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Effect of storage period on postharvest physio-chemical and microbial properties of Fazli and Bombai varieties of mango

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ABSTRACT

The investigation was conducted at the laboratories of the Departments of Horticulture, Biochemistry and Plant pathology, Bangladesh Agricultural University, Mymensingh during 23 June 2009 to 10 November 2009 to study the effect of storage period on physico-chemical and microbial properties of two important varieties of mango- namely, Fazli and Bombai. Time after harvest had significant influence on peel colour, fruit firmness, total weight loss, moisture and dry matter content, pH, titratable acidity, vitamin C, TSS (total soluble solids), disease incidence, and disease severity. It was found that change in colour and firmness were faster in Bombai than Fazli. Fazli contained significantly higher concentration of vitamin C (51.12 mg/100 g) than in Bombai (34.69 mg/100 g). Vitamin C and titratable acidity declined sharply with the progress of storage duration. pH and TSS was found increasing trend within different storage duration in both varieties. β-carotene of mango pulp at mature-green and eating ripe conditions of Fazli and Bombai varieties were 190.53 and 219.13 µg/100g and 1086.61 and 2868.49 µg/100g, respectively, indicating that Bombai contained much higher concentration of β-carotene than in Fazli. The level of disease incidence was found higher in Bombai than Fazli in the period of experiment. Between the two varieties postharvest physico-chemical properties like colour, firmness, total weight loss, diseases incidence and diseases severity changing rate is faster in Bombai which leads to shorter shelf life compare to Fazli. On the other hand, in Fazli variety moisture, dry matter content, titratable acidity, pH, TSS changing pattern is quicker. In aspect of nutrition, Fazli and Bombai are enriched with higher amount of vitamin C and Vitamin A, respectively.

Key Words: *Mango, Storage, Physico-chemical change, Nutritional change, Vitamin C and β-carotene*

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I. Introduction

The mango (*Mangifera indica* L.) belongs to the family *Anacardiaceae* and enjoys wide popularity among millions of people all over the world and has received much attention to the researchers. Mango was originated in the South Asia or Malayan archipelago (Salunkhe and Desai, 1984). The total area under mango cultivation in Bangladesh is 41,700 ha and the total production is 12,88,000 metric ton (BBS, 2018). Mangoes have some special features such as pleasant aroma, attractive colour and delicious taste with high nutritional values, and these attributes make this fruit one of the unique items in the world market. This is termed as the 'king of all fruits' (Shahjahan et al. 1994). Mangoes are rich sources of vitamins and minerals (Paramanik, 1995). Moreover, it is a moderate source of carbohydrate as ripe mango pulp contains 16.9% carbohydrate (Salunkhe and Desai, 1984). In Bangladesh like almost major fruits, mango is available in summer months but a considerable amount of mango was spoiled due to high temperature and humidity. As mango is a climacteric fruit, so the physiochemical properties change at different stages of ripening. It is necessary to study the physicochemical changing pattern of mango at storage. Lots of nutrients like vitamin C was destroyed during storing at the room temperature in traditional method due to oxidation and microbial activity (Ghosh et al. 1966; Srivastava and Tandan, 1966; Parviainen and Nyyssonen, 1992). To prevent physico-chemical changes and microbial activity during storage it is essential to find out the physical and chemical changes with microbial activity during storage. Singh (1960) reported from India that the postharvest loss of fresh mango fruit due to microbial decay varied from 20-33%. Johnson et al. (1989) reported that *Colletotrichum gloeosporioided* (*Glomerella cingulata*) is the main pathogen to cause postharvest diseases of mango. They also noticed that *Botryodiplodia theobromae* and *Aspergillus niger* are fewer common pathogens. Anthracnose, caused by *Glomerella cingulate,* is the most prevalent postharvest disease of mango (Arauz, 2000). Some studies on postharvest behavior of mango have been conducted by several researchers (Hassan et al. 1998; Sarder et al. 1998). But little information is available on physico-chemical changes and nutritional losses especially vitamin C of mango in Bangladesh. Therefore, the present study was undertaken to investigate the physico-chemical changes of quality parameters along with vitamin C of Fazli and Bombai varieties of mango during storage and ripening. Variety Fazli and Bombai has been selected due to being important and small research work about these varieties. In addition, it can be said that Fazli is a commercial and popular mango variety. On the other hand, Bombai is a promising mango variety in Bangladesh.

