

Nutritional evaluation and heavy metals content of selected tropical fruits in Bangladesh

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Abstract

Fruits and vegetables are highly valued in human diet as these contain micronutrients, fiber, potassium, vitamin C, which act as antioxidants within the body as well as bio-functional components. Physico-chemical properties, minerals, vitamin-C, minerals and trace elements and heavy metals content of eight tropical fruits {four different Banana varieties namely Bangla kola (*Musa spp.*), Chapa kola (*Musa spp.*), Sabri kola (*Musa spp.*), Sagor kola (*Musa oranta*) and four other varieties of local fruits namely Bullock's Heart (*Annona reticulata L.*), Lemon (*Citrus aurantifolia*), Indian Persimmon (*Diospyros malabarica*), Dragon fruit (*Hylocereus undatus*)} were determined according to standard methods to address the nutritional composition. Results of this study suggest that the selected tropical fruits are excellent source of vitamin C, one of the major natural antioxidant, trace minerals. Vitamin-C content was ranged from 10.00 ± 1.14 mg to 217.90 ± 3.01 mg/100 g of edible portion of fruits. Highest amount of copper and zinc was found in Chapa kola (*Musa spp.*), 0.25 ± 0.05 mg and 0.45 ± 0.08 mg respectively, maximum amount of iron and manganese was found in Bangla kola (*Musa spp.*), 0.61 ± 0.10 mg and 0.08 ± 0.06 mg per 100 g of edible portion of fruits respectively. Crude fiber content of selected fruits was ranged from 1.38 ± 0.09 g to 2.99 ± 0.10 g per 100 g of edible portion of fruits. These fruits were also good source of potassium, calcium and magnesium but poor source of protein and fat and sodium. Heavy metals were found in few fruit samples, but their concentration was lower than the safe level. As a conclusion, these tropical fruits could be potentially used in alleviating micronutrients deficiency especially for the rural populace as a potent source of natural antioxidants and at the same time people should avoid consuming contaminated fruits considering their hazardous aspects.

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Introduction

Consumption of fruits is essential for a diversified and nutritious diet. Sufficient consumption of fruits and vegetables provides both essential nutrients and compounds that provide other helpful physiological effects, not all of which are known. Increased consumption of fruit and vegetables significantly reduce the incidence of chronic diseases, such as cancer, cardiovascular diseases and other aging-related pathologies (Prakash *et al.*, 2012). The total fruit availability per person per day is 155 g which is much higher than the current consumption of 34 g per person per day in Bangladesh (Bhattacharjee *et al.*, 2007). Fruits offer protection against free radicals that damage lipids, proteins, and nucleic acids. Polyphenols, carotenoids (pro-vitamin A), vitamins C and E present in fruits have antioxidant and free radical scavenging activities and play a significant role in the prevention of many diseases (Prakash *et al.*, 2012).

A number of trace elements protect the cell from oxidative cell damage as these minerals are the cofactor of antioxidant enzymes. Zinc, copper and manganese are necessary for superoxide dismutases in both cytosol and mitochondria. Iron is a component of catalase, a hemeprotein, which catalyzes the decomposition of hydrogen peroxide (Machlin and Bendich, 1987). Small amounts of micronutrients (minerals and vitamins) are required for good physical condition along with energy food and protein. Sodium, potassium, iron, calcium and many trace elements together with antioxidant vitamins and minerals are vital for the body. Fruits and vegetables, particularly leafy, have noteworthy amounts of calcium, iron and potassium along with vitamins C (Bhattacharjee *et al.*, 2007).

Four common banana varieties were chosen because banana is the highest consumed fruit in Bangladesh and people of Bangladesh have a tendency to have it more than any other fruits in their breakfast menu. Peoples are not aware of the

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nutritional value of individual banana varieties. This study will help consumers to purchase banana varieties which have more nutritive value. Bullock's Heart, Lemon and Indian Persimmon are common local fruits and this study will help to make people aware about the nutritional value of cheapest local fruits. Dragon fruit is a popular staff in Bangladesh is cultivated from last few years. We know that this fruit is tasty and has nutritious values but we do not have the nutritional data for fruits that grown in Bangladesh.

