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Evaluation of Quality of Storage of Prickly Pear (Opuntia Ficus Indica (L.)) Using Two Packaging Methods

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Abstract

This research conducted (1) Objectives: to study the effect of preservation methods and packaging materials on quality and safety of Prickly pear (PP) during storage period. Across sectional descriptive study conducted on Palestine. (2) Materials and Metheods: Fruits were hand-harvested, divided to Control and Storage in refrigeration at 8oc grouped with two material packaging in plastic (Polystyrene, Polyethylene terephthalate) and Carton (Tissue paper, Kraft paper). The fruits stored for three months, chemical and microbial quality were evaluated at zero time and during of storage. (3) Results: the samples that wrapped by tissue paper showed gradually significant decrease in Total Sugar and Brix by increase in time during storage, and the samples were deteriorated as it is fall to 8.43 (P≤ 0.05) after second month. The samples that wrapped in Kraft paper also showed slightly decreases in the total sugar, Protein was not affected by the storage period in refrigeration, all samples showed gradually significant decrease (P≤ 0.05) in pH with statistically significant. Visual symptoms of chilling injury on fruits were appeared after the second month of storage in refrigeration. (4) Conclusion: wrapping by Kraft paper kept the PP fruits in refrigeration without spoilage for two months.

Keywords: Fruit packaging; Kraft paper; Opuntia ficus indica; Prickly pear; Storage.

Introduction

Opuntia spp. are endemic to the tropical and subtropical Americas, where they can be found in a variety of agro climatic conditions, whether wild or farmed. cultivated and wild plants continue to offer food and resources, transported by people as they traded and settled (Kader, 2000). Cactus is well established in most West Asian countries, primarily for fruit production, an increase in the crop's popularity Because of the low input

requirements and great endurance to harsh environments, governments and farmers have become more interested in farming cactus as a high water-use efficiency crop to improve local fruit consumption in recent years. Although Opuntia traditionally eat fresh in summer, it is hardly used in modern nutrition and medicine. Producers determine harvest time (ripeness for consumption) in the field depending on the color and texture of the fruit. The pH level changes with ripening progresses, that fact was fixed by Moßhammer et al., (2006) changes occur in the pH and TSS during ripening,

Chiteva & Wairagu (2013) reported that, the fruits irrespective of the origin or variety, are a good natural reservoir of minerals. The fruits is generally consumed fresh, but they are highly perishable, and usually can show spots and rot due to decay after nine days of storage at ambient temperature 19±5 ◦C (Hahn-Schlam et al., 2019). When the peel color is intermediate between that of completely ripened fruit and TSS is 12–15% depending on the variety. Total sugars (TS) for fruit pulp, TS in the control samples in zero time (13.27 %) with sweet taste which in agreement with (Piga, 2004; Yahia, 2012) This is when the fruit is at its best for consumption or storage. Although the TSS in fully ripened fruit increases somewhat, the fruit is no longer in acceptable storage condition and is too mushy to handle (Deane et al., 2015).

El-Samahy et al., (2006) analyse the PP, low acidity and high pH values ranging between 0.049% to 0.057% and 6.00 to 6.20, respectively. Protein is one of the highly important nutrients, the edible pulp is rich in amino acids as noted by (Kamble et al., 2017; Moßhammer et al., 2006). However, the success of storage depends on several factors, including the cultivar, storage atmosphere, orchard management practices (especially irrigation and mineral nutrition), and fruit maturity stage (Zegbe et al., 2015). Postharvest treatments that reduce transpiration rate or make the transpiration process more even on fruit surface may reduce the severity of chilling injury and make the fruit more tolerant to low storage temperatures (Schirra et al., 1997). Storage at high relative humidity, film wrapping, hot water dips, high temperature conditioning and intermittent warming are the postharvest practices reduce transpiration rates. Cantwell, (2016) however, the Fruit packed according to color, size, and condition in 4.5 kg cartons, or packed in single or double layer tray cartons. Large fruit wrapped in tissue paper to reduce scuffing and other physical injury or packaged in cartons with perforated plastic liners to reduce water loss under dry storage conditions. Piga et al., (2000) conclude that, quality of peeled cactus pear fruits placed in polystyrene trays and packaged with a heat-shrinkable film, can be maintained at 4°C for 8 days, while abuse of temperature (15 °C) limits shelf-life to 4 days. Nanda et al., (2001) studied the effects of individual shrink film wrapping with two polyolefin films and skin coating with a sucrose polyester on the shelf life and quality of pomegranates, found that the decrease in acidity significantly less in wrapped than in non-wrapped fruit. So the current study aimed to found the easy package in storage process of OFI for straighten its shelf life with keeping quality and freshness.

