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A comparison with antioxidant and functional properties among five mango (*Mangifera indica* L.) varieties in Bangladesh

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Abstract

A comparative study was conducted to investigate the variation of some functional factors as well as antioxidant markers among commercially important five Bangladeshi ripe mango (*Mangifera indica* L.) varieties such as Fazli, Langra, Ashwina, Himsagor, and Amrupali. Maximum amount of total soluble solid (20.13%) and reducing sugar (3.53%) were found in Amrupali in contrast to other varieties. Highest titratable acidity (0.798%) was observed in Ashwina and lowest acid content (0.154%) was found in Fazli among all varieties. Moreover, Fazli showed significantly higher pH value (6.0) than those of other varieties. The present study on antioxidant markers revealed that Ashwina and Langra showed significantly higher ascorbic acid content (65.66 and 59.17 mg/100 g) whereas Himsagor and Fazli showed lower ascorbic acid content (10.83 and 12.5 mg/100 g) compared to those of other varieties. A significantly highest level of total phenol contents was found in Langra followed by Ashwina, Amrupali, Fazli, and Himsagor. The highest DPPH$^{\cdot}$ radical scavenging activity was observed in Fazli variety among all other varieties. The linear regression analysis revealed that titratable acidity was inversely correlated with pH value. A positive relationship ($R^2 = 0.865$) was found between TSS and reducing sugar. The relationship between total phenolic content and antioxidant activity of five mango varieties was found to be positive ($R^2 = 0.925$) providing strong evidence that phenol content plays a vital role in the antioxidant activity of mango. Ascorbic acid content of the mango varieties was moderately ($R^2 = 0.76$) proportional to their antioxidant activity. Results generated in this study revealed that Langra variety proved to be the best considering its antioxidant and functional properties.

Introduction

Mango (*Mangifera indica* L.) from *Anacardiaceae* family, is one of the most widely eaten tropical fruit because of its unique taste, attractive color and flavor, affordability and nutritional qualities. It is a rich source of vitamins, organic acids, carbohydrates, amino acids, phenolic acids (e.g., gallic acid, caffeic acid, and tannic acid) and certain volatile compounds (Pal, 1998; Sing *et al*., 2004; Pino *et al*., 2005). Many of the pharmacological properties attributed to mango might be due to the presence of phenolic acids. These phenolic compound posses potent antioxidant activity that play an important role in human nutrition as preventative agents against several diseases caused by oxidative stress, protecting the body tissues against oxidative stress with their antioxidant, anti-mutagen, anti-inflammatory, and anti-carcinogenic properties (Kim *et al.*, 2003; Chiou *et al.*, 2007). Apart from the fruit, mango flesh also has been reported to have antilithiatic and free radical scavenging properties, which reduce lipid peroxidation and enhance antioxidant enzymes (superoxide dismutase and catalase) against isoproterenol (Bafna and Balaraman, 2005). It can also play an important role in balancing human diet by providing about 64-86 calories of energy per 100 g (Rathore *et al.*, 2007).

Mango is predominately grown in tropical and warm sub-tropical climates in places such as Asia, Africa, and the America. In Bangladesh, about 250 varieties of mango are available throughout the summer season which has distinct physio-morphological characteristic features and compositional variation (Hossain and Ahmed, 1994). Little information about physio-morphological and chemical composition of Bangladeshi varieties has been recorded (Hossain *et al*., 2001; Shafique *et al*., 2006). But the information based on the antioxidant markers compounds and antioxidant activity is still lacking. In view of the above aspects, the current study has been done to report about the inherent differences in vitamin C, polyphenolics, antioxidant activity, and some other functional profile of five commercially important mango varieties of

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Bangladesh. Information on these health beneficiary profiles could increase consumer awareness for choosing the best one having a good calorific value. Moreover the present study will be helpful for selecting the varieties for plantation with a hope to be a member of the mango exporting countries.

Materials and Methods

Mango sampling

Five popular and widely preferred different ripe mango varieties, e.g., Fazli, Langra, Ashwina, Himsagor, and Amrupali (a dwarf mango variety), were purchased from a local retailer in Dhaka city of Bangladesh. Fruit samples were cut and sampled according to the different chemical analyses. Mango slices were cut longitudinally to the mango pith (from stem end to blossom end), and the pericarp was removed from the slices. Each sample analyzed represents tissue from a single fruit. Each assay was sampled with 3 replications using one independent extraction per fruit.

