Egypt. J. Hort. **Vol. 42,** No.1, pp.153- 167 (2015)

Physiological Studies of Maturity Stages and Some Postharvest Treatments of Loquat Fruits cv. Emanuel

S. M. A. Mehaisen* and A. A. M. Al kfrawey**
**Fruit Handling Research Department and **Tropical and subtropical Fruit Research Department, Horticulture Research Institute, Agriculture Research Centre, Cairo, Egypt.*

A FOUR-YEAR study was conducted during four successive growing seasons of 2010/2011 up to 2013/2014 at the experimental orchard of the Horticulture Research Station at El kanater El khayreia, Kalubia Governorate, Egypt. It included two parts: Part I, studied maturity indices of Loquat fruits (*Eriobotrya japonica*, lindl.) cv. Emanuel in 2010/11 and 2011/12 seasons. Part II, studied effect of some post harvest treatments *i.e* dipping Loquat fruits in acetylsalicylic acid (ASA) solutions at (0.0 mmol / L, 1.0 mmol / L and 2.0 mmol / L), on fruit quality during cold storage (0°C) in 2012/13 and 2013/14 seasons through determination of decayed fruits %, changes in weight loss, firmness, colour, total soluble solids (TSS), total acidity (TA), TSS/TA ratio, ascorbic acid (vit.C), colour and shelf life .

Results indicated that Loquat fruits reached maturity after 104-108 days from full bloom, attained average fruit weight 20.75g, length 4.31cm, diameter 2.6 cm, pulp thickness 1.1cm, fruit firmness 57.7g/ mm^2, yellow colour L value 67.84, Hue angle value 98.95 ,TSS 10.2% ,TA 1.1%, and Vit.C 3.25 mg/100g f.w. Also, results showed that storability of Loquat fruits could be prolonged up to 8 weeks by dipping in ASA solutions during cold storage at 0°C and shelf life of fruits was extended to 6 days at room temperature, especially the high concentration.

Keywords : Loquat fruits, Maturity indices, Acetylsalicylic acid, Cold storage, Fruit quality.

Loquat (*Eriobotrya japonica*, Lindl.) originated in China and spread to many countries. The average area of loquat cultivated in Egypt doubled from1989 (12 ha) to 1993 (32 ha). The total cultivated area of loquat was about 112 ha in 2013, reaching a production of 1421 tons. (Economic Affairs Sector, 2013).

The ability of harvested fruits to maintain their quality, without shrinkage, for a longer period gives an indication, besides other factors, for the best time to harvest. Therefore, maturity indices determination is very important for keeping quality and reducing losses. Therefore after harvest, it becomes necessary to keep loquat fruits quality intact by using different post harvest treatments.

Loquat fruit has a short shelf life and its quality deteriorates rapidly after harvest (Akhtar *et al*., 2010). Decay and mechanical damage leading to browning are the prime problems of loquat after harvest (Ding *et al*., 2002).

Salicylic acid (SA) is a simple phenolic compound involved in various physiological processes in plant, including stomata regulation and induction of disease resistance mechanisms.

It is believed that SA has regulative functions in plant metabolism (Popova *et al*., 1997) and being an endogenous growth regulator in the phenolic group (Karlidag *et al*., 2009) has been extensively used for quality improvement in a number of crops (Peng and Jiang, 2006).

Acetylsalicylic acid (ASA) treatment delayed the membrane lipid peroxidation, inhibited ethylene biosynthesis, thus delaying climacteric rise, and retarded kiwifruit fruit ripening and softening. The effect of ASA on kiwifruit has been attributed to its ability to scavenge O^{-}_{2} ions and to the maintain stability of cell membrane (Zhang *et al.*, 2003).

The use of suitable postharvest storage practices may affect the senescence processes and lengthen shelf life of fruits. Cold storage is one of the most effective postharvest technologies that allows the preservation of the quality of fruits and vegetables, from the harvest until the shelf-life and the consumption by the consumers (Bourne, 2006).

The aims of this work were to determine some maturity indices of loquat fruits cv. Emanuel and to test the effect of some post harvest treatments on loquat fruit quality during cold storage.

Materials and Methods

This study was conducted during four consecutive growing seasons (2010/2011 - 2013/2014) on loquat fruits (*Eriobotrya japonica,* Lindl.) cv. Emanuel. The experimental trees were grafted on Province Quince (*Cydonia oblonga*) and grown on loamy clay soil. They were nearly uniform in vigor and subjected to the same cultural practices in the Experimental orchard of the Horticulture Research Station at El-Kanater El-Khayreia, Kalubia Governorate, Egypt.

