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INVESTIGATING THE POTENTIAL OF DRIED PALM OIL MILL EFFLUENTS FROM PRESSING AND WATER DISPLACEMENT METHODS FOR ANIMAL FEED

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ABSTRACT

Palm oil mill effluent is a wasteful part from production of palm oil. This study intends to investigate if the dried product obtained from the two processing methods; water displacement and pressing methods, can be used as animal feed considering the chemical, anti nutritional and rancidity potentials of the products. Palm oil mill effluent samples from both pressing and water displacement methods were obtained from a small scale palm oil production industry in Itaogbolu, Ondo State. The samples were concentrated to thick slurry using FUTA Concentrator and dried in a cabinet dryer at 70 ^{0}C and milled with attrition mill. Each of the samples was subjected to chemical analyses using AOAC methods, Mineral composition using atomic absorption spectrophotometer and the anti - nutritional factors using standard methods. The study showed that the samples were rich in protein content (17.54) for pressing method (PEP) and (17.81) for water displacement method (PEW). Potassium (835mg/100g), phosphorus (1042mg/100g), and copper 45mg/100g of sample PEW are higher than that of sample PEP which are (495mg/100g), (655mg/100g) and (35mg/100g) for potassium, phosphorus and copper respectively. Zinc value for PEP 50mg/100g is higher than that of PEW which is 30mg/100g. Calcium level of the two samples is low compared to other minerals which is (0.8mg/100g) and (1.14mg/100g) for PEP & PEW respectively. The saponification value (140±0.10g), free fatty acid value (7.47±0.09g), and acid value (14.94±0.18g) for sample PEP is higher than that obtained for sample PEW which are (84.15±0.05g), (5.1±0.10g) and (10.22±0.17g) for saponification value, free fatty acid and acid value respectively. Results of the peroxide value of the palm oil mill effluent from (PEW) (33.50±0.50g/kg) suggest that it is more vulnerable to oxidative rancidity and deterioration than the result obtained for (PEP)(26.5±0.50g/kg) . The low level of iodine value in the two samples suggests that they contain low level of polyunsaturated fatty acid. Based on the results of this study, it was concluded that dried palm oil mill effluent especially PEW is suitable for production of fish feed due to its high fat and mineral content, more especially that fish feed will further undergo heat treatment to reduce the microbial load and the phytate contents.

Keywords: Drying, Effluent, Pressing, Water Displacement

INTRODUCTION

Palm oil is an edible plant oil derived from the fruit and kernels (seeds) of the oil palm *Elaeis guineensis*. Palm oil is naturally reddish because it contains a high amount of beta-carotene . It is packed with nutrients that contribute to daily energy needs (Catharina, *et al.,* 1999; Faessler, 2004; Wu *et al;* 2006)

Palm oil mill effluent (POME) is the waste water from palm oil industry. It is a colloidal suspension which is 95-96% water, 0.6-0.7% oil and 4-5% total solids including 2-4%

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suspended solids originating in the mixing of sterilizer condensate, separator sludge and hydrocyclone wastewater. POME contains 4,000 mg dm^{-3} of oil and grease, which is relatively high compared to the limit of only 50 mg dm^{-3} set by the Malaysian Department of Environment (MA, *et al.*, 1996, Dewwanthi, 2008).

Palm oil mill effluent can be produced in two ways from oil palm fruit. These methods include pressed and water displacement method which is a method accepted internationally (Chew *et al.,* 1994). Figures 1 and 2 show the flowchart for the production process using Pressed Method and Water Displacement method respectively.

POME has a high nutrient content, and large oil palm plantations prefer to use it directly as fertilizer. The POME is first treated to reduce the organic load. The sediments left after treatment, which have a higher nutrient value than the slurry, are either recycled to the field or sold to the public. It is also used to culture microorganism and in the production of polyhydroxyalkanoate which is a biodegradable plastic (MA *et al.*, 1996, Modise *et al*., 2006).