Information about the composition of food is important for nutrition education, training and research (Darton, 1989). It is also necessary for dietary recommendation and supplementation of food. There is a worldwide call to develop a national food composition database. However, in our country the food composition tables presently used are almost forty years back and taken from other country, people of which have different culture, food habit, weather etc. (Haque *et al.*, 2009). Nutritional data of fruits in Bangladesh is not available (Darton, 1989). The objective of this study was to prepare new and updated nutritional information of tropical fruits of Bangladesh and also to magnitude the heavy metals contamination in fruits.

Materials and Methods

Sample collection

This experiment was carried out at Institute of Food Science and Technology, BCSIR, Dhaka. Eight types of fruit were analyzed in this study. These include Bangla kola (*Musa spp.*), Chapa kola (*Musa spp.*), Sabri kola (*Musa spp.*), Sagor kola (*Musa oranta*), Bullock's Heart (*Annona reticulata* L.), Lemon (*Citrus aurantifolia*), Indian Persimmon (*Diospyros malabarica*), Dragon fruit (*Hylocereus undatus*). The selected fruits were collected from different local markets in Dhaka city. Collected samples were fresh, matured, and free from insect's bites and other organoleptic deterioration.

Sample preparation

The freshly collected sample was washed with deionized water to eliminate visible dirt and removed the water quickly with a blotting paper. Then the sample was cut into small pieces, homogenized and accurate amount was weighed as required for different analysis. Five samples from each fruit were selected for measurement.

Determination of physico-chemical properties

The pH was determined with a digital pH meter and titratable acidity was estimated with the visual

acid-base method (Ranganna, 1986). Moisture content was determined by digital moisture analyzer. The total soluble solid (TSS) was determined with a hand refract-meter (Gofur, 1998). Crude fiber, total fat was determined by standard AOAC method (AOAC, 1990) and the estimation of total protein was made by the method of Ronald and Ronald (1991). The content of total carbohydrate and energy was determined by the method of Pearson (1976) and Osborn and Voogt (1978) respectively.

Determination of Vitamin-C and Trace Minerals

Vitamin C was determined by the method of Bessey and King (1933). Ash was determined by the process of Ranganna (1986). Sodium and potassium contents were determined by flame photometric method (Ward and Johnston, 1962). Zinc, copper, manganese, iron and phosphorus content were determined by standard AOAC method (AOAC, 2005). Calcium (Ronald and Ronald, 1991) and Magnesium (CHEM, 2008) were determined by titration process. Copper, Iron, Manganese, Zinc, Calcium, Magnesium, Chromium were determined by the technique of Kirk and Sawyer (1991).

Determination of heavy metals

Arsenic, Mercury, Cadmium and Lead were determined by Flame Atomic Absorption Spectrometric method (Kirk and Sawyer, 1991).

Statistical analysis

Statistical analyses were carried out by using Statistical Package for Social Science (SPSS) for Windows version 16.0. The results obtained in the present study are reported as mean values (obtained from the five replications) \pm standard deviation (SD). The significance differences between mean values were analyzed by Duncan multiple range test at a significance level of $p < 0.05$.

Results and Discussion

Five samples from each type of fruit were selected for measurement of physico-chemical properties, vitamin, trace-elements, minerals and heavy metals content. Each value represents the average from five replications and the outcomes expressed as mean values \pm standard deviations (SD). All the results were expressed as gram (g), percentage (%), kilocalorie (Kcal), milligram (mg) and microgram (μ g) per 100 g of edible portion of fruits.

Physico-chemical properties

Any systematic analysis of nutritional compositions of fruits and vegetable have not

Table 1. Edible portion, moisture content, pH, titratable acidity, total soluble solids (TSS), reducing sugar (RS) and total sugar (TS) content of selected fruit samples

