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QUALITY CHANGES IN CHILI PLUMS (*Spondias purpurea* L.) DURING STORAGE

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ABSTRACT

Chili plums (*Spondias purpurea* L.) harvested and classified as immature (M1), mature green (M2) and slightly turning or breaker (M3) were stored at 4-5°C, 9-10°C, 20-21°C and 30-31°C and evaluated for changes in total soluble solids (TSS), total titratable acidity (TTA), pH, sugar-acid-ratio (TSS/TTA ratio), total sugars, reducing sugars, vitamin C, marketable fruits and decay over 15 days. Sensory evaluation was also done on stored samples. In addition fruits stored for 15 days at 4-5°C and 9-10°C were transferred to 20-21°C for 1 day to assess the development of chilling injury symptoms. Decay due to a fruit rot fungi of the *Phoma* spp terminated the shelf-life of fruit at all three stages of maturity after 8 days at 20-21°C. However, at 30-31°C shelf-life was only six days. M2 and M3 fruit at 20-21°C and 30-31°C had lower TTA and higher TSS, pH, vitamin C, sugar-acid-ratios and total and reducing sugar contents compared to fruit stored at 4-5°C and 9-10°C.

Pitting and shrivelling among M1 fruit rated as moderate and slight after 1 day at 4-5°C and 9-10°C respectively, accelerated to very severe after 7 days. M2 fruit at 4-5°C which appeared marketable during continuous storage for 15 days showed visible symptoms of severe chilling injury upon transfer to the warmer temperature while similar fruit stored at 9-10°C did not. M3 fruit at 4-5°C showed no chilling symptoms but were unmarketable after 11 days due to rapid softening. It was concluded that chili plums harvested at the M2 stage of maturity maintained the best quality when stored at 9-10°C in view of the absence of decay, severe chilling injury and shrivelling as well as the highly acceptable sensory evaluation scores after 15 days of storage.

INTRODUCTION

The Chili plum (*Spondias purpurea* L)is a common fruit grown in the Caribbean and Central and South America where it is also known as 'Lapa', Job, Moyo, Sta Roseno, 'Jismoyo' and De Cocer (Barbeau,1994). It is a member of the Anacardiaceae family and attains a height of 3 - 10 meters. The tree has a grayish, smooth bark with leaves which are 2.5 - 6.5 cm long with 5 -23 leaflets. Fruiting usually occurs between the months of September to November (Adams,1972). The fruit is a smooth and shiny ellipsoid drupe that measures 2.5 to 4cm in length and 1.5 - 2.5 cm in diameter and ripens rapidly (2-3 days) from the mature-green stage (Barbeau,1994). Immature green fruit are made into pickled and candied products while the mature and ripened fruit are eaten fresh (Barbeau,1994).

While studies have been reported on freshly harvested chili plums pertaining to total soluble solids and total titratable acid contents (Pilgrim,1994) there are no data on other major compositional changes of the chili plums during storage. This study investigated quality changes in chili plums during storage at refrigerated and non refrigerated temperatures.

MATERIALS AND METHODS

Fresh chili plums were hand-harvested and graded into immature (M1), mature green (M2) and slightly turning or breaker (M3) according to size, colour and apparent maturity. The fruits were placed in single-ply cardboard boxes and transported to the laboratory in the Department of Food Production at the University of the West Indies, St.Augustine within three (3) hours of harvest. Fruit were dipped for 2 minutes in 200 ppm sodium hypochlorite solution (72ml commercial bleach, Chlorox, in 18.9 litres of water) at 20 - 21°C and air dried on tissue paper with an oscillating fan for 20 minutes. After a second sorting only blemish-free fruits at the 3 maturity stages M1, M2 and M3 and were stored at 4 - 5°C (T1), 9 - 10°C (T2), 20 - 21°C (T3) and 30 - 31°C (T4).

Chemical analyses were conducted at harvest (day 0) and every 5 days up to 15 days. Each treatment was replicated three times with each replicate consisting of 25 fruits. Data were taken for the following parameters:- total soluble solids(TSS), total titratable acidity(TTA), pH, ascorbic acid content (Vit.C), sugar-acid-ratio, total and reducing sugars, taste evaluation, chilling injury, percentage marketable fruit and incidences of decay.

