Nutritional Composition, Antioxidant Activity and Common Phytochemicals of Selected BARI Mango Varieties and Commercial Cultivar Langra

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Abstract — The present study sought to explore the nutritional composition, bioactive phytochemicals and antioxidant activity of BARI mango-4, BARI mango-6 and Langra cultivar. The total phenolic (TPH), vitamin C, total carotene, B-carotene content and antioxidant activity of the mangos were determined by 1,1- diphenyl-2picryl hydrazyl (DPPH) scavenging and reducing power assays (RPA). Phenolic compounds were assessed using high-performance liquid chromatography coupled with a photodiode array detector and auto sampler. Results revealed that moisture, TSS, pH, total acidity, reducing, total sugar and energy of the BARI mango-4 and BARI mango-6 were 76.54 and 75.24 %, 17.10°B and 21.20°B, 4.90 and 5.01, 0.49 and 0.50 %, 3.90 and 4.54 %, 11.20 and 13.46 % and 4028.06 and 3950.27 cal/g respectively whereas the Langra cultivar remained 76.33 %, 17.63°B, 4.25, 0.63 %, 2.79 %, 9.79 % % and 3871.28 cal/g respectively. Phytochemicals especially TPH, ascorbic acid, total flavonoid (TF), total carotenoid (TC), ß-carotene and total anthocyanin content (TAC) of the BARI mango-4 and BARI mango-6 were 20.53 and 20.67 mg GAE/g, 39.98 and 26.26 mg/100 g, 3.14 mg and 2.87 QE/g, 76.38 and 81.33 mg/100 g, 28.17 and 65.84 µg/100 g and 1.67 and 11.69 mg/100 respectively whereas the Langra contained 19.90 mg GAE/g, 25.53 mg/100g, 1.38 mg QE/g, 4.21 mg/100 g, 31.00 µg/100 g and18.22 mg/100 g respectively. In case of antioxidant activities total antioxidant capacity, DPPH radical scavenging activity, reducing power capacity (RPC), metal chelating capacity (MCC), Nitric oxide (NO) free radical scavenging activity and IC₅₀ of the BARI mango-4 and BARI mango-6 were 229.00 and 309.00 μg of ascorbic acid/mg of extract, 96.84 and 94.73 %, 12.20 and 9.71 µg/mL, 157.36 and 132.89 %, 61.74 and 72.65 µg/mL and 0.59 and 0.71 µg/mL respectively whereas the Langra cultivar contained 194.25 µg of ascorbic acid/mg of extract, 87.94 %, 2.54 µg/mL, 177.80 %, 53.74 µg/mL and 25.11 µg/mL respectively. The results indicate that BARI mango-4 and BARI mango-6 exhibited rich source of TPH, TC, ßcarotene, ascorbic acid, TA, TAC and NO free radical scavenging activity whereas the Langra is the rich source of MCC and anthocyanin content. Phenolic acids were leading agent in BARI mango-4 and BARI mango-6. Moreover, BARI mango-4 and BARI mango-6 extract had a great potential to fight free radical chain reactions and for usage in therapeutic applications.

Index Terms — Mangoes; nutrients; bioactive compounds; antioxidants.

I. INTRODUCTION

Bangladesh is blessed with the greatest diversity of fruits and in 2017 placed the 6th position in world ranking for tropical fresh fruit production [1]. A significant quantity of tropical fruits become underexploited, which are generally recognized as indigenous or minor fruits. Major fruits like mango, litchi, guava, banana, jackfruit etc. are commercially cultivated in Bangladesh. Among the major fruits, mango (Mangifera indica L.) is called the king of the fruits and may be due to its deliciousness and very popular among all ages of the people. There are over 500 classes of mango varieties; some of them have evolved and have been distributed throughout the world. The main mango producing countries of the world are India, Pakistan, Mexico, Brazil, Haiti, Philippines, and Bangladesh [2]. Mangoes grow widely throughout the Bangladesh and are raised mostly as homestead plantations. The leading mango producing districts are Chapai Nawabgonj, Rajshahi and Satkhira areas with a large number of superior varieties namely Fazlee, Langra, Gopalbhog, Himsagar, Khirsapat, Kohitoor, Laksmanbhog, Chausa, Amrapali, Mallika, Mohanbhog, Misribhog etc. [2]. The soil and climatic conditions of Bangladesh especially northern and eastern regions are suitable for commercial mango cultivation [3]. But the BARI varieties is grown almost all over the country and are renowned for their emblematic taste, high TSS content (15°B-26°B), fruit weight (207.67-433.67 g), yield (13-22 t/ha), taste and highly adaptation to different regions in Bangladesh. These mango varieties have a great demand throughout the Bangladesh and have commercial importance in the agro-food processing industries.

Bangladesh Agricultural Research Institute (BARI) up to now developed 11 mango varieties that are being tried introduced and disseminated to all over the country. Moisture content, titrable acidity, pH, TSS, total sugar, reducing sugar, total protein, total fat, crude fiber, ash, total carbohydrate, total energy value, vitamin-C content and heavy metals have been analyzed by the Ara et al. [2] only for the commercial cultivars. The detail studies for its nutritional composition, minerals, antioxidant activities and phytochemical compounds are still now meager for both commercial and BARI mango varieties. Among the various

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phytochemicals, polyphenolic compounds comprising phenolic acids, flavonoids, benzoic acids derivatives and other compounds are linked with natural protective agents, astringency, antibiotics, positive health effects or antimicrobial properties [4]. In recent years, interests for antioxidant-rich fruits and their products is growing in both domestic and international markets because of increasing appreciation of their role in the protection of human health.

