Heavy metals, trace elements, minerals and ascorbic acid content of occasionally consumed eight indigenous fruits in Bangladesh

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Abstract

Herein, a study was carried out to assess the nutritional potential of eight indigenous fruits namely sapodilla, stone apple, bilimbi, amla, litchi, strawberry, tamarind, elephant-apple particularly on the basis of heavy metal, mineral and ascorbic acid content along with the physicochemical properties. Inductively coupled plasma mass spectrometer (ICP-MS) and atomic absorption spectrophotometer (AAS) analysis were performed to determine the essential trace elements and heavy metals in the selected fruits, whereas sodium and potassium content was determined by flame photometer. Even though the essential trace elements such as zinc, copper, manganese, selenium and cobalt were found in all the examined fruits, sapodilla, stone apple and tamarind were observed as a rich source of selenium and cobalt. The current research demonstrated the presence of toxic heavy metals like arsenic, cadmium, lead, and mercury in elephant-apple, sapodilla, stone apple and tamarind in trace levels which are below the Maximum Residue Limits (MRLs). All the selected eight fruits are found as rich sources of macro-minerals for instance sodium, potassium, calcium, magnesium and phosphorous. Ascorbic acid was estimated by HPLC which ranged from 4.10 to 475.0 mg/100 g of edible portion and the highest amount was found in amla. In summary, these fruits could be potential sources of macro and micro-minerals and safe from toxic heavy metal contamination. The nutritional data observed in the present study would be played a promising role in dietary recommendation, nutritional education, training, research, and food supplementation.

1. Introduction

Bangladesh is blessed with a wide range of climates (six seasons in a year) and agricultural ecosystems, both are appropriate for the cultivation of diversified tropical fruits (Shajib et al., 2013). Based on the favorable agro-ecological conditions and better marketing facilities, more than sixty different types of fruit species are grown in Bangladesh with great regional variation and the extent of the cultivation process (Rahman, Khan and Hosain, 2007). These fruits are a good source of vitamins, minerals, carbohydrates, and antioxidants (Sajib et al., 2014; Ara et al., 2014). Minerals (e.g., iron, copper, manganese, selenium, cobalt, and zinc) and antioxidants protect the cell from oxidative damage. For example, zinc, copper, and manganese are required for superoxide dismutases in both cytosol and mitochondria. Additionally, Iron is a constituent of catalase, a hemeprotein, which catalyzes the decomposition of hydrogen peroxide (Machlin and Bendich, 1987). Selenium functions as a cofactor of enzymes such as glutathione peroxidase or thioredoxin reductase. Glutathione peroxidase prevents various diseases by reducing oxidative stress (Bampidis et al., 2018). Selenium is a constituent of more than two dozen selenoproteins that play a vital role in reproduction, thyroid hormone metabolism, DNA synthesis, and protection from oxidative damage and infection (Ross et al., 2012). Antioxidant acts as free-radical scavenger by neutralizing free radical intermediates and inhibiting other oxidation reactions (Sies, 1997). Vitamins and minerals are essential micro-nutrients that act as coenzymes and cofactors of many biosynthetic reactions. These beneficial aspects of fruits have remained unknown to the majority of the people in many communities. In 2007, Nishida and Nocito pronounced that reduced fruit and vegetable intakes especially in developing countries could lead to various diseases, including obesity, type II diabetes, coronary heart disease and some forms of cancer as the fruits possess medicinal value in the basis of FAO/WHO scientific update (Nishida and Nocito, 2007).
Numerous indigenous fruits have conventional and Ayurveda medicinal values but are occasionally consumed in Bangladesh. This present study emphasizes fruits that have enormous health benefits however infrequently consumed. In this investigation, eight indigenous low-consumed fruits namely amla, bilimbi, sapodilla, litchi, strawberry, stone apple, elephant apple and tamarind were selected. Firstly, several citrus fruits like amla and bilimbi were chosen for their various properties such as antioxidant, antimicrobial, antidiabetic properties, anti-radiation protection, healing of wounds and applied for the treatment of various ailments of several diseases from the ancient period (Alhassan and Ahmed, 2016; Ikram et al., 2021). In addition, the indigenous variety of sapodilla, litchi, strawberry and stone apple are palatable fruits that were chosen. Previous studies revealed that these fruits have antioxidant, potent anti-inflammatory properties, immune system boosting properties, and beneficial effects on digestive and cardiovascular health as well (Giampieri et al., 2012; Emanuele et al., 2017; Padmavath, 2018; Yadav et al., 2018). Furthermore, minor fruits such as elephant apple and tamarind are rich in phenolic compounds, flavonoids and tannins, which also are used for the treatment of laxative problems, abdominal pain. Both fruits are beneficial for cardiovascular and immunological health as well as have specific roles in antimicrobial and anticancer activities. It also exhibits a defense mechanism as an anti-inflammatory, antidiabetic and anti-hyperlipidemic agent for the treatment of several human health hazards (Bhagyasri et al., 2017; Nayik and Gull, 2020). Apart from these beneficial health aspects, the cultivation and commercialization of fruits could have a huge impact on the economy.

