Project ID-328

Competitive Research Grant

Sub-Project Completion Report

on

The Nutritional Analysis and Popularization of Minor Fruits to Rural and Urban Communities of Bangladesh

Project Duration

May 2017toSeptember 2018

Postharvest Technology Division
Bangladesh Agricultural Research Institute
Joydebpur, Gazipur-1701

Submitted to

Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Acronyms

Abbreviation	Elaboration
LOD	Limit of Detection
LOQ	Limit of Quantification
PDA	Photodiode Array
A.bilimbi	*Averrhoa bilimbi*
Z.mouritiana	*Zizyphus Mauritiana*
G. pedunculata	*Garcinia pedunculata*
G. *xanthochymus*	*Garcinia xanthochymus*
P.emblica	*Phyllunththus emblica*
D. indica	*Dilenia indica*
C.macroptera	*Citrus macroptera*
S.pinnata	*Spondias pinnata*
C.medica	*Citrus Medica*
A.pouchiflorum	*Archidendron pauciflorum*
Ca	Calcium
Mg	Magnesium
Na	Sodium
Fe	Iron
K	Potassium
P	Phosphorus
S	Sulfur
Cu	Copper
Zn	Zinc
Mn	Manganese
B	Boron
Ao	Absorbance of control
As	Absorbance of sample
FRAP	Ferric reducing antioxidant property
DPPH	2, 2-diphenyl-1-picrylhydrazyl
ROS	Reactive Oxyzen Species
CVDs	Cardiovascular diseases
OTA	Ochratoxin A

Table of Contents

Executive Summary

Minor fruits are the cheapest nutritional source and nutrition database is of great importance in addressing nutritional health benefits of rural and urban communities of Bangladesh. The present study was carried out considering documentation, conservation and promoting nutritional health of the local inhabitants and urban people of Bangladesh. Under this study, 10 minor indigenous fruits were analyzed for their phyto chemical, minerals and nutritional compositions. Nutrient data obtained from the study have been compared with published data reported in recognized journals and Books for Standard Reference. The selected minor fruits namely Bilimbi (*Averrohoabilimbi L), Ber(Zizyphus Mauritiana Lam)*,Aonla (*Phyllunththus emblica L), Elephant Apple (Dillenia India L),*Toikar (*Garcinia pedunculata)*,Daophal (*Garcinia xanthochymus*, Satkara(*Citrus macroptera)*, Hog plum (*Spondias pinnata)*, Citmron (*Citrus medica)* and Jengkol (*Archidendron Pauciflorum)*was collected according to the protocol of the sample. Results obtained from the study revealed that 7 primary metabolites (nutritional composition), 11 minerals and 19 secondary metabolites (phytochemical constituents) were determined in the selected fruits. Most of the phytochemical constituents and minerals were rich sources of the selected minor fruits. Allthe selected fruits contained high quantity of total anthocyanin, total flavonoid, total ß-carotene, ascorbic acid, total antioxidant capacity, NO free radical scavenging activity, reducing power activity, ferric reducing antioxidant property, DPPH radical scavenging activity, metallic chelating capacity, total phenolic, gallic acid, ferrulic acid and lutein content followed by other phytochemical constituents. In case of minerals, Ca, Mg, K, Na, P, S, B, Cu, Fe, Mn, Zn and B were present in the selected minor fruits. But the Ca, Mg, K, Fe, Mn, Zn and B were predominant followed by other minerals. Among the nutritional compositions, protein, sugar and starch were higher followed by other primary metabolites.However, the study demonstrated that all the selected minor fruits were rich sources of phytochemical diversity and minerals. The phytochemical diversityand minerals are known to play important rolesin the pharmaceutical industry and health benefits. Flavonoids exhibit as anti-inflammatory, antiallergic, analgesic and antioxidant as well. Rather than that, flavonoids also exhibit a wide range of biological activities such as scavenges for hydroxyl radicals. The minimum daily requirement of ascorbic acid for preventing clinical symptoms of the specific deficiency-scurvy for adults is about 10 mg or little less. The data obtained from the study confirmed that the selected minor fruits contained ascorbic acid content from 22.29 to 664.92 mg/100 g. Therefore, the daily intake of 100 g minor fruits can prevent the scurvy of the rural and urban communities in Bangladesh. Other phytochemicals obtained from the study like anthocyanin, carotenoid, ß-carotene and phenolic content can enrich and increase antioxidant activity. The strong antioxidant activities therefore could be able to reduce all kinds of cancer, anti-tumor, cell damage, carcinogenic, stroke, heart attack, coronary heart diseases, acute liver injury, diabetes and cardiovascular diseases.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. Title of the CRG sub-project: The Nutritional Analysis and Popularization of Minor Fruits to Rural and Urban Communities of Bangladesh.
2. Implementing organization: Bangladesh Agricultural Research Institute (BARI)
3. Name and full address with phone, cell and E-mail of PI/Co-PI (s):

Principal Investigator: Dr. Mohammad Mainuddin Molla
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4. Sub-project budget (Tk):
   - 4.1 Total: 200, 0000/- (Twenty lac only)
   - 4.2 Revised (if any): 200, 0000/- (Twenty lac only)

5. Duration of the sub-project:
   - 5.1 Start date (based on LoA signed): April 2017
   - 5.2 End date:30 September 2018

6 Justification of undertaking the sub-project:

Major fruits like mango, jackfruit, banana, guava, litchi etc. are commercially cultivated in Bangladesh while the minor fruits like Palmyra palm (Taal- *Borassus flabellifer* L), Hog plum (*Spondias pinnata)*, Bilimbi(*Averrohoa bilimbi L)*, Batabi Pumello (*Citrus grandis* Osbeck), Lotkon (*Pirardia sapidia*), Karamcha (*Carisa carundus*), Bael (*Aegle marmelos L Corr.*), Dewa (*Artocarpus lakoocha*), Bread fruit (*Artocarpaus altilis*), Egg plant (*Dillenia india* L), Aonla (*phyllunththus embelica L*) etc. are not commercially cultivated and harvested. In Bangladesh, these are grown in homesteads, forest areas and at roadsides and near railway without much care. That is why these fruits are termed as minor/underutilized fruits because of less awareness of its nutrient value among the mass people. But these minor fruits can be a good source of micronutrients

and phytochemicals. Micronutrients are essential for good health and nutrition, advancing physical and intellectual development. Low dietary intake of micronutrient rich foods as well low absorption and lower bioavailability are the leading cause of the micronutrient deficiencies. Phytochemicals with antioxidant capacity naturally present in fruits are of great interest due to their beneficial effects on human health while the regular consumption of its is associated with reduced the risk of developing chronic diseases such as aging, inflammation, cancer and cardiovascular diseases (CVDs) (Liu, 2004; Paul, 2013) as they offer protection against oxidative deterioration (Scalbert and Williamson, 2000). Nowadays, antioxidants are also considered as important as vitamins for promotion of health and prevention of various diseases linked to reactive oxygen species (ROS). ROS have been linked to over 100 disorders (Halliwell and Gutteridge, 2000). Excess generation of ROS causes oxidative stress that damage DNA, lipids and proteins of cells leading to pathogenesis of various diseases including CVDs.

Nutrition database can play an important rule in addressing nutritional health benefits of rural and urban communities of Bangladesh. It is essential for planning food, nutrition and health related policy tools also. At present, the Bangladesh government has also been emphasized the food and nutrition security in their sustainable development goal (SDG-1 and 2) policy. But unfortunately Bangladesh has a little information on nutrition database on minor fruits of its own. Still now the phytochemical studies as well as antioxidant properties of minor fruits are not scientifically documented and projected towards the consumers. On the other hand, urban elite people consider the minor fruit as inferior fruit since those are eaten by the poor people. So, documentation, conservation and revalorizing indigenous knowledge on minor fruits is essential to promote nutritional health of the local inhabitants and urban people. Keeping view on mind, the present research has undertaken to analyze, document and popularize the nutritional profile especially phytochemical content in highlighting the phenols, flavonoids, and carotenoids of selected minor fruits of Bangladesh.

7 Sub-project goal:
Improvement of human nutrition as well as lifestyle of rural and urban people by diversification of dietary habits

8 Sub-project objective (s):
- To document the nutritional composition of the selected minor indigenous fruits
- To document the mineral composition of the selected minor indigenous fruits
- To document phytochemical diversity of the selected minor indigenous fruits

9 Implementing location (s): Postharvest Technology Division, BARI, Joydebpur, Gazipur.

10 Methodology in brief:

Sample collection

BARI fruit varieties/advance lines were collected from the orchard ofRegional Agricultural Research Station (RARS), Akbarpur, Moulvibazar; Citrus Fruit Research Station, Jointapur, Sylhet; RARS, Jamalpur and Fruit Research Field, Horticulture Research Center (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. Ainci gola (*Archidendron Pauciflorum*) fruits were collected from Technaf and Cox's Bazar.Every samplewasreplicated three times for analysis of every nutrient constituent in the fruit.

Total phenolic content

Twenty milligrams (0.02g) of each dried powder were dissolved in 1 mL of methanol to prepare a stock-solution for experiments. The total concentration of phenolic (TPH) in the extracts was determined according to the Folin-Ciocalteu method (Ough and Amerine, 1988) with gallic acid (GA) as the standard and expressed (mg) as gallic acid equivalents (GAE)/g of extract (Aoshima and Ayabe, 2007) using the following equation:

Calculation

The total Phenolic Content C = C1 x v/m x DF----------(1)

C1= Concentration of GAE established from the calibration curve in mg/ml

V= volume of extract in mL

M= Weight of plant extract in g

DF= Dilution factor

Determination of total flavonoid content

The total flavonoid content (TFC) of fruit extracts were determined by aluminium chloride method (Chang *et al.,* 2002) with slight modifications. Sample solution was prepared by mixing sample in methanol at a concentration of 1 mg/ml. Then 0.5 ml of sample solution was mixed with 1.5 ml of methanol. To this mixture 0.1 ml of 10 % aluminium chloride and 0.1 ml of 1 M potassium acetate was added. The final volume was made to 5 ml by adding 2.8 ml distilled water and left the reaction for 30 minutes at room temperature. The absorbance of the resulting reaction mixture was measured at 415 nm using UV-vis spectrophotometer. Total flavonoid content expressed as quercetin equivalent per 100 g of extract (mg QE/100 g).

Calculation:

The percentage of total flavonoid content (TFC) was calculated from calibration curve of quercetin plotted. The curve obtained was found to be linear with equation y = 0.0018 + 6.9055*x and the correlation coefficient was found to be R^2 = 0.9986. Total flavonoid content was expressed as milligram quercetin equivalent per gram of extract (mg QE/g extract) as given below:

$$TFC = \frac{TFC_{test\ solution} \times 1.25 \times 50}{w - id} \quad \text{----------2)}$$

Where, $TFC_{testsolution}$ is the total concentration of flavonoids in the test solution (mg/mL),1.25 corresponds to the dilution factor, 50 is the volume of the stock solution (mL), *w* is the mass of extract material (g), and *ld* is the loss on drying of extract.

Determination of ferric reducing antioxidant property (FRAP):

FRAP activity of the samples was measured by the method of Benzie and Strain (1996). Briefly, a 40 µL aliquot of properly diluted sample extract was mixed with 3 mL of FRAP solution. The reaction mixture was incubated at 37°C for 4 min and the absorbance was determined at 593 nm in a UV-Vis spectrophotometer against a blank that was prepared using distilled water. FRAP solution was pre warmed at 37°C and prepared freshly by mixing 2.5 mL of a 10 mM 2,4,6-TPTZ [2,4,6-tri(2-pyridyl)-1,3,5-triazine] solution in 40 mM hydrochloric acid with 2.5 mL of 20 mM ferric chloride and 25 mL of 0.3 M acetate buffer (pH 3.6). A calibration curve was prepared, using an aqueous solution of ferrous sulfate (1-10 mM). FRAP values were expressed as µM of ferrous equivalent Fe (II) per 100 g of sample.

Determination of DPPH radical scavenging activity:

Radical scavenging activity of the sample was measured by determining the inhibition rate of DPPH (2, 2-diphenyl-1-picrylhydrazyl) radical (1995). Precisely, 100 µL of extracts were added to 1.4 mL DPPH radical methanolic solution (10^{-4} M). The absorbance at 517 nm was measured at 30 min against blank (100 µL methanol in 1.4 mL of DPPH radical solution) using a UV-Vis Spectrophotometer. The results were expressed in terms of radical scavenging activity.

Radical scavenging activity (%) = [(Ao-As)/ Ao] × 100---- I

Where, Ao is absorbance of control blank, and As is absorbance of sample extract. Then the inhibition curves were prepared and IC_{50} values were calculated. BHT was used as positive control.

Determination of metal chelating capacity:

Metal chelating capacity was determined based on the method of Dinis et al.,1994, an aliquot of 100 µL sample extract was added to 100 µL of 1mM ferrous chloride and 3.7 mL of distilled water. The reaction was initiated by adding 200 µL of 5mM ferrozine. After 20 min incubation at room temperature, the absorbance at 562 nm in a UV-Vis spectrophotometer was recorded. The control contained all the reaction reagents except the extract. Decreased absorbance of the reaction mixture indicated increased activity.

Chelation activity [%] = [(Ao-As)/ Ao] ×100----------II

Where, Ao is absorbance of control blank, and As is absorbance of sample extract.

Determination of Vitamin C:

Vitamin C was extracted from 0.5 g of dried fruits samples in 4.5 mL of 5% w/v aqueous solution of metaphosphoric acid containing 1% w/v dithiothreitol (DTT) following the protocol described by Külenetal [7] and estimated using modified DNP method reported by Cho et al. [17]. The vitamin- C content was expressed in mg/100 g DW.

Determination of total carotenoid content:

Determination of total carotenoid content performed by Thaipong method using Spectro UV-Vis. Absorbance was measured at λ 470 nm, each extract was dissolved in n-hexane pro analysis. Beta-carotene solution in various concentration used as standard of carotenoid compound and to be standard curve. Linier regression equation of standard curve was used for calculating total carotenoid content. Total carotenoid content expressed as beta-carotene equivalent per 100 g of sample (mg/100 g).

B-carotene: **β carotene** content was estimated by the method of Holden, 1981 and values were expressed as µg/100g.

(a) Standard solutions: Weigh with an accuracy of 0.01 mg ca 6 mg all-*trans*-β-carotene reference material into 100 mL volumetric flask, dissolve in about 20 mL tetrahydrofuran by treating in an ultrasonic bath for about 30s. Dilute to volume with tetrahydrofuran (60 µg/mL). From this standard stock solution, pipet exactly aliquots of 5 mL into two 100 mL volumetric flasks. Dilute to volume with cyclohexane in one flask [standard measuring solution, 3 µg/mL β-carotene in cyclohexane-tetrahydrofuran (95 + 5)]. Pipet 5 mL tetrahydrofuran into the other flask and dilute to volume with ethanol [standard working solution, 3 µg/mL β-carotene in ethanol-tetrahydrofuran (9+1)]. Store standard stock, measuring and working solutions at 5°C and use only on day of preparation.

(b) Spectrophotometry: Measure absorption of the standard measuring solution against cyclohexane at the maximum, ca 456 nm. Calculate concentration of β-carotene, C_{std}, as follows:

$$C_{std}(mg/L) = E \times 10\,000/2500$$

Here E is the absorption at the maximum, 2500 is the $E_{1\%,\,1\,cm}$ of pure all-*trans*-β-carotene in cyclohexane, and 10 000 is the factor to convert % to mg/L.

