Problems and Solutions involved in Oil Processing from Kernel Seeds.

O.D. Samuel, M.Eng.[1*] and A.G.F. Alabi, Ph.D.[2]

[1]Department of Mechanical Engineering, Federal University of Agriculture, Abeokuta, PMB 2240, Abeokuta, Nigeria.
[2]Department of Mechanical Engineering, University of Ilorin, Nigeria.

E-mail: samolud@yahoo.com[*]
agfalabi@yahoo.com

ABSTRACT

A study was designed to examine the mechanical-related problems facing palm kernel oil mills. Crushing sections and filter press were assessed. One of the mills has a standard laboratory testing facilities which was used to carry out such tests as oil content of the palm kernel species, percentage moisture content, percentage milling defect of the cake, and percentage moisture content of cake. Besides, samples of kernel seeds from truck was subjected to shell content analysis to ascertain the effect of moisture on oilseeds under open and close conditions. Effect of various moisture contents of the kernel seed samples was tested on the expeller. It was found that the storage condition was irrelevant as long as the storage is within 10 days. Excessive increment in moisture content of kernel seeds could reduce the expulsion ability and wear of mechanical parts of expeller. Reliable laboratory tests and analysis as well as proper maintenance would go a long way to boosting the productivity in the palm kernel oil industry.

(Keywords: crushing mills, oil, maintenance, shell content)

INTRODUCTION

Palm kernel oil is obtained from palm kernel seeds and grows widely in certain locations such as Niger Delta and South Eastern parts of Nigeria (Komolafe and Adegbola, 1980). However, productivity in Nigeria is poor and such vegetable oils are important to meet demands. According to estimates (Vanguard, 2002) the total money Nigeria spends to import vegetable oil from Malaysia in 2001 alone was $186.65 million. The Minister of Agriculture, Mallam Bello agrees (Vanguard,2002) that such is a very sad state of affairs in this country with generous land, wide varieties of soil types throughout the different agro-ecological zones and climate ranging from tropical to temperate, which makes it possible to grow assorted oilseeds from which vegetable oils can be processed.

It has been estimated that production-consumption margin is increasing by thousand tons naturally because of population growth and rise in per capital income. This situation requires a serious consideration for effective futuristic planning of maximizing oilseed production in the country. Undoubtedly, such a measure is the crying demand of the country from the agricultural sector. Samuel (2006) reported that the central government has, for the first time, recognized the need to reduce the dependence on importation of edible oil, and to develop and sustain price stabilization mechanism for the oilseeds in the country. Nigeria should also borrow a leaf from this and develop her oil sources for sustainability by increasing productivity of the industry. Good quality edible oil is fresh, free from odious and any trace of rancidity. The acceptability of the products at world edible oil market depends on its ability to satisfy basic standard tests for fats and oil (Takakura, 2002).

In crushing mill, oil is expressed from oilseed by mechanical expression and two main products are obtainable from the palm kernel in addition to the shells. These are palm kernel oil, palm kernel cake, which are extensively used in livestock (Wallace et al., 2010). Seed crushing industry is one of the oldest industries of the world. The Chinese were the first people to express oilseeds as far back as 300 B.C and Egyptians were reported to obtain oil using a press (Samuel, 2006). The first mechanical screw press was successfully used in 1906. The manufacturers have come a long way since then with improved material of construction, manufacturing method, research and development and have increased the efficiency. Consequently, various types of improved expellers were developed to meet the requirement of the processors. Oil extraction can be done mechanically with an oil press, expeller, or even with a wooden mortar and pestle—a traditional method that originated in India (Bachmann, 2001).

Example of presses are batch presses (small batch presses and commercial batch presses) and expellers or continuous screw expellers. The latter is mostly used throughout the world in extracting oil. Expellers use a horizontally rotating metal 'screw' which feeds oil-bearing raw material into a barrel-shaped outer casing with perforated walls. Raw materials are continuously fed to the expeller, which grinds seeds, crushes and presses the oil out as it passes through the machine. Most small expellers are power-driven, typically requiring about 3 hp and are able to process between 8 and 45 kg per hour of raw material depending upon the type of expeller used.

Bigger units processing greater quantities are available for use in larger mills. The pressure ruptures the oil cells in the raw material, and oil flows through the perforations in the casing and is collected in a trough underneath. There are four main stages in the extraction of oil: preparation of the raw material, extraction, clarification, packaging and storage. Preparation of the raw material involves cleaning, dehulling, cracking, flaking, pulping, grinding, grating, and heating or conditioning (RRRP, 1997). Small-scale oilseed processing is of interest as a potential on-farm or community enterprise that can increase income and employment in rural areas (Fellows et al., 1992).

Particles, such as plant cells left in the oil after the extraction process, are removed by a process referred to as filtering (Bachmann, 2001). Filter press is employed in removing impurities from oil. Service and maintenance of filter press as well as operational principle were reported by Samuel (2006).

In milling plant, shell content is employed on the kernel seeds supplied in order to ascertain the acceptability of a particular supply. The higher the percentage of the pieces of shell content, the lesser the amount of oil that can be extracted from kernel seeds and vice-verse (Samson, 2002). The milling defects analysis of kernel cake provides information concerning the efficiency of expellers. The lower the values of the milling defect of cake, the higher the efficiency of expeller (Samson, 2002).

Palm kernel oil yield decrease with increase in moisture content and increase with increase in roasting duration and temperature (Bachmann, 2001). The standard of a good quality oil as prescribed by the Indian Standard of physical and chemical society is shown in Table 1.

Table 1: The Standard of Chemical and Physical Properties of a Good Quality Kernel.