Decay was rated on each fruit using the following scale 1=no decay, 2=slight, 3=moderate, 4=severe and 5=complete breakdown. Percentage decayed fruits was obtained by calculating the number of fruits with the rating above. Marketable quality was rated as 1=very poor quality, 2=poor quality, 3=moderate quality (marketability limit), 4=good quality and 5=excellent. pH was determined with an Orion Research digital pH meter Expandable Ion Analyser EA 920 (Boston, MA) which was first standardized with two buffer solutions of pH 7.41 and 4.01.

Total soluble solids (TSS) were determined by the use of a hand-held Leica refractometer (model #10431) with a measuring range of 0-50°Brix. Total titratable acidity (TTA) was determined on a sample extract (25g of the edible portion of the fruit macerated in 100ml of distilled water by a Osterizer 8-speed blender for 1 minute). The acidity was measured by titration with phenolphthalein as an indicator, using standard 0.1M NaOH and expressed as mg citric acid $100g^{-1}$ fresh weight(A.O.A.C.,1975).

Ascorbic acid was determined by using a 100ml sample of plum extract plus 1ml of 10% potassium iodide and 2ml sulphuric acid with 0.01 N Iodate. The ascorbic acid equivalent of the iodate was calculated and expressed as mg. $100g^{-1}$ fresh weight (Kefford, 1957).

Total sugars was determined on a 100ml sample of plum extract plus 5mls of 54% HCl, which was then neutralized with 25% NaOH. Two mls of a mixture of sodium potassium tartrate and 3,5, di-nitro-salicylic acid (150g in 250mls distilled water and 5g in 100mls 2N NaOH respectively) were then added to the neutralized mixture. The absorbance reading was taken at 540 nm on a Perkin-Elmer Lambda 3B UV/VIS spectrophotometer (model #C618-0437) (Miller, 1959).

Reducing sugars was determined using a 100ml sample of plum extract plus 2mls of a mixture of sodium potassium tartrate and 3, 5, di-nitro-salicylic acid (150g in 250mls distilled water and 5g in 100mls 2N NaOH respectively). The absorbance reading was taken at 540mm on a Perkin-Elmer Lambda 3B UV/VIS Spectrophotometer (model #C618-0437) (Miller, 1959).
Sugar to acid ratio (TSS/TTA ratio) was determined by dividing the total soluble solids (TSS) values of the plum samples by their respective total titratable acidity values (Ranganna, 1986).

Comparative sensory evaluations of flavour and taste were performed using a 20 member semi-trained panel. Panelists used a hedonic scale of 1-5 with 1 representing unacceptability and 5 extremely acceptable according to Ranganna, (1986).
Chilling injury (CI) based on external damage was scored on each fruit using a subjective scale: 1= no damage, 2= slight damage, 3= medium damage, 4= severe damage, 5= very severe damage. The CI index was calculated according to the formula used by Pesis *et al.*,(1994).

$$\text{CI Index} = \sum_{0}^{5} \frac{(\text{injury level}) \times (\text{number of fruits at this level})}{\text{total number of fruits}}$$

This experiment consisted of a completely randomized design with a factorial arrangement of variables. Significance of the data was tested by the F-test. Mean separation was done using the Least Significant Difference (LSD) method.

RESULTS AND DISCUSSION

Percentage Marketable Fruits, Taste, Decay and Chilling Injury.

Percentage marketable fruit declined over time irrespective of storage temperature and stage of maturity (Tables 1-4). M3 fruit accounted for 100% marketable fruits at 4-5°C after 7 days and declined for each additional day to 50% after 11 days (Table 1). Rapid softening and surface discolouration resulted in M3 fruit becoming unmarketable beyond 11 days (Table 1). The absence of chilling injury among M3 fruit during the first 8 days of storage at 4-5°C was responsible for the significantly higher percentage marketable fruits compared to M1 fruit. M2 fruit had higher percentages marketable fruit with lower incidences of chilling injury than M1 fruit (Table 1). M1 fruit after 5 days at 4-5°C showed a progressive decline in percentage marketable fruit which coincided with increasing severity of chilling injury.