Calculation the apparent $E_{1\%,\,1\,cm}$ of the reference substance (ap $E_{1\%,\,1\,cm}$) used to prepare the standard solutions as follows:

Apparent $E_{1\%,1cm} = E \times 10\,000 \times 2/W$

Where E is the absorption at the maximum, 10 000 is the factor to convert mg/L to %, 2 is the theoretical volume (in L) in which the reference substance is dissolved, and W is the weight of the reference substance (in mg). The apparent $E_{1\%,\,1\,cm}$ must exceed 2375 for a spectrophotometric purity >95%.

Total antioxidant activity:

The total antioxidant capacity of the fruit sample was evaluated by the phosphomolybdenum method according to the procedure described by Prieto et al. [1999]. Briefly 0.3 mL of Averrhoa bilimbi fruit extracts (lyophilized aqueous extract, petroleum ether, ethyl acetate, butanol and aqueous extracts) was mixed with 3 mL of reagent solution (0.6 M sulphuric acid, 28 mM sodium phosphate and 4 mM ammonium molybdate). Reaction mixture was incubated at 95ºC for 90 minutes under water bath. Reading was taken at 695 nm after cooling to room temperature. Total antioxidant activity is expressed as the number of equivalents of ascorbic acid.

Total reducing power:

The reductive potential of the extract was determined by the method of Oyaizu [1986]. The different concentrations of extracts and standard in 1ml of distilled water were mixed with phosphate buffer (0.2 M, pH 6.6) and potassium ferricyanide (1% w/v). The mixture was incubated at 50ºC for 20 minutes and then 10% of Trichloroacetic Acid (TCA) was added to the mixture, subjected to centrifugation for 10 minutes. The upper layer of solution was taken, mixed with distilled water and 0.1% $FeCl_3$. Read the absorbance at 700 nm. Ascorbic acid was the reference standard.

Nitric oxide radical scavenging assay:

Nitric oxide radical scavenging was determined by the method of Garatt [1964]. 2 mL of 10mM sodium nitroprusside was mixed with 0.5 mL fruit extracts (methanol extract) at various concentrations and incubated at 25ºC for 150 minutes. Then 0.5 mL of Griess reagent was added to 0.5 mL incubation mixture and absorbance was read at 540 nm after 30 minutes against reagent blank. Ascorbic acid, a potent free radical scavenger, was used as the reference standard. The percentage inhibition was calculated by using the formula;

Inhibition (%) = (control - test) / control x 100

Phenolic compound determination

Fruits extract were extracted from 1,000 mg dried powdersamples in a ultrasonic bath with 20 mL methanol and 1% BHT at 25°C for 40 min. Extracts were centrifuged at 1,200 × *g* and the supernatants were filtered through a 0.2 µm polyamide membrane and stored at –20°C. HPLC analyses were performed using a pump, an auto-sampler and a PDA diode array detector with 5 cm flow cell and with a system manager as data processor. Separation was achieved by a reversed-phase C_{18} column (5 µm particle size, 250 × 4.6 mm). The mobile phase consisted of 1% aqueous acetic acid solution (A) and methanol (B). Samples were eluted with the following gradient: 90% A from 0 to 27 min, from 90 to 60% A in 28 min, 60% A for 5 min, from 60 to 56% A in 2 min, 56% A for 8 min, from 56 to 90% A in 1 min and 4 min 90% A to re-establish the initial conditions, before

the injection of another sample. All gradients were linear. The flow rate was 1 mL/min and the injection volume were 20 µL. Column temperature was maintained at 20°C.

Chromatograms (SHIMAZU Co Ltd, Tokyo Japan) were acquired at three different wavelengths (254, 278 and 300 nm) according to absorption maxima of analyzed compounds. Each compound was identified by its retention time and by spiking with standards under the same conditions. The identities of constituents were also confirmed with a photodiode array (PDA) detector by comparison with ultraviolet (UV) spectra of standards in the wavelength range of 220–450 nm. Each compound was quantified according to the peak area measurements, which were reported in calibration curves of the corresponding standards. Data are reported as means ± standard deviations of three independent analyses

A chromatogram of the external standard mixture recorded at 278 nm is presented in Fig.1. As shown in the chromatogram, all compounds had responses at 278 nm, where they were successfully separated. The constituents under investigation were also identified by the recorded absorption spectra, which were comparable both for fruit extracts and standard substances.

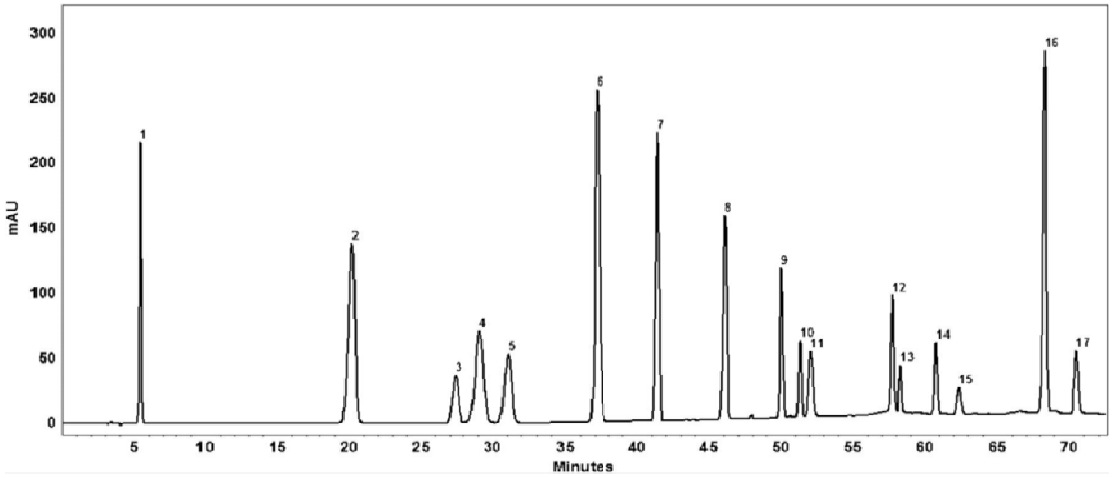

Figure 1. Chromatogram of an external standard mixture at λ = 278 nm. Peaks 1, gallic acid; 2, catechin hydrate; 3, vanillic acid; 4, chlorogenic acid; 5, caffeic acid; 6, syringic acid; 7, epicatechin; 8, p-coumaric acid; 9, ferulic acid; 10, sinapic acid; 11, salicylic acid; 12, rutin; 13, ellagic acid; 14, myricetin; 15, juglone; 16, trans-cinnamic acid; 17, quercetin.

LOD and LOQ

The LOD and LOQ of the individual compounds were calculated based on a signal-to-noise (S/N) ratio > 3, using the following formulas:

$$\mathrm{LOD} = 3 \times c/(S/N), \mathrm{LOQ} = 10 \times c/(S/N)$$

Where,*c* = concentration.

The S/N ratio was calculated by the Chrom Quest 4.2 software

11. Results and Discussion

Bilimbi (*Averrhoa bilimbi L*)

Abstract

Bilimbi (Averrhoa bilimbi, L.)isunderutilized minor fruits in Bangladesh and its cultivation is limited to Sylhet, Brakhonbaria and Comilla. A study was conducted in order to analyze and document the primary (nutritional compositions-sugar, crude protein, starch, acidity, pH, ash, moisture content) and secondary metabolites (phytochemicals) of *A. bilimbi* fruit. Secondary metabolites especially anthocyanin, flavonoids, carotenoids, ascorbic acid content, ß-carotene, total phenolic content, total antioxidant capacity, NO free radival scavenging activity, DPPH free radical scavenging activity, gallic acid and vanilic acid was highly present in the fruit. The fruit contained 192.97±1.01mg/100 g of ascorbic acid where the minimum daily requirement of ascorbic acid for preventing clinical symptoms of the specific deficiency-scurvy for adults is about 10 mg or little less. Thus the daily intake of 100 g bilimbi fruit may prevent the scurvy and cardiovascular diseases.

Introduction

Bilimbi (Averrhoa bilimbi*L*) commonly known as Bilimbi/Cucumber Tree belongs to family Oxalidaceae.It is a tropical tree, more sensitive to cold especially when very young. It prefers direct sunlight and seasonally humid climates, with evenly distributed rainfall throughout most of the year but there should be a 2-3 month dry season (Roy *et al*., 2011). The fruit is crisp when unripe, turns from bright-green to yellowish-green, ivory or nearly white when ripe and falls to the ground. The outer skin is glossy, very thin, soft and tender, and the flesh green (Fig.1). Its may consume as sour in the curry with fish and also suitable for preparation of jam, jelly and cooling beverages.The fruit is available in Bangladesh from Mid-April to mid-August. Its main growing area is in Sylhet, Brakhonbaria and Comilla but possible to cultivate in other parts of the country.

Bilimbi is a native of Moluccas, but the Bilimbi is cultivated throughout Indonesia, Philippines, Ceylon and Burma. It is very common in Thailand, Malaya and Singapore; frequent in gardens across the plains of India.

The plant has an enormous fiscal value since most of the parts like leaves, bark, flowers, fruits, seeds, roots or the whole plant are used as alternative medicine to treat a variety of diseases. It is used for the treatment of fever, mumps, pimples, inflammation of the rectum and diabetes, itches, boils, rheumatism, syphilis, bilious colic, whooping cough, hypertension, stomach ache, ulcer and as a cooling drink (Kumar *et al.,* 2011). When used in high concentrations the fruit juice can lead to acute renal failure due to acute tubular-necrosis, owing to its high oxalate contents which results in intra-tubular oxalate crystal deposition.

There are few studies have been done previously on phytochemical constituents, screening and antimicrobial using Bilimbi fruits in India and Malaysia. Since the phytochemicals, minerals and other physiochemical compositions vary due to various environmental factors such as soil, agro-ecological zone, temperature, humidity, cultural management etc. and it is also new approach to cultivate in Bangladesh. To the best of our concern, no study has been done in Bangladesh context. Therefore, this

study has undertaken to analyze and documents the phytochemical components, minerals and other nutritional compositions of the Bilimbi fruits.

Materials and methods

Material: Bilimbi (BARI advanced line)

Methods: Described in methodology section

Figure 1. Bilimbi (*Averrhoa bilimbi L*)

Results and discussion

Nutritional compositions

The presence of primary metabolites like crude protein, ash, sugar, starch, moisture content, TSS, acidity and pH are 10.18±0.01%,4.33±0.01%, 4.07±0.02%, 6.13±0.02%, 78.77±0.10 %,8.70%,1.84±0.02% and 2.14±0.02% respectively.

Mineral contents

Table 2 shows the mineral composition in the Bilimbi fruit. Amount of Ca, Mg, K, P, S, Cu, Fe, Mn, Zn and B in the fruit. It was noted that the fruit contain higher amounts of copper, zinc, manganese and Boron. The daily micro mineral requirements of an adult man are as follows: 10–15 mg iron/day, 12–15 mg zinc/day and 2–3 mg copper/day (Berdanier, 1998; Smolin& Grosvenor, 2000; Wildmanand Medeiros, 2000). Therefore, the fruits, to some extent, can meet the daily requirement of these minerals.

Phytochemical constituents

The results of the phytochemical constituents are presented in table 3. Methanol extracts of *the* Bilimbi fruit was used to estimate phytochemical content viz. total anthocyanin, total flavonoids, total carotenoids, total ß-carotene, ascorbic acid, total antioxidant capacity, NO free radical scavenging activity, reducing power activity, ferric reducing antioxidant property, DPPH free radical scavenging activity, metallic chelating capacity, IC_{50}, total phenolic content, gallic acid, vanilic acid, þ-courmaric acid, caffeic acid, ferulic acid and lutein. The results revealed that the Bilimbifruitswas good source of phytochemical constituents as it contains of anthocyanin content 47.46±0.22 mg/100g, total flavonoid

content 150.02±1.17 mg QE/ g, total ß-carotene content 39.33±1.52 µg/100g, ascorbic acid content 192.97±1.01 mg/100g, total antioxidant capacity 108.07±0.46µg of ascorbic acid/mg of extracts, NO free radical scavenging activity 70.50±1.0µg/ml, reducing power activity 18.71±0.01µg/ml, ferric reducing antioxidant property 1817.88±3.62 µM/100g, DPPH radical scavenging activity 73.27±0.25%, metallic chelating capacity 28.41±0.09 %, and total phenolic content 192.97±1.01mg GAE/g followed by IC_{50}30.36±1.32 µg/ml. Gallic acid 82.01±0.02 mg/100g, vanilic acid 70.50±0.43 mg/100 g, ferulic acid 9.59±0.06 mg/100 g and lutein 91.13±3.80 µg/100g also higher in *A. bilimbi* fruit followed by Þ-courmaric acid 0.96±0.02 mg/100g and caffeic acid 0.05±0.01 mg/100 g respectively (Table 3).*The* Bilimbi fruit contained 192.97±1.01mg/100 g of ascorbic acid where the minimum daily requirement of ascorbic acid for preventing clinical symptoms of the specific deficiency-scurvy for adults is about 10 mg or little less (Food and Agriculture Organization (FAO), 1998). Therefore, the daily intake of 100 g bilimbi fruit can prevent the scurvy in Bangladesh. The lowest IC_{50} means that the fruit had the strongest radical scavenging activity. Higher chelating activity (28.41±0.09 %) of the extracts suggest that the fruit minimize the concentration of metal in the Fenton reaction. The fruit had the highest reducing power activity where reducing power reportedly, the activity of antioxidants is concomitant with the development of reducing power (Duh *et al*., 1999). The fruit contains total antioxidant capacity because it exhibited extensive DPPH free radical scavenging activity and reducing power (Table 3). Higher total phenolic content in the fruit suggest that the antioxidative activities were increased. Antioxidants are believed to intercept the free radical chain of oxidation and donate hydrogen from their phenolic hydroxyl groups, thereby forming a stable end-product, which does not initiate or propagate further oxidation of lipids (Sherwin, 1978). A. bilimbi fruit contained higher content of total flavonoid content (150.02±1.17mg QE/ g) compared to other minor fruits '*Spondias axillaris* (7.83±0.17) and *Eriolobus indica* (17.48±0.31) described by Pandey *et al*. (2018). The higher flavonoid content suggest that the fruit may capable to inhibit the α-amaylase and α-glucosidase, means that the fruit may have hyperglycemic effects (Hanamura *et al*., 2006), and inhibit the development of diabetes (Zunimo *et al.,* 2007).

Table 1. Nutritional composition, edible and non-edible portion ofBilimbifruits

Sl. No.	Nutritional composition	Quantity (%)
1	Crude protein	10.18±0.01
2	Ash	4.33±0.01
3	Total sugar	4.07±0.06
4	Starch	6.13±0.02
5	Moisture content	78.77±0.10
6	TSS t	8.70±0.20
7	Acidity	1.84±0.02
8	pH	2.14±0.02
9	Edible portion	98.00±1.00
10	Non-edible portion	2.00±0.01

Table 2. Mineral content of Bilimbi fruits

Sl. No.	Mineral content	Quantity
1	Ca	0.58±0.00
2	Mg	0.31±0.00
3	K	1.07±0.01
4	Na	0.18±0.01
5	P	0.12±0.00
6	S	0.06±0.00
7	B	20.00±0.02
8	Cu	14.31±0.06
9	Fe	107.53±0.97
10	Mn	57.48±0.21
11	Zn	81.78±0.03

Ca, Mg,K, Na, P and S expressed as percentage; B, Cu, Fe, Mn and Zn expressed as ppm; 1 ppm=1mg/kg~0.1mg/100g. Daily requirement of Ca (1300 mg/day), Mg (24±0.9 mg/day), Fe (.37 and 2.94 mg/day for men and women), Zn (1.4 mg/day) and K (3510 mg/day) (FAO and WHO, 2001).

