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Variability assessment of different treatment effect on antioxidant capacity, total carotenoid & ascorbic acid content of three Mango (*Magnifera Indica*) cultivars

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Abstract

Mango (*Mangifera indica L.)* is one of the most important tropical fruits commercialized and consumed worldwide, and an excellent source of fiber, bioactive compounds such as pro-vitamin A (carotenoids), vitamin-C (ascorbic acid) and antioxidant. Being perishable fruit different products of Mango are also popular and on that purpose the fruit goes through different treatment effects while processing. Bangladesh is one of the leading mango producing countries and manufacturer are initializing new products frequently through different processing techniques. The aim of the study was to evaluate the different treatment effects T_1= Microwave heating, T_2= UV-C exposure, T_3= Treatment in chilling temperature at 15°C, T_4= Mild heat treatment at 60°C on the content of vitamin-C (ascorbic acid), total carotenoid & antioxidant capacity in three popular fresh-cut mango cultivars of Bangladesh. Total carotenoid content in three mango varieties were analyzed by the solvent extraction method and the results showed that the treatment methods varied the total carotenoid content from 250.27 µg / 100gm to 415.25 µg / 100 gm, 150.09 µg / 100 gm to 174.29 µg / 100 gm & 130.02 µg / 100 gm to 168.60 µg / 100 gm respectively. The ascorbic acid content was determined by the titrimetric method with 2, 4-DCPIP and the results varied from 24.22 mg / 100g to 44.68 mg / 100g, 24.25 mg /100g to 43.42 mg/100g & 25.77 mg/100g to 43.12 mg/100g respectively. The antioxidant capacity has determined by DPPH method resulted in 1.312 mg/100ml to 2.97 mg/100ml, 1.5mg/100ml to 3.02 mg/100ml & 1.23 mg/100ml to 2.85 mg/100ml respectively. It has been assessed that the antioxidant, vitamin-C & beta carotene contents of mango cultivars have a significant variability under the treatment conditions ($p<0.05$). All the values used to follow a decreasing trend after different heat treatments and the UV-C exposure may sometimes give an upward value for the antioxidant & vitamin-C (ascorbic acid).

Keywords: *Carotenoid, Ascorbic acid, Antioxidant capacity, DPPH method, UV-C exposure.*

1. Introduction

Mango *(Mangifera indica L.)* is one of the most popular tropical fruits which have distinctive color, taste and aroma. Over 500 varieties of mango, either fresh or processed, are distributed worldwide (Guiamba, 2016; Singh et al., 2000). Bangladesh is located in tropical monsoon

region where a lot of different varieties of fruits and vegetable are cultivated every year. Mango is one of them and contributes to 3.9 percent of total mango production in the world making Bangladesh world's eighth-largest mango producing country. Mangos are grown almost all over the country but the main growing region is in the northern part of Bangladesh specially Rajshahi, Chapainawabganj, Nawabganj, and Dinajpur. (Rahman and Khatun, 2018).Mango has a strong economic impact on the economy of Bangladesh. The mango varieties available in Bangladesh are Fazlee, Langda, Gopalbogh, Himsagar, Laksmanbhog, Khirsapat, Khisanbogh, Kuapahadi, Lata Bombai, Ashhwina, Foria, Bombai, Kohinoor, Mohanbhog, Misribhog, etc. Rubbi et al. (1985) reported 35- 38% post-harvest losses of mango in Bangladesh. After harvest, fruits undergo many physiological and biochemical changes during storage. Apart from this changes, microbial which often results in a high level of wastage, unsynchronized ripening and poor quality fruit. Different enzymatic and non-enzymatic reactions during maturation and storage of fruits affect the nutritional, sensorial and Physico-chemical properties of fruit. Although processing is considered an important tool to limit the reactions but some vitamins and minerals can be lost during processing.

Mango contains amino acids, carbohydrates, fatty acids, minerals, organic acids, proteins and several vitamins (Mukherjee, 1997). Mango is a very good source of different bioactive compounds like vitamin A, vitamin C, and Phenolic compounds etc. which are beneficial for our health.