Materials and Methods

1. Geography and Climate Conditions

Palestine located in Central of West Asia, Middle East. The climate of the Mediterranean region, warm to hot dry summers, cold rainy winters. Temperate, mild rainy winter, dry warm to hot summers in July and Aug the average annual temperature is 25.4, 25.8°c respectively, with mean Relative Humidity 71% (PCBS, 2009).

2. Experimental Design and preparation of samples

This study was subject of a cross sectional descriptive study conducted on Gaza. From a commercial farm located in North Gaza, Palestine. 40 kg of fruit samples with an average weight of 171.19 g. were hand-harvested using knife on 26-July 2020 at the commercial ripening stage. Once in the field, the spines of fruits were removed with a brush machine (local made). Fruits selected based on the absence of visual defects and by homogeneous size, carefully rotating the fruit off the cladode and using knife to cut a very small amount of the mother cladode attached and packed in the cardboard box. This technique has used effectively to reduce harvest damage. After harvest, fruits immediately transported to laboratory, selected to eliminate unripe and damaged fruits, divided into two groups, the first is a control and the else for saving by refrigeration at 8°c.

2.1 Packaging, storage and inspection

The Control samples laid out on cardboard at room temperature, the fruits has displayed with space. The second treatment was stored in refrigeration, Fruits wrapped with paper and packaged in boxes. the fruits packed into two (plastic) packaging material, as follow. i) Polyethylene terephthalate (PET). ii) whole fruit placed in polystyrene tray, covered with PVC shrink. The third treatment was stored in refrigeration , the fruit packed into (carton) packaging material, as follow: i) Wrapped with Tissue Tall (Fold Napkin for Fast Food) & packed in Paper cup with following specification: type Specialty paper, coated, single side waterproof coated with PE, Pulp Material is wood pulp, food grade. ii) Each fruit wrapped with Kraft paper, put in aluminum foil bag and placed in cardboard at refrigeration storage conditions.

2.2 Chemical analysis

The edible portion analyzed in triplicates, for its chemical and nutritional content. The moisture (Method-925.09), ash contents (Method-930.05), Total protein (Method-950.48), and reducing sugars. all measured according to the method as described in the Association of Official Analytical Chemists techniques. (AOAC, 2005). Data of total soluble solids (TSS) were obtained in pulp samples using a bench refractometer (Abbe Mark 11, Reichert-Jung NY, USA) according to (AOAC, 1990) method 932.12 and expressed as °Brix. The pH and acidity determinations. Direct measurements of pH were done in homogenates of pulp with a potentiometer (Thermo scientific potentiometer). Titratable acidity was determined at room temperature by titration of 10 mL PP sample. The data was obtained according to 945.26 method (AOAC, 1990), and the results were expressed as citric acid content ($mg \cdot g^{-1}$ fresh weight (d.w.).

Results and Discussion

1. Moisture

Table 1 represent the percentage of moisture content in the OFI that in fresh flesh fruit samples in zero time 86.83%. proximately similar results were obtained by Nada, (2005), Moßhammzer et al., (2006) 85%, 84.13% and 85% respectively. But its differ with Muñoz de Chávez et al., (1995) and Patil et al., (2019) as they recorded 91 % and 88.96 % respectively, and less than Salim et al., (2009) 84.14%. for three months, control sample show significant increase (P≤ 0.05) in moisture content during storage, which 86.83 % in zero time and 89.13% in third month. The exposure to low temperature, there were gradually increase in moisture content by increase in time. After one month of storage, the samples has high amount of water in the pulp. Continually increased to 91% after the second month, but at the third month the sample deteriorated and the moisture returned to 89.13%. The decrease of water content become together with a drop of weight. These findings agreed with Schirra et al., (1997) who detected that, without refrigeration, fruit senesce rapidly and become susceptible to infection by microorganism.