Fruit maturity indices study

At full bloom (Dec. 11^{th} and 15^{th} for 2010 and 2011seasons, respectively), flowering panicles were tagged. Fruits at mature dark green, light green and yellow color stage were harvested on March 8^{th}, 19^{th} and 25^{th} in the first season and on March 11^{th}, 20^{th} and April 1^{st} in the second one and packed in 15 foam dishes. Each foam dish contains nine loquat fruits as a sample, and were transferred to the laboratory for determining maturity indices i.e. fruit age (days

from full bloom to harvest), fruit weight, length, diameter, flesh pulp thickness, firmness, colour (Land angle values), total soluble solids (TSS), total acidity(TA), TSS/TA ratio, and ascorbic acid (vit.C). Moreover, another sample was left at room temperature (21±2 °C) for 15 days to determine fruit weight loss (WL) and post harvest shrinkage at 5 days intervals.

Post harvest treatments study

At the last week of March, of 2012/2013 and 2013/2014 seasons, mature Loquat fruits were harvested at one maturity stage(yellow colour) according to the obtained data of maturity indices of 2010/2011and 2011/2012 seasons and directly transported to the laboratory, nearly uniform loquat fruits were washed, air dried, divided into two groups and dipped in acetylsalicylic acid (ASA) solution at 1.0, and 2.0 mmol/L for 5 min, then, dried fruits were packed in foam dishes (10 x 10 cm size, nine fruits/foam dish) and wrapped with shrink film. A third group was dipped in sterile distilled water, packed and wrapped as above, and used as a control. The fruits of each treatment were divided into three replicates (50 dishes per replicate) and stored at 0°C, 85-90 % RH, for eight weeks.

For physical and chemical determinations, a sample consisting of 3 dishes was taken randomly from each replicate within each treatment at two weeks intervals.

Fruit physical and chemical characteristics determinations for maturity indices and post harvest treatments

Fruit physical characteristics determinations

Fruit age (day): days from full bloom to harvest date for every maturity stage in both seasons were calculated and recorded.

Fruit weight (g), length (cm) and diameter (cm) were recorded at harvest.

Fruit decay (%): Decayed fruits (number of defected fruits %) are characterized by abnormal ripening, development of undesirable flavors, odors and skin darkening. These fruit disorders were counted as decayed fruits and calculated as decayed fruit % according to the following equation: Number of defected fruits %=(A/B) ×100.

Where: A= Number of defected fruits at the time of sampling. B= the initial fruit no.

Fruit weight loss (%)

The loss in mass fruit weight during storage at room temperature (21±2°C) or cold storage (0°C) was calculated as the difference between fruit weight at the start of storage and fruit weight at the inspection date as the following equation: [(A-B)/A] ×100.

Where: A=the initial fruit weight, B= fruit weight at the inspection date

Fruit firmness (g/mm^2): fruit firmness was determined by Lfra texture analyzer using a penetrating needle of 1 mm of diameter, 3 mm in distance, speed of 2 mm per second and the peak of resistance was recorded as g / mm^2.

Fruit peel color (L and h◦ values): It was measured by averaging two measurements taken on two opposite points of each fruit equator with a Minolta colorimeter (Minolta Co. Ltd., Osaka, Japan) on the basis of the CIELAB color system. In this system values of (a and b) specify the green-red and blue-yellow axis, while Hue (h◦) determines the position of such vector. h° values are calculated based on (a and b) values according to the following equation: h° =180- tan^{-1} (b / a). h° values were determined , calculated and used as an indicator of loquat ripeness according to (Mc Guire, 1992). Data of hunter L (ranging from black=0 to white=100) were used as surface browning indicator with out further conversion.

Shelf life: a sample of nine dishes of each replicate was taken out at the end of cold storage (0°C) period and left at room temperature (19-22°C) for six days, the percentage of decayed fruits were calculated at two days intervals and considered as an indicator of shelf life.

Fruit chemical characteristic determinations

Total soluble solids percentage (TSS %) were determined in fruit juice by hand Abbe refractometer.

Total acidity percentage (TA %) as malic acid was determined in fruit juice according to Association of Official Analytical Chemists (A.O.A.C.1985).

TSS/TA ratio: were calculated as ratio

Ascorbic acid (Vitamin C) (mg/100gFW) in fruit juice was determined (and expressed as mg/100g fresh weight) by using the dye 2,6-dichlorophenyl indophenols method as described in A.O.A.C. (1985).

Statistical analysis

All data obtained in both seasons were statistically analyzed using randomized complete block design according to Snedecor and Cochran (1989). Differences among means for the specific effect of storage period and the tested postharvest treatments were compared using Duncan's Multiple Range test (Duncan, 1955) at $p \leq 0.5$. The interaction effect between treatments and storage periods were differentiated using the Least Significance Difference (LSD) test at $p \leq 0.5$.

Results and Discussion

Fruit maturity indices study

Fruit maturity indices

Data reported in Table 1 demonstrates that loquat fruits reach yellow colour maturity stage 104-108 days after the full bloom. The values were significantly higher than those scored on loquat fruits at dark green maturity stage (87 days age from full bloom) except for fruit firmness, L and angle values and TA

parameters which showed, comparatively, a lower values. However, loquat fruits at dark green maturity stage recorded comparatively lower values of fruit weight in the first and second seasons, respectively. Furthermore, loquat fruits at light green maturity stage (98-96 days from full bloom) scored an intermediate values of the previously mentioned fruit parameters as they occupied in between position regarding dark green and yellow colour mature stage in this respect.