II. Materials and Methods

The experiment was carried out at the laboratories of the Departments of Horticulture, Biochemistry, and Plant Pathology, Bangladesh Agricultural University, Mymensingh during the period from 23 June 2009 to 10 November 2009. Two commercial mango varieties, namely Fazli and Bombai were selected as experimental materials. The mangoes, which were used in the experiment, were collected from mango grower of Kalinagar, Shibganj, Chapai Nowabgonj. The experimental treatment consists of two factors, variety (Fazli and Bombai) and storage period (0 days after harvest i.e. fresh sample, 3 days after harvest, 6 days after harvest, 9 days after harvest, and 12 days after harvest). This factorial experiment was laid out in a completely randomized design with three replications. One hundred twenty uniform mango fruits were carefully selected both the cultivars to conduct the experiment. During entire storage period, the fruits were keenly observed every day. Data were recorded on physiological weight loss, diseases as well as physico-chemical changes at an interval of 3 days during storage.

Table 01. Key fruit characteristics of Fazli and Bombai varieties of mango

Sl. No.	Characters	Fazli	Bombai	Reference
1.	Fruit shape	Oblique	Ovate	Bhuyan, 1995
2.	Skin colour at ripen stage	Yellowish green	Yellowish	Bhuyan, 1995
3.	Flesh colour	Orange yellow to deep yellow	Orange	Bhuyan, 1995
4.	Fruit weight	560-650 g	300-350g	Bhuyan, 1995; Kobra et al., 2012
5.	Edible portion	72%	65%	Bhuyan, 1995
6.	TSS	15.60-19.8% Brix	16-21.3% Brix	Bhuyan, 1995; Khara et al., 2016; Kobra et al., 2012

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Changes in skin colour of the fruits were observed by using 1-6 numerical rating scale as described by Hassan (2006), where 1= green, 2= breaker (below 25% yellow), 3= 25% yellow, 4= 50% yellow, 5= 75% yellow, and 6= fully yellow. Firmness of the fruits as changed during storage and ripening was determined by using numerical ratting scale of 1-5, where 1 for firm or hard, 2 for sprung (slightly give with strong thumb pressure), 3 for between sprung and eating ripe, 4 for eating ripe, and 5 for over ripe. Similar rating scale was used by Hassan (2006). For the measurement of weight loss, samples were initially weighed by using a weighing balance. Later, the fruits were held at ambient conditions for storage and ripening. The same fruits were weighed again at every 3-day interval, and weight loss was estimated by using the following formula:

%Weight loss (WL) = (IW-FW)/IW × 100;

Where, %WL = Weight loss of fruits in percent,
IW = Initial weight of fruits, and
FW = Final weight of fruits.

Fifteen gram of fruit pulp was weighed in a porcelain crucible (which was previously cleaned, heated to 100°C, cooled and weighed) from each treatment of each replication. The crucible was placed in an electric oven (Gallenkamp) at 80°C for 72 hours until constant weight was attained. It was then cooled in desiccators and weighed again. Percent moisture content was calculated according to the following formula:

$$\% \text{ Moisture content} = \frac{IW - FW}{IW} \times 100$$

Where, IW = Initial weight of pulp
FW = Final weight of oven dried pulp

Percent dry matter content of the pulp was calculated from the data obtained during moisture estimation using the following formula:

% Dry matter = (100 - % moisture content).