Table 3. Phytochemical content of B*ilimbi*fruits

Sl. No.	Phytochemicals	Quantity
1	Total anthocyanin content (mg/100g)	47.46±0.22
2	Total flavonoid content (mg QE/g)	150.02±1.17
3	Total carotenoid content (mg/100g)	4.71±0.30
4	Total ß-carotene content(µg/100g)	39.33±1.52
5	Ascorbic acid content (mg/100g)	192.97±1.01
6	Total antioxidant capacity (µg of ascorbic acid/mg of extracts)	108.07±0.46
7	NO free radical scavenging activity (µg/ml)	70.50±1.0
8	Reducing power activity (µg/ml)	18.71±0.01
9	Ferric reducing antioxidant property (µM/100g)	1817.88±3.62
10	DPPH radical scavenging activity (%)	73.27±0.25
11	Metallic chelating capacity (%)	28.41±0.09
12	IC_{50} (µg/ml)	30.36±1.32
13	Total phenolic content (mg GAE/g)	192.97±1.01
14	Gallic acid (mg/100g)	82.01±0.02
15	Vanilic acid (mg/100g)	70.50±0.43
16	Þ-courmaric acid (mg/100g)	0.96±0.02
17	Caffeic acid (mg/100g)	0.05±0.01
18	Ferulic acid (mg/100g)	9.59±0.06
19	Lutein (µg/100g)	91.13±3.80

Conclusion

Indigenous minor fruit *the* Bilimbi *fruit* was analyzed for its nutritional, minerals and phytochemicals. A total of 19 active phytochemical principles were detected in the FTRI investigation of the methanolic extract. Higher presence of anthocyanin, flavonoids, ß-carotene, ascorbic acid, antioxidant capacity and Phenols indicate that the fruit have medicinal values that can be utilized for production of novel drugs to combat various diseases especially all kinds of cardiovascular diseases. Further studies are recommended to be undertaken to separate the exact compounds and to evaluate the mechanism of actions scientifically and synergistically.

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Ber (*Zizyphus Mauritiana Lam*)

Abstract

Ber *(Ziziphus Mauritania)* locally called Tok Boroi (Sour kul) with its English name Jujube/Ber while it belongs to the family Rhammaceace. Qualitative Phytochemical of the extracts shows the presence of 19 secondary metabolites (total anthocyanin, total flavonoids, total carotenoids, total ß-carotene, ascorbic acid, total antioxidant capacity, NO free radical scavenging activity, reducing power activity, ferric reducing antioxidant property, DPPH free radical scavenging activity, metallic chelating capacity, IC_{50}, total phenolic content, gallic acid, vanilic acid, þ-courmaric acid, caffeic acid, ferulic acid and lutein), 7 primary metabolites (Acidity, pH, Moisture, ash, crude protein, sugar and starch content) and 11 mineral compositions (Ca, Mg, K, Na, P, S, B, Cu, Fe, Zn and Mn). The extracts therefore could be used as the justification for its ethno medicinal importance and in the pharmaceutical industries.

Introduction

Ber while it's Bengali name is Tok boroy and its English name is Ber or Jujube with the scientific name of *Zizyphus Mauritiana Lam*(Figure 1). Its belong to the family of Rhamnaceae. Ziziphus mauritiana Lam. is grown in dry places and found in all over country. Considering the production and yield, it's best growing area is in Borishal, Rajshahi, Khulna, Comilla, Mymensingh, Sylhet, Gazipur and Narsingdi. Although there are different varieties on zuzube in Bangladesh but the country have only one sour ber variety as the name of BARI Kul-1 that is released by Bangladesh Agricultural Research Institute (BARI). The ripe fruits of *Z. mauritiana* are mostly consumed raw and suitable for preparation of dehydrated products. The dried fruits are suitable for preparation of pickles and chutney. Literature suggest that the fruits contain phytochemicals constituents and other physiochemical properties (Abubakar El-Ishaq and Nangere, 2016; Kumar *et al.,* 2017). To the best of our knowledge no phytochemical diversity of Z.mauritania has been well documented. Hence, the present study was aimed to document a highly complex profile containing approximately 19 phytochemicals constituents, 7 nutritional compositions and 11 minerals content of the fruit.

Figure1.BARI Sour Kul-1 **(***Zizyphus Mauritiana Lam***)**

Materials and Methods

Materials: BARI Sour Kul-1

Methodology: Described in methodology section.

Results and discussion

Nutritional compositions

The results of nutritional composition of the Berare shown in Table 1. The fruit contain 82.27% moisture content, 16.44% TSS, 6.15% starch (carbohydrate), 3.18% crude protein, 4.35% total sugar, 1.95% acidity, 2.88% pH and 3.21% ash. Moisture content was the highest value while the carbohydrate was least. The edible portion of the Ber fruit was 88.37% while the non-edible portion was 9.37% only.

Mineral content

Mineral content of the Berfruit are presented in Table 2. It was noted that the fruit contain higher content of Ca(1.02±0.05%), Cu (8.60±0.26 ppm), Fe (155.78±1.31ppm), Zn (93.84±0.78 ppm), B (10.73±0.50 ppm) and Mn(153.71±1.21 ppm). The daily micro mineral requirements of an adult man are as follows: 10–15 mg iron/day, 12–15 mg zinc/day and 2–3 mg copper/day (Berdanier, 1998; Smolin& Grosvenor, 2000; Wildmanand Medeiros, 2000). Therefore, the fruits, to some extent, can meet the daily requirement of these minerals.

Phytochemical constituents

The results of the phytochemical constituents are presented in table 3. The study showed thattotal ß-carotene (41.66±0.76µg/100g), ascorbic acid (160.12±0.11mg/100 g), total antioxidant capacity (242.78±0.02 µg of ascorbic acid/mg of extracts), NO free radical scavenging activity (72.00±1.0 µg/ml), ferric reducing antioxidant property (549.12±0.42 µM/100g), DPPH free radical scavenging activity(74.89±1.12%) and total phenolic content (26.50±1.17 mg GAE/g) was highly present in Berfollowed by total anthocyanin, total flavonoids, total carotenoids, reducing power activity, metallic chelating activity, gallic acid, vanilic acid, þ-courmaric acid, caffeic acid, ferulic acid and lutein (Table 3).The IC_{50} was calculated as 38.27±0.73 µg/ml in methanol extract of Ber fruit was found to be effective in scavenging radicals. The higher absorbance shows greater reducing power of the plants.Ber fruit contained 160.12±0.11mg/100 g of ascorbic acid where the minimum daily requirement of ascorbic acid for preventing clinical symptoms of the specific deficiency-scurvy for adults is about 10 mg or little less (Jukes, 1974). Therefore, the daily intake of 100 g sour kul (*Z. mauritiana*) fruit can prevent the scurvy in Bangladesh. The methanol extract of *Z. mauritiana* fruits exhibit strong antioxidant activity in the sample. Higher presence of flavonoids effectively scavenge most of oxidizing agents and other free radicals involved in several diseases. Total phenols and flavonoids possess diverse chemical and biological activities including radical scavenging properties due to cleaving complex chemical structures. The fruits had higher total antioxidant capacity (242.78±0.02 µg of ascorbic acid/mg of extracts) means that it had the strongest radical scavenging activity. Higher presence of antioxidants are useful for the management of those diseases due to their scavenging activity (Kumar *et al*., 2017).

Table 1. Nutritional composition, edible and non-edible portion of *BARI Sour Kul-1*

Sl. No.	Nutritional composition	Quantity (%)
1	Crude protein	3.18±0.09
2	Ash	3.21±0.10
3	Total sugar	4.35±0.40
4	Starch	6.15±0.02
5	Moisture content	82.27±0.28
6	TSS	16.44±0.05
7	Acidity	1.95±0.05
8	pH	2.88±0.07
9	Edible portion	88.37±0.31
10	Non-edible portion	9.30±0.09

Table 2. Mineral content of *BARI Sour Kul-1*

Sl. No.	Mineral content	Quantity
1	Ca	1.02±0.05
2	Mg	0.57±0.03
3	K	0.87±0.03
4	Na	0.22±0.00
5	P	0.13±0.00
6	S	0.36±0.00
7	B	10.73±0.50
8	Cu	8.60±0.26
9	Fe	155.78±1.31
10	Mn	153.71±1.21
11	Zn	93.84±0.78

Ca, Mg,K, Na, P and S expressed as percentage; B, Cu, Fe, Mn and Zn expressed as ppm; 1 ppm=1mg/kg~0.1mg/100g. Daily requirement of Ca (1300 mg/day), Mg (24±0.9 mg/day), Fe (.37 and 2.94 mg/day for men and women), Zn (1.4 mg/day) and K (3510 mg/day) (FAO and WHO, 2001).

Table 3. Phytochemical constituents of *BARI Sour Kul-1*

Sl. No.	Phytochemicals	Quantity
1	Total anthocyanin content (mg/100g)	2.04±0.06
2	Total flavonoid content (mg QE/g)	2.26±0.09
3	Total carotenoid content (mg/100g)	1.86±0.20
4	Total ß-carotene content(µg/100g)	41.66±0.76
5	Ascorbic acid content (mg/100g)	160.12±0.11
6	Total antioxidant capacity (µg of ascorbic acid/mg of extracts)	242.78±0.02
7	NO free radical scavenging activity (µg/ml)	72.00±1.0
8	Reducing power activity (µg/ml)	1.66±0.01
9	Ferric reducing antioxidant property (µM/100g)	549.12±0.42
10	DPPH radical scavenging activity (%)	74.89±1.12
11	Metallic chelating capacity (%)	14.82±0.07
12	IC5 (µg/ml)	38.27±0.73
13	Total phenolic content (mg GAE/g)	26.50±1.17
14	Gallic acid (mg/100g)	2.46±0.05
15	Vanilic acid (mg/100g)	0.022±0.01
16	Þ-courmaric acid (mg/100g)	5.54±0.03
17	Caffeic acid (mg/100g)	0.02±0.00
18	Ferulic acid (mg/100g)	0.02±0.00
19	Lutein (µg/100g)	105.66±12.09

Conclusion

The analytical results of the *Ber fruits* confirmed that the fruit is the good source of phytochemical constituent while the few constituent are highly presence in the fruits. The presence of these phytochemicals indicates the *BARI Sour Kul-1* has health benefits effect and importance in pharmaceutical industry.

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Toikar (*Garcinia pedunculata*)

Abstract

Multi-diversity of phytochemicals, mineral contents and nutritional compositions of*Toikr(Garcinia pedunculata)* fruits were analyzed for its nutritional, minerals and phytochemicals documentation. *Toikar fruit* was found to contain important phytochemicals viz. total flavonoid (18.33±1.12 mg QE/g), total ß-carotene (45.00±0.50 µg/100g), ascorbic acid (142.81±0.99 mg/100 g), total antioxidant capacity (504.00±1.00 µg of ascorbic acid/mg of extracts), NO free radical scavenging activity (59.51±0.01µg/ml), ferric reducing antioxidant property (1815.88±3.62µM/100g), DPPH free radical scavenging activity (98.24±0.09 %) and total phenolic content (62.74±0.87 mg GAE/g) out of 19 secondary metabolites. Minerals like Ca, Mg, B, Fe, Mn and Zn of *Toikar* fruits were highest out of the eleven mineral compositions.Therefore, the results of the present study indicate that *Toikar* fruits are the good sources of bioactive compounds that may play an important role in the human body and pharmaceuticals industry.

Introduction

*Toikar (Garcinia pedunculata)*is an indigenous medicinal plant that belongs to the family Clusiaceae and is commonly known as "Toikar" in Bangladesh. Its main growing area is concentrated in Sylhet region but possible to cultivate in other parts of the Bangladesh. It's available in Bangladesh from April to June. In Bangladesh have only one variety as the name of BARI Toikar-1. The mature fruit is green and when ripen it turns from greenish to yellow (Figure1). The fruit is consumed as sour by cooking with vegetable curry and also may be used for preparation pickles, chutney, jam and jelly. So far our knowledge, the fruit extract has been reported to evaluate the antihyperglycemic, antidiabetic and antioxidant effects in rats (Ali *et al.,* 2017). But best of our concern, no details study has been well documented for the phytochemical diversity, minerals content and nutritional compositions. Therefore, the aim of present study was to document the nutritional composition, minerals and phytochemical diversityof the *Toikar.*

Figure 1.BARI Toikar-1 (*Garcinia pedunculata*)

Materials and methods

Material: BARI Toikar-1

Methodology: Described in methodology section.

Results and discussion

Nutritional compositions

The result of nutritional composition of BARI Toikar-1 is shown in Table 1. The fruit contain 84.16% moisture content, 14.20% TSS, 7.85% starch (carbohydrate), 6.06% crude protein, 4.02% total sugar, 2.40% acidity, pH 3.09% and 5.49% ash. Moisture content was the highestwhile the carbohydrate was least present in BARI Toikar-1. The edible portion of the BARI Toikar-1was 84.03% while the non-edible portion was 15.33%.

Mineral contents

Table 2 show the minerals contentin the investigatedfruit. Investigation showed that Fe (395.52±1.77 ppm) and Mn (238.26±1.07 ppm) were largely presents in the fruits while the Na (0.19±0.00%) was the least.Iron deficiency leads to reduction of physical working capacity in animals and man (Scrimshaw, 1984) and the impairment of immunologic response and phagocytic action of neutrophil leukocytes. Iron has several essential roles in the body such as in oxygen transport and oxidative metabolism (Bothwell, 1979).Deficiency of Mn may responsible for growth retardation, changes in circulating HDL cholesterol and glucose levels and reproductive failure. But the level of < 1 to > 10 mg Mn/d intake associated with adverse effects (both deficient and toxic) are debatable. Ca salts provide rigidity to the skeleton and calcium ion plays a role in many if not most, metabolic processes. Many neuromuscular and other cellular functions depend on the maintenance of the ionized calcium concentration in the extracellular fluid. Calcium fluxes are important mediators of hormonal effects on target organs through several intracellular signaling pathways (FAO/WHO, 1998). Mg plays an important role in the metabolism of calcium (Al Ghamdi *et al.,* 1994).However, all the minerals content in BARI Toikar-1have vital roles to play in the metabolism of living organisms especially man.

Phytochemical constituents

Table 3 represents the phytochemical constituents of the BARI Toikar-1 fruits. The results revealed that 19 phytochemicals were present of theBARI Toikar-1 fruits while total flavonoid (18.33±1.12 mg QE/g), total ß-carotene (45.00±0.50 µg/100g), ascorbic acid (142.81±0.99 mg/100 g), total antioxidant capacity (504.00±1.00 µg of ascorbic acid/mg of extracts), NO free radical scavenging activity (59.51±0.01µg/ml), ferric reducing antioxidant property (1815.88±3.62µM/100g), DPPH free radical scavenging activity (98.24±0.09 %) and total phenolic content (62.74±0.87 mg GAE/g) was highly present in BARI Toikar-1 fruits followed by total anthocyanin, total flavonoids, total carotenoids, reducing power activity, metallic chelating activity, gallic acid, vanilic acid, þ-courmaric acid, caffeic acid, ferulic acid and lutein (Table 3).

