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Postharvest Handling of Solo Papaya Fruits Harvested at Different Maturity Stages

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Abstract: To facilitate the growth of a commercial Solo papaya fruits (*Carica papaya* L.*)* industry, several problems with harvest and postharvest handling of fruits need to be resolved. The first problem is maturity stage definition. So, papaya fruits were harvested at three maturity stages as follow: 25% yellow, 50% yellow and full yellow evaluated during held at ambient temperature 20°C ± 2 for 4 days and 80- 85% RH or during cold storage at 6°C and 90- 95% RH for 20 days. Papayas fruit softened very rapidly at room temperature after harvest and have 4 days shelf life. However, it can be stored for 20 days at 6°C with little change in fruit firmness and the fruit apparently continue normal ripening upon removal to ambient temperature 20°C for 3 days. Soluble solids content did not alter during ripening at 20°C and remained steady during cold storage duration. Fruit harvested at stage 2 and stored at 6°C for 20 days followed 3 days at 20°C had superior score for sensorial evaluation.

Key words: *Carica papaya* · Maturity · Postharvest · Quality attributes

INTRODUCTION

In Egypt, during the last five years, papaya trees are everywhere and papaya fruit has taken on renewed importance. This importance is due to increase consumer's awareness of health benefits for all parts of this fruit. Papaya contains proteolitic enzyme papain, which extracted from immature fruits therefore valuable for aiding digestion. Papaya seeds used for their effects as antibacterial properties, kidney protection, liver diseases. Papayas are an excellent source of vitamin C as well as a good source of vitamin E and vitamin A (through their concentration of pro-vitamin A carotenoid phytonutrients) [1]. Also, it contains three of very powerful antioxidants. Consequently, there are many uses of ripe papaya fruit such as fresh eating, juice, jam and ice-cream. Papaya fruits have traditionally been harvested from native plants stands for immediate sale and /or consumption. Other than the decline in fruit firmness or in green colour, there are no obvious indicators of fruit maturity. A common practice is to touch each fruit to determine if it is ready to harvest. Thus, fruits are harvested when they have already begun ripening and have lost some firmness. There is a labor intensive may result in slight bruising injury, perhaps lead to off-flavor [2]. Papaya industry is however, experiencing serious problems which holding it back and impacting negatively on the domestic market operation. Supposed to be the main objective of the research issues are keeping quality and postharvest storage life that place constraints on marketing. Quality problems seen in the markets include variable in fruit morphology, mechanical injury, blemishes (freckles), dehydration though not seen, taste as determined sweetness. Many techniques need to be assessed to identify those most applicable to extending papaya storage life while maintaining high fruit quality.

The purpose of the present study was to evaluate maturity indices and storage techniques with the goal of developing a set of recommendation for handling the fruit. The primary problems, through not mutually exclusive, can be categorized maturity and cold storage issues.

MATERIALS AND METHODS

Sound selected papaya fruits (Solo cv) uniform and free from mechanical damage or physiological and pathological disorders were harvested from a private orchard at El-Qssassene area, Ismailia, Governorate placed in three groups according to the maturity stage (Fig. 1) consisted of: 1- 25% yellow, green skin with well-defined

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Table 1: Fruits characteristics of three maturity stages of Solo papaya at harvest in 2008 and 2009 seasons

Attributes	Stage 1	Stage 2	Stage 3	Stage 1	Stage 2	Stage 3
	----------2008----------			----------2009----------		
Weight (g)	711.5	718.9	700.6	688.5	702.3	711.3
Flesh firmness (lb/in^2)	27.5	26.5	22.8	27.0	25.5	21.6
SSC (%)	9.8	10.6	11.8	10.0	11.0	12.0
Titratable acidity (%)	0.15	0.17	0.19	0.16	0.18	0.19
Vitamin C (mg/100 ml)	82.5	91.9	101.8	80.3	90.3	99.6
Total carotene (%)	1.15	1.39	1.91	1.15	1.44	1.98

Stage 1 Stage 2 Stage 3

Fig. 1: Maturity stages of Solo papaya fruits

yellow stripe; pulp is orange in color near seed cavity and light green near skin, although still hard, 2- 50% yellow skin with one or more orange-colored stripes in skin; pulp almost completely orange in color, except near skin, still hard and 3- full yellow stage, full yellow skin clearly orange in color with some light green areas; pulp completely orange, except near peduncle, softer than in stage 2, but still too hard for consumption. From each stage of maturity, harvested fruits were divided into two groups, the first one was held at ambient temperature 20°C ± 2 and 60- 65% RH for 4 days. The second group was stored at 6°C ± 1 for 20 days.

