Effect of Storage Techniques on the Shelf Life of Some Selected Orange Species in Benue State

J. O. Awulu, O. J. Ijabo, P. A. Omale

Department of Agricultural & Environmental Engineering,
College of Engineering, University of Agriculture, Makurdi, Nigeria

Abstract: Orange fruit is an economic fruit that have excellent value in both human diet and medicine. It is available during its harvesting period but becomes scarce after a short while due to its poor storage techniques. This project work aimed at investigating the shelf life of five selected species of orange fruits under five different storage techniques. The storage techniques are refrigerator, room storage, Pit storage, under shade and open space. The five (5) selected species of orange fruits for this work are Tangerine, Valencia, Washington, Grape fruit and Ibadan sweet, and were harvested from Agbo community orange orchard in Makurdi directly by hand into five different boxes of five columns and ten rows each and were transferred to the research environment. Ten (10) oranges were picked out of the fifty (50) orange fruits carefully selected from each species, summing up to two hundred and fifty (250) orange fruits for this research and stored under the various storage techniques for seventy (70) days. Temperature and Relative Humidity were determined using the K-type Multi-meter in three replicates twice in a day and the average value recorded while Affloxiation was determined by Physical observation and counting. The result showed that the maximum/minimum temperature and relative humidity in the various storage techniques were in the range of 39.8oC/11.0oC and 78.8%/55.5% in the various storage techniques. There is significant difference in Temperature in the different storage techniques at $P<0.05$ while there was no significant difference in relative humidity in the different storage techniques at $P>0.05$. Refrigerator storage technique gave the best shelf life of the stored orange species followed by the pit storage techniques. The different orange species has different shelf life and Ibadan sweet specie had the best shelf life followed by Washington species. This information is helpful to farmers and traders involved in orange husbandry in taking right decision on storage technique for various oranges and selection of best species for storage.

Keywords: *Orange Species, Relative Humidity, shelf life, Storage and Temperature*

1 INTRODUCTION

Orange fruit is a round juicy edible fruit with a thick skin that is greenish in colour and turns reddish-yellow when ripe and it forms an important part of a balanced diet and are source of digestible carbohydrates, minerals and vitamins

(Nicolosi *et at*, 2000). Researchers believe this citrus fruits began to appear in Southeast Asia at least 4000BC (Thompson *et. Al*, 1988) and the origin is presumably the Sanskrit word for "orange tree" whose form has changed over time. The Federal Department of Agriculture Nigeria and Missionaries in 1930 introduced orange to Nigeria (Aiyeloagbe *et al,* 1996). Subsequently citrus fruits has spread throughout the country and currently reported to be one of the most widely cultivated fruits in South West Nigeria (Adewale *et al.,* 1996). It is rated as the widely planted fruits trees in the world at large (FAO, 2010). According to Nicolosi *et al,* (2000), the commonly grown citrus species belongs to the genus Citrus and the family Rutacea that contain about 150 general and nearly 2000 species. Karade (2003) said, orange no matter the specie is best cultivated on sandy loam soil. Citrus fruits are said to be the first crops that appeared in the international trade market in terms of values (CIAC, 2002). Some of the most important citrus

species grown worldwide are Sweet Orange (Citrus Sinensis), Lime (Citrus Aurantifolia), Lemon (Citrus Limon), Grape Fruit (Citrus Paradise), Sour Orange (Citrus Aurantium) and Tangerine (Citrus Reticulate) (UNCTAD, 2011). The Citrus Sinensis is subdivided into four classes with distinct characteristics: Common Oranges, Blood or Pigmented Oranges, Navel Oranges and Acidless Oranges (Kimball, 1999). Outside taking as juice, Orange can be used for commercial production of pectin, pharmaceutical formulations, source of animal feed while its fibre is used to modify texture and taste of food (sendra, *et al,* 2010). According to Sheilnows (2011), the nutritional content of orange is good for the skin, eyes, heart and even reduces the risk of cancer.

Unlike cereals, citrus fruits are essentially highly perishable and begins deterioration as soon as they are harvested and the current annual production is estimated at over 105 million tons with more than half of it as orange (Thomas, 2010). 95% of Citrus fruits are consumed fresh with the remaining processed into juice (Layi, 2012). According to Ajibade (1985), orange is grown almost all over the country and in spite of this, large quantities of preserved fruits are still being imported into Nigeria in order to replenish fruits out of season availability just because of the poor processing and storage.