A strong correlation between total phenolic content (TPH) and the IC_{50} values were observed (although correlation data is not presented here). When IC_{50} value decreased the total phenolic content was increased. These results are also supported by the previous data for the *bilimbi* and *ber* fruits. The lowest IC_{50} value (19.26±1.50 µg/ml) of the BARI Toikar-1fruits means that it had the strongest radical scavenging activity. However, a strong correlation between TPH content and the 1/IC50 values for scavenging the DPPH radical suggested that the level of scavenging activity of the fruit extracts was closely related to their phenolic groups.

BARI Toikar-1fruit contained 142.81±0.99 mg/100 g of ascorbic acid. Natural ascorbic acid helps in the growth and repair of tissues in all parts of the body and helps the body to absorb iron from non heme sources. It is required for connective metabolism especially in the tissue, bones and

teeth (Akinmuladon *et al*., 2007). Higher presence of flavonoids effectively scavenge most of oxidizing agents and other free radicals involved in several diseases. Total phenols and flavonoids possess diverse chemical and biological activities including radical scavenging properties due to cleaving complex chemical structures. The fruits had higher total antioxidant capacity (504.00±1.00 µg of ascorbic acid/mg of extracts) means that it had the strongest radical scavenging activity. Higher presence of antioxidants are useful for the management of those diseases due to their scavenging activity (Kumar *et al*., 2017). Thus antioxidants are believed to intercept the free radical chain of oxidation and to donate hydrogen from their phenolic hydroxyl groups, thereby forming a stable end-product, which does not initiate or propagate further oxidation of lipids (Sherwin, 1978).

Table1.Nutritional composition, edible and non-edible portion ofBARI Toikar-1

Sl. No.	Nutritional composition	Quantity (%)
1	Crude protein	6.06±0.00
2	Ash	5.49±0.02
3	Total sugar	4.02±0.02
4	Starch	7.85±0.07
5	Moisture content	81.16±0.05
6	TSS	14.20±0.20
7	Acidity	2.40±0.02
8	pH	3.09±0.02
9	Edible portion	84.01±0.01
10	Non-edible portion	15.33±0.03

Tale 2. Mineral content of BARI Toikar-1

Sl. No.	Mineral content	Quantity
1	Ca	0.87±0.06
2	Mg	0.49±0.03
3	K	0.37±0.04
4	Na	0.19±0.00
5	P	0.21±0.00
6	S	0.37±0.01
7	B	22.33±0.57
8	Cu	6.38±0.40
9	Fe	395.52±1.77
10	Mn	238.26±1.07

11	Zn	19.99±0.99

Ca, Mg,K, Na, P and S expressed as percentage; B, Cu, Fe, Mn and Zn expressed as ppm; 1 ppm=1mg/kg~0.1mg/100g. Daily requirement of Ca (1300 mg/day), Mg (24±0.9 mg/day), Fe (.37 and 2.94 mg/day for men and women), Zn (1.4 mg/day) and K (3510 mg/day) (FAO and WHO, 2001).

Table 3. Phytochemical content of BARI Toikar-1

Sl. No.	Phytochemicals	Quantity
1	Total anthocyanin content (mg/100g)	1.81±0.07
2	Total flavonoid content (mg QE/g)	18.33±1.12
3	Total carotenoid content (mg/100g)	0.02±0.00
4	Total ß-carotene content (µg/100g)	45.00±0.50
5	Ascorbic acid content (mg/100g)	142.81±0.99
6	Total antioxidant capacity (µg of ascorbic acid/mg of extracts)	504.00±1.00
7	NO free radical scavenging activity (µg/ml)	59.51±0.01
8	Reducing power activity (µg/ml)	6.24±0.01
9	Ferric reducing antioxidant property (µM/100g)	1815.88±3.62
10	DPPH radical scavenging activity (%)	98.24±0.09
11	Metalic chelating capacity (%)	16.20±0.10
12	IC_{50} (µg/ml)	19.26±1.50
13	Total phenolic content (mg GAE/g)	62.74±0.87
14	Gallic acid (mg/100g)	0.03±0.01
15	Vanilic acid (mg/100g)	0.02±0.01
16	Þ-courmaric acid (mg/100g)	0.21±0.02
17	Caffeic acid (mg/100g)	1.14±0.02
18	Ferulic acid (mg/100g)	1.27±0.06
19	Lutein (µg/100g)	130.00±5.0

Conclusion

The findings of the present study indicate that BARI Toikar-1contains phytochemical constituents, minerals and nutritional compositions. Therefore the BARI Toikar-1 might also be major contributors to the medicinal value that may have more roles to play, in the synergy of phytochemicals for the health benefit of man.

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Daophal (*Garcinia xanthochymus)*

Abstract

The biochemical test of Daophal (*Garcinia xanthochymus)* fruit revealed that it is the good source of flavonoids (27.00±0.04 mg QE/g) and total phenolic content (176.50±2.40 mg GAE/g). Also has considerable amount of ascorbic acid content (97.56±0.10 mg/100 g). Since both have significant contribution for antioxidant property, it gave an excellent result in DPPH and ferric reducing antioxidant property. The results revealed that Daophalis the potential source of minerals and nutritional compositions.

Introduction

The plant from the genus Daophal (*Garcinia xanthochymus)* belonging to family Clusiaceae with its English name Daophal and locally called Dayphal (Bengali name). It consists of over 200 species distributed in the tropical area of the world. *Garcinia xanthochymus* is popularly known as Yellow mangosteen and is native to India and Myanmar. About 35 species exist in India, many of which are endemic and economically important with huge medicinal properties (Roberts *et al.,* 1984). In Bangladesh, there is no specific variety of the *Daophal* fruits but it grow extensively in the Cox's bazar, Chattragram andSylhet region of the country. The fruits are available from June to October. The fruits have fleshy endocarp (Figure1) which is very delicious (Asinelli *et al.,* 2011). The fruits of Daophal are highly acidic and bitter taste. The fruits are usually consumed by the aboriginals and tribes in hill tracts of the Chattragram. In Sylhet region it is used as sour cooked food with curry. It's may be used as food for preparing pickle, chutney and flavour curries (Facciola, 1998; Krishnamoorthy *et al*., 2006). A few phytochemicals and antibacterial activities of the Daophal fruits have been done but multidiversity of phytochemicals, mineral and nutritional compositions are still now meager. Therefore the present study has undertaken to document the phytochemicals, minerals and nutritional composition of the fruits.

Figure 1. Dayphal (*Garcinia xanthochymus*)

Materials and methods

Materials: Daophal (*G.xanthochymus*)

Methodology: Described in methodology section.

Results and discussion

Nutritional compositions

Crude protein, ash, total sugar, starch (carbohydrate), moisture content, TSS, acidity and pH of the Daophal fruits are 5.04%, 1.40%, 24.20%, 8.77%, 81.16%, 7.01%, 3.58% and 2.63%

respectively. Edible portion of the fruits was 90.95% while the non-edible portion 8.01% only (Table 1).

Mineral contents

The minerals analyzed in this study are presented in Table 3.Daophal fruits contained higher amounts of calcium (0.67±0.02%),Mg(0.29±0.02%), K(0.40±0.02%), Fe(180.99±0.58 ppm) and Mn (116.68±0.38 ppm) respectively.

Phytochemical constituents

Phytochemicals of the Daophalfruits are presented in Table 3.The study showed that total flavonoid (27.00±0.04 mg QE/g), ascorbic acid (97.56±0.10 mg/100 g), ferric reducing antioxidant property (1213.46±0.46 µM/100g), DPPH free radical scavenging activity (87.70±0.49 %) and total phenolic content (176.50±2.40 mg GAE/g) was detected higher in Daophal fruits followed by other secondary metabolites (Table 3).

The presence of flavonoids are currently of growing interest owing to their supposed properties in promoting health (Rauha *et al.,* 2000). The flavonoids have long been recognized and well-established anti-inflammatory, antioxidant, antiallergic, hepatoprotective, antithrombotic, antiviral, and anticarcinogenic properties (Hemshekhar *et al*., 2011).

A strong correlation between total phenolic content (TPH) and the IC_{50} values were observed (although correlation data is not presented here) while the IC50 values decreased (49.57±0.50 µg/ml), the TPH is increased (176.50±2.40 mg GAE/g). The lowest IC_{50} value (49.57±0.50 µg/ml) of the *G. xanthochymus* fruits means that it had the strongest radical scavenging activity. However, a strong correlation between TPH content and the 1/IC50 values for scavenging the DPPH radical suggested that the level of scavenging activity of the fruit extracts was closely related to their phenolic groups.

Daophalfruits contained 97.56±0.10 mg/100 g of ascorbic acid while the minimum daily requirement of ascorbic acid for preventing clinical symptoms of the specific deficiency-scurvy for adults is about 10 mg or little less (Jukes, 1974). Therefore, the daily intake of 100 g Daophal (*G.xanthochymus*) fruit can prevent the scurvy in Bangladesh.

Table 1. Nutritional composition, edible and non-edible portion of Daophal fruits

Sl. No.	Nutritional composition	Quantity (%)
1	Crude protein	5.04±0.01
2	Ash	1.40±0.10
3	Total sugar	4.20±0.10
4	Starch	8.77±0.20
5	Moisture content	81.16±0.06
6	TSS	7.01±0.10
7	Acidity	3.58±0.03
8	pH	2.63±0.10
9	Edible portion	90.95±0.03
10	Non-edible portion	8.01±0.01

Table 2. Mineral content of Daophal fruits

Sl. No.	Mineral contents	Quantity

1	Ca	0.67±0.02
2	Mg	0.29±0.02
3	K	0.40±0.02
4	Na	0.12±0.00
5	P	0.07±0.01
6	S	0.12±0.00
7	B	11.40±0.51
8	Cu	11.67±0.30
9	Fe	180.99±0.58
10	Mn	116.68±0.38
11	Zn	23.34±0.60

Ca, Mg,K, Na, P and S expressed as percentage ; B, Cu, Fe, Mn and Zn expressed as ppm; 1 ppm=1mg/kg~0.1mg/100g. Daily requirement of Ca (1300 mg/day), Mg (24±0.9 mg/day), Fe (.37 and 2.94 mg/day for men and women), Zn (1.4 mg/day) and K (3510 mg/day) (FAO and WHO, 2001).

Table 3. Phytochemical content of Daophalfruits

Sl. No.	Phytochemicals	Quantity
1	Total anthocyanin content (mg/100g)	1.15±0.14
2	Total flavonoid content (mg QE/g)	27.00±0.04
3	Total carotenoid content (mg/100g)	1.26±0.23
4	Total ß-carotene content(µg/100g)	1.41±0.04
5	Ascorbic acid content (mg/100g)	97.56±0.10
6	Total antioxidant capacity (µg of ascorbic acid/mg of extracts)	1.15±0.14
7	NO free radical scavenging activity (µg/ml)	1.41±0.03
8	Reducing power activity (µg/ml)	1.26±0.23
9	Ferric reducing antioxidant property (µM/100g)	1213.46±0.46
10	DPPH radical scavenging activity (%)	87.70±0.49
11	Metalic chelating capacity (%)	16.67±0.53
12	IC_{50} (µg/ml)	49.57±0.50
13	Total phenolic content (mg GAE/g)	176.50±2.40
14	Gallic acid (mg/100g)	3.62±0.01
15	Vanilic acid (mg/100g)	0.04±0.03
16	Þ-courmaric acid (mg/100g)	1.06±0.03
17	Caffeic acid (mg/100g)	0.45±0.01
18	Ferulic acid (mg/100g)	0.01±0.00
19	Lutein (µg/100g)	71.33±1.52

Conclusion

The results revealed that Daopahl fruit is rich in phytochemicals, minerals and nutritional composition. So the fruits could be used as a natural antioxidant source. Being a saponin (data is not included here) rich fruit, it gives a hope to treat cancer.

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Aonla (*Phyllunththus emblica L*)

Abstract

In recent years attention has been focused on the antioxidant properties of plant derived dietary constituents of food. Keeping view on mind, therefore the investigation was carried out to recordnutritional profile, phytochemical constituents and mineral contents. The study showed, the Aonla fruits contained high level of total flavonoid (45.04±0.47 mg QE/g), total ß-carotene content (250.00±0.10 µg/100g), ascorbic acid (664.92±1.0 mg/100 g), total antioxidant capacity (255.20±0.20 µg of ascorbic acid/mg of extracts), ferric reducing antioxidant property (6897.57±0.09 µM/100g), DPPH free radical scavenging activity (83.73±0.3 %) and total phenolic content (279.00±2.13 mg GAE/g). Therefore, the fruits may have activities beneficial to physiological and clinical health.

Introduction

Aonla *(Phyllanthus emblica)*isthe minor indigenous fruits of Bangladesh and locally named as Amloki. In India and Southeast Asia, it is commonly named as 'Indian gooseberry' (Barthakar and Arnold, 1991). The fruit is belongs to the family of Phyllanthaceae.In Bangladesh, its main growing area is concentrated to Sylhet, Khagrachari, Bandarban, Rangamati, Bhawal, Modhupur trace but possible to cultivate all over the country. Its availability from May to June and October to December. The country (Bangladesh) has only one variety as name of BARI Amloki-1.The fruits are fleshy, yellowish green in colour (Figure 1) and having sour and astringent taste. The fruit is consumed as raw or in the form of pickles. But it may be utilized as murrabas, juice, jam, cheese, candy, powder, beverage, chutney and different types of products based on consumer preferences.Literature suggest that Aonla fruit is an excellent source of ascorbic acid (300-900 mg/100 g), amino acid and minerals along with phytochemicals such as polyphenols, tannins, emblicol, linoleic acid, corilagin, phyllemblin and rutin (Ghorai and Sethi, 1996; Jain and Khurdiya, 2004; Murthy and Joshi, 2007; Baliga and Dsouza, 2011).

There is dearth, indefinite and indiscriminate of literature availability on phytochemicals, minerals and nutritional composition of Aonla fruits. The present investigation was therefore planned to make profile for the phytochemicals, minerals and nutritional compositions of the Aonlafruits.

Figure 1.BARI Amloki-1 (*Phyllunththus emblica L)*

Materials and methods

Materials: BARI Amloki-1

Methods:Described in methodology section

Results and Discussion

Nutritional compositions

Aonla (*Phyllunththusemblica*) fruits contained 7.71±0.03% crude protein, 1.92% ±0.01% ash, 2.83±0.02% total sugar, 6.51±0.27% starch (carbohydrate), 82.62±0.10% moisture content, 11.40±0.20 % TSS, 1.82±0.02% acidity and 2.65±0.02% pH respectively (Table 1).The edible portion of the fruit is 84.62±0.02% while the non-edible portion of the fruit is 15.38±0.02% respectively (Table 1).