At 9-10°C percentage marketable fruit was generally higher at all 3 stages of maturity than fruits stored at 4-5°C (Tables 1 and 2). This was due to less chilling injury damage. Chilling injury for example in M1 fruit at 9-10°C was slight to moderate after 5 days with 86% fruits being marketable whereas at 4-5°C chilling injury was rated as severe and this accounted for only 69% of the fruits being marketable over the same period (Tables 1 and 2). M2 fruit at 4-5°C after 12 days had a chilling injury rating of 4.00 (severe) and this accounted for 59% being marketable whereas at 9-10°C over the same period chilling injury was rated as 2.00 (slight) and 85% were marketable (Tables 1 and 2). M3 fruit at 9-10°C had the least chilling injury indicating that fruits at an advanced stage of maturity exhibited a greater tolerance to low temperature storage.

M3 fruit stored at 20-21°C and 30-31°C did not store as well and had variable ratings for taste when compared to M1 and M2 fruit (Tables 3 and 4). For example M3 fruit at 20-21°C after 6 days accounted for 60% marketable fruits and had a 1.67 (slightly acceptable) taste rating whereas M1 and M2 fruit each had 27% more marketable fruits than M3 but the taste rating for M2 fruit was the highest (2.67-acceptable). The variable ratings for taste among M3 fruit at 20-21°C and 30-31°C (Tables 3 and 4) suggested that maximum eating quality was between day 3 and 4. Beyond this period due to overripening, the initiation of senescence and decay (Table 5) due to a fruit rot fungi of the *Phoma* spp, significant reductions in taste were recorded (Tables 3 and 4).

Total Titratable Acidity (TTA) and pH

The pH values of the freshly harvested chili plum fruits prior to storage were 2.79, 2.96 and 2.98 for M1, M2 and M3 fruit respectively (Table 5). However during storage, the pH values changed significantly ($P<0.001$) due to temperature, maturity and their interactions with time. Table 5 showed that after 5 days at 4-5°C M1 fruit had the lowest pH value while M2 fruit had the highest pH. However fruit stored at 9-10°C, 20-21°C and 30-31°C pH values were higher as fruit maturity advanced from M1 to M2 to M3. Storage of the chili plums for an additional 5 days at 4-5°C and 9-10°C resulted in increases in pH with time and with each successive maturity stage at 4-5°C while at 9-10°C M1 fruit maintained a lower pH value than M2 fruit (Table 5). However after 15 days, while fruits stored at 4-5°C experienced increases in pH values, the opposite occurred among fruits stored at 9-10°C. Also at both 4-5°C and 9-10°C M1 fruit maintained lower pH values than M2 fruit (Table 5). The general trend of increases in the pH of the chili plums with advanced fruit maturity and increased storage duration mentioned above were expected since according to Jackson (1986) mature fruits usually undergo a reduction in their level of acidity with the initiation of ripening. This was confirmed even further on the basis of the total titratable acidity results shown in Table 5. Data in Table 5 revealed that after 5 days at 4-5°C M1 fruit had the highest TTA value and M2 fruit the lowest but at 9-10°C, 20-21°C and 30-31°C TTA of the chili plums decreased with fruit at an advanced stage of maturity. Storage of the chili plums for an additional 5 days at 4-5°C and 9-10°C resulted in decreases in TTA with time except for M2 and M3 fruit at 4-5°C and M1 fruit at 9-10°C. There were also decreases in TTA with advanced fruit maturity at 4-5°C and 9-10°C (Table 5). However after 15 days, while fruits stored at 4-5°C experienced decreases in TTA values, the opposite occurred among M1 fruit stored at 9-10°C. Also at both 4-5°C and 9-10°C M1 fruit maintained higher TTA values than M2 fruit (Table 5).

Table 1. Changes in Percentage Marketable Fruits, Taste and Chilling Injury of Chili Plums Stored at 4-5 °C After 15 Days.