| Physico-chemical Properties | | | | | | | | | |
|-----------------------------|-----------------------------|--------------------|----------------------------|----------------------------|--------------------------|--------------------------|---------------------------|---------------------------|---------------------------|
| Sample | n | Edible portion (g) | Moisture content (%) | pH | Titratable acidity (%) | TSS (%) | RS (g) | TS (g) | |
| Local Name | Scientific Name | | | | | | | | |
| Bangla Kola | <i>Musa sapientum</i> | 5 | 70.09 ± 2.30 ^a | 64.81 ± 2.34 ^a | 4.46 ± 0.05 | 0.33 ± 0.05 | 20.89 ± 1.64 ^a | 8.73 ± 0.09 ^c | 14.05 ± 0.11 ^a |
| Chapa Kola | <i>Musa sapientum</i> | 5 | 80.36 ± 2.81 ^b | 73.27 ± 2.04 ^b | 4.7 ± 0.06 ^a | 0.44 ± 0.05 | 21.32 ± 1.28 ^b | 9.48 ± 0.18 ^b | 14.27 ± 0.16 ^a |
| Sabri Kola | <i>Musa sapientum</i> | 5 | 76.06 ± 1.49 ^{ab} | 60.92 ± 2.04 ^a | 4.36 ± 0.05 | 0.58 ± 0.07 ^a | 19.79 ± 1.58 ^a | 8.97 ± 0.08 ^c | 13.76 ± 0.13 ^a |
| Sagor Kola | <i>Musa oranta</i> | 5 | 63.35 ± 2.20 ^a | 61.25 ± 1.17 ^a | 5.08 ± 0.06 ^a | 0.18 ± 0.06 ^a | 19.59 ± 1.39 ^a | 8.15 ± 0.07 ^c | 11.52 ± 0.15 ^a |
| Ata-fol | <i>Annona reticulata</i> L. | 5 | 63.35 ± 1.64 ^{ab} | 66.71 ± 1.01 ^c | 6.67 ± 1.01 ^c | 0.33 ± 0.06 ^a | 22.32 ± 0.93 ^c | 11.12 ± 1.23 ^a | 19.65 ± 0.22 ^b |
| Lemon | <i>Citrus aurantifolia</i> | 5 | 33.89 ± 1.24 ^c | 86.01 ± 1.31 ^{ab} | 2.80 ± 0.07 ^a | 3.46 ± 0.11 ^b | 4.01 ± 0.16 ^c | 0.99 ± 0.08 ^c | 2.00 ± 0.06 ^c |
| Gab | <i>Diospyros malabarica</i> | 5 | 44.11 ± 1.54 ^a | 75.71 ± 1.17 ^a | 5.58 ± 0.50 ^b | 2.73 ± 0.10 ^b | 8.68 ± 0.10 ^c | 6.66 ± 0.07 ^c | 12.80 ± 0.16 ^a |
| Dragon fruit | <i>Hylocereus undatus</i> | 5 | 58.13 ± 1.93 ^a | 80.53 ± 2.27 ^b | 4.1 ± 0.07 ^a | 0.26 ± 0.05 | 8.50 ± 0.08 ^d | 7.34 ± 0.05 | 7.89 ± 0.06 ^c |

Note: Results were expressed as mean values ± standard deviation and values followed by different letters are significantly ($p < 0.05$) different from each other

Table 2. Crude fiber, total carbohydrate, total energy, total protein, total fat and ash content of selected fruit samples

| Physico-chemical Properties | | | | | | | | |
|-----------------------------|-----------------------------|-----------------|--------------------------|----------------------------|----------------------------|--------------------------|--------------------------|--------------------------|
| Sample | n | Crude Fiber (g) | Total Carbohydrate (g) | Total Energy (Kcal) | Total Protein (g) | Total Fat (g) | Ash (g) | |
| Local Name | Scientific Name | | | | | | | |
| Bangla Kola | <i>Musa sapientum</i> | 5 | 1.90 ± 0.06 ^b | 30.75 ± 1.26 ^a | 132.09 ± 1.76 ^a | 1.39 ± 0.21 ^a | 0.39 ± 0.10 ^b | 0.75 ± 0.11 ^a |
| Chapa Kola | <i>Musa sapientum</i> | 5 | 1.60 ± 0.05 | 29.28 ± 1.28 ^a | 125.08 ± 1.12 ^a | 1.40 ± 0.14 ^a | 0.26 ± 0.05 | 0.88 ± 0.08 ^b |
| Sabri Kola | <i>Musa sapientum</i> | 5 | 1.79 ± 0.12 ^a | 35.27 ± 0.81 ^b | 147.55 ± 1.68 ^a | 0.99 ± 0.14 ^a | 0.28 ± 0.10 ^b | 0.74 ± 0.06 ^b |
| Sagor Kola | <i>Musa oranta</i> | 5 | 1.38 ± 0.09 ^a | 35.15 ± 1.06 ^b | 147.98 ± 1.69 ^b | 1.17 ± 0.09 ^b | 0.29 ± 0.11 ^b | 0.75 ± 0.05 |
| Ata-fol | <i>Annona reticulata</i> L. | 5 | 2.99 ± 0.10 ^a | 27.49 ± 0.29 ^{ab} | 118.84 ± 1.26 ^a | 1.98 ± 0.39 ^a | 0.10 ± 0.05 | 0.72 ± 0.14 ^a |
| Lemon | <i>Citrus aurantifolia</i> | 5 | 1.85 ± 0.06 ^b | 10.85 ± 0.32 ^{ab} | 50.52 ± 0.94 ^{ab} | 0.48 ± 0.05 | 0.59 ± 0.09 ^c | 0.26 ± 0.06 ^b |
| Gab | <i>Diospyros malabarica</i> | 5 | 1.59 ± 0.05 | 20.34 ± 1.22 ^a | 88.36 ± 1.31 ^b | 1.36 ± 0.13 ^b | 0.17 ± 0.06 ^c | 0.82 ± 0.08 ^b |
| Dragon fruit | <i>Hylocereus undatus</i> | 5 | 2.86 ± 0.10 ^a | 14.80 ± 0.47 ^{ab} | 65.84 ± 0.84 ^{ab} | 1.00 ± 0.09 ^b | 0.29 ± 0.06 ^c | 0.51 ± 0.10 ^a |