Crushing / Milling Parameters	IS Indian Standard
Shell content of palm kernel seeds	8.00
Oil content in kernel cake	10.00
Milling defect in cake	10.00
Moisture content in cake	10.00
Moisture content in kernel seeds	8.50
Free fatty acid	5.00

Source: IS. (1964)

Problems Experienced in Crushing Section of Vegetable Industry

Tours of three oil mills (Polema, RIVOC and Golden Mills) were undertaken and assessed so as to investigate operational problems militating against their productions. Such visits to the oil mills used as case study produced insights into the problem affecting the crushing plant. The problems militating against effective and efficient productivity via crushing are explained:

- **Low oil recovery from oilseeds**: This is a situation when the kernel oil crushed from its seeds is extremely low.

- **Shooting effect and uncomely decline in the efficiency of the expeller**: shooting effect is a technical term used to explain the abnormal noise in an expeller. This leads to low productivity.

- **High Oil Content in Cake Fibre**: This has to do with inability of operator to extract enough oil from cake after final crushing.

- **Mold Formation and Offensive Odor Generated By the kernel Cake:** This problem has to do with formation of mold and generation of odor by palm kernel cake after being packed and stored. This hinders the kernel cakes from further processing such as solvent extraction.

- **Foaming and Sludge Effect:** Foaming is a phenomenon where by small air bubbles are formed on oil crushed. This hinders proper filtration and refining. The oil extracted will be prevented from settling and proper filtration will not be effective.

Problems in Filter press Section

The operational problem encountered in filter press section is mainly connected to the foot valve. The foot valve is a type of valve, which enables filter press to draw oil. Its function is based on the pressure given by the pump itself. The foot valve develops certain problems as follows:

- **Air Pocket:** Presence of air pocket within the foot valve makes the valve not to function. This is caused by foreign material such as seed or stick blocking the inner parts of the valve. Consequently, the oil which ought to be stored in the line begins to wash out and the valve will not function when operated.

- **Gasket:** Burnt or torn gasket has air pocket within the joint. Hence, the pump will not be able to function as expected.

- **Priming or Bleeding:** This is a situation whereby you are trying to get rid of air so that enough pressure could be built up so as to ensure pumping action to take place.

- **Type of Filter Clothe:** Determines the efficacy of the crude oil filtration. If poor quality of filter cloth is used, proper filtration will be hindered and vice-versa.

- **Lack of proper Maintenance:** This causes inefficiency in filter press.

Satisfactory reports have appeared on the literature on improving productivity in vegetable industry. Akpobi and Owoniho (2004) reported overall efficiency in his S-neck cracking machine and Aniki (2002) recommended a special modified drying machine that will prevent cracking in drying palm kernel seeds Fapetu and Oke (2000) developed regression equation that can be employed in predicting flake thickness for given operational parameters. Jekayinfa (2006) developed empirical equation for estimating energy requirement in palm kernel oil processing.

Akinoso, et al. (2006) developed a model equation to effectively predict palm kernel oil yield at any yield moisture content, roasting temperature, roasting duration and roasting temperature. Oyilola, et al. (2004) developed a laboratory model screw press for model expeller and they reported of better quality of oil expressed from oilseed. It would appear that there has not been any study done to determine the functional parameters in the processing operations of palm-kernel. Such information is vital to enchase efficiency and develop strategies for better control of their production operation. In light of the problems encountered at the palm kernel crushing and filtering plants, some tests are necessary in order to ascertain the quality of oil produced and to improve efficiency. Therefore, the tests mentioned below will be employed to ascertain acceptability and to improve productivity.

So far, there was no research evidence reported on the utilization of laboratory analysis in monitoring productivity of palm kernel crushing mills. Therefore, the purpose of this study is to scale up production capacity of crushing mills, using eastern Nigerian oil mills as case study.

MATERIALS AND METHODS

The materials used for this work include: weighing balance, desiccators, conical flask, Palm kernel seeds, white nylon, funnel, 50ml of Ethanol and a burette.

In this study, palm kernel seeds, oil extracted and cake crushed were subject to various tests and analysis such as shell content, milling defect, oil content, moisture content and effects of varied moisture content of palm kernel seeds were investigated on the expeller. The behaviour of palm kernel seeds under open and closed conditions was determined. The desired temperature for drying kernel seeds (moisture content is 8.50%) was assessed.

Percentage Piece of Shell Content

A sample of palm kernel seeds is randomly collected by scooping from the supplier truck. The collected sample was well mixed and 700 gram was weighed out pieces of shells were separated from the kernel seed and weighed. The percentage of pieces of shell content was then determined using the expression 1.

% Piece Shell Content
$$= W_s * 100 / W_{ks} \quad \textbf{(1)}$$

Where:
W_s = Weight of a Piece of Shell
W_{ks} = Weight of kernel seed with pieces of shell = 700g

The procedures mentioned above were repeated by collecting various samples at different days.

Milling Defect Analysis of Palm Kernel Cake

Samples of the cake produced are collected and well mixed. 50g of each was then weighed. The milling defect is assessed using physical appearance of the cake which is usually whitish. The affected cake is weighed and then the percentage milling defect is calculated. The procedures were repeated by collecting samples of cake from expellers.