The purpose of the present study is to prepare new and updated nutritional information about tropical fruits which would be related to our food habits. This nutritional and food compositional information will play a crucial role in the dietary recommendation, nutritional education, training, research, and supplementation of food. For this purpose, eight indigenous occasionally consumed fruits mentioned above were selected for the study of physicochemical properties, minerals, ascorbic acid and trace elements, and heavy metal contents.

2. Materials and methods

2.1 Reagents and standards

Ascorbic acid, mineral and heavy metal standards were acquired from Sigma-Aldrich Company Ltd. (St. Louis, USA). The analytical grade metaphosphoric acid, methanol, acetic acid, sulfuric acid, nitric acid, hydrochloric acid, sodium hydroxide, potassium sodium tartrate, sodium acetate, copper sulphate, potassium sulphate, hydrogen peroxide were purchased from Merck (Darmstadt, Germany). Phenolphthalein and methylene blue indicators were obtained from Thomas Scientific (Swedesboro, New Jersey, USA).

2.2 Sample collection

A total of eight different types of fruits were analyzed in this study. These were sapodilla (Manilkara zapota), stone apple (Aegle marmelos), bilimbi (Averrhoa bilimbi), amla (Phyllanthus emblica), litchi (Litchi chinensis), strawberry (Fragaria x ananassa), tamarind (Tamarindus indica), and elephant apple (Dillenia indica). The sources of these selected fruits are different local markets in Dhaka city, Bangladesh during February to May. These collected samples were fresh, well-shaped, and free from insect bites and other organoleptic deterioration. The biochemical analyses were carried out at the laboratory of the Institute of Food Science and Technology, Bangladesh Council of Scientific and Industrial Research (IFST, BCSIR), Dhaka.

2.3 Sample preparation

Whole fruits were thoroughly washed with deionized water. The edible portion of the fruits was separated carefully and used for all analytical investigation. The analytical data were presented on a raw weight basis. Three replications of each type of fruit were selected for measurement.

2.4 Determination of physico-chemical properties

The pH was determined with a digital pH meter (Type H1 98106 by HANNA) and titratable acidity was estimated with the visual acid-base method (Ranganna, 1986). The moisture content was determined by the digital moisture analyzer (AnD MX50). The total soluble solids (TSS) were determined with a hand refract-meter (Jahan et al., 2011). Crude fibre, total fat and ash were determined by the standard AOAC method (AOAC, 1990) and total protein was estimated according to the method described by the Kjeldahl method (Ronald and Ronald, 1991). Total carbohydrate and energy contents were determined by the proximate analysis method (Osborn and Voogt, 1978). Total sugar and reducing sugar were determined by following the Lane and Eynon method (Ranganna, 1986).

2.5 Analysis of ascorbic acid

Ascorbic acid was determined by HPLC (model: Thermo Scientific Dionex UltiMate 3000 Rapid Separation LC systems (RSLC) from Thermo Fisher Scientific Inc., MA, USA) according to the following
described method (Van de Velde et al., 2012). Extraction was carried out by adding 1 g of homogenized sample to a 10 mL solution of metaphosphoric acid (30 g/L) and acetic acid (80 g/L). The mixture was homogenized for 1 min, then sonicated in an ultrasonic bath for 15 mins, and centrifuged at 12,000×g for 20 mins at 4°C. The supernatant was separated, and 0.5 mL of it was diluted with mobile phase to achieve a final volume of 5 mL and then filtered through a 0.45-μm Millipore membrane and injected into the HPLC system for quantification. A stock standard solution of ascorbic acid (4.0 g/L) was prepared in an extracting solution of metaphosphoric acid (30 gL⁻¹) and acetic acid (80 g/L).

HPLC Conditions: separations were achieved in a reversed-phase column Thermo 5μC18 110A attached to a guard column (Phenomenex Inc., CA, USA) at room temperature (25°C). The mobile phase, under isocratic conditions, consisted of a 0.03 M sodium acetate/acetic acid buffer, and 5% methanol. Mobile phase pH was adjusted to 5.8 and was filtered through a 0.45-μm nylon membrane filter and degassed under vacuum. The flow rate was 1 mL/min and the reading was taken at a wavelength 270 nm.