Table 1. Effect of Refrigeration, packaging materials and storage period on (moisture %) of PP

Storage periods	control	Carton		Plastic		Overall mean of packaging
		Tissue paper	Kraft paper	PET	PS& PVC	
Zero time	86.83^{b} ±1.76	86.83^{c} ± 1.76	86.83^{b} ±1.76	86.83^{b} ±1.76	86.83^{b} ± 1.762	86.83^{A}
After one month	88.50^{b} ±0.75	90.03^{b} ± 1.05	87.93^{b} ±0.15	88.20^{b} ±0.361	89.03^{a} ± 0.153	88.74^{A}
After two month	91.00^{a} ±1.83	91.33^{a} ±0.83	89.83^{a} ±0.05	90.53^{a} ±0.45	90.30^{a} ±0. 72	90.06^{A}
After three month	89.13^{a} ±0.80	92.60^{a} ± 0.30	89.43^{a} ±0.89	91.47^{a} ±1.41	90.13^{a} ± 0.902	90.55^{A}
Overall mean of storage periods	88.87^{B}	90.20^{A}	88.51^{B}	89.26^{A}	89.08^{A}	
CV %	4.682	3.714	3.361	3.923	3.5563	
$Lsd_{0.05}$	2.106	1.665	1.505	1.772	1.6036	
S.E. ±	0.160	0.103	0.081	0.113	0.0929	

*Means in the same column and same row with different letters are significantly different (P< 0.05) according to least significant test (LSD). **Each value in the Table is a mean of three replicates ±S.D

The samples that wrapped by tissue paper showed also gradually significant increase in moisture content by increase in time during storage after first month (P≤ 0.05), while, nonsignificant after two, three months. The samples that wrapped in Kraft paper + aluminum bag also slightly increases the moisture content from 86.83 to 89.43% with nonsignificant. About the samples packed in plastic that put in (PET) and the second conducted in (PS) foam and filmed by (PVC), have the same results of moisture content. changes on Total soluble solid (TSS)

for fruit pulp in the control samples, the TSS in zero time (14.33 Brix) is in agreement with Piga, (2004) who reviewed that fruit has no distinctive aroma,. Effect of storage on Brix were clear that gives decrease of sweet taste from zero time (14.33 Brix) to 12.47, 8.50, 8.1 after first, second, and third months respectively in the control samples but the samples were deteriorate after the second month. On the other hand, Results in Table 2 represent the effect of (refrigeration), packaging in carton (TPC), (KPF) and plastic (PET) and PS with PVC (PSPVC) during the storage period on Brix. The results indicate that storage in low temperature lead to decrease in TSS content of PP, control sample show significant decrease (P≤ 0.05). The samples that wrapped by tissue paper and put in carton there were also gradually significant decrease in TSS by increase in time during storage after first month from 14.33 to 10.97 (P≤ 0.05), while, nonsignificant after two months, then it falls to 8.7 (P≤ 0.05) after three months and deteriorated. The samples that wrapped in Kraft paper pouched in aluminum bag also showed slightly decreases in the TSS content from 14.33 to 10.27, 10.2 and 9.3 after one, two and three months respectively with non-statically significance, these samples remained good condition in appearance and texture up to two months then deteriorated after two months. While, the samples which packed in (PET), the results indicate that exposure to low temperatures for (three months) lead to decrease in TSS content of PP during storage after first month from 14.33° to 12.8° (nonsignificant), while, it is 9° and 9.2° (P≤ 0.05) after two and three months respectively. The samples which packed in PS and wrapped with PVC had obtained the same results (10.77°,9°,9.33°) respectively with non-statistical significant.

Table 2. Effect of Refrigeration, packaging materials and storage period on (Brix %) of PP

Storage periods	control	Carton		Plastic		Overall mean of packaging
		Tissue paper	Kraft paper	PET	PS& PVC	
Zero time	14.33^{a} ±1.154	14.33^{a} ± 1.154	14.33^{a} ± 1.154	14.33^{a} ± 1.154	14.33^{a} ± 1.154	14.33^{A}
After one month	12.47^{b} ±0.737	10.97^{b} ± 0.057	10.27^{b} ±0.404	12.80^{a} ±1.9287	10.77^{b} ± 1.050	11.45^{B}
After two month	8.50^{c} ±0.519	10.63^{b} ±0.404	10.20^{b} ±0.200	9.00^{b} ±0.200	9.00^{c} ±0.100	9.47^{C}
After three month	8.17^{c} ±0.305	8.70^{c} ± 0.100	9.30^{b} ±0.557	9.20^{b} ±0.173	9.33^{c} ± 0.351	8.94^{C}
Overall mean of storage periods	10.87^{B}	11.16^{A}	11.03^{A}	11.33^{A}	10.86^{B}	
CV %	20.659	16.518	18.488	29.9577	22.1459	
$Lsd_{0.05}$	1.1364	0.9331	1.0318	1.7187	1.2173	
S.E. ±	0.0466	0.0314	0.0384	0.106736	0.0535	