The value of the Milling Defect was determined using Equation (2):

$$MD = Wd / W * 100 \quad \textbf{(2)}$$

Where:
MD = Milling Defect
W_d = Weight of defect kernel cake
W = Weight of the sample used = 50g

Oil Content Analysis of Palm Kernel Cake

10 grams of the grounded sample was put into the thimble. 200mls of hexane was poured into a pre- weighed flask._The soxhlet extraction was started by putting on the heating mantle for 2 hour. When this period has elapsed, the thimble containing the sample was removed to separate the oil from the solvent used for the extraction. When the solvent has completely dried out from the flask, the solvent extraction unit is dismantled and the flask was cooled in a desiccator. The cooled flask with oil was weighed out to know the quality of oil in the sample as shown in Figure 1. The procedures were repeated by collecting sample of cake from expellers and the procedure were repeated from the 1st to 6th day. The percentage oil content for different days was determined using Equation 3.

$$\text{\% Oil Content} = Wc / W * 100 \quad \textbf{(3)}$$

Where:
W_c = Weight of oil after condensed only
W = Weight of ground sample used = 10g

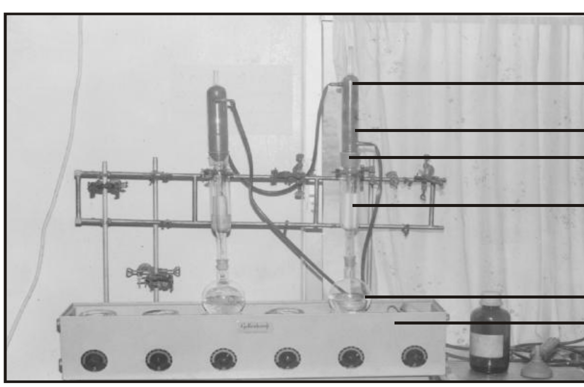


Figure 1: Soxhlet Extracting Unit Showing Extraction of oil in Palm Kernel Courtesy of Polema Oil Laboratory Complex, Aba.

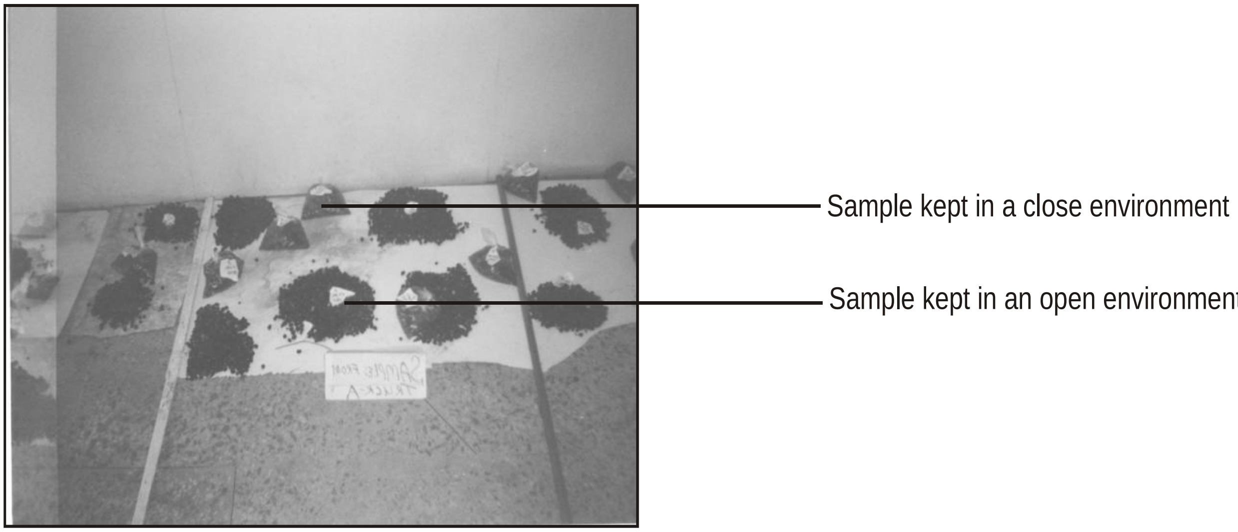


Figure 2: A Typical Representation of Kernel Seed Samples in Open and Closed Environment.

Moisture Content Analysis of Palm Kernel Cake

20gram of the grounded sample of seeds was weighed in Petri dishes. The dishes were placed inside an oven maintained at 105^{o}C and heated for three hours. The content was re-heated for another 30 minutes, then cooled and again re-weighed until the change in weight did not exceed 1 gram. The value of the moisture content of each sample was then determined using the Expression 4:

Moisture Content (Mc)

$$= \% \ (W_{bh} - W_{ah}) / W_{bh} \qquad \textbf{(4)}$$

Where,

W_{bh} = Weight of kernel seed before heated

W_{ah} = Weight of ground seed after heated

Determination of the Behavior of Palm Kernel under Open and Closed Conductions

In this analysis, the behavior of palm kernel seeds is looked at in term of it percentage shell content and moisture content.

A truck of kernel seeds was employed. 60 sample of kernel weight taken the truck. A closed environment was stimulated by keeping 30 samples each in well dried and sealed nylon container and an open environment was employed by keeping 30 samples each in dried, exposed and well-ventilated atmosphere.

The specimens were first scooped and mixed from the supplier truck to enhance seed uniformity. The specimens taken from the truck in the two environments were kept on a clean and dried of reasonable and specious dimension (Figure 2). The period of exposure in both environments was 30days. The percentage shell content of the sample was determined each day to assess the condition of the seed.

The moisture content analysis was conducted on each sample of seed taken from the trucks in 30days in order to confirm whether or not condensation has any effect. Also, the moisture content analysis of a batch was conducted on kernel seeds at varying temperature using the method described earlier to ascertain the desirable temperature for drying palm kernel seeds whose moisture content is 8.50%.

The seed samples kept in the two environments were crushed on the expeller for each number of days of storage to ascertain the effect of foaming and sludge effect on the kernel seeds.

