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Estimation of post-harvest losses of Manfalouty pomegranate fruits

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ABSTRACT: Weight loss considered one of the main causes of quality loss in pomegranate fruits during chain marketing. Therefore, this study was conducted on Manfalouty pomegranate (*Punica granatum* L.) in a private orchard in El Badary, Assiut Governorate, Egypt in 2017 and 2018 to define the various causes of losses during chain handing and estimate it. The fruits harvested at three periods early (September) mid (October) and late season (November). The total losses at harvest were 5.94%, 9.30% and 23.50% for early, mid and late season, respectively. The main cause of losses is due to cracked and infected pests. The total loss of fruits during chain marketing was highest in retail market in comparison with wholesale during early, mid and late season. The main causes of losses due to weight loss and shrinkage fruits. According to data dealing with storage pomegranate fruits at 5±1°C and relative humidity 85-90%, the highest fruit losses found in the third month and this losses due to fruit weight loss and internal chilling injury (brown discoloration) so the storage life of fruit should be two months.

Keywords: Fruit quality; Fruit losses; Pomegranate storage; Weight losses.

1. INTRODUCTION

Pomegranate (*Punica granatum* L.) fruit have greatly expanded in recent years due to increasing consumer awareness of the potential health benefits of the fruit and consequently more demand for fresh fruit in the market [1]. The total losses of pomegranate fruits at different levels of handling was 35.44% consisting of 9.86% at field, 10.10% at the wholesale market and 15.48% at retail market. The damage due to borer and anthracnose were the two major causes of losses at the field level 4% scorching due to extreme heat, 1.28% and cracking of fruits, 1.22% due to the irregular, irrigation and fertilization [2]. The main problems associated with export and prolonged storage of Pomegranate fruit are weight loss, shrinking, chilling injury and maintaining fruit quality during transport and storage. El-Oraby et al. [3], Mahajan et al. [4], and Caleb et al. [5] reported that lowers temperature and relative humidity play a major role in reducing rate of water loss. Yahaya and Mahajan [6] found that most cases farmers suffered a huge economic loss due to lack of proper preservation methods and their transportation and marketing techniques of fruits and vegetables. However this may be reduced tremendously by using adequate cultural methods, such as handling, packaging and other environmental damage. This will reduce the loss and maximizing the returns from which may result in

increased availability and reduce cost of the commodity. The purpose of this investigation was to define the various causes of losses in Manfalouty pomegranate fruits during chain handling and estimate it.

2. MATERIALS AND METHODS

Fruit samples of Manfalouty pomegranate were collected from a private orchard at El Badary, Assiut Governorate Egypt in 2017 and 2018. The fruits harvested at three periods early (September), mid (October) and late (November) season. Average meteorological data during the harvest period for the experimental area during growing seasons are presented in Table 1.

Table 1. Average meteorological data during the harvest period (September, October and November) for Assiut weather station during two years of 2017 and 2018.

Year	Month	T max (°C)	T min (°C)	RH %	w.s / km/h	Sunshine	ETo (mm/day)
2017	September	35.3	20.9	44.6	20.7	10.8	9.50
	October	30.3	16.5	47	17.2	10.0	6.94
	November	25.1	10.9	54.6	15.2	9.4	4.75
2018	September	35.5	22	46.2	20.5	10.8	9.43
	October	32.6	18.9	46.5	18.1	10.0	7.58
	November	26.5	13.1	53.8	14.7	9.4	4.93

T Max = Maximum temperature (°C), T min = Minimum temperature (°C), RH= Relative humidity (%), W.S = Wind speed (Km/h), ETo = Reference evapotranspiration.

Each sample consisted of six carton boxes, each box contains 5 kg. This study divided to three parts. Evaluation of fruit quality was done at harvest time according to the following system:

- sound fruit: fruit without defects
- marketable fruits: fruit with slight and moderate defects.
- unmarketable fruits: fruits include infected with insects and cracked.