*Means in the same column and same row with different letters are significantly different (P< 0.05) according to least significant test (LSD). **Each value in the Table is a mean of three replicates ±S.D

2. Total sugars

The fruit is the most interesting part of the plant given its low acidity and useful sugar content. Table3 represent the changes on Total sugars (TS) for fruit pulp, TS in the control samples in zero time (13.27 %) with sweet taste which in agreement with (Piga, 2004; Yahia, 2012) that the fruit is very sweet, TS ranged 10-17% and 12-16% respectively. This sweet taste was duo to the sugar component is primarily glucose and fructose in similar amounts as obtained by Piga, (2004), or the highest sugar amount are glucose and fructose (29 and 24%, respectively) in the pulp, as registered by Salim et al., (2009), also, fruit pulp is rich in polysaccharides as indicted by Moßhammer et al., (2006). The results of Total Sugar in pulp of edible part in orange pulp fresh samples was less than those represented by (Moßhammer et al., 2006; Sáenz & Sepúlveda, 2001) which approximately 15% sugar. There is no significant effect between film wrapped in the two varieties of plastic or put in carton, this agree with Nanda et al., (2001) who reported no significant effect between film wrapped and non- wrapped pomegranate fruits on TSS and TS content, while, it is significant between variables, which packed in carton, and plastic.

Table 3: Effect of refrigeration, packaging materials and storage period on (Total sugar %) of PP

Storage periods	control	Carton		Plastic		Overall mean of packaging
		Tissue paper	Kraft paper	PET	PS& PVC	
Zero time	13.27^{a} ± 0.252	13.27^{a} ± 0.252	13.27^{a} ± 0.252	13.27^{a} ± 0.252	13.27^{a} ± 0.252	13.27^{A}
After one month	10.43^{b} ±0.586	9.02^{b} ± 0.208	8.90^{b} ±0.105	8.80^{b} ±0.006	8.70^{b} ± 0.095	9.17^{B}
After two month	8.80^{c} ±0.500	8.43^{c} ±0.479	8.05^{c} ±0.150	7.87^{c} ±0.152	8.40^{b} ±0.608	8.31^{C}
After three month	8.63^{c} ±0.902	7.07^{d} ± 0.473	7.65^{c} ±0.431	7.13^{d} ±0.115	6.87^{c} ± 0.252	7.47^{C}
Overall mean of storage periods	10.28^{A}	9.45^{B}	9.47^{B}	9.27^{C}	9.31^{C}	
CV %	17.685	11.871	8.4349	5.1205	11.4605	
$Lsd_{0.05}$	0.9207	0.5676	0.4042	0.2401	0.53998	
S.E. ±	0.0306	0.0116	0.0059	0.0020	0.0105	

*Means in the same column and same row with different letters are significantly different (P< 0.05) according to least significant test (LSD). **Each value in the Table is a mean of three replicates ±S.D

Decrease in TS content of PPF, control sample showed significant decrease (P≤ 0.05). The samples that wrapped by tissue paper and put in carton showed also gradually significant decrease in TS by increase in time during storage after first month from 13.27 to 9.02, 8.43 and 7.07 respectively with statistically significant in all periods, and deteriorated when it is fall to 8.43 (P≤ 0.05) after second month. The samples that wrapped in Kraft paper also showed slightly decrease in the TS content from 13.27 to 8.9, 8.05 and 7.65 after one, two and three months respectively with statically significant, these samples remained in good condition in appearance and texture up to

50 days -two months. Samples packed in plastic (PET) during the storage period, results indicate that prolonged exposure to low temperature decrease in TS content of PPF after first month from 13.27° to 8.8° (nonsignificant), while, it is 7.87% and 7.13 (P≤ 0.05) after one, two and three months respectively. The samples which put in PS and wrapped with PVC had obtained the same results (8.7, 8.4% respectively with non-statistical significant after one and two months, the decrease continuous to 6.87% after three months with significant. This finding disagree with Anorve Morga et al., (2006). The changes undergone by the products at the beginning of storage and after 12 days showed that the total sugars content increased to above 10ºC.

