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ANTIOXIDANT PROFILE OF COMMONLY CONSUMED FRUITS AND VEGETABLES IN INDIA

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Abstract

Vitamin C, β carotene and phenolics constitute the major class of antioxidants in fruits and vegetables which protect cell against oxidative damage and prevent humans from degenerative diseases. Antioxidants profile in terms of content and capacity in each 10 commonly consumed fruits and green leafy vegetables (GLV) using phenolics, flavonoids, FRAP, DPPH radical scavenging activity, vitamin C and β carotene analysis were determined. Among fruits aonla had the highest total phenolics (1654 mg GAE/100 g), total flavonoids (512.49 mgRE/100 g), FRAP (23055 mgTE/100 g), DPPH radical scavenging activity (6322.36 mgRE/100 g) and vitamin C (401 mg/100g) followed by grapes, *Ziziphus* and guava. Mango contained exceptionally high (2210.99 µg/100 g) amount of β- carotene whereas papaya contained 630.48 µg/100 g. Among GLVs mint leaves, curry leaves and *Chinopodium* leaves had been an excellent source of antioxidants. Regular consumption of GLVs and fruits can protect from degenerative diseases and aging and may provide longevity.

Introduction

Quenching free radicals and reactive oxygen species has been known as a mode of operation of plants foods in the prevention or treatment of degenerative diseases like arthritis, diabetes, cancer, atherosclerosis, alzheimer's, osteoporosis, cataract, aging etc.(Subhasree *et al*. 2009).Vitamin C, β carotene and phenolics constitute the major class of antioxidants in fruits and vegetables which protect cell constituents against oxidative damage by acting directly on reactive oxygen species or by stimulating endogenous antioxidants enzymes (Scalbert *et al*. 2005). Phenolic acids are non-flavonoid polyphenolic compounds which can be further classified as benzoic acid and cinnamic acid based on the derivatives position on carbon skeleton (Tsao 2010). Phenolics, however have been considered the major bioactive component in fruits and vegetables bearing strong antioxidant and anti-proliferative activities. Approximately one fourth of the total phenolics mainly in bran and hull of grains and seeds have been found in bound form, and that is why it has been underestimated in plant foods. However, in fruits and vegetables most of it is available in free from (Chandrasekara and Shahidi 2010).

Flavonoids have C6–C3–C6 general carbon skeletonwhere two C6 units are of phenolic nature and due to the hydroxylation sequencing in the chromane ring (C3), flavonoids can be further classified as flavanones, flavan-3-ols, anthocyanins, flavones and flavonols(Tsao 2010).Fruits and green leafy vegetables have been known as an excellent source of vitamin C, β carotene, phenolics and flavonoids. The 2011 Dietary Guidelines for Indian recommend that majority of the Indian population (adolescents and adults) should eat at least 500 g of vegetables and fruits everyday (NIN 2011). However, National survey conducted by National Nutrition Monitoring Bureau (NNMB 2006) showed a huge gap between recommended and per capita consumption level of fruits and vegetables.

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Profiling commonly consumed fruits and vegetables on the basis of their antioxidants activity will provide a simple guide to the consumers to choose them judiciously. No doubts, irrespective of races people are obsessed worldwide to feel younger and live longer, and antioxidantin a natural way is the key for that. Thus the present study was aimed to analyse the antioxidant content as per total phenolics and flavonoids and antioxidants capacity as per 2,2-diphenyl-1-picrylhydrazyl (DPPH) and Ferric Reducing Antioxidant Power (FRAP) in commonly consumed fruits and vegetables.