Mineral contents

Mineral contentsare presented in Table 2. Aonla fruits contained Ca, Ma, K, Na, P, S, B, Cu, Fe, Mn and Zn while some of them are rich or least present in this fruit. The results showed that K(0.93%), B (68.046ppm), Fe (90.12±0.02ppm), Mn (47.93±0.01ppm) and Zn (18.84±0.02 ppm) highly present in the fruit followed by other minerals.The average amount of boron in plants and animals is estimated to be between 30 to 50 ppm while it was found 68.04±2.16 ppm inAonla (*P.emblica)* fruits. However, intake of Aonlafruits may apply role for the growth and cell division. It also plays a role for carbohydrate metabolism. Epidemiological and clinical studies show that a high-potassium diet lowers blood pressure in individuals with both raised blood pressure and average population blood pressure (He and MacGregor, 2008). Prospective cohort studies and outcome trials show that increasing potassium intake reduces cardiovascular disease mortality. This is mainly attributable to the blood pressure-lowering effect and may also be partially because of the direct effects of potassium on the cardiovascular system. A high-potassium diet may also prevent or at least slow the progression of renal disease. An increased potassium intake lowers urinary calcium excretion and plays an important role in the management of hypercalciuria and kidney stones and is likely to decrease the risk of osteoporosis (He and MacGregor, 2008).

Phytochemical constituents

Table 3 represents the phytochemical diversity of the Aonlafruits. The results revealed that Aonlafruits contained higher amount of phytochemical constituents. Among them, the Aonla fruitscontained high quantity of total flavonoid (45.04±0.47 mg QE/g), total ß-carotene content (250.00±0.10 µg/100g), ascorbic acid (664.92±1.0 mg/100 g), total antioxidant capacity (255.20±0.20 µg of ascorbic acid/mg of extracts), ferric reducing antioxidant property (6897.57±0.09 µM/100g), DPPH free radical scavenging activity (83.73±0.3 %) and total phenolic content (279.00±2.13 mg GAE/g) followed by other phytochemical constituents (Table 3).

The presence of flavonoids are currently of growing interest owing to their supposed properties in promoting health (Rauha *et al.,* 2000). The flavonoids have long been recognized and well-established anti-inflammatory, antioxidant, antiallergic, hepatoprotective, antithrombotic, antiviral, and anticarcinogenic properties (Hemshekhar *et al*., 2011).

Ferric reducing antioxidant property of the Aonla fruits were higher (6897.57±0.09 µM/100g) means that the reducing power of Aonla fruit was more pronounced and the power of a compound was related to its electron transfer ability and may, therefore serve as an indicator of its potential antioxidant activity (Sanchez Moreno, 2002).

A strong correlation between total phenolic content (TPH) and the IC_{50} values were observed (although correlation data is not presented here) while the IC_{50}were very low and it was 3.00±0.05 µg/ml. The lowest IC_{50} value (3.00±0.05 µg/ml) of the Aonla fruits means that it had the strongest radical scavenging activity. However, a strong correlation between TPH content and the 1/IC50 values for scavenging the DPPH radical suggested that the level of scavenging activity of the fruit was closely related to their phenolic groups.

Aonlafruit contained high quantity ofascorbic acid 664.92±1.0 mg/100 g while the minimum daily requirement of ascorbic acid for preventing clinical symptoms of the specific deficiency-scurvy for adults is about 10 mg or little less (Food and Agriculture Organization (FAO), 1998). Therefore, the daily intake of 100g Aonla (*P.emblica*) fruit can prevent the scurvy in Bangladesh.

Table 1.Nutritional composition, edible and non-edible portion of Aonlafruits

Sl. No.	Nutritional composition	Quantity (%)
1	Crude protein	7.71±0.03
2	Ash	1.92±0.01
3	Total sugar	2.83±0.02
4	Starch	6.51±0.27
5	Moisture content	82.62±0.10
6	TSS	11.40±0.20
7	Acidity	1.82±0.02
8	pH	2.65±0.02
9	Edible portion	84.62±0.02
10	Non-edible portion	15.38±0.02

Table 2. Mineral content of Aonlafruits

Sl. No.	Mineral contents	Quantity
1	Ca	0.254±0.00
2	Mg	0.157±0.01
3	K	0.937±0.02
4	Na	0.328±0.01
5	P	0.428±0.00
6	S	0.079±0.00
7	B	68.04±2.16
8	Cu	4.82±0.02

9	Fe	90.12±0.02
10	Mn	47.93±0.01
11	Zn	18.84±0.02

Ca, Mg,K, Na, P and S expressed as percentage ; B, Cu, Fe, Mn and Zn expressed as ppm;1ppm=1mg/kg~0.1mg/100g. Daily requirement of Ca (1300 mg/day), Mg (24±0.9 mg/day), Fe (.37 and 2.94 mg/day for men and women), Zn (1.4 mg/day) and K (3510 mg/day) (FAO and WHO, 2001).

Table 3. Phytochemical content of Aonlafruits

Sl. No.	Phytochemicals	Quantity
1	Total anthocyanin content (mg/100g)	2.10±0.09
2	Total flavonoid content (mg QE/g)	45.04±0.47
3	Total carotenoid content (mg/100g)	38.01±1.9
4	Total ß-carotene content(µg/100g)	250.00±0.10
5	Ascorbic acid content (mg/100g)	664.92±1.0
6	Total antioxidant capacity (µg of ascorbic acid/mg of extracts)	255.20±0.20
7	NO free radical scavenging activity (µg/ml)	33.89±0.02
8	Reducing power activity (µg/ml)	15.53±0.03
9	Ferric reducing antioxidant property (µM/100g)	6897.57±0.09
10	DPPH radical scavenging activity (%)	83.73±0.3
11	Metalic chelating capacity (%)	12.036±0.05
12	IC5 (µg/ml)	3.00±0.05
13	Total phenolic content (mg GAE/g)	279.00±2.13
14	Gallic acid (mg/100g)	43.77±0.15
15	Vanilic acid (mg/100g)	0.096±0.08
16	Þ-courmaric acid (mg/100g)	0.209±0.15
17	Caffeic acid (mg/100g)	0.026±0.00
18	Ferulic acid (mg/100g)	7.97±1.0
19	Lutein (µg/100g)	490.5±0.51

Conclusion

The results confirmed that the Aonla fruits have high amount of phytochemical constituents, minerals and nutritional compositions that play a vital role for the extraction and application of its components in the human diet and diet rich products to reduce the cancer, diabetes, liver injury and all kinds of cardiovascular diseases.

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Elephant Apple (*Dilenia indica L)*

Abstract

The phytochemical constituents, mineral and nutritional composition of the Elephant apple (*Dilenia indica L)* fruits were studies to document the nutritional profile of the fruits. The results obtained from the study showed thatElephant apple(*Dilenia indica)* fruits possessed high quantity of total flavonoid (26.16±1.90 mg QE/g), total ß-carotene content (41.95±0.05 µg/100g), ascorbic acid (22.29±0.09 mg/100 g), total antioxidant capacity (85.90±0.03 µg of ascorbic acid/mg of extracts), ferric reducing antioxidant property (2325.23±6.09 µM/100g), DPPH free radical scavenging activity (68.40±4.6 %) and total phenolic content (62.85±0.05 mg GAE/g). Most of these phytochemicals are potent antioxidants and have corresponded to thefree radical scavenging activities and other biological activities of the fruits.

Introduction

Elephant apple (*Dilenia indica L)*is an indigenous minor fruits that belongs to the family Dilleniaceae and in Bengali known as “Chulta” and English named as Elephant apple. Its main growing area is concentrated in Sylhet, Khagrachari, Bandarban, Rangamati region but indiscriminately it is cultivated all over the Bangladesh. It’s available in Bangladesh from June to December. In Bangladesh have one variety as the name of BARI Chulta-1. The mature fruit is green and when ripen it turns from greenish to light yellow (Fig.1). The fruit is consumed as sour by cooking with vegetable curry and also may be used for preparation pickles, chutney, jam and jelly. Best of our concern, no details study has been well documented for the phytochemical diversity, minerals and nutritional compositions. Therefore, the aim of present study was to document the phytochemicals, minerals and nutritional compositions of the Elephant apple *(Dilenia indica L).*



Figure 1.BARI Chulta-1 (*Dilenia indica L*)

Materials and methods

Materials: BARI Chulta-1

Methods:Described in methodology section

Results and Discussion

Nutritional compositions

Elephant apple (Dillenia *indica L*) fruits contained 9.17±0.00% crude protein, 4.45±0.02% ash, 4.13±0.04% total sugar, 4.71±0.03% starch (carbohydrate), 81.35±0.47% moisture content, 8.26±0.15ºB TSS, 1.92±0.03% acidity and 3.29±0.02% pH respectively (Table 1).The edible portion of the fruit is 79.03±0.02% while the non-edible portion of the fruit is 18.02±1.01% respectively (Table 1). The data showed that Chulta fruit is the good source of crude protein, ash and moderate source of starch. The ash content of the fruits denotes the overall availability of minerals.

Mineral contents

Mineral contents of the Elephant apple (*Dillenia indica L*) fruit is presented in Table 2. The fruit contained Ca, Mg, K, Na, P, S, B, Cu, Fe, Mn, Zn and B while Ca, K, Fe and Zn are highly presents and others arecomparatively less. Ca accounts for most predominant element in the body and is essential in regulating muscle contractions and formation of bones (Soetan *et al.,* 2010). Fe is considered as an essential as it provides energy and supplies oxygen. Its deficiency may lead to anaemia (Cook, 2005). Zn is associated with cell growth and testosterone production. It is reported that its deficiency may cause several severe disorders including poor appetite and night blindness (Evans, 1986). K intake reduces cardiovascular disease mortality due to its blood pressure-lowering effect (He and MacGregor, 2008).

Phytochemical constituents

The phytochemical constituents of Elephant apple (*Dillenia indica L*) are presented in Table 3.The results of the phytochemical constituents indicates thatElephant applefruits contained high quantity of total flavonoid (26.16±1.90 mg QE/g), total ß-carotene content (41.95±0.05 µg/100g),ascorbic acid(22.29±0.09 mg/100g), total antioxidant capacity (85.90±0.03 µg of ascorbic acid/mg of extracts),ferric reducing antioxidant property (2325.23±6.09 µM/100g),DPPH free radical scavenging activity (68.40±4.6 %)and total phenolic content (62.85±0.05 mg GAE/g) followed by other phytochemical constituents (Table 3).

The presence of flavonoids are currently of growing interest owing to their supposed properties in promoting health (Rauha *et al.,* 2000).-carotene is the most abundant in Elephant apple fruits, while the carotenoid is less present (Table 3).

Ferric reducing antioxidant property of the Elephant apple fruits were (2325.23±6.09 µM/100g) means that the reducing power of Elephant apple fruit was more pronounced and the power of a compound was related to its electron transfer ability and may, therefore serve as an indicator of its potential antioxidant activity (Sanchez Moreno, 2002).

Total phenolic content (TPH) is one of the most popular indicators for estimation of phenolic antioxidants in fruit. The IC_{50} were very low (4.98±0.24 µg/ml) and it had strong relation with total phenolic content (data is not shown). The lowest IC_{50} value of the Elephant apple fruits means that it had the strongest radical scavenging activity. However, a strong correlation between TPH content and the IC50 values for scavenging the DPPH radical suggested that the level of scavenging activity of the fruit was closely related to their phenolic groups.

Ascorbic acid *D.indica (*Chulta*)* fruits were 22.29±0.09 mg/100 g means that the daily intake of 100g *D.indica* (Chulta) fruit can prevent the scurvy in Bangladesh. (Food and Agriculture Organization (FAO), 1998 reported that the minimum daily requirement of ascorbic acid for preventing clinical symptoms of the specific deficiency-scurvy for adults is about 10 mg or little less.

Phenolic compounds are good antioxidants found in the *D.indica* of fruits especially phenolic acids and flavonoids. Among the phenolic acids, gallic acid, Þ-courmaric acid (mg/100g), caffeic acid, ferulic acid and lutein is the major component of the Elephant applefruits (Table 3). Since phenolic are potent antioxidants, increased consumption of a mixture of fruits daily should be able to provide an adequate phenolic antioxidant. Thus, consumption of proper amount of Elephant apple fruits may help to promote the usage of these underutilized fruits for their functional and health benefits.

Table 1. Nutritional composition, edible and non-edible portion of Elephant apple fruits

Sl. No.	Nutritional composition	Quantity (%)
1	Crude protein	9.17±0.00
2	Ash	4.45±0.02
3	Total sugar	4.13±0.04
4	Starch	4.71±0.03
5	Moisture content	81.35±0.47
6	TSS	8.26±0.15
7	Acidity	1.92±0.03
8	pH	3.29±0.02
9	Edible portion	79.03±0.02
10	Non-edible portion	18.02±1.01

Table 2. Mineral contents of Elephant apple fruits

Sl. No.	Mineral contents	Quantity
1	Ca	0.54±0.00
2	Mg	0.28±0.00
3	K	1.08±0.00

4	Na	0.19±0.00
5	P	0.311±0.01
6	S	0.05±0.01
7	B	17.84±0.28
8	Cu	26.30±0.14
9	Fe	157.77±0.24
10	Mn	83.91±0.05
11	Zn	151.19±0.90

Ca, Mg,K, Na, P and S expressed as percentage; B, Cu, Fe, Mn and Zn expressed as ppm; 1 ppm=1mg/kg~0.1mg/100g. Daily requirement of Ca (1300 mg/day), Mg (24±0.9 mg/day), Fe (.37 and 2.94 mg/day for men and women), Zn (1.4 mg/day) and K (3510 mg/day) (FAO and WHO, 2001).

Table 3. Phytochemical content of Elephant apple fruits

Sl. No.	Phytochemicals	Quantity
1	Total anthocyanin content (mg/100g)	1.74±0.23
2	Total flavonoid content (mg QE/g)	26.16±1.90
3	Total carotenoid content (mg/100g)	1.58±0.09
4	Total ß-carotene content(µg/100g)	41.95±0.05
5	Ascorbic acid content (mg/100g)	22.29±0.09
6	Total antioxidant capacity (µg of ascorbic acid/mg of extracts)	85.90±0.03
7	NO free radical scavenging activity (µg/ml)	40.18±0.03
8	Reducing power activity (µg/ml)	5.89±0.02
9	Ferric reducing antioxidant property (µM/100g)	2325.23±6.09
10	DPPH radical scavenging activity (%)	68.40±4.6
11	Metalic chelating capacity (%)	40.29±0.11
12	IC_{50} (µg/ml)	4.98±0.24
13	Total phenolic content (mg GAE/g)	62.85±0.05
14	Gallic acid (mg/100g)	38.14±0.15
15	Vanilic acid (mg/100g)	0.02±0.00
16	Þ-courmaric acid (mg/100g)	11.51±0.07
17	Caffeic acid (mg/100g)	30.04±0.05
18	Ferulic acid (mg/100g)	20.44±0.05
19	Lutein (µg/100g)	97.35±2.08

Conclusion

The analysis provides important information on phytochemicals, minerals and nutritional composition of the Elephant apple fruits. Results revealed phytochemicals detected in these fruits are mainly the total anthocyanin, total flavonoid, total ß-carotene, total carotenoid, ascorbic acid, total antioxidant capacity, ferric reducing antioxidant property, metallic chelating capacity, DPPH free radical scavenging activity, NO free radical scavenging activity, Reducing power activity, $IC_{50,}$ total phenolic content, gallic acid, vanilic acid, ferulic acid, caffeic acid, þ-courmaric acid and lutein.

