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# Influence of Palm Kernel Storage Systems on the Yield and Quality of Palm Kernel Oil

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**Abstract** The palm kernel oil derived from the oil-palm kernels can be utilized as food, industrial raw materials, and alternative fuel for making biodiesel which can help address the problems of energy crisis. In this study, the effect of palm kernel storage systems on the yield and quality of palm kernel oil (PKO) was investigated. Oil-palm kernels were stored for three months (90 days) in woven basket, open plastic jerry-can, airtight plastic jerry-can, jute bag, and bare concrete floor. The average percentage oil yields, moisture impurities and volatile matters (%MIV), free fatty acid (%FFA), and peroxide values were: 43.72, 4.1, 7.1, 6.1 (for woven basket system); 43.49, 4.2, 6.9, 5.9 (for jute bag system); 43.89, 4.0, 6.5, 4.8 (for open plastic jerry-can system); 51.96, 3.8, 6.1, 3.5 (for airtight plastic jerry-can system); and 35.29, 4.9, 7.3, 7.5 (for kernels stored on bare concrete floor). In conclusion, the airtight plastic jerry-can storage was found to be the best system followed by open jerry-can, woven basket, jute bag, and bare concrete floor.

**Keywords** Palm kernel, storage, woven basket, jute bag, percentage oil yield, peroxide value

## Introduction

Palm kernel oil production in developing economies with oil-palm resource is important not just to industrialists, but also to rural people, employing a large workforce and serving as an income source for the rural populace concerned [1-2]. Oil extraction from palm kernels is achieved by *traditional and improved methods*. The *traditional method* which is manual involves cleaning and hand pressing. The *improved method* includes chemical and mechanical processes. The chemical process uses organic solvents to extract the oil, while the mechanical process applies pressure using hydraulic and screw presses [3]. Other mechanical devices in use include improved *ghanis* and oil expellers [4]. According to several researchers [5-7] the quality yield of extracted oils depended on raw materials' handling history, heating time, pressure application, operating temperature, etc.

It is estimated that in the tropics each year between 25 and 40% of stored agricultural products is lost due to inadequate farm and village level storage [8]. In the field and during storage, the products are threatened by insects, rodents, birds, and other pests. Moreover, the products may be spoiled by infection from fungi, yeasts or bacteria. In addition to sowing seed, it is important that the viability (its capacity to germinate) is maintained. In order to minimize the losses during storage, it is important to know the optimum environmental conditions for storage of the product, as well as, the conditions under which it's 'attackers' flourish.

Vegetable oil productivity in Nigeria is low, and as such vegetable oils are imported to meet national demand. According to [9], the total money Nigeria spent to import vegetable oil from Malaysia in 2001 alone was $186.65 million. Such is a very sad state of affairs in a country (Nigeria) blessed with abundant land, and numerous soil types throughout the different agro-ecological zones; and climate ranging from tropical to temperate.

In many PKO producing communities in Nigeria, palm kernels are kept in woven baskets, plastic cans, or heaped on the bare floor for some period of time before processing. Low capacity production of palm kernel oil in Nigeria may, well, be as a result of poor storage techniques and duration and probably the method of oil extraction from the oil seed. It was therefore thought necessary to investigate the effects of different palm kernel storage systems on the PKO yield and quality. The objectives of this study therefore were:

1. To store palm kernels in open jerry-can, air-tight jerry-can, woven basket, jute bag, and on bare concrete floor;
2. To process the kernels after three months and compare the yields and quality of palm kernel oil for each storage system.

## 2. Materials and Methods

### 2.1 Materials

The materials used for this work included: palm kernel samples (Tenera specie) (16kg), round bottom flask, desiccators with very active silica gel, absorbent cotton, clean thimble, electronic weighing balance (capable of weighing to the nearest 0.1 mg), heating mantle (rheostat controlled), petri dishes, separating funnel, spatulas, filter paper, retort stand, burette, an oven (capable of maintaining a temperature 104.5℃), laboratory mill, Erlenmeyer flask (300ml), pipette, extraction tube, basket, jute bag, 2 jerry-cans (about 20 litres each).

The solvents, and reagents used included: hexane, neutralised solvent (ethanol), phenolphthalein indicator solution-1.0% in isopropyl alcohol, acetic acid – chloroform solution (3:2, v/v), Potassium iodide solution, $Na_2S_2.SH_2O$ solution – 0.1N (accurately standardized with potassium dichromate), and starch indicator solution.