Free Fatty Acid Analysis of Palm Kernel Oil

5grams of oil sample was carefully weight into conical flask and 50ml of the neutralized hot ethanol was added into the flask.

The content was heated until it boiled. Phenolphthalein indicator was added. The mixture was then titrated with 0.IN sodium hydroxide in a state of hotness. The titration was stopped when an addition of single drop change the color from yellow to pink. The volume titrated was noted and recorded. The free fat acid (FFA) of each sample then calculated using the expression:

$$FFA = T_V \bullet 2 / W_g \qquad \textbf{(5)}$$

Where:

FFA = Free Fatty Acid (%)
T_V = Titrated Value (cm^3)
W_g = Weight of oil sample taken (g).

Determination of Extraction Ability of Expeller as a Function of Moisture Content of Palm Kernel Supplied.

Fradex oil expeller was employed to express the oil. Eight sample of equal weight {80kg) of palm kernel seeds were collected from the eight trucks. The moisture contents of the sample and average weight of material expelled per minute {extraction} ability were determined and shown in Figure 6.

RESULTS AND DISCUSSION

Effect of piece of Shell Content

From Figures 3 to 5, the kernel seeds supplied on days 1, 2, 3, 4, 5, and 6 for the Golden mill are out of the standard. It falls within the standard only on the day 3. In contrast, Polema mill supplies are out of standard on days 2 and 3. The seeds supplied were within standard on other days. RIVOC mill on the other hand got excellent seed supplies on all day 1 to 6. However, other parameters that are important are assessed for good productivity.

Effects of Milling Defect in Palm Kernel Cake

The values of % milling defect of cake at the mills in Figures 3 to 5 are compared with the standard in Table1. It was observed that the cakes from the three mills are acceptable since the values fall within the standard. However, because of the variation in the shell content the quality was different. Also, the lower the % milling defect, the higher the efficiency of the expeller. It probable means that the efficiency of the expeller would be highest for RIVOC mill followed by Polema and the Golden mill. This again is in line with earlier assessment of the % shell content.

Effects of % oil Content in Palm Kernel Cake

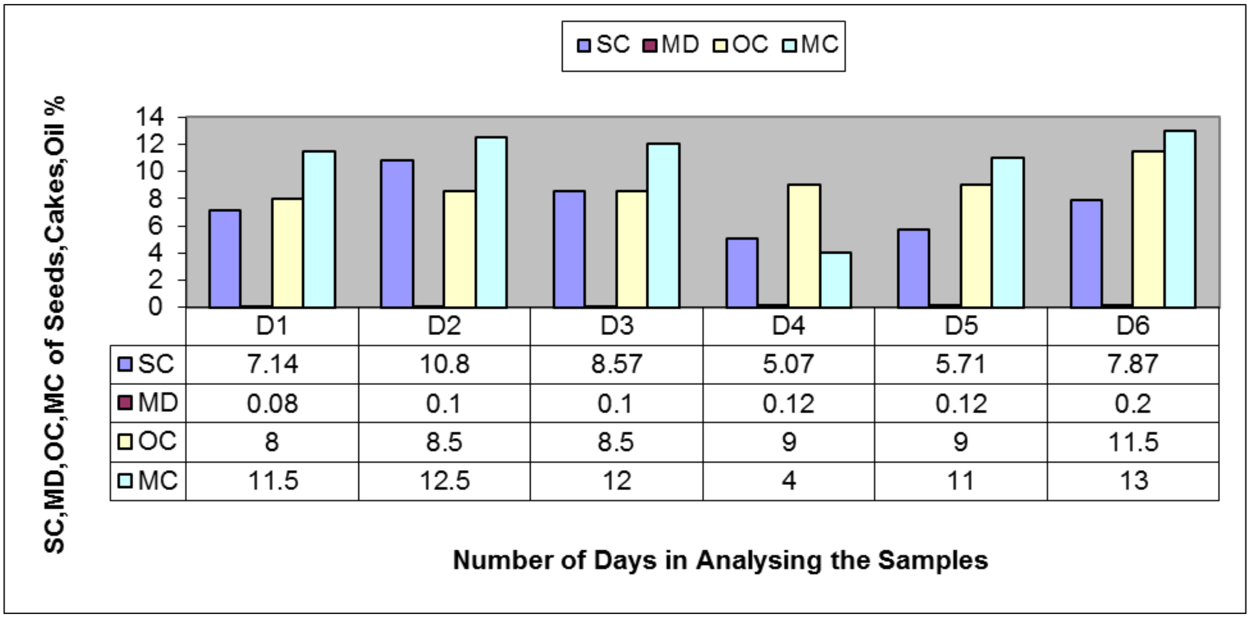
The values of % oil content in Figures 3 to 5 showed that the % oil content in cake is within the standard for Polema mill in day 1 to 5 and only out of the standard in day 6. For RIVOC mill, the values of oil content from days 1 to 3 are within the standard and higher for Golden mill however, the values were higher and only fall within standard I days 1 and 2. The lower value of mill content in Polema may be an indication of timely service of expeller then RIVOC, followed and then Golden.

Effect of Moisture Content

Since the cake with high oil content would need to be reprocessed for economic of productivity, It is of interest to know the moisture content must be within 10% in order to prevent unpleasant odor and mold formation on storage from Figures 3 to 5, the RIVOC has the lowest moisture content in cake and the Polema has the highest followed by Golden mill. The lower values of moisture content at RIVOC can be attributed to well-ventilated environment that it stored her oilseed.