Total soluble solids (TSS) content of fruit pulp was estimated using hand refractometer (Atago N1). A drop of juice squeezed from the fruit pulp was placed on the prism of the refractometer and total soluble solids content were recorded as %Brix from direct reading of the instrument. Temperature corrections were made using the temperature correction chart that accompanied the instrument. Samples of 10 g fresh mango pulp were homogenized in 10mL of distilled and deionized water (pH 7.0) and the pulp of homogenate was measured with pH meter (Hanna). Vitamin C content of mango was determined by 2, 6-dichlorophenol indophenol visual titration method (Plummer, 1971). Titratable acidity was determined using method described by Ranganna (1979). β-carotene content of the experimental sample was determined using coloum chromatography (AOAC, 1965). The disease incidence of fruit was calculated using the following formula:

% disease incidence = (Number of infected fruits/Total number of fruits) × 100

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Disease severity was measured based on eye estimation. Diseased fruits were collected and taken to the laboratory of Plant Pathology laboratory, BAU, Mymensingh where semi- permanent slides were prepared by using nail polish and images were taken. The collected data on various parameters were statistically analyzed using The R project for Statistical Computing Software version (3.5.1) (R Core Team, 2018). Mean separation was done by Honestly Significant difference (HSD) test at 5% level of probability. For percentage data, transformation was carried out using $\sqrt{(x+1)}$ formula to normalize data and satisfy the assumption of ANOVA, and statistical analysis were performed on the transformed data.

III. Results and Discussion

Changes in colour

Storage period had significant effect on colour change (Table 02). In case of Fazli variety, the colour change score was 1.00 at 0 days of storage, which was increased to 1.43, 2.00, 2.67, and 3.50 at 3, 6, 9, and 12 days, respectively after storage. On the other hand, for Bombai variety the color change score was 1.00 at 0 days of storage, which increased to 2.33, 3.33, 4.23, and 4.60 at 3, 6, 9, and 12, respectively days after storage. It was observed that change in colour was faster in Bombai than Fazli. It may be due to genetic differences between the varieties. The increase in colour change throughout storage period was due to the progress in rates of ripening with the progress in time. The colour changes due to breakdown of chlorophyll leading to disappearance of green colour and development of carotenoid in the peel (Rathore, 2007).

Changes of firmness

Storage duration had statistically significant variation on change of firmness of Fazli and Bombai varieties of mango. In case of Bombai, significantly highest firmness showed at 12 days of storage but there was trend to increase with the increase of duration. Similar trend was followed in case of Fazli variety. It was observed that the change of firmness was faster in Bombai compare to Fazli. This was may be due to genetic variation between the two varieties. The increase of firmness score means reduction of firmness i.e. softening. During storage a characteristic of the ripening process, common to most fruit, is an increase in the activity of the cell wall degrading enzymes responsible for fruit softening and increasing membrane permeability (Suwapanich and Haewsungcharern, 2005). Enzymatically mediated degradative changes in the cell walls during ripening is the responsible for reduction of firmness. The enzymes are pectinesterases and polygalacturonases either synthesized, activated, or a combination of both, at or near the onset of the ripening process (Kays, 1991).

Total weight loss

Statistically significant variation was observed between Fazli and Bombai in respect of total weight loss during storage. The duration after storage exhibited pronounced effects on total weight loss of mango. The total weight loss was 1.00% at 0 days of storage, which increased to 2.22, 2.91, 3.74, and 4.13% at 3, 6, 9, and 12 days, respectively after storage in Fazli variety. In case of Bombai total weight loss was 1.00% at 0 days of storage, which increased to 2.48, 2.91, 3.71, and 4.34 at 3, 6, 9, and 12 days, respectively after storage (Table 02). Total weight loss change percentage was higher in Bombai than Fazli. The total weight loss change trend was found sharply increased from 0 days to 3 days of storage then steady for the both varieties. Haque (1985) reported that the weight loss of banana occurred due to the loss of water from the fruits, microbial decay and storage environment like temperature and humidity. High temperature enhanced weight loss but low temperature reduced weight loss during ripening and storage.

Moisture content

Significant variation was observed in relation to moisture content between Fazli and Bombai (Table 02). Both the variety showed highest moisture content at 0 days of storage but decrease with the increase of duration. Similar trend was followed in both the variety. The reduction in moisture contents with the advancement of storage period was in agreement with the research findings of Joshi and Roy (1988).