2.6 Analysis of minerals and heavy metals

Heavy metals and trace elements (Copper, Manganese, Zinc, Selenium, Cobalt, Cadmium, Chromium, Lead, Mercury and Arsenic) were measured by inductively coupled plasma mass spectrometer (ICP-MS) (Agilent 7700, USA). Other minerals (iron, calcium, magnesium, and phosphorous) were measured by the Graphite Atomic Absorption Spectrometric method using (iCE 3300, Thermo Scientific) (Kirk and Sawyer, 1991). For the analysis samples were prepared by using a microwave digestion system. As a digestion reagent, 5 mL 69% HNO₃ acid and 2 mL 30% H₂O₂ were used. About 0.3 g of samples were placed into the digestion reagent in a Teflon vessel. After digestion, samples were transferred into a Teflon beaker and the total volume was made up to 25 mL with MilliQ water. The digest solution was filtered using a syringe filter (pore size= 0.45 mm) and then stored in a screw cap plastic tube for analysis.

2.7 Analysis of sodium and potassium

About 2.0 g of each fruit powder was weighed in a crucible and burned at 550°C using a muffle furnace for 5.0 hrs to produce ash. The resultant ash was dissolved in 5 N HCl and heated gently on a hot plate until brown fumes disappeared. Subsequently, 5 mL of deionized water was added and heated till the colourless solution was obtained. Next, to determine potassium and sodium by a flame photometer (Jenway PFP7), the final solution was prepared by transferring the ash solution to 100 mL volumetric flask thru filtration with an ashless Whatman filter paper and the volume was made up to the mark with deionized water. The calibration curve was prepared with 1, 2, 4, 8 ppm of sodium and 5, 10, 20, and 40 ppm of potassium solution from the purchased 1000 ppm stock solution. Sodium and Potassium analysis was done at wavelengths 589 nm and 768 nm with air pressure of 10 lb/in² (Ranganna, 1986).

2.8 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) ± standard deviation (SD). The significant differences between mean values were analyzed by the Duncan multiple range test at a significance level of p<0.05.

3. Results and discussion

This study was conducted to evaluate the nutritional quality of selected fruits by studying their ascorbic acid, trace-element, mineral, and heavy metal content, and physicochemical properties. Each value represents the average from five replications and the outcomes are expressed as mean values ± standard deviations (SD).

3.1 Micro-minerals

The micro-mineral contents of the studied fruits are shown in Table 1. In the present study, it was found that the selected fruits are a poor source of copper (0.02-0.41 mg/100 g of edible portion). The highest amount of copper was found in sapodilla (0.41±0.05 mg/100 g of edible portion). Another study showed that fruits contain 0.03-0.23 mg of copper per 100 g of an edible portion (Almeida et al., 2009). Copper content was almost the same as in the study except for sapodilla. It was also mentioned in a study that most fruits contain a small amount of copper 0.39-1.31 mg/100 g (Jahan et al., 2011; Shaheen et al., 2013). As it is an essential trace element, according to the results people may partially fulfil their dietary allowance by consuming sapodilla, bilimbi and litchi.

The amount of iron, zinc, and manganese was found in the studied fruits 0.30±0.02 to 2.69±0.07 mg/100 g, 0.03±0.00 to 0.16±0.03 mg/100 g and 0.03±0.01 to 0.36±0.04 mg/100 g respectively. The highest amount of iron, zinc, and manganese was found in tamarind, sapodilla and strawberry respectively. A previous study showed that fruits contain 0.50-1.00 mg/100 g of iron and 0.04-1.68 mg/100 g of zinc (Shaheen et al., 2013). A study reported that some indigenous fruits available in
Previous a study has revealed that fruits contain 8.54 to 60.6 mg/100 g of edible portion (Shajib et al., 2013). Thirty-five milligrams/kg cobalt was found in elephant apples and bilimbi contains a good amount of selenium. (Okello et al., 2017). An almost similar result was found in tamarind (22.30±0.27 mg/100 g), sapodilla (10.19±0.06 mg/100 g) and stone apple (7.04±0.06 mg/100 g) that contains the highest selenium content ranges between 0.11-3.13 μg/100 g of edible portion and tamarind contains the highest (Almeida et al., 2009). It was noted that tamarind contains a good amount of selenium.