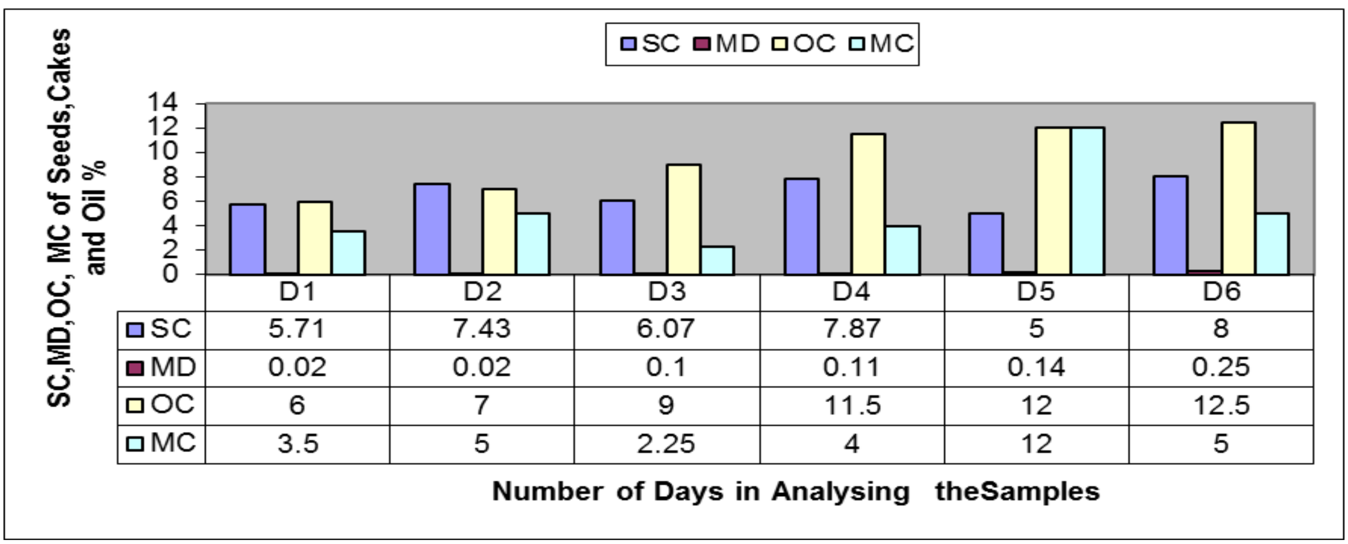
Effects of moisture Content on Expeller

The relationship between the moisture content of kernel seed and extraction ability of expeller is shown in Figure 6. Increase in moisture content of kernel seeds reduces expulsion ability of expeller. This resulted into decline in effective performance of oil expeller and rapid wear of the worm shaft.



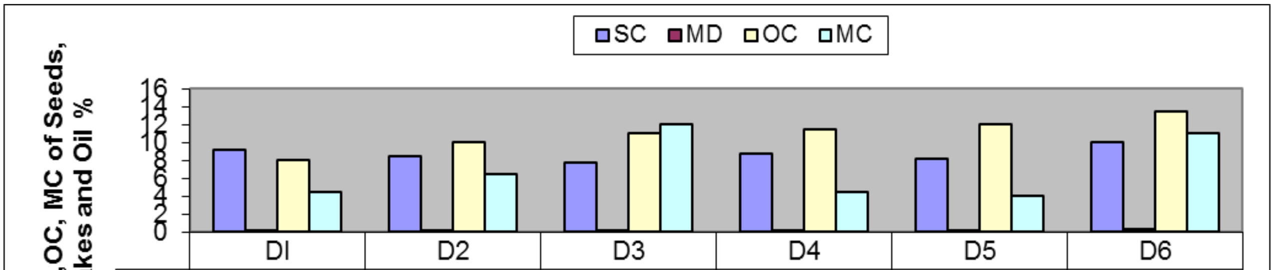
	D1	D2	D3	D4	D5	D6
SC	7.14	10.8	8.57	5.07	5.71	7.87
MD	0.08	0.1	0.1	0.12	0.12	0.2
OC	8	8.5	8.5	9	9	11.5
MC	11.5	12.5	12	4	11	13

Figure 3: Graph of Shell Content of Palm Kernel Seeds, Milling Defect of Palm Kernel Cakes Oil Content in Palm Kernel Cakes and Moisture Content in Palm Kernel Cakes Versus Number of Days in Analyzing the Samples in Polema Crushing Seed Industry.



	D1	D2	D3	D4	D5	D6
SC	5.71	7.43	6.07	7.87	5	8
MD	0.02	0.02	0.1	0.11	0.14	0.25
OC	6	7	9	11.5	12	12.5
MC	3.5	5	2.25	4	12	5

Figure 4: Graph of Shell Content of Palm Kernel Seeds, Milling Defect of Palm Kernel Cakes Oil Content in Palm Kernel Cakes and Moisture Content in Palm Kernel Cakes Versus Number of Days in Analyzing the Samples in RIVOC Crushing Seed Industry.



	DI	D2	D3	D4	D5	D6
SC	9.14	8.42	7.71	8.71	8.14	10
MD	0.06	0.06	0.1	0.16	0.23	0.3
OC	8	10	11	11.5	12	13.5
MC	4.5	6.5	12	4.5	4	11

Figure 5: Graph of Shell Content of Palm Kernel Seeds, Milling Defect of Palm Kernel Cakes Oil Content in Palm Kernel Cakes and Moisture Content in Palm Kernel Cakes versus Number of Days in Analyzing the Samples in Polema Crushing Seed Industry.