The unripe fruit is acidic, astringent and rich in ascorbic acid (vitamin C). However, ripe mangoes contain moderate levels of vitamin C but are rich in pro-vitamin A (β- carotene) and Vitamins B1and B12 (Nanjundaswamy, 1997; Mukherjee, 1997). Mango varieties contain a significant amount of vitamin C (46.53- 26.53 mg/100 gm).

L-Ascorbic acid is very unstable as it can be easily oxidized into Dehydroxy Ascorbic Acid by ascorbic acid oxidase (AAO) enzyme at the time of processing like cutting, crushing, heat treatment etc. and storage. (Guiamba et al., 2016; Barros et al., 2010; Lima et al., 2010; Santos and Silva,2008). High temperature treatment destroys vitamin C and being a water-soluble vitamin, it may lead to leaching (Igwemmar et al., 2013).

Carotenoids are synthesized by the plants, algae, yeast fungi etc. They are lipid soluble pigments present in the mango fruits especially higher in the ripe mangoes (Britton et al., 1998). The carotenoid composition of mangoes varies between 5 to 30 mg per kg of fresh mango due to different mango verities, maturity, different harvesting period, different location etc. (Manthey and Perkins-Veazie, 2009).

For various purposes like developing fruit juices or other products, long term storage, availability etc. mangoes are processed in different ways.

This study indicates that mango varieties are a rich source of carotenoid, antioxidant & Vitamin-C and encouraging intake of these mangoes would alleviate Vitamin A, Vitamin C deficiency in Bangladesh. The processing industries are getting interested in fresh-cut products as a consumer may prefer the fresh cut for consuming optimum nutrients. Moreover, different processing methods increase the shelf life of that kind of perishable fruit. So, the amount of nutrient which retains after the processing & other treatment effect is also important. The present study is focused on the treatment effects which can be done during mild processing of fresh-cut mango in processing industries & tried to give a clear idea about the effects on the Carotenoid, vitamin C and antioxidant capacity.

2. Materials and Methods

Three cultivars of mango *(Magnifera Indica L.)* sample were collected from different locations of Chittagong City. Three mango cultivars were Amrupali, Fazlee & Himsagar and each mango sample was weighed 1500 gm.

2.1 Sample Preparation

The mango cultivars were washed by tap water to remove adherences, dirt and other surface impurities. Then thin peels of mangoes were taken manually with a stainless steel knife and cut into small pieces.

2.2 Treatment Methods

After preparation of the samples, all the samples were stored in PET boxes for further steps. The experiments were done as early as possible to reduce the losses of nutrients. Four treatment methods, T_1 (Microwave heating), T_2 (UV-C exposure at 254 nm), T_3 (Chilling Temperature at 15°C) & T_4 (Mild heat treatment at 60°C) were applied as their standard method in order to determine their effects on the fresh-cut mango products.

2.2.1 Microwave Heating (T_1)

10gm of fresh-cut mango (*Magnifera Indica L.)* samples were weighed from each cultivar & treated in a microwave oven (Model: SAMSUNG Microwave Processor ME21K7010DS/AA) at 2450 MHz for 05 minutes. The treated mango samples were then used for further analysis as early as possible.

2.2.2 UV-C Exposure (T_2)

The UV-C exposure was done by following the procedure described by George et al., 2015. The fruit samples were placed on autoclaved Petri dishes and exposed to a UV light (germicidal fluorescent lamp with a peak emission of 254 nm, Biological Safety Cabinet Class II, 240 V, 50 Hz, 10A) with a distance of 15 cm from the lamp to the surface of the samples. The exposure was done for 1 min. After that 10 grams of fruit samples were taken from the exposed sample and mashed into a paste using mortar and pestle, for determining the carotenoid, Vitamin C and antioxidant capacity.

2.2.3 Treatment in Chilling Temperature at 15 °C (T_3)

Twelve fruit disc samples were placed on sterilized beaker (250ml) and low heat treated at 15°C in a chillier for 10 to 20 min. Ten grams of treated fruit discs were mashed into a paste using a mortar and pestle, for further analysis. The further analyses have done just after the treatment process to get an exact value.