In this study, cobalt content in the selected fruits was found 1.70±0.02 to 11.20±0.05 μg/100 g. The highest amount of cobalt was found in elephant apples and followed by stone apples, sapodilla, and tamarind. Previous a study has revealed that fruits contain 8.54 to 53.99 μg cobalt per 100 g of the edible portion (Almeida et al., 2009). As cobalt is an essential element for the human body and has a significant role in some biochemical reactions (Miller et al., 2005), these fruits may partially contribute to meet the dietary requirement.

### 3.2 Macro-minerals

Macro-minerals (Na, K, Ca, Mg, P) content of studied fruits is shown in Table 2. In this study, the sodium content in different fruits ranged from 0.91±0.08 to 22.30±0.27 mg/100 g of edible portion. Other studies showed that sodium content in tamarind was 13.95 mg/100 g (Almeida et al., 2009) and 59.60 - 171.30 mg/100 g (Okello et al., 2017). Results noted that tamarind (22.30±0.27 mg/100 g), sapodilla (10.19±0.06 mg/100 g) and stone apple (7.04±0.06 mg/100 g) were good sources of sodium and which was very resembled the latest Food Composition Table for Bangladesh (FCTB) prepared by Shaheen et al. (2013). Potassium content in the selected fruits ranged from 13.00±0.12 to 606.00±1.01 mg/100 g of edible portion and the highest was in tamarind. An almost similar result was found in tamarind of Brasil for potassium which was 790.11 mg/100 g of an edible portion (Almeida et al., 2009). Whereas potassium content for stone apple in FCTB was five times higher than that of the present study (Shaheen et al., 2013).

### Table 1. Trace elements content of studied fruits

<table>
<thead>
<tr>
<th>Name of Fruits</th>
<th>Scientific name</th>
<th>Copper (mg)</th>
<th>Iron (mg)</th>
<th>Manganese (mg)</th>
<th>Zinc (mg)</th>
<th>Selenium (mg)</th>
<th>Cobalt (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amla</td>
<td>Phyllanthus emblica</td>
<td>0.02±0.00f</td>
<td>0.87±0.03e</td>
<td>0.04±0.01ef</td>
<td>0.09±0.02e</td>
<td>0.62±0.05e</td>
<td>2.16±0.02e</td>
</tr>
<tr>
<td>Bilimbi</td>
<td>Averrhoa bilimbi</td>
<td>0.17±0.02b</td>
<td>0.96±0.07b</td>
<td>0.03±0.01f</td>
<td>0.12±0.05b</td>
<td>0.52±0.01f</td>
<td>2.80±0.01e</td>
</tr>
<tr>
<td>Elephant Apple</td>
<td>Dillenia indica</td>
<td>0.08±0.02de</td>
<td>0.49±0.03c</td>
<td>0.10±0.02ed</td>
<td>0.15±0.04b</td>
<td>1.07±0.04b</td>
<td>11.20±0.05a</td>
</tr>
<tr>
<td>Litchi</td>
<td>Litchi chinensis</td>
<td>0.16±0.01f</td>
<td>0.45±0.02c</td>
<td>0.07±0.02ed</td>
<td>0.11±0.01b</td>
<td>0.51±0.02b</td>
<td>18.00±0.01f</td>
</tr>
<tr>
<td>Sapodilla</td>
<td>Manilkara zapota</td>
<td>0.41±0.05a</td>
<td>0.97±0.05c</td>
<td>0.16±0.01c</td>
<td>0.16±0.03a</td>
<td>0.30±0.02e</td>
<td>9.20±0.06c</td>
</tr>
<tr>
<td>Stone apple</td>
<td>Aegle marmelos</td>
<td>0.04±0.01ef</td>
<td>0.30±0.02f</td>
<td>0.31±0.03b</td>
<td>0.03 ±0.00c</td>
<td>0.80±0.04c</td>
<td>9.46±0.04b</td>
</tr>
<tr>
<td>Strawberry</td>
<td>Fragaria X ananassa</td>
<td>0.13±0.03d</td>
<td>0.41±0.04c</td>
<td>0.36±0.04a</td>
<td>0.09±0.01a</td>
<td>0.43±0.02b</td>
<td>1.70±0.02th</td>
</tr>
<tr>
<td>Tamarind</td>
<td>Tamarindus indica</td>
<td>0.07±0.01d</td>
<td>2.69±0.07a</td>
<td>0.11±0.01d</td>
<td>0.13±0.03b</td>
<td>1.32±0.05e</td>
<td>6.26±0.03d</td>
</tr>
</tbody>
</table>

Values are presented as mean±SD per 100 g of edible portions. Values with different superscript are significantly different (p<0.05).

