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ASCORBIC ACID CONTENTS OF PAKISTANI FRUITS AND VEGETABLES

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ABSTRACT

Fresh fruits and vegetables are good sources of vitamin C which is known for its antioxidant and immune-enhancing effects. The objective of this study was to determine ascorbic acid (vitamin C) contents of regularly consumed fruits and vegetables available in Pakistani markets. Most commonly used fresh fruits and vegetables were homogenized in 5% trichloroacetic acid, and ascorbic acid contents in the extracts were determined using a spectrophotometric method. Banana, custard apple, orange, lemon, guava and papaya were found to be very rich in ascorbic acid. Among vegetables, capsicum (green sweet pepper), cauliflower, bittergourd, roundgourd, beetroot, spinach, cabbage and radish contained high concentrations of ascorbic acid. Chikoo, grapes, pear, apricot, peach, carrot, cucumber, lettuce and "kakri" were found to be poor sources of ascorbic acid. Several Pakistani fruits and vegetables (pear, melon, onion, sweet green pepper, spinach, cucumber) had ascorbic acid values similar to those reported by US Department of Agriculture in these fruits and vegetables in USA. However, wide differences in vitamin C contents were also observed in certain other fruits and vegetables from these two countries. This indicates that regional varieties of fruits and vegetables could vary in their ascorbic acid contents. Since subclinical deficiency of vitamin C appears to be quite common in developing countries like Pakistan, there is a need to develop awareness among masses to consume fresh fruits and vegetables with high contents of vitamin C.

Keywords: Ascorbic acid, fruits, Pakistan, vegetables, vitamin C.

INTRODUCTION

Consumption of fruits and vegetables in diet protects the human body from chronic illnesses (Willet, 1994; Heber, 2004). This has mostly been attributed to the anti-oxidant and anti-proliferative effects of various phytochemicals present in high amounts in vegetables and fruits (Proteggente *et al.,* 2002; Chu *et al.,* 2002; Sun *et al.,* 2002). Vitamin C (L-ascorbic acid) is a water-soluble vitamin, which is found in variable quantities in different fruits and vegetables (Davidson, 1974; USDA, 1998; Szeto *et al.,* 2002; Iqbal *et al.,* 2004). It has well documented anti-oxidant and immune-enhancing effects (Wintergerst *et al.,* 2005). A number of epidemiological studies have shown the protective and therapeutic effects of vitamin C in cardiovascular diseases (hypertension, heart disease and stroke) (Gey *et al.,* 1993; Duffy *et al.,* 1999; Gocke *et al.,* 1999; Kurl *et al.,* 2002), cancer (Block, 1991; Pudayatty *et al.,* 2000), cataract (Jacques, 1999), and lead toxicity (Simon and Hudes, 1999; Dawson *et al.,* 1999). Besides vitamin C is also required by the human body for growth and repair of tissues. It is necessary for collagen formation, which is involved in the building and maintenance of cartilage, joints, skin and blood vessels. The vitamin has also been shown to be essential for the healing of wounds (Levin, 1986; MacKay and Miller, 2003), and has been reported to be beneficial in common cold (Pauling, 1976; Hemilia, 1997) and aging brain (Masaki *et al.,* 2000). Vitamin C deficiency is quite common in developing countries and can lead to slow wound healing, gingivitis and bleeding gums, anemia, dry and scaly skin, easy bruises, epistaxis, dyspnea, fatigue, gastrointestinal problems, frequent infections, splitting hair, and arthritis (Fain, 2004; Khan and Iqbal, 2006). A more severe deficiency of vitamin C may lead to scurvy, which is more common in geriatric and malnourished populations (Braunwald *et al.,* 2001).

Fresh citrus fruits and green leafy vegetables are known to be a good source of vitamin C. Pakistan being an agricultural country is home to a wide variety of fruits and vegetables. The objective of this study was to determine the vitamin C contents of regularly consumed fruits and vegetables available in Pakistani markets.

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METHODS

Preparation of extract

Fresh fruits and vegetables of different varieties available in the market were obtained. Each one of these in a quantity of 2-3 grams was chopped into small pieces. Two to three ml of ice cold 5% trichloroacetic acid (TCA) was added to these pieces and the material was homogenized using a Potter-Elvehjem-type tissue grinder at 4°C. Insoluble debris was then pelleted by centrifugation at 30,000xg for 10 min at 4°C. The clear extract obtained was immediately subjected to analysis for L-ascorbic acid.