Nowadays, antioxidants are also considered as important as vitamins for promotion of health and prevention of various diseases linked to reactive oxygen species (ROS) and scarcity of vitamin-C. ROS have been linked to over 100 disorders [5]. Excess generation of ROS causes oxidative stress that damage DNA, lipids and proteins of cells leading to pathogenesis of various diseases including CVDs. Vitamin-C may contribute to promote the health beneficial effect for the COVID-19 patients. Minerals are essential for good health and nutrition, advancing physical and intellectual development. Low dietary intake of mineral rich foods as well as low absorption and lower bioavailability of those minerals are the leading cause of the micronutrient deficiencies. Since nutrition database is of great importance in addressing nutritional health benefits and it is essential for planning of food, nutrition, and health related policy tools for the country and pharmaceutical industries. From these points of view, the present study has undertaken for analyzing and documentation of phytochemicals, nutritional composition, minerals, and antioxidant properties and for comparing those with commercial variety to promote nutritional health of the people.

II. MATERIALS AND METHODS

The materials were BARI mango-4, BARI mango-6 and Langra cultivar. Analytical grade chemicals and reagents used in this study were procured from Millipore Sigma (Merck KGaA).

A. Sampling

The sample used for the analysis was collected from the Fruit Research Field of Horticulture Research Center (HRC), BARI, Gazipur-1701, Bangladesh. The fruits were harvested and collected when attained physiological maturity. Three fruits trees for each variety was scientifically tagged in the orchard and randomly fifty fruits were harvested from each tree for each variety. There were three replications (one tree comprises one replication) and each replication contained fifty fruits. Thus 600 fruits ($50 \times 1 \times 3 \times 4$) were harvested from three replications of the two varieties (BARI mango-4 and BARI mangio-6).

B. Determination of Physical Characters

Physical characters such as weights of fruit, peel and seed weight were measured by digital electrical balance. The edible and non-edible portion of the fruit was measured using the gravimetric method.

C. Determination of Physicochemical Parameter

The physicochemical properties of the fruit in terms of moisture, total sugar, reducing sugar, total soluble solids (TSS), pH and titratable acidity were determined as per the method mentioned by AOAC [6]. Starch and total sugar content were determined based on the procedure of Ranganna [7].

D. Preparation of Fruit Extract

The fruits were washed with potable water and peeled using peeler. After peeling, the fruits were sliced and freezedried to make powder using a laboratory grinder. The powdered samples were either used for the extraction or packed in HDPE pouch [8] and stored at -18 °C until used for analysis. Fruit powder of known quantity was extracted in a thermostatic water bath (Vision Scientific Co. Ltd.) at 60 °C for 60 min. using methanol (80%, v/v) maintaining the fruit to solvent ratio of 1:20 (w/v). The fruit extract was filtered under vacuum, centrifuged at 4000×g for 10 min and supernatant were collected and kept at -18 °C until used for analysis.

E. Determination of Phytochemicals

a) Total phenolic content

Twenty milligrams (0.02 g) of powder were dissolved in 1 mL of methanol to prepare a stock-solution for experiments. A volume of 0.5 mL of the each extract (100 µg/mL) was mixed with 2 mL of the Folin-Ciocalteu reagent (diluted 1:10 with de-ionized water) and were neutralized with 4 mL of sodium carbonate solution (7.5%, w/v). The reaction mixture was incubated at room temperature for 30 min. with intermittent shaking for color development. The absorbance of the colored solution was measured at 765 nm using double beam UV-VIS spectrophotometer. The total phenolic content was determined from the linear equation of a standard curve prepared with gallic acid. The content of total phenolic compounds expressed as mg/g gallic acid equivalent (GAE) of dry extract. Determination of total phenolic content in the extracts was determined according to the Folin-Ciocalteu method [9] with gallic acid (GAE) as the standard and expressed (mg) as gallic acid equivalents (GAE)/g of extract [10].

b) Determination of total flavonoid content

The total flavonoid content (TFC) of the fruit powder was determined by aluminium chloride method [11] with slight modifications. Sample solution was prepared by mixing fruit powder in methanol at a concentration of 1 mg/ml. 0.5 ml of sample solution was then 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 reaction mixture solution was measured at 415 nm using UV-vis spectrophotometer. The TFC was calculated based on R^2 value of the calibration curve and expressed as milligram quercetin equivalent per gram of extract (mg QE/g extract).

c) Determination of ascorbic acid content

Ascorbic acid was determined according to the method described by Ranganna [7].

d) Determination of total anthocyanin

The method was adapted from Burgos et al. [12]: 0.2 g of freeze-dried samples was mixed with 10 mL of methanol/ 1.0 M HCl (75:25, v/v) and sonicated for 10 min at room temperature. The mixture was centrifuged at 5000 rpm for 10 min. and the pellet was re-extracted. The combined supernatants were filtered and the volume made up to 25 mL with the extraction solution. Absorbance of the extract was read at 545, 535 and 515 nm and the concentration of TA was calculated using the molar extinction coefficient and molecular weight of malvidin-3-p-coumaroyl-glucoside for blue-violet pigments (545 nm, 3.02×10^4 L/mol/cm, 718.5 g/mol), pelargonidin-3-glucoside for red pigments (515 nm, 2.73×10^4 L/mol/cm, 486.5 g/mol), and cyanidin-3-glucoside for purple pigments (535 nm, 3.43×10^4 L/mol/cm, 449.2 g/mol). Results were expressed in mg/100 g DW.