Material and Methods

The samples of 10 selected green leafy vegetables (GLV) and 10 selected fruits were purchased from local market of Hisar city. Samples of individual GLV were washed with tap water and rinsed thoroughly to remove dirt and dust. Damaged leaves and yellow colored leaves were discarded. Leaves were pat dried by spreading on filter paper and edible parts were separated and chopped. Samples of fruits were thoroughly washed and dried using muslin cloth by rubbing with hands. Apple, papaya and mango were peeled and the inedible parts and seeds were removed and edible parts were cut into uniform pieces. Rind, seeds and skin of orange were removed. Banana was peeled while aonla (*Emblica officinalis* Gaertn.) and *Ziziphus* (locally known as *ber*) were deseeded and cut into uniform pieces. Grapes were used as a whole. Pomegranates were deseeded and then only seeds were used for extraction.The concentration of total phenolics of the 80% methanolic extracts was determined by the Folin–Ciocalteau colorimetric method (Singleton *et al*. 1999). The phenolics present in plant extract reacted with specific redox reagent (Folin–Ciocalteau reagent) to form blue chromophore constituted by a phosphotungstic phospho-molybdenum complex which was measured at 750 nm. The amount of flavonoids in methanolic extracts was determined by aluminium chloride colorimetric method (Zhishen *et al*. 1999). The natural flavonoids compounds present in the sample extracts reacts with sodium nitrite; the pink colored flavonoids-aluminium complex developed using aluminium chloride in alkaline condition which was measured by spectrophotometer at 510 nm.

Total antioxidant capacity of the methanolic extracts was determined by using FRAP Assay (Benzie and Strain1996) and modified by (Tadhani *et al*. 2009). The antioxidant activity of the extracts, on the basis of the scavenging activity of the stable DPPH) free radical, was determined by the method followed by Brand-Williams *et al.* (1995) as previously described by Tadhani *et al*. (2009).Vitamin C was estimated using titration method and β-carotene was estimated using column chromatography method given by AOAC (2010). The statistical analysis of data was performed using the software package for social sciences (SPSS, version 20). To analyse the differences between 10 different fruits and vegetables data were analyzed using analysis of variance (ANOVA). Significant differences were considered at $p < 0.05$. Data were expressed in the tables as mean ± standard errors. Least significant difference test was applied to evaluate the difference between means at 95% confidence interval.

Results and Discussion

Results presented in Table 1 showed that curry leaves were packed with the maximum amounts of total phenolics followed by mint leaves while spinach had the lowest. Total phenolics content among C*hinopodium,* locally known as *bathua*, amaranth, coriander and chickpea leaves did not differed significantly.Total flavonoids were found maximum in mint leaves followed by curry leaves, both the leaves had wonderful amount of total flavonoids. Among the studied GLV spinach was observed as a poor source of phenolics as well as flavonoids. Results of present study are in close agreement of earlier finding of Naveena *et al*. (2016) who also observed the maximum content of phenolics in mint leaves. Vitamin C content of GLV ranged from 39.46 to 148.07 mg/100 g being the highest in coriander leaves and the lowest in spinach (Fig. 1a). Further, results indicated that GLV contained very good amounts of β- carotene ranging from 2053.33 to 4625.33 µg/100 g being the highest in curry leaves and the lowest in mint leaves (Fig. 1b). GLV have been an excellent source of both the vitamin C and β carotene. As per the results, 100 g of spinach which contained least amount of vitamin C has a potential to satisfy more than half of the daily requirement of vitamin C and same in case of mint leaves which contained least β carotene which can meet more than the half of the daily requirement. Mint leaves had the highest ferric reducing

Table 1. Total phenolics, flavonoids and antioxidant activity of green leafy vegetables.

Green leafy vegetables (GLV)	Total phenols (mgGAE/100 g)	Flavonoids (mgRE/100 g)	FRAP (mgTE/100 g)	DPPH (mgTE/100 g)
Spinach	39.90 ± 1.57^{g}	26.09 ± 0.95^{g}	175.92 ± 0.87^{f}	15.26 ± 0.16^{f}
Mint	531.44 ± 13.7^{b}	238.42 ± 4.63^{a}	2053.75 ± 14.2^{a}	143.68 ± 1.04^{a}
Chinopodium	144.44 ± 3.09^{c}	96.15 ± 2.22^{c}	360.19 ± 1.43^{e}	98.05 ± 0.85^{b}
Mustard	67.59 ± 1.23^{e}	58.79 ± 0.92^{ef}	616.66 ± 2.75^{c}	25.24 ± 0.12^{e}
Fenugreek	57.86 ± 0.93^{eg}	50.00 ± 0.55^{f}	210.54 ± 0.86^{e}	10.89 ± 0.03^{f}
Amaranth	142.77 ± 2.42^{c}	56.01 ± 2.01^{ef}	131.03 ± 1.27^{f}	62.53 ± 1.70^{c}
Chickpea	121.25 ± 1.25^{cd}	69.44 ± 1.20^{e}	361.25 ± 1.48^{e}	44.07 ± 0.43^{d}
Coriander	127.32 ± 1.97^{c}	77.35 ± 1.71^{d}	439.78 ± 1.07^{d}	45.76 ± 0.67^{d}
Curry	733.09 ± 5.47^{a}	187.22 ± 3.38^{b}	776.04 ± 13.7^{b}	57.65 ± 1.89^{c}
Radish	98.29 ± 1.13^{cd}	61.11 ± 1.86^{ef}	573.95 ± 5.51^{c}	45.19 ± 0.26^{d}

