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PALM KERNEL SEPARATION EFFICIENCY AND KERNEL QUALITY FROM DIFFERENT METHODS USED IN SOME COMMUNITIES IN RIVERS STATE, NIGERIA

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ABSTRACT

The separation efficiency and palm kernel quality of five palm kernel shell separation methods used in selected communities in Rivers State, Nigeria were evaluated. The methods include traditional handpicking, clay-water bath (kaolin), mechanical dry separation, pneumatic and hydrocyclone separations. The weight of recovered palm kernels obtained from each separation method was determined and used in the calculation of separation efficiencies. Free fatty acid (FFA), shell/fibre and moisture content of the palm kernels recovered from each separation method was determined. The results show that the least free fatty acid (FFA) content of (3%) was found in sample separated by the pneumatic method and highest (8%) in the clay-water bath (kaolin) method. High moisture content of 11% was recorded for kernels separated by clay-water bath (kaolin). Pneumatic separation method retained the least percentage of shell/fibre content (2%). Hand picking and clay-water bath (kaolin) methods had shell/fibre retention of 8% and 6%, respectively. However, mechanical, pneumatic and hydrocyclone separation techniques conform to the quality parameters when compared to SON/NIS standard. The mechanical, pneumatic and hydrocyclone separation methods gave higher separation efficiencies of 74, 90 and 96% respectively and palm kernels of superior quality that meets the palm kernel industrial standards. There was no significant difference ($P>0.05$) in separation efficiencies between the traditional hand picking and the clay water bath methods however there was a significant difference ($P<0.05$) between the above two methods and mechanical, pneumatic and hydrocyclone separation methods.

Contribution/Originality: This study shows that pneumatic and hydrocyclone separation methods are the most efficient in separating cracked palm kernel mixtures. This study also provide information on the best method of palm kernel recovery that meets quality requirement for Nigerian Industrial standard.

1. INTRODUCTION

The oil palm tree (*Elaesis guineensis*) is one of the greatest economic assets a nation has, provided its importance is realized and fully harnessed. Palm kernel industry is very popular in southern Nigeria because of the dependent of many chemical industries on palm kernel oil as a raw material for the making of soap, detergents, vegetable oil, cosmetics and oleochemicals (Hartley, 1987; Oke, 2007). The processing of palm kernels into palm oil involves the cracking of palm nuts, separation of the palm kernel shells from the cracked mixture (Kernels and Shells), washing, cleaning, kernel size reduction and the extraction of palm kernel oil.

Due to the high demand by the chemical industries for palm kernel oil as raw material, an efficient palm kernel cracking and separation method has become very important. An efficient cracking and separation method normally produces kernels and oils of superior quality with low free fatty acid content of less than 5%. Although the technology of palm kernel cracking and separation has advanced in recent years with new innovations to separate the shells from the kernels to obtain kernels of superior quality, survey results reveals that eighty percent (80%) of Nigerian palm kernel is still being produced by small and medium scale processors (Badamus, 2002). The separation of palm kernel and shell mixture has remained a major problem militating against high production of palm kernel to meet industrial demand (Adewale and Olufermi, 2014).

Owolarafe *et al.* (2002) reported that about 90% of annual palm oil production in Nigeria generated palm kernel for palm kernel oil extraction. The techniques employed in the separation of the mixture are the wet or dry method or a combination of both. The wet method is done in a liquid medium based on the difference in specific gravities of the constituents while in the dry method, no liquid medium is used. Akubuo and Eje (2002) reported that the kernel recovered from the wet systems must be sterilized (dried) against the growth of moulds and redried for 14 – 16 hr to remove moisture absorbed during the separation process.

Many small and medium scale processors in southern Nigeria are still contending with the problem of how to easily, efficiently and quickly crack their palm nuts and separate the shells from the kernels. In Nigeria, several methods of shell separation are used by small, medium and large scale palm kernel processing industries; they include traditional hand picking method, clay water bath (kaolin), mechanical, pneumatic and Hydrocyclone methods. Most small and medium scale processors use both the traditional hand picking and the wet clay water bath (kaolin) methods which are very cumbersome, inefficient and time consuming. The clay water bath (kaolin) and the hydrocyclone are two cracked mixture separation methods based on density and are called the wet method since water is always involved and the kernels have to be dried at the end of the separation (Amoah *et al.*, 2007).

