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Impact of Production Location on the Postharvest Fruit Quality of Bari Mango-4

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ABSTRACT

This study aimed to assess the impact of production location on the postharvest physiochemical attributes of BARI Mango-4. For this reason, mature ripe fruits of BARI Mango-4 were obtained from two different locations: Rajshahi and Sylhet district of Bangladesh. Fruits from both locations were then preserved for 5 days at room temperature, when they reached an ideal stage for processing. Various physical and chemical characteristics of the fruits such as- fruit weight, size of the fruit and seed in terms of length, width and thickness, proportions of peel, seed, edible portion, dry matter and total soluble solids, pH, vitamin C, anthocyanin, beta-carotene and antioxidant activity were estimated in 4 replications. The individual fruit weight of BAR Mango-4 obtained from the Rajshahi district was remarkably higher when compared to the Sylhet district. Significantly higher length and width of the Rajshahi district-grown mango contributed to the higher individual fruit weight. In addition to these, total soluble solids, vitamin-C, beta-carotene and antioxidant activity of the mangoes assembled from the Rajshahi district were markedly higher. Compared to the Rajshahi district, the Sylhet district-grown BARI Mango-4 had a higher value for the fruit hardness, dry matter content and edible portion. The results indicate a significant impact of the production location on the postharvest physiochemical attributes of BARI Mango-4. Studies identifying the factors that have impact on the mango fruit quality will help to enhance the postharvest quality of the fruits to meet the market requirements.

INTRODUCTION

Mango (*Mangifera indica* L.) is the most important and popular fruit in Bangladesh. It has often been referred to as the 'king of fruit' (Majumder *et al.*, 2012). High nutritional composition of the mango along with stunning color, lovely flavor and delightful taste helped to attain a unique position among the fruits grown in Bangladesh (Ali *et al.*, 2019). This tropical and subtropical fruit cultivated for more than 4000 years and belongs to the family Anacardaceae (Barua *et al.*, 2013). It is believed to be originated in the north-eastern parts of India, western parts of Bangladesh and Mayanmar (Duval *et al.*, 2006). Currently, mango is commercially cultivated in more than 80 countries in the world (Thakor, 2019). However, key mango producing countries of the world are India, Brazil, China, Thailand, Egypt, Indonesia, Mexico, Philippines, Pakistan, Bangladesh, and Vietnam (Ara *et al.*, 2014; Thakor, 2019).

In Bangladesh, mango cultivation occupies an area of around 306,000 acres of land with an annual production of over 1,483,000 metric tons (MT) (BBS, 2024). Mango grows in almost all districts of Bangladesh, but high-quality mangoes are commercially cultivated in the north-western districts of the country (Ali *et al.*, 2019). According to Shirin *et al.* (2013), the leading mango-producing districts in Bangladesh are Rajshahi, Chapainawabgonj, Naogaon, Dinajpur, and Rangpur. But, the scenario has changed to some extent recently due to the development of high yielding mango varieties and improvement in production technologies (Azad *et al.*, 2019). Farmers from different non-mango producing districts are showing keen interest in collecting and cultivating high-quality grafted mango commercially, including the hilly areas of north-eastern parts of Bangladesh (Barua *et al.*, 2013).

Sylhet is situated in the north-east part of Bangladesh and is considered as a special agricultural zone. This hilly region is not reputed for mango cultivation in comparison to Rajshahi district. Although different local unknown cultivars (seedling mangoes) are found to grow haphazardly under the homestead conditions of this region, but cultivation of commercial cultivars are limited. A few progressive farmers of this region are cultivated mangoes commercially without knowing the fact that commercial varieties are location specific and varieties from one region may not do well when grown in other region in terms yield and physiochemical attributes of the fruits. Therefore, the study of production location impact on physiochemical attributes of mango fruits are imperative. In the current study, fruits of a popular mango variety called 'BARI Mango-4' developed by Bangladesh Agricultural Research Institute (BARI) were taken from both the Sylhet district and the Rajshahi district to observe the impact of production location on postharvest physiochemical properties.