Values are mean ± SE of three independent determinations. Means with different superscripts indicate significant difference ($p \leq 0.05$).

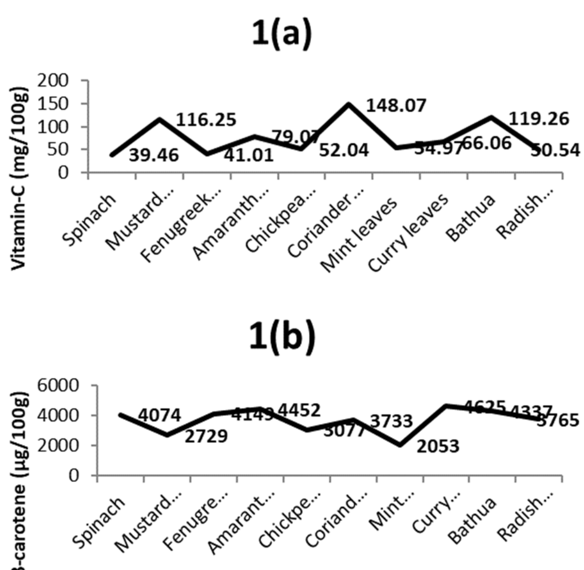

Fig. 1. Vitamin C (a)and β carotene (b) contents of commonly consumed GLV.

antioxidant power (FRAP) as well as DPPH radical scavenging activity (Table 1) followed by curry leaves in case of FRAP and *Chinopodium* leaves in case of DPPH. FRAP did not differed significantly among mustard, amaranth, radish and fenugreek leaves. The lowest FRAP was observed for amaranth leaves whereas the lowest DPPH radical scavenging activity was observed for fenugreek leaves. DPPH radical scavenging activity did not differed significant among chickpea, radish and coriander leaves.

Among fruits aonla had the highest total phenolics (1654 mg GAE/100g), total flavonoids (512.49 mg RE/100g), FRAP (23055 mg TE/100g), radical scavenging activity (6322.36 mg RE/100 g) (Table 2) and vitamin C (401 mg/100g) (Fig. 2a). Next to aonla, grapes had been an excellent source of FRAP, DPPH and flavonoids by having 1057.33mg TE/100 g, 4646.73 mgRE/100 g and 111.46 mg RE/100 g, respectively. *Ziziphus* followed by guava was next to

Table 2. Total phenolics, flavonoids and antioxidant activity of fruits.

Fruits	Total phenols (mgGAE/100 g)	Flavonoids (mgRE/100 g)	FRAP (mgTE/100 g)	DPPH (mgTE/100 g)
Apple	98.71 ± 1.96^{d}	49.37 ± 1.14^{d}	466.66 ± 1.82^{f}	89.78 ± 0.63^{cd}
Guava	153.89 ± 2.42^{c}	112.39 ± 1.86^{b}	583.33 ± 3.75^{e}	162.21 ± 0.47^{c}
Banana	31.76 ± 0.87^{e}	28.23 ± 0.46^{de}	150.84 ± 1.15^{g}	34.13 ± 0.19^{d}
Orange	49.68 ± 1.37^{e}	46.75 ± 0.92^{d}	594.00 ± 5.85^{e}	99.51 ± 0.48^{c}
Ziziphus	254.62 ± 4.62^{b}	71.38 ± 0.55^{c}	910.44 ± 2.98^{c}	150.91 ± 0.47^{c}
Mango	50.40 ± 1.21^{e}	32.22 ± 0.56^{d}	57.82 ± 1.10^{h}	4659.0 ± 6.00^{b}
Papaya	96.15 ± 1.95^{d}	10.68 ± 0.47^{e}	140.83 ± 1.26^{g}	$23.48 \pm 0.26d^{e}$
Pomegranate	91.02 ± 1.28^{d}	76.94 ± 1.20^{c}	753.12 ± 3.60^{d}	95.74 ± 0.94^{cd}
Grapes	142.14 ± 2.74^{c}	111.46 ± 3.88^{b}	1057.33 ± 9.82^{b}	4646.73 ± 16.20^{b}
Aonla	1654.00 ± 14.97^{a}	512.49 ± 4.81^{a}	23055 ± 20.00^{a}	6322.36 ± 28.67^{a}