e) Determination of total carotenoid content

Determination of total carotenoid content performed by Thaipong et al. [13] method. The extracted fruit powder was dissolved in n-hexane pro analysis. β-carotene solution in various concentrations was used as standard of carotenoid compound and to be standard curve. Absorbance was measured at 470 nm. Linear regression equation of standard curve was used for calculating total carotenoid content. Results were expressed as beta-carotene equivalent per 100 g of powder (mg/100 g).

f) Determination of β -carotene content

 β -carotene content was determined using the procedure of Holden et al. [14] and the value was expressed as $\mu g/100$ g of fruit powder.

F. Determination of Antioxidant Activity

a) Total antioxidant activity

The total antioxidant activity was assessed by the phosphomolybdenum system rendering to the technique described by Prieto et al. [15]. Briefly, 0.3 g of fruit powder was taken in a glass tube and 3 mL of reagent solution (0.6 M sulphuric acid, 28 mM sodium phosphate and 4 mM ammonium molybdate) was added. The mixture was heated at 95 °C in a water bath for 90 min. Then the mixture was cooled at room temperature and the absorbance was read at 695 nm. The result was stated as microgram ascorbic acid (AA) per gram (μ g/mL) of the sample.

b) Reducing power assay

The reducing power of the fruit powder was assessed using the approach of Guo et al. [16]. The fruit powder (0.2 g) was mixed with 0.5 mL phosphate buffer (0.2 M, pH 6.6) and 0.5 mL potassium ferricyanide (1% w/v) and mixed properly. The mixture was then incubated at 50°C for 30 min, 0.5 mL of trichloro acetic acid (10%, w/v) was added, subjected to centrifugation for 10 min. The upper portion of the solution (0.5 mL) was taken, mixed with 0.1 mL of 0.1% (w/v) FeCl₃ and 0.5 mL distilled water. The absorbance was noticed at 700 nm and ascorbic acid was used as the standard for the preparation of the calibration curve.

c) DPPH radical scavenging activity (DPPH-RSA) and IC₅₀

The 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical quenching property was evaluated by measuring the inhibition rate following the procedure described by Brand-Williams et al. [17] with some alteration. Exactly 0.1 mg of the fruit powder was put into a falcon tube and 1.4 mL methanolic solution of DPPH was added. The mixture was left in rest for 30 min in dark and the absorbance at 517 nm was measured against blank (0.1 mL methanol in 1.4 mL DPPH solution). The result was stated in terms of percent radical scavenging activity.

DPPH radical scavenging activity (%) =
$$\frac{A_0 - A_s}{A_0} \times 100$$

where, A_o is absorbance of blank and A_s is absorbance of sample extract. Then, the inhibition curves were prepared and IC₅₀ values were calculated [17]. BHT was the positive control.

d) Metals chelating capacity

The metal chelating capacity (MCC) was determined based on Bahadori et al. [18] with little modification. Briefly, 2 mg fruit powder was taken in a glass tube to which 0.05 mL ferrous chloride (2 mM), 3.7 mL distilled water, and 0.2 mL ferrozine (5 mM) were added. After 20 min of incubation at atmospheric condition, the absorbance was read at 562 nm against blank. The following formula was applied to calculate the metal-chelating capacity.

$$\frac{\text{Metal chelating capacity (\%)}}{\text{Absorbance (control)} - \text{Absorbance (sample)}} \times 100$$

e) Nitric oxide radical scavenging activity

Nitric oxide radical quenching activity was determined according to the procedure of Bogucka-Kocka et al. [19] with some modification. Shortly, 0.5 mg fruit powder was taken in a glass tube to which 2 mL sodium nitroprusside (10 mM) was mixed. This was followed by incubation at the atmospheric condition for 60 min. Thereafter, 0.5 mL incubated mixture was transferred into another centrifuge tube and Griess reagent (0.5 mL) was added and kept in rest for 30 min. The absorbance of the solution was read at 540 nm against blank. The following formula was employed to calculate the result and expressed as percent inhibition.

Inhibition (%)
=
$$\frac{\text{Absorbance (control)} - \text{Absorbance(sample)}}{\text{Absorbance (control)}} \times 100$$

G. Assessment of Phenolic Acids by HPLC

Phenolic compounds were assessed according to Pandey and Negi [20] with some adjustment using highperformance liquid chromatography (Shimadzu SPD-M10A) coupled with a photodiode array detector and auto sampler at 280 and 320 nm. The separation was achieved by C18 column (250 mm \times 4.6 mm) with 5 µm particle size at room temperature. The mobile phase was 1% acetic acid (A) and 80% acetonitrile in A (B). The following gradient was followed: 0.01-35 min, 0% of B; 35-40 min, 50% of B; 40-45 min, 100% of B; and 45-60 min, 0% of B. The flow rate was 1 mL/min, and the injection capacity was 20 μ L. A total of 60 min was taken for chromatographic analysis. All solvents used for HPLC were degassed using vacuum filter. Six phenolic standards (P-courmaric acid, gallic acid, vanillic acid, caffeic acid, ferulic acid, and lutein) were used for identification of respective phenolics, and quantification was accomplished using standard curve prepared by injecting the mixture of all the standards (0.1-0.7 mg/mL).