2.2.4 Mild Heat treatment at 60°C (T_4)

Twelve fruit disc samples were placed on sterilized beaker (250ml) and heat-treated at 60°C in a water bath for 10 to 20 min to reach the core point. Ten grams of treated fruit discs were mashed into a paste using a mortar and pestle, for further analysis. The further analyses have done just after the treatment process to get an exact value.

2.3 Determination of Total Carotenoid

The method for determination of Total Carotenoid is a solvent extraction method. The method was done by Rodriguez (2001).Carotenoid analysis method can be described by the following procedure:

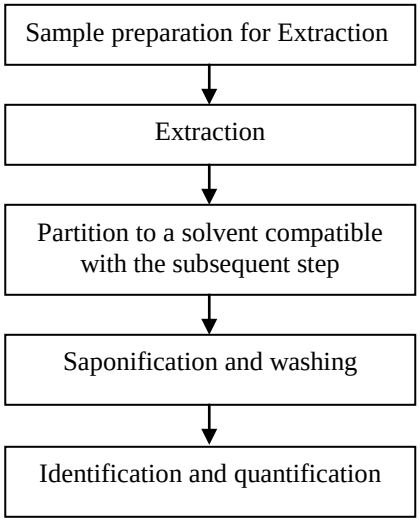

Fig: Flow Diagram for Carotenoid Determination Method

2.3.1 Sample preparation for extraction

The treated fresh-mango samples were marked to identify individually. A portion of the homogeneous, representative sample has been weighed. The weight depends on the carotenoid content of the sample, varying from 2 gm to 100 gm. For this study 3gm of each sample have weighed.

2.3.2 Extraction

The weighted samples have been blended in a mortar for 30–60 seconds with enough cold acetone. Then the blended samples have filtrated with suction through a Buchner funnel. The mortar, funnel, and residue have been washed with small amounts of acetone & the washings were also filtered to avoid the loss of residue. The extract were received in the suction flask .The residue has returned to the mortar, fresh acetone added, and macerated again. Filtered and

washed as before until the extraction and filtration residue is devoid of any color. The process has repeated for three times.

2.3.3 Partitioning to Petroleum Ether

100 mL of petroleum ether was taken in a separatory funnel and a small portion of the acetone extract was added. Distilled water was added slowly, letting it flow along the walls of the funnel. To get rid of formation of an emulsion, shaking was avoided. (If an emulsion forms it can be broken by adding acetone or saturated salt solution and mixing through swirling the funnel. If the emulsion is difficult to break, it is better to start the analysis over rather than proceed because this can lead to inappropriate result). Due to no shaking, the two phases were separated and the lower aqueous-acetone phase was discarded. Again another portion of the acetone extract was added and repeated the operation until all of the extracts has been transferred to petroleum ether, then washed it for 4-5 times with water to remove residual acetone. The petroleum ether phase was collected and dried with sodium sulfate (add sodium sulfate until some crystals become loose).

2.3.4 Spectrophotometric reading and calculation

The diluted solution was submitted to spectrophotometric measurements in wavelength of 450 nm, using petroleum ether as the control. The total carotenoid content has calculated by using the following equation:

$$\text{Total carotenoid content: (CAR) } (\mu g / g) = \frac{\text{Abs} \times V \text{ (Volume)} \times 10^4}{A_{1cm}^{1\%} \times \text{Sample Weight}}$$

Where, Abs= absorbance;
Volume = total volume of extract (25 to 50 mL);
$A_{1cm}^{1\%}$=absorption.
Co-efficient of β-carotene in petroleum ether (2592).

2.4 Ascorbic Acid Extraction and Measurement

The ascorbic acid content of the mango samples of different treatments were estimated by titration method using 2, 6-dichlorophenol indophenol dye solution (Wani *et al.*, 2016). The method of estimation involves the reduction of 2,6-dichlorophenol indophenol dye to a colorless form by ascorbic acid in an alkaline solution. The reaction is quantitative and particularly specific for ascorbic acid in solution in the pH range of 1-3.5. In the procedure followed, the dye solution was first standardized against standard ascorbic acid to determine the dye factor. The sample was diluted with 3% meta-phosphoric acid and then the phosphoric acid extract of the sample was titrated against the dye solution until a pink color was obtained which persists for 15 seconds.