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Satkara (*Citrus macroptera*)

Abstract

The purpose of the present study was to study and document the nutritional composition, mineral contents and phytochemical constituents of Satkara (*Citrus macroptera)* underutilized fruits in Bangladesh. The present investigation revealed that the fruit of *Satkara* was found to be rich in crude protein (6.06±0.02 %) and sugar (3.91±0.06%) as compared to others. Minerals like Mg (0.99±0.00 %), S (1.36±0.01 %), B (10.14±0.01 ppm), Cu (62.61±0.02 ppm) and Fe(65.30±0.03 ppm) was found to be highest in theSatakara fruits and some other elements were present less. Phytochemical viz. total flavonoids (23.38±1.25 mg QE/g), total ß-carotene content (39.70±0.20 µg/100g), ascorbic acid content (210.43±0.02mg/100g), total antioxidant capacity (362.00±0.05 µg of ascorbic acid/mg of extracts), NO free radical scavenging activity (40.76±0.09 µg/ml), ferric reducing antioxidant property (2318.44±5.60 µM/100g), DPPH radical scavenging activity (93.91±0.80 %), total phenolic content (66.00±0.52 mg GAE/g) were found highest in Satkara fruits. Anthocyanin and total carotenoid were also present in minute quantity in Satkara fruits. The study suggests that fruit of Satkara could be good sources of nutrients, minerals and phytochemical and must be researched further for its beneficial effect in human health.

Introduction

Satkara (*Citrus macroptera*) fruits belong to the family Rutaceae. Its Bengali and English nameis "Satkara". Its main growing area is concentrated to greater Sylhet region but it is possible to cultivate all over the Bangladesh. It's available in Bangladesh from June to December. Themature fruit id green and when ripe turns to yellow. Still now, Bangladesh has one variety as the name of BARI Satkara-1. The fruit is eaten cooked with meat (beef, mutton and chicken) and also suitable for preparation of pickles and chutney. Traditionally the fruit (Satkara) has good reputations to remedies abdominal pains, hypertension, in flu, fever and diarrhea in infants (Grover *et al.*, 2002).The fruit is the main source of antioxidants but few phytochemicals compound and antioxidant activities were analyzed by Islam et al. (2017). Therefore, the present study was carried out to details study of phytochemical constituents,minerals and nutritional composition of the Satkara fruits.

Figure 1.BARI Satkara-1 (*Citrus macroptera*)

Materials and Methods

Material: BARI Satkara-1

Methods: Described in methodology section

Results and Discussion

Nutritional composition

The result of the nutritional assessment shown in Table 1 indicate that the fruit of Satkaracontains 85.83±0.10 % moisture content, 6.06±0.02 % crude protein, 4.31±0.10 % ash, 3.44±0.03 % starch, 3.91±0.06% total sugar, 8.50±0.20% TSS, 1.78±0.10 % acidity and 3.58±0.09 % pH. It's noteworthy that the starch (carbohydrate) content of the fruit is low. The edible portion of the fruit had 44.70±0.20 % while the non-edible portion had 50.01±0.09 %.

Mineral contents

Table 2 show the minerals contentofSatkara (*C.macroptera*)fruits. All 12minerals content investigated were found in the extract more or less. The presence of Mg, S, B, Cu and Fe occurring in the largest amount and others were the least. Fe is considered as an essential as it provides energy and supplies oxygen. It deficiency may lead to anaemia (Cook, 2005). Mg deficiency may lead to severe disorders such as diarrhoea, hypertension and cardiovascular diseases (Swaminathan, 2003). Nevertheless, it helps to tackle muscle cramping.

Phytochemical constituents

The phytochemical constituents of the Satkara (*Citrus macroptera)* are shown in Table 3. The result of qualitative analysis showed the presence of phytochemical constituents such as flavonoids (23.38±1.25 mg QE/g), total ß-carotene content (39.70±0.20 µg/100g), ascorbic acid content (210.43±0.02mg/100g), total antioxidant capacity (362.00±0.05 µg of ascorbic acid/mg of extracts), NO free radical scavenging activity (40.76±0.09 µg/ml), ferric reducing antioxidant property (2318.44±5.60 µM/100g), DPPH radical scavenging activity (93.91±0.80 %), total phenolic content (66.00±0.52 mg GAE/g) and gallic acid (4.04±0.05 mg/100g) are highly possessed by the Satkara fruits. But the total carotenoid content (0.35±0.05 mg/100g) was less present in the fruit.

Flavonoids are potent water-soluble antioxidants and free radical scavengers which prevent oxidative cell damage and have strong anticancer activity (Salah *et al*., 1995; Del-Rio *et al.,* 1997; Okwu, 2004). Flavonoids also lower the risk of heart diseases.

The presence of ascorbic acid (664.92±1.0 mg/100 g) in Satkara fruits can prevent clinical symptoms of the specific deficiency-scurvy for adults is about 10 mg or little less (Food and Agriculture Organization (FAO), 1998). Therefore, the daily intake of 100g Satkara fruit can prevent the scurvy in Bangladesh.

The lowest IC_{50} value of the Satkara fruits means that it had the strongest radical scavenging activity. However, a strong correlation between TPH content and the IC50 values for scavenging the DPPH radical suggested that the level of scavenging activity of the fruit extracts was closely related to their phenolic groups.

Table 1. Nutritional composition, edible and non-edible portion of Satkara (*C.macroptera)* fruits

Sl. No.	Nutritional composition	Quantity (%)
1	Crude protein	6.06±0.02
2	Ash	4.31±0.10
3	Total sugar	3.91±0.06
4	Starch	3.44±0.03
5	Moisture content	85.83±0.10
6	TSS	8.50±0.20
7	Acidity	1.78±0.10
8	pH	3.58±0.09
9	Edible portion	44.70±0.20
10	Non-edible portion	50.01±0.09

Table 2. Mineral content of Satkara(*C.macroptera)*fruits

Sl. No.	Mineral contents	Quantity
1	Ca	0.29±0.00
2	Mg	0.99±0.00
3	K	0.15±0.00
4	Na	0.34±0.00
5	P	0.065±0.00
6	S	1.36±0.01
7	B	10.14±0.01
8	Cu	62.61±0.02
9	Fe	65.30±0.03
10	Mn	11.22±0.03
11	Zn	

Ca, Mg, K, Na, P and S expressed as percentage; B, Cu, Fe, Mn and Zn expressed as ppm; 1 ppm=1mg/kg~0.1mg/100g. Daily requirement of Ca (1300 mg/day), Mg (24±0.9 mg/day), Fe (.37 and 2.94 mg/day for men and women), Zn (1.4 mg/day) and K (3510 mg/day) (FAO and WHO, 2001).

Table 3.Phytochemical content of Satkara (*C.macroptera)* fruits

Sl. No.	Phytochemicals	Quantity
1	Total anthocyanin content (mg/100g)	1.58±0.08
2	Total flavonoid content (mg QE/g)	23.38±1.25
3	Total carotenoid content (mg/100g)	0.35±0.05
4	Total ß-carotene content(µg/100g)	39.70±0.20
5	Ascorbic acid content (mg/100g)	210.43±0.02

6	Total antioxidant capacity (µg of ascorbic acid/mg of extracts)	362.00±0.05
7	NO free radical scavenging activity (µg/ml)	40.76±0.09
8	Reducing power activity (µg/ml)	6.25±0.04
9	Ferric reducing antioxidant property (µM/100g)	2318.44±5.60
10	DPPH radical scavenging activity (%)	93.91±0.80
11	Metalic chelating capacity (%)	12.62±0.12
12	IC5 (µg/ml)	78.96±0.13
13	Total phenolic content (mg GAE/g)	66.00±0.52
14	Gallic acid (mg/100g)	4.04±0.05
15	Vanilic acid (mg/100g)	0.076±0.10
16	Þ-courmaric acid (mg/100g)	0.025±0.00
17	Caffeic acid (mg/100g)	0.013±0.00
18	Ferulic acid (mg/100g)	1.096±0.06
19	Lutein (µg/100g)	93.00±2.0

Conclusion

The results of nutritional assessment revealed that the fruitsSatkara(*C.macroptera)* were good source of phytochemicals, minerals and nutritional compositions.

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Hog plum (*Spondias pinnata*)

Abstract

Hog plum *(Spondias pinnata*) fruit is minor indigenous fruits in Bangladesh while its phytochemical properties are still now meager. Therefore, the aim of the study was to document the phytochemical constituents, mineral contents and nutritional compositions. Results obtained from the study revealed that *Hog plum* fruits contained 19 phytochemicals, 12 minerals and 7 nutritional compositions more or less. Among them, total ß-carotene content (314.00±0.50 µg/100g), ascorbic acid (67.90±0.05 mg/100 g), total antioxidant capacity (856.70±0.20 µg of ascorbic acid/mg of extracts), ferric reducing antioxidant property (1137.11±3.27 µM/100g), DPPH free radical scavenging activity (68.45±0.12 %) and total phenolic content (58.33±0.33 mg GAE/g), gallic acid (42.02±0.02 mg/100g) and lutein (634.00±1.00 µg/100g) was rich source of the Hog plum fruits. Therefore, the fruits may be recommended as potential anti-inflammatory, immunomodulatory, mast cells, stabilizing, blood pressure and cholesterol lowering natural resource.

Introduction

Hog plum *(Spondias pinnata*) fruits belong to the family Anacardiaceae with its English name as Hog plum and in Bengali called “Amra”. Its best growing area is concentrated to greater Barisal and Sathkhira region but it is possible to cultivate all over the Bangladesh. It’s available in Bangladesh from June to October. The mature fruit is green (Figure1). Bangladesh havethree variety as the name of BARI Amra-1, BARI Amra-2 and BAU Amra-3. Among them, BARI Amra-1 and BARI Amra-2 have been developed by Bangladesh Agricultural Research Institute (BARI) and BAU Amra-1 has been developed by Bangladesh Agricultural University (BAU).

The fruit is consumedas fresh and somewhere of the country cooked with curry. Apart from fresh consume, its suitable for preparation of delicious pickles, chutney, jam and jelly. Traditionally the fruit (Hog plum) has good reputations to remedies diarrhea, dysentery, skin disease and other diseases. The fruit is the main source of antioxidants and phytochemicals compound (Khatoon, 2015). To the best of our concern, no antioxidant and phytochemicals profile have been studied. Nutritional composition and few minerals have been done indiscriminately and the data are mostly unclear. Therefore, the present study was conducted to document the phytochemicals, minerals and nutritional composition of the Hog plum fruits.

Figure 1. Amra (*Spondias pinnata*)

Materials and Methods

Material: BARI Amra-1

Methods: Described in methodology section

Results and Discussion

Nutritional composition

The nutritional composition of the Hog plum (*Spondias pinnata*) fruits are presented in Table 1. The fruits (Hog plum*)* contained 10.91±0.02 % crude protein, 3.23±0.02 % ash, 5.64±0.03 % total sugar, 4.45±0.08 % starch (carbohydrate), 78.40±0.11 % moisture content, 8.80±0.10 % TSS,2.29±0.02 % acidity and 2.94±0.00 % pH respectively (Table 1).The edible portion of the fruit is 47.59±0.32 % while the non-edible portion of the fruit is 50.50±0.16 % respectively (Table 1). The data showed that Hog plum fruit is the good source of crude protein and its contained higher moisture content with lower starch (carbohydrate) content. The high level of moisture content in the fruit may be responsible for the comparatively low carbohydrate observed (Agu and Okolie, 2017).The ash content of the fruits denotes the overall availability of minerals.

Mineral contents

Table 2 represents the mineral composition of the S.*pinnata* (Amra). The fruit contained Ca, Mg, K, Na, P, S, B, Cu, Fe, Mn, Zn and B while allthe minerals are presence with high or less quantity. The results showed that Ca, K, Fe, Mn and Zn were presents highly as compared to others. Ca accounts for most predominant element in the body and is essential in regulating muscle contractions and formation of bones (Soetan *et al.,* 2010). Fe is considered as an essential as it provides energy and supplies oxygen. Its deficiency may lead to anaemia (Cook, 2005). Zn is associated with cell growth and testosterone production. It is reported that its deficiency may cause several severe disorders including poor appetite and night blindness (Evans, 1986). K intake reduces cardiovascular disease mortality due to its blood pressure-lowering effect (He and MacGregor, 2008) although its high intake have adverse effect on human health (He and MacGregor, 2008).

Phytochemical constituents

The results of phytochemical analysis of methanol extract of the Hog plumare presented in Table 3. The results indicate that 19 phytochemical constituents are detected high or less in the Hog plumfruits. Total ß-carotene content (314.00±0.50 µg/100g), ascorbic acid (67.90±0.05 mg/100 g), total antioxidant capacity (856.70±0.20 µg of ascorbic acid/mg of extracts), ferric reducing antioxidant property (1137.11±3.27 µM/100g), DPPH free radical scavenging activity (68.45±0.12 %) and total phenolic content (58.33±0.33 mg GAE/g), gallic acid (42.02±0.02mg/100g) and lutein (634.00±1.00 µg/100g) followed by other phytochemical constituents (Table 3).

The presence of -carotene is the most abundant in Hog plum fruits, while the flavonoid and carotenoid content were less present (Table 3). Ferric reducing antioxidant property of the Hog plum fruits were (1137.11±3.27 µM/100g) means that the reducing power of the fruit was more pronounced and the power of a compound was related to its electron transfer ability and may, therefore serve as an indicator of its potential antioxidant activity (Sanchez Moreno, 2002). Higher presence of total phenolic content (TPH) was detected in *the* Hog plum fruits and had the

highest abilities of scavenging DPPH radicals which could be attributed to the high total phenolic content (Agu and Okulie, 2017).

The fruits were the rich source of antioxidant properties. Therefore, the fruits may have abilities to mitigate free radical damage, to chelate and reduce materials.Ascorbic acid of the Hog plumfruits was very high (67.90±0.05 mg/100 g), such that the consumption of thefruit would meet the recommended dietary allowance (RDA) for vitamin C. Food and Agriculture Organization (FAO) (1998) reported that the minimum daily requirement of ascorbic acid for preventing clinical symptoms of the specific deficiency-scurvy for adults is about 10 mg or little less. Phenolic compounds are good antioxidants found in the Hog plumfruits especially phenolic acids and flavonoids. Among the phenolic acids, gallic acid and lutein is the major component of the Hog plumfruits (Table 3). Since phenolic are potent antioxidants, increased consumption of a mixture of fruits daily should be able to provide an adequate phenolic antioxidant. Thus, consumption of the Hog plumfruits may help to promote the health benefits.

Table 1. Nutritional composition, edible and non-edible portion of Hog plum (*S.pinnata*) fruits

Sl. No.	Nutritional composition	Quantity (%)
1	Crude protein	10.91±0.01
2	Ash	3.23±0.02
3	Total sugar	5.64±0.03
4	Starch	4.45±0.08
5	Moisture content	78.4±0.11
6	TSS	8.80±0.10
7	Acidity	2.29±0.02
8	pH	2.94±0.00
9	Edible portion	47.59±0.32
10	Non-edible portion	50.50±0.16

Table 2. Mineral contents of *Hog plum* fruits

Sl. No.	Mineral content	Quantity
1	Ca	0.27±0.00
2	Mg	0.15±0.00
3	K	0.94±0.00
4	Na	0.16±0.00
5	P	0.43±0.00
6	S	0.07±0.00
7	B	13.16±0.15
8	Cu	4.82±0.02
9	Fe	128.30±0.10
10	Mn	68.32±0.06
11	Zn	27.52±0.02

Ca, Mg, K, Na, P and S expressed as percentage; B, Cu, Fe, Mn and Zn expressed as ppm; 1 ppm=1mg/kg~0.1mg/100g. Daily requirement of Ca (1300 mg/day), Mg (24±0.9 mg/day), Fe (.37 and 2.94 mg/day for men and women), Zn (1.4 mg/day) and K (3510 mg/day) (FAO and WHO, 2001).