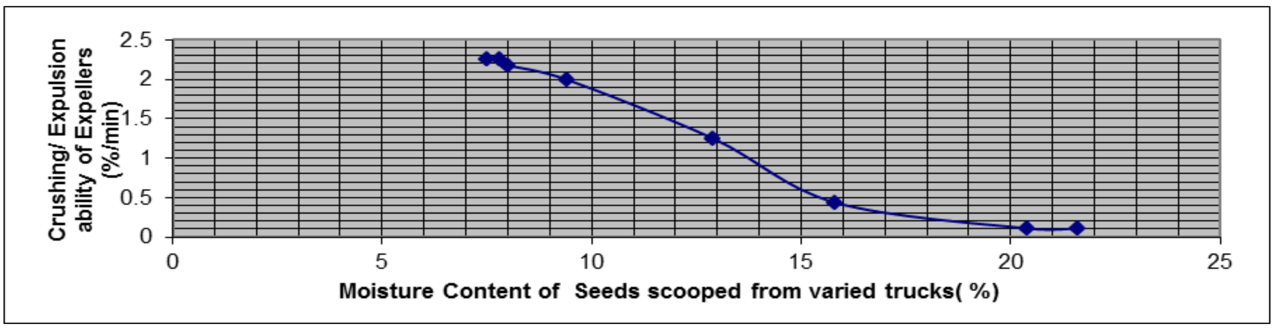


Figure 6: Graph of Crushing ability of Oil Expeller Versus Moisture Content of Seeds Scooped from Varied Trucks.

Effects of Storage Condition on the Palm Kernel Seeds

It was observed that the values of piece of shell content of seed kept in the open and close environment are almost similar even though the closed system shows negligible enhancement in % piece-shell content in Figure 7. There is a formation of foam from the seed taken from the used condition when being crushed. The may be due some condition resulting from high moisture content and mold formation. Beyond the 14th days, the piece-shell content of seeds at closed condition disagrees with the standard. On other hand, all the values of piece-shell content of open environment are in line with the standard. The higher shell content, the lesser the oil that can be extracted from such seeds and vice-verse. Hence, there is a greater possibility of the higher oil produce from seeds kept in the open environment than open condition.

Effects of Free Fatty Acid

Figure 8 shows that the free fatty acid increased as the day of storage increased. On the first week, the FFA value was 7.32. The value of free fatty acid of palm kernel oil stored was greater than the maximum value recommended by the Indian standard of physical and chemical society (IS, 1964). The reason for the disparity could be attributed to the processing techniques and microbial activity on the cells of oilseed.

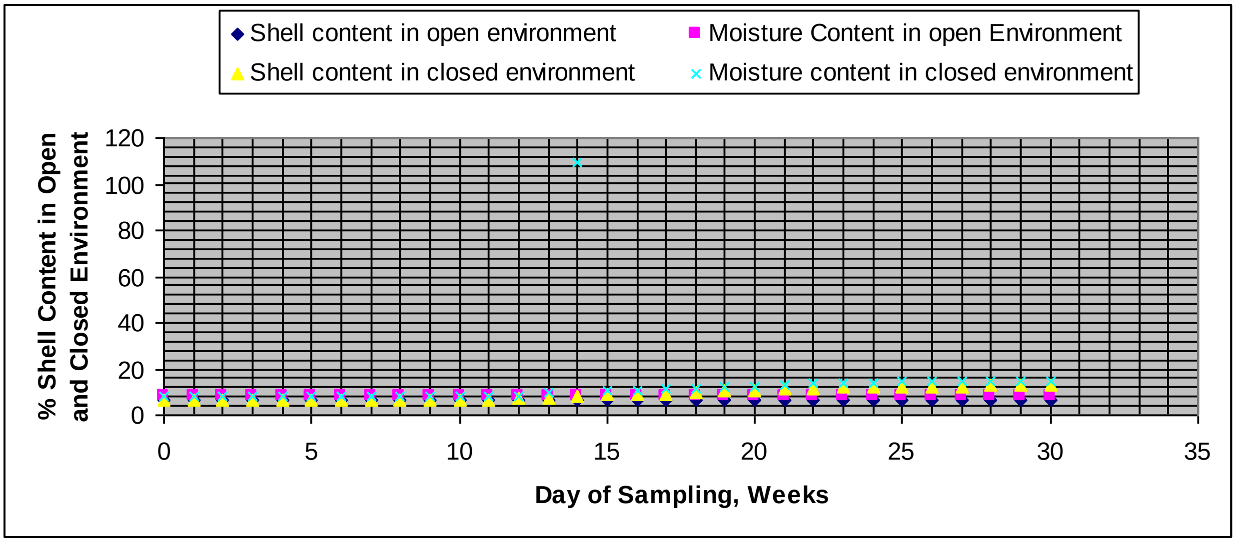


Figure 7: Graph of Pattern of Change in % Shell Content and Moisture Content of Palm Kernel sees with Shell under two Storage Conditions.