### 2.2. Methods

In this study, the palm kernels samples were stored in five storage materials which included: woven basket, jute bag, open jerry can, airtight jerry can, and bare concrete floor. Also, solvent extraction method was used in determining the oil content. Few quality indices determined were: peroxide value which was used to determine the shelf-life of the oil, percentage free fatty acid for determining the amount of non-esterified fatty acid released by the hydrolysis of triglycerides within adipose tissues, and percent moisture for determining the amount of water in the palm kernel samples after storage for 3 months. This work was done in three phases which included: procurement, handling, and storage of palm kernel samples; determination of oil yield; and determination of oil quality.

#### 2.2.1. Procurement, handling, and storage of palm kernel samples

Storage materials that were used for this project included: Jute bag, Jerry-cans (open & air tight) and basket. A sample was stored on the bare floor (floor storage). 16kg of mature palm kernels were obtained from an oil palm farm in Amaigbo in Imo State, Nigeria. The seeds were gotten from a common farm so as to retain sample's genetic identity. The samples were dried under the sun for 2 days and then a hot air oven was used to determine the moisture content by drying at 105℃ for 24 hours [10]. The kernels moisture content was 7.39%, which is considered safe for storage [11]. 3kg samples each were stored under ambient conditions of 28 – 30$^{o}$ C for a period of 3 months in the 5 different systems. Thereafter, the samples were analyzed for oil content, FFA, MIV, and Peroxide value to determine the yield and quality of the oil gotten from the seed samples of each method of storage respectively. The physicochemical determination of the palm kernel for % moisture, % oil content, % FFA, and peroxide value (PV) were carried out in RIVOC (Rivers Vegetable Oil Company) Rivers State, Port Harcourt using the methods of [12].

#### 2.2.2. Experimental procedures

**Extraction and determination of oil yield using Soxhlet extraction method**

The palm kernel samples were milled into cakes using a laboratory mill. An empty thimble was weighed, and the weight recorded. 5g of each ground sample was weighed into a thimble to prevent escape of the meal. A piece of absorbent cotton was placed on the top of the thimble to distribute the solvent evenly as it drops on the sample. The wrapped sample was placed in the butt extraction tube, and assembled. About 25ml of petroleum ether was added into the tarred extraction flask before attaching to the tube. The extraction tube was set to heat on an electric hot plate at such a rate that the solvent will drop from the condenser on the centre of the thimble at the rate of at least 150 drops/minute [13]. The volume of solvent was kept fairly constant by adding enough to make up for any that may be lost due to evaporation. The extraction was continued for 4 hrs. Thereafter, the extraction flask was cooled and disconnected. The petroleum ether on a steam bath was evaporated until no odour of solvent remained; using a gentle stream of clean, dry nitrogen to facilitate removal of the solvent. The flask was cooled to room temperature; moisture or dirt was removed carefully from the outside of the flask; and the flask weighed [12]. The procedure was repeated twice for samples from each storage system and the percentage (%) oil content was determined using equation (1):

$$\%\ Oil\ content = \frac{W_c}{W} \times 100 \quad (1)$$

$Where$:

$W_c = weight\ of\ oil\ after\ condensation$

$W = weight\ of\ the\ sub - sample\ of\ milled\ palm\ kernel\ seeds$

**Determination of percentage moisture impurities and volatile matter of palm kernel samples**

Petri dishes were used to weigh 20 grams of the ground sample of kernels from each storage system. The Petri dishes were put into an oven at 105$^o$C for three hours. The content was re-heated, cooled, and re-weighed at 30 min interval until weight changes were below 1gram [12]. The value of the moisture content of palm kernel samples for each storage system sample was determined using equation (2):

$$Moisture\ Content\ (MC) = \frac{W_{bh} - W_{ah}}{W_{bh}} \quad (2)$$

$Where$:

$W_{bh} = Weight\ of\ kernel\ before\ heating;\ and$

$W_{ah} = Weight\ of\ kernel\ after\ heating$

**Determination of free Fatty acid of palm kernel oil extracted**

5 grams of palm kernel oil and 50 ml of hot ethanol were put into a conical flask. The mixture was heated to boiling point. Phenolphthalein was added and the mixture titrated with 0.IN sodium hydroxide while still hot. The titration process was terminated when the colour changed from yellow to pink [12]. The volume titrated was noted and recorded. The free fatty acid (FFA) of each sample was then calculated using equation (3) [12]:

$$\%\ Free\ Fatty\ Acid = \frac{TD\ X\ N\ X\ MW\ X\ 100}{Wt\ X\ 1000} \quad (3)$$