Storage Duration (Days)	Marketable Fruits (%)			Taste Ratiings			Chilling Injury Index		
	M1	M2	M3	M1	M2	M3	M1	M2	M3
1	94op[y]	100q	100q	1.00a	1.33ab	1.33ab	3.00c	2.00b	1.00a
2	891m	100q	100q	1.00a	1.00a	2.00cd	3.00c	2.00b	1.00a
3	83k	100q	100q	1.00a	2.00cd	3.00f	3.00c	2.00b	1.00a
4	77j	98pq	100q	1.00a	2.33de	2.67ef	3.00c	2.00b	1.00a
5	69i	98pq	100q	1.00a	2.33ed	2.67ef	4.00d	2.00b	1.00a
6	61h	95op	100q	1.00a	2.67ef	3.67g	4.00d	2.00b	1.00a
7	53ef	93mo	100q	1.33ab	2.67ef	4.00g	5.00e	2.00b	1.00a
8	47c	87i	95op	133ab	3.00f	3.67g	5.00e	3.00c	1.00a
9	44c	82k	88i	1.00a	3.00f	2.67ef	5.00e	3.00c	2.00b
10	39b	75j	70i	1.00a	3.00f	2.00cd	5.00e	3.00c	2.00b
11	35b	67i	50de	1.00a	2.67ef	2.00cd	5.00e	3.00c	3.00c
12	28a	59gh	ND[x]	1.00a	2.67ef	ND	5.00e	4.00d	ND
13	25a	55fg	ND	1.00a	2.00cd	ND	5.00e	4.00d	ND
14	25a	45c	ND	1.00a	2.00cd	ND	5.00e	4.00d	ND
15	25a	45c	ND	1.00a	1.67bc	ND	5.00e	4.00d	ND
LSD (0.05)		**4.82**			**0.50**			**0.12**	

NDx = no data due to fruit decay. M1-immature M2 - Mature Green M3 - Breaker

Table 2. Changes in Percentage Marketable Fruits, Taste and Chilling Injury of Chili Plums stored at 9-10 °C after 15 Days.

Storage Duration (Days)	Marketable Fruits (%)			Taste Ratiings			Chilling Injury Index		
	M1	M2	M3	M1	M2	M3	M1	M2	M3
1	98kl[y]	1001	1001	1.00a	1.00a	1.00a	2.00b	2.00b	1.00a
2	93j	1001	1001	1.00a	1.00a	3.00de	2.00b	2.00b	1.00a
3	881	1001	1001	1.33ab	1.67bc	3.33ef	2.00b	2.00b	1.00a
4	86hi	99k1	1001	1.33ab	1.67bc	3.33ef	3.00c	2.00b	1.00a
5	86hi	99k1	1001	1.33ab	1.67bc	3.33ef	3.00c	2.00b	1.00a
6	80g	97jkl	1001	1.33ab	2.67d	3.67f	4.00d	2.00b	1.00a
7	75f	97jkl	95jk	1.33ab	2.67d	3.33ef	5.00e	2.00b	2.00b
8	68e	93j	75f	1.00a	3.00de	2.67d	5.00e	2.00b	2.00b
9	65e	86hi	50c	1.00a	3.00de	2.00c	5.00e	2.00b	3.00c
10	58d	85hi	ND[x]	1.00a	3.67f	ND	5.00e	2.00b	ND
11	49bc	85hi	ND	1.00a	3.67f	ND	5.00e	2.00b	ND
12	45b	85hi	ND	1.00a	3.33f	ND	5.00e	2.00b	ND
13	45b	85hi	ND	1.00a	3.00de	ND	5.00e	2.00b	ND
14	45b	83gh	ND	1.00a	3.00de	ND	5.00e	3.00e	ND
15	40a	80g	ND	1.00a	3.00de	ND	5.00e	3.00c	ND
LSD (0.05)		**4.82**			**0.50**			**0.12**	

NDx = no data due to fruit decay. M1-immature M2 - Mature Green M3 - Breaker

Table 3.Changes in Percentage Marketable Fruits and Taste of Chili Plums stored at 20-21 °C after 7 Days

