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Fruits and vegetables: Nature's gift to obtain better health through antioxidants

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Fruits and vegetables contain different nutrients and other components which help in maintaining healthy body. These components possess antioxidant activity. In recent times natural antioxidants have raised considerable interest among nutritionists, food manufacturers and consumers because of their presumed safety and potential therapeutic value. Dietary antioxidants, such as water-soluble vitamin C and phenolic compounds, as well as lipid-soluble vitamin E and carotenoids, present in vegetables contribute both to the first and second defence lines against oxidative stress. As a result, they protect cells against oxidative damage, and may therefore prevent chronic diseases, such as cancer, cardio-vascular disease, and diabetes. Naturally occurring antioxidants are capable of inhibiting the ill effects of free radical damage to human body system, but their consumption also boost the body's endogenous antioxidant mechanism to combat oxidative stress. Natural ingredients in food are considered safer option than synthetic additives. This review paper presents different natural antioxidants present in fruits and vegetables.

Key Words : Fruits, Vegetables, Antioxidants

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INTRODUCTION

Bio gerontologist Denham Harman was the first to discover the concept of free radicals in 1954, while researching an explanation for aging (Beckman and Ames 1998). Free radicals are a type of a highly reactive metabolite that is naturally produced by body as a result of normal metabolism and energy production. They are natural biological response to environmental toxins like cigarette smoke, sunlight, chemicals, cosmic and manmade radiation, and are even a key feature of pharmaceutical drugs (Gosslau and Chen, 2004).

Antioxidants are a class of molecules that are capable of inhibiting the oxidation of another molecule. Body naturally circulates various nutrients in blood due to their antioxidant properties. It also manufactures antioxidant enzymes in order to control free radical chain reactions. Some antioxidants are produced by body, but some are not. In addition, body's natural antioxidant production can decline with age. Body also produces free radicals when exercise or due to inflammation anywhere in body. Free radicals tend to collect in cell membranes (lipid peroxidation), which makes the cell lipids prone to oxidative damage. When this happens, the cell membrane becomes brittle and leaky, causing the cell to eventually fall apart and die. If body does not get adequate protection, free radicals can become rampant, causing cells to perform poorly. This can lead to tissue degradation and put at risk of diseases.

These beneficial effects have been partly attributed to the compounds which possess antioxidant activity. The major antioxidants of vegetables are vitamins C and E, carotenoids and phenolic compounds, especially

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flavonoids. These antioxidants scavenge radicals and inhibit the chain initiation or break the chain propagation (the second defence line). Vitamin E and carotenoids also contribute to the first defence line against oxidative stress, because they quench singlet oxygen (Krinsky, 2001).

Vitamin C:

Vitamin C, which includes ascorbic acid and its oxidation product—dehydro ascorbic acid, has many biological activities inhuman body. Block*et al.* (2004) have found that vitamin C can reduce levels of C-reactive protein (CRP), a marker of inflammation and possibly a predictor of heart disease. More than 85 per cent of vitamin C in human diets is supplied by fruits and vegetables (Table 1). Biological function of L-ascorbic acid can be defined as an enzyme cofactor, a radical scavenger, and as a donor/acceptor in electron transport at the plasma membrane. Ascorbic acid is able to scavenge the superoxide and hydroxyl radicals, as well as regenerate α-tocopherol (Davey *et al.*, 2000). Vitamin C levels varied over a 4-fold in broccoli and cauliflower, 2.5-fold in Brussels sprouts and white cabbage, and twice in kale. The cause of reported variations in vitamin C content might be related to the differences in genotype (Vallejo *et al.*, 2002). Climatic conditions also might alter vitamin C level (Howard *et al.*, 1999 and Singh and Kumari, 2015). In nine cohort studies (221,080 participants, 5007 events) showed that 4 per cent reduction in coronary heart disease risk for each portion of vegetables consumed (Dauchet *et al.*, 2006). This rose to a 7 per cent reduction in risk for portions of fruit alone. The authors also observed marked reductions in cardio-vascular mortality and myocardial infarction, the reduction in risk may be due to increased vitamin C intake. Boekholdt*et al.* (2006) found that higher plasma vitamin C is associated with lower risk of coronary artery disease (CAD).

