Effect of Cold storage and packaging to improve the quality of local orange fruits after harvest

Dr.Khalid Naji Abd Asl **Abdulmuhsen Jaber Ahmed**

E mail: khaildasal@tu.edu.iq

Abstract:

This study was carried out using two home-based refrigerators with a volume equal to 377 L each. The storage duration of local orange fruits was five months, ranging from 1/12/2019 to 1/5/2020. An experiment comprised two factors, including two levels of storage temperature at five °C and ten °C and three different types of packaging; non-packaging, packaging with a polyethene bag and packaging with a paper bag. The experimental design is a completely randomized design with five replications per treatment. *The mean values were compared* using *Duncan's test* at a significance level (P=*0.05*). Results showed that storage at five °C reduced the weight loss% and fruit damage% to 56.16% and 16.79%, respectively. As for the packaging factor, paper bags showed the lowest value of weight loss fruit damage and the highest value of fruit juice was recorded, 11.18%, and 41.52%, respectively.

Regarding the interactions between storage temperature and packaging types, the treatment combinations, five °C with paper bag packaging, achieved the lowest weight loss and fruit damage and the highest rate of fruit juice with percentages equal to 2.7%, 9.79, and 41.52%, respectively. The same trend is actual for a combination of storage temperature at ten °C with paper bag packaging gave the highest percentage of fruit juice, 41.52%. Various storage temperatures at ten °C and polyethene bag packaging revealed the highest ratio of total sugars, reaching 11.34%.

INTRODUCTION

Citrus sinensis L. Osbeck, belongs to family Rutaceae and is of the citrus genus. The quality of fresh fruit depends on post-harvest handling, transportation and storage. Storage is recognized as one of the essential operations, insufficient storage results in losses in quantity and quality of fruits [1]. Estimates of post-harvest crop losses about 30-40% of total fruits and vegetable production is lost between harvest and final consumption [2]. Temperature and humidity are essential factors in post-harvest storage conditions to maintain quality and prolong storage and shelf life. Post-harvest water loss softens the fruit and reduces shelf life [3]. Using appropriate storage practices is essential in maintaining high-quality fruits. The temperature reduces the spread of microorganisms which attack fresh produce quickly upon storage at low temperatures, as these organisms multiply and spread quickly at high temperatures, as well as reduce or prevent weight loss as a result of moisture loss which is not compensated after harvesting and the rate of respiration. It also reduces respiration rate and heat-release RH as the storage at high temperature causes brown and green mold infestation and increases the moisture loss of the fruit [4]. Packaging is an important stage of the storage process to protect the product against damage. Many packages are designed to facilitate the cooling process, and perforated packaging materials are recommended to eliminate the excess heat and humidity of produce during storage [5] added as [6] the increase of storage temperature of lemon fruits at 5, 10, and 15 °C led to the rise in the rate of weight loss. The same result was obtained by [7] upon storing grapefruit at the following temperatures 5, 10 and 15 °C. As reported by [8], the rate of weight loss of lemon fruits stored at two °C and 13°C increases with the increase of storage temperature with values equal to 5.8 and 12%, respectively.

ISSN 2072-3875

Higher rates of weight loss were observed at the end of the storage period at 13°C compared to those stored at 2°C. As a result, cold-damaged fruits showed higher moisture loss than healthy fruits due to increased respiration rates at higher temperatures. Storage of Shamouti orange at 5 ° C and 98% relative humidity in various polyethene bag types showed an approximate five-fold reduction in moisture loss after 35 days [9]. After storing local orange fruits at 4 ° C for three months, the rate of weight loss increases with the advancement of the storage period, as the loss percentage was 1.4% at the beginning of storage and reached 3.69% at its end [10]. Generally, refrigerated stores have a temperature range of 6 - 7 ° C. He mentioned [4] that There is a direct correlation between temperature and an increase in moisture loss, as the higher temperature will increase the capacity of air to carry more water vapour which will be obtained from the fruit. The high temperature of fruit increases water evaporation, especially the free water in the intersections inside the fruit, as the temperature is an essential factor in converting water from a liquid state to a gaseous state. 540 calories per gram of water are needed to convert one gram of liquid water to one gram of water vapour. The liberated heat will raise the temperature of the fruit and its components. The higher the temperature of the fruit, the greater the moisture loss. Grapefruit was stored at 10°C for 16 weeks using large and precise perforated bags and without packaging. Fruits stored in modified atmospheric packaging (MAP) reduced weight loss compared to unpacked fruits [11]. This experiment aimed to investigate the effect of storage temperature and packaging type on local orange fruit quality.