Considering the enormous challenges confronting the small and medium scale palm kernel processors in separating their cracked kernels from the shells, there is the need to evaluate the quality of palm kernel recovered and the efficiencies of the different methods of palm kernel shell separation to enable small and medium scale palm kernel entrepreneurs to choose separation method that are efficient and ensure good quality palm kernels. Inefficient separation process could cause shells to be carried together with kernel to the palm kernel expeller which could damage the crushing hammer mill.

The objective of this study therefore is to investigate or evaluate the separation efficiency of five different techniques commonly used in Rivers State, Nigeria. As well as determine the quality parameters of the separated kernels.

2. MATERIALS AND METHODS

2.1. Materials

Separated palm kernels were collected from traditional and mechanized palm kernel processors in selected communities and companies visited in Rivers State, Nigeria such as Elele, Isiokpo, Oyigbo, Eleme, Ahoada, Ubima and Umerelu as shown in Table 1.

Table-1. Palm kernel separation methods used by operators in the different communities

Traditional hand picking Method	Clay bath (kaolin) Method	Mechanical Separation Method	Pneumatic Separation Method	Hydrocyclone Method
Communities	**Communities**	**Communities**	**Communities**	**Communities**
Elele Isiokpo Umerelu Oyigbo Ahoada	Elele Isiokpo Umerelu Oyigbo Ahoada	Ubima Elele Ahoada	Ubima	Ubima

Source: Author's tabulation based on field survey

2.2. Methods

The methods used for the separation of cracked kernel mixtures includes; traditional hand picking method, clay water bath (kaolin) method, the use of mechanical separator, the pneumatic kernel separator and the hydrocyclone methods as presented in Figure 1.

The weights of the recovered kernels in all the five separation methods were determined and use to calculate the separation efficiency of each method. Two kilograms of kernel recovered from each separation method was used to determine the free fatty acid content, moisture and shell/fibre content of each separation method.

2.2.1. The Traditional Hand Picking Method

Two hundred kilograms (200kg) of uncracked kernel was cracked using stone and the cracked mixture consisting of kernels, unbroken nuts and dusts were obtained. The kernels were separated by hand picking, the total weight of the kernel recovered was determined and use to calculate separation efficiency.

2.2.2. The Clay Water Bath (Kaolin) Method

The clay water bath uses a clay solution that is maintained within a relative density of 1:12, when the cracked mixture is admitted into the clay-water bath, the denser shells will sink to the bottom while the less dense kernels will float (Oguoma *et al*., 1993). Two hundred kilograms (200kg) of uncracked kernels was cracked using a kernel cracking machine and poured into a drum containing water and clay (kaolin). The density difference makes the shells to sink and the kernel to float. The kernels are then skimmed off from the water/clay solution, washed and dried under the sun according to the method of Amoah *et al.* (2007). The weight of the kernel recovered was determined and used in the calculation of separation efficiency.

2.2.3. The Mechanical Separation Method

This is the Nigerian institute for oil palm research (NIFOR) type of mechanical separator in which the cracking and separation operations occurs in the same machine. This consist of a nut cracker and separator built together, it is a semi-automated processing method that speed up cracking of the nuts and separation/recovery of kernels. Two hundred kilograms (200kg) of the uncracked kernels was cracked and separated using the NIFOR type of mechanical separator (Two-in-one), the total weight of the kernels separated was determined for calculation of separation efficiency.

2.2.4. The Pneumatic Palm Kernel Separator (Dry Method)

This is based on the shape of the shells and kernels. The system includes winnowing colum and the vibrating table. This method uses dry forced air or induced draught to separate the kernels from the shells. Two hundred kilograms (200kg) of uncracked kernel was fed into the pneumatic separator which then cracked the kernel and the cracked mixture was conveyed by a screw conveyor to the winnowing colum where forced dry air was used to separate kernels from the shells. The total weight of the separated kernels was then determined and use in the calculation of the separation efficiency, moisture, shell/fibre and free fatty acid content.

2.2.5. The Hydro-Cyclone (Wet Method)

The hydro-cyclone separator uses both water and air in two different compartments within the same chamber. The clay water bath and the hydrocyclone separation methods are based on density differences. Two hundred (200kg) of uncracked palm kernel was cracked within the system, the water compartment of the hydrocyclone separate the nuts from the shells while the air filled compartment within the chamber dries the wet separated kernels before finally being emptied into a bucket from where it was bagged. At the end of the drying operation, the total weight of the kernel recovered was determined and use in the calculation of the separation efficiency, moisture, shell/fibre and free fatty acid content determination.