H. Statistical Analysis

Data obtained for each analysis were expressed in duplicate as means (3 replications) \pm standard deviation. Data was analyzed by One-way ANOVA with post-hoc using Turkey Multiple Comparisons Test. The significance was defined at the 95 % confidence level. Statistical analysis and data processing were performed using software SPSS 17.0 (IBM INC., New York).

III. RESULTS AND DISCUSSION

A. Physico-Chemical Properties

The physicochemical properties of the BARI mango-4, BARI mango-6 and commercial cultivar Langra are shown in Table 1. Results revealed that TSS of the BARI mango-4, BARI mango-6 and Langra were statistically differed and found maximum in BARI mango-6 (21.20 °B). The TSS obtained by Ara et al. [2] for the ten commercial mango cultivars ranged from 12.87 to 21.05 °Brix which indicates that BARI mango varieties contain higher amount of TSS. As a reason it is said that BARI varieties were obtained from our own orchard and it was physiologically matured than Ara et al. [2]. They [2] collected samples from the market and sometimes market samples found physiologically immature and treated by ripening agents. pH of the BARI mango-4, BARI mango-6 and Langra found 4.93, 5.01 and 4.25 whereas the acidity calculated as 0.49 %, 0.50 % and 0.63 % respectively. The results obtained by Ara et al. [2] for the pH and acidity of the ten commercial cultivars ranged from 4.35 to 4.70 and 0.30 to 0.75%. It is noted that BARI mango-4 and BARI mango-6 had higher pH and lower acidity than the results obtained by Ara et al. [2] and Langra cultivar. However, TSS, pH and acidity varied for all the varieties and these variations might be due to different cultivars, fruit maturity and ripening with the conversion of pectic substances. Moisture content of the BARI mango-4, BARI mango-6 and Langra found 76.54 %, 75.27 % and 76.33 % respectively FW while it was reported from 78.078 to 79.078 % FW by Maldonado-Celis [21] for different Colombia, Mexico and United States mango cultivars. Total sugar and reducing sugar content of the BARI mango varieties and Langra cultivar varied significantly (p<0.05) and ranged from 9.79-13.46 % and 2.79-4.54 % respectively. Ara et al. [2] reported reducing sugar content for ten commercial cultivars and ranged from 4.27 to 5.48 %. Here, it is noteworthy that BARI mango variety had higher total sugar and reducing sugar content than the commercial cultivar Langra. Literature suggest that the variation of total sugar content depends on the nature of the fruit maturity, time of harvest, oxidation of important constituents, soil conditions and differences in composition [22]. Energy is essential for rest, activity, growth, and maintenance of sound health. Its content is of concern to health-conscious consumers [23]. The highest energy (4028.28 Kcal/g1) found in BARI mango-4 whereas the lowest was recorded as 3950.28 Kcal/g and 3871.28 Kcal/g in BARI mango-6 and Langra cultivar (Table 1).

TABLE 1: PHYSICO-CHEMICAL PROPERTIES OF BARI MANGO-4, BARI

MANGO-0 AND LANGRA					
Parameter	BARI mango-4	BARI mango-6	Langra	LSD	
Moisture content (%)	76.54±0.04	75.27±0.03	76.33±1.70	**	
Total soluble solid (°B)	17.10±0.03	21.20±0.04	17.63±0.02	**	
pH	4.90±0.03	5.01±0.01	4.25±0.04	*	
Acidity (%)	$0.49{\pm}0.02$	0.50 ± 0.03	0.63 ± 0.02	**	
Total sugar (%)	11.20±0.02	13.46±0.04	9.79±0.02	**	
Reducing sugar (%)	3.90±0.02	4.54±0.04	2.79±0.05	**	
Energy (Kcal/g)	4028.06±0.04	3950.28±0.02	3871.28±0.06	**	

All values are means of triplicate determinations \pm SD. * indicates significant result at p<0.05; ** indicates significant result at p<0.01.

B. Phytochemicals Properties

Phytochemicals or bioactive compounds e.g. phenolic acids, carotenoids, and vitamins, naturally exist in foodstuffs including fruits, vegetables, herbs, and spices [24]. These components supposed to have the ability to lower the prevalence of different degenerative diseases such as cancer, heart attack, and cardiovascular disease etc. by terminating the free radical's activity [25]. Literature supports that stages of fruit maturity, cultural practice and processing technique are directly influenced these phytochemicals [24].

The results recorded for the phytochemical analyses such as total phenolic, flavonoids, carotenoids, β -carotene, ascorbic acid, and anthocyanin are presented in Table 2. Total phenolic content of the BARI mango-4 and BARI mango-6 found 20.53 and 20.67 mg GAE/g DM whereas the Lnagra possessed 19.90 mg GAE/g DM. The lower phenolic content obtained by the Langra cultivar than the BARI mango-6 might be due to the effect of regional soil characteristics, fruit maturity, time of harvest, fruit and orchard nature [22]. Our results are supported with the findings of Burgos et al. [12], who reported that pineapple and passion fruit had a polyphenol content of 21.7 mg GAE/100g and 20.2 mg GAE/100g DM, respectively.

