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Research Article

Chemical Changes in Mango (CV.Fazli) as Affected by Fruit Maturity and Condition of Ripening

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Abstract

An experiment was carried out at the Department of Horticulture and Department of Biochemistry of Bangladesh Agricultural University, Mymensingh. The objectives of the experiment were to evaluate the pattern of chemical changes associated with ripening and the numbers of days required for full ripening of mango (CV.Fazli) harvested at three maturity stages and preserved under different ripening conditions, viz; control, spread over brown paper, bamboo basket covering with straw, spread on straw and calcium carbide. The fruits were assessed for chemical changes during ripening. Some of the chemical properties such as sugar content (reducing, non-reducing and total), total soluble solid and pH of pulp increased while titratable acidity and vitamin C (ascorbic acid) content decreased with the increase in the duration of ripening. In respect of all chemical parameters, mature fruits kept in bamboo basket covering with straw showed best performance whereas CaC_2 treated fruits showed poorer performance though good colours were developed. The ripening conditions maturity stages showed significant variations in relation to days required for full ripening. Among the treated and untreated mature mango fruits, bamboo basket covering with straw and spread on straw exhibited better ripening performance. Over- mature mango kept in bamboo basket covering with straw required the lowest days for full ripening but at 9th day of ripening some fruits were not in edible conditions whereas mature fruits kept in the same conditions were in edible conditions.

Keywords

Reducing Sugar, Non-Reducing Sugar, Ascorbic Acid, Fruit Pulp, Total Sugar Content

1. Introduction

Mango *(Mangifera indica*) belongs to the family Anacardiaceae, is one of the most popular fruits in Bangladesh. Mango is now a commercial crop in many countries of South-East Asia viz. India, Pakistan, the Philippines, Indonesia, Malaysia, Burma, Srilanka and Bangladesh. It also ranks third among the tropical fruits grown in the world with a total production of 23.87 million tons [1]. Nutritionally mango is very rich because it contains appreciable quality of vitamin A, vitamin C, soluble sugars and minerals which are readily available and easily assumable in human body [2]. Losses in terms quality and quantity of fruits occur all stages in the postharvest system from harvesting to consumption. Approximately 30-50% go waste during postharvest handling, ripening and storage [3]. Among the fruits, mango manifested high postharvest losses because of its high perishability and climatic pattern of respiration. Quality of mango and its

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postharvest losses depends largely upon maturity of harvested crop. Ripening treatment is another important factor which influences quality of fruits for marketing and consumption. During the process of transportation and marketing, the sellers go for different treatment for ripening of which-keeping fruits in closed room, inside straw on floor, inside straw in basket and use of chemicals for early ripening. All these treatments affect quality and test of the fruit. Hence the chemical changes during ripening of mango need to be studied extensively for the development of proper ripening conditions. In Bangladesh several authors [4-7] studied the postharvest losses and chemical changes during ripening of mango, but such studies were not enough to explain situation. Therefore, the present study was undertaken to study the chemical changes during ripening of the aforesaid mango variety.

2. Materials and Methods

The experiment was conducted at the Laboratories of the Departments of Horticulture and Biochemistry of Bangladesh Agricultural University, Mymensingh. The experimental methods were premature, mature and over mature fruits of the mango variety namely Fazli which were collected from Fruit Research Centre, Binudpur, Rajshahi. A total of 5 unblemished, physically similar fruits of approximately more or less uniform in size, shape and color were placed under each treatment. Sixty fruits of each maturity stage and one hundred eighty fruits in total were included for the study. The skin of fruit was cleaned with the help of a cloth just before placement under ripening conditions. Three maturity stages were; (1) Premature (S_1), (2) Mature (S_2), (3) Over mature (S_3). The ripening conditions were 1. Control (T_0), 2. Bamboo basket covering with straw (T_1), 3. Spread on straw (T_2), 4. Calcium carbide (CaC_2 @ 10 gm/ 2kg of mango) (T_3). The experiment was laid out in the completely randomized design with three Replication. Fruits from each replication were randomly collected at 3rd, 6th and 9th days of ripening for chemical analysis. The chemical parameters (Vitamin C, Titratable acidity, Total soluble solid, Reducing sugar, Non-reducing sugar, Total sugar) were estimated by the methods cited in the Manual of Analysis of Fruit and Vegetable products [8]. The collected data were statistically analyzed by analysis of variance methods. The mean of different parameters was composed by LSD.