Total soluble solid (TSS) and pH estimation

Total soluble solids (TSS) content was determined using an Abbe refractometer (TAGO 9099, Japan); pulp samples were homogenized in a blender. By placing a drop of thoroughly mixed sample on its prism, a direct refractometer reading was taken. Percent TSS obtained from direct reading. The pH of the mango varieties were measured by digital pH meter (type H1 98106; HANNA) at ambient temperature using juice extracted directly from pulp.

Titratable acidity (TA)

Titratable acidity was determined by dissolving a known amount of mango pulp in distilled water and then titrated against 0.1N sodium hydroxide (NaOH) using phenolphthalein as an indicator (Srivastava and Sanjeev, 2003). The results were calculated as percent citric acid.

Estimation of reducing sugar (RS)

Total reducing sugar content of the samples was determined according to the classical and widely used method (Nelson-Somogyi, 1944). Briefly, mango pulps were homogenized with benzoic acid solution (0.2%). An aliquote of the filtrate was mixed with the copper reagents (a mixture of alkaline Rochelle salt and acidic $CuSO_4$). After heating in boiling water (15 min) and cooling, arsenomolybdate color reagent was added. Finally a blue color produced, the absorbance measured at 520 nm and compared with a set of standard (glucose).

Determination of antioxidant markers

Two gram of blended mango pulps were suspended in 20 ml 80% methanol, kept stirring condition for 1 hr and filtered through filter paper (Whatman 11.0 cm). Then the filtrates were used for subsequent analysis.

Total phenol content

Total phenol content was determined according to the Folin-Ciocalteu (FC) method (Singleton and Rossi, 1965). An aliquot of sample (0.5 ml) was added to diluted 2N FC reagent (1:10) (2.5 ml). After 3-4 min, 7.5% sodium carbonate solution (2 ml) was added to the mixture and kept in dark for 2 hr at room temperature. The absorbance of the solution was measured UV visible spectrophotometer at wavelength 765 nm. Gallic acid was used as a calibration standard. The data was expressed as mg Gallic acid equivalents/100 g sample.

DPPH radical scavenging activity

The stable free radical ($DPPH^{\bullet}$) scavenging activity of the mango pulps was determined according to the method of Brand-Williams *et al.* (1995) with some modifications. The stock DPPH solution was prepared by dissolving in methanol (2.4 mg/mL). Before use, stock DPPH radical solution was diluted in 80% methanol to give initial OD517 at 0.89 using UV visible spectrophotometer. An aliquot of samples (150 µL) was added to 4.5 ml of diluted DPPH solution, vortexed well and kept in dark for 15 min at room temperature.

The absorbance was taken at 517 nm. Total antioxidant capacity was calculated relative to the reactivity of Trolox under the same conditions and the results were shown as µM Trolox equiv./g mango pulp. The ability to scavenge $DPPH^{\bullet}$ was also calculated as:

$$\% \text{ Inhibition} = Ab\text{-}As/Ab * 100$$

where Ab and As were the absorbance of the blank and the sample, respectively.

Ascorbic acid (Vit-C) estimation

Ascorbic acid was determined by 2,6-dichloroindophenol titrimetric method (Rangana, 1986). Briefly, sample (2 g) was homogenized with 3% metaphosphoric acid (25 ml) and was filtered through filter paper (Whatman 1, 7.0 cm). Then an aliquot (5 ml) of filtrate was titrated with the 2,6-dichloroindophenol dye (standardized by the metaphosphoric acid) to a pink end-point. Results were expressed on a fresh weight basis as mg ascorbic

acid equivalent/100 gm.

Statistical analysis

All determinations were obtained from triplicate measurements and results were expressed as mean ± standard deviation. Data were analyzed by the SPSS.18 (Statistical Package for Social Sciences) software. Statistical significance was declared at $p < 0.05$.

Results and Discussion

Biochemical properties of mango cultivars

The measurements of pH, titratable acidity, reducing sugar, and total soluble solid for five mango varieties have shown at Table 1. Higher Total soluble solid (TSS) content is an indicator of good quality of fruits (Palaniswamy *et al*.,1975). In the present study, the amount of TSS was found to be maximum in Amrupali (20.13%) in contrast to other varieties and the difference was significant. Ripening was associated with increasing soluble solids and total sugars (Andrew *et al.*, 1989) and generally taste and particularly sweetness of the fruits depend on the percentage of TSS content (Shafique *et al*., 2006). Amprupali has highest TSS content probably it was riper than the other varieties. TSS contents among Fazli, Langra, and Ashwina were not significantly different.