Table 3. Phytochemical content of *Hog plum* dfruits

Sl. No.	Phytochemicals	Quantity
1	Total anthocyanin content (mg/100g)	0.23±0.02
2	Total flavonoid content (mg QE/g)	2.84±0.11
3	Total carotenoid content (mg/100g)	4.87±0.10
4	Total ß-carotene content(µg/100g)	314.00±0.50
5	Ascorbic acid content (mg/100g)	67.90±0.05
6	Total antioxidant capacity (µg of ascorbic acid/mg of extracts)	856.70±0.20
7	NO free radical scavenging activity (µg/ml)	182.39±0.06
8	Reducing power activity (µg/ml)	5.11±.012
9	Ferric reducing antioxidant property (µM/100g)	1137.11 ±3.27
10	DPPH radical scavenging activity (%)	68.45±0.12
11	Metalic chelating capacity (%)	29.74±0.11
12	IC5 (µg/ml)	13.13±0.22
13	Total phenolic content (mg GAE/g)	58.33±0.33
14	Gallic acid (mg/100g)	42.02±0.02
15	Vanilic acid (mg/100g)	0.01±0.00
16	Þ-courmaric acid (mg/100g)	0.22±0.01
17	Caffeic acid (mg/100g)	0.01±0.00
18	Ferulic acid (mg/100g)	0.02±0.00
19	Lutein (µg/100g)	634.00±1.00

Conclusion

The results suggest that Hog plum (*S.pinnata)*fruits possessed rich source of minerals and phytochemical constituents such as ß-carotene, total antioxidant capacity, DPPH radical scavenging activity, total phenolic content, gallic acid and lutein.

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Citron (*Citrus Medica*)

Abstract

Phytochemicals are a widely distributed assecondary metabolites having with health-related properties, which are based in their antioxidant activity. These properties viz. flavonoids (27.85±1.05 mg QE/g), ascorbic acid content (210.43±0.02 mg/100g), total antioxidant capacity (278.24±0.03 µg of ascorbic acid/mg of extracts), NO free radical scavenging activity (178.87±0.02µg/ml), ferric reducing antioxidant property (1247.50±3.25 µM/100g), DPPH radical scavenging activity (70.20±0.19 %), total phenolic content (50.00±0.08 mg GAE/g) and lutein (71.33±1.52 mg/100g) were detected high in the citron fruits out of 19 phytochemicals.The extract of the citron fruits were also rich source of minerals and nutritional composition. Therefore, the extract of the fruits may apply as anticancer, antiviral, anti-inflammatory activities, effects on capillary fragility, and an ability to inhibit human platelet aggregation.

Introduction

Citron (*Citrus medica L*.) native to Southeast Asia about 4000 years ago, has been cultivated since ancient times. The fruits belong to the family Rutaceae. Its English name as Citron and Bengali called Jara lebu. Its main growing area is concentrated to Moulvibazar, Sylhet, Jamalpur, Mymensingh and Khagrachari. The mature fruit isgreen (Figure 1) and consume as fresh fruits and also suitable for preparation of pickle, juice and squash. Flesh is the common consumption part of the fruit rather than juice. That is the main difference than other citrus fruit as well as lemon. Risk of common diseases can be reduced by frequent consumption of the fruits. Consumption of its dietary fiber plays a significant role in the prevention, reduction and treatment of chronic diseases such as bowel, gastrointestinal disorders, obesity, diabetes, cancer, cardiovascular diseases and also promotes physiological functions such as lowering blood triglycerides and glucose control (Figuerola *et al.,* 2005). The recommended dietary fiber intake of 25-30 g/day can help to overcome the fiber deficit diet and has been related in several physiological and metabolic effects (Drzikova *et al*., 2005). Cholesterol aster accumulation which led to the risk of heart diseases can be controlled by phenolic compounds present in the fruit (Meyer *et al.,* 1997; Williams and Elliot, 1997). To the best of our knowledge, as no phytochemicals study has been profiled yet in Bangladesh. Therefore, an attempt has taken to analyze, document and popularize its phytochemicals constituents, minerals and nutritional compositions of the fruit.

Figure 1.BARI Jara Lebu-1 (*Citrus medica*)

Materials and Methods

Material: BARI Jara Lebu-1

Methods: Described in methodology section

Results and discussion

Nutritional composition

The result of the nutritional assessment shown in Table 1 indicate that the *Citron*fruit contains 82.73±0.25 % moisture content, 7.54±0.25 % crude protein, 3.78±0.02 % ash, 5.02±0.01 % starch, 4.27±0.03 % total sugar, 6.10ºB TSS, 0.79±0.02 % acidity and 3.53±0.03 % pH. It's noteworthy that crude protein is highly present in the citron fruit. The edible portion of the fruit had 79.77±0.20 % while the non-edible portion had 20.23±0.09 %.

Mineral content

Table 2 show the minerals content of Citron (*Citrus medica*) fruits. All 12 minerals content investigated were found of the methanol extract more or less. The presence of Ca (0.83±0.05 %), Mg (0.37±0.02 %), K (0.65±0.02 %), Cu (114.22±5.02 ppm) and Fe (73.47±2.98) occurring in the higher amount and others were the least. Fe is considered as an essential as it provides energy and supplies oxygen. It deficiency may lead to anaemia (Cook, 2005). Mg deficiency may lead to severe disorders such as diarrhoea, hypertension and cardiovascular diseases (Swaminathan, 2003). Nevertheless, it helps to tackle muscle cramping. Ca accounts for most predominant element in the body and is essential in regulating muscle contractions and formation of bones (Soetan *et al.,* 2010). K intake reduces cardiovascular disease mortality due to its blood pressure-lowering effect (He and MacGregor, 2008) although its high intake have adverse effect on human health (He and MacGregor, 2008).

Phytochemical constituents

The phytochemical constituents of the Citron (*Citrus medica*) fruits are shown in Table 3. The result obtained from the study showed thatphytochemical constituents such as total flavonoids (27.85±1.05 mg QE/g), ascorbic acid content (210.43±0.02 mg/100g), total antioxidant capacity (278.24±0.03 µg of ascorbic acid/mg of extracts), NO free radical scavenging activity (178.87±0.02µg/ml), ferric reducing antioxidant property (1247.50±3.25 µM/100g), DPPH radical scavenging activity (70.20±0.19 %), total phenolic content (50.00±0.08 mg GAE/g) and lutein (71.33±1.52 mg/100g) are highly possessed by the *Citron* fruits. But the total carotenoid (0.35±0.05 mg/100g) and ß–carotene content (2.07±0.11 mg/100 g) was comparatively less in the fruit.

Flavonoids arepolyphenolic compounds having a phenyl benzopyrone structure as two benzene rings (C6) joined by a linear three carbon chain (C3) with a carbonyl group at the C position. Although flavonoids are generally regarded as non-nutritive agents, there potential role in the prevention of major chronic diseases has attracted the focus of many researchers. The citrus flavonoids include a class of glycosides namely, hesperidin and naringin and another class of O-methylatedaglycones of flavones such as nobiletin and tangeretin, which are relatively two common polymethoxylated flavones (Li *et al.,* 2014). The citrus flavonoids have been found to have a health related property, which include anticancer, antiviral and anti-inflammatory activities, reduce capillaryfragility, and restricts human platelet aggregation (Huet, 1982; Benavente-Garcia *et al.,* 1997).

The presence of ascorbic acid (210.43±0.02 mg/100 g) in *Citron*fruit can prevent clinical symptoms of the specific deficiency-scurvy for adultsis about 10 mg or little less (Food and Agriculture Organization (FAO), 1998). Therefore, the daily intake of 100g *citron*(Jara lebu) fruit can prevent the scurvy in Bangladesh.

The lowest IC_{50} value (11.26±0.26 µg/ml) of the *Citron* fruits means that it had the strongest radical scavenging activity. However, a strong correlation between TPH content and the IC_{50} values for scavenging the DPPH radical suggested that the level of scavenging activity of the fruit extracts was closely related to their phenolic groups.

Table 1. Nutritional composition, edible and non-edible portion of**citron fruits**

Sl. No.	Nutritional composition	Quantity (%)
1	Crude protein	7.54±0.25
2	Ash	3.78±0.02
3	Total sugar	4.27±0.03
4	Starch	5.02±0.01
5	Moisture content	82.73±0.25
6	TSS	6.10±0.10
7	Acidity	0.79±0.02
8	pH	3.53±0.03
9	Edible portion	79.77±1.59
10	Non-edible portion	20.05±1.20

Table 2. Mineral content of citron fruits

Sl. No.	Mineral content	Quantity
1	Ca	0.83±0.05
2	Mg	0.37±0.02
3	K	0.65±0.02
4	Na	0.08±0.01
5	P	0.10±0.00
6	S	0.02±0.00
7	B	8.03±0.30
8	Cu	114.22±5.02
9	Fe	73.47±2.98
10	Mn	16.06±0.60
11	Zn	11.20±0.42

Ca, Mg, K, Na,P and S expressed as percentage; B, Cu, Fe, Mn and Zn expressed as ppm; 1 ppm=1mg/kg~0.1mg/100g. Daily requirement of Ca (1300 mg/day), Mg (24±0.9 mg/day), Fe (.37 and 2.94 mg/day for men and women), Zn (1.4 mg/day) and K (3510 mg/day) (FAO and WHO, 2001).

Table 3. Phytochemical content of Citron fruits

Sl. No.	Phytochemicals	Quantity
1	Total anthocyanin content (mg/100g)	1.19±0.03
2	Total flavonoid content (mg QE/g)	27.85±1.05
3	Total carotenoid content (mg/100g)	2.07±0.11
4	Total ß-carotene content(µg/100g)	9.58±0.09
5	Ascorbic acid content (mg/100g)	210.43±0.02
6	Total antioxidant capacity (µg of ascorbic acid/mg of extracts)	278.24±0.03

Conclusion	7	NO free radical scavenging activity (µg/ml)	178.87±0.02
	8	Reducing power activity (µg/ml)	3.85±0.02
	9	Ferric reducing antioxidant property (µM/100g)	1247.50±3.25
	10	DPPH radical scavenging activity (%)	70.20±0.19
	11	Metalic chelating capacity (%)	24.28±0.61
	12	IC5 (µg/ml)	11.26±0.26
	13	Total phenolic content (mg GAE/g)	50.00±0.08
	14	Gallic acid (mg/100g)	0.94±0.02
	15	Vanilic acid (mg/100g)	0.03±0.02
	16	Þ-courmaric acid (mg/100g)	0.16±0.01
	17	Caffeic acid (mg/100g)	0.01±0.00
	18	Ferulic acid (mg/100g)	0.02±0.00
	19	Lutein (µg/100g)	71.33±1.52

The present study demonstrated that the citron (Citrus *medica)*fruits possessed rich source of phytochemical diversity (total flavonoid,, ascorbic acid, total antioxidant capacity, NO free radical scavenging activity, ferric reducing antioxidant property, DPPH free radical scavenging activity, total phenolic content and lutein), minerals (Ca, K, Mg, Cu and Fe) and nutritional composition (crude protein, total sugar and starch). The fruit hold promise in the food industry as sources of bioactive compounds.

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Ainci gola fruit (*Archidendron pauciflorum*)

Abstract

*Aincigola (Archidendron pouchiflorum*gola) is a leguminous tree plant belonging to the family of Fabaceae. Aincigola has been commonly named as Jengkol, Dogfruit, Jering Bean etc. This species is native to tropic countries of Southeast Asia; such as Malaysia, Myanmar, South Thailand and parts of Indonesia. The fruit is deep purple color and easily broken by hand. Crushed fruit produces a faint sulphurous odour. It's usually consumed as raw, roasted or fried. Considering it new approaches in Bangladesh as exotic minor fruits therefore, emphasize has given to study and documentation its phytochemicals, minerals, nutritional compositions, Aflatoxins, mycotoxins and antibacterial activities. The results obtained from the study showed that 19 phytochemicals, 12 minerals and 7 nutritional compositions are detected more or less content in the fruit. Among the phytochemical constituents, total anthocyanin (94.12±0.12 mg/100g), total flavonoid (6.66±0.38 mg QE/g), total ß-carotene content (12.51±0.48 µg/100g), ascorbic acid (39.61±0.61 mg/100 g), total antioxidant capacity (194.32±0.06 µg of ascorbic acid/mg of extracts), ferric reducing antioxidant property (3288±0.46 µM/100g), DPPH free radical scavenging activity (91.97±0.39 %) and total phenolic content (97.50±2.45 mg GAE/g), gallic acid (1.79±0.38 mg/100g), þ-courmaric acid (4.35±0.10 mg/100g) and lutein (634.00±1.00 µg/100g) were highly present in the *Aincigola* fruits. Aflatoxin and mycotoxin study indicates that the fruit contain Ochratoxin A which is higher than the EU recommended level.

Introduction

Ainci gola)(*Archidendron pauciflorum)* commonly recognised as Dogfruit, Jering (Malaysia), Jengkol (Indonesia) or Luk Nieng (Thailand). This species is native to tropic countries of Southeast Asia; such as Malaysia, Myanmar, South Thailand and parts of Indonesia (Barceloux, 2009). Now it's being popularizing in Bangladesh especially Technaf, Cox's Bazar and some parts of Chattragram. In Bangladesh, it is called Ainci gola. The fruit is available in Bangladesh from June to September. There is no release variety as it is new approaches in Bangladesh. It is deep purple 20-25 cm by 4-5 cm wide and easily broken by hand. It grows in large, dark purple pods which contain usually 3 to 9 beans (Fig.1). Crushed fruit produces a faint sulphurous odour. Aincigola fruits are usually consumed as raw, roasted or fried and are available in Teknaf and Cox's Bazar market. People in this region consume parts of this fruit because of its therapeutic value which includes blood purification or overcoming dysentery (Ong and Norzalina, 1999). The fruits have been found to have high polyphenolic contents (>150ug gallic aci equivalents/mg dried fruits). Antioxidant activities when measured using ferric reducing antioxidant power (FRAP) (Razab and Aziz, 2010).The methanolic extract of Aincigola fruit at concentration of200mg/mL was considered to inhibit the Epstein-Barr virus (inhibition test of anticancer) activation by 30% or more (Murakami *et al.,* 1995). Ibrahim *et al*. (2012) reported that pre-treatment of the *Aincigola fruit* significantly reduced the development of ethanol-induced gastric lesions and gastric wall mucus waswell-preserved. Additionally, the results also showed a significant increase in superoxide dismutase (SOD), the enzyme that is important in protecting gastrointestinal mucosa. Shukri *et al.* (2011) reported that Aincigola fruits are capable to reduce blood sugar and improved appetite, body weight and organ oxidative status. Apart from health beneficial effects, Aincigola fruit caused hypertrophy and lesions to liver, kidneys, heart, lungs and pancreas (Shukri *et al.,* 2011). Since the fruit is popularizing as exotic minor fruits in Bangladesh and peoples believe that consumption of Aincigola fruits mitigate their hunger, reduce diabetes and dysentery therefore,

the emphasize has given to document its phytochemical constituents, minerals and nutritional composition.