Dye factor was determined by the following equation:

$$\text{Dye factor} = 0.5/\text{Titrate Value}$$

Ascorbic acid was estimated as mg of ascorbic acid / ml, and was determined by the following equation:

$$\text{mg of ascorbic acid /ml} = \frac{\text{Titrate Vol.(ml of Dye used)} \times \text{Dye factor} \times \text{Vol. made up} \times 100}{\text{Amount of sample taken for estimation} \times \text{Volume of Sample}}$$

2.5 Determination of Antioxidant Capacity

2.5.1 Extract Preparation

Treated Mango samples were transferred into respective beakers added with absolute ethanol, and left to shake on a shaker for 72 hrs at room temperature. The solvent was then separated from the plant residue by straining. The filtrate was collected and stored at room temperature while the residue was re-extracted twice, each time with fresh solvent. Finally, all the filtrates were combined and evaporated under reduced pressure at 60°C using a rotary evaporator to obtain the crude extracts. The crude extracts were weighed and stored at 4°C until further analysis.

2.5.2 Measurement of antioxidant capacity

The antioxidant capacity of the extracts was determined using DPPH assay as described by Chan (2007) & Azlim (2010) with slight modifications. Stock solution (1mg/mL) of extract was diluted to concentrations of 0.10, 0.20, 0.30, 0.40, 0.60, and 0.80 mg/mL in methanol. Methanolic DPPH solution was prepared by dissolving 6 mg of DPPH in 100 mL methanol. The methanolic DPPH solution (2 mL) was added to 1 mL of each extract solution of different concentrations and the mixture was left for 30 min and the absorbance will be read at wavelength 517 nm. Control was prepared by mixing 1 mL of methanol with 2 mL of DPPH solution. Methanol was used as a blank.
Antioxidant capacity based on the DPPH free radical scavenging ability of extracts was calculated using the following equation:

$$\% \text{ inhibition} = (1 - \text{Absorbance of Sample} / \text{Absorbance of Control}) \times 100$$

% each experiment was replicated three times.

3. Result and Discussion

3.1 Result

The results of the investigation for different treatment effects effecting on some parameters especially antioxidant & vitamins of three mango cultivars (Amrupali, Fazlee & Himsagar) are given in the Table 1,Table 2 and Table 3 in this section. The statistical analysis was performed by using SPSS software version 26.0.

3.1.1 Analysis for Total Carotenoid Content

One way ANOVA (Analysis of variance) test was performed to see the overall mean difference of samples under different treatment conditions for determination of total carotenoid content (Table 1). The result showed that there was highly significant mean difference of the total carotenoid content in different situation ($P<0.05$). Different treatment conditions evidenced that the mango cultivar treated at T2 contained significantly better level of total carotenoid ($p<0.05$). The total carotenoid content of mango cultivars prior to treatment effect was $4.44\times10^2 \pm 0.908$, $1.85\times10^2 \pm 1.131$ and $1.74\times10^2 \pm 1.030$ µg/100g respectively (Table 1). The changes in Total carotenoid content among the mango cultivars were varied from $2.51\times10^2 \pm 1.243$ to $4.15\times10^2 \pm 0.911$, $1.20\times10^2 \pm 1.119$ to $1.74\times10^2 \pm 0.968$ and $1.20\times10^2 \pm 1.071$ to $1.68\times10^2 \pm 1.005$ µg/100 g respectively in different treatment methods ($p<0.05$).

Table1: Variability of Total carotene content (µg/100g) at different treatment effect in mango *(Magnifera Indica L.)* cultivars (Amrupali = Mango Cultivar 1, Fazlee = Mango Cultivar 2 & Himsagar = Mango Cultivar 3)

Sample under different treatment effect	Total carotene content (µg/100g)		
	Mango Cultivar 1	Mango Cultivar 2	Mango Cultivar 3
Control	$4.44\times10^2 \pm 0.908$	$1.85\times10^2 \pm 1.131$	$1.74\times10^2 \pm 1.030$
T_1	$2.51\times10^2 \pm 1.243$	$1.20\times10^2 \pm 1.119$	$1.20\times10^2 \pm 1.071$
T_2	$3.20\times10^2 \pm 1.086$	$1.74\times10^2 \pm 0.968$	$1.68\times10^2 \pm 1.005$
T_3	$4.15\times10^2 \pm 0.911$	$1.68\times10^2 \pm 0.988$	$1.50\times10^2 \pm 0.978$
T_4	$3.20\times10^2 \pm 1.519$	$1.52\times10^2 \pm 0.937$	$1.35\times10^2 \pm 1.001$
P (1-ANOVA)	0.001	0.001	0.001
P (Post hoc test)	All sample <0.001	All sample <0.001	All sample <0.001