### Table 2. Macro minerals content of studied fruits

<table>
<thead>
<tr>
<th>Name of Fruits</th>
<th>Sodium (mg)</th>
<th>Potassium (mg)</th>
<th>Calcium (mg)</th>
<th>Magnesium (mg)</th>
<th>Phosphorous (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amla</td>
<td>1.21±0.02f</td>
<td>156.10±0.72c</td>
<td>26.40±0.13c</td>
<td>76.40±0.26b</td>
<td>25.16±0.07b</td>
</tr>
<tr>
<td>Bilimbi</td>
<td>3.30±0.07d</td>
<td>13.00±0.12b</td>
<td>5.80±0.08b</td>
<td>8.80±0.02e</td>
<td>11.80±0.05f</td>
</tr>
<tr>
<td>Elephant Apple</td>
<td>0.91±0.08g</td>
<td>42.06±0.21f</td>
<td>13.90±0.09f</td>
<td>7.65±0.03g</td>
<td>24.72±0.02e</td>
</tr>
<tr>
<td>Litchi</td>
<td>2.22±0.05e</td>
<td>181.00±0.23c</td>
<td>8.79±0.06f</td>
<td>10.92±0.05d</td>
<td>22.40±0.02d</td>
</tr>
<tr>
<td>Sapodilla</td>
<td>10.19±0.06b</td>
<td>204.00±1.23b</td>
<td>21.10±0.07d</td>
<td>10.61±0.08d</td>
<td>11.68±0.07g</td>
</tr>
<tr>
<td>Stone apple</td>
<td>7.04±0.04c</td>
<td>89.00±0.87f</td>
<td>32.60±0.21b</td>
<td>19.80±0.06e</td>
<td>95.12±0.04a</td>
</tr>
<tr>
<td>Strawberry</td>
<td>1.16±0.03f</td>
<td>170.00±1.64d</td>
<td>16.16±0.11e</td>
<td>8.72±0.09f</td>
<td>25.14±0.03b</td>
</tr>
<tr>
<td>Tamarind</td>
<td>22.30±0.27b</td>
<td>606.00±1.01f</td>
<td>78.71±0.91f</td>
<td>93.30±0.12a</td>
<td>95.60±0.08a</td>
</tr>
</tbody>
</table>

Values are presented as mean±SD per 100 g of edible portions. Values with different superscript are significantly different (p<0.05).

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Calcium levels among the analyzed fruits were 5.80±0.08 to 78.71±0.91 mg/100 g of the edible portion were highest in tamarind and lowest in bilimbi. According to FCTB calcium content was found 11.0 mg, 127.0 mg and 41.0 mg per 100 g of edible portion in litchi, tamarind and stone apple respectively which was nearly similar to our research (Shaheen et al., 2013). Conforming the calcium content of tropical fruits varied from 4-50 mg/100 g (Gopalan et al. 1993). Magnesium found in fruits ranged between 7.65±0.03 to 93.30±0.12 mg/100 g of edible portion. It was noted that amla (76.50 mg/100 g) and tamarind (93.30 mg/100 g) contained a much higher amount of magnesium than other selected fruits. Previous research found that amla contained 24.50 mg/100 g of magnesium (Paul et al., 2004) which was almost three times lower than this study while FCTB showed a parallel result (Shaheen et al., 2013). It was observed that selected fruits were rich in calcium and magnesium.

Phosphorus content in selected fruits ranged from 11.68±0.07 to 95.60±0.08 mg/100 g of edible portion. The highest amount of phosphorus was found in tamarind and followed by Stone apple, strawberry, amla and elephant apple, the results were quite alike to FCTB (Shaheen et al., 2013). In addition, other studies showed that phosphorous content in tropical fruits varied from 10.00-98.90 mg/100g (Paul et al., 2004) and 5.36-98.49 mg/100 g (Almeida et al., 2009). The research revealed that tamarind contains a good amount of sodium, potassium, calcium, magnesium and phosphorus than other selected fruits. Minerals content in studied fruits might vary for other agro-ecological zones’ fruits as agro -ecological zones may differ in minerals content (Okello et al., 2017).

