjab Agricultural University, Ludhiana, Punjab, India

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Abstract: A balanced diet constitutes a good amount of fruits and vegetables which is essential for human health. Citrus fruits are rich in antioxidants and play an important role in preventing cataracts, macular degeneration, diabetes, coronary heart disease, stroke, arthritis, cancer, inflammatory bowel disease and Alzheimer's disease. Its juices are the main source of ascorbic acid, niacin, thiamin and riboflavin and also contain significant amounts of beta-carotene, dietary fibre, folic acid depending upon the variety. Higher consumption of cruciferous vegetables lowers the risk of lung, colorectal, stomach, colon and rectum cancers. Selenium enriched broccoli helps to reduce mammary tumors and colon cancer in animal models. Cited literature concluded that inclusion of nutritionally adequate foods in daily diet plays a significant role in providing the beneficial healthy effects against many diseases.

Keywords: Carcinogens, citrus fruits, cruciferous vegetables, health.

Introduction

Vegetables are important source of dietary fiber, vitamins, minerals and phytochemicals so they are considered an essential component of balanced diet. Each group of vegetables covers a distinctive combination and quantity of phytonutraceuticals, which makes it indispensable. Regular intake of vegetables have been strongly linked with improvement in gastrointestinal health, good vision, reduced risk of heart disease, stroke, chronic diseases such as diabetes and some forms of cancer. Some phytochemicals of vegetables are strong antioxidants and are linked with a reduced risk of chronic lifestyle diseases by modifying metabolic activation and detoxification of carcinogens and protecting against free radical damage (Dias JS. *et al.* 2012). The intake of 400 to 600 g/d of fruits and vegetables in daily diet is associated with reduced incidence of many common forms of cancer.

Diets constituted of higher levels of plant based ingredients are also associated with a reduced risk of heart disease and many chronic diseases related with ageing. Such diet also contains phytochemicals having anti-inflammatory and anticancer properties. Recommendation of colorful

fruits and vegetables is an easy way to incorporate diverse foods in daily diets of consumers. For example, red colored foods a pigment named contain lycopene, has been linked with a decreased risk of cardiovascular disease and its localization in the prostate gland signals and its potency in maintaining prostate health. Green foods (broccoli, Brussels sprouts and kale) contain glucosinolates associated with a decreased risk of cancer. Garlic and other white green foods in the onion family contain allyl sulphides which may inhibit cancerous cell growth (Heber D. 2004). This paper reviews the antioxidant activity of citrus fruits and cruciferous vegetables involved in prevention of diseases.

Health beneficial effects of citrus fruits and cruciferous vegetables

Citrus fruits

Citrus fruits such as grapefruit (*Citrus vitiis*), lemon (*Citrus limonum*), lime (*Citrus aurantifolia*) and tangerine (*Citrus reticulata*) belong to the family of rutaceae and are grown throughout the world (Okwi DE *et al.* 2006). These are evergreen trees which yield fruits of different colored skin ranges from green to yellow and in different sizes and forms. Epicarp and mesocarp - a white, thick and spongy layer together

forms the peel (pericarp) of the fruit and also protect from contamination. Its typical citrine flavour is due to potassium salt and different organic acids present in the fruit (Roger GDP *et al.* 2002). Vitamin C helps in iron absorption from the intestines (Okwu DE *et al.* 2003) and prevents scurvy and muscle fatigue and also important as an anti-stress, protects against cold (Wintergerst ES *et al.* 2006). During pregnancy, it also helps to reduce the risk of pre-eclampsia (Turner T *et al.* 2013).

Phytonutrients present in fruits, act as antioxidants, block the damage of the genetic materials, induce protective enzymes in the liver and stimulate the immune system (Okwu DE *et al.* 2008). Phytochemicals provide strong inherent ability to body to react with different types of allergens, carcinogens and viruses and also have anti-allergic, anti-cancer, anti-inflammatory and anti-microbial activity (Etebu E *et al.* 2014). Most common flavonoids found in citrus fruits are hesperidin, myricitin, naringin, quercetin, rutin and tangeritin (Okwu DE *et al.* 2005). Limonin and nomilin occur in highest amount in orange juice (*C. sinensis*) and grapefruit (*C. vitis*) provide the bitter taste partly (Craig EJ *et al.* 2002). Studies revealed that due to its antioxidant activity, play an important role in prevention of Alzheimer's disease, arthritis, asthma, cancer, cataracts, cholera, cognitive impairment, coronary heart disease, Crohn's disease, diabetes, gallstones, gingivitis, inflammatory bowel disease, macular degeneration, multiple sclerosis, optimal lung function, Parkinson's disease, stroke and ulcerative colitis. They also had effects on capillary fragility and have an ability to inhibit platelet aggregation (Okwu DE *et al.* 2008).