Here, Control=Fresh-cut samples without any treatment, T_1=Treatment with microwave heating, T_2= Treated with UV-C exposure, T_3=Treatment at 15°C, T_4=Treatment at 60°C.

** Significant at P <0.01; Values in the same column with different superscripts denotes significant difference. Results are means ± standard deviation of triplicates (n=3).

3.1.2 Analysis for Vitamin-C (Ascorbic Acid)

The mean score for ascorbic acid (Vitamin C) content of three mango cultivars under different treatment effects are represented in Table-2. It was observed that the mean scores were significantly different for ascorbic acid (Vitamin-C) content under different treatments ($p<0.05$). The Ascorbic acid (Vitamin C) content of three Mango cultivars prior to treatment were 44.35 ± 1.03mg/100g, 43.76 ±0.95mg/100g & 43.32±1.03mg/100g respectively. The changes in Ascorbic acid (Vitamin C) of Mango *(Magnifera Indica)* cultivars after different treatment show that the Ascorbic acid (Vitamin C) among the mango cultivars were varied from 27.26 ± 1.05 mg/100g to

44.67 ± 1.04 mg/100g, 24.33 ± 1.12 mg/100g to 43.41 ± 0.96 mg/100g & 22.28±1.03 mg/100g to 43.24 ±0.86 mg/100g respectively in different treatment methods.

Table 2: Variability of Ascorbic acid (Vitamin C) content (mg/100g) at different treatment effect in three mangoes *(Magnifera Indica L)* cultivars (Amrupali = Mango Cultivar 1, Fazlee = Mango Cultivar 2 & Himsagar = Mango Cultivar 3).

Sample under different treatment effect	Vitamin-C (Ascorbic Acid) (mg/100g)		
	Mango Cultivar 1	Mango Cultivar 2	Mango Cultivar 3
Control	44.35 ± 1.03	43.76 ± 0.95	43.32±1.03
T_1	23.01 ± 1.58	42.84 ± 1.03	22.28±1.03
T_2	44.67 ± 1.04	43.41 ± 0.96	43.24 ±0.86
T_3	27.26 ± 1.05	27.23 ± 0.840	27.40 ± 0.98
T_4	27.27 ± 1.05	24.33 ± 1.12	25.79 ± 0.93
P (1-ANOVA)	<0.001	<0.001	<0.001
P (Post hoc test)	All sample <0.001	All sample <0.001	All sample <0.001

Here, Control=Fresh-cut samples without any treatment, T_1=Treatment with microwave heating, T_2= Treated with UV-C exposure, T_3=Treatment at 15°C, T_3=Treatment at 60° C.

** Significant at P <0.01; Values in the same column with different superscripts denote significant difference. Results are means ± standard deviation of triplicates (n=3)

3.1.3 Analysis for Antioxidant Activity

Antioxidant activity has measured by 2, 2-diphenyl-1-picrylhydrazyl (DPPH) assay. The mean score of samples under different treatment conditions for determination of Antioxidant capacity has done one-way ANOVA (Analysis of variance) (Table 3). The antioxidant capacity of three Mango cultivars prior to treatment was 3.06±0.99, 3.21±1.11 & 3.03±1.01mg / 100ml respectively. The post hoc test suggested that the mean scores under treatment effect, T_1 is significantly lower with compared to other treatment effects ($p<0.5$). The test also showed that means score was significantly lower in all treatment effects as compared with treatment effect T2 ($p<0.5$). The treatments show a variable effect on the antioxidant capacity of mango cultivars & the values were varied significantly from 1.14 ± 0.96 mg/100 ml to 2.88 ± 0.92 mg/100 ml, 3.02 ± 1.00 mg /100 ml to 1.56 ± 1.00 mg/100 ml & 2.84 ± 1.04 mg/100 ml to 1.26 ± 1.05 mg/100 ml respectively ($p<0.5$).