MATERIALS AND METHODS

Experimental Site

The experiment was implemented in Salah al-din governorate. The experimental material consisted of local orange fruits harvested from adult trees of 25 years old located in Balad district. Experiment duration was 5 months starting from 1/12/2019 till 1/05/2020

Experimental material

Fruits were harvested manually at the beginning of colouring stage (green to yellow colour) from adult trees with great care to avoid mechanical damage. Harvested fruits were transported by refrigerated vehicle. Fruits were stored at conditions 5 °C and 10 °C with relative humidity 85%.

Experimental Factors

The experiment was conducted with completely randomized design (CRD) of 2 factors with five replications. The treatment consisted of a combination of two factors:

The first factor included two levels of storage temperature 5° C and 10° C

The second factor refers to packaging consisting of 3 types: Without packaging (control), packaging with polyethylene and packaging with paper bags.

1- Storage temperature at two levels:

A) 5 °C

B) 10 °C

2- Packaging at 3 levels:

A) Without packaging
B) Packaging with polyethylene bags
C) Packaging with paper bags

Application of Packaging

Packaging of fruits with paper bags: They were then packed in 1kg containers perforated with 12 holes/bag with a diameter of 0.5 cm. Holes were made to prevent condensation of water vapour inside the containers [12].

Packaging of fruits with polyethene bags: They were then packed in 1kg containers in paper polyethene bags perforated with 12 holes/bag of 0.5 cm in diameter Holes were made to prevent condensation of water vapour inside the containers, as aforementioned.

ISSN 2072-3875

Studied Traits

The chemical and physical properties were studied at the end of storage period and the measurements were taken in 1/5/2020.

1- Weight loss%

The weight loss percentage was calculated according to the below equation as reported by [13].

$$Weight\ Loss\ \% = \frac{Fruit\ Weight\ at\ Initial\ Date\ (beginning\ of\ storage) - Fruit\ Weight\ at\ Measurement\ Date}{Fruit\ Weight\ at\ Initial\ Date\ (beginning\ of\ storage)} \times 100 \quad (1)$$

2- **Juice%**

The percentage of fruit juice was estimated using the below equation:

$$Juice\ \% = \frac{Juice\ Weight\ (g)}{Fruit\ Weight\ (g)} \times 100 \quad (2)$$

3- Microbial damage%

The fruits are considered damaged as soon as microbial infection becomes visible. Percentages of fruit damage were assessed and calculated using the following equation:

$$Microbial\ Damage\% = \frac{Weight\ of\ Damaged\ Fruits(g)}{Total\ Weight\ of\ Fruits(g)} \times 100 \quad (3)$$

A) Total reducing sugars%

Estimation of total reducing sugars using the method reported by [14].

B) **Total soluble solids%**

TSS was measured using portable refractometer as reported by [15].

C) Vitamin C content (mg/100ml)

Determination of vitamin C in fruit juice by using redox titration with 2,6-Dichloro-Indophenol as an indicator [13].

RESULTS AND DISCUSSIONS

Effect of storage temperature, packaging type and their overlap on weight Loss% in local orange fruits:

The results of Table 1demonstrated a significant difference in temperature effects on the weight loss percentage, as storage temperature at five °C recorded the lowest rate of weight loss reaching 5.6%. In contrast, the weight loss reached 6.2% upon storage at 10°C.