3. Results and Discussions

Different chemical changes that observed in the present study are presented and discussed under the following sub-leading.

3.1. Sugar (Reducing, Non-Reducing and Total) Content

Highly significant variation was observed in respect of reducing, non-reducing and total sugar content among three maturity stages during ripening period (Table 1). The reducing sugar contents were in increasing during ripening period in all the maturity stages of fruits (Table 1). Various ripening conditions in relation to reducing sugar content were statistically non-significant at 3rd and 9th days of ripening, but was highly significant at 6th day of ripening. At 6th day of ripening, the highest and lowest reducing sugar contents were found in control and bamboo basket covering with straw fruits. The variation among the maturity stages was highly significant in terms of non reducing sugar content at 3rd, 6th and 9th days of ripening and it was noticed non reducing sugar content increased over a period of ripening in three maturity stages (Table 1). At 3rd and 6th days of ripening the highest non reducing sugar content was found in control fruits. Variations in total sugar contents were found to be significant among three maturity stages at 3rd, 6th, and 9th days of ripening. It was also observed the total sugar content in over mature fruits was always higher than in fruits of other two maturity stages. At all the ripening intervals, the total sugar content was higher in bamboo basket covering with straw fruits than other treatments and the lower total sugar content was recorded in CaC_2 treated fruits (Table 2). The combined effect of maturity stages and ripening conditions on reducing, non-reducing and total sugar of mango were found highly significant during ripening period (Table 3). An increasing trend of sugar was found in the fruits of three maturity stages, in all ripening conditions which agrees with the findings of *Tsuda et al* [9]. This increase may be attributed to the metabolic transformation in soluble compounds and more conversion of starch into sugars.

3.2. Total Soluble Solids (%Brix)

Difference among the three-maturity stage in terms of total soluble content was found to be statistically highly significant. Percent total soluble content increased with ripening duration. The mango of over mature stage had higher TSS content then those of maturity stages throughout the ripening period (Table 4). The different ripening treatments used in the present investigation showed statistically significant effects in relation to percent total soluble solids (TSS) at 6th and 9th days of ripening. At 6th day of ripening the highest TSS was found in fruits of bamboo basket covering with straw fruit followed by those spread on straw, control, CaC_2 treated fruits respectively (Table 5). Calcium carbide releases acetylene which results in poor flavor and fruit quality [15]. But use of carbide to ripen fruits is associated with many health hazards and is now banned under Prevention of Food Adulteration (PFA) act. Another widely acceptable method involves the use of ethylene gas; however, lack of infrastructural facilities limited its use [14]. The combined effects of postharvest ripening treatments and the three maturity stages in terms of percent total soluble solids were found to be highly significant at 3rd, 6th and 9th days of ripening. The increase in percent TSS contents found in the present investigation was in partial

agreement with the research findings of *Shahjahan et. al* [10]. This increase in TSS content up to certain period during ripening was possibly due to hydrolysis of Starch into Sugar.

3.3. Vitamin C (Ascorbic Acid) Content

Highly significant variation in vitamin C content was noticed among the three maturity stages of mango up to 9th day of ripening (Table 4). It was also observed that vitamin C content was always higher in premature mango then matures and over-matures mangoes. The ripening conditions adopted in the present study showed highly significant variation in relation to vitamin C content at 3rd and 9th days ripening and at 6th day of ripening condition it was not significant. At 9th day of ripening, vitamin C content was the highest in bamboo basket covering with straw fruits. The combined effects of ripening conditions and maturity stages exhibited highly significant variation at 3rd, 6th and 9th days of ripening. The vitamin C content declined steadily during ripening. This result has got support of Tripathi [11]. The decrease in vitamin C content during ripening period may be due to oxidation of ascorbic acid.

3.4. Titratable Acidity

Variation among the maturity stages of mango in terms of titratable acidity was statistically highly significant during the ripening period up to 9th day of ripening (Table 4). It was observed that premature mangoes always retained higher titratable acidity throughout the ripening period than in mature and over-mature mangoes. The ripening conditions used in the present study in terms of the titratable acidity exhibited highly significant variations at 3rd, 6th and 9th days of ripening. The highest and lowest titratable acidity was observed in bamboo basket covering with straw and control fruits. Marked reduction in titratable acidity content was observed with the advancement of ripening period. The combined effects of maturity stages and ripening conditions on titratable acidity were significant during ripening period. In this study decrease in percent titratable acidity was observed during ripening period which is partially like the result of Rangavalli *et al* [12]. The decrease in titratable acidity may be attributed due to increasing rate of metabolic activities and conversion of different organic compounds into sugars during ripening.