Table 3. Variability of Antioxidant capacity content (mg/100ml) at different treatment effect in three mangoes (*Magnifera Indica*) cultivars (Amrupali = Mango Cultivar 1, Fazlee = Mango Cultivar 2 & Himsagar = Mango Cultivar 3).

Sample under different treatment effect	Antioxidant Capacity (mg/100mL)		
	Mango Cultivar 1	Mango Cultivar 2	Mango Cultivar 3
Control	3.06 ± 0.99	3.21 ± 1.11	3.03 ± 1.01
T_1	1.14 ± 0.96	1.56 ± 1.00	1.26 ± 1.05
T_2	2.69 ± 1.10	2.95 ± 1.01	2.83 ± 1.04
T_3	2.88 ± 0.92	3.02 ± 1.00	2.84 ± 1.04
T_4	2.10 ± 0.96	2.91 ± 0.90	2.75 ± 1.09
P (1-ANOVA)	<0.001	<0.001	<0.001
P (Post hoc test)	All sample <0.001	All sample <0.001	All sample <0.001

Here, Control=Fresh-cut samples without any treatment, T_1=Treatment with microwave heating, T_2= Treated with UV-C exposure, T_3=Treatment at 15°C, T_4=Treatment at 60°C.

** Significant at P <0.01; Values in the same column with different superscripts denotes significant difference. Results are means ± standard deviation of triplicates (n=3)

3.2 Discussion

3.2.1 Effects of different treatment on total carotenoid content

Carotenoids are pigments responsible for the yellow color of products and have a protective function against oxidative damage. Previous studies have shown that mango is one of the major sources of carotenoids (Chen et al. 1996; Chen et al. 2004, 2007). The Total Carotenoid content USDA data showed that β-carotene was the richest carotenoid component in edible portion of mango. The total carotenoid content of the Mango cultivars determined in this study has shown that the content of total carotenoid diminishes after different treatment methods (Table 1). The total carotenoid content of three mango cultivars varies in their fresh sample seems as alike to that observed by other researchers Zaman et al., 2014 and higher than Balaswamy et al. (2015).
It is known that exposure of mangoes to oxygen, peroxides, temperature and light may cause unwanted alterations in terms of isomerization, oxidation or degradation in structure and bioactivity of carotenoids (Van den Berg et al., 2000). This study evaluates that the total carotenoid contents of the mango cultivars declined after the treatment with microwave heating is higher than any other method. The evaluated values are 252, 120 & 130 µg/100g respectively for the T_1 (Microwave Heating). Heat treatment can induce disruption of cell membrane and intensify chemical extractability of total carotenoids (Kidmose et al., 2002). In this study the values of total carotenoid in treatment at chilling temperature (T_4, 15°C) are 415, 168 & 150 µg/100g which are higher than other process. Lower total carotenoid contents during storage have also been reported after heat treatment of whole persimmon fruit (Luo, 2006) and fresh-cut peach (Koukounaras et al., 2007). Zotarelli et.al, 2017; reported the total carotenoid value of mango pulp powder produced by spray-drying was 113µg g^{-1} which is than the result of this study. The literature reported that the loss of beta-carotene in processing is approximately 13 %. Divergence

