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POSTHARVEST QUALITY OF MANGO (*MANGIFERA INDICA* L.) FRUIT AFFECTED BY DIFFERENT LEVELS OF GIBBERELLIC ACID DURING STORAGE

(Kesan Kandungan Asid Giberelik Berbeza ke atas Kualiti Buah Mangga (*Mangifera Indica* L.) Lepas Tuai Semasa Penyimpanan)

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Abstract

The experiment consisted of two popular mango varieties of Bangladesh (*viz*., Langra and Khirshapat) and four different levels of Gibberellic acid (GA_3) solution, namely, control, 100, 200 and 400 ppm. The two factors experiment was assigned in randomized complete block design with three replications. Data obtained from various biochemical analyses in terms of physicochemical properties and shelf life of postharvest mango, were recorded and statistically analyzed for comparison among the mean values using Duncan's Multiple Range Test (DMRT) and Least Significant Difference (LSD). The Khirshapat showed better performance in achieving higher quantity of moisture, progressively lost physiological weight, increased pulp pH, TSS after 6th day of storage, produced more quantity of sugar (total, reducing and non-reducing), as well as extended shelf life and delayed skin color changes than Langra at all the storage duration. Different levels of GA_3 solution subjected to the investigation demonstrated significant variation on most of the physicochemical properties and shelf life of mango at different days after storage. The results explored that some physicochemical properties *viz*., physiological weight loss, moisture content, pulp pH, TSS, sugar (total, reducing and non-reducing), were rapidly increased from untreated mangoes. GA_3 at 400 ppm showed better performance in delaying the changes in physicochemical properties and extended shelf life.

Keywords: postharvest, mango, varieties, GA_3, storage

Abstrak

Eksperimen ini melibatkan dua jenis mangga popular di Bangladesh (Langra dan Khirshapat) dan empat tahap kandungan asid Giberelik yang berbeza (GA3) iaitu kawalan, 100, 200 dan 400 ppm. Dua faktor eksperimen ini ditandai secara rawak lengkap pada reka bentuk blok dengan tiga replikasi. Data yang diperolehi daripada pelbagai analisis biokimia dari segi sifat fizikokimia dan jangka hayat mangga lepas tuai telah direkodkan dan dianalisis untuk perbandingan antara nilai min menggunakan ujian DMRT dan LSD. Mangga Khirshapat menunjukkan prestasi yang lebih baik dalam kuantiti kelembapan yang lebih tinggi, kehilangan berat fisiologi secara beransur - ansur, meningkatkan pH pulpa, jumlah pepejal larut selepas hari ke-6 penyimpanan, kuantiti gula yang terhasil lebih banyak (jumlah , penurun dan bukan penurun) serta jangka hayat yang panjang dan perubahan warna kulit lebih lambat berbanding Langra bagi semua tempoh penyimpanan. Tahap kandungan GA3 yang berbeza menunjukkan perbezaan yang ketara dalam kebanyakan sifat-sifat fizikokimia dan jangka hayat mangga pada hari yang berbeza selepas penyimpanan. Keputusan menunjukkan bahawa beberapa ciri-ciri fizikokimia iaitu kehilangan berat fisiologi, tahap kelembapan, pH pulpa, jumlah pepejal larut, kandungan gula (jumlah , penurun dan bukan penurun) telah meningkat dengan pesat berbandiing mangga yang tak terawat. GA3 pada 400 ppm menunjukkan prestasi yang lebih baik dalam proses melambatkan perubahan sifat fizikokimia dan memanjangkan jangka hayat.

Kata kunci : Lepas Tuai , mangga, variasi, GA3 , penyimpanan

Introduction

Mango being a highly perishable fruit possesses a very short shelf life and reach to respiration peak of ripening process on 3rd or 4th day after harvesting at ambient temperature [1]. The shelf life of mango varies among its varieties depending on storage conditions. It ranges from 4 to 8 days at room temperature and 2-3 weeks in cold storage at 13ºC [2]. This short period seriously limits the long distance commercial transport of this fruit [3]. Usually after harvesting, the ripening process in mature green mango takes 9-12 days [4]. The ripening process of mango fruit involves a series of biochemical reactions, resulting into increased respiration, ethylene production, change in structural polysaccharides causing softening, degradation of chlorophyll, developing pigments by Carotenoids biosynthesis, change in carbohydrates or starch conversion into sugars, organic acids, lipids, phenolics and volatile compounds, thus leading to ripening of fruit with softening of texture to acceptable quality [4].

Fruit sensitivity to decay, low temperature and general fruit perishability due to the rapid ripening and softening limits the storage, handling and transport potential [5]. On the other hand, application of modified atmosphere (MA) or controlled atmosphere (CA) is not always compatible with this fruit. Although CA storage has been shown to extend the shelf-life of mango [6], it is cost prohibitive. MA storage was also reported to slow mango ripening, but was often accompanied by high CO_2 and off flavor [7].