According to Igwe and Onyegbado (2007) and Parveen *et al* (2010), waste generated from palm fruit during crude palm-oil production is a general problem for processors. While these compounds are non-toxic, they can't safely be discharged into local waterways due to their high acidity. Large and medium scale mills produce copious volumes of waste and these effluents must be treated before discharge to avoid serious environmental pollution. These lead into various methods of treating the mill effluents to prevent this pollution and also the creation of some palm oil mill effluent plants. During the processing of fresh fruit bunches (FFB) water is the most needed resource. It has been reported that 5 - 7.5 tons of water is required to produce 1 ton of crude palm oil, of which more than 50% of the water will end up as (POME) (Ahmad *et al*., 2003; Yusoff, 2006). The raw POME is a colloidal suspension containing 95-96% water, 0.6-0.7% oil and 4-5% total solids including suspended solids. In year 2004, more than 40 million tons of POME was estimated to have been generated from 372 mills in Malaysia (Yacob *et al.*, 2006).

The discharge of POME into local water courses without treatment creates serious problems of environmental pollution due to its high load chemical oxygen demand (COD), total suspended solids (TSS), protein and carbohydrate with the respective estimated values of 70,900 mg/L, 25,800 mg/L, 12.9 g/L and 28.9 g/L (Mohammad *et al.*, 2007). Consequently, this partially treated waste water still pollutes water courses receiving it (Wong, *et al.*, 2002, Okwute and Isu, 2007).

Palm oil mill effluent treatment plants cater for all raw effluent produced. Approximately 0.65 tonnes of raw POME is produced for every tones of fresh fruits bunches (FFB) processed. In 2003, a total of 2,106,756 tonnes of fresh fruit bunches (FFB) were processed resulting in 1,369,521 tonnes of palm oil mill effluent being produced (MA *et al.,* 1996)

Studies have shown that palm oil mill effluent has been treated in so many ways leading to the production of many bye products. (APHA, 1998; APOC, 2001). Golden Hope in Indonesia addressed this issue by treating raw POME with anaerobic bacteria that broke the effluent into methane (which can be recaptured as fuel), carbon dioxide, and water and used he treated POME as a substitute for inorganic fertilizer. Golden Hope also attempted to compost empty fruit bunches and other wastes from the production process, further diminishing the need for petroleum-based fertilizers. (MA, *et al.*, 1996, Igwe, 2006, Wu, *et al*., 2006). For example the use of a bioreactor process, called compositing system has been used in the treatment of palm oil mill effluent to yield product called compost. The compost

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when used in sufficient quantity is capable of replacing 66% of chemical fertilizers (Chew *et al.,* 1999).

It has also been found that because of its high organic content and almost being non-toxic, POME could be suitable for polyhydroxyalkanoate production which is a biodegradable plastic (MA *et al.,* 1996). Other methods used for the treatment of palm oil mill effluent include; Anaerobic Digestion