Flavonoids are regarded as a low molecular weight substance exists in foodstuffs, which boosts the antioxidants activity [11]. Its content depends on the amount of polyphenols and geographical locations. The value of total flavonoids existing in the examined BARI mango-4 and BARI mango-6 found 3.14, 2.87 and 1.38 mg QE/g while the highest was recorded in BARI mango-4 (3.14 mg QE/g).Total flavonoid content of Thailand ten mango cultivars were reported by Maldonado-Celis et al. [21] and ranged from 0.035 to 13.09 mg QE/g DM. Since flavonoids

possessed a fair amount of flavonoids like other exotic fruits, its consumption would help to contribute to add antioxidants to our daily diet.

It is evidenced from different studies that carotenoid has a crucial part in human nutrition and health, which can lessen the risks of cancer and heart diseases because of the activity of pro-vitamin A [24]. It can be seen that total carotenoids and total β -carotene content of the BARI mango-4 and BARI mango-6 found as 76.38 and 81.33 mg/100 g and 28.17 and 65.84 µg/100 g, respectively while it was recorded in Langra cultivar 4.21 mg/100 g and 31.00 µg/100 g respectively (Table 2). Results show that BARI mango-6 donated higher amount of total carotenoids and total β -carotene content than BARI mango-4 and Langra cultivar. The total carotenoids contained in our examined sample is comparable to the reported by Haque et al. [26] for the twelve mango varieties while it ranged from 108.00 to 444.66 µg/100 g.

Studies evidenced that ascorbic acid is considered as the most powerful antioxidants in foodstuffs whose regular intake lowers the cancer risks in the human body [27]. However, ascorbic acid is also considered as the most unstable compounds existing in foodstuffs and its content depends on various factors such as heat, pH, metal content, oxygen content etc. [28]. Therefore, the indication of nutrient loss in foodstuffs is evaluated through the containment of its ascorbic acid. Interestingly, the ascorbic acid content of the BARI mango-4 and BARI mango-6 found 39.98 and 26.26 mg/100 g FW while the Langra was recorded as 25.53 mg/100 g FW. Total ascorbic acid content of five commercial mango varieties (Tommy Atkins, Keitt, and Kent) was reported by Manthey and Perkins-Veazie [29] as 22 mg/100 g FW. In addition, total ascorbic acid content of three commercial mango varieties ranged from 15.80 to 16.4 mg/100 g those reported by Dars et al. [30]. FAO [31] reported that jackfruit which is recognized as the national fruit of Bangladesh contained 11.08 mg/100 g ascorbic acid content. Results obtained from our study indicates that BARI mango is the rich source of ascorbic acid than Langra cultivar and Jackfruit and the results obtained by Manthey and Perkins-Veazie [29] and Dars et al. [30]. According to Jukes [32], the RDA of vitamin C, i.e. ascorbic acid to prevent scurvy for adults is about 10 mg, which indicates that the current study found a higher amount of ascorbic acid that can prevent scurvy adequately with daily consumption of 100 g of mango fruit. One of the important bioactive compounds existent in foodstuffs is the anthocyanin. Previous research supported that this compound showed potent antioxidant capacity. The anthocyanin content of the BARI mango-4, BARI mango-6 and Langra cultivar were highly significant. The highest anthocyanin content was recorded as 18.22 mg/100g in Langra cultivar than the BARI mango varieties. This value is well supported with the previous findings of Rufino et al. [33] who reported that strawberries had anthocyanin content as 21 mg/100g.

TABLE 2: PHYTOCHEMICAL PROPERTIES OF BARI MANGO-4, BARI MANGO-6 AND LANGPA

6 AND LANGRA				
Parameter	BARI	BARI	Langra	LSD
	mango-4	mango-6		
Anthocyanin	1.67 ± 0.02	11.69 ± 0.01	18.22 ± 0.04	**
Total phenolic	20.53 ± 0.03	20.67 ± 0.07	19.90 ± 7.20	*
Ascorbic acid	39.98±0.01	26.26 ± 0.05	25.53 ± 0.02	**
ß-carotene	28.17 ± 0.03	$65.84{\pm}0.04$	31.00 ± 0.90	**
Total	3.14 ± 0.01	2.87±0.01	1.38 ± 0.12	**
flavonoid	5.11 = 0.01	2.07=0.01	1.2 0 - 0.12	
Total	76 38+0 01	81 33+0 01	4 21+0 17	**
carotenoid	70.50±0.01	01.55±0.01	1.21±0.17	
All values are	means of triplica	te determinatio	ns \pm SD. *	indicates

All values are means of triplicate determinations \pm SD. * indicates significant result at p<0.05; ** indicates significant result at p<0.01.

C. Evaluation of Antioxidant Activity

Present research has reported that major fruits are an ample source of different bioactive compounds and phytochemicals, which contribute to their antioxidant properties. Antioxidants terminate the free radical reactions and purify the harmful actions of it. Foodstuffs with high antioxidants properties play a crucial role in the inhibition of reactive oxygen species (ROS) tempted diseases [34].

In this investigation, the antioxidant activity of BARI mango-4 and BARI mango-6 was assessed by an assortment of different tests and the findings of these analyses are shown in Table 3. Statistically a highly significant difference was observed among the BARI mango varieties and Langra cultivar those exhibited a potent antioxidant activity. Total antioxidant capacity of the BARI mango-4 and BARI mango-6 was 229.00 and 309.00 μ g of ascorbic acid/mg of extract while the Langra cultivar was 194.25 μ g of ascorbic acid/mg of extract. Results indicate that BARI mango is the rich source of antioxidant capacity than the commercial cultivar Langra. The highest antioxidant capacity obtained in BARI mango varieties might be the result of the abundances of phenolic constituents of the fruit [35].