Storage of citrus poses a problem to the farmer after harvest. Despite the fact that Orange is an important tree crop and highly produced by farmers, large number of Orange fruits produced deteriorates even while they are stored after harvest or during transportation. (Gretchen, 2002). Commercially, oranges can be stored refrigerated in controlled-atmosphere chambers for up to 12 weeks after harvest and storage life ultimately depends on cultivar, maturity, pre-harvest conditions and handling. In stores and markets, oranges should be displayed on non-refrigerated shelves and at home, orange has a shelf life of about one week at room temperature and one month in the refrigerator and in either case, they are optimally stored loosely (USDA, 2004). According to Mijinyawa (2010), deterioration of fruits and vegetables during storage depends largely on temperature/humidity; refrigeration and open-air storage at ambient temperature are common practice used for short-term storage of fruits including orange. The key design constraints for produce storages is to uniformly maintain desired temperature and relative humidity and high relative humidity of 85-95% is needed to reduce product moisture loss (ASHRAE, 1999). According to Rice and Robert (1986), the ideal storage temperature of Orange is between 4-6^{o}C.

ASHRAE (1999) said the optimum relative humidity for orange storage is 85-90% while the temperature is 2^{o}C, 3^{o}C and 6-10^{o}C for 4-8weeks, 8-10 weeks and 16 weeks respectively. Orange can stayed up to 16 weeks at the temperature of 6-10^{o}C and a relative humidity of 85-90%. Orange fruits can be store from 3-12 weeks due to high temperature and low relative humidity, and can be stored refrigerated in controlled atmosphere chambers for up to 12 weeks after harvest (Ritenour, 2004). Storage life ultimately depends on cultivar, maturity, pre-harvest conditions and handling (ASHRAE, 1999).

Shelf life is a term used to indicate how long a product will remain acceptable for consumption once it is harvested or processed. According to Chandler (1988), farmers locally store their harvested orange under shed, in open space, dug pit and very few are store in refrigerator since it requires electricity that is limited in most production areas.

1.1 Objectives

The objectives of this research is to identify the storage techniques of orange fruits after harvest, determine the period by which different orange species can be stored in some of these identified

storage techniques, make recommendation on the best storage techniques for orange and to determine the best orange specie good for storage.

2 SAMPLING AND METHOD

Fifty different species of ripped fresh orange fruits namely Valencia, Tangerine, Grape fruit, Washington and Ibadan sweet were harvested from Agbo community orange orchard in Makurdi directly by hand into five different boxes of five columns and ten rows each (See figure 1), summing up to 250 orange fruits were transferred to the research environment for this research. Ten samples each of the species were randomly selected and stored evenly into five different storage techniques (Refrigerator, Room, Pit, Open place and under shade) for the period of ten (10) weeks. Temperature (^{o}C) and Relative Humidity (%) for each of the storage medium were measured using K-type Multi-meter twice daily in three replicates. The average values were recorded in ^{0}C and % respectively. Number of spoilt orange fruit per day and duration by which the orange fruits stayed without losing its shelf life was determine by visual inspection and counting of orange fruits in the various storage techniques.

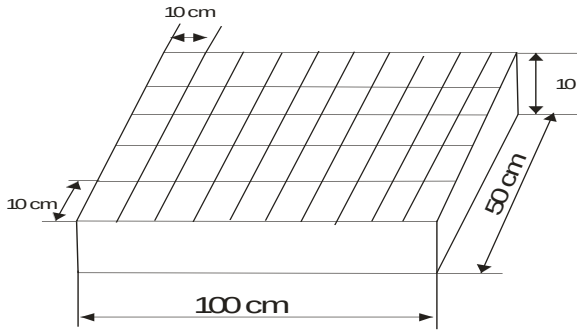

Figure 1: Box for collection of Orange.

2.1 Determination of Temperature

The temperature of each of the storage techniques measured by placing the probe of the K-type Multi-meter into the sample of oranges stored within each of the storage techniques and the temperature value was read from the indicator screen and recorded in ^{o}C for each storage technique.