$Where$:

$TD = titre\ difference$

$N = normality\ of\ sodium\ hydroxide$

$MW = molecular\ weight\ of\ sodium\ hydroxide$

$Wt = weight\ of\ sample$

**Determination of peroxide value of palm kernel oil extracted using acetic acid-chloroform method**

5.00 g of oil sample from each storage system was weighed into a 250 Erlenmeyer flask with glass stopper and 30 ml of 3.2 acetic acid- chloroform solution was added. The sample was stirred to dissolve. 0.5 ml of KI solution was added using a suitable volumetric pipette. The solution was allowed to stand with occasional shaking for exactly 1 minute, and 30 ml of distilled water was added immediately. The mixture was titrated with 0.1N $Na_2S_2O_3$ solution, added gradually with constant agitation. The titration continued until the yellow iodine colour had almost disappeared. About 0.5 ml of starch indicator solution was added. The titration was continued with constant agitation especially near the end point, to liberate all of the iodine from the solvent layer. Thiosulphate solution drop was added until the blue colour disappeared. A blank determination of the reagents was conducted. The blank titration did not exceed 0.1ml of the 0.1N sodium thiosulphate solution [12].

## 3. Results and Discussion

### 3.1 Effects of Storage Systems on Percentage Oil Yield of Palm Kernels

The effect of the studied storage systems on percentage oil yield of palm kernels is shown in Table 1. The table shows that the samples stored in air tight jerry-can has the highest average percentage oil yield of 51.9610% followed by the samples stored in open jerry-can with 43.8962%; and 43.7217 % for the samples stored in woven basket. These results agree with the work of [14].

**Table 1:** Effect of studied storage systems on PKO yield

| Parameters | Storage Systems | | | | |
|---|---|---|---|---|---|
| | **Basket(A)** | **Jute bag(B)** | **Jerry-can (Open) (C)** | **Jerry-can (Airtight) (D)** | **Concrete floor storage (E)** |
| %Yield (sample 1) | 43.7225 | 43.4875 | 43.8961 | 53.9610 | 37.9529 |
| % Yield (sample 2) | 43.7217 | 43.4881 | 43.8961 | 51.9607 | 34.9529 |
| % Yield (sample 3) | 43.7210 | 43.4866 | 43.8962 | 49.9605 | 32.9530 |
| Average values | 43.7217 ± 0.000751 | 43.4872 ± 0.000755 | 43.8962 ±0.0000577 | 51.9610 ± 2.00025 | 35.2863 ± 2.516565 |

Table 2 is the One-way Analysis of Variance (ANOVA) table of the treatments. The p-value corresponding to the F-statistic is lower than 0.05, suggesting that one or more storage systems have significantly different effect.

**Table 2:** One-way ANOVA of k=5 storage systems (Table 1)

| Source | Sum of squares SS | Degrees of freedom ν | Mean square MS | F statistic | p-value |
|---|---|---|---|---|---|
| Treatment | 417.3312 | 4 | 104.3328 | 50.4799 | 1.3486e-06 |
| Error | 20.6682 | 10 | 2.0668 | | |
| Total | 437.9994 | 14 | | | |

The Tukey HSD test result to identify which of the pairs of storage systems are significantly different from each other is shown in Table 3. Basket compared to jute bag and open jerry-can had no significant different effect on percentage oil yield of the stored palm kernels. But, basket vs air-tight can; basket vs concrete floor; air-tight can vs jute bag, concrete floor, open can; open can vs concrete floor and jute bag vs concrete floor had significant different effect on the oil yield.

**Table 3:** Tukey HSD results for effect of storage systems on PKO yield

| Treatments pair | Tukey HSD Q statistic | Tukey HSD p-value | Tukey HSD inference |
|---|---|---|---|
| Basket vs Jute bag | 0.2823 | 0.8999947 | insignificant |
| Basket vs Open J. Can | 0.2101 | 0.8999947 | insignificant |
| Basket vs Airtight Can | 9.9262 | 0.0010053 | ** $p<0.01$ |
| Basket vs Conc. floor | 10.1629 | 0.0010053 | ** $p<0.01$ |
| Jute bag vs Open J. Can | 0.4924 | 0.8999947 | insignificant |
| Jute bag vs Airtight Can | 10.2085 | 0.0010053 | ** $p<0.01$ |
| Jute bag vs Conc. floor | 9.8806 | 0.0010053 | ** $p<0.01$ |
| Open Can vs Airtight Can | 9.7161 | 0.0010053 | ** $p<0.01$ |
| Open Can vs Conc. floor | 10.3730 | 0.0010053 | ** $p<0.01$ |
| Airtight Can vs Conc. floor | 20.0891 | 0.0010053 | ** $p<0.01$ |