The Amrupali had the highest (3.53%) reducing sugar content as compared to others. There was significant difference in sugar content among all other mango cultivars. It is assumed that reducing sugar content is influenced by ripening condition of fruits (Hossain *et al*., 2012). An increase in TSS and reducing sugars in five mango cultivars may probably be due to accumulation of more sugars in the fruits due to hydrolysis of starch from increased amylase activity during ripening (Fuchs *et al*., 1980; Tandon and Kalra, 1983; Pawar *et al*., 2011). The main reducing sugar identified was fructose (Medlicott *et al.*, 1985; Vazquez-Salinas *et al*., 1985) while Selvaraj *et al.* (1989) reported glucose to be predominant in mango. The conflicting reports on the relative concentrations of individual sugars present in mango may be attributed to varying cultivars and storage conditions used (Medlicott *et al*., 1985).

A significantly higher titrable acidity (0.798%) was found in Ashwina compared to other varieties. In contrast, Fazli showed significantly lowest (0.154%) acid content compared to other varieties. The difference in acid content among Langra, Amprupali and Himsagor was not significant at P = 0.05.

In case of pH value, a significantly higher pH value (6.0) was found in Fazli compared to other varieties. This may be due to the lowest acid content which was found in present study. pH value between Fazli and Amrupali was not significantly difference.

Table 1. Variation in different chemical characteristics of five ripe mango varieties

Variety name	pH	Titrable acidity (%)	Total soluble solid (%)	Reducing sugar (%)
Himsagor	5.37 ± 0.03^{a}	0.257 ± .018^{a}	19.0 ± 0.52^{abd}	2.65 ± 0.05^{a}
Fazli	6.00 ± 0.05^{b}	0.154 ± 0.02^{b}	17.93± 0.11^{ab}	2.44 ± 0.06^{b}
Amrupali	4.94 ± 0.03^{c}	0.374 ± 0.01^{acd}	20.13± 0.1^{c}	3.53 ± 0.11^{c}
Langra	4.91 ± 0.02^{e}	0.321 ± 0.06^{ad}	17.6 ± 0.2^{abd}	1.44 ± 0.01^{d}
Ashwina	3.58 ± 0.03^{d}	0.798 ± 0.10^{e}	17.27± 0.72^{abd}	0.82 ± 0.07^{e}

Values are the mean of 3 replicates
In this and all subsequent tables, mean values with different superscript letters are significantly different at P = 0.05 and LSD values are at P = 0.05

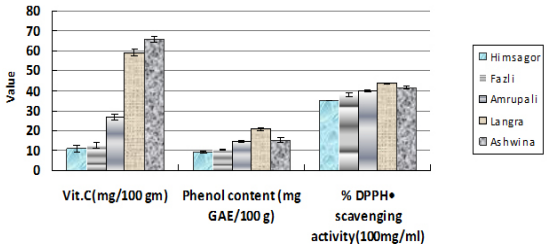

Figure 1. Comparison of antioxidant markers and antioxidant activity among five mango cultivars

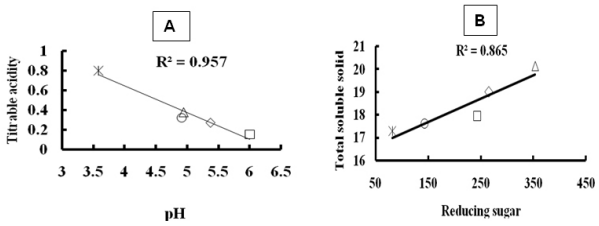

Figure 2. A: Correlation between pH and titrable acidity of mango varieties. (The order is as: Ashwina(*)-Langra(o)-Amrupali(Δ)-Himsagor(◊)-Fazli(□); B: Correlation between reducing sugar and total soluble solid of mango varieties. The order is as: Ashwina(*)-Langra(o)-Fazli(□)-Himsagor(◊)-Amrupali(Δ).

Assay of antioxidant properties

The antioxidant constituents (ascorbic acid and total phenol contents) and antioxidant activities of five mango varieties were investigated and shown in Figure 1.

In case of ascorbic acid (vit-C), Ashwina showed significantly higher ascorbic acid content (65.67 mg/100 g) compared to other varieties. A significantly lower ascorbic acid content was found in Himsagor and Fazli compared to those of other varieties, but the difference between Himsagor and Fazli was not significant at P = 0.05. Similarly, difference between Ashwina and Langra was not significant in case of ascorbic acid.