Storage Duration	Marketable Fruits (%)			Taste Ratiings		
	M1	M2	M3	M1	M2	M3
1	100f[y]	100f	100f	1.00a	1.67bc	2.33de
2	100f	100f	100f	1.00a	1.67bc	3.33f
3	100f	100f	94e	1.33ab	2.67e	4.00g
4	100f	100f	87d	2.00cd	3.67fg	4.67h
5	100f	100f	87d	2.33de	4.67l	3.33f
6	87d	87d	60c	2.00cd	2.67e	1.67bc
7	53b	27a	ND[x]	1.33ab	1.67bc	ND
$LSD_{(0.05)}$		4.82			0.50	

ND[x] = no data due to fruit decay. M1-Immature M2- Mature Green M3- Breaker

Table 4. Changes in Percentage Marketable Fruits and Taste of Chili Plums stored at 30-31 °C after 6 Days.

Storage Duration	Marketable Fruits (%)			Taste Ratiings		
	M1	M2	M3	M1	M2	M3
1	100h[y]	100h	100h	1.00a	1.67bc	2.67ef
2	100h	96gh	98gh	1.33ab	2.33de	3.33gh
3	100h	90ef	91ef	1.67bc	2.33de	4.00ij
4	100h	83cd	87de	2.00cd	3.00fg	4.33j
5	93fg	80c	ND[x]	2.00cd	3.67hi	2.33de
6	51b	35a	ND	1.33ab	1.67bc	ND[x]
$LSD_{(0.05)}$		4.82			0.50	

ND[x] = no data due to fruit decay. M1-Immature M2- Mature Green M3- Breaker

Table 5. Changes in pH, total titratable acidity, TSS/TTA ratio and decay of chili plums after 15 days.

Parameters	Days Storage	Temperature (°C) 4 - 5 M1	4 - 5 M2	4 - 5 M3	9 - 10 M1	9 - 10 M2	9 - 10 M3	20 - 21 M1	20 - 21 M2	20 - 21 M3	30 - 31 MI	30 - 31 M2	30 - 31 M3
.pH	5	2.79a[y]	3.16.i	3.09h	2.93e	3.05g	3.23k	2.89b	3.16l	3.29m	2.92d	3.09h	ND[x]
	10	2.89b	3.05g	3.23k	3.09h	3.26e	ND	ND	ND	ND	ND	ND	ND
	15	2.94f	3.17a	ND	2.90c	3.09h	ND	ND	ND	ND	ND	ND	ND
$LSD_{(0.05)}$							0.01						
TTA	5	1.14m	0.73a	0.76b	0.95h	0.87e	0.73a	1.06k	0.78c	0.76b	0.98l	0.82d	ND
	10	1.01j	0.93g	0.90f	0.98.i	0.76b	ND	ND	ND	ND	ND	ND	ND
	15	0.95h	0.76b	ND	1.09c	0.76b	ND	ND	ND	ND	ND	ND	ND
$LSD_{(0.05)}$							0.02						
TSS/ TTA Ratio	5	3.50a	10.90e	11.80e	6.30b	10.30e	18.40h	15.10fg	20.30i	28.20j	13.80f	20.20.i	ND
	10	8.00bc	11.90e	20.60.i	8.17c	14.40fg	ND	ND	ND	ND	ND	ND	ND
	15	8.40cd	10.50e	ND	10.22de	15.74g	ND	ND	ND	ND	ND	ND	ND
$LSD_{(0.05)}$							1.86						
Decay	4	0a	0a	0a	0a	0a	0a	0a	0a	13.33c	0a	20.00d	13.33c
	5	0a	0a	0a	0a	0a	0a	0a	0a	13.33c	6.70b	20.00d	26.70e
	6	0a	0a	0a	0a	0a	0a	13.33c	13.33c	40.00f	53.30h	73.30.i	86.70j
	7	0a	0a	0a	0a	0a	0a	46.70g	73.30i	86.70j		ND	ND
$LSD_{(0.05)}$							1.37						

Table 6. Changes in total sugars, reducing sugars and vitamin C content of chili plums after 15 days