Weight loss (%)

It is clear from Table 1. that loquat fruits stored at yellow colour mature stage, recorded the lowest weight loss (2.8 and 3.13%) against (17.33 and 21.97%) for those stored at dark green mature stage and (14.6 and 16.6%) for the analogous ones stored at light green mature stage, which showed an intermediate values in this respect in the first and second seasons, respectively.

Generally, all combinations of yellow colour mature stage and storage periods (5,10,15 days) scored the lowest values of weight loss (%) in comparison with those stored at dark green mature stage which reported the highest values in this respect, followed by those stored at light green maturity stage.

Fruit shrinkage

Loquat fruits harvested at yellow colour mature stage showed no symptoms of fruit shrinkage during storage periods 5, 10, 15 days under room conditions (Table 1). Conversely, loquat fruits harvested at dark green mature stage shrinked during all tested storage periods (5, 10, 15 days) under room conditions. Moreover, loquat fruits harvested at light green mature stage showed no symptoms of fruit shrinkage during 5 days of storage, but shrinked after 10, 15 days of storage under room conditions (Table 1).

Pinillos *et al.* (2011) reported that fruit titratable acidity (TA) tend to decline as harvest season progresses. Besada *et al.* (2011), mentioned that the changes in loquat fruit colour during maturity were linked to an increase in weight, diameter and soluble solids content, as well as to a decrease in firmness, acidity and soluble tannins.

Development of loquat fruit occurs in two phases: a growth phase characterized by the growth of the seed, and a maturation phase, which is characterized by ripening-related changes, such as decreasing organic acid content, color development and softening of the pulp tissue. Sugar accumulation and a rapid increase in the fresh weight of the pulp tissue are also observed during maturation (Hirai, 1980). Loquat quality, including color, flavor, aroma and chemical compounds, is highly dependent on the ripening degree at harvest, (Hamauzu *et al.*, 2011).

The results from our experiments are in agreement with those obtained by Pinillos *et al.* (2011) and Mittra *et al.*, (2011), reporting that the harvest maturity indices of loquat is determined based on peel colour, fruit age from full bloom (days), firmness and TSS/TA ratio.

TABLE 1. Effect of Maturity stage on fruit age, weight, length, diameter, flesh pulp thickness, firmness, colour (L and Hue angle values),TSS%,TA%,TSS/TA ratio, VIT.C(g/100gf.w.) , weight loss and post harvest shrinkage of Loquat "Emanuel" cv. in (2010/11 and 2011/12) seasons.

Season	1st season																		
Character	Fruit age (day)	fruit Weight (g)	fruit length (cm)	fruit diameter (cm)	pulp thickness (cm)	firmness (g/mm²)	Lvalue	Hue value	TSS (%)	TA (%)	TSS / TA ratio	Vit.C g/ 100g	Weight loss (%)				Post harvest shrinkage		
Days at room temperature													5	10	15	Mean	5	10	15
Maturity stage																			
Dark green	87c	18.83c	3.47c	2.38c	0.67b	68.30a	70.10a	113.23a	8.09b	1.5oa	6.0c	3.4a	8.5	20	23.5	17.33a	×	×	×
Light green	98b	20.9a	3.9b	2.62b	0.68b	66.02b	69.2ab	107.02b	9.20a	1.3ob	7.1b	3.1a	7.6	12.4	23.8	14.67b	√	×	×
Yellow colour	104a	21.5a	4.32a	2.65a	1.2a	57.74c	68.36b	100.1c	10.0a	1.15b	11.5a	3.0a	1.9	3.1	3.5	2.83c	√	√	√
Mean													6.0c	11.83b	16.93a				
L.S.D. p ≤ 0.05	2.17	0.296	0.059	0.0188	0.084	0.942	1.1	0.82	1.02	0.166	0.404	0.6	T=0.932 P=0.93 T×P=1.6i5						
Season	2nd season																		
Dark green	87c	18.0c	3.55c	2.45b	0.65b	67.86a	69.88a	102.27a	9.5b	1.40a	6.8c	3.7a	11.2	24.8	29.9	21.97a	×	×	×
Light green	96b	19.6b	3.67b	2.54a	0.70b	66.42b	68.2b	99.99b	10.4a	1.20b	8.7b	3.6a	7.8	13.2	28.8	16.6b	√	×	×
Yellow colour	108a	20.0a	4.3a	2.55a	1.00a	55.74c	67.32c	97.8c	11.oa	1.20b	9.2a	3.5a	2.0	3.6	3.8	3.13c	√	√	√
Mean						0.785	1.357	0.836	0.82	191	0.43	0.53	7.0c	13.87b	20.83a				
L.S.D. p ≤ 0.05	2.36	0.265	0.084	0.027	0.103								T=0839 P=0.84 T×P=1.453						

√ =fine fruit condition (No shrinkage) ×= shrinked fruit

Means followed with the same letter (s) within each column or row are not significantly different as Least Significance Difference (LSD) test at $p \leq 0.5$.