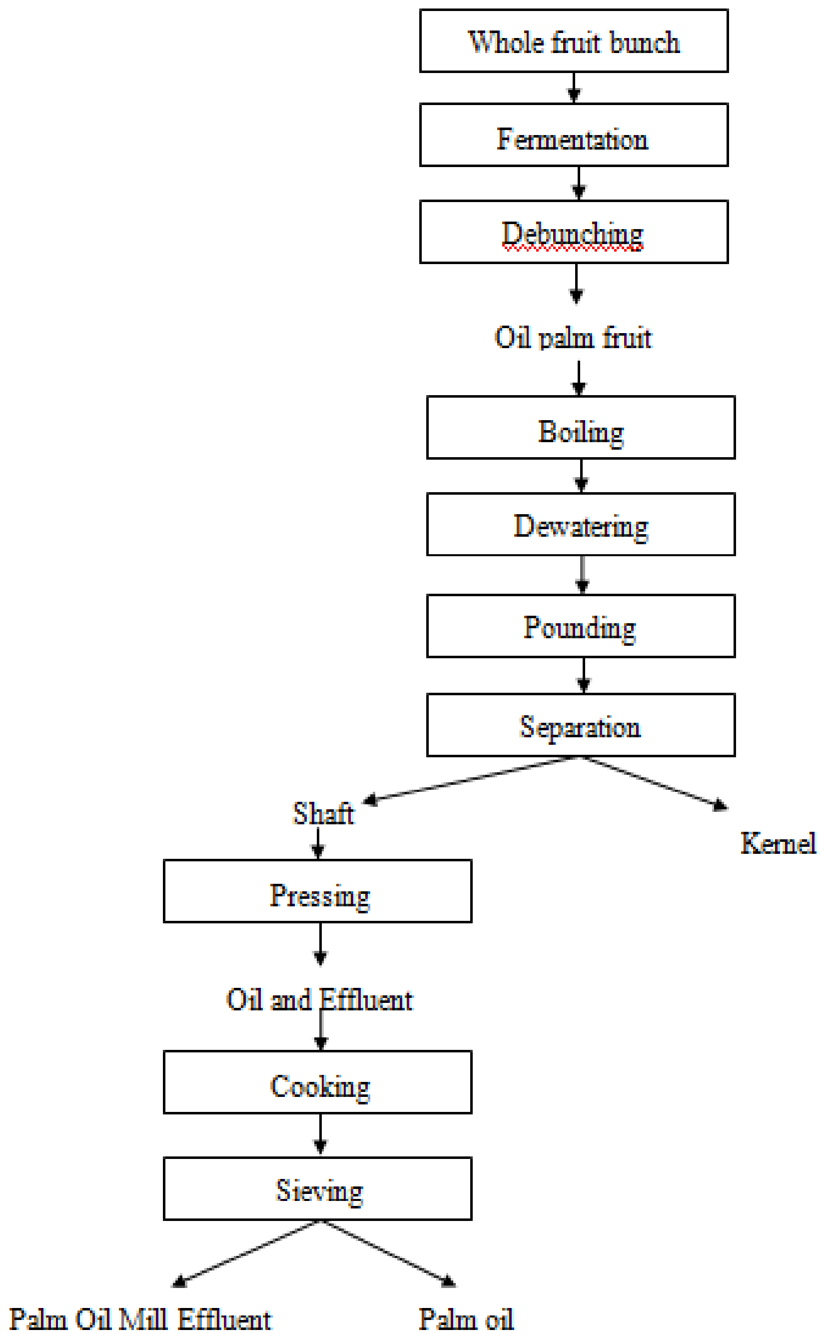

Figure 1. Flow Chart for the Production of Raw Palm Oil Mill Effluent from Pressed Method (Pep)

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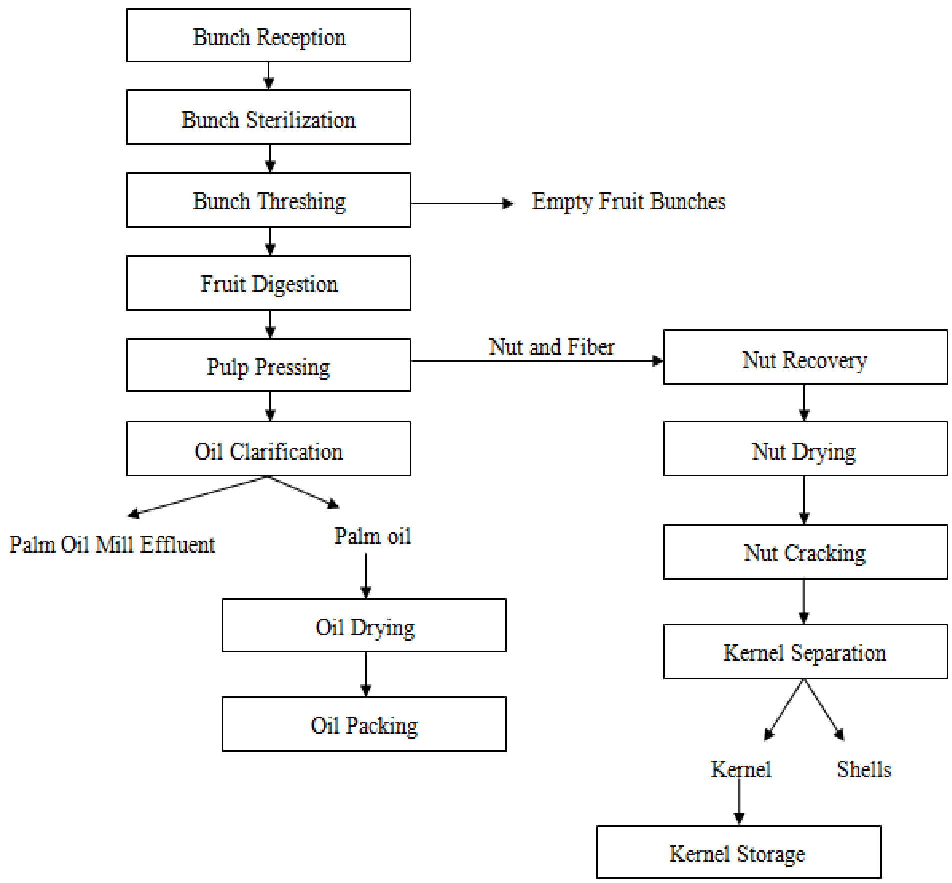