2.2 Determination of Relative Humidity

The relative humidity of each of the storage techniques measured was taken by placing the probe of the K-type Multi-meter into the sample of oranges stored within each of the storage techniques and the relative humidity read from the screen and recorded. The values were recorded in percentage (%) for each storage technique.

2.3 Determination of Affloxiation

The period in which the orange fruits were stored in all the storage techniques before losing their shelf life was recorded through physical observation of the oranges twice daily and affloxiation was determined by visual inspection and counting of the deteriorated orange fruits in each of the storage techniques recorded.

3 RESULTS AND DISCUSSION

Figure 2 illustrates the variation of the total deterioration of the orange species stored in the various storage techniques while *Table* 1 indicates that Valencia specie stayed up to 10 weeks when stored in the refrigerator, 8 weeks in the room, 6

weeks under shed, 10 weeks in the pit and 4 weeks in open space. Tangerine stayed up to 10 weeks in the refrigerator, 6 weeks in the room, 7 weeks under shed, 10 weeks in the pit and 3 weeks in open space. Grape fruit stayed 10 weeks in the refrigerator, 6 weeks in the room, 6 weeks under shed, 10 weeks in the pit and 4 weeks in open space. Ibadan sweet orange stayed 10 weeks when stored in the refrigerator, 9 weeks in the room, 7 weeks under shed, 10 weeks in the pit and 4 weeks in open space. Washington stayed up to 10 weeks in the refrigerator, 9 weeks in the room, 7 weeks under shed, 10 weeks in the pit and 4 weeks in the open space.

The deterioration for Valencia started the in 5th week in the refrigerator, 3rd week in the room and pit, 4th week under shed, and 2nd week in the open space. Tangerine started deteriorating in the 1st week in the refrigerator, room and open space, and 3rd week under shed and in the pit. Grape fruits started deteriorating in the 2nd week in the refrigerator, room, under shed and open space, 4th week in the pit. Ibadan sweet started deteriorating at 6th week in the refrigerator, 4th week in the room, 3rd week under shed, 5th week in the pit and 1st week in the open space. Washington started deteriorating at 6th week in the refrigerator, 4th week in the room, 3rd week under shed, 5th week in the pit and 1st week in the open space. The oranges stored in the room, under shed and in open place has a shelf life of 9weeks, 7weeks and 4weeks respectively while oranges stored in refrigerator and pit has a shelf life of ≥ 10weeks and the high-ranking of the different orange species' shelf life in descending order is Ibadan sweet>Washington>Valencia>Grape fruit>Tangerine.

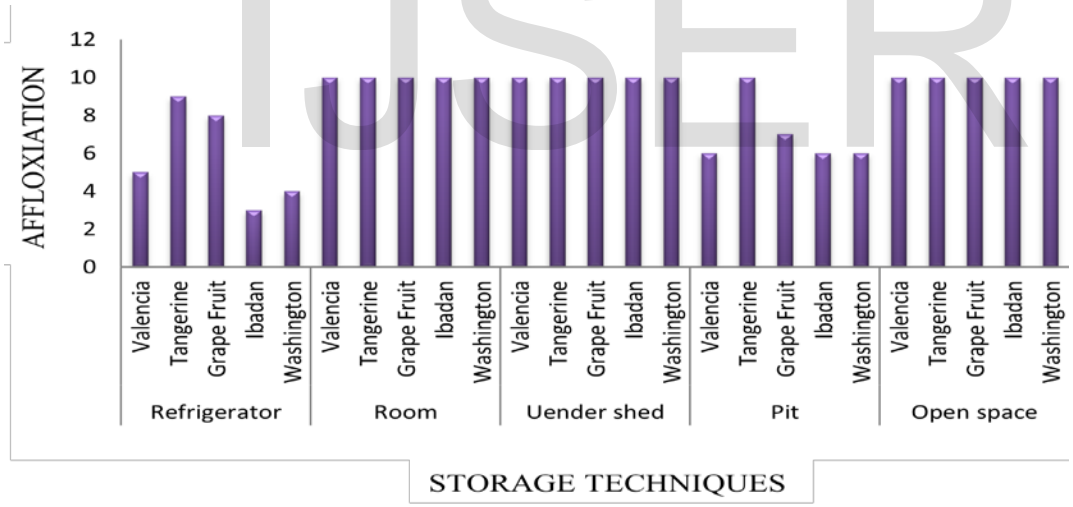

Figure 2: Illustration of total deterioration of orange species in the various storage techniques