Procedure

A modification of a previous method (Zannoni *et al.*, 1974), as described in a recent publication from our laboratory (Mehboobali and Iqbal, 2005) was used to quantitate L-ascorbic acid. Briefly, a reaction mixture for standard curve in a total volume of 500 µl contained freshly prepared ascorbic acid (0.25 µg – 4 µg in a volume of 300 µl), 20 µl of 85% orthophosphoric acid, 160 µl of 1% α, ά-dipyridyl and 20µl of 3% ferric chloride. For reactions involving fruit/vegetable extract 10 µl to 300 µl of the acidified extract could be added in place of standard ascorbic acid, while for the blank reaction, 300 µl of 5% TCA was used in place of standard ascorbic acid or acidified extract. The final reaction volume in blank, standard and experimental reaction tubes was 500 µl. The tubes were mixed and incubated for 15 min at room temperature for color development. The absorbance in standard and experimental reactions was measured at 525 nm using 0.5 ml cuvette against the blank reaction in a DU-70 spectrometer (Beckman Instrument, Palo Alto, CA, USA).

A standard curve was obtained by plotting absorbance vs amount of ascorbic acid. The levels of ascorbic acid in the experimental (unknown) samples were obtained from this standard curve. The method is based on reduction of ferric ion by ascorbic acid into ferrous ion which is then coupled with α, ά dipyridyl (Zannoni *et al.*, 1974). The colored complex is detected spectrophotometrically at 525 nm.

RESULTS AND DISCUSSION

Table 1 and table 2 show the contents of ascorbic acid in Pakistani fruits and vegetables, respectively. Highest quantities of ascorbic acid were found in custard apple, banana, bittergourd, cauliflower, roundgourd, capsicum and cabbage. Chickoo, pear, grapes, carrot, kakri (a local variety of cucumber) and coriander contained small quantities of this vitamin.

To the best of our knowledge, this is the first study reporting ascorbic acid contents in Pakistani fruits and vegetables. Our analysis showed a significant difference in the ascorbic acid contents of different fruits and vegetables available in Karachi markets. Custard apple and banana were found to have the highest concentrations of vitamin C. Orange (both musambi and kinnow), guava, lemon, papaya and pomegranate, were also found to have good quantities of vitamin C. Among vegetables, bittergourd, cabbage, capsicum, cauliflower and beetroot can be considered good sources of vitamin C.

It should, however, be noted that these values are of fresh and mostly unpeeled fruits and vegetables. It is well known that vitamin C is easily lost during processing and cooking. The losses during cooking alone have been estimated to be about 35% (Agte *et al.*, 2002). Therefore, only raw, uncooked vegetables and fresh fruits are good sources of vitamin C.

Table 1: Ascorbic acid contents of Pakistani fruits

Food (Fruits)	Ascorbic acid (mg/100 gms)
Grapes	1.64
Peach	3.5
Apple	12
Pear	2.3
Banana	55.5
Papaya	21.6
Plum	10.2
Apricot	3.7
Guava	25.1
Melon	14.5
Custard apple	70.8
Pomegranate	17.4
Orange(Kinnow)*	12.7
Orange(Musambi)**	32.1
Lemon	28.7
Grape fruit	15.1
Mango Dosehri***	10.5
Anwaratol	15.5
Water melon	4.57
Chickoo	0.63
"Garma"****	13.3

*Kinnow is a hybrid of two citrus cultivars; "King" and "Willow Leaf" and is classified as kinnow mandarin. It is widely cultivated in Pakistan and is one of the most popular fruits in the country. ** Musambi is a sweet orange cultivar. ***Dosehri and Anwaratol are two varieties of mangoes in Pakistan. ****A regional variety of a large melon.

We compared our results with the existing data on vitamin C contents of fruits and vegetables in USA. According to the United States Department of Agriculture (USDA) database for standard references (USDA, 1998), the high concentrations of vitamin C have been found to be in guava (183 mg/100 gm), strawberry (57 mg/100 gm), grapefruit (38 mg/100 gm), melon-honey dew (18 mg/100 gm), green sweet pepper (80 mg/100 gm) cauliflower (46.9 mg/100 gm), lemon (52.9 mg/100 gm), cabbage (32.1 mg/100 gm) and spinach (28 mg/100 gm).