Fruits percentage of each grade and defects was calculated in relation to the total number of samples.

Estimate losses in marketable fruits during the marketing chain (wholesale and retailsale markets) during early, mid and late season. Physical and chemical properties were examined at the end of the wholesale period (2 days) and retail sale (6 days). Physical properties (fruit weight, unmarketable fruits and total losses percentage, peel %, arile % and juice %) were calculated. Chemical characteristics (total soluble solids, titrable acidity and anthocyanin) were estimated.

Estimate losses during storage at 5±1°C relative humidity (RH) 85-90% for three months. Six replicates from mid season (October) were stored at 5±1°C and 85-90% RH, each replicate was carton box (5 kg) physical and chemical properties were studied every month.

2.1. Physical properties

Fruit weight loss (%) = [(Initial fruit weight – Final fruit weight) / Initial fruit weight] x 100

Fruit Decay (%) = [Weight of decayed fruit / Initial fruit weight] x 100

Juice content was expressed as juice volume produced from 100 g arils.

2.2. Chemical properties of juice

Total soluble solids (TSS %) were determined using a hand refractometer. Titratable acidity of the fruit juice was determined by titration 5 ml juice against 0.1 N sodium hydroxide using phenolphthaline as an indicator. Titratable acidity was expressed as grams of citric acid per 10 m; fruit juice according to the AOAC [7]. Total soluble solids/acidity ratio (TSS/Acid ratio) was calculated by dividing TSS% by total acidity % in fruit juice. Total anthocyanin content was estimated spectrophotometrically as described by Ranganna [8].

2.3. Statistical analyses

A randomized complete block design was followed for statistical analysis of the present investigation. The differences between various treatment means were compared using new L.S.D. parameters at 0.05% according to Snedecor and Cochran [9].

3. RESULTS AND DISCUSSION

Data presented in Table 2 illustrated types of defects in Manfalouty pomegranate fruits as well as the percentage of each defect in all inspected samples collected through the seasons 2017, 2018. A gradual reduction in percentage of sound fruits was reported according to the time of sampling during two seasons. The percentage of sound fruits was highest significant in the early season in comparison to mid and late seasons during both of the two seasons of study.

Table 2. Time of harvest and its effect on sound, marketable, un-marketable fruits and total losses during 2017 and 2018 seasons.

Time of harvest	Sound fruits	Marketable	Un-market		Total losses
			Cracked fruits	Fruits infected pests	
First Season 2017					
Early season	79.66±1.6	14.40±1.6	3.64±0.7	2.30±0.7	5.94±1.4
Mid season	70.53±3.5	20.17±2.6	6.30±0.5	3.00±1.0	9.30±1.3
Late season	29.27±2.1	47.23±1.6	19.40±1.6	4.10±0.7	23.50±1.9
L.S.D. 0.05	3.08	3.69	1.42	1.13	4.89
Second Season 2018					
Early season	78.15±0.7	15.85±1.6	4.33±1.6	1.67±0.2	6.00±1.8
Mid season	70.13±3.8	18.87±2.2	7.45±1.6	3.55±0.7	10.00±1.2
Late season	18.43±0.9	60.63±1.6	16.84±1.2	4.10±0.7	20.94±1.6
L.S.D. 0.05	3.15	1.89	2.18	0.89	3.08

The percentage of unmarketable fruits was higher in samples collected during mid and late seasons than that of early season. This increment might be due to the reduction of sound fruits percentage in these periods in comparison with the early season.

Generally, total losses increased gradually during early, mid and late seasons cracked fruits was the major cause of total loss percentage especially at the late season. This may be due to the irregular irrigation and fertilization [2].