in this result can be interpreted be the fact that the drying temperature of the mango was not very important in the study (50°C), which had preserved carotenoids of the mango in comparison to others. UV-C exposure has showed a slight difference from the total carotenoid content of the fresh one (Table 1). Over the last years, some researchers studied MTLT heat treatments (temperature <80 °C and holding times >30 s) to improve the shelf life of minimally processed products. MTLT can provide high retention of β-carotene content in reduced calorie content in carrot juice (Sinchaipanit and others 2013). But in this study the treatment method shows the decreased values than others (Table 1). However, some studies were conducted on BARI released the total carotenoid content of mango varieties by Rahman and Khatun (2018), Rahman et al. (2019), Barua et al. (2013) and Uddin et al. (2018). The composition of Mangoes especially carotenoid content may vary largely due to topographical variations. This variation may be due to climatic condition, nature of soil and sometime rainfall. Maturity of mango is also responsible for this variation. Stages of harvest and storage period had significant effect on β-carotene content of mango fruits. It was the minimum after harvest and was maximum at last edible stage. Minimum β-carotene was recorded in the fruits harvested first. The amount of βcarotene increased gradually with the delay in harvest and being highest at last harvest. Similar trend was noted in all periods of storage. The findings of the study conformed to those of Absar et al. (1993). Significant variations inβcarotene content was observed among the mango varieties. It was the highest in Langra and the lowest in Gopalbhog both after harvest and full ripe stage. At last edible stage, the highest amount of βcarotene (Haque et al.2015). Treatment in cold temperature used in various processing industry for short term preservation may induce browning reaction but changes in total carotenoid contents have also showed a significant difference (Table 1). This study indicates that mango varieties are rich source of carotenoid. The IOM (Institute of Medicine) states that consuming 3-6 mg of beta-carotene daily (equivalent to 833 IU to 1,667 IU vitamin A) will maintain blood levels of beta- carotene in the range associated with a lower risk of chronic diseases. In addition to its role in addressing the widely prevalent vitamin A malnutrition, carotenoid also have potential antioxidant activity. Encouraging intake of these mangoes would alleviate Vitamin A deficiency in Bangladesh (Haque et al. 2015). During storage, total carotenoid contents remained stable in the control and hot water dipping at 46ºC/30 min treatment, whereas for the other treatments it decreased (Vanden Berg et al., 2000).

3.2.2 Effects of different treatments on Ascorbic Acid (Vitamin-C) Content

Moreover, as the oxidative processes occur more rapidly in fresh-cut products, they are expected to get mass losses. In this study, Ascorbic acid content of the fresh cut mango fruit cultivars were significantly influenced by the treatment of different methods (Table 2). It shows the highest value of Vitamin-C has obtained just after the exposure in UV-C for Amrupali cultivar & Fazlee cultivar and the values are 44.68 & 43.82 mg/100g respectively. This is similar to another report where ascorbic acid, total phenolic compounds or flavonoids were slightly enhanced immediately after UV-C exposure in mortino fruits *(Vaccinium floribundum Kunth*) (Andrade-cuvi et al. 2017). The ascorbic acid values obtained in present study were in close agreement to those reported previously. Another report studied that UV-C treatment believed to have positive effects on the antioxidant retention in fruit juice (Kamarul Zaman et al., 2017). Similarly, fresh cut mango also decreased in vitamin C content after UV-C treatment (Pala and Toklucu, 2011). The decrement of vitamin C content in fruit juice was related to the UV-C dosage induced by the

treatment. Pala and Toklucu (2013) added that the higher the UV-C dosage, the greater degradation in vitamin C content will be observed. Shah et al. (2016) stated that vitamin C was an excellent UV light absorber and light sensitive in which too much exposure to light will degrade the amount of vitamin C in juice. In this study it was observed that all the cultivars of mango are rich sources of vitamin C (ascorbic acid). Mango varieties showed significant differences in ascorbic acid content. At initial stage, Amrupali Cultivar contained the highest amount of ascorbic acid, which significantly decreased after the mild heat treatment (Table 2). The results of the present study agree with that of Djioua et al. (2009). Fazlee Cultivar and Himsagar Cultivar also show a decrease in Vitamin-C content after treatment effects (Table 2). Ascorbic acid content for whole mango was 93.59±4.2 mg/100 g FW and a lower level of this vitamin was observed in fresh-cut mango (86.7±6.3 mg/100 g), by Azoubel et al., (2008). Fruit are natural source of ascorbic acid (vitamin C) and it is known that its level decreases during processing and ripening (Lee and Kader, 2000). It is clear that heat treatment induced a decrease in the amount of vitamin C as compared to the control. Processing and cooking subjects the vitamin C to degradation (Seung and Kader, 2000). It is obvious that with increasing temperature the amount of vitamin C decreases, which is in agreement with previous studies. Jilani et al., (2010) have reported vitamin C content from mature mango fruits in different varieties ranged from 131 to 178 mg/100 g. On the basis of Jilani et al., (2010) results there is huge variation in vitamin C content of different varieties from immature to mature fruits. The vitamin C content ranged between 13 and 178 mg/100 g in the ripe fruit of 50 cultivars surveyed by Singh et al. (1960). In control samples, the amount of vitamin C was determined without any treatment. It is clear that heat treatment induced a decrease in the amount of vitamin C as compared to the control. Yahia et al. (2007) have reported that ascorbic acid levels were higher in control tomatoes than in heat- treated fruit (38◦C or 34◦C for 24h). However, with a proper time–temperature combination, like hot water dipping in 50◦C/30 min, this decrease can be reduced and fresh-cut products can still contain significant amounts of vitamin C during the storage (Djioua et al. 2009). The North American Dietary Reference Intake recommends 90 milligrams per day and no more than 2 grams (2,000 milligrams) of vitamin C per day 31. So daily 50-90 g mango or processed mango products is enough to meet the daily requirements of vitamin C.