### 3.2 Effect of Storage Systems on Moisture Impurities and Volatile Matter (MIV)

From Table 4 the results show that the average moisture content of kernel samples stored in airtight jerry-can was the least with a value of 3.7781% (wb), followed by open jerry-can with a value of 4.0299% and 4.1176% for the sample stored in basket. A figure of 4.2102% was recorded for kernel samples stored in jute bag. The highest moisture of 4.8869% was recorded for the kernel samples stored on an open floor. The low oil yield recorded for the kernel samples on the bare floor is partly attributed to this high moisture content for the same sample.

**Table 4:** Effect of storage systems on percentage moisture impurities and volatile matter (MIV)

| Parameters | Storage systems | | | | |
|---|---|---|---|---|---|
| | **Woven basket** | **Jute bag** | **Jerry-can (open)** | **Jerry-can (air tight)** | **Concrete floor storage** |
| % MIV(1st) | 4.1171 | 4.2121 | 4.0298 | 3.7781 | 4.8870 |
| % MIV(2nd) | 4.1180 | 4.2120 | 4.0296 | 3.7781 | 4.8868 |
| % MIV(3rd) | 4.1176 | 4.2120 | 4.0299 | 3.7779 | 4.8869 |
| **Average Value** | **4.1176 ±0.000451** | **4.2120 ±0.0000577** | **4.0299 ±0.000153** | **3.7781 ±0.000115** | **4.8869 ±0.000100** |

Table 5 is the One-way Analysis of Variance (ANOVA) table of the treatments. The p-value corresponding to the F-statistic is lower than 0.05, suggesting that one or more storage systems have significantly different effect. The Tukey HSD test result to identify which of the pairs of storage systems are significantly different from each other is shown in Table 6. All the five storage systems had significant different effect on the percentage MIV of the stored palm kernels.

**Table 5:** One-way ANOVA of **k**=5 storage systems (Table 4)

| **Source** | **Sum of squares SS** | **Degrees of freedom νν** | **Mean square MS** | **F statistic** | **p-value** |
|---|---|---|---|---|---|
| treatment | 2.0571 | 4 | 0.5143 | 10,149,998.1865 | 1.1102e-16 |
| error | 0.0000 | 10 | 0.0000 | | |
| total | 2.0571 | 14 | | | |

**Table 6:** Tukey HSD results for effect of storage systems on MIV

| **Treatments pair** | **Tukey HSD Q statistic** | **Tukey HSD p-value** | **Tukey HSD inference** |
|---|---|---|---|
| Basket vs Jute bag | 726.9056 | 0.0010053 | ** p<0.01 |
| Basket vs Open J. Can | 675.6067 | 0.0010053 | ** p<0.01 |
| Basket vs Airtight Can | 2,612.6538 | 0.0010053 | ** p<0.01 |
| Basket vs Conc. floor | 5,919.8948 | 0.0010053 | ** p<0.01 |
| Jute bag vs Open J. Can | 1,402.5123 | 0.0010053 | ** p<0.01 |
| Jute bag vs Airtight Can | 3,339.5594 | 0.0010053 | ** p<0.01 |
| Jute bag vs Conc. floor | 5,192.9892 | 0.0010053 | ** p<0.01 |
| Open Can vs Airtight Can | 1,937.0470 | 0.0010053 | ** p<0.01 |
| Open Can vs Floor | 6,595.5016 | 0.0010053 | ** p<0.01 |
| Airtight Can vs Floor | 8,532.5486 | 0.0010053 | ** p<0.01 |

### 3.3 Effect of Storage Systems on Free Fatty Acid Content of PKO Extracted

Fatty acids are aliphatic mono-carboxylic acids present in esterified form in an animal or vegetable fat. The un-combined or free fatty acids may become the breakdown of triglycerides. The results shown in Table 7 indicates the fact that because of the length of storage (3 months) for all the samples, the FFA content in all the kernels increased slightly above the SON value of 4-5% for crude palm kernel oil (CPKO).