Effect of post harvest ASA treatments on fruit quality of loquats.
Physical and chemical characteristics:

Decayed fruits (%)

Data reported in Table 2 show that fruit decay% was significantly increased as the duration of the cold storage period increase. Acetylsalicylic acid (ASA) treatments cleared much lower values of decayed fruits percentage, especially at 2.0 mmol/L (10.7 and 12.5%), as compared with untreated control (17.24 and 19.6%) for the first and second seasons, respectively.

The interaction effect of storage period and ASA treatments showed especially high significant effect on fruit decay percentage in both seasons**.** The obtained results were similar to those reported by Raskin (1992).

Fruit weight loss percentage (WL)

The weight loss in loquat fruits was significantly increased with the advancement of storage period under all treatments **(**Table 2). Control fruits exhibited higher WL 3.25%. However, the tested postharvest treatments induced reduction effect on fruit WL as compared with control, especially at the high level of ASA (2.0 mmol / L) in both seasons. The interaction effect of storage period and ASA treatments was significant and the high WL 7.45% was obtained in control fruits at the end of storage period.

The higher WL in the control fruits was attributed to water leakage and higher respiration rate. However, ASA- treated fruit which showed lower WL might be due to the suppression of the transpiration and respiration rates of fruits by closing the stomata. These observations are in agreement with those obtained by Zheng and Zhang (2004) on Ponkan mandarin and by Tareen *et al.*, (2012) on Peach.

Fruit firmness (g /mm^2)

Data in Table 2 shows that firmness of loquat fruits exhibited high significant decrease by extending storage period at cold storage in all treatments in both seasons. ASA-treated fruits 2.0 mmol / L had highest value 52.63 and 52.77 g / mm^2 of fruit firmness than other treatments in both seasons. Firmness of control fruits showed faster decrease 49.75 and 50.23 g/mm^2 than other treatments in both seasons. The higher fruit firmness in ASA- treated fruits may be due to the reduction of enzymatic activities degrading the cell wall and membrane by suppressing the ethylene production (Cai *et al*., 2006).

According to Srivastava and Dwivedi (2000), Zhang *et al*. (2003), and Wang *et al*. (2006), SA prevents fruit softening, in fact, rapid softening of fruits during ripening was simultaneously associated with a rapid decrease in endogenous SA of fruits. Moreover, SA affects cell swelling which leads to higher firmness of fruits (Zhang *et al*., 2003 and Shafiee *et al*., 2010).

TABLE 2. Effect of Acetylsalicylic acid(ASA) on decay %, weight loss , firmness in fruits of loquat "Emanuel" cv. during cold storage at (0 °c) in (2012/2013 and 2013/2014) seasons.

Character	decay%						Weight loss (%)						Firmness(g/mm^2)					
Storage periods(P) (week)	0	2	4	6	8	Mean	0	2	4	6	8	Mean	0	2	4	6	8	Mean
Treatments(T)																		
1st season (2012/2013)																		
ASA(0.0mmol/L)	0.00	9.20	20.00	24.00	33.00	17.24a	0.00	1.64	3.00	4.21	7.42	3.25a	57.74	54.13	50.10	45.10	41.67	49.75b
ASA(1.0mmol/L)	0.00	4.50	12.00	18.00	24.00	11.70b	0.00	1.62	2.90	4.20	7.36	3.22a	57.74	53.20	49.27	46.10	44.44	50.15b
ASA(2.0mmol/L)	0.00	3.80	11.87	16.00	22.00	10.73c	0.00	1.47	2.60	3.78	7.10	2.99b	57.74	54.20	52.20	50.10	48.91	52.63a
Mean	0.00e	5.83d	14.62c	19.33b	26.33a		0.00e	1.68d	2.83c	4.06b	7.29a		57.74a	53.84b	50.52c	47.1d	45.01e	
L.S.D. p ≤ 0.05	T=.822		P=1.018	T×P=1.77			T=0.057		P=0.074	T×P=0.0128			T=0.77		P=0.99	T×P=1.72		
2 ed season (2013/2014)																		
ASA(0.0mmol/L)	0.00	11.00	22.00	29.00	36.00	19.60a	0.00	2.87	4.40	6.14	7.16	4.11a	55.74	53.00	50.10	48.00	44.30	50.23c
ASA(2.0mmol/L)	0.00	5.20	17.00	21.00	25.00	13.64b	0.00	2.68	4.25	6.06	6.91	3.98b	56.77	53.50	51.20	48.70	46.50	51.33b
ASA(2.0mmol/L)	0.00	4.50	15.00	19.00	24.00	12.50c	0.00	2.37	3.89	5.54	6.32	3.62c	55.74	54.00	53.00	51.00	50.10	52.77a
Mean	0.00e	6.9d	18c	23b	28.a33		0.00e	2.64d	4.18c	5.91b	6.80a		56.08a	53.5b	51.43c	49.23d	46.47e	
L.S.D. p ≤ 0.05	T=0.82		P=1.058	T×P=1.833			T=0.04		P=0.052	T×P=0.09			T=0.74		P=0.95	T×P=1.65		

Means followed with the same letter (s) within each column or row are not significantly different as Least Significance Difference (LSD) test at $p \leq 0.5$.