The DPPH of the BARI mango-4, BARI mango-6 and Langra cultivar found 96.84 %, 94.73% and 87.94 % respectively while the almost similar results (2.91 to 92.00 %) have been reported by Anaya-Esparza and Montalvo-Gonzalez [36]. Results revealed that BARI mango varieties exhibited strong capacity to scavenge free radicals' activities. The IC₅₀ is a widely accepted method to assess the antioxidant activity of foodstuffs and its value is expected to be lower for higher free radical quenching ability [37]. Our study exposed that BARI mango-4 and BARI mango-6 extract had potential antioxidant capacity due to its lower value of IC₅₀ (0.59 and 0.71 μ g/mg), which might be due to the presence of significant amounts of phenolics and flavonoids. This finding is also corroborated with the forgoing research of Sathyanarayanan et al. [37]. The reducing power assay (RPA) of the BARI mango-4 and BARI mango-6 found 12.20 and 9.71µg/mL while the lower value 2.54 µg/mL recorded in Langra cultivar. Lower metal chelating capacity (MCC) was recorded as 157.36 % and 132.89 % in BARI mango-4 and BARI mango-6 while the highest MCC 177.80 % was recorded in Langra cultivar. It indicates that the capability of the BARI mango varieties and Langra cultivar to reduce different metallic ions to make a stable chemical bond to fight free radicals. Modern studies reported that redox properties of phenolic species let them perform as reducing agents by donating hydrogen and quenching the singlet oxygen that shows antioxidant activity and chelates metal ions [38]. Previous reports evidenced that fruits with high phenolic can react with free radicals to form a stable product that ceases the radical-chain-reaction [37]. Reactive nitrogen species (RNS) are notorious to produce nitric oxide radicals, which could convert into toxic oxidants and nitrating agents. This RNS has been linked with many health complications like cardiovascular diseases, cancer, asthma, Alzheimer, diabetes etc. [39]. Our study reported a good nitric oxide radical foraging activity in BARI mango-4 and BARI mango-6 recorded as 61.74 and 72.65 μ g/mL whereas the lowest was in Langra cultivar (53.74 %).The highest nitric oxide free radical scavenging activity might have attributed owing to the presence of different polyphenolic substances in BARI mango varieties.

TABLE 3: ANTIOXIDANT PROPERTIES OF BARI MANGO-4, BARI MANGO-6

AND LANGRA					
Parameter	BARI mango-4	BARI mango-6	Langra	LSD	
DPPH radical scavenging activity (%)	96.84±0.02	94.73±0.02	87.94±1.19	**	
Total antioxidant capacity (µg of ascorbic acid/mg of extract)	229.00±1.00	309.00±1.00	194.25±1.00	**	
Metal chelating capacity (%)	157.36±0.06	132.89±0.09	177.80±0.40	**	
Reducing power assay (µg/mL)	12.20±0.02	9.71±0.01	2.54±0.02	**	
Nitric oxide free radical scavenging activity (µg/mL)	61.74±0.03	72.65±0.05	53.74±0.0	**	
$IC_{50}(\mu g/mL)$	0.59±0.01	0.71 ± 0.00	25.11±2.70	**	
All values are means of triplicate determinations + SD ** indicates					

All values are means of triplicate determinations \pm SD. ** indicates significant result at p<0.01.

D. Phenolic Compounds

The chromatograms and values obtained for phenolic acids are displayed in Fig. 1, 2 and 3 and Table 4. Five major phenolic acids were analyzed by High-Performance Liquid Chromatography and matched with the respective standards. Results depict that BARI mango varieties are plentiful of phenolic acids. Among the identified phenolic acids, gallic, vanilic, caffeic and ferulic acid of the BARI mango-4 and BARI mango-6 found 17.52 and 19.11 mg/ 100 g, 4.36 and 5.71 mg/100 g, 2.16 and 19.4 mg/100 g and 10.27 and 8.08 mg/100 g respectively whereas the Langra cultivar recorded as 0.95 mg/100 g, 0.16 mg/100 g, 0.48 mg/100 g, 0.15 mg/100 g and 0.31 mg/100 g respectively. Gallic, vanillic, caffeic and ferulic acid of the nine mango varieties cultivated in China ranged from 0.93 to 2.98 mg/100 g, 0.57 to 1.63 mg/100 g, 0.25 to 0.10 mg/ 100 g and 0 to 33.75 mg/100 g FW [21]. Results show that BARI mango varieties contain higher amount of gallic, vanillic and caffeic acids followed by Chinese nine mango varieties. However, BARI mango-4 and BARI mango-6 was rich source of phenolic acids that act as defense against different hazardous chemical reactions and diseases, and their involvement in antioxidants depends on their structure [40].

TABLE 4: PHENOLIC COMPOUNDS OF BARI MANGO-4, BARI MANGO-6

AND LANGRA					
Parameter	BARI mango-4	BARI mango-6	Langra	LSD	
Gallic acid (mg/100 g)	17.52±0.02	19.11±0.01	0.95±0.02	**	
Vanilic acid (mg/100 g)	4.36±0.02	5.71±0.01	0.16±0.01	**	
Þ-courmaric acid (mg/100g)	0.11±0.02	0.23±0.01	0.48±0.02	**	
Caffeic acid (mg/100 g)	2.16±0.01	$1.94{\pm}0.01$	0.15±0.01	**	
Ferulic acid (mg/100 g)	10.27±0.01	8.08±0.02	0.31±0.02	**	

All values are means of triplicate determinations \pm SD. ** indicates significant result at p<0.01.