***Table 1*:** Deterioration of orange species per week in the Various Storage Techniques.

Type of Orange	Weeks										Total Damages	Remainders
	1	2	3	4	5	6	7	8	9	10		

Refrigerator	Valencial					3	1	1				5	5
	Tangerine	1	2	2			3	1				9	1
	Grape Fruit		1			3	2	2				8	2
	Ibadan						1	1		1		3	7
	Washington						2	2				4	6
Room	Valencial			2	4	1	1	1	2			10	0
	Tangerine	2	1	1	1	3	2					10	0
	Grape Fruit		1	2	1	4	1					10	0
	Ibadan				2	2	1	2	1	2		10	0
	Washington				1	5	1	1	1	1		10	0
Under shed	Valencial				1	3	6					10	0
	Tangerine			3	2	2	1	2				10	0
	Grape Fruit		1	3	2	2	2					10	0
	Ibadan			2	1	3	2	2				10	0
	Washington			2	1	2	4	1				10	0
Pit	Valencial			1	1	1	1	1			1	6	4
	Tangerine			2	2	2	1		1	1	1	10	0
	Grape Fruit				2	3	2					7	3
	Ibadan					2	1	1	1	1		6	4
	Washington					2	1	1	1	1		6	4
Open space	Valencial		5	4	1							10	0
	Tangerine	3	6	1								10	0
	Grape Fruit		5	4	1							10	0
	Ibadan	1	2	3	4							10	0
	Washington	1	5	3	1							10	0
Total		8	30	35	29	41	35	20	7	4	2	214	36

Table 2 shows the temperature and relative humidity in the various *storage techniques. This table* shows that the variation in the temperature and relative humidity in the various storage techniques ranged from 11.1°C - 15.3°C and 57.5% - 78.8% in the refrigerator, 33.5°C - 39.8°C and 60.5% - 75% in open place, 34.3°C - 37.7°C and 60.9% - 77.3% in room, 33.1°C - 38.7°C and 59.3% - 78.2% in pit and 32.9°C - 37.3°C and 55.5% - 77.8°C under shed respectively. At 95% (Confidence Level), the ANOVA result on Table 3 shows that there is significant difference in the temperature of the various storage techniques, although the Duncan analysis indicated the temperature was the same for all the storage techniques except for refrigerator as shown on table 2. The ANOVA also shows that the relative humidity in the various storage techniques was not significantly different and this is confirm by the Duncan analysis that the relative humidity in the storage techniques is the same as shown on table 2.

Table 2: Variance and mean separation of temperature and Relative Humidity in the various storage Techniques (95% CL)

Storage	Parameter					
	Temperature			Relative Humidity		
	Min	Max	Mean ± SEM	Min	Max	Mean ± SEM
In Room	34.30	37.50	35.84 ± 0.62[b]	60.90	77.30	70.16 ± 0.58[a]
Open Place	33.50	39.80	36.19 ± 0.35[b]	60.50	75.00	66.81 ± 0.91[a]
Pit	33.10	38.20	35.08 ± 0.12[b]	59.30	78.20	71.96 ± 0.46[a]
Refrigerator	11.00	15.30	12.57 ± 0.09[a]	57.50	78.80	73.39 ± 0.51[a]
Under shed	32.90	37.30	35.38 ± 0.17[b]	55.50	77.75	70.45 ± 0.72[a]
LSD			0.8007			1.798

**Different letters within the same column indicate significant difference while same letters indicate no significant difference.*

Table 3: ANOVA Result for the temperature and relative humidity in the various storage techniques at 95% CL

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Temperature	Between Groups	825.134	4	206.283	18.128	.004[S]
	Within Groups	56.895	5	11.379		
	Total	882.029	9			
RH	Between Groups	7.440	4	1.860	.010	1.000[NS]
	Within Groups	892.586	5	178.517		
	Total	900.026	9			

S = Significant (p<0.05), NS = Not Significant (p>0.05)

4 CONCLUSION

It can be concluded that:

i. Maximum/minimum temperature and relative humidity observed in the various storage techniques were in the range of 39.8°C/11.0°C, and 78.8%/55.5%

ii. Refrigerator storage technique gave the best shelf life among the general stored orange species followed by the pit storage techniques

iii. Different orange species has different shelf life and Ibadan sweet specie has the best shelf life followed by the Washington species.

iv. There is significant difference in Temperature of the different storage techniques at P<0.05 while there was no significant difference in relative humidity in the different storage techniques at P>0.05.