Changes in physical and chemical properties were followed up at four days intervals throughout the experimental period. For determine weight loss, ten papaya fruits were labeled in each treatment and initially weighted to calculate fruit weight loss% during the storage period in relation to its original weight. Patches of skin were removed from 4 opposite sides around the equator of papaya fruit to measure flesh firmness by using the hand Magness Taylor pressure tester (lb/in^2). Four opposite peeled segments from the rose to the stem were squeezed and the obtained juice was used to determine the percentage of SSC by using a hand refractometer, the titratable acidity as g citric acid /100 ml fruit juice and vitamin C as mg / 100 ml [3]. Flesh total carotene content was determined in its acetone extracts. The absorption of the above extraction was measured spectrophotometerically at 663, 644 and 440 nm to determine chlorophyll a, b then carotene, respectively as mg/100 g fresh weight [4]. For sensorial evaluation, portion containing two pieces of papaya fruit were placed in a plastic recipient and offered to 20 untrained panelists. Fruits were evaluated for flavor, odor, firmness and appearance on a five points scale (corresponding to excellent, good, regular, bad and very bad [5]. The obtained data were statistically analyzed according to Sendecor and Cochran [6]. Means were compared by Multiple Range Test according to Duncan [7] at 5% level by using Costat programme.

RESULTS AND DISCUSSION

Concerning the effect of maturity stage and following ambient temperature (20°C) on Solo papaya fruit characteristics, it is clear from Table 2 that stage 3 of maturity had significant higher effect on papaya fruit weight loss and firmness cruelly declined followed by stage 2 and stage 1 in the two seasons, respectively. Weight loss is a consequence of fruit dehydration and leads to loss of quality. The rate of firmness loss was also affected by maturity stage at harvest and following ambient temperature. Possibly, in stages 1 and 2 the enzymes related to softening were still not completely synthesized and activated. In addition, the quantity of ethylene receptors is reduced in fruits harvested when still green and for this reason, the ethylene -dependent process can be delayed [8]. Independent of the maturity stage at which papayas were harvested, soluble solids content did not differ during ripening. According to Zhou and Paull [9], the papaya sugar content remains constant during postharvest ripening suggesting that sugar accumulation in pulp is related to continued sugar translocation from plant to fruit.

The present study showed that the titratable acidity in papayas was reduced during ripening mainly in fruit harvested at maturity stages 2 and 3. Lazan *et al.* [10] concluded that the titratable acidity increased with fruit

Table 2: Quality parameters of three maturity stages of Solo papaya fruits after 4 days at ambient temperature (20±2°C) in 2008 and 2009 seasons

Stages of maturity	Weight loss (%)	Firmness (lb/in^2)	SSC (%)	Acidity (%)	Vitamin C (mg/100 ml)	Total carotene (mg/100g f. w.)
			2008			
1	4.3 c	8.6 a	9.8 c	0.14 b	84.2 b	2.33 a
2	6.6 b	4.2 b	11.4 b	0.19 a	91.4 b	2.55 a
3	8.3 a	2.6 c	12.3 a	0.19 a	108.0 a	2.66 a
			2009			
1	3.8 c	7.8 a	10.2 c	0.14 b	86.0 b	2.48 a
2	6.6 b	5.5 b	11.5 b	0.19 a	94.8 b	2.33 a
3	8.4 a	1.8 c	12.3 a	0.19 a	106.6 a	2.65 a

Values followed by the same letter (s) in each column are not significantly different at 5% level.

Table 3: Effect of maturity stage and following cold storage temperature at 6°C and 90 - 95% RH on Solo papaya fruits weight loss (%) in 2008 and 2009 seasons

Stage of maturity	Storage period in days: 0	4	8	12	16	20
			2008			
1	0.00	1.00 c	1.6 c	2.2 c	3.6 c	5.5 c
2	0.00	1.40 b	2.4 b	3.8 b	5.6 b	7.4 b
3	0.00	1.80 a	2.8 a	5.5 a	7.2 a	8.3 a
			2009			
1	0.00	1.1 c	1.4 c	2.3 c	3.3 c	5.4 c
2	0.00	1.5 b	2.6 b	4.1 b	5.4 b	7.5 b
3	0.00	2.0 a	3.1 a	5.2 a	6.8 a	8.8 a