Note: Results were expressed as mean values ± standard deviation and values followed by different letters are significantly ($p < 0.05$) different from each other

Table 3. Vitamin-C and trace elements content of selected fruit samples

| Vitamin-C and Trace Minerals Content | | | | | | | |
|--------------------------------------|-----------------------------|----------------|------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Sample | n | Vitamin-C | Trace Minerals | | | | |
| Local Name | Scientific Name | Vitamin-C (mg) | Copper (mg) | Iron (mg) | Manganese (mg) | Zinc (mg) | |
| Bangla Kola | <i>Musa sapientum</i> | 5 | 28.62 ± 1.04 ^a | 0.23 ± 0.07 ^a | 0.61 ± 0.10 ^a | 0.08 ± 0.06 ^b | 0.16 ± 0.07 ^a |
| Chapa Kola | <i>Musa sapientum</i> | 5 | 30.22 ± 1.57 ^b | 0.25 ± 0.05 | 0.60 ± 0.09 ^a | 0.02 ± 0.07 ^b | 0.45 ± 0.08 ^a |
| Sabri Kola | <i>Musa sapientum</i> | 5 | 29.09 ± 1.99 ^c | 0.24 ± 0.06 ^b | 0.39 ± 0.08 ^b | 0.06 ± 0.06 ^b | 0.33 ± 0.07 ^a |
| Sagor Kola | <i>Musa oranta</i> | 5 | 27.59 ± 2.06 ^d | 0.16 ± 0.05 | 0.10 ± 0.05 | Not detected | 0.10 ± 0.05 |
| Ata-fol | <i>Annona reticulata</i> L. | 5 | 37.40 ± 1.53 ^b | 0.15 ± 0.06 ^b | 0.02 ± 0.06 ^b | 0.01 ± 0.05 | 0.21 ± 0.06 ^b |
| Lemon | <i>Citrus aurantifolia</i> | 5 | 217.90 ± 3.01 ^{abc} | 0.14 ± 0.05 | 0.13 ± 0.06 ^b | 0.01 ± 0.05 | 0.10 ± 0.06 ^b |
| Gab | <i>Diospyros malabarica</i> | 5 | 14.25 ± 1.23 ^a | 0.07 ± 0.06 ^b | Not detected | 0.46 ± 0.11 ^a | 0.08 ± 0.05 |
| Dragon fruit | <i>Hylocereus undatus</i> | 5 | 10.00 ± 1.14 ^a | 0.05 ± 0.05 | 0.03 ± 0.05 | 0.03 ± 0.05 | 0.44 ± 0.09 ^c |

Note: Results were expressed as mean values ± standard deviation and values followed by different letters are significantly ($p < 0.05$) different from each other

launched yet in Bangladesh. Moreover, there are lots of high yielding fruits and vegetables have been cultivated with the improvement of agricultural technology. These fruits and vegetable replace some of our traditional foods, the nutritive values of which are not yet to be determined. The physico-chemical properties of the studied fruits are shown in Table 1 and Table 2. Most fruits are composed of 70% to 90% water (Haque *et al.*, 2009). The moisture content of studied fruits ranged between $60.92 \pm 2.04\%$ and $86.01 \pm 1.31\%$. The high moisture content of these fruits give great impact on energy density (amount of energy in a given weight of food (kcal/g) as water adds substantial weight to the food without adding energy and this may give the consumers a better satiety without increase their energy intake (Ng *et al.*, 2012).