Carotenoids:

Carotenoids (carotens and xanthophylls) are yellow, orange, and red pigments present in many fruits and vegetables. Several of them are precursors of vitamin A (*i.e.* β-carotene, γ-carotene, and β-cryptoxanthin), and due to conjugated double bonds they are both radical scavengers and quenchers of singlet oxygen. Lower serum β-carotene levels have been linked to higher rates of cancer and cardio-vascular diseases, as well as to increased risk of myocardial infarction among smokers (Rice-Evans *et al.*, 1997). In the Hiroshima Nagasaki prospective life span study (38,540 men and women), daily fruit consumption was associated with a 12 per cent reduction in total cancer mortality compared to consumption once a week or less (RR = 0.88 (95% CI = 0.80–0.96)). Data from Sauvaget *et al.* (2003) specifically linked consumption of green and yellow vegetables with a 0.75 relative risk (95% CI = 0.60–0.95) of liver cancer and fruit intake with a 0.80 relative risk (95% CI

Table 1 : Comparison of total antioxidant, ascorbic acid and total phenolic content of commonly consumed whole fruit and vegetables and fresh juices (Wootton-Bread and Ryan, 2011)

Fruit	TAC using FRAP method		Total ascorbic acid content		Phenolic content (Folin)	
	Whole fruit (μmol/ kg)	Fresh juice (μmol L)	Whole fruit (mg /g fw)	Fresh juice (mg/ml fw)	Whole fruit (mg /g fw)	Fresh juice (mg /ml fw)
Orange	9420	4700–5828	0.53	0.5	2.8	0.5
Apple	4200–6300	2536–9946	0.05	0.009	2.1	0.34
Grapefruit	8080	7268–7668	0.33	0.38	1.6	0.53
Pineapple	3480	5689–8576	0.48	0.1	1.5	0.36
Cranberry	32,900	6733–7582	0.13	0.09	3.15	1.7
Pomegranate	19,400	8557–10,232	0.06	< 0.0001		2.3
Red grape	4160	5653–6697	0.11	0.001	1.8	0.68
Blueberry	18,500	4200	0.1		6.6	2.3
Mango	5060		0.28		1.4	
Strawberry	15,940	4300	0.59		2.9	
Blackcurrant	5490		1.81		8.2	1.2
Cherry	3500	3400	0.07		1.7	2.1
Tomato	1600	1843–3104	0.13	0.18	0.45	
Beetroot	16,800	8355–9500	0.04		1.6	0.53
Carrot	600	1369–1533	0.06	0.08	0.57	0.26

= 0.65–0.98) of stomach and lung cancer. Green and yellow vegetables are good sources of the carotenoid β-cryptoxanthin which has been proposed to have protective effects, particularly against lung cancer (Yuan *et al.*, 2003). In the Singapore Chinese health study of 63,257 men and women, and showed that participants in the highest quintile of total crypto xanthin intake had a relative risk of lung cancer of 0.73 (95% CI = 0.54–0.98) compared to the lowest quintile which decreased further to 0.63 (95% CI = 0.41–0.99) if they were smokers. Additionally, lycopene has been shown to decrease the relative risk of prostate and digestive tract cancers in large prospective studies (Gann *et al.*, 1999) and it has been observed that high plasma concentrations of lycopene decrease biomarkers of oxidation in prostate cancer patients in case–control studies (Rao *et al.*, 1999). Other studies, including a meta analysis of 16 case–control studies revealed a 49 per cent reduction in the incidence of oral cancers for each portion of fruit consumed per day (odds ratio (OR) = 0.51 (95% CI = 0.40–0.65) based on pooled data from 65,802 subjects and a 50 per cent reduction for each portion of vegetables (OR = 0.50 (95% CI = 0.38–0.65) from data for 57,993 subjects (Pavia *et al.*, 2006). Cruciferous vegetables, in particular, have been shown to significantly decrease the risk of bladder cancer in a cohort of males from the health professionals' follow up study. The highest intake of cruciferous vegetables resulted in a relative risk of 0.49 (95% CI = 0.32–0.75) compared with the lowest intake (Michaud *et al.*, 1999).

Vitamin E:

In addition to carotenoids, vitamin E also belongs to a group of lipid-soluble antioxidants. The biological activity of vitamin E exhibit tocopherols and tocotrienols, especially α-tocopherol. The predominant reaction responsible for tocopherol antioxidant activity is hydrogen atom donation, where a tocopheroxyl radical is formed (Lampi *et al.*, 2002). Vitamin E shows protective effects against the coronary heart disease due to inhibition of LDL oxidation (Stampfer and Rimm, 1995). Although vegetables in addition to fats, oils and cereal grains, constitute the major source of vitamin E in our diet, there are only few data of tocopherol content in vegetables. The descending order of total tocopherols and tocotrienols in Brassica vegetables is as follows: broccoli (0.82 mg/100 g)>Brussels sprouts (0.40 mg/100 g)>cauliflower (0.35 mg/100 g)>chinese cabbage (0.24 mg/100 g)>red cabbage (0.05 mg/100 g)>white cabbage (0.04 mg/100 g) (Piironen *et al.*, 1986). Kurilich *et al.* (1999) have also reported similar rank on the basis of concentration, but in their study total tocopherol values were about 2-fold higher. These differences are probably caused by the differing varieties and growing conditions. According to these authors, kale was the best source of α-tocopherol and γ-tocopherol (2.15 mg/100 g). Piironen *et al.* (1986) reported that α-tocopherol was predominant tocopherol in all Brassica vegetables, except in cauliflower, containing predominantly γ-tocopherol. In contrast, Kurilich *et al.* (1999) reported lower concentration of γ-tocopherol than α-tocopherol in cauliflower. Stephens *et al.* (1996) showed a significant reduction in cardio-vascular events in the Cambridge antioxidant study following α-tocopherol supplementation. Furthermore, a significant reduction in intima-media arterial thickness following acute supplementation with vitamin C and α-tocopherol in hyper-cholesterolaemic patients was observed by Salonen *et al.* (2003), and an inverse relationship between atherosclerosis and fruit and berry consumption was observed by Ellingsen *et al.* (2008).

Phenolic compounds:

Phenolic compounds are a large group of the secondary metabolites widespread in plant kingdom. They are categorized into classes depending on their structure and subcategorized within each class according to the number and position of hydroxyl group and the presence of other substituents. The most widespread and diverse group of the polyphenols are the flavonoids which are built upon C_6–C_3–C_6 flavone skeleton. In addition, other phenolic compounds such as benzoic acid orcinnamic acid derivatives have been identified in fruits and vegetables (Aherne and O'Brien, 2002). Phenolic compounds, especially flavonoids, possess different biological activities, but the most important are antioxidant activity, capillary protective effect, and inhibitory effect elicited in various stages of tumour. Phenolics are able to scavenge reactive oxygen species due to their electron donating properties. Their antioxidant effectiveness depends on the stability in different systems, as well as number and location of hydroxyl groups. In many *in vitro* studies, phenolic compounds demonstrated higher antioxidant activity than antioxidant vitamins and carotenoids (Re *et al.*, 1999).

Studies in animal brain models have reported deleterious effects of ROS in the length of neuronal survival and neurotransmission (Maneesub *et al.*, 1993). Following this, several studies have demonstrated positive effects of supplementary polyphenols on cognitive function in animal models (Xu *et al.*, 2010). A number of recent human studies have focussed on the effects of polyphenols, in particular, dietary flavanols on cognitive function. Recent reviews of the link between cognitive impairment and dietary flavanols (polyphenolic compounds) have generally concluded that flavanols can delay the onset of neurodegenerative diseases although further *in vivo* research is required (http://www.sciencedirect.com/science/article/pii/S0963996911005461 - ref_bb0650 Singh *et al.*, 2008). Red pigmentation of red cabbage is caused by anthocyanins, which belong to flavonoids. Red cabbage contains more than 15 different anthocyanins which are acylglycosides of cyaniding (Dyrby *et al.*, 2001). Total anthocyanins content in red cabbage was 25 mg/100 g (Wang *et al.*, 1997) or 44.4–51.2 mg/100 g for anthocyanidins released after acid hydrolysis (Franke *et al.*, 2004). The richest sources of polyphenols in the diet are fruits, vegetables and beverages (Table 1). Some plants may contain several different polyphenols from various classes. Roughly one third of the total amount of polyphenols in an average human diet comes from the phenolic acid group, mostly coffee and tea, but also blueberries, cranberries, raspberries, strawberries, pomegranate juice, lettuce and spinach. Tannins are present in grapes, wine, tea, coffee, lentils and walnuts. Blueberries, grapes and wine are also contain stilbenes; and the culinary spice turmeric is the only known source of diferuloylmethanes. However, the major sources of polyphenols in the average diet are flavonoids.

Conclusion:

Sufficient evidence exists that an increase in fruit and vegetable consumption can contribute significantly to good health. The specific contributions of antioxidant compounds to heaIth are yet to be fully elucidated *in vivo* although promising evidence still exists *in vitro* and many bioactive phytochemicals may have positive non-antioxidant effects. Indian Council of Medical Research have recommended that 400 g of fruits and vegetables per day to protect against certain chronic disorders. Such a level of intake of fruits and vegetables also provides some of the vitamins, *viz.*, vitamin A, vitamin E, etc. at higher than RDA levels which can deliver natural antioxidants and other bioactive phytochemicals, and may offer a convenient method of consumption and contribute significantly level of antioxidants.

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