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Original Article

The Effect of Some Storage Systems on the Shelf Life of Avocado Pear (*Persea Americana M.*)

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Abstract - *Determination of the shelf life of Avocado pear fruits and seeds stored under three different conditions such as cold storage, immersed in water and ambient condition for the duration of 1- 10 days and also some physical properties of avocado pear were investigated, such as axial dimensions volume, mean square diameters, surface area, aspect ratio, sphericity, arithmetic mean diameter, geometric mean diameter, equivalent diameter. Investigation shows that the width and thickness of the fruits and seeds values stored under cold storage conditions ranged from 89.4 to 91.34 mm, 65.3 to 69.1 mm and 65.1 to 68.2 mm, respectively, and the ones submerged in water ranged from 94.97 and 105.6 mm, 61.3 and 76.7 mm to 60.5 and 65.84 mm respectively and finally for ambient temperature conditions values ranging from 79.34 and 97.7 mm, 61.32 and 66.66 mm and, 60.5 and 65.84 mm respectively. The sample stored under cold storage on day 5 were still found to be green and unripe, while the ones immersed in water were found to be green; however, softening at the stem was observed, and those at ambient condition were found to be fully ripe and completely discolored(deteriorated). Therefore, cold storage system using a household refrigeration system was the best among the three storage conditions investigated, which is necessary to increase the shelf life of the sample. Finally, the results obtained are also essential for designing equipment for harvesting, processing, transporting, cleaning, sorting, separation, packaging and storage systems.*

Keywords - *Physical properties, Cold storage, Avocado pear fruits, Household refrigeration system.*

1. Introduction

Avocado is a tropical fruit plant that originates from south-central Mexico. It has the botanical name *Persea Americana* and is from a family of Lauraceae. Avocado is one of the most cultivated fruit plants globally, with Mexico being its largest producer, accounting for 25% of its production, followed by Chile with 8.5% (Castillo, 2008). Due to its increasing awareness and proof of usefulness in the health sector, especially in the agricultural industry, both semi-commercial and commercial farmers are now involved.

Fruits like avocados and pears are incredibly wealthy and contain specific nutrients having tremendous medicinal and health benefits. It treats diarrhea and dysentery, acts as an antibiotic, and controls cholesterol levels (Orhevba and Jinadu, 2011). The edible portion of an avocado fruit makes up 65% of the overall fruit, 20% of the seed, and 15% of the skin; the fruit contains dietary fibre, carbohydrates, 75% insoluble and 25% soluble fibre, vitamin K, vitamin B6, vitamin C, and a good potassium source (Davies, 2018).

The avocado pear's weight varies according to the variety, but its yellow-green flesh, which has a delectable, creamy, buttery smoothness and a subdued nutty flavor, is edible. The 20-meter-tall tree has alternately arranged leaves 12 to 25 centimeters long. The flowers are small, greenish-yellow, and 5 to 10 mm broad (Whiley, 2000). The fruit is shaped like a pear and is 7 to 20 cm long. It weighs 100 to 1000 grams and bears a huge central seed 5 to 6.4 cm long. The climacteric fruit avocado ripens off the tree yet matures on the tree. (Casalto, 2008).

2. Literature Review

Due to the perishable nature of Avocado pear once picked from the tree and due to the effect of ethylene gas, which starts the ripening process, avocados grow quickly when stored with other fruits like apples or bananas and in a few days at room temperature (Orhevba and Jinadu, 2011). On ripening, it yields gentle palm pressure. It can be stored in the refrigerator for some days, but when the flesh is cut and exposed, they tend to rapidly turn brown due to the oxidation of enzymatic browning reactions from iron compound (Orhevba and Jinadu, 2011). However, since freshly harvested vegetables and fruits cannot be sold and consumed simultaneously, some of these products need to be stored either for further processing or consumption. Thus, the need for Cold storage. Avocados used in commerce are picked hard and green and kept in cold systems or coolers at 38°F to 42°F (3.3°C to 5.6°C). Still, they get to their final destination (Orhevba and Jinadu, 2011).

The avocado's skin turns purplish-black when fully mature; the fruit's edible flesh takes up 65% of its weight, followed by the seed (20%) and the skin (15%). Between 71 and 88% of the calories in avocado, fruits are made up of fat, which is a high-fat content that is roughly 20 times higher than that of other fruits. High consumption of avocados lowers blood serum cholesterol levels (USDA, 2009).