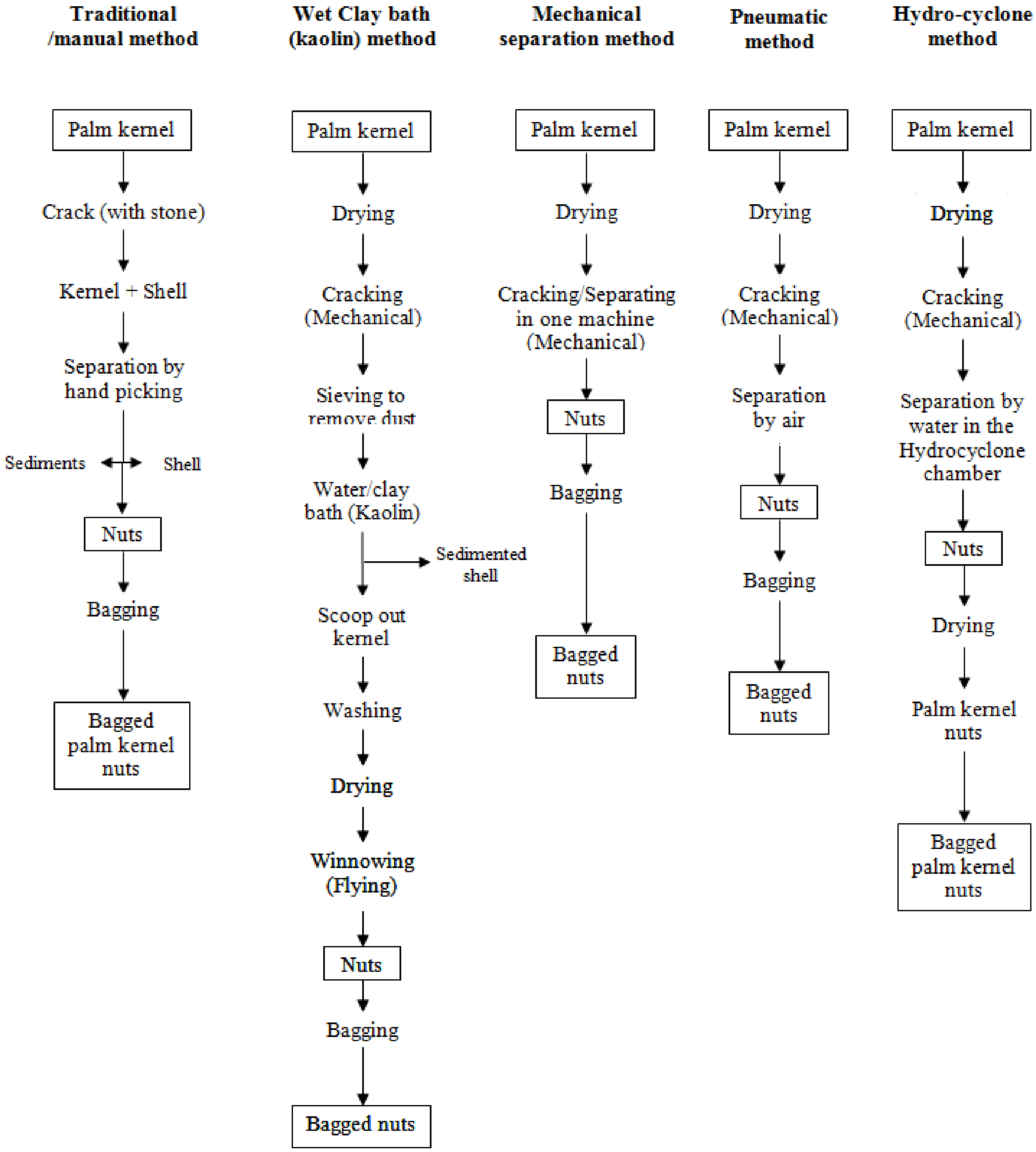

Fig-1. A flow chart of different methods of palm kernel cracking and separation operated in Rivers State, Nigeria.
Source: Arthurs compilation

2.2.6. Determination of Efficiency of Each Separation Method

The efficiency of each separation method was determined by determining the weight of the uncracked kernels that was feed into the cracking/separation process. The total weight of the kernel recovered at the end separation process was determined. The time taken for the separation to occur was also noted.