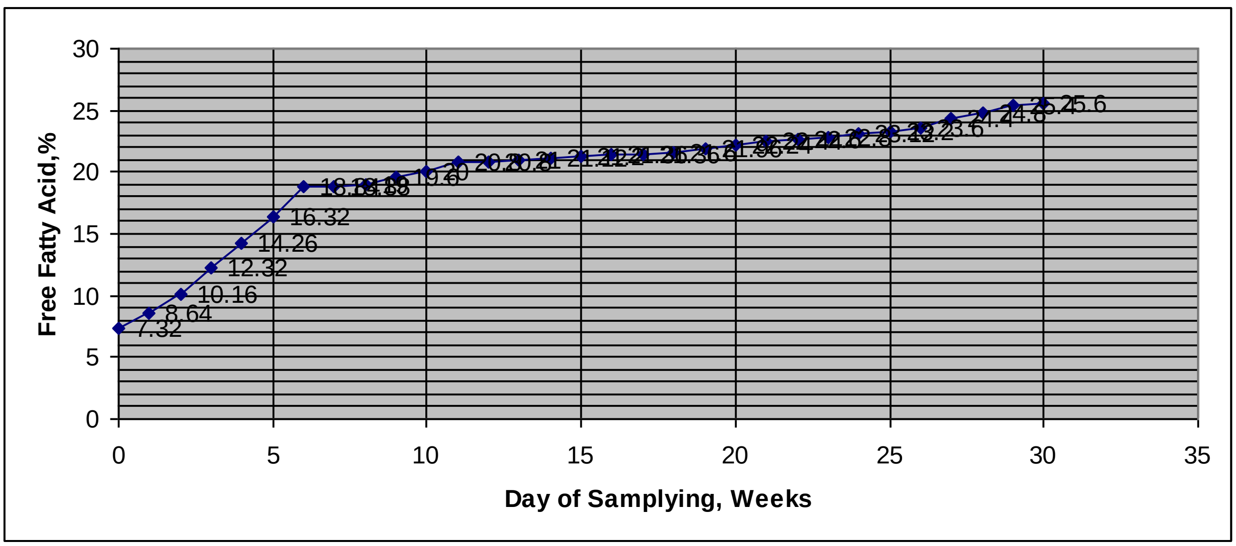


Figure 8: Graph of Free Fatty acid of PKO for Different Day of Storage.

Effects of Drying Temperature

From Figure 9, it was observed that the constant drying weight was obtained after 1½ hour. The result implies that the moisture content of 8.50% of palm kernel seeds can be obtained after drying at about 1½ hours, and drying time for kernel seeds is best done between 100 – 105^{o}C.

Solutions Proffered in the Problems Confronting the Crushing Seed Industry

The problems confronting the crushing seed industries as identified earlier are discussed with a view to providing some possible solutions. Some of the problems include low oil recovery from oilseeds, shooting effect, high oil content in cake fibres, foaming and sludge effect.

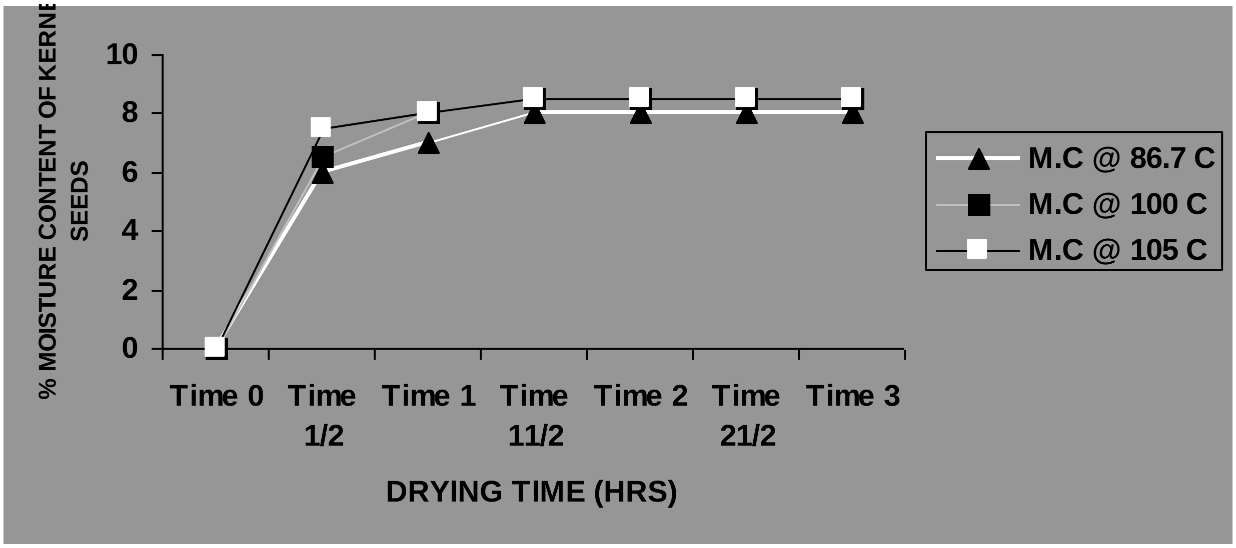


Figure 9: Graph of Moisture Content of Kernel Seeds at Varying Drying Time.

Low oil recovery from oilseed has been identified be caused by the nature of kernel seeds purchased by the mill during the shell content analysis and assessment from the three oil mill used as case study, Polema will experience low oil capacity if it process oilseeds supplied on day 2 and 3, but high oil capacity would be realized on other days. In addition, Golden mill will extract low oil each day. On the other hand, RIVOC mill would experience high productivity if it process oilseeds between days 1 to 6. Hence, the oil mills have to conduct piece shell content analysis on kernel seeds before purchasing and accepting oilseeds in order to recover optimum oil yield.

Problem of untimely decline in the efficiency of expeller and shooting effect can be rectified by employing maintenance culture. This could be realized by embarking on an adequate time for maintenance on the basis of milling defect analysis of kernel cake like RIVOC mill. High oil content in cake sample in oil mills such as RIVOC and Golden mill should be checked by employing Soxhlet extractive analysis on the cake sample. The cakes with high oil content have to be sent back for re-crushing operation for economics of productivity.