Annual post-harvest food losses are as high as 30% of the total production in sub-Saharan Africa. Latin America and the Caribbean are responsible for 6% of global food losses; these regions lose nearly 15% of the whole agricultural produce of this loss, 28% occurs at the producer level and 22% during the post-harvest handling and storage (Orhevba and Jinadu, 2011). The value chain accounts for roughly 90% of food waste in underdeveloped nations. Post-harvest food losses directly affect small-scale or local farmers, which reduces their incomes by at least 15%. Cold storage is one of the most indulged agricultural post-harvest practices carried out in the world, with India as its largest investor and producer, has an annual growth rate estimated to be 25.8%, with about 6,227 cold stores with the capacity of storing produce worth 30 million tonnes (Lipinski *et al*., 2013)

Although losses happen at every stage of the post-harvest cycle, cold storage facilities are essential for reducing post-harvest losses. In order to avoid post-harvest spoiling, cold storage must be viewed as a stand-alone option (Kitinoja *et al.,* 2013). Post-harvest losses are affected by both internal and external factors, such as pH, total soluble solids content, weight loss, fruit hardness, juice content, and other quality indicators (Song and Bangerth, 1993; Sams and Conway, 1993; Tu *et al.,* 2000). Post-harvest losses have dire economic implications for the farmers. They are especially significant in developing countries (such as Nigeria), where rural areas lack the basic infrastructure to store agricultural produce. The absence of storage facilities negatively influences farmers' revenues as well because it forces them to frequently sell their produce for very little money to prevent losses from rotting (Kitinoja *et al.,* 2013).

Because not all produced fruits and vegetables may be sold fresh at once, post-harvest management of produce is a crucial component of farming. A certain amount of these items must be kept in storage for upcoming processing or table usage. In such cases, cold storage becomes essential to post-harvest management procedures. Thus, a cold storage system can be used to prevent the losses that could result from not storing the goods at the right temperatures.

Due to the perishable nature of avocado pear, there are huge post-harvesting losses after being harvested, which has led to a huge setback. Thus, the need for the availability of Cold storage for such purposes. This research aims to determine some physical properties of the avocado pear (Persea americana), determine the physical dimensions of avocado fruit and kernel and discover the effect of cold storage on avocado pear.

3. Materials and Methods

Swali Town Market in Yenagoa, Bayelsa State, Nigeria, is where researchers obtained the avocado pear fruits and kernels (Plates 1 and 2) used in this study. In order to prevent early, soft, and ripe fruit from being chosen, the samples were carefully arranged. For this experiment, only ripe, healthy fruits were used. Forty avocado fruits in all were used. All measurements were made in the Crop Processing Laboratory at Niger Delta University, Department of Agricultural and Environmental Engineering—Nigerian State of Bayelsa.

3.1. Selection of Materials

Material selection is of utmost importance to ensure that the experiments meet the required standard.

3.2. Materials Used

The materials and instruments used as shown in plates 1 and 2

Plate 1. Samples of avocado pear

Plate 2. Sample of avocado seed

3.3. Experimental Procedures

3.3.1. Determination of Physical Properties

To determine the physical effect of household refrigeration of avocado fruits and seeds, a total of nine (9) fruits and seeds were randomly and carefully selected; three (3) fruits from a sealed cellophane bag exposed to cold storage using a refrigerator, three (3) fruits exposed to ambient temperature and immersed in water, and three (3) fruits exposed to ambient temperature without being immersed in water. The linear dimensions of the fruits, namely, length (L), width (W) and thickness (T), were measured using the digital Vernier Caliper with an accuracy of 0.01 mm. The mean length of the pear fruits and seeds was determined using the three axial dimensions. The arithmetic mean diameter (D_a), geometric mean diameter (D_g), sphericity (Φ), surface area (S), and aspect ratio (R_a) of Velvet tamarind were calculated using the following relationships (Lorestani et al., 2012). The toluene displacement method determined the volume (V) of the avocado fruit and seeds (Davies, 2018).

$$D_a = \frac{(L+W+T)}{3} \quad (1)$$

$$D_g = (LWT)^{0.33} \quad (2)$$

$$D_{sm} = (\frac{LW+WT+LT}{3})^{0.5} \quad (3)$$

$$D_e = \frac{D_a+D_g+D_{sm}}{3} \quad (4)$$

$$\Phi = \frac{\sqrt[3]{(LWT)}}{L} \quad (5)$$

$$Ra = (\frac{W}{L}) \times 100 \quad (6)$$

$$S = \pi {D_g}^2 \quad (7)$$

$$V = \frac{\pi B^2 L^2}{6(2L-3)} \quad (8)$$

The mass of the avocado fruits and seeds was determined using precision electronic balance to an accuracy of 0.01g. Nine (9) randomly selected avocado fruits were weighed. This experiment was carried out for ten (10) days.