Fig. 3. Chromatogram of Phenolic acid of methanolic Langra fruits extracts.

IV. CONCLUSION

This study first time exposed the details information regarding the nutritional, bioactive compounds and antioxidant activities profiling of the selected BARI mango-4 and BARI mango-6. From the present findings, it can be concluded that BARI mango-4 and BARI mango-6 is the rich source of TPH, ascorbic acid, TC, ß-carotene, TAC and NO whereas the Langra is the rich source of anthocyanin and MCCw22. Phenolic acids are the leading agents in BARI mango varieties than the cultivar Langra. The findings showed a promising standpoint for possible exploitation of this fruit to be applied as the raw material for food and pharmaceutical usages. Further research studies are recommended using different modern extraction methods isolation of health beneficial constituents for for pharmaceutical usages.

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REFERENCES

- FAO STAT(2019) Statistics Division, Food and Agriculture Organization of the United Nations. Viale delle Terme di Caracalla 00153 Rome, Italy.
- [2] Ara R, Motalab M, Uddin MN, Fakhruddin ANM, Saha BK (2014) Nutritional evaluation of different mango varieties available in Bangladesh. International Food Research Journal 21: 2169-2174.
- [3] BBS (2006) Year Book of Agricultural Statistics, Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.
- [4] Osorio-Esquivel O, Alicia-Ortiz-Moreno A, Álvarez VB, Dorantes-Álvarez L, Giusti MM (2011) Phenolics, betacyanins and antioxidant activity in Opuntia joconostle fruits. *Food Research International*: 2160-2168.
- [5] Halliwell B, Gutteridge JMC (2000) Free radicals in biology and medicine. Oxford Science Publications, Oxford. pp. 617-624.
- [6] AOAC (2005) Official Methods of Analysis, Association of Official Analytical Chemists. Arlington, VA, United States of America.
- [7] Ranganna S (1995) Handbook of Analysis and Quality Control for Fruit and Vegetable Products, Second ed., McGraw Hill publishing Co. Ltd., New Delhi. pp.1169.
- [8] Shishir MRI, Taip FS, Saifullah M, Aziz NA, Talib RA (2017) Effect of packaging materials and storage temperature on the retention of physicochemical properties of vacuum packed pink guava powder. Food Packaging Shelf life 12: 83–90.
- [9] Ough CS, Amerine MA (1988) Phenolic compounds, In: Methods for analysis of musts and wines, J Wiley and Sons, Inc., New York, USA.
- [10] Aoshima H, Hirata S, Ayabe S (2007) Antioxidative and Anti-Hydrogen Peroxide Activities of Various Herbal Teas. Food Chemistry 103: 617-622.
- [11] Chang CC, Yang MH, Wen HM, Chern JC (2002) Estimation of total flavonoid content in propolis by two complementary colorimetric methods. Journal of Food and Drug Analysis 10:178-182.
- [12] Burgos G, Amoros W, Muñoa L, Sosa P, Cayhualla E, Sanchez C, Díaz C, Bonierbale M (2013) Total phenolic, total anthocyanin and phenolic acid concentrations and antioxidant activity of purple-fleshed potatoes as affected by boiling. Journal of Food Composition Analysis 30: 6–12.
- [13] Thaipong K, Boonprakob U, Crosby K, Cisneros-Zevallos L, Hawkins Byrne D, Comparison of ABTS, DPPH, FRAP, and ORAC assays for estimating antioxidant activity from guava fruit extracts. Journal of Food Compositiona Analysis 19:669–675.