Quality losses of Manfalouty pomegranate fruits during handling and marketing i.e. physical properties fruit weight loss, unmarketable and total fruit losses. Also peel, Arile and juice percentage were studied. In Table 3 the total losses increased significantly from the whole to the retail market during early, mid and late

season in both seasons of study. The main causes of losses due to fruit weight loss and shrinkage (unmarketable fruits). These results indicated a direct correlation between display period and temperature (2 days at wholesale and 6 days at the retail market. These results were supported by Fawole and Opara [10] and Arends et al. [11] they illustrated that repeal moisture loss is among the main quality problems affecting post-harvest life of pomegranate fruits. Also, on top of losing marketable fruit weight, fruit that lose moisture above 5% will shrivel, and this reduction due to their visual appearance and commercial value.

Table 3. Total losses of marketable pomegranate fruits during market chain during 2017 and 2018 seasons.

Source of samples	Early season			Mid season			Late season		
	First Season 2017								
	Un-market	Weight	Total losses	Un-market	Weight	Total losses	Un-market	Weight	Total losses
Orchard	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0
Whole sale	0.0±0.0	4.7±0.3	4.7±0.1	0.0±0.0	4.2±0.2	4.2±0.1	0.0±0.0	3.5±0.1	3.5±0.2
Retail sale	11.2±0.2	8.3±0.3	19.5±0.1	12.2±0.2	10.1±0.1	22.3±0.3	6.3±0.3	6.6±0.4	12.9±0.1
L.S.D. 0.05	1.31	1.31	1.46	1.05	1.32	2.71	0.39	0.73	2.27
	Second Season 2018								
Orchard	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0	0.0±0.0
Whole sale	0.0±0.0	4.7±0.2	4.7±0.1	0.0±0.0	4.2±0.2	4.2±0.1	0.0±0.0	3.8±0.1	3.8±0.4
Retail sale	11.4±0.4	10.6±0.4	22.0±2.0	12.5±0.5	11.4±0.6	23.9±3.0	7.9±1.0	7.0±1.5	14.9±2.0
L.S.D. 0.05	1.83	1.44	3.46	3.27	1.79	3.46	1.31	1.13	1.33

Table 4. Changes of physical properties peel %, arile % and juice % of pomegranate fruit during marketing chain during 2017 and 2018 seasons.

Source of samples	Early season			Mid season			Late season		
	First Season 2017								
	Peel %	Arile %	Juice %	Peel %	Arile %	Juice %	Peel %	Arile %	Juice %
Orchard	39.8±1.0	60.2±1.0	67.3±0.0	41.8±1.0	58.2±0.2	70.5±0.5	45.4±0.4	54.6±0.3	71.7±0.1
Whole sale	38.0±0.5	62.0±1.0	67.2±0.2	40.1±1.0	59.9±1.0	70.0±1.0	45.8±0.2	54.2±0.2	71.6±0.2
Retail sale	34.7±1.0	65.3±1.0	65.9±1.0	34.9±1.0	65.1±0.1	69.0±1.0	43.6±0.3	56.4±0.2	69.8±0.0
L.S.D. 0.05	2.35	2.61	NS	1.30	1.50	NS	0.85	0.13	NS
	Second Season 2018								
Orchard	40.9±0.2	59.1±0.1	64.8±0.2	40.6±0.2	59.4±0.2	68.7±0.2	44.9±1.0	55.1±1.0	72.0±1.0
Whole sale	39.2±0.2	60.8±0.2	66.6±0.2	38.9±0.1	61.1±0.1	68.7±1.0	43.8±1.0	56.2±0.2	71.9±1.0
Retail sale	35.3±1.0	64.8±1.0	65.7±1.0	33.9±1.0	66.1±1.0	67.1±1.0	40.0±1.0	60.0±1.0	70.3±0.3
L.S.D. 0.05	1.38	1.28	NS	1.50	0.34	NS	2.61	2.28	NS

Table 4 illustrated losses in peel percentage from orchard to wholesale until the retail market, this may be due to fruit weight loss, temperatures and marketing period (2 days at wholesale and 6 days at retail markets) which fruit exposure to it. The data dealing with aril percentage exhibited a significant increase from harvest till the retail market, this increases unreal but may be due to an increase in fruit weight loss during the chain market. This was observed in first, mid and late season during 2017, 2018.