4. Results and Discussion

4.1. Physical Properties

The physical properties of avocado pear fruits are presented in Table1, 2, and 3. Investigation shows that the diameter of the vertical axis is greater than the diameter of the horizontal axis, proving that the shape of the avocado pear is taken as oblong. Determining the axial dimensions of the fruit is imperative for the processing and preservation of the fruits, which is necessary for considering any material handling equipment; the size of the product to be conveyed enables one to select the right equipment to carry out the operation.

The length, width and thickness of the avocado pear fruits ranged from 89.4 to 91.34 mm, 65.3 to 69.1 mm and 65.1 to 68.2 mm, respectively, for cold storage conditions, as shown in Table 1, 94.97 to 105.6 mm, 61.3 to 76.7 mm and 60.5 to 65.84 mm respectively, for conditions submerged in water as shown in table 2; 79.34 to 97.7 mm, 61.32 to 66.66 mm and 60.5 to 65.84 mm respectively, for ambient temperature conditions, see table 3. The length, width and thickness of fruits tend to vary with the size of the fruit. The maximum, minimum and mean of the unit mass of avocado pear fruit read: 179.80g, 174.40g and 177.10g, respectively, for cold storage conditions; 187.08g, 181.66g and 184.37g, respectively, for conditions submerged in water; and for ambient temperature conditions, 175.42g, 141.02g and 158.22g respectively, using 10 replicates.

The24veragee arithmetic means the diameter of the fruits were also evaluated, which is: 74.74 mm for cold storage conditions, 77.48 mm for conditions submerged in water, and 71.89 mm for ambient temperature conditions. The geometric mean diameter was also determined with the geometric diameter of the fruit-derived: 70.86 mm for cold storage conditions, 72.65 mm for conditions submerged in water, and 68.01 mm for ambient temperature conditions.

The average sphericity of avocado pear fruits was: 81.84% for cold storage conditions; 75.56% for conditions submerged in water; 80.51% for ambient temperature conditions, and the average aspect ratio of avocado pear fruit was: 74.35% for cold storage conditions; 68.59% for conditions submerged in water; 72.76% for ambient temperature conditions. The obtained result indicates that the avocado pear fruits will rather roll than slide. This is useful information in the design of hoppers (Davies, 2018). The range of the average surface area of the avocado pear was: 15131.04 – 16426.56 mm^2 for cold storage conditions, 14390.32 – 18922.79 mm^2 for conditions submerged in water, 12783.66 – 16385.69 mm^2 for ambient temperature conditions. Surface area is significant in determining the shape of fruit, seed and grain. Studies conducted by Davies and Zibokere (2011) showed that the surface area of gbafilo fruits varied from 1584.80 to 2455.90 mm^2. The mean surface area of velvet tamarind fruits was 339.31 mm^2. The surface area of avocado pear fruit was found to be higher than that of reported gbafilo fruit, tamarind fruits and date fruits. Thus, the parameter determines the natural resting position of fruits, grains and seeds and evaluates spray coverage, residue removal, respiration rate, light reflectance and colour.

The value of the volume of avocado fruit pear ranged from: 138962.73 – 153449.32 mm^2 for cold storage conditions, 158859.59 – 227144.28 mm^2 for conditions submerged in water, 103003.28 – 169176.69 mm^2 for ambient temperature conditions. The evaluation of this property is important in the design of equipment for cleaning using aerodynamic forces, separation, conveying and elevating unit operations, and estimation of the diffusion coefficient of shrinking systems.

4.2 Avocado Kernel

Some physical properties of avocado pear seeds are shown in Table 4.4. The avocado seed's length, width and thickness ranged from 53.09 to 61.96 mm, 42.31 to 52.89 mm and 40.48 to 47.82 mm, respectively. The arithmetic mean diameter of the seed for maximum, minimum, and mean were 54.22 mm, 44.96 mm and 49.6 mm, respectively. The average mean geometric diameter for the seed was 48.50 mm. The average sphericity of avocado pear seeds was 86.40%, and the average aspect ratio was 83.29%. The obtained result indicates that the avocado seeds will rather roll than slide, which is a piece of useful information in the design of hoppers.