- [14] Holden JM, Eldridge AL, Beecher GR, Marilyn Buzzard I, Bhagwat S, Davis S, Schakel CS (1999) Carotenoid Content of U.S. Foods: An Update of the Database. Journal of Food Composition and Analysis 12:169–196.
- [15] Prieto P, Pineda M, Aguilar M (1999) Spectrophotometric quantitation of antioxidant capacity through the formation of a phosphomolybdenum complex: Specific application to the determination of vitamin E. Analytical Biochemistry 269: 337.
- [16] Guo H, Saravanakumar K, Wang M (2018) Total phenoli Stachys affinis. Biocatalysis and Agricultural Biotechnology 15:235–239.
- [17] Brand-Williams W, Cuvelier ME, Berset C (1995) Use of a free radical method to evaluate antioxidant activity. LWT Food Science and Technology 28:25–30.
- [18] Bahadori MB, Zengin G, Bahadori S, Dinparast L, Movahhedin N (2018) Phenolic composition and functional properties of wild mint (*Mentha longifolia var. calliantha* (Stapf) Briq.). International Journal of Food Properties 21:198–208.
- [19] Bogucka-Kocka A, Zidorn C, Kasprzycka M, Szymczak G, Szewczyk K (2018) Phenolic acid content, antioxidant and cytotoxic activities of four Kalanchoë species. Saudi Journal of Biological Science 25:622– 630.
- [20] Pandey A, Negi PS (2018) Phytochemical composition, in vitro antioxidant activity and antibacterial mechanisms of *Neolamarckia cadamba* fruits extracts. Natural Product Research 32:1189–1192.
- [21] Maldonado-Celis ME, Yahia EM, Bedoya R, Landázuri P, Loango N, Aguillón J, Restrepo B, Guerrero Ospina JC (2019) Chemical Composition of Mango (Mangifera indica L.) Fruit: Nutritional and Phytochemical Compounds. Frontiers and Plant Sciences 10: 1073.
- [22] Ahmed M., Akter MS, Lee JC, Eun JB (2010) Encapsulation by spray drying of bioactive components, physicochemical and morphological properties from purple sweet potato. LWT Food Science andTechnology 43:1307–1312.
- [23] Liji A, Dibaka S (2015) Quality evaluation of a raw jackfruit based ready to cook (RTC) mix. International Journal of Applied Home Science 2(11&12):316-323.
- [24] Tiburski JH, Rosenthal A, Deliza R, de Oliveira Godoy RL, Pacheco S (2011) Nutritional properties of yellow mombin (*Spondias mombin* L.) pulp. Food Research International 44: 2326–2331.
- [25] Wang S, Melnyk JP, Tsao R, Marcone MF (2011) How natural dietary antioxidants in fruits, vegetables and legumes promote vascular health. Food Research International 44:14–22.
- [26] Haque S, Begum P, Khatun M, Islam SN (2015) Total carotenoid content in some mango (*Mangifera indica*) varieties of Bangladesh. International Journal of Pharmaceutical Sciences and Research 6:4875-4878.
- [27] Almeida MMB, de Sousa PHM, Arriaga ÂMC, do Prado GM, Magalhães de C, Maia GA, de Lemos TLG (2011) Bioactive compounds and antioxidant activity of fresh exotic fruits from northeastern Brazil. Food Research International 44: 2155–2159.
- [28] Mondal SC, Kamal, MM, Mumin MIA, Hosain MM, Ali MR (2017) Effect of sucrose on the physicochemical properties, organoleptic qualities and shelf-life stability of aonla (*Emblica Officinalis*) candy. IOSR Journal of Environmental Science Toxicology and Food Technology 11:85–94.
- [29] Manthey JA, Perkins-Veazie P (2009) Influences of harvest date and location on the levels of beta-carotene, ascorbic acid, total phenols, *in vitro* antioxidant capacity, and phenolic profiles of five commercial varieties of mango (*Mangifera indica* L.). Journal of Agricultural Food Chemistry 57: 10825–10830. doi: 10.1021/jf902606h.
- [30] Dars AG, Hu K, Abbas A, Chen Y, Khaskheli A A, Liu Q, Li X, Homaida MA, Lakho ABJ, Bijun Xie B, Sun Z (2018) Comparative analysis of antioxidant activities of different varieties of mangos with some selected fruits. African Journal of Agricultural Research 13: 1633-1640.
- [31] FAO (2010) The State of Food Insecurity in the World: Addressing food insecurity in protracted crises, Food and Agriculture Organization of the United Nations Publishing Policy and Support Branch, Office of Knowledge Exchange, Research and Extension, FAO, Viale delle Terme di Caracalla, 00153 Rome, Italy.
- [32] Jukes TH (1974) Are recommended daily allowances for vitamin C adequate? Proceedings of the National Academy of Sciences of the United States of America. 71:1949–1951.
- [33] Rufino M do SM, Alves RE, de Brito ES, Pérez-Jiménez J, Saura-Calixto F, Mancini-Filho J(2010) Bioactive compounds and antioxidant capacities of 18 non-traditional tropical fruits from Brazil. Food Chemistry 121: 996–1002.
- [34] Dutta S, Ray S (2018) Comparative assessment of total phenolic content and in vitro antioxidant activities of bark and leaf methanolic extracts of *Manilkara hexandra* (Roxb.) Dubard. Journal of King Saud University-Science. https://doi.org/10.1016/j.jksus.2018.09.015.

- [35] Garzón GA, Narváez CE, Riedl KM, Schwartz SJ (2010) Chemical composition, anthocyanins, non-anthocyanin phenolics and antioxidant activity of wild bilberry (*Vaccinium meridionale Swartz*) from Colombia. Food Chemistry 122: 980–986.
- [36] Anaya-Esparza LM, Montalvo-Gonzalez E (2018) Nutritional quality of *Mangifere* Species. Laboratorio de Microbiología de Alimentos, Departamento de Ciencias Pecuarias y Agrícolas, Universidad de Guadalajara, Centro Universitario de los Altos, Tepatitlán de Morelos, Jalisco, Mexico.
- [37] Sathyanarayanan S, Chandran R, Thankarajan S, Abrahamse H, Thangaraj P (2018) Phytochemical composition, antioxidant and antibacterial activity of *Syzygium calophyllifolium* Walp fruit. Journal of Food Science and Technology 55:341–350.
- [38] Elfalleh W, Kirkan B, Sarikurkcu C (2018) Antioxidant potential and phenolic composition of extracts from *Stachys tmolea*: An endemic plant from Turkey. Industrial Crops and Products 127: 212–216.
- [39] Pistón M, Machado I, Branco CS, Cesio V, Heinzen H, Ribeiro D, Freitas M (2014) Infusion, decoction and hydroalcoholic extracts of leaves from artichoke (*Cynara cardunculus L. subsp. cardunculus*) are effective scavengers of physiologically relevant ROS and RNS. Food Research International 64:150–156.
- [40] Vicente AR, Manganaris GA, Sozzi GO, Crisosto CH (2014) Nutritional Quality of Fruits and Vegetables. Postharvest Handling, third eds., Elsevier Inc., pp. 69-122.



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