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Dry matter content

Significant variation was observed in dry matter content between Fazli and Bombai and duration of storage of mango. Dry matter contents were found to increase with the increase of storage period. Among the variety, duration of 9 and 12 days showed statistical identical and higher among the treatments. On an average, dry matter content was higher in Bombai variety compare to Fazli which may be due to less amount of moisture content in Bombai than Fazli (Table 02).

Table 02. Effect of storage period on colour, firmness, total weight loss (%), moisture content (%), and dry matter content (%) of two varieties of mango

Variety	Storage duration (Days)	Colour (Score)	Firmness (Score)	Total weight loss (%)	Moisture content (%)	Dry matter content (%)
Fazli	0	1.00 e	1.00 f	0.00 (1.00) e	86.44 a	13.56 f
	3	1.43 e	1.13 f	3.95 (2.22) d	81.79 cd	18.56 cd
	6	2.00 d	2.40 d	7.66 (2.91) c	79.93 de	20.51 bc
	9	2.67 c	3.23 b	13.02 (3.74) b	78.68 ef	21.36 ab
	12	3.50 b	3.43 b	16.07 (4.13) ab	77.40 ef	22.60 ab
Bombai	0	1.00 e	1.00 f	0.00 (1.00) e	84.96 ab	14.89 ef
	3	2.33 cd	1.67 e	5.27 (2.48) cd	82.79 bc	17.21 de
	6	3.33 b	2.70 cd	7.49 (2.91) c	78.78 ef	21.22 bc
	9	4.23 a	3.20 bc	12.75 (3.71) b	77.91 ef	22.06 ab
	12	4.60 a	3.97 a	17.80 (4.34) a	76.33 f	24.00 a
$HSD_{0.05}$		0.48	0.51	0.55	2.73	2.68
CV (%)		6.29	7.30	6.58	1.16	4.68

followed by same letter (s) in a column are not significantly different by HSD at 5% level Values

Titratable acidity

Fazli had higher titratable acidity than Bombai (Table 03). Different storage times had noticeable effects on titratable acid contents in mango pulp. Among the treatments, significantly highest titratable acidity was recorded from Fazli at 0 days of storage. Titratable acidity declined with the advancement of storage period. The abating trend was hastily from the 0 days of storage to 3 days of storage, and thereafter, it was slower in both varieties. This observed abating trend may be due to increasing rate of metabolic activities and conversion of different organic compounds into sugars. The abating trend of titratable acidity during storage period was observed by Rangavalli et al. (1993); Upadhayay et al. (1994); and Shahjahan et al. (1994).

pH of fruit pulp

There was no significant difference among the 6 to 12 days of storage periods in case of Fazli. Simultaneously, in case of Bombai, 3 to 9 days of storage had no significant difference (Table 03). Both the observed mango variety showed highest fruit pulp pH at 12 days after storage. At different days after storage a growing up fashion of pH with the increase of storage duration was observed. The increase in the pH may be due to the oxidation of acid during storage. This growing up trend of pH was also observed by Medlicot et al. (1990); Kumar and Singh, 1993; Kumar et al. (1993); Shahjahan et al. (1994).

Total soluble solids

In most of the fruits TSS content is considered as a measure of quality. Statistically highest TSS was recorded from Bombai variety at 9 days of storage. In case of Fazli, 6 to 12 days of storage showed statistically identical and higher TSS (Table 03). The increase in TSS content of the fruits pulp was possibly due to the hydrolysis of polysaccharides and dehydration of fruits for longer period of time. The increase in TSS contents of mango pulp with the advancement of storage period found in the present study was in agreement with the findings of Yuniarti and Suhardi (1992).