Parameters	Days Storage	Temperature (°C) 4 - 5 M1	4 - 5 M2	4 - 5 M3	9 - 10 M1	9 - 10 M2	9 - 10 M3	20 - 21 M1	20 - 21 M2	20 - 21 M3	30 - 31 MI	30 - 31 M2	30 - 31 M3
Total Sugars	5	2.00b[y]	4.30h	4.91k	3.80f	5.63l	8.63p	8.36o	12.81q	12.89r	6.56m	6.80n	ND[x]
	10	2.06b	3.00d	4.50l	3.33e	4.06g	ND	ND	ND	ND	ND	ND	ND
	15	2.38c	3.38e	ND	1.80a	4.81j	ND	ND	ND	ND	ND	ND	ND
$LSD_{(0.05)}$							0.07						
Reducing Sugars	5	0.95b	2.57l	2.97n	1.24c	2.08j	3.42o	1.88h	2.88m	2.98n	1.56e	2.25k	ND
	10	0.98b	1.51e	2.51l	1.33d	1.66f	ND	ND	ND	ND	ND	ND	ND
	15	1.33d	2.00l	ND	0.70a	1.75g	ND	ND	ND	ND	ND	ND	ND
$LSD_{(0.05)}$							0.07						
Vitamin C	5	9.60b	9.60a	11.20c	9.60b	11.20c	11.20c	11.20c	11.20c	11.20c	9.60b	11.20c	ND
	10	9.60b	11.20c	6.40a	12.80d	14.40e	ND	ND	ND	ND	ND	ND	ND
	15	11.20c	11.20c	ND	11.20c	11.20c	ND	ND	ND	ND	ND	ND	ND
$LSD_{(0.05)}$							0.09						

Sugar-Acid-Ratio

Fruits generally experienced increased sugar-acid-ratio values with advanced fruit maturity throughout storage with the only exception being after 5 days at 4-5°C as M1 fruit had a lower ratio compared to M2 and M3 fruit which showed no significant differences (Table 5). At 4-5°C M1 and M3 fruit recorded higher levels of TSS/TTA ratio between days 5-10. At 9-10°C sugar-acid-ratios increased among M1 and M2 fruit over the same period (Table 5). Increases obtained in sugar-acid-ratio values were due to increases in total soluble solids (Table 7) and simultaneous decreases in the total titratable acidity (Table 5).

Total and Reducing Sugars.

The temperature x maturity interactions at the ($P<0.001$) and ($P<0.05$) levels on total and reducing sugars respectively are shown in Table 6. Table 6 showed that after 5 days in storage total and reducing sugars levels increased with each successive maturity stage among the chili plums stored at 4-5°C, 9-10°C and 20-21°C, while at 30-31°C M2 fruit recorded higher levels of total and reducing than M1 fruit. Storage of the chili plums at 4-5°C and 9-10°C for 10 and 15 days resulted in increases in the levels of total and reducing sugars with advanced fruit maturity. However, after 10 days lower values were recorded in total and reducing sugars among all except M1 fruit stored at 9-10°C which had higher levels (Table 6). It was also observed that fruits stored at 20-21°C had higher total and reducing sugars levels than those stored at 30-31°C after 5 days. There was a general increase in the levels of both total and reducing sugars among the plums during storage with increased maturity throughout the 15 days storage duration. Such increases could possibly be attributed to the breakdown of complex polysaccharides and subsequent conversion into sugars mainly sucrose, fructose and glucose. This is characteristic of ripening and results in significant increases in the level of sugars in fruits (Jackson,1986). Lower levels of total and reducing between 5 and 10 days during storage at 4-5°C and 9-10°C could probably be due to the sugars being utilized for respiratory proeesses. A possible explanation for fruits stored at 30-31°C having lower total and reducing sugars levels than those stored at 20-21°C is that the fruits stored at 30-31°C experienced higher rates of respiration hence there was a greater depletion of sugars from such fruits. Similar findings were reported by Gur,(1986) with plums of the *Prunus* spp. It was reported that at 30°C sugar and acid depletion of the plums was greater when compared to plums stored at 10°C and 25°C.