3.5. pH of Fruit Pulp

Highly significant variations in pulp pH were observed among the three maturity stages at 3rd, 6th and 9th days of ripening. An increasing trend of pulp pH was observed in three maturity stages of fruits during ripening. All the ripening conditions exhibited marked influence on pH of mango pulp. The variation among treatment means in terms of pulp pH was highly significant at 3rd, 6th and 9th days of ripening. The higher and lower pulp pH was observed in CaC_2 treated and bamboo basket covering with straw fruits respectively. In the present investigation, increase pulp pH was recorded during ripening and this result is an agreement with the fulfillment of Kumar *et al* [13] & Jakir *et.al* [16]. The increase in pulp pH may be due to continuous fall in acidity during ripening.

Table 1. *Effect of maturity stage on reducing, non-reducing and total sugar content of mango.*

Maturity stage	Reducing sugar content (%)				Non-reducing sugar content (%)				Total sugar content (%)			
	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS
S_1	1.23	1.19	3.28	3.49	1.53	1.95	2.68	3.43	2.76	3.13	5.96	6.91
S_2	1.29	2.47	3.76	4.37	2.06	2.29	3.78	4.12	3.35	4.75	7.54	8.49
S_3	2.00	2.71	3.86	4.50	2.06	2.20	3.82	4.22	4.06	4.91	7.68	8.72
LSD (0.05)	0.119	0.194	0.276	0.385	0.065	0.116	0.099	0.155	0.146	0.141	0.262	0.310
LSD (0.01)	0.162	0.263	0.374	0.522	0.088	0.157	0.135	0.211	0.198	0.191	0.356	0.420

S_1: Pre mature, S_2: Mature, S_3: Over mature

Table 2. *Effect of ripening condition on reducing, non-reducing and total sugar content of mango.*

Ripening condition	Reducing sugar content (%)				Non-reducing sugar content (%)				Total sugar content (%)			
	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS
T_1	1.53	2.14	3.96	4.29	1.89	2.23	3.61	4.20	3.42	4.37	7.57	8.49

Ripening condition	Reducing sugar content (%)				Non-reducing sugar content (%)				Total sugar content (%)			
	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS
T_2	1.52	2.13	3.37	4.07	1.86	2.18	3.51	3.93	3.38	4.32	6.88	8.00
T_3	1.44	2.02	3.55	4.13	1.90	2.18	3.40	3.99	3.34	4.20	6.95	8.13
T_4	1.53	2.18	3.66	4.07	1.88	1.98	3.18	3.56	3.41	4.17	6.83	7.42
LSD (0.05)	--	--	0.318	--	--	0.134	0.115	0.179	--	0.163	0.303	0.358
LSD (0.01)	--	--	0.431	--	--	0.182	0.156	0.243	--	--	0.411	0.484

T_1: Control, T_2: Bamboo basket covering with straw, T_3: Spread on straw, T_4: Calcium Carbide

Table 3. *Combined effect between maturity stage and ripening condition on reducing, non-reducing and total sugar content of mango.*