Table 1. Some physical properties of Avocado pear fruit in Cold Storage

Properties	No. of Samples	Maximum	Minimum	Mean
Length (mm)	9	91.34	89.40	90.37
Width (mm)	9	69.10	65.30	67.20
Thickness (mm)	9	68.20	65.10	66.65
Arithmetic Mean Diameter (mm)	9	76.21	73.27	74.74
Geometric Mean Diameter (mm)	9	72.31	69.40	70.86
Square Mean Diameter (mm)	9	75.84	72.82	74.33
Equivalent diameter (mm)	9	74.79	71.83	73.31
Sphericity	9	82.66	81.02	81.84
Aspect Ratio (%)	9	75.65	73.04	74.35
Surface Area (mm^2)	9	16426.56	15131.04	15778.80
Volume (mm^3)	9	153449.32	138962.73	146206.03
Unit Mass (g)	9	179.8	174.4	177.10

Table 2 Some physical properties of Avocado pear fruit, Submerged in water

Properties	No. of Samples	Maximum	Minimum	Mean
Length (mm)	9	105.60	94.97	100.29
Width (mm)	9	76.70	61.30	69.00
Thickness (mm)	9	65.84	60.50	63.17
Arithmetic Mean Diameter (mm)	9	82.71	72.25	77.48
Geometric Mean Diameter (mm)	9	77.61	67.68	72.65
Square Mean Diameter (mm)	9	81.86	71.36	76.61
Equivalent diameter (mm)	9	80.73	70.43	75.58
Sphericity	9	76.76	74.36	75.56
Aspect Ratio (%)	9	72.63	64.55	68.59
Surface Area (mm^2)	9	18922.79	14390.32	16656.56
Volume (mm^3)	9	227144.28	158859.59	193001.94
Unit Mass (g)	9	187.08	181.66	184.37

Table 3 Some physical properties of Avocado pear fruit at Ambient temperature.

Properties	No. of Samples	Maximum	Minimum	Mean
Length (mm)	9	97.70	79.34	88.52
Width (mm)	9	66.66	61.32	63.99
Thickness (mm)	9	65.84	60.50	63.17
Arithmetic Mean Diameter (mm)	9	76.73	67.05	71.89
Geometric Mean Diameter (mm)	9	72.22	63.79	68.01
Square Mean Diameter (mm)	9	76.01	66.77	71.39
Equivalent diameter (mm)	9	74.99	65.87	70.43
Sphericity	9	77.18	83.84	80.51
Aspect Ratio (%)	9	68.23	77.29	72.76
Surface Area (mm^2)	9	16385.69	12783.66	14584.68
Volume (mm^3)	9	169176.69	103003.28	136089.99
Unit Mass (g)	9	175.42	141.02	158.22

The mean surface area of the pear seeds was 745.79 mm^2. Davies and Mohammed (2014) reported that the surface area of soursop seeds differed from 195.10±7.73 mm^2 to 385.05±4.75 mm^2. The velvet tamarind fruits' mean surface area was 339.31 mm^2 (Davies and Zibokere, 2011). The mean surface area of gbafilo fruits varied between 1584.80 to 2455.90 mm^2. Thus, the parameter evaluates spray coverage, residue removal, respiration rate, light reflectance and colour.

Table 4. Some physical properties of Avocado pear kernel

Properties	No. of Samples	Maximum	Minimum	Mean
Length (mm)	9	61.96	52.09	57.0
Width (mm)	9	52.89	42.31	47.60
Thickness (mm)	9	47.82	40.48	44.20
Arithmetic Mean Diameter (mm)	9	54.22	44.96	49.6
Geometric Mean Diameter (mm)	9	53.01	44.02	48.5
Square Mean Diameter (mm)	9	54.07	44.82	49.5
Equivalent diameter (mm)	9	53.77	44.60	49.2
Sphericity	9	87.01	85.78	86.40
Aspect Ratio (%)	9	85.36	81.23	83.29
Surface Area (mm^2)	9	882.81	608.77	745.79
Volume (mm^3)	9	701.48	422.17	561.83
Unit Mass (g)	9	86.79	52.63	69.71

Table 5. Physical observation of Avocado pear stored under three different storage conditions