REFERENCE

Adewale, J.A. Oladosu, L.O. and Laogun E.A. (1996) Factors limiting fruits tree production in south Western Nigerian, Implication strategy. Proceedings of 14th annual conference of Horticultural society of Nigeria.

Aiyeloagbi, I.O, O.Afolayan, S.O. Odeleye, O.O, Ogungbayigbe, I.O and olufolaji, A.O (1996); citrus production in the savannah of western Nigeria: current status and opportunities for Research input..http://www.citrusproductioninnigeria.org. Retrieved 08-05-2012

Ajibade, E.T, (1985). Personal communication, pomology kabba, college of Agriculture Ahmadu Bello University, Zaria American Society of Heating, Refrigerating and Air-conditioning Engineers. (1999, ASHRAE Handbook series (4 books).

American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE), (1999), Handbook series (4 books). Thompson, J.F, F.G. Michael

Chandler R.P (1988) fruits and vegetables production in Africa. The Macmillan press LTD, London PP 40-48

CIAC, 2002. Strategic Investment Plan (Horticultural Australia). An https documents available at www.ciac.org accessed on …2009.

United Nations Food and Agriculture Organization (FAO) (2010) "Top production orange

2010". Statistics, Retrieved 26 June, 2013.

Gretchen, E. (2002), Tropical products transport hand book, U.S Department of Agriculture, Washington DC. 148pp

Karade J.M. (2003). The spread of sub-region, standard press, Jos. Pp 9-17

Kimball, D.A. (1999) citrus processing, a complete guide (2d ed.). New York: Springer. Pp.450.

Layi, A (2012). break through in concentrates manufacturing to save Nigeria one Billion US Doller per year.http://www.punchng.com/march30,2012. Retrieved:08/05/2012.

Mijinyawa, Y. (2010), Farm Transportation in Developing countries, Aluelemhegbe publishes, Ibadan Nigeria.

Nicolosi, E.; Deng, Z.N.; Gentile, A.; La-Malfa, S.; Continella, G. and Tribulato, E. (2000). "Citrus phylogeny and genetic origin of important species as investigated by molecular markets". TAG Theoretical and Applied Genetics 100 (8): 1155-1166

Rice, L.M. and Robert, P. (1986); Fruits vegetable production in Africa. California polytechnic State University formerly of Bunda College of Agriculture, University of Malawi. Sendra, E., Kuri, V., Fernandez-Lopez, J.,

Ritenour, M .A., (2004). Orange from the commercial storage of fruits, vegetables and florist and nursery stocks. USDA

Sendra, E., Kuri, V., Fernandez-Lopez, J., Sayas-Barbesa, E., Navarro, C. and Perez-Alvazez, J.A. (2010). Viscoelastic properties of orange fiber Enriched Yoghurt as a function of fiber Dose, Size and thermal Treatment. Journal of Food Science and Technology, 4(3), 708-714. Published by the university of phymouth, Drake circus Denvon, United Kingdom

Sheilnows, K.J (2011); Article posted on Health and Wellness/Diet and fitness.

Thomas, H.S. (2010). Projections of world production and consumption of citrus 2010. http:en.wikipedia.org/wiki/citrus production Retrieved: 08/05/2012.

Thompson, J.F, F.G. Michael Chandler R.P (1988) fruits and vegetables production in Africa. The Macmillan press LTD, London PP 40-48 IAC, 2002. Strategic Investment Plan (Horticultural Australia). An https documents available at www.ciac.org accessed on …2009.

United Nation conference on Trade and Development (UNCTAD), (2011). Market information in the commodity Area. http://en.wikipedia.org/wiki/market-citrus. Revieved: 08/05/2012