As Table 1 clarified the effect of packaging type on weight loss with a significant difference, paper bags showed the lowest percentage of weight loss, reaching 3.1%, followed by polyethene bags at 5.7%. Non-packaged fruit showed the highest rate of weight loss (8.9%). As for the combined effect of storage temperature and packaging type, results in Table 1 showed the presence of a significant difference, fruits stored at 5° C and packed with paper bags generated the lowest percentage of weight loss, reaching 2.7%. In contrast, storage at 10° C without packaging gave the highest weight loss percentage at 9.1%. Weight loss increases with the advancement of the storage period and the consumption of food reserve (substrate loss) in the fruit as a result of respiration [14]. This is back to low storage temperature, which provides an adequate amount of moisture in the surrounding environment of the fruits, which in turn reduces water vapour losses. At the same time, this percentage raised when the fruits were stored at 10° C as a result of

ISSN 2072-3875

carrying more significant amounts of water vapour released from the fruit to substitute water vapour pressure inside the fruit and storage environment [15], this result agrees with [17] and [6]. As for the effect of packaging type to reduce weight loss, it refers that packaging creates a modified atmosphere surrounding the fruits where higher carbon dioxide and lower oxygen percentages exist, which reduces the rate of respiration and moisture loss as the weight loss includes moisture loss and loss of substrate served in respiration [16].

Table 1. Effect of storage temperature, packaging type and their overlap on weight Loss% in local orange fruits for 5 months stored

Storage temperature (°C)	**Packaging Type**			**Effect of storage temperature (°C)**
	Non Packaged	**Polyethylene Bags**	**Paper Bags**	
5	8.8 [a]	5.3 [c]	2.7 [e]	5.6 [b]
10	9.1 [a]	6.0 [b]	3.5 [d]	6.2 [a]
Effect of Packaging Type	8.9 [a]	5.7 [b]	3.1 [c]	

Results of mean comparison using multiple ranges Duncan test at 5% probability level. Means with same letter are not significantly different. Whereas means of each group followed by different letter mean there is significant differences according to Duncan's multiple range test (P=0.05).

Effect of storage temperature, packaging type and their overlap on juice% in local orange fruits:

There was no significant difference of storage temperature effects on the juice% as shown in TABLE .2 Significant effect of packaging type on juice% was observed. Packaging with paper bags revealed the highest juice% reaching 41.52%, followed by polyethylene bags reaching 40.20%. Non packaged fruit gave the lowest percentage of juice reaching 39.71%. As for overlapping of both factors (storage temperature and package type), results indicated the presence of significant difference, storage temperature at 5° C and 10° C using paper bags gave the highest percentage of fruit juice reaching 41.52%. While the temperature at 10° C without packaging gave the lowest percentage of juice as 39.44%. The result of our study is consistent with the previous results achieved by [7], [6], and [10], as their studies on orange, grapefruit, and lemon fruits showed that juice% decreases as the temperature increases as well.

ISSN 2072-3875

Table 2. Effect of storage temperature, packaging type and their overlap on juice% in local orange fruits for 5 months stored

Storage temperature (°C)	**Packaging Type**			**Effect of storage temperature (°C)**
	Non Packaged	**Polyethylene Bags**	**Paper Bags**	
5	39.99 [b]	40.77 [ab]	41.52 [a]	40.76 [a]
10	39.44 [b]	39.64 [b]	41.52 [a]	40.20 [a]
Effect of Packaging Type	39.71 [b]	40.20 [b]	41.52 [a]	

Means with same letter are not significantly different. Whereas means of each group followed by different letter mean there is significant differences according to Duncan's multiple range test (P=0.05).