**Table 7:** Effect of storage systems on free fatty acid content of pko extracted

| Parameters | Storage systems | | | | |
|---|---|---|---|---|---|
| | **Basket** | **Jute bag** | **Jerry-can (Open)** | **Jerry-can (Air tight)** | **Concrete floor storage** |
| 1st % FFA | 7.1174 | 6.9116 | 6.5372 | 6.1030 | 7.2903 |
| 2nd % FFA | 7.1174 | 6.9115 | 6.5375 | 6.1029 | 7.2909 |
| 3rd % FFA | 7.1171 | 6.9114 | 6.5371 | 6.1036 | 7.2903 |
| **Average value** | **7.1173 ± 0.000173** | **6.9116 ± 0.0001000** | **6.5373 ± 0.000208** | **6.1032 ± 0.000379** | **7.2905 ± 0.000346** |

The kernels stored in the air tight jerry can has an FFA of 6.1032%, those stored in open jerry can was recorded as 6.5673%. The samples stored in jute bag had 6.9116% while 7.1173% and 7.2905% were recorded for samples stored in basket and bare floor respectively. These values are in agreement with the experiment conducted by [15].

Table 8 is the One-way Analysis of Variance (ANOVA) table of the treatments. The p-value corresponding to the F-statistic is lower than 0.05, suggesting that one or more storage systems have significantly different effect. The Tukey HSD test result to identify which of the pairs of storage systems are significantly different from each other is shown in Table 9. All the five storage systems had significant different effect on the free fatty acid content of the stored palm kernels.

**Table 8:** One-way ANOVA of **k**=5 storage systems (Table 7)

| Source | Sum of squares SS | Degrees of freedom νν | Mean square MS | F statistic | p-value |
|---|---|---|---|---|---|
| treatment | 2.7239 | 4 | 0.6810 | 9,821,930.7643 | 1.1102e-16 |
| error | 0.0000 | 10 | 0.0000 | | |
| total | 2.7239 | 14 | | | |

**Table 9:** Tukey HSD results for effect of storage systems on Free fatty acid (FFA)

| Treatments pair | Tukey HSD Q statistic | Tukey HSD p-value | Tukey HSD inference |
|---|---|---|---|
| Basket vs Jute bag | 1,353.7390 | 0.0010053 | ** $p<0.01$ |
| Basket vs Open J. Can | 3,815.4215 | 0.0010053 | ** $p<0.01$ |
| Basket vs Airtight Can | 6,670.9030 | 0.0010053 | ** $p<0.01$ |
| Basket vs Conc. floor | 1,139.2983 | 0.0010053 | ** $p<0.01$ |
| Jute bag vs Open J. Can | 2,461.6825 | 0.0010053 | ** $p<0.01$ |
| Jute bag vs Airtight Can | 5,317.1640 | 0.0010053 | ** $p<0.01$ |
| Jute bag vs Conc. floor | 2,493.0373 | 0.0010053 | ** $p<0.01$ |
| Open Can vs Airtight Can | 2,855.4815 | 0.0010053 | ** $p<0.01$ |
| Open Can vs Floor | 4,954.7198 | 0.0010053 | ** $p<0.01$ |
| Airtight Can vs Floor | 7,810.2013 | 0.0010053 | ** $p<0.01$ |

### 3.4 Effect of Storage Systems on Peroxide Value of PKO Extracted

The peroxide value of oil is used as a measurement of the extent to which rancidity reactions have occurred during storage. The double bond found in fats and oil plays a role in auto-oxidation. The peroxide value is determined by measuring the amount of iodine which is formed by the reaction of peroxides with iodide-ion as shown below:

$2I^- + H_2O + ROOH^- > ROH + 2OH^- + I_2$

**Table 10:** Effect of storage systems on peroxide value of pko extracted

| Parameters | Storage systems | | | | |
|---|---|---|---|---|---|
| | Basket | Jute bag | Jerry-can (Open) | Jerry-can (Air tight) | Floor storage |
| 1st P.V | 6.1205 | 5.5840 | 4.7660 | 3.4665 | 7.5020 |
| 2nd P.V | 6.1211 | 5.5853 | 4.7658 | 3.4670 | 7.5045 |
| 3rd P.V | 6.1203 | 5.5855 | 4.7651 | 3.4669 | 7.5029 |
| **Average value** | **6.1207 ± 0.000416** | **5.5850 ± 0.000814** | **4.7651 ± 0.000473** | **3.4668 ± 0.000265** | **7.5033 ± 0.00127** |

From the results in Table 10, the samples stored in air tight jerry can has the least peroxide value of 3.4668 followed by the samples stored in the open jerry can with 4.7651.The samples stored in jute bag has a peroxide value of 5.5850 while the samples stored in basket has 6.1207.