The pH among the tropical fruits varied from 2.80 ± 0.07 to 5.58 ± 0.50 . The highest pH was observed in Gab, 5.58 ± 0.50 and the lowest amount of titratable acidity was found in Sagor kola, $0.18 \pm 0.06\%$. Generally higher TSS indicates more sugar in the pulp. The more ripe the fruits the more amount of sugar in fruits (Haque *et al.*, 2009). According to Norman, the sugar content of fresh fruits ranges

between 2% and 30% (Potter, 1976). The total soluble solids among eight different fruits were $4.01 \pm 0.16\%$ to $22.32 \pm 0.93\%$. This range is similar to the results found by Haque *et al.* (2009).

In this study, it was found that dietary fiber, the important constituent of fruit ranges from $1.38 \pm 0.09\%$ to $2.99 \pm 0.10\%$. The recommended daily dietary fiber intake is 28 g/day for adult women and 36 g/day for adult men (USDA, 2005). Most health advisory groups provide guidance for obtaining the recommended levels of fiber consumption from foods, especially fruits, vegetables, and whole grains (USDA, 2005). Carbohydrate of fruit is less concentrated than cereals because of their high water content. Fruits rich in carbohydrate provides high amount of energy. Sagor kola showed the highest amount of energy, 147.98 ± 1.69 Kcal due to its high carbohydrate content. Fat and protein content of fruits is not greater than 1% and 3.5% respectively (Potter, 1976) and the findings of this result are similar to the results found by Potter. The amount of total ash (mineral) present in selected fruits ranges between 0.26 ± 0.06 g and 0.88 ± 0.08 g. Gardner *et al.* (1939) observed that the total content of mineral salt as ash in fruits varied from 0.2% to 1.5% (Gardner *et*

Table 4. Minerals content of selected fruits

| Sample | n | Minerals Content | | | | | |
|--------------|-----------------------------|------------------|----------------|--------------|----------------|---------------|-------------|
| | | Sodium (mg) | Potassium (mg) | Calcium (mg) | Magnesium (mg) | Chromium (mg) | |
| Bangla Kola | <i>Musa sapientum</i> | 5 | 1.91 ± 0.15 | 26.33 ± 1.27 | 5.27 ± 0.13 | 3.07 ± 0.18 | 0.04 ± 0.05 |
| Chapa Kola | <i>Musa sapientum</i> | 5 | 2.17 ± 0.13 | 27.61 ± 0.91 | 4.81 ± 0.15 | 4.29 ± 0.28 | 0.04 ± 0.06 |
| Sabri Kola | <i>Musa sapientum</i> | 5 | 1.86 ± 0.13 | 19.81 ± 1.18 | 4.96 ± 0.13 | 3.35 ± 0.13 | 0.03 ± 0.05 |
| Sagor Kola | <i>Musa oranta</i> | 5 | 2.69 ± 0.15 | 34.01 ± 0.92 | 4.76 ± 0.13 | 5.37 ± 0.10 | 0.03 ± 0.06 |
| Ata-foi | <i>Annona reticulata L.</i> | 5 | 1.01 ± 0.43 | 33.96 ± 0.84 | 11.39 ± 0.15 | 2.55 ± 0.08 | 0.03 ± 0.05 |
| Lemon | <i>Citrus aurantifolia</i> | 5 | 2.60 ± 0.12 | 76.98 ± 1.40 | 8.61 ± 0.10 | 5.76 ± 0.14 | 0.25 ± 0.07 |
| Gab | <i>Diospyros malabarica</i> | 5 | 1.05 ± 0.07 | 37.90 ± 1.02 | 18.91 ± 0.12 | 1.35 ± 0.10 | 0.01 ± 0.05 |
| Dragon fruit | <i>Hylocereus undatus</i> | 5 | 4.50 ± 0.15 | 16.14 ± 0.83 | 5.81 ± 0.10 | 3.73 ± 0.13 | 0.02 ± 0.05 |

Note: Results were expressed as mean values ± standard deviation and values followed by different letters are significantly ($p < 0.05$) different from each other