Maturity stage × ripening condition		Reducing sugar content (%)				Non-reducing sugar content (%)				Total sugar content (%)			
		Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS
S_1	T_1	1.32	1.30	3.21	3.70	1.50	2.05	2.88	3.70	2.82	3.35	6.10	7.40
	T_2	1.24	1.13	3.22	3.65	1.50	1.95	2.78	3.40	2.74	3.08	6.00	7.05
	T_3	1.16	1.17	3.40	3.80	1.55	1.98	2.65	3.45	2.71	3.15	6.05	7.25
	T_4	1.20	1.15	3.30	2.80	1.55	1.80	2.40	3.15	2.75	2.95	5.70	5.95
S_2	T_1	1.30	2.47	4.33	4.45	2.05	2.35	3.92	4.40	3.35	4.82	8.25	8.85
	T_2	1.35	2.50	3.45	4.20	2.00	2.35	3.85	4.15	3.35	4.85	7.30	8.35
	T_3	1.21	2.25	3.49	4.25	2.10	2.40	3.81	4.20	3.31	4.65	7.30	8.45
	T_4	1.28	2.65	3.75	4.58	2.10	2.05	3.55	3.72	3.38	4.70	7.30	8.30
S_3	T_1	1.98	2.66	4.32	4.73	2.12	2.29	4.03	4.50	4.10	4.95	8.35	9.23
	T_2	1.97	2.78	3.45	4.35	2.08	2.25	3.90	4.25	4.05	5.03	7.35	8.60
	T_3	1.95	2.65	3.75	4.35	2.05	2.15	3.75	4.33	4.00	4.80	7.50	8.68
	T_4	2.10	2.75	3.92	4.55	2.00	2.10	3.58	3.80	4.10	4.85	7.50	8.35
LSD (0.05)		0.238	0.388	0.551	0.770	0.131	0.232	0.199	0.311	0.292	0.282	0.525	0.619
LSD (0.01)		0.323	0.526	0.747	1.044	0.177	0.315	0.270	0.421	0.396	0.382	0.711	0.839
CV (%)		9.40	10.87	9.02	11.09	4.22	6.45	3.48	4.70	5.10	3.92	4.42	4.57

S_1: Pre mature, S_2: Mature, S_3: Over mature, T_1: Control, T_2: Bamboo basket covering with straw, T_3: Spread on straw, T_4: Calcium Carbide

Table 4. *Effect of maturity stage on vitamin C content, titratable acidity, pulp pH and total soluble solid (%Brix) of mango.*

Maturity stage	Vitamin C (mg/100 g)				Titratable acidity (%)				Pulp pH				Total soluble solid (% Brix)			
	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS
S1	37.26	32.67	26.63	15.68	3.05	2.42	0.793	0.475	2.60	3.59	4.21	4.53	10.66	10.90	15.12	19.06

Maturity stage	Vitamin C (mg/100 g)				Titratable acidity (%)				Pulp pH				Total soluble solid (% Brix)			
	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS
S_2	33.78	31.20	25.45	14.82	2.49	2.04	0.758	0.412	3.91	4.02	4.46	4.75	11.80	12.36	15.78	20.04
S_3	32.50	29.93	24.17	14.38	2.09	1.94	0.709	0.343	4.04	4.09	4.50	4.75	12.71	13.86	16.28	21.31
LSD (0.05)	2.038	1.302	1.088	0.723	0.084	0.060	0.027	0.008	0.205	0.096	0.175	0.187	0.944	0.801	0.573	1.069
LSD (0.01)	2.762	1.764	1.474	0.980	0.114	0.081	0.036	0.011	0.277	0.130	0.237	--	1.279	1.085	0.777	1.449

S_1: Pre mature, S_2: Mature, S_3: Over mature

Table 5. *Effect of ripening condition on vitamin c content, titratable acidity, and total soluble solid (%Brix) and pulp pH of mango.*

Ripening condition	Vitamin C (mg/100 g)				Titratable acidity (%)				Pulp pH				Total soluble solid (% Brix)			
	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS
T_1	34.43	31.76	25.70	13.76	2.53	2.12	0.762	0.363	3.51	3.94	4.42	4.80	11.57	12.40	15.53	20.09
T_2	34.65	32.27	26.13	16.67	2.53	2.06	0.709	0.453	3.54	3.75	4.08	4.39	11.85	12.86	16.62	21.28
T_3	34.61	31.43	25.48	15.67	2.57	2.12	0.757	0.437	3.52	3.90	4.53	4.80	11.67	12.67	15.56	20.36
T_4	34.37	29.61	24.35	13.74	2.53	2.23	0.786	0.387	3.50	4.01	4.53	4.72	11.82	11.57	15.19	18.82
LSD (0.05)	--	1.503	1.256	0.835	--	0.069	0.031	0.010	--	0.111	0.202	0.215	--	0.925	0.662	1.235
LSD (0.01)	--	2.037	--	1.132	--	0.093	0.042	0.013	--	0.150	0.273	0.292	--	--	0.897	1.673

T_1: Control, T_2: Bamboo basket covering with straw, T_3: Spread on straw, T_4: Calcium Carbide

Table 6. *Combined effect between maturity stage and ripening condition on vitamin c content, titratable acidity, pulp pH and total soluble solid (%Brix) of mango.*