3.3 Heavy metals

The heavy metals content of the studied fruits is shown in Table 3. The result exposed that the chromium level was from 0.02±0.01 to 0.05±0.01 mg/100 g of edible portion in the fruits. The maximum amount of chromium was found in Amla. Arsenic was found in amla (0.02±0.01 μg/100 g), litchi (0.03±0.01 μg/100 g), and strawberry (0.08 μg/100 g). Most human foods like vegetables, fruits, dairy products, and meats contain less than 0.05 mg/kg and rarely exceed 0.1 mg/kg of arsenic (Dara, 2004). Cadmium was found in sapodilla, stone apple, tamarind, and elephant apple, ranging from 0.02-0.04 mg/100 g. The lead was found in tamarind, stone apple, sapodilla, elephant apple and litchi ranging from 0.01 to 0.04 mg/100 gm of edible portion. The presence of heavy metals may be due to solid waste disposal into the land with a high amount of heavy metals, usage of arsenic-contaminated water during cultivation, as its consequences groundwater may contain heavy metals and it may be utilized by plants and ultimately absorbs in the fruits (Heikens et al., 2007). The heavy metal content of the fruits was lower than the recommended safe value (arsenic max 0.1 mg/kg; chromium max 2.3 mg/kg; cadmium max 0.2 mg/kg, lead max 0.3 mg/kg) by WHO/FAO (CAC, 2001).

3.4 Ascorbic acid

 Among the fruits analyzed, ascorbic acid content was found the highest in the amla (475±2.01 mg/100 g), whereas, the lowest amount (4.10±0.07 mg/100 g) was found in tamarind (Table 4). The ascorbic acid content in bilimbi, elephant apple, litchi, sapodilla, stone apple and strawberry were recorded 16.1±0.61 mg/100 g, 6.5±0.09 mg/100 g, 35.0±0.73 mg/100 g, 15.6±0.11 mg/100 g, 8.9±0.20 mg/100 g and 57.0±0.93 mg/100 g of edible portion respectively. Some previous studies revealed that the ascorbic acid content in low-consumed tropical fruits as like sapodilla 21.72 mg/100 g (Rahman et al., 2007), litchi 39±5.5 mg/100 g (Paul et al., 2004) and 11.00 mg/100 g (Shaheen et al., 2013), elephant apple 12.80 mg/100 g (Shaheen et al., 2013), tamarind 11.20 mg/100 g (Shaheen et al., 2013) and bilimbi 182.98 mg/100 g (Yan et al., 2013). This study also exposed that these low -consumed fruits were rich in ascorbic acid content although some of those grow carelessly at homesteads, forests, and roadsides as well as cheaper.

### Table 3. Heavy metals and metalloid content of selected fruits

<table>
<thead>
<tr>
<th>Name of Fruits</th>
<th>Cadmium (mg)</th>
<th>Chromium (mg)</th>
<th>Lead (mg)</th>
<th>Mercury (μg)</th>
<th>Arsenic (μg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amla</td>
<td>ND</td>
<td>0.05±0.01</td>
<td>ND</td>
<td>ND</td>
<td>0.02±0.01</td>
</tr>
<tr>
<td>Bilimbi</td>
<td>ND</td>
<td>0.04±0.02</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Elephant Apple</td>
<td>0.03±0.02</td>
<td>0.03±0.02</td>
<td>ND</td>
<td>0.52±0.06</td>
<td>ND</td>
</tr>
<tr>
<td>Litchi</td>
<td>ND</td>
<td>0.04±0.03</td>
<td>0.01±0.00</td>
<td>0.24±0.02</td>
<td>ND</td>
</tr>
<tr>
<td>Sapodilla</td>
<td>0.02±0.01</td>
<td>0.04±0.03</td>
<td>ND</td>
<td>0.44±0.02</td>
<td>ND</td>
</tr>
<tr>
<td>Stone apple</td>
<td>0.04±0.01</td>
<td>0.03±0.01</td>
<td>0.03±0.01</td>
<td>0.26±0.04</td>
<td>ND</td>
</tr>
<tr>
<td>Strawberry</td>
<td>ND</td>
<td>0.02±0.01</td>
<td>ND</td>
<td>ND</td>
<td>0.08±0.02</td>
</tr>
<tr>
<td>Tamarind</td>
<td>0.04±0.02</td>
<td>0.03±0.02</td>
<td>0.04±0.01</td>
<td>0.29±0.03</td>
<td>ND</td>
</tr>
</tbody>
</table>