Table 5. Heavy metals content of selected fruits

| Samples | n | Heavy metals content | | | | |
|--------------|-----------------------------|----------------------|--------------|--------------|--------------|--------------|
| | | Arsenic (µg) | Cadmium (mg) | Lead (mg) | Mercury (µg) | |
| Bangla Kola | <i>Musa sapientum</i> | 5 | 0.015 ± 0.07 | Not detected | Not detected | Not detected |
| Chapa Kola | <i>Musa sapientum</i> | 5 | 0.013 ± 0.07 | Not detected | 0.010 ± 0.05 | Not detected |
| Sabri Kola | <i>Musa sapientum</i> | 5 | 0.029 ± 0.06 | Not detected | 0.001 ± 0.06 | Not detected |
| Sagor Kola | <i>Musa oranta</i> | 5 | 0.013 ± 0.09 | Not detected | Not detected | Not detected |
| Ata-foi | <i>Annona reticulata L.</i> | 5 | Not detected | Not detected | Not detected | Not detected |
| Lemon | <i>Citrus aurantifolia</i> | 5 | Not detected | Not detected | 0.001 ± 0.06 | Not detected |
| Gab | <i>Diospyros malabarica</i> | 5 | Not detected | 0.031 ± 0.07 | Not detected | 0.039 ± 0.06 |
| Dragon fruit | <i>Hylocereus undatus</i> | 5 | Not detected | Not detected | Not detected | Not detected |

Note: Results were expressed as mean values ± standard deviation and values followed by different letters are significantly ($p < 0.05$) different from each other

al., 1939). This range is more or less similar to the present study.

Vitamin C

In this study it was observed that Lemon is a rich source of vitamin C (ascorbic acid), 217.90 ± 3.01 mg. The North American Dietary Reference Intake recommends 90 mg/day and no more than 2 g (2,000 milligrams) of vitamin C per day (Wikipedia, 2010). So, consumption of 40-45 g Lemon is sufficient to meet the daily requirements. Vitamin-C and trace-elements content of the studied fruits is revealed in Table 3.

Trace elements

Trace element is any substance that when present at low concentration compared to those of an oxidisable substrate significantly delays or prevents oxidation of that substrate. Trace elements sometimes act as an antioxidant. Antioxidant functions are associated with decreased DNA damage, diminished lipid peroxidation, maintained immune function and inhibited malignant transformation of cells (Maisarah et al., 2013).

There are many epidemiological studies suggest that consumption of polyphenol-rich foods and beverages is associated with a reduced risk of cardiovascular diseases, stroke and certain types of cancer in which polyphenol is linked to the antioxidant properties (Barros et al., 2007; Jagadish et al., 2009). The consumption of dietary trace-elements will help to prevent free radical damage. According to Olajire and Azeez (2011), trace-elements have the ability to scavenge free radicals by inhibiting the initiation step or interrupting the propagation step of oxidation of lipid and as preventive antioxidants which slow the rate of oxidation by several actions.

The trace elements that were found in selected fruit samples are copper, iron, manganese and zinc.

The highest amount of copper and zinc was found in Chapa kola, 0.25 ± 0.05 mg and 0.45 ± 0.08 mg respectively. Also the highest amount of iron and manganese was found in Bangla kola. These minerals are also called micro-minerals which also worked as antioxidants, which are required in amounts less than 100 mg/day. Recommended Dietary Allowance (RDA) for copper is 900 µg/day for both adult male and female (IOM, 2001). Most fruits contain a small amount of copper. This study shows that the highest amount of copper is in Chapa kola, 0.25 ± 0.05 mg.

Iron content was found higher in Bangla kola, 0.61 ± 0.10 mg. According to USDA the daily recommended intake of iron is 8 mg for adult male and 18 mg for adult female. The highest amount of manganese was found in Gab, 0.46 ± 0.11 mg. RDA for manganese is 2.3 mg/day for adult male and 1.8 mg/day for female (USDA, 2005). Thus, consumption of these tropical fruits can be suggested as a food based strategy to alleviate or improve the unsatisfactory dietary iron intake of adolescents in the low-income areas.