Our results also show high concentrations of ascorbic acid in guava (25.1 mg/100 gm), orange (Musambi 32.1 mg/100 gm), lemon (28.7 mg/100 gm), custard apple (70.8 mg/100 gm), pomegranate (17.4 mg/100 gm), grapefruit (15.1 mg/100 gm), and banana (55 mg/100 gm).

Similarly, in vegetables, green sweet pepper, cabbage and cauliflower have high levels of ascorbic acid both in USA and Pakistan. According to the USDA data onion (6.4 mg/100 gm), pear (3.8 mg/100 gm), carrot (5.8 mg/100 gm),

cucumber (3.2 mg/100 gm) were poor sources of vitamin C. Our data, too, indicate that these vegetables are not rich in ascorbic acid.

Table 2: Ascorbic acid contents of Pakistani vegetables

Food (Vegetables)	Ascorbic acid (mg/100 gms)
Potato	7.9
Ginger	4.0
Brinjal	6.8
Cucumber	4.7
Bittergourd	85
Roundguord	60.3
Spinach	33.8
Coriander	0.34
Green chili	12.9
Pea	9.4
Garlic	4.0
Tomato	9.6
Cabbage	51
Cauliflower	73.6
Lady finger	8.4
Radish	28.7
Beetroot	30.8
Onion	5.4
Carrot	1.9
Lettuce	5.0
Colocasia	12.5
Capsicum (green sweet pepper)	73.5
Turnip	20.2
"Kakri"*	2.3

*A local variety of cucumber.

While there was remarkable concordance in the values of ascorbic acid in onion, pear, cucumber, spinach, sweet green pepper and melon from USA and Pakistan, differences too were noticed in contents of vitamin C in other fruits and vegetables from these two countries. These differences are most probably due to different regional varieties of fruits and vegetables (Davidson, 1979). It has been reported that the amounts of vitamin could even vary between different samples of the same species (Davidson, 1979).

Subclinical vitamin C deficiency is being recognized increasingly in the general population. Restricted eating patterns, severe illnesses, poor dietary intake cause deficiency with significant clinical consequences (MacKay and Miller, 2003). A preliminary study recently carried out in our laboratory revealed that 65% of normal healthy Pakistani adults working at the Aga Khan University had plasma levels of ascorbic acid below 10 µg/ml (lower limit of normal plasma concentration of ascorbic acid) indicating that ascorbic acid status is low even among the Pakistanis belonging to the middle class socio-economic stratum of the society (Mehboobali and Iqbal, 2005). This problem, perhaps, would be more acute in people belonging to the lower socio-economic strata.

According to the revised guidelines by the Food and Nutrition Board of National Academy of Sciences, the recommended dietary allowance (RDA) for vitamin C has been proposed to be 120 mg/day (Levine *et al.*, 1999). Smokers, cancer patients and those with higher risk of developing coronary artery disease would, perhaps, require additional dietary and supplemental ascorbate (Banerjee *et al.*, 1998; Gey, 1998; Head, 1998). Vitamin C intake, whenever possible should come from fruits and vegetables and people should be encouraged to eat 5 servings of vegetables and fruits daily (Levine *et al.*, 1999). For those unable to or unwilling to consume fruits, vegetables, or vitamin C-fortified foods or beverages, a supplement containing 200 mg of vitamin C should be adequate (Levine *et al.*, 1999).

According to nutritionists, any food serving which provides 10-25% of the daily RDA of vitamin C in a low calorie intake is a 'good' source. A single food serving of a fruit or vegetable for an average healthy Pakistani adult can be an apple, an orange, a slice or two of papaya or melon, a small guava, or pieces of radish in salad. Considering this, custard apple and banana which are exceptionally good sources of vitamin C could provide adequate daily requirement of vitamin C in a single serving. Also musambi, guava, melon, papaya, mango and kinnow are good sources and additionally they are not very expensive, widely available and the most popular fruits in Pakistan.

It is a traditional advice to eat five servings of fruits and vegetables a day to keep one healthy and fit (Williams, 1995). Based on our findings, we can suggest that one or two of these servings must be a fruit or vegetable with high vitamin C content, for example guava, orange, banana, radish, or melon.

Further studies would be required to ascertain the losses in ascorbic acid contents in Pakistani fruits and vegetables during storage, transportation, processing, cooking etc. Keeping in view the possibility of high prevalence of vitamin C deficiency in our population, studies at the community level must be carried out to find out the extent of the problem in our country. An understanding of the factors contributing towards deficiency of vitamin C in our population would be of value to the scientific community in developing guidelines for healthy and balanced diet for masses in Pakistan.

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