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

Table 4: Effect of maturity stage and following cold storage temperature at 6°C and 90 - 95% RH on Solo papaya fruits flesh firmness (lb/in^2) in 2008 and 2009 seasons

Stage of maturity	Storage period in days: 0	4	8	12	16	20
			2008			
1	27.0 a	26.5 a	25.1 a	24.5 a	24.3 a	24.0 a
2	26.0 a	24.4 a	23.5 b	23.0 b	22.3 b	22.0 b
3	20.0 b	18.5 b	17.6 c	17.5 c	16.8 c	16.2 c
			2009			
1	27.0 a	26.6 a	25.6 a	25.2 a	25.0 a	24.8 a
2	25.0 a	24.0 a	23.5 b	23.1 b	22.0 b	21.0 b
3	21.0 b	18.8 b	17.5 c	17.2 c	17.0 c	16.2 c

Values followed by the same letter (s) in each column are not significantly different at 5% level.

Table 5: Effect of maturity stage and following cold storage temperature at 6°C and 90 - 95% RH on Solo papaya fruits SSC (%) in 2008 and 2009 seasons

Stage of maturity	Storage period in days: 0	4	8	12	16	20
			2008			
1	9.8 c	9.4 c	10.2 c	10.0 c	10.0 c	10.2 c
2	11.4 b	11.3 b	11.2 b	11.4 b	11.2 b	11.4 b
3	12.3 a	12.4 a	12.6 a	12.2 a	12.6 a	12.6 a
			2009			
1	10.2 c	10.2 c	10.4 c	10.6 c	10.4 c	10.6 c
2	11.4 b	11.1 b	11.2 b	11.6 b	11.4 b	11.6 b
3	12.4 a	12.2 a	12.6 a	12.8 a	12.8 a	12.8 a

Values followed by the same letter (s) in each column are not significantly different at 5% level.

Table 6: Effect of maturity stage and following cold storage temperature at 6°C and 90 - 95% RH on Solo papaya fruit acidity (%) in 2008 and 2009 seasons

	Storage period in days					
	0	4	8	12	16	20
Stage of maturity	2008					
1	0.15 b	0.17 b	0.17 a	0.18 a	0.18 a	0.18 a
2	0.16 ab	0.18 ab	0.18 a	0.19 a	0.18 a	0.18 a
3	0.18 a	0.19 a	0.18 a	0.19 a	0.19 a	0.19 a
	2009					
1	0.15 b	0.17 a	0.18 a	0.18 a	0.18 a	0.18 a
2	0.16 ab	0.18 a	0.19 a	0.19 a	0.18 a	0.18 a
3	0.18 a	0.18 a	0.18 a	0.19 a	0.19 a	0.19 a

Values followed by the same letter (s) in each column are not significantly different at 5% level.

Table 7: Effect of maturity stage and following cold storage temperature at 6°C and 90 - 95% RH on Solo papaya fruit vitamin C (%) in 2008 and 2009 seasons

	Storage period in days					
	0	4	8	12	16	20
Stage of maturity	2008					
1	83 c	83 c	86 c	84 c	86 c	89 c
2	94 b	93 b	96 b	94 b	96 b	98 b
3	101a	106 a	111 a	124 a	136 a	143 a
	2009					
1	86 c	86 c	88 c	90 c	92 c	92 c
2	93 b	94 b	94 b	94 b	98 b	100 b
3	99 a	102 a	113 a	122 a	136 a	141 a

Values followed by the same letter (s) in each column are not significantly different at 5% level.

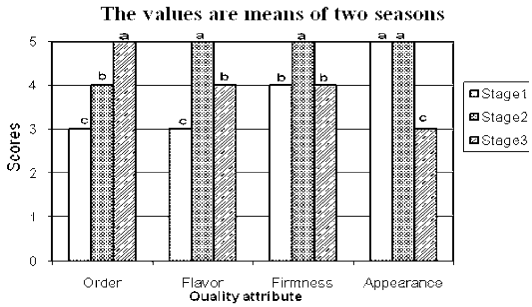
Table 8: Effect of maturity stage and following cold storage temperature at 6°C and 90 - 95% RH on Solo papaya fruit total carotene content (mg / 100g fresh weight) in 2008 and 2009 seasons