Values are mean ± SE of three independent determinations.Means with different superscripts indicate significant difference ($p \leq 0.05$).

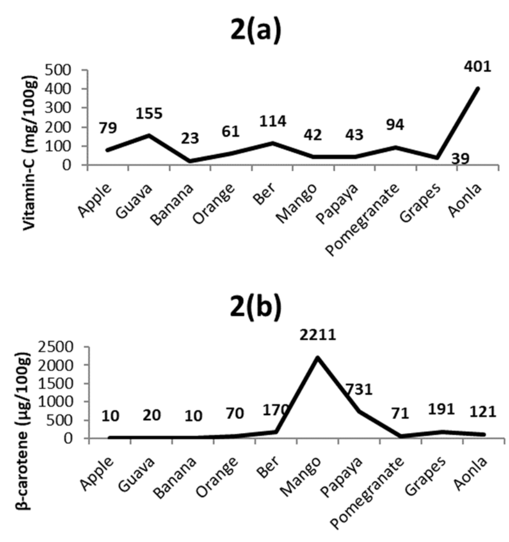

Fig. 2. Vitamin C (a) and β carotene (b) contents of commonly consumed fruits.

grapes in having excellent overall antioxidants profile including vitamin C. Mango contained maximum (2210.99 µg/100 g) content of β carotene followed by papaya (Fig. 2a) and also exhibited excellent radical scavenging activity (4659 mg RE/100 g). Overall results showed that fruits had higher contents as well as capacities of antioxidants than green leafy vegetables except β carotene which was found to be higher in GLV.A wide variation was observed in the contents and capacities of antioxidants among tested GLV (Kaur and Sharma 2014, Venkatachalam *et al*. 2014, Pritwani and Mathur 2017) and fruits (Lim *et al*. 2007, Patel and Patel 2016) worldwide, that might be due to different environmental condition i.e. sun exposure, soil type and rainfall and varied agronomic condition like biological culture, culture in greenhouses or fields, hydroponic culture, etc. Further, light and heat exposure, storage conditions, methods of culinary preparation may have considerable effect on antioxidants contents and capacities (Naveena *et al*. 2016). Further, variations may be attributed to the differences in the extraction solvent type, treatment, and concentration extraction methods, experimental methodology etc. (Hiba *et al*. 2019)

Similar to the reported results of Hiba *et al*. (2019) and Kaur and Mondal (2014) no correlation was observed between the antioxidant contents measured by total phenolics, flavonoids, vitamin C and β**-** carotene and antioxidant capacity as because the antioxidant capacity is not merely due to these contents. Exploring an equation between antioxidants contents and capacities is quite challenging as within biological systems there are a number of endogenous antioxidant enzymes, large molecules such as albumin, ceruloplasmin, ferritin and other proteins, small molecules such as ascorbic acid, glutathione, uric acid, tocopherol, carotenoids, polyphenols, and some hormones like estrogen, angiotensin, melatonin act in a complex manner (Naveena *et al*.2016).

It may be concluded that among commonly consumed green leafy vegetables and fruits mint leaves, curry leaves, *Chinopodium* leaves and aonla, grapes, *Ziziphus* and guava had excellent antioxidants profile. Consuming 50 g of guava or *Ziziphus* or 20 g of aonla can meet the daily recommended doses of vitamin C and consuming 50 g of spinach or amaranth or *Chinopodium* or curry leave can meet the daily recommended doses of β carotene. Regular consumption of these GLVs and fruits can protect humans from degenerative diseases and aging and may provide them longevity.

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