MATERIALS AND METHODS

Experimental Site, Sample Collection and Sample Preparation

The experiment was conducted in the laboratory of the Horticulture Department, Sylhet Agricultural University,

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Bangladesh, in June 2023. The mature ripe fruits of BARI Mango-4 were obtained from two different districts in Bangladesh (Figure 1). The fruits were harvested by trained person from both the locations to ensure all the fruits were in the same stage of maturity stage and were not fallen in the ground while harvesting. Immediately after harvesting, all the fruits were transported to the laboratory as early as possible. After reaching the laboratory, all the fruits were washed with running tap water and dried with tissue paper. Then, they were stored for 5 days at room temperature (26°C) until reach to the optimum ripening stage for processing. Data on various physiochemical properties were measured in 4 replications to obtain the mean value.

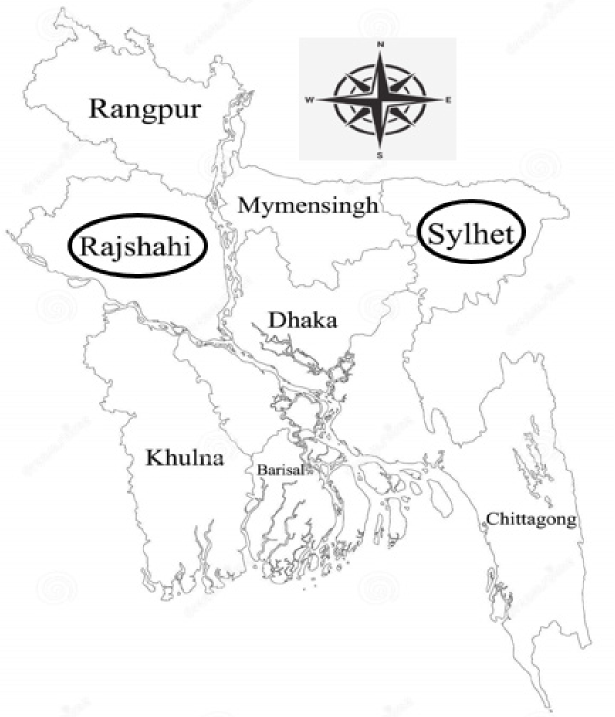

Figure 1: Map displaying the locations of the BARI Mango-4 collection in Bangladesh

Data Collection

After measuring the fruit weight (g) with a digital balance, peel, pulp and seed of the fruits were separated and weighted to calculate their respective percentages. Fruit and seed size in terms of length (cm), width (cm) and thickness (cm) were measured using a digital slide calipers. The pulp weight was divided by the seed weight to determine the pulp-seed ratio. A Fruit Hardness Tester (Model: FR-5120) was used to measure the hardness value (N/m2) of the mango fruits. In this case, a 6 mm penetrometer tip was penetrated to the pulp after removing a section of fruit peel with a sharp knife and the maximum reading was considered as the hardness of the mango fruit.

The fruit pulp was cut into pieces, homogenized and weighed accurate quantity for different biochemical studies. The total soluble solids (TSS) content of the fruit juice was quantified by following Jha *et al.* (2010). A digital pH meter was used to quantify the pH value of the fruit juice. The dry matter content of the fruit pulp was calculated by using Equ. 1. For this purpose, dry weight of the pulp was obtained after drying the pulp for 60 hours at 70°C in an electric oven.

Dry matter (%) = (Dry Weight of the Pulp)/(Fresh Weight of the Pulp) ×100 …….(Equ.1)

A slightly modified procedure described by Salkic *et al.* (2009) was used to quantify vitamin C content of the fruit pulp. For this purpose, fruit pulp (100 mg) was properly homogenized with $Na_2C_2O_4$ solution (10 ml of 0.056 M) for 2 minutes before the mixture was passed through Whatman No. 1 filter paper. Before measuring the absorbance at 266 nm using spectrophotometer (UV-100i, Shimadzu, Japan), 0.5 ml filtrate was diluted with 5 ml of 0.056 M $Na_2C_2O_4$ solution. A calibration curve using L-ascorbic acid served as the reference.