Effect of storage temperature, packaging type and their overlap on vitamin C content (mg/100ml) in local orange fruits:

The results shown in Table 3 revealed no significant difference for each of storage temperature (°C) effect and packaging type separately on vitamin C content. As for combined effect of temperature and packaging type which reported the highest vitamin C content in fruit juice reaching 35.8 mg/100ml upon storage at 10° C without packaging. Whereas storage at 5° C with polyethylene bags gave the lowest vitamin C content reaching 33.2 mg/100ml.

Table 3. Effect of storage temperature, packaging type and their overlap on vitamin C content (mg/100ml) in local orange fruits for 5 months stored

Storage temperature (°C)	**Packaging type**			**Effect of storage temperature (°C)**
	Non packaged	**Polyethylene bags**	**Paper bags**	
5	35.7 [a]	33.2 [b]	34.5 [ab]	34.47 [a]
10	35.8 [a]	35.6 [b]	33.6 [a]	35 [a]
Effect of Packaging type	35.75 [a]	34.4 [a]	34.05 [a]	

Means with same letter are not significantly different. Whereas means of each group followed by different letter mean there is significant differences according to Duncan's multiple range test (P=0.05).

Effect of storage temperature, packaging type and their overlap on total sugars% in local orange fruits:

There was no significant difference of the storage temperature effect on total sugars content as shown in Table 4. A significant difference was observed from the packaging type. Packaging with polyethylene gave the highest rate of 11.17%, followed by paper bags with a significant difference where percentage of sugars amounted to 7.35%. On the other hand, Non packaged fruits gave the lowest rate of 6.35%. As for combined effect of average storage temperature and packaging type, the highest percentage of total sugars of

ISSN 2072-3875

11.34% was recorded at 10° C using polyethylene packaging, compared to the rate of 6% obtained at 5°C and without packaging. The increase in the total sugars refers to the direct effect of temperature on this parameter through the increase of respiration rate, and thus the oxidation of sugars into simple compounds. The increase of total sugar percentage of fruits packaged with polyethylene can be explained as the respiration process consumes acids faster than sugars, thus the percentage of sugar increases [18]. The continuous loss of moisture leads to an increase in fruit juice concentration which results in an increase of sugars concentration as well. As the increase in the ratio of total sugars with the advancement of storage period was due to degradation of hemicellulose and pectin in the cell walls as the fruit ripens [19].

Table 4. Effect of storage temperature, packaging type and their overlap on total sugars% in local orange fruits for 5 months stored:

Storage temperature (°C)	**Packaging Type**			**Effect of storage temperature (°C)**
	Non packaged	**Polyethylene Bags**	**Paper Bags**	
5	6.0 [b]	11.0 [a]	8.0 [b]	8.3 [a]
10	6.7 [b]	11.34 [a]	6.7 [b]	8.24 [a]
Effect of Packaging Type	6.35	11.17 [a]	7.35 [b]	

Results of mean comparison using multiple ranges Duncan test at 5% probability level. Means with same letter are not significantly different. Whereas means of each group followed by different letter mean there is significant differences according to Duncan's multiple range test (P=0.05).

Effect of storage temperature, packaging type and their overlap on damaged fruits % in local orange fruits:

The results of TABLE .5 showed when storage increased from 5 to 10° C the damage of fruit significantly increased from 16.78 to 19.79%. Packaging with paper bags leads to significant decrease in the damaged fruits, as it achieved the lowest percentage 11.18%, followed with a significant difference by polyethylene packaging, and non-packaged treatment 15.89% and 27.75%, respectively. As for the combined effect of both storage temperature and packaging type, storage at 5°C with paper bags revealed the lowest ratio of damaged fruits reaching 9.79%, whereas storage at 10°C and non-packed fruit gave the highest rate of 29.66%. The ratio of damaged fruit decreased upon storage at low temperature (5° C) which contributes in reducing the microbial activity which can cause damages including pitting and spotting on the external layer which results in unmarketable produce, low temperature is the main factor to slow the growth rate and activities of microorganisms and pathogens. As low temperature also contributes to reduce the respiration rate, inhibit microbial activity and reduce water loss from the fruits during the storage period, for which positively correlated to reduce the ratio of the damage. These findings agree with [20,21].