**Table 11:** One-way ANOVA of **k**=5 storage systems (Table 10)

| Source | Sum of squares SS | Degrees of freedom νν | Mean square MS | F statistic | p-value |
|---|---|---|---|---|---|
| treatment | 27.2323 | 4 | 6.8081 | 12,453,813.1791 | 1.1102e-16 |
| error | 0.0000 | 10 | 0.0000 | | |
| total | 27.2323 | 14 | | | |

Table 11 is the One-way Analysis of Variance (ANOVA) table of the treatments. The p-value corresponding to the F-statistic is lower than 0.05, suggesting that one or more storage systems have significantly different effect. The Tukey HSD test result to identify which of the pairs of storage systems are significantly different from each other is shown in Table 12. All the five storage systems had significant different effect on the peroxide value of the stored palm kernels.

Table 13 displays the whole average values for % yield, MIV, % FFA, and PV.

**Table 12:** Tukey HSD results for effect of storage systems on peroxide value of PKO extracted

| Treatments pair | Tukey HSD Q statistic | Tukey HSD p-value | Tukey HSD inference |
|---|---|---|---|
| Basket vs Jute bag | 1,254.9343 | 0.0010053 | ** p<0.01 |
| Basket vs Open J. Can | 3,174.2317 | 0.0010053 | ** p<0.01 |
| Basket vs Airtight Can | 6,216.8870 | 0.0010053 | ** p<0.01 |
| Basket vs Conc. floor | 3,238.6534 | 0.0010053 | ** p<0.01 |
| Jute bag vs Open J. Can | 1,919.2974 | 0.0010053 | ** p<0.01 |
| Jute bag vs Airtight Can | 4,961.9527 | 0.0010053 | ** p<0.01 |
| Jute bag vs Conc. floor | 4,493.5876 | 0.0010053 | ** p<0.01 |
| Open Can vs Airtight Can | 3,042.6553 | 0.0010053 | ** p<0.01 |
| Open Can vs Floor | 6,412.8851 | 0.0010053 | ** p<0.01 |
| Airtight Can vs Floor | 9,455.5404 | 0.0010053 | ** p<0.01 |

**Table 13:** General result of the effects of storage systems on PKO yield and for quality

| Parameters | Storage systems | | | | |
|---|---|---|---|---|---|
| | **Basket** | **Jute bag** | **Jerrycan (Open)** | **Jerrycan (Air tight)** | **Floor storage** |
| % YIELD | 43.7217 ± 0.000751 | 43.4872 ± 0.000755 | 43.8962 ± 0.0000577 | 51.9610 ± 2.00025 | 42.9529 ± 2.516565 |
| % MIV | 4.1176 ± 0.000451 | 4.2120 ± 0.0000577 | 4.0299 ± 0.000153 | 3.7781 ± 0.000115 | 4.8869 ± 0.000100 |
| % FFA | 7.1173 ± 0.000173 | 6.9116 ± 0.000100 | 6.5373 ± 0.000208 | 6.1032 ± 0.000379 | 7.2905 ± 0.000346 |
| PV (me kOH/g oil) | 6.1207 ± 0.000416 | 5.5850 ± 0.000814 | 4.7651 ± 0.000473 | 3.4668 ± 0.000265 | 7.5033 ± 0.00127 |

## 4. Conclusion and Recommendations

### 4.1 Conclusion

The comparative evaluation of influence of the five storage systems used in determining the yield and quality of the oil from the kernel samples stored in them suggests that the air tight jerry-can has a comparative advantage over the basket, jute bag, open jerry-can and floor storage in terms of oil yield and quality. From this study, it can be concluded that, storage periods, and storage systems (structures) influence oil yield, and free fatty acid content of oil-palm kernels. The FFA content increased slightly above the SON value of 4 – 5% because of the length of storage. Oil-palm kernel is yet to be fully explored in most parts of Africa. Its oil has a lot of agro-industrial potential and there is an abundance of possibilities for improvement in its methods of handling, processing, storage and utilization.

### 4.2 Recommendations

1. Therefore, it is recommended that, entrepreneurs of palm kernel vegetable oil production should not store kernels for long periods of time especially under the open air.

2. It is also recommended that, further research should be carried out on other physical and chemical parameters that were beyond the scope of this study such as proximate and elemental analysis of oils from these stored samples, so as to ascertain the suitability of these oil samples for consumption and other industrial uses.

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