There was fluctuated in juice percentage observed in samples collected from different sources orchard, whole sale and retail market. Kader and Barret [12] found that high lost percentage is related to the water loss in fresh produce it results in losses of saleable weight, appearance, nutritional quality and texture quality that

includes softening, as well as loss of crispness and juiciness. Factors such as temperature surface area, relative humidity (RH) air movement and respiration rate were influenced in transpiration rate and water loss [4].

Data presented in Table 5 summarize the change in chemical quality of Manfalouty pomegranate fruits during marketing. Total soluble solids and total soluble solids/acid ratio increased by time from harvest till retail market and from early till late season during two seasons of study. The previous results were supported by Mshraky et al. [13] who found that total soluble solids and total sugar increased with increased period of storage both at room as well as at low temperature. There was a significant decrease in total acidity from harvest till retail market; this was found for three periods of study during two seasons of study. The decrease of acidity may be due to the effect of temperature on the respiration rate of fruit [14]. The date dealing with anthocyanin showed that slight differences found between harvest and retail market with some fluctuated. This variation of red color may be due to the effect of storage temperature on the activity of the enzymes of the anthocyanin biosynthetic pathway [15].

Table 5. Changes of chemical properties (TSS, TA, TSS/TA and anthocyanin) during marketing chain during 2017 and 2018 seasons.

Source of samples	Early season				Mid season				Late season			
	TSS	TA	TSS/TA	Antho-cyanin	TSS	TA	TSS/TA	Antho-cyanin	TSS	TA	TSS/TA	Antho-cyanin
First Season 2017												
Orchard	15.96 ±0.0	1.22 ±0.2	13.21 ±1.0	60.53 ±1.0	16.08 ±1.0	1.25 ±0.1	12.90 ±1.0	54.84 ±0.0	16.86 ±1.0	1.02 ±0.2	16.63 ±0.0	60.14 ± 0.1
Whole sale	15.98 ±1.0	1.20 ±0.2	13.43 ±0.0	60.5 3±1.0	16.08 ±1.0	1.12 ±0.1	14.68 ±0.0	54.84 ±0.0	16.86 ±1.0	1.01 ±0.1	16.87 ±1.0	60.14 ± 0.1
Retail sale	16.30 ±0.3	1.00 ±0.0	16.48 ±1.0	59.10 ±0.1	16.83 ±1.0	0.87 ±0.0	19.42 ±1.0	55.02 ±2.0	17.22 ±0.2	0.92 ±0.2	18.76 ±1.0	59.44 ± 0.4
L.S.D. 0.05	NS	NS	1.31	1.18	NS	0.21	NS	1.31	NS	0.04	NS	0.39
Second Season 2018												
Orchard	16.18 ±0.2	1.36 ±0.2	12.05 ±1.0	58.26 ±0.3	16.26 ±1.0	1.19 ±0.1	13.76 ±1.0	55.65 ±1.0	17.08 ±0.1	1.06 ±0.1	16.26 ±0.3	62.42 ± 0.4
Whole sale	16.18 ±0.2	1.33 ±0.3	12.31 ±0.3	58.26 ±0.0	16.32 ±0.3	0.95 ±0.0	17.41 ±0.0	56.80 ±0.1	17.08 ±1.0	0.95 ±0.0	18.06 ±1.0	62.42 ± 2.0
Retail sale	16.44 ±0.0	1.07 ±0.1	15.69 ±1.0	59.00 ±1.0	16.98 ±0.0	0.85 ±0.1	20.4 ±0.4	55.45 ±0.4	17.42 ±0.0	0.88 ±0.0	19.81 ±1.0	62.53 ± 0.3
L.S.D. 0.05	NS	0.46	2.30	NS	NS	0.19	1.64	NS	NS	NS	2.29	NS

Table 6. The change in weight loss %, discarded fruit % and total losses of cold storage during 2017 and 2018 seasons.