Days	Cold Storage	Submerged in water	Ambient temperature
1 – 3	Fruits were fresh, unripe and Green	Fruits were fresh, unripe and Green	Fruits were fresh, unripe and Green
Day4	Green and unripe	Green and unripe	Noticeable brown discolouration is observed.
Day5	Green and unripe	Green, however, softening at the stem is observed	Fully ripe and completely discoloured.
Day6	Green and unripe	Stem rot is observed	-
Day7	Green and unripe	No noticeable change	-
Day8	Noticeable brown patches on the fruit. Fruit is ripe.	Still green, however, deterioration in the body is observed.	-
Day9	No noticeable change	-	-
Day10	No noticeable change was observed.	-	-

4.3. Effect of Cold Storage

The fruits seemed fresh and green from day 0 to day 3. By day 4, however, the experimental fruits were still fresh, but one of them had been exposed to ambient temperature and felt squishy and had grown brown areas. On day 5, the sample of avocado pear exposed to ambient temperature was completely discoloured. At day 6, a sample of avocado fruit immersed in water was observed to experience stem rot though unripe; a sample of avocado pear exposed to ambient temperature was completely discoloured and very soft; a sample of avocado fruit exposed to cold storage, still fresh and green. At day 7, a sample of avocado pear exposed to ambient temperature is observed to have changed colour from brown to purple-black. A sample of avocado fruit exposed to cold storage started having brown patches on the skin. According to studies conducted by Cutting *et al*., 1990, discoloration and browning of the skin (pulp) of avocado during cold storage is one of the symptoms of chilling injury: On day 8, the appearance of mucus formation on a sample of avocado pear exposed to ambient temperature. A sample of avocado fruit immersed in water remains unripe though deterioration is consistent. A sample of avocado fruit exposed to cold storage is observed to be ripe and has brown patches. On day 9, the avocado-pear sample had completely degraded and was covered in mucus from exposure to the ambient temperature. When an avocado fruit sample is submerged in water, it is seen to be soft in the body but deteriorating from the stem without becoming ripe. There was no noticeable change in the sample of avocado fruit exposed to cold storage. On day 10, there was no noticeable change from the preceding report.

Chilling injury, one of the impacts of cold storage, only manifested during earlier shelf-life testing and not during cold storage. Chilling injury is induced by extended cold storage at 0 to 4°. (which no softening occurred, however, peel shrinkage and browning appeared). This is because fruit is still metabolically active at very low temperatures, as evidenced by the finding that storing fruit at these temperatures had no impact on how long it stayed fresh (Naveh *et al.*,2002). The sample completely immersed in water was damaged and did not soften normally. The average shelf life before deterioration commenced was six (6) days; the fruit did not soften satisfactorily.

Studies conducted proved the influence of fruit softening of ethylene is responsible for avocado softening (Pesis *et al*., 1978). The type and amount of decay that develop depend on some rate of resistance of the avocado to disease (Ruehle,1958). For this reason, there is no fungicide treatment available to control post-harvest decay. Thus, proper regulation of temperature and humidity in storage is essential. The appropriate storage temperature for the longest post-harvest life was recorded at 6-8℃ temperature; for the fastest ripening, storage at 25℃ was best (Lutz and Hardenburg, 1968). The rot occurrence of the sample exposed to cold storage began two days after 10 days storage period when samples were exposed to ambient temperature. According to Campbell *et al*., 1960, the onset of symptoms occurs because of reduced production of phenolic compounds and epidermal softening. This explains the fact that in our study, there was no rotting fruit at removal from the cold storage, but the symptoms were observed after two days at ambient temperature.

5. Conclusion

The fruits and seeds of avocado pears were examined for their physical characteristics. The shape was believed to be spherical and was anticipated to roll rather than slide, according to the average values of aspect ratio and sphericity of avocado fruits and seeds. The sample stored under cold storage on day 5 were still found to be green and unripe, while the ones immersed in water were found to be Green. However, softening at the stem was observed, and those at ambient conditions were found to be fully ripe and completely discolored. From the experiment, it was observed that the avocado pear stored in cold storage gave better results and a longer shelf life compared to the other storage conditions. The use of low-temperature storage not only reduces the rate of respiration of the avocados but also retarded the development of decay. Fungal spore (mucus) germination, infection of fruit tissue and decay resulted from free water on the fruits, which caused the sample immersed in water to deteriorate without getting ripe. Hence, the storage temperature should be low enough to retard decay but not so low as to cause chilling injury to the avocado pear fruits.

The data generated from this study are useful in designing systems for handling and processing Avocado pear fruit and seed. Further research should be carried out on the study of the effect of cold storage on Avocado pear and kernel to obtain a detailed report about the fruit.

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