Gibberellic acid 2000 ppm gave a highly effective treatment for retarding rate [8]. If mangoes are treated with GA3 150 ppm and Bavistin 1000 ppm, both the treatment slowdown the process of ripening. Significant delay in the ripening of mango fruits was observed with Gibberellic acid [9]. The interaction between post-harvest treatments and storage periods was found to be significant for physical quality parameters and non-significant for chemical quality parameters, whereas storage period significantly affected both type of parameters [10].

In this present investigation, we tried to study the behavioral pattern of physicochemical properties of postharvest mango in the storage conditions. Especially the effects of GA_3 on pH, titratibility and sugar contents were studied in details. It was also aimed to find out a desirable technology for extension of storage of mango.

Materials and Methods

Preparation of GA3 solution

The solution of GA3 of 100, 200, and 400 ppm was prepared by dissolving 100, 200, and 400 mg of GA3 in one litre of distilled water. The fruits of both varieties were dipped into the solution for a period of 5 minutes. Care was taken to ensure sufficient absorption of GA3 by the fruits and then they were stored at room temperature on brown paper.

Application of GA3

Different levels of GA_3 used in the experiment were sequentially assigned to the collected fruits. After the application of treatments, the fruits were kept on a brown paper, which was previously laid out in Randomized Complete Block Design and placed on the laboratory floor at ambient condition. Each of the blocks consisted of the experimental type. For each treatment combination of replication, there were six fruits, of which one was kept to record shelf life, changes in weight, color and other external fruit characteristics. The remaining five fruits were preserved in a deep refrigerator (-85^0 C) at Protein and Enzyme Laboratory in the Department of Biochemistry and Molecular Biology, University of Rajshahi, for recording the data periodically at five different dates (at 3 days interval). Five fruits from each treatment combination of every replicate were chemically analyzed for the determination of the changes, total titratable acidity, pulp pH, total soluble solid (TSS), sugar content (total, reducing and non-reducing). To ensure the application of different storage treatment of the fruits for each variety, the following procedures were accomplished.

Parameter Study

Titratable acidity of mango pulp was determined by the method of Ranganna [19] The pH 7 and pH 4 buffer tablets (BDH chemicals Ltd., Poole, England) were used to determine pulp pH of mango. Total soluble solid (TSS) content of mango pulp was estimated by using Abbe Refractometer. Temperature correction was done using the methods as described by Ranganna [19] Total sugar content of mango pulp was determined calorimetrically by the Anthrone method as stated by Jayaraman [20]. Reducing sugar content of mango was determined by Dinitrosalicylic acid

method as denoted by Miller, [21]. Non-reducing sugar content of mango pulp was calculated by using the following formulae: % Non-reducing sugar = % total sugar - % reducing sugar.

Results and Discussion

Titratable acidity

Variation in between varieties means in terms of titratable acidity was observed to be highly significant at different days after storage. At various days during storage, Langra showed higher titratable acid content as compared with Khirshapat. Titratable acidity fell off with the passing of storage period. The diminishing trend was very fast from initial to 3rd day and thereafter, its trend was comparatively slower (Table 1). At initial day, the highest (3.88%) was derived from Langra whereas the lowest (2.60%) was derived from Khirshapat. At 12th day, the highest (0.35%) was reported from langra whereas; Khirshapat produced the lowest amount (0.29%). The abating trend of titratable acidity at storage period was reported by Upadhyay and Tripathi [11]. According to them, acidity was reduced during storage growth on attainment of maturity and ripening. The results of the present investigation might be possibly due to genetical dissimilarities between two varieties.

Table 1. Changes of titratable acidity and pulp pH of postharvest mango pulp between varieties during storage at ambient condition

Treatments	Titratable acidity (%) at different days					Pulp pH at different days				
Variety (V)	Initial	3	6	9	12	Initial	3	6	9	12
V_1	3.88a	1.20a	0.86a	0.61a	0.35a	3.50	4.30b	5.30b	5.93b	6.70
V_2	2.60b	1.03b	0.71b	0.49b	0.29b	3.58	4.55a	5.55a	6.18a	6.80
Level of significance	***	***	***	***	***	NS	***	***	***	NS

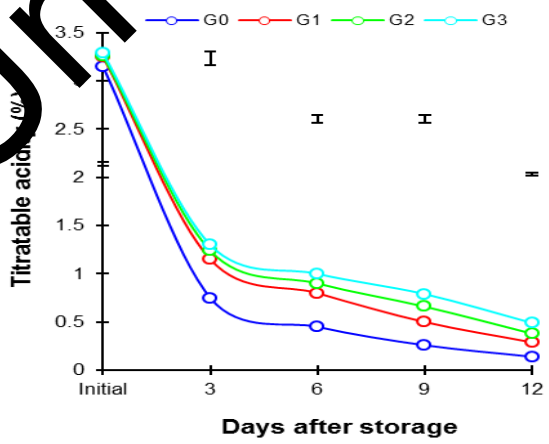

Figure 1. Titratable acidity of mango pulp as influenced by different doses of GA3 at different days after storage. Vertical bars represent LSD at 0.05 level.