Citrus sinensis (*L. Osbeck*) is originated from south East Asia. It provides strong immune system to the body to fight against infectious agents, stimulate white blood cell function and scavenging harmful, pro-inflammatory free radicals from the blood (Wintergerst ES *et al.* 2006). As citrus fruits have low sodium to potassium ratio and are low in fat and dietary energy with low glycaemic index protect human body from being overweight and

obese and also decrease the risk of various conditions associated with obesity. A study was conducted by (Joshi-pura KJ *et al.* 2001) and observed that 19 per cent reduction was observed with the consumption of one extra serving of citrus fruits per day. Citrus fruits contain carotenoids such as terpenes (Katsuura S *et al.* 2009) which are responsible for colors (Bruno RS *et al.* 2000). Lycopene, the red pigment present in largest amount in pink grapefruit has a significant anti-tumor activity. Carotenoids are antioxidants which stimulate gap junction communication between cells and promote eye health (Turner T *et al.* 2013), improvement in immune system (Katsuura S *et al.* 2009) and help to promote bone formation and health (Sahni S *et al.* 2009).

In vitro experiments by (Szeto YT *et al.* 2002) found that ascorbic acid contribute 40 to 54 per cent of the antioxidant potential among grapefruit, mandarins and oranges. Supplementation of three servings of orange juice (which provides ~100 mg of vitamin C per serving) for a period of six weeks doubled milk vitamin C concentrations but if only one serving per week is provided showed non-significant results (Daneel-Otterbech S *et al.* 2005). There was increased concentration of vitamin C in plasma by 40 to 64 per cent and reduction in oxidative markers among adults with consumption of 500 ml/day orange juice for two weeks showed more pronounced positive results in smokers by (Sánchez-Moreno C *et al.* 2003). Another study found reduction in plasma lipid peroxidation by 47 per cent when an adult daily consumed 8 ounces (~236 ml) of orange juice which contains ~70 mg vitamin C for a period of two weeks (Johnston CS *et al.* 2003). A study with obese children showed reduction in blood pressure and insulin levels and biomarkers of oxidative stress, improve insulin resistance homeostasis and also observed increase in antioxidants (vitamin E, C and glutathione) with the consumption of mandarin juice (500 ml/day) for a period of one month (Codoñer-Franch P *et al.* 2010). Orange juice which contains about 500 mg of vitamin C help to reduce the severe effects of

inflammatory and oxidative and stress even in the presence of a high carbohydrate or fat diet (Ghanim H 2010).

Cruciferous vegetables

Cruciferous vegetables are a rich source of glucosinolates, indoles and isothiocyanates. Hydrolysis of glucosinolate alters the metabolism or activity of sex hormones so that it could prevent the development of hormone-sensitive cancers. Certain epidemiological studies indicated the association between higher intake of cruciferous vegetables and lower risk of cancers of lung, colorectal (Higdon JV *et al.* 2007), stomach, colon and rectum (Avci A *et al.* 2010). On the contrary, an inverse relationship between intake of cruciferous vegetable and breast or prostate cancer in humans which is limited and inconsistent. The National Cancer Institute does not give any separate recommendations about the intake of cruciferous vegetables but recommended intake of fruits and vegetables from 5 to 9 servings per day (Higdon JV *et al.* 2007).

Some cruciferous vegetables are good sources of calcium such as brussels sprouts, kales, kailan, pak-choy, rutabaga, tronchuda cabbages and turnip. Crucifers also contain significant amounts of dietary fiber and about 40 per cent of non-starch polysaccharides. Additionally, Brussels sprouts contain 36 and 14.5 per cent of cellulose and lignin, whereas in cauliflower it was about 16 and 13 per cent on dry matter basis, respectively. In comparison to broccoli, Galega kale comprises a high concentration of calcium, fiber, protein and sulfur. When crucifers are grown in selenium rich soil, they accumulate significant amounts of selenium (Dias JS *et al.* 2012). Selenium enriched broccoli helps to reduce mammary tumors and colon cancer in animal models (Finley JW *et al.* 200).

A total of 62 vegetables were examined for their flavonoid content (Miean KH *et al.* 2001) and observed that it ranges from 148 to 219 mg/kg among broccoli, cauliflower, cabbage, chinese cabbage and kailan but did not notice presence of kaempferol in tested cruciferous vegetables. Another study conducted by (Nielson JK *et al.* 2013) found

Kaempferol and only myricetin in cabbage. Moreover, luteolin, myricetin and quercetin are observed in broccoli whereas, myricetin and quercetin in cauliflower and quercetin and apigenin in kailan. Cauliflower contains high content of carotenoids, ascorbic acid, dietary fiber, foliate and water but low amount of fat and carbohydrate. While cauliflower is chopped or chewed, a compound named sulforaphane, released which might provide protection against cancer (Chavan UD *et al.* 2013).