Values are presented as mean±SD per 100 g of edible portions. Values with different superscript are significantly different (p<0.05). ND, not detected
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Amla</th>
<th>Bilimbi</th>
<th>Elephant Apple</th>
<th>Litchi</th>
<th>Sapodilla</th>
<th>Stone apple</th>
<th>Strawberry</th>
<th>Tamarind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edible portion (%)</td>
<td>89.15±1.93c</td>
<td>99.98±1.45c</td>
<td>68.19±1.98e</td>
<td>59.11±2.32f</td>
<td>77.36±2.12d</td>
<td>60.00±1.21f</td>
<td>95.51±2.15b</td>
<td>29.92±2.63f</td>
</tr>
<tr>
<td>Moisture content (%)</td>
<td>79.56±1.32d</td>
<td>94.26±1.53a</td>
<td>83.30±1.98c</td>
<td>79.96±1.67d</td>
<td>73.28±1.23c</td>
<td>63.48±1.25f</td>
<td>89.64±1.21b</td>
<td>14.49±2.12e</td>
</tr>
<tr>
<td>pH</td>
<td>3.3±0.06d</td>
<td>2.2±0.01f</td>
<td>3.3±0.05d</td>
<td>3.5±0.03c</td>
<td>5.2±0.10a</td>
<td>5.3±0.04a</td>
<td>3.7±0.09b</td>
<td>2.8±0.07c</td>
</tr>
<tr>
<td>Titratable acidity (%)</td>
<td>6.4±0.09b</td>
<td>1.19±0.11c</td>
<td>0.06±0.01c</td>
<td>0.82±0.03d</td>
<td>0.11±0.01e</td>
<td>0.71±0.04d</td>
<td>1.02±0.05b</td>
<td>15.12±0.28e</td>
</tr>
<tr>
<td>Total soluble solids (%)</td>
<td>9.17±0.70f</td>
<td>3.0±0.09g</td>
<td>7.25±0.07f</td>
<td>12.70±0.87d</td>
<td>15.92±1.12c</td>
<td>25.80±1.15b</td>
<td>6.0±0.08f</td>
<td>28.06±1.18e</td>
</tr>
<tr>
<td>Reducing sugar (%)</td>
<td>0.99±0.02f</td>
<td>1.91±0.03e</td>
<td>0.99±0.03f</td>
<td>6.54±0.21d</td>
<td>11.91±0.09b</td>
<td>8.97±0.11c</td>
<td>2.14±0.06e</td>
<td>17.11±1.02e</td>
</tr>
<tr>
<td>Total sugar (TS) (%)</td>
<td>1.61±0.03f</td>
<td>2.41±0.08f</td>
<td>2.52±0.04f</td>
<td>7.97±0.21d</td>
<td>13.06±1.03c</td>
<td>24.36±1.23b</td>
<td>3.95±0.08e</td>
<td>27.07±1.05e</td>
</tr>
<tr>
<td>Crude fiber (%)</td>
<td>2.19±0.04f</td>
<td>0.72±0.01f</td>
<td>2.50±0.05f</td>
<td>0.90±0.02f</td>
<td>4.5±0.07f</td>
<td>2.61±0.03c</td>
<td>2.11±0.06f</td>
<td>8.51±0.09f</td>
</tr>
<tr>
<td>Total carbohydrate (%)</td>
<td>19.43±0.12c</td>
<td>4.66±0.06a</td>
<td>13.77±0.04f</td>
<td>17.81±0.08e</td>
<td>24.84±0.08d</td>
<td>33.65±0.10b</td>
<td>30.1±0.05c</td>
<td>79.73±0.10f</td>
</tr>
<tr>
<td>Energy (kcal/100 g)</td>
<td>80.37±0.18e</td>
<td>22.93±0.32d</td>
<td>60.17±0.12c</td>
<td>78.43±0.34d</td>
<td>111.33±0.12c</td>
<td>148.90±0.62b</td>
<td>126.97±0.52f</td>
<td>335.37±0.36e</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>0.19±0.01b</td>
<td>0.55±0.03f</td>
<td>0.71±0.03c</td>
<td>1.01±0.04c</td>
<td>0.45±0.02k</td>
<td>2.62±0.07b</td>
<td>0.81±0.03d</td>
<td>3.10±0.07a</td>
</tr>
<tr>
<td>Total fat (%)</td>
<td>0.21±0.02ef</td>
<td>0.16±0.01f</td>
<td>0.25±0.02c</td>
<td>0.35±0.05d</td>
<td>1.13±0.05a</td>
<td>0.43±0.03bc</td>
<td>0.37±0.03ad</td>
<td>0.45±0.06b</td>
</tr>
<tr>
<td>Ash content (%)</td>
<td>0.75±0.03f</td>
<td>0.21±0.01b</td>
<td>3.14±0.04f</td>
<td>0.53±0.04f</td>
<td>0.62±0.05c</td>
<td>1.07±0.07c</td>
<td>0.43±0.02e</td>
<td>2.74±0.07b</td>
</tr>
<tr>
<td>Ascorbic acid (mg/100 g)</td>
<td>475.0±2.01a</td>
<td>16.1±0.61d</td>
<td>6.5±0.09f</td>
<td>35.0±0.73c</td>
<td>15.6±0.11d</td>
<td>8.9±0.20c</td>
<td>57.0±0.93b</td>
<td>4.1±0.07e</td>
</tr>
</tbody>
</table>