Fruit peel color

Table 3 indicates that postharvest treatments delayed the change in fruit colour, the lightness (L value) and the hue angle (h° value) decreased during storage in all the tested treatments. ASA–treated fruits showed a lower reduction of h◦ value than other the treatments in both seasons.

SA treatment effectively decreased ethylene production in fruit and noticeable decrease metabolic activity which delays fruit senescence process (Wills *et al*., 1998). These results are in agreement with those reported by Shafieee *et al*. (2010).

Shelf life

Data in Fig. 1 showed that prolonging storage period, determine an increase of the decay percentage of loquat fruits and a reduction of the shelf life. Moreover ASA treatments extended shelf life by reducing decayed fruits and extended shelf life of loquat fruits. Such results were reported in banana fruit by Srivastava and Dwivedi (2000). Post harvest treatments of AS and $KMnO_4$ sachet alone or in combination, is effective methods of extending the shelf life of kiwifruit in storage (Bal and Celik, 2010).

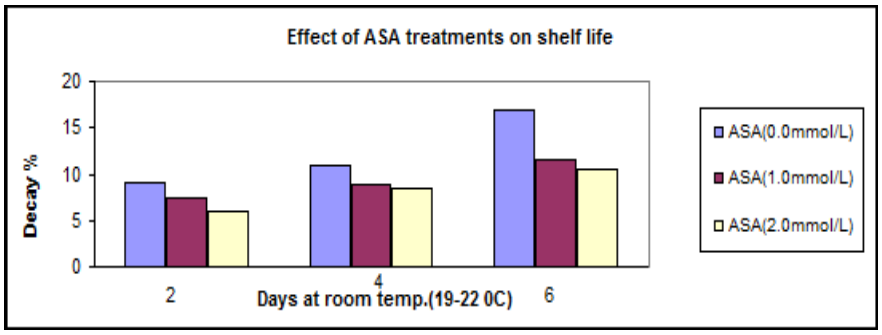

Fig.1. Effect of Acetylsalicylic acid(ASA) treatments on shelf life (average of two seasons)

Fruit chemical characteristics

Total soluble solids (TSS%)

Table 4 shows that slight increase was observed in TSS content of all treatments. However fruits were treated with ASA at 2.0 mmol/L had the lowest values (10.55 and 11.24%) at the end of storage period and the highest values (10.82 and 11.70%) were recorded in control in both seasons, respectively. Lower TSS values in ASA-treated fruits may be attributed to a reduced hydrolysis of soluble starch. These observations are in agreement with those reported by Kazemi *et al.*, (2011) on kiwifruit. Similar results were also reported by Han and Li (1997) as apple fruits increased TSS without decreasing firmness when treated with SA.

TABLE 3. Effect of Acetylsalicylic acid (ASA) on fruit colour (L and h °values) of loquats "Emanuel" cv. During cold storage at (0 °C) in (2012/2013 and 2013/2014) seasons.

Character	L value						h° value				
Storage periods (P) (week)	0	2	4	6	8	Mean	0	2	4	6	8
Treatments (T)											
1st season (2012/2013)											
ASA (0.0 mmol/L)	68.36	67.33	65.93	64.33	63.85	65.96b	100.10	99.13	97.17	95.83	82.73
ASA (1.0 mmol/L)	68.36	67.63	66.43	65.47	64.20	66.42ab	100.10	97.30	92.27	86.03	84.73
ASA (2.0 mmol/L)	68.36	67.93	66.97	66.20	65.59	67.01a	100.10	95.00	91.00	87.00	83.50
Mean	68.36a	67.63a	66.44b	65.37c	64.55c		100.1a	97.14b	93.48c	89.6d	83.65e
L.S.D. $p \leq 0.05$	T=0.75		P=0.97	T×P=1.68			T=1.178		P=1.45	T×P=2.52	
2ed season (2013/2014)											
ASA (0.0 mmol/L)	67.32	65.09	63.33	61.83	60.70	63.66b	97.80	92.96	92.00	89.00	84.33
ASA (1.0 mmol/L)	67.32	65.99	63.90	63.13	65.47	65.16a	97.80	93.38	90.33	88.00	88.00
ASA (2.0 mmol/L)	67.32	65.40	64.67	63.93	63.43	64.95a	97.80	93.14	90.07	88.00	86.87
Mean	67.32a	65.49b	63.97c	62.97c	63.2c		97.8a	93.16b	90.8b	88.3c	86.4d
L.S.D. $p \leq 0.05$	T=0.92		P=1.19	T×P=2.74			T=1.134		P=1.47	T×P=2.53	

Means followed with the same letter (s) within each column or row, are not significantly different as Least Significance Difference (LSD) test at $p \leq 0.5$.