Indole-3-carbinol, a component is having chemoprotective effect reported in mouse models of colon cancer (Avci A *et al.* 2010). When cruciferous vegetables are cooked or boiled in water for at least 9 to 15 minutes resulted in decrease in 18 to 59 per cent of total glucosinolate (water soluble compound) content (McNaughton SA *et al.* 2003). Microwaving and steaming in which less amount of water is used help to reduce the losses of glucosinolate in water but in contrast, can inactivate the enzyme myrosinase which catalyzes hydrolysis of glucosinolate at high power i.e. 850 to 900 watts. In addition, it declines the bioavailability of isothiocyanates among humans (Conaway CC *et al.* 2000).

In a crossover design, the metabolic fate of glucosinolates was compared after ingestion of 200 g of steamed and fresh broccoli among 12 male subjects. No glucosinolates or isothiocyanates containing foods were allowed for 48 hour baseline period. During the 24 hour period, collected blood and urine samples were analysed for total isothiocyanate equivalents using high-performance liquid chromatography (HPLC) as the cyclo-condensation product of 1, 2-benzenedithiol. After giving the myrosinase treatment, the amount of isothiocyanates in fresh and steamed broccoli was found to be 1.1 and 1.0 mmol/g. The excretion of isothiocyanate equivalents in urine was 32.3 ± 12.7 per cent during 24 hour and the amounts of fresh and steamed broccoli ingested were 10.2 ± 5.9 per cent. Total isothiocyanates equivalents and sulforaphane excretion in urine occurred primarily between 2 and 12 hours whereas, in plasma, total isothiocyanates metabolites peaked between 0 and 8

hours. Furthermore, from fresh broccoli, the bioavailability of isothiocyanates is three times greater than that from cooked broccoli, in which myrosinase is inactivated (Conaway CC *et al.* 2000).

Diet pattern of 40,684 Spanish adults (both men and women) aged 35-64 years was recorded using dietary history method while, calculation of intake of glucosinolate was measured using published food composition database. The mean daily intake of cruciferous vegetables was 11.3 g (5 % of total vegetable consumption). The results indicated that the total intake of glucosinolates was higher among men (6.8mg/day) as compared to women (6.2 mg/day), while glucosinolate density per energy unit was higher among women's diet (3.4mg/4200 kJ) than men (2.7 mg/4200 kJ). Further, average daily consumption of glucosinolates was 36 per cent more in Northern regions (7.3 mg) as compared to Southern regions (5.4 mg). A significant positive correlation was found between glucosinolate intake and body mass index, educational level and physical activity whereas an inverse association with alcohol consumption. In contrast, daily intake pattern of cruciferous vegetables and glucosinolates was relatively low in Europe and in turn is also lower than North America and several Asian populations (Agudo A 2008).

Cabbage belongs to family Brassicaceae or cruciferae. Sometimes, tastes bitter or sharp and only the leafy head part of the plant is usually eatable. The cultivated cabbage also called wild cabbage and sea cabbage, known by the ancient Romans and Greeks. It is an excellent source of vitamin C and a good source of riboflavin. It is having anti-inflammatory properties due to the presence of significant amounts of an amino acid glutamine and its leaves are useful to treat severe inflammation in European folk medicine. For example, in cabbage leaf, a paste of raw cabbage was wrapped and applied to the affected

area which helped reduce discomfort and also found effective for breastfeeding women in relieving painfully engorged breasts. Rapid healing of peptic ulcers is also possible with the fresh cabbage juice reported (Chavan UD *et al.* 2013). A study conducted on 12 healthy human volunteer subjects provided raw and microwaved cabbage along with watercress juice which is rich in phenethyl isothiocyanate at 48 hour intervals. After every meal, the volume and time of each urination was recorded for a period of 24 hours. The results revealed that with the intake of raw cabbage, allyl isothiocyanate was rapidly excreted while lesser and delayed excretion for microwaved cabbage was observed (Rouzaud G *et al.* 2004).

Cabbage may also act as goitrogen and blocks organification in thyroid cells, hence inhibiting the thyroid hormones production such as thyroxine and triiodothyronine (Chavan UD *et al.* 2013). Remarkably more incidence of thyroid cancer was found in New Caledonia, particularly among Melanesian women. To clarify this, comparison of about 293 Caledonian women of multiethnic population with 354 subjects treated as control. Among women, high incidence of thyroid cancer was observed with high consumption of cruciferous vegetables and low iodine intake (Truong T *et al.* 2010).

Conclusion

Phytonutrients present in citrus fruits have therapeutic and dietetic properties. Vitamin C also helps to reduce the duration of cold symptoms. Cruciferous vegetables are a rich source of glucosinolates and indoles and isothiocyanates. There is association between higher intake of cruciferous vegetables and lower risk of various types of cancers. It concluded that antioxidants present in citrus fruits and cruciferous vegetables acts as boon for immunity.

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