Statistical analysis showed that total phenol contents were significantly different ($P < 0.001$) between varieties with the mean levels in pulp of Himsagor < Fazli< Aprupali < Ashwnia < Langra. From Fig. 1 it can be seen that langra variety showed

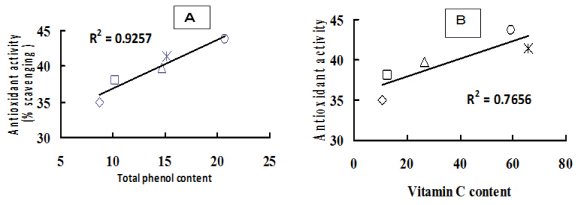

Figure 3. A: Correlation between total phenol and antioxidant activity. The order is as: Himshagor(◊)-Fazli(□)-Amrupali(Δ)-Ashwina(*)-Langra(o);B: Correlation between antioxidant activity and vitamin C. (The order is as: Himshagor(◊)-Fazli(□)-Amrupali(Δ)-Langra(o)-Ashwina(*)

the highest DPPH· scavenging activity among all other varieties may be due to having its higher phenolic content.

Relationship between pH and titratable acidity

The correlation analysis revealed that titratable acidity was negatively correlated with pH value (Figure 2A). The same trend was found by Dent *et al.* (2002) in different citrus fruits. Andrew *et al.* (1989) reported that loss of acidity was attributed by decreasing titratable acidity and increasing pH values in Keitt mangoes.

Relationship between TSS and reducing sugar

The relationship between TSS and reducing sugar of five mango varieties is shown in Figure 2 B. The result indicated that there was a significant positive linear relationship ($R^2 = 0.865$) with a greater TSS associated with a greater rate of reducing sugar. Similar relationship was found between TSS and reducing sugar in pineapple (Smith, 1988; Bartoleme *et al*., 1996). The soluble solids including organic acids, reducing sugars, and other constituents of the fruit pulp affect the % soluble solid content and considered as an indicator of ripeness (Stephen *et al*., 2008). During the ripening process, sugars and organic acids develop and tend to increase with the import of sugar from the plant and from mobilization of the starch reserves in the fruit itself (Selvarai *et al*., 1989).

Relationship between total phenol content and antioxidant activity

Total phenolic content and antioxidant activity of mango varieties were highly correlated ($R^2 = 0.925$) (Figure 3A), providing strong evidence that the predominant source of antioxidant activity derives from phenolic compounds in mango as supported by other works for fruits (Choong *et al.*, 2007; Akond *et al.*, 2010) as well as phenolic compounds in plants are good sources of natural antioxidants (Stratil *et al.*, 2007). In general, there was a trend of increased antioxidant activity with increased total phenolic content. An increased number of hydroxyl groups in polyphenols and flavonoid compounds molecular structure led to higher antioxidant activity (Cai, 2003). Palafox-Carlos *et al.* (2012) found four major phenolic compounds in 'Ataulfo' mango pulp are chlorogenic, gallic, protocatechuic and vanillic acid and also found synergistic interactions between the major phenolic acids contributing total antioxidant activity.

Relationship between ascorbic acid content and antioxidant activity

In the present study the ascorbic acid content of the mango cultivars were moderately ($R^2 = 0.76$) proportional to their antioxidant activity (Figure 3B) suggesting that ascorbic acid also plays role in the antioxidant activity of mango extracts. This phenomena was found by other researchers for mango and for other fruits (Kyung *et al*., 2004; Dumbrava *et al*., 2012; Rekha *et al*., 2012). According to Rekha *et al*. (2012), ascorbic acid acts as a specific antioxidant by reducing ferric ions. They also mentioned that ascorbic acid transfers its hydrogen atoms to oxygen radicals making the oxygen unavailable for further reactive oxygen chain reaction. Further, ascorbic acid may exert a metal chelating action, if present will promote oxidation (Gow-Chin Yen *et al.*, 2002) .

Conclusion

The present investigations conducted on five Bangladeshi ripe mango (*Mangifera indica* L.) varieties showed differences in functional factors and antioxidant markers. Among all mango varieties studied, it can be concluded that Langra variety is proved more potential for its higher phenol content as well as antioxidant property compared to those of other four mango varieties. Ashwina variety has the highest ascorbic acid content. It was also revealed that antioxidant activity of the mango varieties were positively correlated with total phenol content and vitamin C. With respect to total soluble solids and sugar content Amrupali was found to be superior to other varieties. It is apparent that this study would be helpful in selecting mango variety for fresh consumption, to produce mango based food products and for cultivars depending on individual preferences.

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