	Storage period in days					
	0	4	8	12	16	20
Stages of maturity	2008					
1	1.20 c	1.23 c	1.29 c	1.43 a	1.42 b	1.44 b
2	1.35 b	1.36 b	1.41 b	1.54 a	1.52 ab	1.56 b
3	1.54 a	1.55 a	1.60 a	1.63 a	1.70 a	1.78 a
	2009					
1	1.15 c	1.22 c	1.35 c	1.42 a	1.48 b	1.47 b
2	1.33 b	1.40 b	1.50 b	1.55 a	1.60 ab	1.62 b
3	1.56 a	1.58 a	1.60 a	1.63 a	1.78 a	1.80 a

Values followed by the same letter (s) in each column are not significantly different at 5% level.

ripening until approximately 75% of yellow skin, decreasing therefore. Wills and Widjanarko [11] observed that titratable acidity reached the maximum values when fruits had already achieved a completely yellow skin. Fruit harvested at stage 3 showed highest vitamin C concentration. These results are quite similar to those of Bron and Jacomino [5] and Pal *et al.* [12]. Mannose and L-galactose are key substrates for ascorbic acid synthesis in plants [13]. Therefore, cell wall degradation during ripening process may provide substrates for ascorbic acid synthesis, explaining the ascorbic acid increase in Solo papaya after held at ambient temperature (20°C). There was no significant effect of maturity stage on flesh total carotene content of Solo papaya fruit after 4 days at 20°C in both seasons (Table 2). However, the fruits had significant higher content of flesh total carotene than those at harvest.

Concerning the effect of maturity stage and following cold storage at 6°C and 90-95 % RH on papaya fruit characteristics, there was a significant difference among all stages in fruit weight loss along the storage period. The stage 3 fruits had highest weight loss percentage



Scores: 1= very bad, 2= bad, 3= regular, 4= good and 5= excellent Values followed by the same letter (s) are not significantly different at 5% level.

Fig. 2: Sensorial evaluation of solo papaya fruits as affected by maturity stage and cold storage at 6°C and 90 - 95% RH for 20 days followed by market period for 3 days at 20°C

followed by stage 2 and stage 1, respectively. Generally, weight loss percentage was increased with increasing the storage period (Table 3).

As shown in Table 4 there was a gradual decrease in fruit firmness during cold storage period, but, all maturity stages still firm until the end of the storage period. Generally, cold storage temperature 6°C had even stronger effects delaying softening until the end of storage period, when, 10%, 15% and 21% softening was noticed for stage 1, stage 2 and stage 3, respectively, at cold storage fruits compared with 70%, 80% and 90% in fruits held at ambient temperature (these percentages as average of two seasons). It is clearly evidence from Table 5 that the papaya soluble solids content almost remains constant during cold storage period.

As shown in Table (6), acidity of all stages of maturity was slightly increased with increasing the storage period at 6°C and there was a slight difference or absent in titratable acidity between all stages of maturity during or at the end of cold storage period. There was an increment in percentages of ascorbic acid during cold storage period independent on maturity stage at harvest and time duration. Fruits harvested at stage 3 showed highest concentration of ascorbic acid comparing with fruits of the other stages (Table 7). These data are similar to those of Pal *et al*. [12] and Bron and Jacomino [5]. They recorded maximum ascorbic acid percentages in ripe papayas. A slight increase occur in flesh total carotenecontent of papaya fruits during cold storage period (Table 8), but there was a significant difference among all stages of maturity in flesh total carotene content within storage periods.

In sensory analysis, the highest scores were attributes to fruit harvested at stage 2 and 3, respectively. Comparing the results obtained in sensorial analysis (Fig. 2) with soluble solids percentages (Table 4) it is noticeable that the panelists detected the differences found in soluble solids. Harvesting at early stage did not decrease fruit quality but also did not make the fruit acceptable for consumption.

CONCLUSION

It is important to harvest papaya fruits at the proper maturity stage, because they do not increase in sugar content after harvest. Non-destructive indices can be used to determine papaya harvest maturity, including the number of days from flowering, fruit size external color. Destructive indices used for determining harvest maturity include internal pulp color % and soluble solids content (sugar content). These indices are used to test randomly selected fruits in order to correlate fruit size with maturity. The internal pulp color of mature papaya fruit changes from cream to yellow orange as the external skin color changes from green to yellow-orange during ripening. The soluble solids content of mature fruits should be at least 11.5% can be determined by placing several drops of juice on a hand-held refractometer. Growers must be use a combination of external and internal maturity indices to determine when to harvest. At the stage of 50% yellow skin of papaya fruit may have a 5-7 days shelf life. Cold storage is a likely solution for slowing the loss of firmness and short term storage for the purpose of long distance only, not for orderly marketing schedule.

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