Maturity stage × ripening condition		Vitamin C (mg/100 g)				Titratable acidity (%)				Pulp pH				Total soluble solid (% Brix)			
		Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS
S_1	T_1	37.50	32.92	25.85	15.12	3.05	2.45	0.810	0.420	2.59	3.54	4.10	4.70	10.55	11.30	14.47	18.63
	T_2	37.80	34.23	27.02	16.32	3.00	2.40	0.753	0.510	2.71	3.38	4.03	4.33	10.95	11.38	15.80	19.87
	T_3	36.95	33.05	26.85	16.73	3.10	2.35	0.800	0.520	2.56	3.65	4.45	4.75	10.35	10.22	15.38	20.17
	T_4	36.80	30.48	26.82	14.55	3.05	2.50	0.807	0.450	2.53	3.78	4.25	4.35	10.80	10.72	14.83	17.58
S_2	T_1	33.55	32.10	26.15	13.90	2.45	2.00	0.787	0.370	3.95	4.08	4.60	4.85	11.85	12.20	15.68	20.10
	T_2	34.15	31.96	26.24	16.25	2.55	2.01	0.710	0.490	3.85	3.85	4.10	4.43	11.65	12.90	16.85	21.53
	T_3	33.95	31.15	25.30	15.35	2.50	2.02	0.780	0.390	3.91	4.05	4.55	4.85	11.95	13.00	15.05	19.50
	T_4	33.45	29.58	24.10	13.78	2.45	2.11	0.757	0.400	3.94	4.10	4.60	4.85	11.75	11.35	15.53	19.02

Maturity stage × ripening condition		Vitamin C (mg/100 g)				Titratable acidity (%)				Pulp pH				Total soluble solid (% Brix)			
		Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS	Initial	3 DAS	6 DAS	9 DAS
S_3	T_1	32.25	30.25	25.10	12.27	2.10	1.90	0.690	0.300	4.00	4.18	4.55	4.85	12.30	13.70	16.45	21.55
	T_2	32.00	30.63	25.14	17.43	2.05	1.78	0.663	0.360	4.05	4.02	4.12	4.42	12.95	14.30	17.20	22.43
	T_3	32.92	30.10	24.30	14.93	2.10	2.00	0.690	0.400	4.10	4.00	4.60	4.80	12.70	14.80	16.25	21.40
	T_4	32.85	28.75	22.12	12.90	2.10	2.07	0.793	0.310	4.02	4.15	4.75	4.95	12.90	12.63	15.22	19.87
LSD (0.05)		4.077	2.603	2.175	1.447	0.169	0.119	0.053	0.023	0.409	0.192	0.349	0.373	1.888	1.601	1.47	2.139
LSD (0.01)		5.52	3.528	2.948	1.961	0.228	0.162	0.072	0.017	0.555	0.260	0.474	0.506	2.558	2.170	1.554	2.899
CV (%)		7.01	4.94	5.08	5.74	3.93	3.18	4.35	4.56	6.91	2.94	4.71	4.74	9.55	7.68	4.33	6.30

S_1: Pre mature, S_2: Mature, S_3: Over mature, T_1: Control, T_2: Bamboo basket covering, T_3: Spread on straw with straw, T_4: Calcium Carbide

4. Conclusions

The present experiment was carried out in the laboratories of the Department of Horticulture and the Department of Biochemistry, Bangladesh Agricultural University, Mymensingh to find out the technically sound and economically viable techniques for ripening of mango. The experiment was designed to evaluate the pattern of chemical changes of different maturity stages of mango variety Fazli during storage under different ripening conditions.

Chemical analyses of the mango pulp were performed to determine the titratable acidity, vitamin C content, reducing, non-reducing and total sugar contents, total soluble solids and pH of pulp. Mango fruits of each maturity stage and ripening conditions were used at 3rd, 6th and 9th days of ripening for chemical analysis.

From the findings of the present investigation and foregoing discussion, it may be concluded that mature mango gave the best taste and flavor after full ripening. Though over-mature mango required shortest (6.18 days) days to full ripening compared to the mature mangoes (7.26 days) and they did not develop good taste.

Abbreviations

CV: Cultivated variety
LSD: Least significant difference
DAS: Day after storage

Conflicts of Interest

The authors declare no conflicts of interest.

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