TABLE 4. Effect of Acetylsalicylic acid (ASA) on Total soluble solids (TSS) %. Acidity (TA) %, TSS/TA ratio and Vit. C (mg/100g f.w.) in fruits of loquat) "Emanuel" cv. during cold storage at (0 °c) in (2012/2013 and 2013/2014) seasons.

Character	TSS%						TA (%)						TSS/TA ratio						VIT. C.(g/100mg f.w.)					
Storage periods (P) (week)	0	2	4	6	8	Mean	0	2	4	6	8	Mean	0	2	4	6	8	Mean	0	2	4	6	8	Mean
Treatments (T)																								
1st season (2012/2013)																								
ASA (0.0mmol/L)	10.20	10.80	11.00	10.90	11.20	10.82a	0.90	0.55	0.60	0.45	0.30	0.56bc	11.38	19.72	18.40	14.44	37.93	22.37a	3.10	2.53	1.90	2.33	2.00	2.37c
ASA (1.0mmol/L)	10.20	10.60	10.80	10.80	11.00	10.68ab	0.90	0.60	0.65	0.50	0.45	0.62a	11.38	17.97	16.70	21.60	24.45	18.42b	3.10	2.60	2.77	2.60	2.50	2.71b
ASA (2.0mmol/L)	10.20	10.60	10.80	10.53	10.60	10.55b	0.90	0.59	0.62	0.49	0.40	0.60ab	11.38	18.05	17.46	21.50	26.51	18.98b	3.10	2.80	3.00	3.13	3.00	3.01a
Mean	10.2b	10.67a	10.87a	10.74a	10.93a		0.9a	0.58b	0.62b	0.48c	0.38d		11.38d	18.58c	17.52c	22.51b	29.63a		3.1a	2.64b	2.56bc	2.69b	2.5c	
L.S.D. p ≤ 0.05	T=0.256	P=0.331	T×P=0.572				T=0.04	P=0.052		T×P=0.09			T=1.12	P=1.44	T×P=2.5				T=0.116	P=0.15	T×P=0.26			
2ed season (2012/2013)																								
ASA (0.0mmol/L)	11.00	11.60	11.90	11.80	12.20	11.70a	1.20	0.90	0.70	0.55	0.40	0.75b	9.19	21.91	17.04	21.54	30.76	18.29a	3.33	3.20	3.03	2.77	2.30	2.93b
ASA (1.0mmol/L)	11.00	11.40	11.50	11.40	11.50	11.36b	1.20	0.95	0.99	0.70	0.52	0.87a	9.19	12.01	11.61	16.31	22.16	14.26b	3.33	3.27	3.50	3.00	2.90	3.20a
ASA(2.0mmol/L)	11.00	11.30	11.20	11.30	11.40	11.24b	1.20	0.92	0.89	0.65	0.50	0.83a	9.19	12.30	12.58	17.44	23.01	14.90b	3.33	3.20	3.40	3.00	2.80	3.15a
Mean	11.00b	11.43a	11.53a	11.50a	11.70a		1.20a	0.92b	0.86c	0.63d	0.47e		9.19d	12.40c	13.75c	18.43b	25.31a		3.33a	3.23a	3.31a	2.92b	2.67c	
L.S.D. p ≤ 0.05	T=0.259		P=0.335	T×P=0.58			T=0.047		P=0.061		T×P=0.105		T=1.043		P=1.347	T×P=2.33			T=0.099		P=0.128	T×P=0.221		

Means followed with the same letter (s) within each column or row, are not significantly different as Least Significance Difference (LSD) test at $p \leq 0.5$.

Total acidity % (TA)

Table 4 indicates that changes in TA were significantly decreased by prolonging the storage period under all treatments during cold storage. The maximum TA values observed in ASA-treated fruit especially 1.0 mmol/L 0.62 and 0.87% and the lowest TA values were recorded in control (0.56 and 0.75%) in both seasons respectively. It is matter of fact that fruit taste is mainly made up of sugars and acids combination. It has been suggested that TA decreases in fruits as a result of breakup of acids to sugars during respiration (Ball, 1997). These results are in agreement with those reported by Kazemi *et al.* (2011).

TSS/TA ratio

Data in Table 4 showed that the higher values of TSS/TA ratio 22.37 and 18.29 were observed in control fruits. On other contrary, ASA-treated fruits had the lowest values of TSS/ TA without significant differences between the two concentrations of ASA. In fact, control fruits have the higher TSS with lowest TA values.

Ascorbic acid (Vit.C)

Results in Table 4 indicate that values of Vit.C were significantly decreased by prolonging the storage period under all treatments during cold storage, especially in last four week of both seasons. ASA treatments had significant effect on values of Vit.C. However, 2.0 mmol / L ASA-treated fruits maintained higher Vit.C content in both seasons, reaching 3.01 and 3.15 mg/100g, respectively. These observations are in agreement with those obtained by Kalarani *et al.*, (2002) and Tareen *et al.*, (2012).