β-Carotene content of the fruit pulp was measured by following a little modified protocol of Nagata and Yamashita (1992). About 1 g pulp was homogenized with 10 ml mixture of acetone and hexane (4:6). The homogenized was therefore centrifuged at 8000 rpm and 4°C for 10 minutes. Absorbance at 663 nm, 645 nm, 505 nm and 453 nm were taken using a Spectrophotometer (Model UV-1900i, Shimadzu, Japan) for calculating β-Carotene content using following formula:

β carotene (mg/100g) = 0.216(Ab663) + 0.452(Ab453) – 1.22 (Ab645) – 0.304 (Ab505) …….(Equ.2)

Where Ab indicates absorbance.

A modified method previously described by Chu *et al.* (2013) was used for quantifying the anthocyanin content of the fruit pulp. In this purpose, a mixture of 1 g fruit pulp and 3 ml acidic ethanol (95% ethanol mixed with 1.5 N HCl) was incubated at 4°C for 1 hour with moderate shaking before centrifuging at 8000 rpm and 4°C for 10 minutes. Absorbance at 530 nm and 657 nm were taken using a Spectrophotometer (Model UV-1900i, Shimadzu, Japan) to calculate the anthocyanin content of the sample using following equation.

Anthocyanin (mg/100g) = ((Ab 530nm-0.25)×Ab 657nm)/(Weight of the sample taken) …….(Equ.3)

Where Ab indicates Absorbance.

Antioxidant activity of the mango fruit pulp was quantified by following a modified version of the protocol described by Brand-Williams *et al.* (1995). Before storing in the darkness, 4 mg of DPPH was mixed with 100 ml of 95% methanol. The extract was prepared by mixing 5 mg dried pulp with 5 ml of methanol. Then, 1 ml of the extract was diluted with 3 ml of previously prepared DPPH solution and stored in the dark condition for 30 minutes. After that, absorbance of the sample at 517 nm was taken using Spectrophotometer (Model UV-1900i, Shimadzu, Japan). Methanol and DPPH in a ratio of 1:3 was used as control solution and the following equation (Equ. 4) was used to compute the antioxidant activity.

Antioxidant (%)=(Control reaction absorbance-Testing specimen absorbance)/(Control reaction absorbance) ×100 …….(Equ.4)

Statistical Analysis

One-way analysis of variance (ANOVA) was performed in RStudio (Version 4.0.3). Differences between mean values were assessed by using the Tukey HSD (Honest Significant Difference) test. Significant differences were defined at $p<0.05$.

RESULTS AND DISCUSSION

The production locations can markedly influence various aspects of fruit quality (Hofman *et al.*, 1997). This study observed the potential of two different production sites to affect the postharvest quality of BARI Mango-4. While the study did not aim to find the specific factors affecting quality, it assessed the differences in BARI Mango-4 fruit quality collected from Rajshahi and Sylhet district. Difference in individual fruit weight was observed due to the production location (Table 1). The average fruit weight (487.63 g) of the Rajshahi district was higher than those from Sylhet district (396.96 g). Previously, the individual fruit weight of BARI Mango-4 was around 540 g reported in Jamalpur district (Rahman & Akter, 2019) and was approximately 373 g reported in Chittagong district of Bangladesh (Barua *et al.*, 2013). Although the fruit thickness did not differ significantly due to the production sites, fruits collected from Rajshahi district had higher length (9.45 cm) and width (9.63 cm). Rahman and Akter (2019) reported the length and width of BARI Mango-4 in Jamalpur district around 9.43 cm and 7.16 cm, respectively. The fruit length (10.54 cm) and width (9.18cm) of BARI Mango-4 were also reported in Chittagong district (Barua *et al.*, 2013). These differences in BARI Mango-4 fruit weight and fruit size between Rajshahi and Sylhet district may be due to the different altitudes of the production sites, cultural practices performed and environmental factors such as light intensity, temperature, soil type etc. In a research by Zhang *et al.* (2022) observed that altitude of the production area significantly affect the individual fruit weight and fruit size of mango. Urban *et al.* (2003) described extensively how light intensity influenced photosynthesis in mango leaves, therefore influencing the nearby fruit size. A high level of CO_2 concentrations was also noted to improve the fruit size of fruiting plant (Bindi *et al.*, 2001). Peel weight (15.26%) and seed weight (9.35%) of BARI Mango-4 were noted higher in Rajshahi district. Rahman and Akter (2019) observed that seed of around 7.4% and peel of around 12.96% were contributed to the total fruit weight of BARI Mango-4 in the Jamalpur district. On the other hand, the Chittagong district measured a different value for both seed (13.62%) and peel (7.72%) of the same mango variety than that of Jamalpur district (Barua *et al.*, 2013). Fruit size variations due to the production locations could be the reason for these variability. Moreover, production sites may also have an impact on the variability of seed weight and peel weight of mango.