Figure 2. Flow Chart for the Production of Raw Palm Oil Mill Effluent from Water Displacement Method (Pew)

System, Extended Aerobic Process, Ponding System and Composting System (Yacob *et al*., 2006, Singh *et al*., 2010). The intents of this study therefore are to dry POME obtain from the two processing methods to powder form, and to carry out chemical, microbiological, anti - nutritional factor and mineral content analyses on the sample.

MATERIALS AND METHODS

Samples Collection

The sample, palm oil mill effluent was obtained from a small scale palm oil processing mill industry in Ita- Ogbolu, Ondo State.

Concentration of the Samples

Each of the collected POME sample was concentrated using FUTA concentrator to thick liquor at 102 ^{0}C for five hours.

Drying and Milling of the Samples

All the samples were dried at 90 ^{o}C in a Cabinet dryer until constant weights were obtained. They were milled with Attrition mill and were sieved with 0.30 µm mesh. Plates 1, 2 and 3 showed the thick paste obtained after pressing the concentrated liquor, dried and milled samples respectively.

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Plate 1. Raw POME Plate 2. Dried POME Plate 3. Milled POME after Pressing

Analyses Carried out

Chemical Analyses

The proximate composition of the samples were determined following procedures of Association of Official Analytical Chemists AOAC (1990) method. Average of three replications was used. The mineral compositions of the samples were determined using an Atomic Absorption Spectrophotometer following the manufacturer's specifications. Saponification, Iodine, Free Fatty Acid and Peroxide values were determined by AOAC (1994) methods

Anti Nutrient Determination

Tannin was determined according to the method of Makker & Good-child (1996), Oxalate was determined using the method of Day & Underwood (1986). The method of Young & Graves (1940) was employed for determination of Phytin.

Microbial Analysis

Microbial count was done using the method of Baumann and Bisping, (1995)

RESULTS AND DISCUSSION

Table 1 shows the proximate composition of the two samples; pressed method (PEP) and water displacement method (PEW). The fat content of PEP is significantly greater than that obtained for PEW and this is as a result of the processing method, higher percentage of oil is not recovered by using pressing method. The ash content of PEW is significantly different from that of PEP which is an indication of the presence of high mineral content in PEW. The crude fibre and protein of the two samples are not significantly different.

Table 1. Proximate Composition of Palm Oil Mill Effluent on Dry Weight Basis

Sample	*Fat*	*Ash*	*Crude Fibre*	*Protein*	*Cho*
PEP	80.03^{a}±0.11	8.21^{b}±0.12	0.15^{a}±0.02	8.62^{ab}±0.17	3.02^{b}±0.17
PEW	69.39^{b}±0.08	10.49^{a}±0.05	0.14^{a}±0.02	9.89^{a}±0.08	9.97^{a}±0.40

Mean values with different superscripts along the same row are significantly different.at ($p<0.05$)
Values are means of three replicates; values in a column denoted by different letters differ significantly at $p < 0.05$.