Conclusions

Data collected from these experiments suggest that it is preferable to harvest loquat fruits at yellow colour maturity stage, when loquat fruits aged 104-108 days from full bloom and attained scores of the following parameters: fruit weight 20.75g, length 4.31cm, diameter 2.6 cm, pulp thickness 1.1cm, fruit firmness 57.7g/ mm^2, yellow colour, L value 67.84, Hue angle value 98.95, TSS 10.2%, TA 1.1% and Vit.C 3.25 mg/100g f.w. average of two seasons. Also, it can be concluded that dipping loquat fruits in ASA solution at1.0 mmol/L and 2.0 mmol/L as postharvest treatments, could be maintain fruit quality, storability and shelf life.

References

A.O.A.C. (1985) Association of Official Analytical Chemists, "*Official Methods of Analysis*" Benjamin Franklin Station, Washington D.C., U.S.A., 495-510.

Akhtar, A., Abbasi, N.A. and Hussain, A. (2010) Effect of calcium chloride treatments on quality characteristics of loquat fruit during storage. *Pak. J. Bot.*, **42** (1), 181-188.

Bal, E. and Celik, S. (2010) The effect of post harvest treatments of salicylic acid and potassium permanganate on the storage of kiwifruit. *Bulg. J. Agric. Sci.*, **16** (5), 576-84.

Ball, J.A. (1997) Evaluation of two lipid based edible coating for their ability to preserve post harvest quality of green bell peppers. Master Diss., Faculty of the Virginia Polytechnic Institute and State University. Blacksburg, Virginia, USA.

Besada, C., Gil, R., Navarro, P., Soler, E. and Salvador, A. (2011) Physiological characterization of 'algeri' loquat maturity: external colour as harvest maturity index. *Acta Hort.,* (ISHS) **887**, 351-356

Bourne, M.C. (**2006**) Selection and use of post harvest technologies as a component of the food chain, *J. Food Sci.,* **69**, 43–46.

Cai, C., Li, X. and Chen, K.S. (2006) Acetylsalicylic acid alleviates chilling injury of post harvest loquat (*Eriobotrya japonica*, Lindl.) fruit, *Eur. Food Res. Technol.,* **223,** 533-539.

Ding, C.K., Chachin, Y., Ueda, Y., Imahori, Y. and Wang, C.Y. (2002) Modified atmosphere packaging maintains post harvest quality of loquat fruit. Post harvest Biology and Technology, **24** (3), 341-348.

Duncan, D.B. (1955) Multiple range and multiple F. Tests. *Biometrics,* **11**, 1-42.

Economic Affairs Sector (2013) Agri. Economics Central Administration, Ministry of Agri. and Land Reclamation, Egypt.

Hamauzu, Y., Chachin, K., Ding, C.K. and Kurooka, H. (1999) Differences in surface color, flesh firmness, physiological activity, and some components of loquat fruit picked at various stages of maturity. *J. Jpn. Soc. Hort. Sci.,* **65**, 859–865

Han, T. and Li, L.P. (1997) Physiological effect of salicylic acid on storage of apple in short period. *Plant Physiol. Commun.,* **33,** 347-348.

Hirai, M. (1980) Sugar accumulation and development of loquat fruit. *J Jpn.*

Kalarani, M.K., Thangaraj, M., Sivakumar, R. and Mallika, R. (2002) Effects of salicylic acid on tomato (*Lycopersicon esculentum* Mill) productivity. *Crop Res. (Hisar),* **23,** 486-492.

Karlidag, H., Yildirim, E. and Turan, M. (2009) Exogenous applications of salicylic acid affect quality and yield of strawberry grown under antifrost heated greenhouse conditions. *J. Plant Nutr. Soil Sci.,* **172,** 270-276.

Kazemi, M., Aran, M. and Zamani, S. (2011) Effect of calcium chloride and salicylic acid treatment on quality characteristics of kiwifruit (*Actinidia deliciosa* cv. Hayward) during storage. *American Journal of Plant Physiology,* **6,** 183–189.

Mc Guire, R.G. (1992) Reporting of objective colour measurements. *Hort. Sci.,* **27** (12), 1254-1255.

Mittra, S.K., Chakraborty, I., Majhi, D. and Pathak, P.K. (2011) Recent development in post harvest physiology and storage of loquat. *Acta Hort. (ISHS)* 887, 339-343.

Peng, L. and Jiang, Y. (2006) Exogenous salicylic acid inhibits browning of fresh-cut Chinese water chestnut. *Food Chem.,* **94,** 535-540.

Pinillos,V., Juan, J., Jose, H.L., Filho, M. and Cuevas, J. (2011) hanges in fruit maturity indices along the harvest season in 'Algerie' loquat. *Scientia Horticulturae,* **129** (4), 769-776.

Popova, L., Pancheva, T. and Uzunova, A. (1997) Salicylic acid: Properties, biosynthesis and physiological role. *Bulg. J. Plant Physiol.,* **23**, 85-93.

Raskin, I. (1992) Salicylic, a new plant hormone. *Plant Physiol.*, **99**, 799-803.