Vitamin C

The significant ($P<0.05$) interaction of temperature x maturity is shown in Table 6. Storage of the chili plums for 5 days at 4-5°C resulted in M3 fruit recording the highest vitamin C content and M1 fruit the lowest at 9-10°C (Table 6). At 30-31°C M1 fruit had a lower vitamin C content than M2 fruit. However, after 10 days at 4-5°C M2 fruit had the highest vitamin C level and M3 the lowest while at 9-10°C M1 fruit recorded a lower vitamin C level than M2 fruit (Table 6). Increased storage duration from 5 to 10 days at 4-5°C resulted in M2 fruit undergoing an increase in its vitamin C content and M3 fruit a decrease while at 9-10°C fruits recorded increased levels. Between 10 and 15 days, at 4-5°C M1 fruit had increased vitamin C levels while at 9-10°C both M1 and M2 fruit were reduced (Table 6). Based on the data presented in Table 6 it was evident that mature chili plums (M2 and M3) were of a higher nutritional value (in terms of higher vitamin C values) than immature (M1) plums. Shani and Khurdiya,(1989) claimed that a reduction in vitamin C in ripening mangoes occurred simultaneously with increases in pH. This was attributed to the oxidation of the ascorbic acid as it's a reducing agent. They cited the work of Hulme,(1970)in which it was reported that the rate at which the change occurs is largely conditioned by pH. As the pH increased the vitamin C level decreased. Maybe a similar explanation is possible for declines in the vitamin C content of M3 fruit after 10 days at 4-5°C and M2 fruit after 15 days at 9-10°C. Such reductions in both instances were accompanied by increases in pH (Tables 5).

Total Soluble Solids (TSS)

Increases in TSS were obtained with advanced fruit maturity up to 10 days of storage (Table 7a). M1 fruit had increased levels after 5 and 15 days but reduced levels after 10 days. M2 fruit on the other hand had higher TSS after 5 days followed by lower levels thereafter (Table 7a). M3 fruit had the highest TSS levels up to 10 days in

Table 7a. Interaction effects on chili plums after 15 days.

Parameter and Interaction	Storage Period (Days)	M1	M2	M3
TSS	0	5.33a	6.50b	8.00c
	5	9.87d	12.38f	14.67g
Day x Maturity	10	8.00c	11.00e	18.50b
	15	9.50d	10.00d	ND
LSD $_{(0.05)}$			0.94	

Table 7b. Interaction effects on chili plums after 15 days.

Parameter and Interaction	Storage Period (Days)	T1	T2	T3	T4
TSS	0	-	-	-	6.61a
	5	7.00ab	9.50c	17.83f	15.00e
Day x Temperature	10	12.50d	9.50c	ND	ND
	15	8.00b	11.50d	ND	ND
LSD (0.05)			1.30		

Table 7c. Interaction effects on chili plums after 15 days.

Parameter and Interaction	Storage Period (Days)	T1	T2	T3	T4
TSS	M1	6.67a	8.33bc	16.00g	9.42cd
Maturity x Temperature	M2	9.00bc	10.67de	16.00g	11.50e
	M3	13.75f	13.50f	21.50h	8.00b
LSD (0.05)			1.30		

T1:- 4-5°C T2:- 9-10°C T3:- 20-21°C T4:- 30-31°C storage. Data in Table 7b showed that after 5 days increases in TSS were experienced across T1, T2 and T3. After 10 days TSS declined with increased storage temperatures but the opposite occurred after 15 days. TSS peaked at 12.50° brix after 10 days at 4-5°C and dropped to 8.00° brix by day 15. At 9-10°C peak levels were attained after 15 days. At 30-31°C increased levels were observed after 5 days (Table 7b). Based on data presented in Table 7c it was evident that TSS increased with increased storage temperature among M1 and M2 fruit except those stored at 30-31°C which recorded lower levels than those at 20-21°C. Among M3 fruit, those stored at 20-21°C had the highest TSS levels and those at 30-31°C the lowest (Table 7c). At 4-5°C and 9-10°C TSS increased with advanced fruit maturity while at 20-21°C M3 fruit had the highest levels. At 30-31°C M3 fruit were responsible for the lowest TSS levels and M2 fruit the highest (Table 7c). Increases in total soluble solids could be attributed to the increases in the total and reducing sugar levels of the chili plums (Table 6), since according to Jackson (1986) most of the soluble solids in fruits are in fact sugars.

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