The separation efficiency was calculated by using the equation below;

$$\% \text{ separation efficiency (n)} = \frac{output}{input} \ x \ \frac{100}{1}$$

Where

Output = Quantity of kernels recovered after separation

Input = Quantity of uncracked palm kernel that goes into each system.

2.3. Determination of Palm Kernel Quality from each Separation Method

2.3.1. Determination of Free Fatty Acid (%)

Twenty grams of ground (palm kernel meal) was accurately weighed into a soxhlet extraction thimble. The oil was extracted for 4 hr using n-hexane as a solvent. After removal of the hexane from the extracted oil, the free fatty acid (FFA) was determined by weighing five gramme (5g) of the oil, dissolving with 20ml neutral alcohol and titrating against 0.1N NaoH using phenolpthalen as indicator. A blank titration was also carried out.

The FFA was expressed as lauric acid

$$\% \text{ FFA} = \frac{V \ x \ 0.1 \ x \ 200 \ \ x \ 100}{weight \ of \ \ sample \ x \ 1000}$$

Where V = Titre value

2.4. Determination of Moisture Content (%) of Recovered or Separated Palm Kernel

Ten (10g) of kernels was ground in a grinder and weighted the ground meal was dried to constant weight in an air oven at 105^{0}$_{c}$ for 3 hr moisture content was calculated from the weight loss and expressed as a percentage of the original weight as % moisture = $\frac{a-b}{a} x \frac{100}{1}$

Where a = weight of ground kernel before heating and b = weight of ground kernel after heating.

2.5. Determination of Shell/Fibre (%) In Recovered Palm Kernel

Five hundred grammes (500g) of (W_2) representative sample of separated kernels obtained from each of the five methods were used. The shell, fibre and any other impurity present in each sample was carefully separated from the kernel. Knife was used to remove any shell attached to any kernel. The shell, fibre and any other impurity that was separated from each set of the samples was then weighed in an electronic balance as (W_3).

The percentage shell and fibre was then calculated as follows;

$$\% \text{ shell/fibre} = \frac{W_3 - W_1}{W_2} \ x \ \frac{100}{1}$$

Where W_3 = weight of shell and fibre, W_1 = weight of empty weighing dish and W_2 = weight of separated kernels i.e the representative sample (500g).

3. RESULTS AND DISCUSSION

The result of cracked palm kernel separation efficiencies using different separation methods are shown in figure 2. The traditional hand picking methods have an average of 53% and the clay water bath method an average of 60% efficiency. There was no significant difference (P>0.05) in separation efficiencies between the two methods. Whereas there was a significant difference (P<0.05) between the above two methods and mechanical separation method which have the separation efficiency of 74%. The most efficient cracked palm kernel mixture separation methods are hydrocyclone (96%) and pneumatic (90%) although there is no significant difference (P>0.05) followed by mechanical (74%).

Adewale and Olufermi (2014) were able to design a mechanical cracked kernel separator having separation efficiency of between 73-78% while Asibeluo and Abu (2015) designed and constructed a modified version of a mechanical palm kernel cracker and separator with higher separation efficiency. The result obtained in this study compared favourably with the ones designed by Adewale and Olufemi (2013;2014) and Asibeluo and Abu (2015).

Ronald (2012) reported that the kaolin used in clay water bath separation method was expensive and produces a lot of waste after the separation process. He attributed the poor efficiency of the method to the fact that it is very hard to obtain the right ratio of water and kaolin for a perfect separation hence processors use trial and error methods which do not give an efficient separation. This could be the probable reason for the low efficient separation of 60% obtained in this study.

The imbalance in the water and kaoline ratio may be responsible for the sinking of some kernels along with the shells as was observed in this study which could also cause low separation efficiency.