Shafiee, M., Taghavi, T.S. and Babalar, M. (2010) Addition of salicylic acid to nutrient solution combined with postharvest treatments (hot water, salicylic acid, and calcium dipping) improved post harvest fruit quality of strawberry, *Scientia Horticulturae*, **124,** 40- 45.

Snedecor, G.W. and Cochran W.G. (1989) "*Statistical Methods*". 8th ed., Iowa State Univ. Press Amer. Iowa, USA., pp.85-86.

Srivastava, M.K. and Dwivedi, U.N. (2000) Ripening of banana fruit by salicylic acid, *Plant Science,* **158,** 87-96.

Tareen M.J., Abbasi, N.A. and Hafiz, I.A. (2012) Post harvest application of salicylic acid enhanced antioxidant enzyme activity and maintained quality of peach cv. Flordaking fruit during storage. *Scientia Horticulture,* **142,** 221- 228.

Wang, L.J., Chen, S.J., Kong, **W.F., Li, S.H. and Archbold, D.D. (2006**) Salicylic acid pretreatment alleviates chilling injury and effects the anti-oxidant system and heat shock proteins of peaches during cold storage, *Post harvest Biol. Technol.,* **41**, 244-251.

Wills, R., McGlasson, B., Graham, D. and Joyce, D. (1998) Post harvest, and introduction to the physiology and handling of fruit and vegetables and ornamentals (Fourth ed.). Sydney 2050. NA Australia University of New South Wales Press Ltd., University of New South Wales.

Zhang, Y., Chen, K., chen, Q., Zhang S., Ren, Y. (2003) Effects of acetylsalicylic acid (ASA) and ethylene treatments on ripening and softening of post harvest kiwifruit. *Acta Botanie Sinica,* **45** (12), 1447-1452.

Zhang, Y., Chen, K., Zhang S., and Ferguson, I. (2003) The role of salicylic acid in post harvest ripening of kiwifruit, *Post harvest Biol. And Technol.,* 28 (1), 67-74.

Zheng, Y. and Zhang, Q. (2004) Effects of polyamines and salicylic acid post harvest storage of 'Ponkan' mandarin. *Acta Hort.,* **632**, 317-320.

(*Received* 11/9/2014;
accepted 13/1/2015)

دراسات فسيولوجية على مراحل إكتمال النمو و بعض معاملات ما بعد الجمع لثمار البشملة صنف إيمانويل

صلاح محمود أحمد محيسن* و أيمن عبد الرحمن الكفراوي**
*قسم بحوث تداول الفاكهة و**قسم بحوث الفاكهة الإستوائية و شبه الاستوائية - معهد بحوث البساتين - مركز البحوث الزراعية – القاهرة – مصر.

أجريت هذه الدراسة لمدة أربعة مواسم من ٢٠١٠/٢٠١١ إلى٢٠١٣/٢٠١٤ على أشجار البشملة صنف ايمانويل عمرها ١٠ سنوات و نامية بمزرعة محطة بحوث البساتين بالقناطر الخيرية – القليوبية – مصر.

اشتملت هذه الدراسة على جزئين: الجزء الاول هو تقدير دلائل اكتمال النمو لثمار البشملة تحت ظروف التجربة خلال موسيمي (٢٠١٠/٢٠١١ ،٢٠١١ /٢٠١٢)، الجزء الثاني هو معاملات ما بعد الحصاد خلال موسيمي (٢٠١٢/٢٠١٣ ،٢٠١٣ /٢٠١٤) وهي الغمر في محلول استيل حمض السالسيليك (صفر مليمول/لتر(المقارنة)- ١ مليمول/لتر-٢ مليمول /لتر) ثم التعبئة في عبوات فوم و التغليف بال warp film ثم التخزين على درجة الصفر المئوي لمدة ثمانية أسابيع. وتم دراسة الصفات التالية لمعاملات ما بعد الحصاد:- نسبة التالف-الفقد في الوزن-الصلابة –اللون - المواد الصلبة الذائبة الكلية- - الحموضة الكلية- المواد الصلبة الذائبة الكلية/ الحموضة الكلية- فيتامين ج - مدة بقاء الثمار في جو الغرفة بعد خروجها من التخزين المبرد .

أوضحت نتائج هذة الدراسة أن ثمار البشملة تصل لاكتمال النمو بعد ١٠٤- ١٠٨ يوم من اكتمال التزهير عندما يكون متوسط وزن الثمرة ٢٠,٧٥جم، طول الثمرة ٤,٣١سم، القطر ٢,٦سم، سمك اللحم ١,١سم والمواد الصلبة الذائبة الكلية ١٠,٢٪ ، وإصفرار لون الثمرة، و صلابة الثمار ٥٦,٧جم على عمق ٣مم في سمك اللحم. كما أوضحت النتائج أن معاملات ما بعد الحصاد قد أطالت المقدرة التخزينية لثمار البشملة مع الحفاظ على صفات الجودة لمدة ٨ أسابيع عند التخزين على درجة الصفر المئوي و إطالة مدة بقاء الثمار في جو الغرفة لمدة ستة أيام بعد خروجها من التخزين المبرد .