Values are presented as mean±SD. Values with different superscript are significantly different (p<0.05).
3.5 Proximate analysis and physicochemical properties

The edible portions of the studied fruits varied from 29.92±2.63 to 99.98±1.45% (Table 4). The results showed that bilimbi has the highest amount of edible portions because it is free from larger seeds and almost the whole fruit body could be eaten. Strawberry also has a good edible portion (95.51±2.15%) due to the lack of big seeds and hard shells. Whereas, tamarind contains the lowest amount of edible portion (29.92±2.63%) owing to its heavy peel weight and proportionally bigger seeds.

The moisture content of the selected fruits was 14.49±2.12 to 94.26±1.53% (Table 4). Bilimbi contains the highest amount of moisture, whereas, tamarind contains the lowest moisture content. Generally, most tropical fruits are composed of 70% to 90% water (Haque et al., 2009). The moisture content has a great impact on energy density as water adds substantial weight to the fruit without adding energy. The variation in moisture content among fruits is due to climate change, soil conditions, and total rainfall (Webster and Wilson, 1966).

The results showed that fruits were poor sources of protein (Max 3.10±0.07%) and fat (Max 1.13±0.05%). In general, the protein and fat content of different fruits are not greater than 3.5% and 1.0% respectively (Potter, 1976). The amount of total ash (mineral) present in the selected fruits ranged from 0.21±0.01 to 3.14±0.04%. The highest amount of ash was found in elephant-apple, followed by tamarind, whereas, the minimum amount of ash was present in bilimbi. Ash content reveals the communal picture of minerals present in the food (Mumtaz et al., 2019) and this study also exposed that the more the ash content, the more the mineral content in fruits.

Among the fruits, the highest amount of fibre was present in tamarind (8.51±0.09%) which was followed by sapodilla, stone apple, and elephant apple (Table 4). A previous study indicated that some tropical fruits in Bangladesh comprise 0.32% to 2.69% fibre (Jahan et al., 2011).

The total carbohydrate content of selected fruits was 4.66±0.06 to 79.73±0.10%. The highest amount of total carbohydrate and energy content were found in tamarind, whereas, the lowest amount was found in bilimbi. From this data, it can be stated that there was a positive correlation between carbohydrates and energy content as fruits contain a very low amount of protein and fat.

The pH of the selected fruits was from 2.20±0.01 to 5.30±0.03 and titratable acidity was from 0.06±0.01-15.12±0.28% (Table 4). Among the fruits, the stone apple showed the highest pH value, whereas, bilimbi showed the lowest. In the case of titratable acidity, tamarind showed the highest amount of titratable acidity whereas; elephant apple showed the lowest.

The highest amount of TSS was present in tamarind 28.06±1.18% and the lowest (3.00±0.09%) in bilimbi (Table 4). The total sugar content is directly proportional to the sweetness of the fruits (Salma et al., 2015). The total sugar and reduced sugar content of the selected fruits were 1.61±0.03% to 27.07±1.05% and 0.99±0.03% to 17.11±1.02% respectively (Table 4). Both total sugar and reducing sugar content were the highest in tamarind.

4. Conclusion

In summary, the investigation of nutritional and physicochemical parameters of the selected fruits suggested that these fruits are an excellent source of ascorbic acid, micro and macro-minerals such as zinc, copper, manganese, iron, potassium, calcium, and magnesium. Contrariwise, Bangladeshis people tend to purchase expensive foreign fruits due to ignorance and unavailability of the data on these fruits. The current study is promising for consumers to choose cost-effective local fruits in their daily diet to fulfil their required dietary allowance for minerals and trace elements. To conclude, further study is needed to find out the sources of the contamination of the heavy metals in quite a few fruits and preventive measures to control such contamination.

Conflict of interest

The authors have no conflicts of interest to declare. All co-authors have seen and agree with the contents of the manuscript and there is no financial interest to report.

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References


Almeida, M.M.B., de Sousa, P.H.M., Fonseca, M.L.,