Table 1: Fruit weight, fruit size (length, width and thickness), peel weight and seed weight of BARI Mango-4 grown in Sylhet and Rajshahi district of Bangladesh

Districts	Fruit Weight (g)	Fruit Length (cm)	Fruit Width (cm)	Fruit Thickness (cm)	Peel Weight (%)	Seed Weight (%)
Sylhet	396.96±10.18	8.40±0.31	8.63±0.18	7.10±0.11	12.09±0.40	7.97±0.29
Rajshahi	487.63±14.82	9.45±0.52	9.63±0.29	7.53±0.28	15.26±0.22	9.35±0.24
CV(%)	15.86	11.48	7.87	6.43	13.50	10.79
P Value	<0.01	<0.01	0.03	0.23	<0.01	0.02

The data are means ± standard error of 4 replications. Significant differences were considered at p<0.05

The seed size of the BARI Mango-4 collected from Rajshahi district was measured significantly larger, measuring 7.65 cm in length, 4.63 cm in width, and 2.00 cm in thickness (Table 2). A higher fruit size of Rajshahi district may contribute to the increased seed size. Additionally, different environmental factors such as water availability, soil fertility, temperature, and light conditions could also play a role. Baker (1972) observed that drier environments often favor larger seeds, and the Rajshahi district is generally drier than that of the Sylhet district in Bangladesh, which experiencing a lower total rainfall and higher average temperatures, especially during the mango growing season. In contrast to fruit size, the edible portion of the fruits grown in the Sylhet district (79.93%) was found to be significantly higher than that of the Rajshahi district (75.39%). Barua *et al.* (2013) observed that pulp weight contributed about 78.66% of the total fruit weight of BARI mango-4 when grown in Chittagong district. Rahman and Akter (2019) reported that approximately 79.63% of the total fruit weight of BARI Mango-4 contributed to the pulp in Jamalpur district of Bangladesh. These results indicated that the production location could influence the edible portion of mangoes. In the current study, a lower contribution of peel and seed to the total fruit weight in the Sylhet district could be the main reason for the higher pulp percentage. A higher pulp to seed ratio (10.10) was reported in Sylhet district when compared to Rajshahi district (Table 2). A pulp to seed ratio of around 10.76 in Chittagong district with BARI Mango-4 was previously reported by Rahman and Akter (2019). On the other hand, a ratio of only 5.77 with the same cultivar in Jamalpur district was observed by Barua *et al.* (2013). These previous findings suggested that there may be a significant impact of the production locations on pulp to seed ratio.

Fruit hardness is one of the most important parameters affecting consumer acceptance of mangoes. Sylhet district grown mango was shown a slightly higher hardness value (15.95 N/m2) than that of Rajshahi district (14.48 N/m2) grown mango (Table 2). Similar variability in mango fruit firmness during ripening stage was previously reported by Ali *et al.* (2019). Variation in maturity stage might be one of the factors for the difference in fruit hardness. Other factor that may contributed to the variation in mango fruit firmness was production location (Jha *et al.*, 2010).