Vitamin C

Progress in storage duration exerted significant effects on vitamin C contents of mango pulp. In case of Fazli variety, vitamin C content was 51.12 mg/100 g just after harvest is statistically different from all other treatments. There was trend to (34.60, 32.29, 27.25, and 19.73 mg/100 g at 3, 6, 9, and 12 days, respectively) decrease with the advancement of storage duration. In Bombai variety, vitamin C content was 34.69 mg/100 g at 0 days of storage, which decreased to 24.67, 18.67, 16.54, and 12.27 mg/100 g at 3, 6, 9, and 12 days, respectively after storage (Table 03). From the observations it was found that

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vitamin C content was higher in Fazli variety than Bombai. It may be due to genetic dissimilarity between the varieties. During the different days of storage vitamin C contents declined sharply from 0 days to 3 days, and then it declined steadily in both Fazli and Bombai variety. Results indicated that the fresh and mature-hard mangoes contained higher levels of vitamin C as compared to ripe mangoes. This result was agreement with Mondal et al. (1998) and Gofur et al. (1994). Levels of vitamin C in mango were also reported by several authors as 6.8-38.8 mg/100 g (Majumder et al. 2001); 16 mg/100 g (Gopalan et al. 1981) and 41 mg/100 g (Darnton-Hill et al. 1988). The decrease in vitamin C with time is possibly due to the oxidative degradation of the compounds under ambient conditions.

Disease incidence and disease severity

Storage duration caused noticeable effects on disease incidence in mango. Disease incidence increased with the increase of storage duration but static in case of Fazli from 0 to 6 days of storage. The level of disease incidence at day 0 was 1.00%, which increased to 2.19 and 5.09% at day 9 and 12 days, respectively after storage in Fazli. On the other hand, disease incidence level in Bombai was 1.00% at 0 days of storage, which increased to 1.77, 2.97, 8.78, and 10.5 at 3, 6, 9, and 12 days, respectively after storage (Table 03). The level of diseases incidence was higher in Bombai compare to Fazli mango variety. This may be due to genetical variation between two varieties. In terms of disease severity, storage duration had no significant effect on Fazli variety. On the other hand, Bombai showed statistically highest disease severity (6.42%). The variety Bombai had higher level of severity than Fazli. It may be due to the more disease susceptibleness of Bombai variety compare to Fazli. The present results suggested that Fazli is more tolerant to postharvest diseases than Bombai, and disease severity increased rapidly with the progress in storage duration.

Table 03. Effect of storage period on titratable acidity, pH, TSS, vitamin C, diseases incidence and diseases severity of two varieties of mango

Variety	Storage duration (Days)	Titratable acidity	pH	TSS (%Brix)	Vitamin C (mg/100 g)	Diseases incidence (%)	Diseases severity (%)
Fazli	0	5.12 a	4.94 f	14.87 f	51.12 a	0.00 (1.00) c	0.00 (1.00) c
	3	2.03 c	5.25 e	18.53 e	34.60 b	0.00 (1.00) c	0.00 (1.00) c
	6	0.76 de	5.99 abc	22.47 d	32.29 b	0.00 (1.00) c	0.00 (1.00) c
	9	0.57 ef	6.13 ab	23.27 cd	27.25 c	6.67 (2.19) bc	0.33 (1.14) c
	12	0.32 g	6.25 a	22.47 d	19.73 d	26.67 (5.09) b	4.13 (2.09) c
Bombai	0	2.46 b	5.15 ef	17.33 e	34.69 b	0.00 (1.00) c	0.00 (1.00) c
	3	0.90 d	5.57 d	24.80 bc	24.67 c	3.33 (1.77) bc	0.00 (1.00) c
	6	0.58 ef	5.72 cd	25.93 b	18.67 de	10.00 (2.97) bc	0.17 (1.07) c
	9	0.37 fg	5.80 cd	27.73 a	16.54 e	76.67 (8.78) a	9.70 (3.27) b
	12	0.22 g	5.90 bc	24.80 bc	12.27 f	100.00 (10.5) a	40.50 (6.42) a
$HSD_{0.05}$	-	0.24	0.29	1.73	3.07	3.45	1.17
CV (%)	-	6.27	1.73	2.66	3.85	33.81	21.05

Values followed by same letter (s) in a column are not significantly different by HSD at 5% level

β-carotene (Vitamin A)

β-carotene contents of two mango varieties were determined at mature-hard and eating ripe conditions. Varietal difference was noticeable between the varieties at both mature-hard and eating ripe conditions. The variety Bombai contained much higher amounts of β-carotene (219.13 and 2868.49 µg/100 g at mature-hard and eating ripe stages, respectively) than Fazli (190.53 and 1086.61 µg/100 g) (Table 04). Gopalan et al. (1981) reported that ripe mango contained 2743 µg/100 g carotene. Khara et al. (2016) also reported that ripe mango may contain 1089-17452 µg/100g β-carotene.