Table 2. Combined effects of varieties and different doses of Gibberellic acid solution on titratable acidity and pulp pH of postharvest mango during storage at ambient condition

Treatments combination	Titratable acidity (%) at different days					Pulp pH at different days				
Varieties × Treatments	Initial	3	6	9	12	Initial	3	6	9	12
V_1G_0	3.80 b	0.95d	0.55e	0.30e	0.15g	3.60ab	4.60ab	5.60ab	6.90a	7.00ab
V_1G_1	3.90ab	1.20bc	0.85c	0.58c	0.33e	3.50ab	4.30de	5.30de	5.80cd	6.80bd
V_1G_2	3.82 b	1.28ab	0.95b	0.72b	0.40c	3.50ab	4.20ef	5.20ef	5.60 e	6.60df
V_1G_3	3.98 a	1.35 a	1.10a	0.85a	0.52a	3.40b	4.10f	5.10f	5.40f	6.40f
V_2G_0	2.50d	0.55e	0.35f	0.22f	0.12h	3.70a	4.70a	5.70a	7.00a	7.10a
V_2G_1	2.60 d	1.10 c	0.75d	0.42d	0.25f	3.60ab	4.60ab	5.60ab	6.10 b	6.90ac
V_2G_2	2.70 c	1.20bc	0.85c	0.60c	0.35d	3.50ab	4.50c	5.50bc	5.90 c	6.70ce
V_2G_3	2.60cd	1.25ab	0.90bc	0.73b	0.45b	3.50 b	4.50cd	5.50cd	5.70de	6.50ef
Level of significance	**	***	*	NS	NS	NS	NS	NS	NS	NS
CV%	1.65	4.82	4.07	5.80	5.26	2.95	2.40	1.96	1.73	1.85

In a column values having the same letter(s) do not differ significantly as per DMRT at 5% level; V_1 = Langra; V_2=Khirshapat; *** indicate at 0.1% level; NS means non-significant

Different doses of GA_3 solution used in this investigation in terms of titratable acidity exhibited significant variation among the means at various days after storage. At various days of storage, titratable acid content came down very sharply from initial to 3 days and then, it came down steadily (Figure 1). In all the storage period, higher titratable acidity (3.29, 1.30, 1.00, 0.79 and 0.49%) was noted at G_3 treatment from initial to 12th days followed by 3.15, 0.75, 0.45, 0.26 and 0.14% from untreated mangoes, respectively. These results are in conformity with the findings of Khumlert [12].

The combined effect of varieties and different doses of GA_3 solution in relation to titratable acidity of mango pulp exhibited significant variation at different days after storage except 9th and 12th days. At different days of storage, there showed a diminishing trend of titratable acid content with the expansion of storage period. At 6th day, the highest (1.10%) quantity was obtained from the treatment combination of V_1G_3 which was statistical similar with the combination of V_1G_2 and the lowest acid concentration (0.35%) obtained from the treatment combination of V_2G_0. These occurrences might be probably due to the reduction of acid oxidation at V_2G_3 combination and, to have genetical variation in between varieties (Table 2).

Pulp pH

The analysis of variance in between the varieties showed significant in respect of pulp pH of mango at different days after storage except initial and 12th day (Table 1). At various days of storage, there noticed an increasing trend of pulp pH with the rising of storage period. In each storage period, pulp pH exposited more in Khirshapat compared with Langra. Higher pulp pH (4.55) was notified from Khirshapat at 3rd day whereas; lower (4.30) was identified from Langra. At 12th day, the highest pH (6.80) was identified with Khirshapat and the lowest value (6.70) was identified with Langra. The growing up trend of pulp pH was also observed by Kumar *et al.* [13] and Shahjahan *et al.*[14]. This phenomenon might be possible due to oxidation of acid during storage resulting in higher pH and also might have genetically dissimilarities between varieties.

Different doses of GA3 solution imposed to this trial demonstrated significant variation in pulp pH at different days after storage .The rising trend of pulp pH was found from different treated and untreated fruits at various days of storage (Figure 2). Pulp pH was higher in control at all stages of storage period followed by the fruits treated with

G_1, G_2 and G_3 treatments. The pH of mango pulp was the highest (7.05) in control whereas the fruits treated with G_3 treatment gave the lowest (6.45) value at 12th day. The results of the present investigation of GA3 solution at G_3 treatment retarded the loss of acid oxidation resulting in lower pH value. These results are in partially supported by the report of Jain and Mukherjee [15].