Sample Keys

PEP: Palm oil mill effluent from pressed method

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PEW: Palm oil mill effluent from water displacement method

Antinutrient Composition

Table 2 shows the anti nutrient value of the two samples. The tannin value for sample PEP is (1.28±0.03 mg/100g) and that of sample PEW is (1.15±0.02 mg/100g) is not significantly different. Tannins are a diverse group of polyphenolic compounds, which yield sugar residues, phenolic carsoxylic acids and condensed tannins on hydrolysis (Muller – Harvey and McAllan, 1992). Tannin have been reported to interfere with digestion by displaying antitrypsm and anti amylase activity (Helsper *et al.,* 1993) and by binding digestive enzymes or by direct binding with dietary protein. (Elkin and Rogler, 1990; Hagerman *et al*., 1992)

Oxalic acid is one of the polyphenolics found in plants. It has the ability to bind some divalent metals such as calcium and magnesium. It has therefore been suspected that oxalic acid interferes with the metabolism of these minerals. PEW is significantly higher in oxalic acid (1.18±0.01 mg/100g) than in PEP (0.80±0.01 mg/100g). It can be said that PEW has the ability to bind some divalent metals more than the sample obtained from the pressed method.

Phytic acid is an important constituent of certain legumes, cereal and forage plant which is capable of chelating divalent cationic minerals like calcium, iron, magnesium and zinc. Such chelates make such element nutritionally unavailable thereby inducing dietary deficiency (Oatway *et al*., 2001). The unique structure of phytic acid gives it the ability to bind minerals, to form complexes with protein and starch and to inhibit the enzymatic digestion of both protein and starches. (Oatway *et al*., 2001). Thus the higher the level of phytates, the more will be the tendency to mop out divalent cations like Ca & Mg from the medium. The phytate value of sample PEP (18.07±0.16mg/100g) is significantly lower than that of PEW which is (22.05±0.17 mg/100g). In view of high level of phytate in PEW it has to be treated if it is to find its use for animal feed.

Table 2. Antinutrient Composition of Palm Oil Mill Effluent (Mg/100g)

Sample	*Tannin*	*Oxalate*	*Phytate*
PEP	1.28^{a}±0.03	0.8^{b}±0.01	18.07^{b}±0.16
PEW	1.15^{a}±0.02	1.18^{a}±0.01	22.05^{a}±0.17

Mean values with different superscripts along the same row are significantly different.at (p<0.05)
Values are means of three replicates; values in a column denoted by different letters differ significantly at $p < 0.05$.

Sample Keys

PEP: Palm oil mill effluent from pressed method

PEW: Palm oil mill effluent from water displacement method

Mineral Composition

The zinc value for PEP is 50 mg/100g and that of PEW is 30 mg/100g. It can be said that PEP aid in the synthesis of carbohydrate due to its higher zinc content. The value reported for copper for PEP is 35 mg/100g and that reported for PEW is 45 mg/100g. There is higher amount of potassium in PEW (835mg/100g) than in PEP (495 mg/100g). The sample PEW has higher value for Na while PEP is low in sodium. Sodium acts as an electrolyte of the body and regulates the pH balance of the body system. Phosphorus content of sample PEW is (1042 mg/100g) and that of PEP is (655 mg/100g). Phosphorus is an essential component of nucleic acid. Iron content of sample PEW is higher and that of PEP is lower. Magnesium

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content of PEW (750 mg/100g) is higher than that of PEP (680 mg/100g). Calcium level of the two samples is lower than other minerals which is 0.8 mg/100g and 1.14 mg/100g for PEP & PEW respectively. Generally sample PEW can be said to be a good source of Fe, Cu, Zn, K, Na, Mg, but low in Ca, since it shows higher value for these mineral content than sample PEP. The absence of lead and arsenic is desirable in view of their carcinogenic nature (Saifuddin and Kunaran, 2005).

Chemical Composition

Table 4 shows the chemical composition of the two samples. Saponification value is used to detect adulteration in food samples and it is also a measure of the alkali which is required to combine with the fatty acids liberated by the hydrolysis of fats. (Champe & Harvey, 1994) The saponification value in sample PEP (140±0.10mg/g) is significantly higher than in sample PEW (84.15±0.05mg/g).