Table 04. β-carotene (µg/100g) content of Fazli and Bombai varieties at mature-hard and eating ripe stages

Variety	Fresh Sample	Eating ripe stage sample
Fazli	190.53	1086.61
Bombai	219.13	2868.49

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Shelf life

Shelf life is one of the most important character for climactric fruits including mango. From this study it was observed that shelf life of Fazli was higher than Bombai (Figure 01). Tolerance to postharvest diseases increased the shelf life of Fazli mango variety compare to Bombai.

Isolation and identification of pathogen from infected fruits

Infected fruits were picked up from the different treatments and were examined to identify the causal organisms. Fruits were infected predominantly by *Colletotrichum gloeosporioides* (Plate 01).

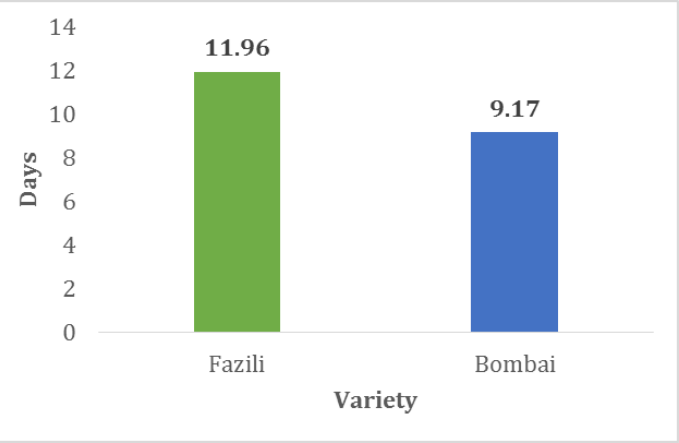

Figure 01. Shelf life of Fazli and Bombai mango variety.

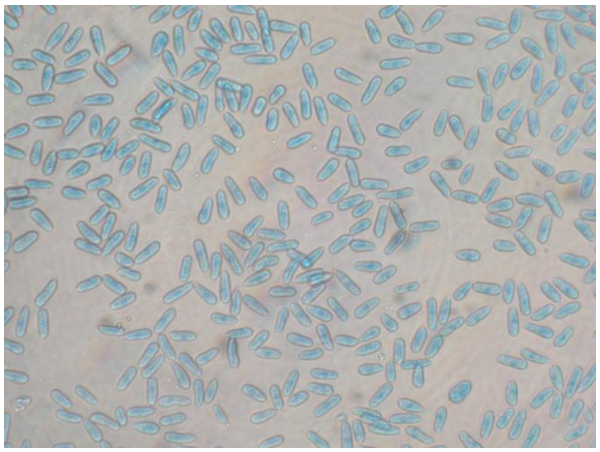

Plate 01. Spores of *Colletotrichum gloeosporioides* isolated from infected mango fruits

IV. Conclusion

In case of appearance, the rates of colour change and firmness was higher in Bombai than in Fazli during storage period. Weight loss was minimal at the early part of storage and increases sharply at the later part of storage. Considering the bio-chemical change during storage, the variety of Fazli was found in higher level of pH and titratable acidity than that of Bombai. In the respect of TSS and β-carotene content, Bombai was found higher than that of Fazli. It was also revealed that, vitamin C degraded quickly during storage period in both varieties. β-carotene content differed among the variety, and Bombai had much higher levels of β-carotene both at mature-hard and eating ripe conditions than Fazli. The level of disease incidence and disease severity was found higher in Bombai than Fazli. The shelf life of Fazli was higher compare to Bombai. Considering the physico-chemical and microbial aspect, it may be concluded as Fazli variety found better compare to Bombai. The physico-chemical properties and nutritional composition of other commercial varieties should also be extensively investigated to minimize the postharvest loss of mango.

Conflict of interest

The authors declare that they have no conflict of interest.

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