Table 2: Seed size (length, width and thickness), edible portion, pulp-seed ratio and hardness of BARI Mango-4 grown in Sylhet and Rajshahi district of Bangladesh

Districts	**Seed Length (cm)**	**Seed Width (cm)**	**Seed Thickness (cm)**	**Edible portion (%)**	**Pulp-Seed Ratio**	**Hardness (N/m^2)**
Sylhet	6.98±0.15	3.98±0.08	1.58±0.02	79.93±0.65	10.10±0.42	15.95±0.28
Rajshahi	7.65±0.15	4.63±0.11	2.00±0.04	75.39±0.46	8.08±0.25	14.48±0.39
CV(%)	6.59	9.30	13.18	3.51	14.69	6.93
P Value	0.03	<0.01	<0.01	<0.01	0.01	0.03

The data are means ± standard error of 4 replications. Significant differences were considered at $p<0.05$

The dry matter content of BARI Mango-4 was found to be higher significantly in the Sylhet district (Table 3). In a previous study by Hofman *et al.* (1997) reported that differences in dry matter content of mango could be attributed to the location, indicating that rainfall before harvesting may negatively impact dry matter content. The total soluble solids (TSS) content is one of the most important parameters of the mango fruit quality (Barua *et al.*, 2013). The total soluble solids (TSS) content was measured higher in fruits collected from the Rajshahi district (15.10%) in comparison to Sylhet district (12.73%) (Table 3). Around 17.10% TSS in the Gazipur district (Molla *et al.*, 2020), 19.20% TSS in the Chittagong district (Barua *et al.*, 2013), and 20.00% TSS in Jamalpur district (Rahman & Akter, 2019) in BARI Mango-4 were previously reported. Production location may have an effect on these variations in the TSS content of BARI Mango-4, although variations in the fruit's maturity stage could also contribute to these differences. Significantly higher vitamin C content was measured in the pulp of Rajshahi district grown mangoes (82.36 mg/100g). The vitamin C content of the pulp can vary between 9.79 to 186 mg/100g depending on the cultivar (Manthey and Perkins, 2009). However, the difference in the vitamin C content with the same cultivar in the present study may be due to the preharvest climatic conditions and cultural practices. Lee and Kader (2009) reported that elevated light intensity during the growing season and infrequent irrigation positively influence vitamin C content in horticultural crops, while high rates of nitrogen fertilizers can negatively affect. BARI Mango-4 grown in Rajshahi district (0.60 mg/100g) contained higher β-Carotene than that of Sylhet district (0.49 mg/100g) grown (Table 3). This variation in the findings of β-Carotene content aligns with the findings of Manthey and Perkins-Veazie (2009) that variations in β-Carotene content can occur due to the production location. The antioxidant activity of BARI Mango-4 was also influenced by the growing region (Table 3), with mango from Rajshahi district exhibiting a higher antioxidant activity of around 66.01%. Molla *et al.* (2020) reported approximately 96.84% antioxidant activity for the same mango cultivar grown in Gazipur district, suggesting that differences in antioxidant activity could be attributed to varying growing conditions.

Table 3: Dry matter, TSS, pH, vitamin C, β-Carotene content, anthocyanin content and antioxidant activity of BARI Mango-4 grown in Sylhet and Rajshahi district of Bangladesh

Districts	Dry Matter (%)	TSS (%)	pH	Vitamin C (mg/100g)	β-Carotene (mg/100g)	Anthocyanin (mg/100g)	Antioxidant Activity (%DPPH)
Sylhet	17.50±0.07	12.73±0.17	4.77±0.07	73.88±0.66	0.49±0.02	0.58±0.01	53.79±1.10
Rajshahi	16.39±0.12	15.10±0.14	4.73±0.07	82.36±1.08	0.60±0.03	0.53±0.04	66.01±0.99
CV(%)	3.67	9.44	3.14	6.23	13.79	10.79	11.53
P Value	<0.01	<0.01	0.735	<0.01	0.02	0.28	<0.01

The data are means ± standard error of 4 replications. Significant differences were considered at $p<0.05$

CONCLUSION

This study represents the first investigation into the production location effects of BARI Mango-4 on the physiochemical attributes. Preliminary findings indicate a significant impact of the production location on different physiochemical properties of BARI Mango-4. Further studies are required to explore genotype-environment interactions across multiple genotypes, thereby expanding our understanding of the environmental effects on mango fruit quality. Identifying those production factors that have the greatest impact on fruit quality of mango will help to control both quality and yield to meet the market requirements.

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