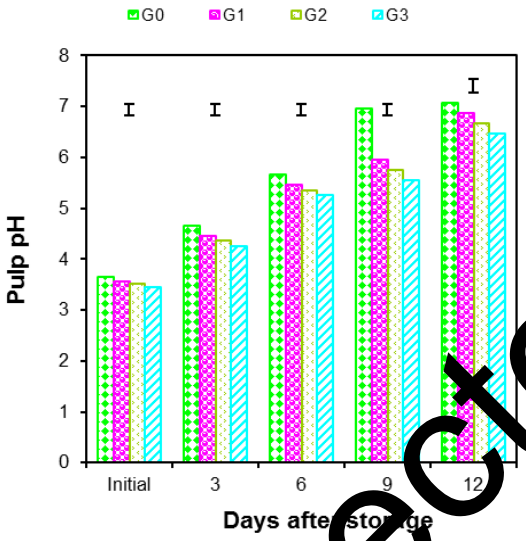

Figure 2. Pulp pH of mango pulp as influenced by different doses of GA3 at different days after storage. Vertical bars represent LSD at 0.05 level

The combined effect of varieties and different doses of GA_3 solution implied to this study in pulp pH were noticed to be non significant at different days after storage. There was the indication of an enhancing trend of pulp pH from various treatment combinations at different days of storage. At 12th day, the highest (7.10) pH value was obtained from the treatment combination of V_2G_0 and the lowest (6.4) was obtained from the treatment of combination of V_1G_3 (Table 2)

Total soluble solid (Brix %) content

Statistically highly significant variation was found in TSS content between two varieties at different days after storage. The results showed that TSS content of mango pulp enlarged continuously with the rising of storage period. The increasing trend was faster from initial to 6th day thereafter; it increased slower. From initial to 6th day, Khirshapat was performed better in TSS accumulation than Langra. But, after 6th day, Langra performed better than Khirshapat up to 12th day. At 9th day, the highest (16.28%) TSS quantity was noticed from Khirshapat and the lowest (16.03%) was noticed from Langra (Table 3).

Different doses of GA_3 solution subjected to the postharvest mangoes in this study were observed to be significant variation in respect of TSS content at different days after storage. At different days of storage, it narrated that TSS accumulation augmented with the expansion of storage duration. The results also illustrated that TSS content was sharply grown up from untreated mangoes from initial to 6th day and then, it fell off significantly (Figure 3). The other treatment such as G_1 also increasingly provided TSS from initial to 9th day and thereafter, it decreased sharply. Mango fruits treated with G_2 also produced more or less similar increasing trend from initial to 12th day. But, the fruits treated with G_3 dose provided very steady rate in TSS accumulation at various days. The highest (19.25, 19.25 and 19.30%) accumulation of TSS was derived from G_0, G_1 and G_2 treatment at 6, 9 and 12th days whereas, the lowest (10.20, 13.00 and 16.00%) was derived from G_3 treatment, respectively. The results of the present study are strongly supported by the findings of Jain and Mukherjee [15]. These happened possibly due to ripening condition

resulting in maximizing TSS gathering in control and 400 ppm of GA3 solution retarded in ethylene synthesis that caused delay ripening and ultimately in lower TSS accumulation. It also explained that TSS gathering is strongly related to ripening and it caused decrease owing to decaying.

Table 3. Changes of total soluble solid and total sugar content of postharvest mango pulp in varieties during storage at ambient condition

Treatments	TSS content (%)at different days					Total sugar content (%) at different days				
Variety (V)	Initial	3	6	9	12	Initial	3	6	9	12
V_1	5.30b	9.28b	13.78b	16.28a	16.35a	5.34b	8.08b	12.80b	16.08b	18.35b
V_2	6.35a	10.33a	14.28a	16.03b	16.05b	5.80a	8.58a	13.28a	16.58a	18.80a
Level of significance	***	***	***	***	***	***	***	***	***	***

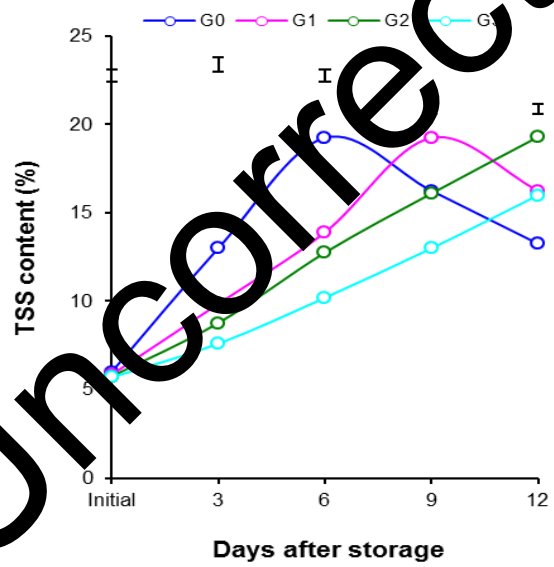

Figure 3. Effect of different doses of GA3 on total soluble solid content of mango pulp at different days after storage. Vertical bars represent LSD at 0.05 level