3. Protein

Figure 1 represent the changes on protein in edible pulp during the period of storage in different conditions, the protein content in zero time (1%) similarly findings of Muñoz de Chávez et al., (1995) which revealed that, proteins in cactus pear are similar to other fruits, the contents of protein is (0.21–1.6 g [100 g]$^{-1}$). Also, in agreement with Dhar (2021) who found that the Nutrient Content of PP is 1.1 (per 100gm of edible portion). While it is less than findings by Nada, (2005) who detect Protein contents of 1.25%, and more than the percentage of protein recoded by Sáenz & Sepúlveda, (2001) in edible part of cactus pear 0.82% protein, and the results by Moßhammer et al., (2006) less than 1% protein.

The percentage of protein showed no significant variation during the period of storage, there was slightly increase from zero time (1%) to 1.1, 1.11% after first and second month, but dropped to 0.86% after three months of storage with significant in the control samples, contamination such as growth of fungi were observed on samples after the second month.

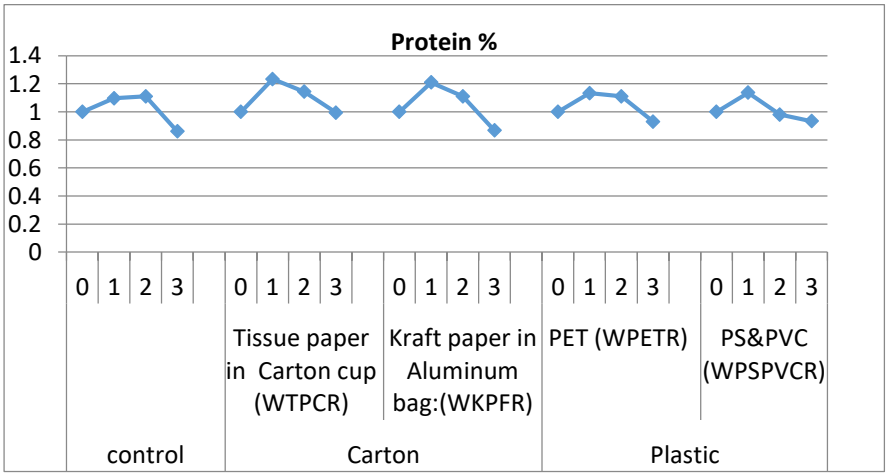

Figure 1: Effect of packaging materials and storage period on (Protein %) of PP.

Figure 1 represent the effect of refrigeration, packaging in carton (TPC) and (KPF) and plastic (PET) and PS with PVC (PSPVC) during the storage period on protein in the edible part of PPF. The results indicate that storage cause to decrease in protein content, control sample was stable with significant after third month (P≤ 0.05). The samples that wrapped by tissue paper and put in carton showed also gradually significant increase in protein after first month but decreases in time during storage after second and third month from 1.14 to 0.99 (P≤ 0.05). The samples that wrapped in Kraft paper was also the same, these samples remained in good appearance and texture

up to two months then deteriorated after two months.

The results indicate to decrease in protein content of samples packed in (PET) by increase in time during storage, after first month from 1.0 to 1.13% (nonsignificant). The samples deteriorate after one month, the protein reduced to 1.11 and 0.93 % after two and three months respectively with significant ($P \leq 0.05$). The samples which put in PS and wrapped with PVC showed the same results from 1 to 1.14% after the first month, after the second and third month it is reduce to 0.98 and 0.93% respectively with non-statistical significant, however, at this point the samples were deteriorated before other method of packaging. In conclusion, the packaging in PET and preservation in refrigeration is preserving PPF for up to one month. Also, there is no significant effect between films wrapped in the two varieties of plastic or packaging in carton, while, it is significant between variables, which packed in carton, and plastic.

Image captions Picture 1: Wrapped with Kraft paper and packed in aluminium foil bag. The photo after 50 days of zero time

Conclusions

This study has performed an easy way to store PP for consumption where possible; the control samples were saved for one month as whole in room temperature in a good place. The samples that were wrapped in Kraft paper, kept acceptable percent of TS and remained with good appearance and texture up to two months. Samples that wrapped by tissue paper and put in cardboard boxes and the samples that packed in the PET were deteriorated after one month of storage.

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