ISSN 2072-3875

Table 5. Effect of storage temperature, packaging type and their overlap on damaged fruits % in local orange fruits for 5 months stored

Storage temperature (°C)	Packaging type			Effect of storage temperature (°C)
	Non packaged	Polyethylene bags	Paper bags	
5	25.84 [b]	14.56 [d]	9.79 [e]	16.73 [b]
10	29.66 [a]	17.12 [c]	12.57 [d]	18.78 [a]
Effect of Packaging type	27.75 [a]	15.84 [b]	11.18 [c]	

Means with same letter are not significantly different. Whereas means of each group followed by different letter mean there is significant differences according to Duncan's multiple range test (P=0.05).

Effect of storage temperature, packaging type and their overlap on TSS% in local orange fruits:

Results shown in table .6 revealed no significant difference of the storage temperature on the TSS%. However, there was a significant difference of the packaging type on this parameter as shown in same table. As the treatment without packaging gave the highest rate followed by paper bags and the lowest rate observed with polyethylene bags, as the ratios were 13.32, 11.52, and 11.08%, respectively. As for the overlap between storage temperature and packaging type, there was no significant difference at the end of storage period. TSS content of juice decreased upon packaging fruits with polyethylene and paper bags, this type of bags is made up of materials that creates a modified atmosphere which contributes in reducing moisture loss. Contrarily to unpackaged fruits, as water loss increases with the advancement of the storage period and increase of TSS concentration. These findings of our study are compatible with those reported by [6].

Table 6. Effect of storage temperature, packaging type and their overlap on TSS% in local orange fruits:

Storage temperature (°C)	Packaging Type			Effect of storage temperature (°C)
	Non Packaged	Polyethylene Bags	Paper Bags	
5	13.24 [a]	11.07 [b]	11.77 [b]	12.02 [a]
10	13.32 [a]	11.10 [b]	11.26 [b]	11.89 [a]
Effect of Packaging Type	13.28 [a]	11.08 [b]	11.52 [b]	

Means with same letter are not significantly different. Whereas means of each group followed by different letter mean there is significant differences according to Duncan's multiple range test (P=0.05).

ISSN 2072-3875

CONCLUSION

The temperature effect of 5 ° C and paper packaging each alone have a clear effect on reducing weight loss and improving marketing qualities as well reduced losses of fruit. The interaction also had a clear effect on reducing the fruit damage percentage.

REFERENCES

1. Tefera. A, T. Seyoum and K. Woldetsadik, "Effect of disinfection, packaging, and storage environment on the shelf life of mangos," Biosystems Engineering, (2007), 96(2): pp. 201-212.

2. Salami.P, H. Ahmadi, A. Keyhani, and M. Sarsaifee, "Strawberry post-harvest energy losses in Iran," *Researcher*, (2010), 2(4): pp. 67-73.

3. Smith, D. L., J. R. Stommel, R. W. M. Fung, C. Y. Wang, and B. D. Whitaker. 2006. Influence of cultivar and harvest method on postharvest storage quality of pepper (*Capsicum annuum* L.) fruit Postharvest Biology and Technology, 42: 243-247.

4. Al-Shemmar, G.N. Care and Storage of Horticultural Crops. 1st Ed. Diyala University- College of Agriculture, Ministry of High Education and Scientific, Iraq (2017).

5. Alsadon, A.A. and A. M. Alhamdan. Post-harvest Techniques of Horticultural crops. Saudi Society of Agricultural Sciences-Scientific publications-series. Issue No. 20 (2011).

6. Al-Hiti.S. M. J., "Effect of packaging type and temperature on storage susceptibility of local limes (*Citrus lemon*)," *Iraqi Journal of Agricultural Sciences* (1995), 26 (2): pp. 92-100.