The combined effect of varieties and imposed different doses of GA_3 solution on TSS content were found to be significant at different days after storage except initial and 3rd day. The result was expounded a rising behavior of TSS content at different days after storage. The highest accumulation (19.50, 19.30 and 19.50) was derived from the treatment combination of V_1G_0, V_1G_1 and V_1G_2 at 6, 9 and 12th days, whereas; the lowest value (10.30, 12.90 and 15.90) was identified from the treatment combination of V_2G_3, respectively (Table 4).

Table 4. Combined effects of varieties and different doses of Gibberellic acid solution on total soluble solid and total sugar content of postharvest mango during storage at ambient condition

Treatments combination	TSS content (%) at different days					Total sugar content (%) at different days				
Varieties × Treatments	Initial	3	6	9	12	Initial	3	6	9	12
V_1G_0	5.50d	12.5b	19.5a	16.5b	13.50f	5.50d	10.2b	18.80b	20.70b	19.80d
V_1G_1	5.30e	9.30d	13.30d	19.30a	16.30c	5.40 d	7.90d	13.20d	18.40d	20.40b
V_1G_2	5.20e	8.20e	12.20e	16.20c	19.50a	5.30de	7.30e	10.30f	13.80f	18.80f
V_1G_3	5.20e	7.10f	10.10g	13.10e	16.10d	5.17e	6.90f	8.90 h	11.40h	14.40h
V_2G_0	6.50a	13.50a	19.00b	16.00d	13.00g	6.00a	10.7a	19.20a	21.20a	20.20c
V_2G_1	6.40ab	10.40c	14.50c	19.20a	16.2cd	5.80b	8.30c	13.60c	18.80c	20.80a
V_2G_2	6.30bc	9.33 d	13.30d	16.00d	19.10b	5.70bc	7.90d	11.90e	14.40e	19.40e
V_2G_3	6.20c	8.10 e	10.30f	12.90f	15.90e	5.68bc	7.40e	9.40g	11.90g	14.80g
Level of significance	NS	NS	***	**	**	NS	NS	NS	NS	NS
CV%	1.82	1.17	0.76	0.49	0.50	2.05	1.27	0.79	0.76	0.57

In a column values having the same letter(s) do not differ significantly as per DMRT at 5% level. V_1 = Langra; V_2 = Khirshapat; *** indicate at 0.1% level; NS means non-significant

Total sugar content

Highly significant variation was noticed between both the varieties means in terms of total sugar content of mango pulp at different days after storage. The results interpreted that TSC accumulated successively with the rising of storage duration. The accumulating trend was more or less sharp from initial to 9th day in both the varieties, thereafter; it grew up slightly slower. At all days of storage Khirshapat contributed more accumulation of of TSC than Langra. At initial day, Khirshapat gave the highest (5.80%) whereas; Langra produced the lowest (5.34%). At 12th day, Khirshapat produced the highest quantity (18.80%) and the lowest (18.35%) was obtained from the Langra (Table 3). Upadhyay and Tripathi [11] reported that total sugar content was augmented gradually, when stored for 6 days at room temperature. These results are in conformity with the findings of Shahjahan *et al.* [14]. Tsuda *et al.* [16] also found the similar results. The increase in TSC might be due to conversion of complex starch or carbohydrate into simple compound like sucrose, Fructose, galactose etc.

Different doses of GA_3 solution implied to the investigation on total sugar content of mango pulp exhibited significant variation at different days after storage (Appendix 3.5). At different days of storage, the results noticed that TSC augmented markedly with the rising of storage period (Figure 4). The developing trend was very fast in untreated mango followed by other treatments *viz.*, G_1, G_2 and G_3, respectively. The highest quantity of TSC (20.95% and 20.60%) was recorded in control and G_1 treated mangoes at 9 and 12th days, whereas; the lowest (11.64% and 14.60%) was recorded at G_3 treatment. The findings of the present investigation are inconformity with the reports of Jain and Mukherjee [15] and Singh *et al*. [17]. The enhancing trend of total sugar at untreated mangoes might be possible due to breaking down of complex carbohydrate into simple compound but, G_3 treatment made delay ripening at storage period resulting in lower conversion of complex compound into simple molecules.