The U.S. recommended dietary allowance (RDA) for zinc is listed by gender and age group, the RDA for zinc (8 mg/day for adult women and 11 mg/day for adult men) appears sufficient to prevent deficiency in most individuals (IOM, 2001). Most fruits contain a small amount of zinc as the zinc in whole grain products and plant proteins is less bio-available due to their relatively high content of phytic acid, a compound that inhibits zinc absorption (King et al., 2006). The highest amount of zinc found 0.45 ± 0.08 mg in Chapa kola and lowest level found 0.08 ± 0.05 mg in Gab.

Minerals

Minerals play an important role in maintaining proper function and good health in the human body (Ho et al., 2010). According to Hendricks (1998),

approximately 98% of the calcium (Ca) and 80% of the phosphorus (P) in the human body are found in the skeleton. Inadequate intake of minerals in the diet is often associated with an increased susceptibility to infectious diseases due to the weakening of the immune system. Plants, animal foods and drinking water are an important source of essential elements (Chaturvedi *et al.*, 2004).

Table 4 shows the minerals content of selected tropical fruits. These fruits were also enriched with minerals like sodium, potassium, calcium, magnesium and chromium. Sodium content of selected fruits ranges between 1.01 ± 0.43 mg and 4.50 ± 0.15 mg per 100 g of edible portion. Sodium variability of fruits sometimes relies on soil sodium. Black soil contains fair amount of sodium. Among the fruits analyzed, the highest quantity of potassium was found in Lemon, 76.98 ± 1.40 mg. For the healthy adult, RDA for sodium and potassium intake is not more than 2,400 mg and 4700 mg respectively per day (USDA, 2005).

Among the fruits analyzed, highest amount of calcium found in Gab, 18.91 ± 0.12 mg. Calcium with the name of “super nutrient” has been proven clinically associated with reduced risk of various non-communicable diseases such as osteoporosis, cardiovascular diseases and it also helps to reduce colorectal cancer risk by promoting the apoptosis in human colorectal epithelium that reduce colorectal neoplasm (Ng *et al.*, 2012). Highest amount of magnesium found in Lemon (5.76 ± 0.14 mg/100 g). Amount of chromium in selected fruits ranged from 0.01 ± 0.05 mg to 0.25 ± 0.07 mg per 100 g of edible portion.

Heavy metals

Nowadays some growers as well as traders in Bangladesh are commercially using some chemicals namely Ripen, Gold-Plus, Profit etc. for the ripening of banana and some other fruits. Children are at particular risk to the harmful side effects of food adulteration, which may lead to serious liver and kidney diseases including various forms of cancer and hepatitis (Per *et al.*, 2007). Heavy metals are harmful and become toxic for health if they are taken above the limit of daily dietary allowance recommended.

Heavy metals content of the selected fruits are given away in Table 5. Among the fruits analyzed arsenic was only found in banana varieties ranging from 0.013 ± 0.07 mg to 0.029 ± 0.06 mg. It may be due to the solid waste disposal into land, arsenic contaminated water use during cultivation and mixing of chemicals. Analysis of food and intake data from the U.S. Department of Agriculture Continuing Survey of Food Intakes by Individuals indicates that

the intake of Arsenic for all age groups ranged from 0.50 to 0.81 $\mu\text{g/kg/day}$ (Gunderson, 1995).

According to the national standard of China on Maximum Levels of Contaminants in Foods (published on January 25, 2005), maximum levels for lead, cadmium and mercury in fruits are 0.10 mg/kg, 0.05 mg/kg and 0.01 mg/kg respectively (NSCMLCF, 2005). Cadmium and mercury was found only in Gab, 0.031 ± 0.07 mg and 0.039 ± 0.06 mg respectively. Lead was found in two banana varieties namely Chapa kola and Sabri kola and in Lemon with a very negligible amount. Availability of lead in fruits may be due to the use of ripening agents or due to the air surrounding the area is high in lead aerosol resulting from emission from automobile exhaust. Despite the fact that arsenic, cadmium, lead and mercury was found in selected fruits but their concentration was lower than the safe level.

Conclusion

Fruits are highly valued in human diet for vitamins and minerals. This study indicates that the tropical fruits of Bangladesh are rich source of vitamin-C, trace minerals, potassium, calcium and magnesium but poor source of fiber, protein and manganese. The foremost findings of this study comprise that selected banana varieties are rich in energy, iron, magnesium and among them Chapa kola contains the highest amount of vitamin C, copper and zinc. So people can replace other banana varieties with Chapa kola from their breakfast menu to obtain maximum amount of antioxidants.

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