7. Al-Ani and M. Rajab, "Effect of package type and temperature on storage susceptibility of local grapefruit (Citrus paradise)," *Iraqi Journal of Agricultural Sciences* (1998), 47(2): pp.72-130.

8. Cohen.E, B. Shapiro, Y. Shalom and J.D. Klein, "Water loss: A Nondestructive indicator of enhanced cell membrane permeability of chilling injured *Citrus* fruit," *Journal of the American Society for Horticultural Science*, (1994), 119 (5): pp. 983-986.

9. Ben Yehoshua.S, J. Peretz, R. Moran, B. Lavie, and J. J. Kim, "Reducing the incidence of superficial flavedo necrosis (noxan) of 'Shamouti' oranges (*Citrus sinensis*, Osbeck). Postharvest Biology and Technology, (2001), 22(1): pp. 19-27.

10. Al-Jubouri, M. Qasim and S. M. J. Al-Hiti. The effect of individual packaging and temperatures on the storage characteristics of the local orange fruits *Citrus sinensis* L. Iraqi Journal of Agricultural Sciences (1995), 36 (2): pp.109-118.

11. Chaudhary.P. R, G. K. Jayaprakasha R. Porat and B. S. Patil, "Influence of modified atmosphere packaging on 'Star Ruby' grapefruit phytochemicals," *J. Agric. Food Chem.*, (2015), 63 (3): pp. 1020–1028.

12. Singh.D, and G. Mandal, "Post-harvest quality and spoilage of peach fruits stored in perforated poly bags," *Indian Journal of Horticulture*, (2006), *63*(4), 390-392.

13. Ranganna, S. 1977. Manual of analysis of fruit and vegetable products. Tata Mc Graw Hill Publishing Company Limited,New Delhi.

14. Joslyn, M. A. 1970. Methods in Food Analysis, Physical Chemical and Instrumental Methods of Analysis. 2nd ed. Academic Press, New York and London.

15. Kitinoja, L. and A.A. Kader. 2003. Small-Scale Postharvest Handling Practices: A Manual for Horticultural Crops (4th Edition) University of California, Davis, Postharvest Technology

ISSN 2072-3875

Research and Information Center. Postharvest Horticulture Series No. 8E.

16. Al-Issawi S.A.A.S. 2004. The effect of gibberellin, licorice extract, storage temperature on yield, and its properties for date palm cultivars. M.Sc. Thesis, College of Agriculture, University of Baghdad, Iraq.

17. Tain and D. Ahmed, "Effect of package type and storage temperature on the specific characteristics and storage behavior of the date palm fruits (Barhi variety)," Master's Thesis - College of Agriculture - University of Basra- Iraq (2005) 4: pp. 1-2

18. Al-Jebori, M.K. and S. M. J. Al-Hiti. "Effect of paraffin wax and storage temperature on (*Citrus reticulata* L.) local variety" *Iraqi Journal of Agricultural Sciences*, (1995) 26 (2): pp. 102-108.

19. Chen.J. L, J. H. Wu, Wang, Q., Deng, H., and X. S. Hu, "Changes in the volatile compounds and chemical and physical properties of Kuerle fragrant pear (*Pyrus serotina* Reld) during storage," *Journal of agricultural and food chemistry*, (2006), *54*(23): pp. 8842-8847.

20. Binyamin, N. Daoud, H. Abdel-Rahman, Al-Shaker, S. Abdel-Hamid, M. S. Seera and T. K. Ibrahim, "The cold storage of palm fruits in the wet stage. 1- Determine the appropriate varieties and storage period." *Journal of Agricultural Research and Water Resources*, (1984) 4 (2): pp. 209-229.

21. Binyamin, N. Daoud, M. S. Al-Khalidi, H. R. Shabana, and A. S. Haruky, "Effect of cold storage on the quality traits of six palm fruit varieties the wet stage," *Agricultural Research and Water Resources Center* (1985), Baghdad- Iraq 1985.

ISSN 2072-3875