The combined effect of varieties and used different doses of GA_3 solution in this study in relation to total sugar content of mango pulp showed non-significant variation at different days after storage. These results noted that total sugar content accumulated successively with the rising of storage period. At 12th day the maximum (20.80 %) quantity of TSC was achieved from the treatment combination of V_2G_1 whereas, the minimum (14.40 %) was achieved from the treatment combination of V_1G_3 (Table 4).

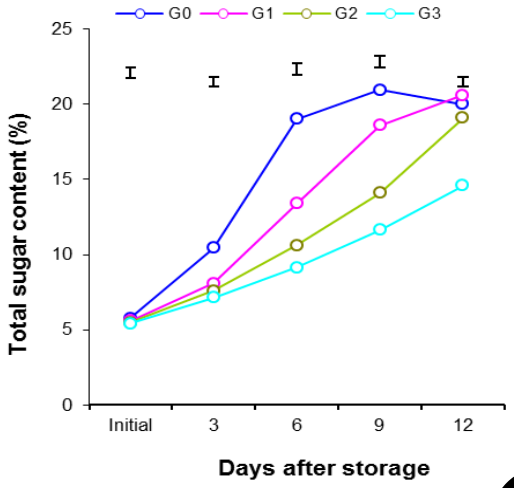

Figure 4. Effect of different doses of GA3 on total sugar content of mango pulp at different days after storage. Vertical bars represent LSD at 0.05 level

Table 5. Changes of reducing and non reducing sugar content of postharvest mango pulp between varieties and influenced by different doses of Gibberellic acid solution during storage at ambient condition

Treatments	Reducing sugar content (%) at different days					Non-reducing sugar content (%) at different days				
Variety (V)	Initial	3	6	9	12	Initial	3	6	9	12
V_1	1.29b	1.96 b	3.82	4.81 b	4.86 b	4.03 b	6.11b	9.29 b	11.26 b	13.46 b
V_2	1.66 a	2.35 a	3.83	5.13 a	5.18 a	4.13 a	6.23 a	9.43 a	11.48 a	13.63 a
Level of significance	***	***	NS	***	***	*	*	**	***	**
Treatments (G)										
G_0	1.55	3.05 a	6.05 a	6.25 a	4.75 c	4.20 a	7.40 a	12.90 a	14.70 a	15.20 a
G_1	1.48	2.03 b	4.14 b	5.98 b	6.18 a	4.10 ab	6.08 b	9.93 b	12.63 b	14.43 b
G_2	1.43	1.83 c	2.88 c	4.38 c	5.38 b	4.05 b	5.78 c	7.73 c	9.73 c	13.73 c
G_3	1.45	1.73 c	2.23 d	3.28 d	3.78 d	3.98 b	5.43 d	6.88 d	8.43 d	10.82 d
Level of significance	NS	***	***	***	***	*	***	***	***	***

In a column values having the same letter(s) do not differ significantly as per DMRT at 5% level. V_1 = Langra; V_2 = Khirshapat; *** indicate at 0.1% level; NS means non-significant

Reducing sugar content

Analysis of variance demonstrated significant variation on reducing sugar content of mango pulp at different days after storage except at 6th day. There was noticed an enhancing trend of reducing sugar with the expanding of storage period (Table 5). It also stated that Khirshapat was better in achieving of reducing sugar than Langra at different days of storage. The highest (5.18%) quantity of this sugar was notified from Khirshapat whereas; the lowest (4.86%) was notified from Langra at 12th days of storage. These results are in agreement with the report of Upadhyay and Tripathi [11]. Castrillo *et al.,* [18] elucidated that reducing sugar was increased during storage

period. Khirshapat producing comparatively more reducing sugar might be possibly due to genetical variation in both the varieties.

Different doses of GA_3 solution applied to this study were found to be significant in respect of reducing sugar content of mango pulp at different storage period except initial day. The results narrated that reducing sugar of mango pulp was grown up continuously at different days after storage. It also revealed that untreated mangoes were performed better in accumulating of reducing sugar as compared to the other treatments. Control treatment was recorded as more successive producer of reducing sugar up to 9^{th} day and then, it fell off due to starting spoilage. At 12^{th} day, the maximum (6.18%) amount of reducing sugar was recorded at G_1 and the lowest (3.78%) was recorded at G_3 treatment (Table 5). The results of the present investigation are in conformity with the findings of Jain and Mukherjee [15]. Lower changing trend of reducing sugar content treated with G_3 treatment might be possibly due to delay ripening which resulted in lower conversion of carbohydrates into simple's molecules.