Figure 1. Ainci gola **(***Archidendron Pauciflorum***)**

Materials and Methods

Material: Ainchi gola**(***Archidendron pouchiflorum)*

Methods: Described in methodology section

Results and Discussion

Nutritional composition

The nutritional composition of the Ainchi gola(*Archidendron pouchiflorum)*fruits are presented in Table 1. The fruits contained 8.23±0.34 % crude protein, 1.80±0.20 % ash, 1.84±0.01 % total sugar, 6.32±0.24 % starch (carbohydrate), 74.06±0.65 % moisture content, 6.50±0.50 TSS, 1.91±0.01 % acidity and 2.43±0.12 pH respectively (Table 1).The edible portion of the fruit was44.29±0.66 % while the non-edible portion of the fruit is 52.21±2.01 % respectively (Table 1). The data demonstrated that Ainchi gola fruit was the good source of crude protein and starch (carbohydrate) content.The ash content of the fruits denotes the overall availability of minerals.

Mineral contents

Table 2 represents the mineral composition of the Ainchi gola (*Archidendron pouchiflorum)*. The fruit contained Ca, Mg, K, Na, P, S, B, Cu, Fe, Mn, Zn and B while all the minerals are presence with high or less quantity. The results revealed that Ca, Mg, K, S, B, Fe, Mn and Zn were presents highly as compared to others. Ca accounts for most predominant element in the body and is essential in regulating muscle contractions and formation of bones (Soetan *et al.,* 2010). Fe is considered as an essential as it provides energy and supplies oxygen. Its deficiency may lead to anaemia (Cook, 2005). Zn is associated with cell growth and testosterone production. It is reported that its deficiency may cause several severe disorders including poor appetite and night blindness (Evans, 1986). K intake reduces cardiovascular disease mortality due to its blood pressure-lowering effect (He and MacGregor, 2008) although its high intake have adverse effect on human health (He and MacGregor, 2008).

Phytochemical constituents

The results of phytochemical analysis of methanol extract of the Ainci gola (*Archidendron pauciflorum*)are presented in Table 3. The results indicates that 19 phytochemical constituents are detected high or less content in the Ainci gola fruits. Total anthocyanin (94.12±0.12

mg/100g), total flavonoid (6.66±0.38 mg QE/g), total ß-carotene content (12.51±0.48 µg/100g), ascorbic acid (39.61±0.61 mg/100 g), total antioxidant capacity (194.32±0.06 µg of ascorbic acid/mg of extracts), ferric reducing antioxidant property (3288±0.46 µM/100g), DPPH free radical scavenging activity (91.97±0.39 %) and total phenolic content (97.50±2.45 mg GAE/g), gallic acid (1.79±0.38 mg/100g), þ-courmaric acid (4.35±0.10 mg/100g) and lutein (634.00±1.00 µg/100g) followed by other phytochemical constituents (Table 3).

The presence of -carotene is the most abundant in Ainci gola fruits, while the flavonoid and carotenoid content were less present (Table 3). Ferric reducing antioxidant property of the Ainci gola fruits were (3288±0.46 µM/100g) means that the reducing power of Ainci gola fruit was more pronounced and the power of a compound was related to its electron transfer ability and may, therefore serve as an indicator of its potential antioxidant activity (Sanchez Moreno, 2002). Higher presence of total phenolic content (TPH) was detected in Ainci gola fruits and had the highest abilities of scavenging DPPH radicals which could be attributed to the high total phenolic content (Agu and Okulie, 2017).

The fruits were the rich source of antioxidant properties (194.32±0.06 µg of ascorbic acid/mg of extracts). Razab and Aziz (2010) reported that the Ainci gola fruits have been found to have high polyphenolic contents (>150ug gallic aci equivalents/mg dried fruits) and antioxidant activities when measured using ferric reducing antioxidant power (FRAP). Here our results obtained from the extract of the Ainci gola fruits found 194.32±0.06 µg of ascorbic acid/mg of extracts which was greater than the obtained value by the Razab and Aziz (2010). Therefore, the fruits may have abilities to mitigate free radical damage, to chelate and reduce materials.

Ascorbic acid of Ainci gola fruits was very high (67.90±0.05 mg/100 g), such that the consumption of Ainci gola fruit would meet the recommended dietary allowance (RDA) for vitamin C. Food and Agriculture Organization (FAO) (1998) reported that the minimum daily requirement of ascorbic acidfor preventing clinical symptoms of the specific deficiency-scurvy for adults is about 10 mg or little less. Phenolic compounds are good antioxidants found in the Ainci gola fruits especially phenolic acids and flavonoids. Among the phenolic acids, gallic acid and lutein is the major component of the Ainci golafruits (Table 3). Since phenolic are potent antioxidants, increased consumption of a mixture of fruits daily should be able to provide an adequate phenolic antioxidant. Thus, consumption of Ainci gola fruits may help to promote the health benefits.

Table 1. Nutritional composition, edible and non-edible portion of Ainci golafruits

Sl. No.	Nutritional composition	Quantity (%)
1	Crude protein	8.23±0.34
2	Ash	1.80±0.20
3	Total sugar	1.84±0.01
4	Starch	6.32±0.24
5	Moisture content	74.06±0.65
6	TSS	6.50±0.50
7	Acidity	1.91±0.01
8	pH	2.42±0.12
9	Edible portion	44.29±0.66
9	Non-edible portion	52.21±2.01

Table 2. Mineral content of Ainci gola fruits

Sl. No.	Mineral content	Quantity
1	Ca	2.14±0.11
2	Mg	1.13±0.12
3	K	0.52±0.02
4	Na	0.43±0.03
5	P	0.17±0.03
6	S	1.40±0.05
7	B	48.60±0.05
8	Cu	7.16±0.14
9	Fe	80.36±0.13
10	Mn	42.61±0.04
11	Zn	21.48±0.11

Ca, Mg, K, Na, P and S expressed as percentage; B, Cu, Fe, Mn and Zn expressed as ppm; 1 ppm=1mg/kg~0.1mg/100g. Daily requirement of Ca (1300 mg/day), Mg (24±0.9 mg/day), Fe (.37 and 2.94 mg/day for men and women), Zn (1.4 mg/day) and K (3510 mg/day) (FAO and WHO, 2001).

Table 3. Phytochemical content of Ainci gola fruits

Sl. No.	Phytochemicals	Quantity
1	Total anthocyanin content (mg/100g)	94.12±0.12
2	Total flavonoid content (mg QE/g)	6.66±0.38
3	Total carotenoid content (mg/100g)	1.13±0.12
4	Total ß-carotene content(µg/100g)	12.51±0.48
5	Ascorbic acid content (mg/100g)	39.61±0.61
6	Total antioxidant capacity (µg of ascorbic acid/mg of extracts)	194.32±0.06
7	NO free radical scavenging activity (µg/ml)	53.76±0.06
8	Reducing power activity (µg/ml)	2.54±0.03
9	Ferric reducing antioxidant property (µM/100g)	3288±0.46
10	DPPH radical scavenging activity (%)	91.97±0.39
11	Metalic chelating capacity (%)	18.65±0.27
12	IC_{50} (µg/ml)	11.28±0.37
13	Total phenolic content (mg GAE/g)	97.50±2.45
14	Gallic acid (mg/100g)	1.79±0.38
15	Vanilic acid (mg/100g)	0.07±0.02
16	Þ-courmaric acid (mg/100g)	4.35±0.10
17	Caffeic acid (mg/100g)	0.056±0.01
18	Ferulic acid (mg/100g)	0.03±0.01
19	Lutein (µg/100g)	233.67±5.5

Mycotoxins in Ainci gola(*Archidendron pauciflorum*) fruits

Table 4 represents the results of mycotoxins of the **Ainci gola fruits**. The results indicates that aflatoxin B1, B2, G1 and G2 were not detected in freshAinci gola fruits. But the Ochratoxin A and Patulin were presence in fresh *A.* Ainci gola fruits. The value of Ochratoxin A in the freshfruits were exceeded than the recommended value of the European Union (Table 4 and Table 5). The value of Patulin was detected in fresh Ainci gola fruits were acceptable as compared to the recommended value of the European Union (Table 4 and Table 5). Engelhardt*et al.* (1999) analyzed different fruits after removal of rotten parts of the fruits while the fruits were contaminated with Ochratoxin A OTA) up to 2.71 µg/kg in cherries, 1.44 µg/kg

in strawberries, 0.21 µg/kg in peaches and 0.41 µg/kg in apples. Logrieco *et al*. (1990) analyzed the rotten mandarin fruits while they found OTA up to 1000-5200 µg/kg. However, both researchers recommended that damaged or moldy fruits can be contaminated with OTA to a certain degree, even after removal of rotten parts of the fruits. OTA is a potent kidney toxin and has been classified by the International Agency for Research on Cancer (IARC, 1993). It is responsible for nephropathies and urinary tract tumors in man. High exposure to OTA, high concentration in blood serum and long-life (35 days), as well as the deposition in kidneys foster the development of nephrotoxicity. With high concentration of OTA in Food, there was a high incidence of renal adenomas and carcinomas (Redovano-vic *et al*., 1991), and there is a correlation between the occurrence of BEN and urinary tract tumors.

Table 4.Aflatoxin and mycotoxin analysis of Ainci golafruits

Aflatoxin	Unit	LOD	Results
Aflatoxin B1	µg/kg	1.0	ND
Aflatoxin B2	µg/kg	0.50	ND
Aflatoxin G1	µg/kg	1.0	ND
Aflatoxin G2	µg/kg	0.50	ND
Ochratoxin A	µg/kg	-	2.50
Patulin	µg/kg	-	20.00

ND= Not detected, LOD= Lower detection limit

Table 5. Antibacterial activities of Aincigola fruits

Bacteria	Unit	Results
Total Coliform	MPN/g	1100.00
Total Plate Count	cfu/g	$1.36x10^8$
Enterobacteriaceae Count	Cfu/g	$8.9x10^5$
Listeria spp.	Per 25g	Present
E.coli	MPN/g	<3
Salmonella spp.	Per 25g	Present
Staphylococcus Aureus	MPN/g	<3
Pseudomonas aeruginosa	Per g	Present
Faecal streptococci	cfu/g	530,000.00
Vibrio cholerae	Per 25g	Absent

Table 6. EU maximum levels (MLs) for mycotoxins in fruits and their processed products

Commodities	MLs (µg/kg)

Aflatoxins	B_1	$B_1+B_2+G_1+G_2$
Dried fruit to be subjected to sorting or other physical treatment, before human consumption or use as an ingredient in foodstuffs	5.0	10.0
Dried fruit and processed products thereof, intended for direct human consumption or use as an ingredient in foodstuffs	2.0	4.0
Processed cereal based foods and baby foods for infants and young children	0.10	-
Ochratoxin A		
Dried vine fruit (currants, raisins and sultana)		10.0
Wine (including sparkling wine, excluding liqueur wine and wine with an alcoholic strength not less than 15 vol%) and fruit wine		2.0
Aromatised wine, aromatized wine-based drinks and aromatized wine product cocktails		2.0
Grape juice, concentrated grape juice as reconstituted, grape nectar, grape must and concentrated grape must as reconstituted, intended for direct human consumption.		2.0
Processed cereal based foods and baby foods for infants and young children		0.50
Patulin		
Fruit juices, concentrated fruit juices as reconstituted and fruit nectars		50.0
Spirit drinks, cider and other fermented drinks derived from apples or containing apple juice		50.0
Solid apple products, including apple compote, apple puree intended for direct consumption		25.0
Apple juice and solid apple products including apple compote and apple puree, for infants and young children and labelled and solid as such		10.0
Baby foods other than processed cereal-based foods for infants and young children		10.0

Conclusion

The results obtained from the study confirmed that the Ainci gola fruits is the good source of phytochemical constituents viz. total anthocyanin, total flavonoid, total ß-carotene, ascorbic acid, total antioxidant capacity, ferric reducing antioxidant property, DPPH free radical scavenging activity, total phenolic content gallic acid, þ-courmaric acid and lutein. Minerals Ca, Mg, K, S, B, Fe, Mn and Zn were presents highly in Ainci gola fruits.Mycotoxins study revealed that Aflatoxins A_1, A_2, G_1 and G_2 were not detected in Ainci gola fruits. Patulins were present within the range of EU recommended limits. Ochratoxins A was found higher in Ainci gola fruits than the recommended level of EU.The fruits have also toxicology effects whereit's leading to azotemia and is capable to causing spasmodic pain and urinary obstruction and acute renal failure.

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12. Research highlight/findings (Bullet point – max 10 nos.):

- Nutritional compositions (Primary metabolites) of selected 10 minor indigenous fruits were documented
- Mineral compositions of selected 10 minor indigenous fruits were documented
- Phytochemical constituents of selected 10 minor indigenous fruits were documented
- Growing area, availability and uses of 10 selected minor indigenous fruits were well documented

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	4	108,000.00	4	108,000.00	
(b) Lab &field equipment	1	200,000.00	1	200,000.00	
(c) Other capital items	-	-	-	-	

2. Establishment/renovation facilities: N/A

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

3. Training/study tour/ seminar/workshop/conference organized: N/A

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					
(b) Workshop					

C. Financial and physical progress

Fig in Tk

Items of expenditure/ activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A.Contractual staff salary	212240	155015	155015	0	7.99	
B. Field research/lab expenses and supplies	1405771	1405771	1405771	0	72.46	
C. Operating expenses	185286	184210	184210	0	9.50	
D. Vehicle hire and fuel, oil & maintenance	60000	60000	60000	0	3.09	
E. Training/workshop/ seminar etc.	0	0	0	0	-	
F. Publications and printing	60000	0	0	0	-	
G. Miscellaneous	27012.38	27012.38	27012.38	0	1.39	

H. Capital expenses	108000	108000	108000	0	5.57	

D. Achievement of Sub-project by objectives: (Tangible form)

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output(i.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
To document nutritional composition of the selected minor fruits	Sample collection, preparation and spectrophotometric and chromatogram analysis	Nutritional compositions data obtained	Nutritional compositions of 10 selected minor fruits are well documented
To document mineral composition of the selected minor fruits	-	Mineral composition data obtained	Mineral compositions of 10 selected minor fruits are well documented
To documentphytochemical diversity of the selected minor fruits	-	Phytochemical constituents data obtained	Phytochemical constituents of 10 minor selected fruits are well documented

E.Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.	-	-	-
Journal publication	02	**Submitted**	-
Information development	10	**Documented**	-
Other publications, if any	-	-	-

F. Technology/Knowledge generation/Policy Support (as applied): Knowledge on phytochemical constituents of the selected minor fruits.

i. Generation of technology (Commodity & Non-commodity)

Nutritional compositions, mineral s and phytochemicals constituents are well documented

Generation of new knowledge that help in developing more technology in future

N/A

iii. Technology transferred that help increased agricultural productivity and farmers' income

Through using nutritional information, minerals and phytochemicals constituents farmers, food industry, pharmaceutical industry as well as consumers will be benefitted.

ii.Policy Support

N/A

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring [description & output of consultation meeting, monitoring workshops/seminars etc.):

5 February 2017 & 1 time visit by Dr. Md. Monirul Islam, MD, Nutrition Unit

ii) Field Monitoring (time& No. of visit, Team visit and output):02
Visited two times at13 February 2018 by the following personnel;

- Dr. Md. Zashim Uddin, CSO, BARI
- Md. Moniruzzaman, SSO, BARI
- Dr. Md. Nazrul Islam, SSO, BARI

I. Lesson Learned/Challenges (if any):

i) Nutritional compositions of the selected minor fruits
ii) Mineral content of the selected minor fruits
iii) Phytochemical constituents of the selected minor fruits

J. Challenges (if any): N/A

Signature of the Principal Investigator
Date …….

Seal

Counter signature of the Head of the organization/authorized representative
Date …….
Seal