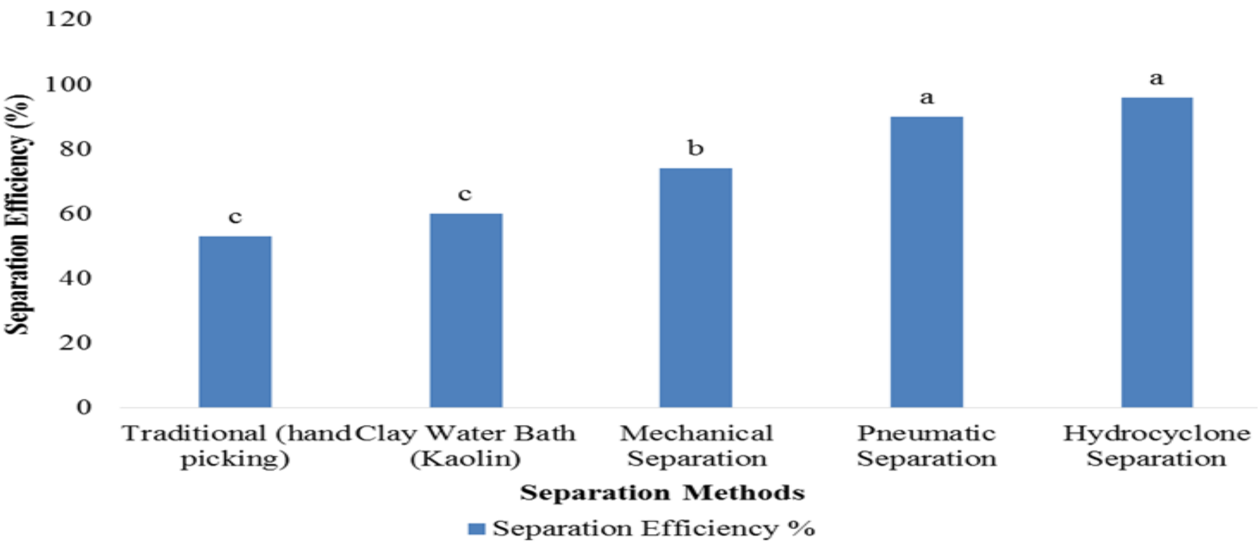

Figure-2. Separation efficiency of different methods of palm kernel Separation

Source: Arthurs results

1. Means of triplicate determination
2. abc = means with the same superscript do not differ significantly (P<0.05).

Table 2 shows the palm kernel quality parameters of the different separation methods. The moisture and free fatty acid content of all the separation methods were within the SON (2002) standard of 5% except for kernels obtained from the clay water bath method which have moisture and FFA content far above the recommended SON/NIS standards.

High moisture content encourage the growth of moulds which secret lipase enzymes to break down the triglyceride in the palm kernel causing an increase in the free fatty acid content. Poku (2002) and Kuku (1978) reported poor kernel quality kernels obtained from clay water bath separation method was as a result of large volume of water use to wash the kernels and drying possess a problem especially during the raining season which subject the kernels to mould attack causing high FFA in kernels.

In the cause of this study, it was observed that the clay water bath and the hydrocyclone which are wet methods generates high volume of waste effluent making the discharge of the effluent a problem, this observation was also reported by Amoah *et al.* (2007) that these methods are environmentally unfriendly.

The shell and fibre content of all the separation methods were within the NIS (1992) recommended level of 5% except for the traditional handpicking method having about 8% shell/fibre content. This is related to the low separation efficiency of this method (53%) obtained in this study.

Okoronkwo *et al.* (2013) reported that inefficient separation process leds to high shell/fibre content of palm kernels which causes shells to be carried together with kernels to the palm kernel expellers which could damage the crushing mechanism.

Table-2. Palm kernel quality from different separation methods

Palm Kernel/shell separation method	Palm kernel quality attributes			
	Moisture content (%)	**Shell/fibre content (%)**	**Free fatty acid content (FFA) (%)**	**SON/NIS standard (%)**
Traditional hand picking (dry method)	6^{b}	8^{a}	6^{b}	Moisture (5) Shell/Fibre (5) FFA Content 5 Max.
Clay water Bath (Kaolin) wet method	11^{a}	6^{b}	9^{a}	
Mechanical Separator (dry method)	4^{b}	4^{c}	5^{b}	
Pneumatic Separation (dry method)	3^{bc}	2^{c}	3^{bc}	
Hydrocyclone Separation (wet method)	4^{b}	3^{c}	4^{b}	

Means bearing the same superscript within the column do not differ significantly ($p<0.05$).
SON: Standard Organization of Nigeria
NIS: Nigeria Industrial Standard

4. CONCLUSION

Pneumatic, hydrocyclone and mechanical methods are the most efficient in separating cracked palm kernel mixtures and recovery of palm kernels of superior quality that meet industrial standards. Therefore small scale and medium scale operators can pool their resources together or obtain loan to be able to acquire a more efficient crack palm kernel separation plant such as the mechanical separator which will enable them to produce palm kernels of superior quality that meets industrial standard.

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