The combined effect of varieties and used different doses of GA_3 solution of mango pulp exhibited non significant variation in terms of reducing sugar content of mango pulp at different days after storage except 6^{th} day. The results elucidated that reducing sugar content augmented continuously at three days interval up to 9^{th} day thereafter, it abated from the treatment combination of V_2G_0. At 12^{th} day, the highest (6.35%) quantity was obtained from the treatment combination of V_2G_2 and the lowest (3.7%) was obtained from V_1G_3 (Table 6).

Non reducing sugar content

The variation between the varieties means exhibited highly significant in respect of non-reducing sugar content at different days after storage. There appeared an enlarging trend of non reducing sugar content at different days of storage. At all days, it was noticed that the Khirshapat was much better than Langra in achieving of non reducing sugar content (Table 5). At 12^{th} day, higher (13.63%) amount of non reducing sugar was recorded from the Khirshapat and the lowest (13.46%) amount was recorded from the Langra. The results of the present investigation are partially supported by the reports of Islam [22]. The result obtained from the investigation might be possible due to varietals dissimilarities.

Different doses of GA_3 solution subjected to this trial produced the significant variation in respect of non reducing sugar content of mango pulp at different days. The results stated that non reducing sugar content of mango pulp grew up markedly at various days. It also mentioned that untreated fruits were notified better in accumulation of more quantity of non reducing sugar followed by other treatments. This growing up trend was continued up to 9^{th} day and then, it fell off owing to becoming hackneyed. Lower rising trend was noted from the fruit treated with G_3 treatment. The highest result (15.23%) was obtained from control and the lowest value (10.82%) was obtained from G_3 treatment (Table 5). These events might be probably due to G_3 treatment resisted ethylene synthesis of mango pulp resulted in delay ripening and little amount of non reducing sugar deposition. These results are in partially agreement with the reports of Kumlert [12].

The combined effect of varieties and used different doses of GA_3 solution showed not significant variation in terms of non reducing sugar content of mango pulp at different days after storage. There was exposition that a hastening trend of non reducing sugar was notified from different treatment combinations at various days of storage. At 9^{th} day, the highest (14.80%) quantity of non reducing sugar was derived from the treatment combination of V_2G_0 whereas; the lowest (8.20%) was derived from the treatment combination of V_1G_3 (Table 6).

Table 6. Combined effects of varieties and different doses of Gibberellic acid solution on reducing and non reducing sugar content of postharvest mango pulp during storage at ambient condition

Treatments combination	Reducing sugar content (%) at different days					Non-reducing sugar content (%) at different days				
Varieties × Treatments	Initial	3	6	9	12	Initial	3	6	9	12
V_1G_0	1.40 b	2.90 b	5.90 a	6.10b	4.60f	4.10ab	7.30 b	12.80b	14.60b	15.10b
V_1G_1	1.30bc	1.80ef	4.63 b	5.80c	6.00b	4.05 b	6.10 c	9.90 c	12.60c	14.40c
V_1G_2	1.25bc	1.65fg	2.65de	4.15e	5.15d	4.00 b	5.65 e	7.65 d	9.65 d	13.65d
V_1G_3	1.20 c	1.50 g	2.10 e	3.20f	3.70g	3.97 b	5.40 f	6.80 e	8.20 f	10.70f
V_2G_0	1.70 a	3.20 a	6.20 a	6.40a	4.90e	4.30 a	7.50 a	13.00a	14.80a	15.30a
V_2G_1	1.65 a	2.25 c	3.65 c	6.15b	6.35a	4.15ab	6.05cd	9.95c	12.65c	14.45c
V_2G_2	1.60 a	2.00 d	3.10cd	4.60d	5.60c	4.10ab	5.90 d	7.80 d	9.80 d	13.80d
V_2G_3	1.69 a	1.95de	2.35de	3.35f	3.85g	3.98 b	5.45 e	6.9 e	8.65 e	10.95e
Level of significance	NS	NS	*	NS	NS	NS	NS	NS	*	NS
CV%	7.20	4.80	11.14	2.13	2.11	2.63	1.72	1.13	0.93	0.78

In a column values having the same letter(s) do not differ significantly as per DMRT at 5% level. V_1 = Langra; V_2 = Khirshapat; *** indicate at 0.1% level; NS means non-significant

Conclusion

Different doses of GA_3 solution imposed to this investigation in terms of titratable acidity showed significant variation among the means at various days of storage. There appeared a slightly rising trend of pulp pH from various treatment combinations at different days of storage. At different days of storage, the results showed that TSS accumulation increased with the increase of storage duration. The combined effect of varieties and different doses of GA_3 solution exhibited non-significant in terms of non-reducing sugar content of mango pulp at different days after storage.