The problem constituted by seeds with high moisture content at the Polema should be solved by ensuring that seeds are kept in open and well-ventilated atmosphere. Also, moisture content analysis should be employed on the seeds before processing. If there is a tendency of high moisture content in the oilseeds, it could be brought low by drying the seeds at a temperature range of 100 – 105^{o}C at 1½ hours. The problem of foaming and sludge effect should be effect by within the first 14days is kept in open and dry atmosphere. In addition, the oilseeds should be property dried before processing. Oil crushed has to be refined as soon as possible in order to prevent fermentation which could lead to increase in free-fatty acid of palm kernel oil.

SOLUTIONS PROFFERED IN THE PROBLEMS CONFRONTING THE FILTER PRESS

The problems confronting the filter press section have been identified and discussed. Air pocket and gasket problem have been identified to be prevalent in the filter press section of the mills. This was resolved by bleeding the valve until the air-trapped has been completely eliminated and building enough pressure so as to ensure pumping action of the valve.

The gaskets that were torn and weak were changed with new one whenever there was any indication that it was not strong.

A highly quality cloth was utilized on the filter press so as to avoid sludge formation. The filter press was properly positioned when tightening in order to avoid gap formation which can lead to oil wastage.

Regular maintenance of the filter section is necessary to eliminate filter press problems.

The management of such typical organization should employ the solutions proffered to the problem confronting their milling section; and the test method would go a long way in providing excellent information to would-be vegetable oil producers and serves as useful tool in monitoring the productivity in palm kernel mills.

REFERENCES

1. Akinoso, J., J.T. Igbeka, T. Olayanju, and L. Bankole. 2006. "Modeling of Oil Expression from Palm Kernel (*Elaeis guineensis* Jacq.)". *Agricultural Engineering International: The CIGR Ejournal*. Manuscript FP 05 016.

2. Aniki, A.O. 2002. "Industrial Concern of Kwara State". Unpublished B.Eng. Project: Mechanical Engineering Department, University of Ilorin, Ilorin, Nigeria.

3. Akpobi, J.A. and E.S. Owoniho. 2004. "Development of an S-Neck Palm Kernel Cracking Machine". *Nigeria Journal of Engineering Research and Development*. 3(4).

4. Bachmann, J. 2001. "Small Scale Oilseed Processing: Value Added and Processing Guide". *NCAT.* 1- 24.

5. Fellows, Peters, and Hampton. 1992. "Small Scale Food Processing: A Guide to Appropriate Equipment". *Intermediate Technology Publications*. 158.

6. Fapetu, O.P. and P.K. Oke. 2000. "Investigation into Factors Affecting Flake Thickness in a Typical Vegetable Industry". *Nigerian Journal of Engineering Management*. 44-52.

7. Indian Standard. 1964. "Indian Standard of Physical and Chemical Test of Oil Sample". 1: 548.

8. Jekayinfa, S.O. 2006. "Development of Equations for Estimating Energy Requirements in Palm Kernel Oil Processing Operations". *Journal of Food Engineering*. 79(1):322-329.

9. Jekayinfa, S.O. 2004. "Modeling Direct Energy Utilization in Palm-Kernel Oil Industry in Osun and Oyo States of Nigeria". Unpublished Ph.D. Thesis. University of Ibadan, Nigeria.

10. Komolafe, M.F. and A.A. Adegbola. 1980. "Agricultural Science for West Africa Schools and Colleges". Oxford University Press: Oxford, UK. 130.

11. Oyinlola, A., A. Ojo, and I.O. Adekoya. 2004. "Development of a Laboratory Model Screw Press for Peanut Oil Expression". *Journal of Food Energy*. 64(2):221-227.

12. RRPP. 1997. "Rural Radio Resources Pack-Processing of Vegetable Oil". www.martinlinsted.org.

13. Samuel, O.D. 2006. "Palm Kernel Oil Processing Mills-Problems and Solution". Unpublished M.Eng. Thesis, Department of Mechanical Engineering, University of Ilorin, Nigeria.

14. Samuel, O.D. 2010."The Need to Increase Productivity in Milling Section of Vegetable Oil Industry". *Journal of Research in Engineering*.7:94- 100.

15. Samson, M. 2002. *Laboratory Instructional Manual for Testing and Analysis of Vegetable Oil*. Golden Oil Mill: Onitsha, Nigeria.

16. Takakura, T. 2008. "Food Production Strategy in East-Asia-Engineering Perspective in the Third Millennium". *CIGR Journal of Scientific Research and Development*. Chicago, IL.

17. Vanguard. 2002. "Importation of Vegetable Oil to Nigeria".

18. Wallace, P.A., E.K. Adu, and S.W.A. Rhule. 2010. "Optimal Storage Conditions for Cocoa with Shell, Palm Kernel Cake and Copra Cake as Poultry and Livestock feed in Ghana". *Livestock Research for Rural Development*.22:2

ABOUT THE AUTHORS

Engr. Olusegun David Samuel, is currently undertaking his Ph.D. degree at the University of Agriculture, Abeokuta, Ogun State, Nigeria. He holds M.Eng. degree in Mechanical Engineering. His research interests are in renewable energy, manufacturing, production, residual stress, lubrication technology, and engineering.

Dr. A.G.F. Alabi, is an Associate Professor of Metallurgical & Materials Engineering in the University of Ilorin, Nigeria. He holds a Ph.D. degree in Mechanical Engineering. His research interests are in manufacturing, corrosion, iron, steel, and material engineering.

SUGGESTED CITATION

Samuel, O.D. and A.G.F. Alabi. 2012. "Problems and Solutions involved in Oil Processing from Kernel Seeds". *Pacific Journal of Science and Technology*. 13(1):372-383.

Pacific Journal of Science and Technology