Storage period	First Season 2017			Second Season 2018		
	Weight loss %	Discarded fruit %	Total losses	Weight loss %	Discarded fruit %	Total losses
At harvest	0.00±0.0	0.00±0.0	0.00±0.0	0.00±0.0	0.00±0.0	0.00±0.0
After one month	4.10±0.9	3.70±0.3	7.80±0.2	5.30±0.3	6.67±1.0	11.9±71.0
After two month	6.70±2.2	10.20±1.2	16.90±1.2	8.20±0.2	14.12±2.3	22.34±1.0
After three month	19.70±0.8	20.70±1.2	40.40±1.4	11.68±1.0	20.74±1.5	32.47±1.0
L.S.D. 0.05	1.17	1.51	2.08	0.68	0.71	0.76

Results presented in Table 6 exhibited a significant increase of fruit weight loss, discarded and total losses with advancing storage period. The data revealed that fruits stored for 3 months had the significant highest value of weight loss, discarded and total fruit losses. The main cause of discarded fruits due to internal

chilling injury browning color of fruit. For these reasons, the storage life of fruits should be two months at 5±1°C and relative humidity (85-90%). The results were similar in two seasons of study. These results are in agreement with those reported by Sercan et al. [16] who found that pomegranate cultivars were monitored at refrigeration temperature for two months.

Effect of storage at 5±1°C on juice percentage, total soluble solids, titratable and total soluble solids/ treatable acidity percentage of pomegranates fruits are shown in Table 7. The data showed a slight decrease of juice percentage of stored fruits at the end of storage in comparison of fruit at harvest similar results were found in two seasons. Concerning the effect of storage on acidity percentage in stored fruits were significantly decreased gradually than the beginning of storage during the first and second seasons. The data in Table 7 illustrated that total soluble solids and TSS/acid ratio of fruits increased with a prolonged storage life of fruits especially at the end of storage. These changes in chemical properties due to develop fruits from ripe to over ripe. The previous results were supported by Mshraky et al. [13] and Abd-El-Maaboud et al. [14].

Table 7. The change in juice %, TSS, TA and TSS/TA of Manfalouty pomegranate fruits during cold storage during 2017 and 2018 seasons.

	First Season 2017				Second Season 2018			
Storage period	**Juice %**	**TSS**	**TA**	**TSS/TA**	**Juice %**	**TSS**	**TA**	**TSS/TA**
At harvest	70.3±0.4	15.6±0.2	1.21±0.2	12.9±1.0	67.1±0.2	15.9±0.2	1.03±0.1	15.4±0.3
After one month	70.2±0.3	15.9±0.1	0.97±0.0	16.3±0.3	67.1±0.1	16.1±0.1	0.96±0.0	16.8±0.1
After two month	70.1±1.1	16.6±0.2	0.96±0.0	17.3±0.7	67.0±1.0	16.4±0.4	0.89±0.1	18.5±0.2
After three month	69.9±0.1	16.9±0.1	0.82±0.5	20.6±1.2	66.7±0.1	16.9±0.1	0.80±0.1	21.2±0.1
L.S.D. 0.05	NS	0.27	0.07	1.43	NS	0.50	0.09	0.97

4. CONCLUSION

Manfalouty pomegranate fruits should be picked during early and mid-season, and not extended to late-season, in order to avoid increased post-harvest losses. Moreover, when storing the fruits, the cold storage period should not exceed than two months, in order to preserve the quality of the fruits and get the least percentage of losses.

Authors' Contributions: AHAM designed the experiment, performed the practical work. SGEEl-O wrote and revised the manuscript. AMH helped in the manuscript reviewing. The final manuscript has been read and approved by all authors.

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