Free fatty acid is a measure of the edibility and the level of rancidity. The free fatty acid of sample PEW (5.1±0.10mg/g) is significantly lower than that of sample PEP (7.47±0.09mg/g), it can be concluded that sample PEP will go rancid faster than sample PEW.

Acid value is a measure of the extent to which glyceride in the oil has been decomposed and decomposition is accelerated by heat and light. It is used as a general indication of the condition and edibility of oils (Pearson, 1975) The acid value of sample PEP (14.94±0.18mg/g) is significantly higher than that of sample PEW (10.22±0.17mg/g) and this is due to the decomposition of the glyceride in sample PEP by lipase action.

Table 3. Mineral Composition of Palm oil Mill Effluent (Mg/100g)

Minerals	*PEP*	*PEW*
Zinc	50	30
Copper	35	45
Arsenic	Nd	Nd
Lead	Nd	Nd
Magnessium	680	750
Iron	80	100
Sodium	235	485
Phosphorus	655	1042
Pottasium	495	835
Calcium	0.8	1.14

Sample Key

PEP: Palm oil mill effluent from pressed method

PEW: Palm oil mill effluent from water displacement method

ND: Not detected

According to Adelaja (2006) that peroxide value between (20-40mgOH/g) results to a rancid taste, the two samples will exhibit rancidity. This high level of peroxide value can be

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prevented if processing is done quickly to avoid oxidation taking place. When oxidation takes place, the double bond in the unsaturated fatty acids are broken down to form peroxides and the peroxides then decompose to form secondary oxidation products which causes rancidity (Champe & Harvey 1994).

Iodine value is a measure of unsaturation. The result of the iodine value for the two samples shows that the two samples are stable. The value obtained for the two samples are less than that obtained by Pearson (1975), which states that iodine value for fatty material should be within the range of (80-110mg/g) for the oil to be stable. Also increases in iodine value increase the liability of the sample to go rancid. The low level of iodine value in the two samples suggests that they contain low level of polyunsaturated fatty acid.

Table 4. Chemical Compositions of Palm Oil Mill Effluent

Sample	*Saponification (Mg/G)*	*Free Fatty Acid (Mg/G)*	*Acid Value (Mg/G)*	*Peroxide Value (Mgoh/G)*	*Iodine Value (Mg/G)*
PEP	$140.20^{a}\pm0.10$	$7.47^{a}\pm0.09$	$14.94^{a}\pm0.18$	$26.5^{b}\pm0.50$	$18.81^{a}\pm0.03$
PEW	$84.15^{b}\pm0.05$	$5.1^{ab}\pm0.10$	$10.22^{b}\pm0.17$	$33.50^{a}\pm0.50$	$19.93^{a}\pm0.13$

Mean values with different superscripts along the same row are significantly different.at ($p<0.05$)
Values are means of three replicates; values in a column denoted by different letters differ significantly at $p < 0.05$.

Key

PEP: Palm oil mill effluent from pressed method

PEW: Palm oil mill effluent from water displacement method

ND: Not detected

Microbial Load Count

Table 5 shows the microbial load count value of the two samples. Sample PEP is higher in bacteria count than for sample PEW because during the production, hands were used to remove the pulp from the kernels. Fungi can be said to decompose sample PEP because of its higher moisture content. But for sample PEW, fungi has little effect on it because it is dried immediately after production except if left for a longer period of time prior to processing that fungi proliferation can occur at higher rate.

Table 5. Microbial Load Count (Cfu/Ml)

Sample	*Bacterial Count*	*Fungi Count*
PEP	5×10^{4}	1×10^{4}
PEW	3.8×10^{4}	4×10^{4}

Sample Key

PEP: Palm oil mill effluent from pressed method

PEW: Palm oil mill effluent from water displacement method

CONCLUSION AND RECOMMENDATION

In conclusion, PEW is suitable for use as animal feed ingredient when compared to the nutrient requirement of animals especially for fish feed which requires further heat treatment during pelleting/extrusion and drying processes (Ng *et al*., 2003; FAO, 2006, Adeparusi and Famurewa, 2011). Its utilization as ingredient of animal feed will be a more environment friendly way of managing the enormous waste from palm oil mills.

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