3.2.3 Effects of different treatment methods on antioxidant capacity content

One parameter that has been introduced recently for the interpretation of the results from the DPPH method is the “efficient concentration” or EC50 value (otherwise called the IC50 value). This is defined as the concentration of substrate that causes 50% loss of the DPPH activity (Molyneux et al., 2004). Table-6 shows the dose–response mean values of DPPH-scavenging effect to the mango cultivars under different treatment methods. The antioxidants are believed to intercept the free radical chain of oxidation and to donate hydrogen from the phenolic hydroxyl groups, thereby forming a stable end product, which does not propagate further oxidation of the lipid. Kasliwali and Quadri (2016) found IC50 Value 20mg/ml by DPPH assay. The results obtained from both research are higher than the current research. The reasons for these variations may be the cultivars, methodology, climatic condition etc. The effect different treatments on the antioxidant properties were the one of the major focus of the present study and the measurement was used to evaluate this effect, which is DPPH assay. Our results showed that there was an increase in the Ascorbic acid (Vitamin C) content in UV-C exposure (significant) and treatment,

whereas the total carotenoid content decreased. Such changes can affect the antioxidant properties, which were monitored in this study using Trolox as standard in all the four techniques employed. Though there is no specific reference on microwave heating effect on antioxidants, however, the effect of heat treatments or UV-C have been shown to improve antioxidant properties (Gonzalez-Aguilar and others 2010). The antioxidant properties of the fresh-cut mango cubes with DPPH method followed a similar trend as was observed with the other studies. Statistical analysis showed that IR treatment increased the antioxidant properties significantly ($P \leq 0.05$), measured by DPPH assay. Storage effect indicated a significant decrease in antioxidant capacity as the time lapsed in control and treated samples (10 and 15 min) up to 12 d ($P \leq 0.05$). The untreated sample showed a DPPH value of 270μM TE/100 g FW, which marginally increased with the given IR treatment and varied from 289 to 36μM TE/100 g FW. During storage, the antioxidant properties of the untreated sample decreased whereas they remained unchanged in IR treated samples. In this study, the antioxidant capacity was determined using DPPH scavenging assay, which is a commonly used assay in foods (Perez-Jimenez et al., 2008). However, some reports have failed to detect antioxidant activity of carotenoids using this assay (Corral-Aguayo et al., 2008; Liu et al., 2008; Muller et al., 2011) as was also found in the present study. Therefore, further study using other methods is needed to verify antioxidant capacity in mango cultivars.

4. Conclusion

The study investigated the effects of different treatment methods on the quality of fresh cut mangoes. A UV exposure in 254nm for 10min has shown to have the potential for maximizing the Vitamin C (ascorbic acid) compared to the other treatment. 15°C/15min uphold the total carotenoid content in highest amount. This treatment also has a higher value of total carotenoid content in fresh cut mangoes. As the amount of total carotenoid content has no significant effect on the antioxidant capacity, the treatment effects suits for total carotenoid content cannot have a negative impact on antioxidant properties. These results suggest that a treatment effect at 15°C/15min can be an effective, inexpensive and environmentally safe method to improve the quality of fresh cut mangoes till further processing. There are some other suggestions for combined treatment in fresh cut mango sample which can be suggested to maintain the maximum amount of nutrients to overcome the limitations of the treatments done in the study.

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