References

1. Narayana, C. K., Pal, R. K. & Roy, S. K. (1996). Effect of pre-storage treatments and temperature regimes on shelf-life and respiratory behaviour of ripe Baneshan mango. *Journal Food Science Technology* 33: 79 – 82
2. Carrillo, L. A., Ramirez-Bustamante, F. Valdez-Torres, J. B. Rojas-Villegas, R. & Yahia, E. M. (2000). Ripening and quality changes in mango fruit as affected by coating with an edible film. *Journal Food Quality* 23: 479 – 486.
3. Gomer-Lim, M. A. (1997). Post harvest physiology. In: The Mango: Botany, Production and Uses. (Es.): R.E. Litz. , CAB International, New York. pp. 425-446
4. Herianus, J. D. Singh, L. Z. & Tan, S. C. (2003). Aroma volatiles production during fruit ripening of Kensington Pride Mango. *Postharvest Biology Technology* 27: 323 – 336.
5. Hoa, T. T., Duamp, M. N. Lebrun, M. & Baldwin, E. A. (2002). Effect of different coating treatments on the quality of Mango fruit. *Journal Food Quality* 25: 471 – 486.
6. Bender, R. J., Brecht, J. K. Baldwin, E. A. & Malundo, T. M. M. (2000). Aroma volatiles of maturegreen and tree ripe 'Tommy Atkins' mangoes after controlled atmosphere vs air storage. *Horticultural Science* 35: 684 – 686.
7. Gonzalez-Aguilar, G., Zacarias, L. Mulas, M. & Lafuente, M. T. (1997). Temperature and duration of water dips influence chilling injury, decay and polyamine content in Fortune mandarins. *Postharvest Biology Technology* 12: 61 – 69.
8. Parmar, P. B. and Chundawat, B. S. (1989). Effect of various post-harvest treatments on the physiology of Kesar Mango. *Acta Horticultural* (ISHS), 231: 679 – 684.

9. Khader, S. E. S. A. (1992). Effect of Gibberellic acid and vapor guard on ripening, amylase and peroxidase activities and quality of mango fruits during storage. *Journal of Horticultural Science & Biotechnology* 67(6): 855 – 860.
10. Singh A. K., Singh, C. P. Kushwaha, P. S. & Chakraborty, B. (2012). Efficacy of post-harvest treatments on fruit marketability and physico-chemical characteristics of dashehari mango. *Progressive Horticulture* 44: 215-219.
11. Upadhyay, N. P., & Tripathi, B. M. (1985). Postharvest changes during storage and ripening of Gaurjeet mango (*Mangifera indica* L.) fruits. *Progressive Horticultural* 17(1): 25-27.
12. Khumlert, R. (1992). Effect of gibberellic acid (GA3) on some physico-chemical characteristics of 'Kheaw' and 'Sawoey' mango fruit. *Collage Laguna*, Philippines, p. 95.
13. Kumar, P., & Singh, S. (1993). Effect of GA3 and Ethrel on ripening and quality of mango cv. Amrapali. *Horticultural. Journal* 6(1): 19 – 23.
14. Shahjahan, M. S., Sheel, M. A., Zaman, M. A. and Sakur, M. A. (1994). Optimization of harvesting maturities for major mango cultivars in Bangladesh. *Bangladesh Journal Science Research* 1(22): 209 – 215.
15. Jain, S. K. & Mukherjee, S. (2001). Postharvest application of GA3 to delay ripening in mango (*Mangifera indica* L.) cv. Langra. *Journal of Eco-physiology.* 4(12): 27 – 30.
16. Tsuda, T., Chachin, K. & Ueda, Y. (1999). Studies on keeping quality of imported 'Carabao' mango fruit from the Philippines. *Journal Japan Society. Horticultural Science* 68(3): 669 – 674.
17. Singh, S., Kumar, P. Brahmachari, V. S. & Singh, D. M. (1995). Effect of post harvest spray of GA_3 and Ethrel on storage life of mango cv. Amrapali. Orissa *Journal Horticultural* 23(1/2): 112 – 118.
18. Castrillo, M., Kruger, N. J. & Whatley, F. R. (1992). Sucrose metabolism in mango during mango ripening. *Plant Science* 84(1): 45 – 51.
19. Ranganna, S. (1979). Manual of analysis of fruits and vegetable products. Tata McGraw Hill Pub. Co. Ltd., New Delhi, p. 634
20. Jayaraman, J. (1981). Laboratory Manual in Biochemistry (Ist ed.). Wiley Eastern Ltd. New Delhi, India.
21. Miller, G.L. (1972). Use of Dinitro Salicylic acid reagent for determination of reducing sugar. *Analytcal Chem*istry, 31: 426-428
22. Islam, M. K. (2013). Behavioral Pattern of Physiochemical Constituents of the Postharvest Mango (*Mangifera indica* L.) Influenced by Storage Stimuli**.** *Pakistan Journal Biology Sci*ence 16 (24):1985 – 1990.