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Calorific Value of Palm Oil Residues for Energy Utilisation

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Abstract **– Energy is a social and economic necessity of any country. These energy services are essential for economic growth and improved living standards for the increasing population. Nigeria generates a lot of residues from the oil palm industries and these residues can be used as an alternative energy source. This paper presents a laboratory analyses carried out on oil palm fruit residues, particularly Empty fruit bunch EFB, Palm kernel shell PKS, and Palm kernel fibre PK. Moisture content and Calorific value of the residues were determined for energy utilisation. The moisture content for the palm kernel shell is 6%, fibre is 14% and empty fruit bunch is 29%. The calorific value of the palm kernel shell is 23,604.71kJ/kg; fibre is 14,511.96kJ/kg and empty fruit bunch is 17,854.807kJ/kg. From the result, oil palm residues could serve as an alternative energy source that could significantly and sustainably contribute to the Nigeria energy mix.**

Keywords **– Biomass, Oil Palm Residues, Moisture content, Calorific Value, Energy.**

I. Introduction

Energy is a social and economic necessity of any country. The energy use in any country is expected to continue to increase as its population increases. The increase in population brings about an increase in the demand of electricity for homes and industries. These energy services are essential for economic growth and improved living standards for the increasing population [1].

Thus, without adequate basic energy supply, people cannot cook their food, light their homes, or keep essential medication chilled. Alongside the introduction of efficient and clean thermal use of traditional biomass for cooking, the provision of electricity from renewable waste resources can provide basic energy services for lighting, communication and promote local economic growth [2].

In [3], the 85% of the world's energy demand is met by combustion of fossil fuels which are depletable. The global energy demand is expected to grow by about 50% by 2025, the major part of this increase coming from rapidly emerging countries. Nigeria generates a lot of waste from biomass, a renewable energy resource, an alternative source to the combustible fossil fuel which causes global warming, but unfortunately, has not been able to fully exploit this source of energy. Thus, given the growing world population, increasing energy demand per capita and global warming, the need for a long term alternative energy supply is clear.

II. Potential Biomass Resource in Nigeria

The total biomass potential in Nigeria, consisting of animal, agricultural and wood residues, was estimated to be 1.2 PJ in 1990 [4]. In 2005, research revealed that bio-energy reserves/potential of Nigeria stood at: Fuel wood 13071,464 hectares, animal waste, 61 million tonnes per year, crop residues, and 83 million tonnes [5].

According to [6], Nigeria has a total of 1,160 constituted forest reserves, covering a total area of 10,752,702 hectares, representing about 10 % of the total land area. Most of the forests in Nigeria are man-made for the purpose of timber exploitation, and in some cases for fuel wood and furniture making industries. Fuel wood is the most widely used domestic renewable energy resource in rural Nigeria and especially by low income groups in the urban areas.

Table 1 gives year 2004 estimate of fuel wood and some other waste resources in the country. Fuel wood forms the largest percentage of the non-commercial energy (about 37.4 % of the total energy demand) and will continue to dominate the non-electricity energy needs for the majority of people in the country.

Table 1: Biomass resources and estimated quantities in Nigeria (2004)

Resource	Quantity (million tonnes)	Energy value (MJ)
Fuel wood	39.1000	531.0000
Agro-waste	11.2444	147.7000
Saw dust	1.8000	31.4333
Municipal solid waste	4.0750	

Source: [7]

Presently, about 80 million cubic metres, equivalent to 43.4 x 109 kg (or 43.4 million tonnes) of fuel wood with an average daily consumption ranging from 0.5- 1.0 kg of dry fuel wood per person is being consumed in the country annually for cooking and domestic purposes [8].The energy content of the fuel wood that is being used is (6.0 x 10 9MJ) out of which only between 5-12 % is gainfully utilized for cooking and other domestic uses [7].

IIII. The Oil Palm Tree

According to [9], the oil palm tree (Eleasisguineensis) is native to the wetlands of West Africa. The oil was introduced to the Americans hundreds of years ago, where it became naturalized and associated with slave plantations, but did not become an industry of its own until the1960s.The first plantations were established in Sumatra in 1911, and in 1917 in Malaysia [10].

IV. Oil Palm Processing

The palm tree produces palm fruits from which oil is extracted. Oil extraction is a complex process, which is carried out by large mills that may process up to 60 tons of fruit per hour, or by small scale mills in rural villages that produce only about 1ton (1000kg) of oil in an 8hr shift [11].

Oil extraction follows the sequence:

1. Bunch threshing: is the removal of the fruit from bunches;
2. Fruit digestion: is the process of releasing the palm oil in the fruit through the rupture or breaking down of the oil – bearing cells;
3. Pulp pressing: is the extraction of oil from the digested palm fruit;
4. Oil clarification: is the separation of the oil from its entrained impurities;
5. Oil drying and packaging: are referred to as oil storage processes and are done to prevent solidification and fraction.

The residue from the press consists of a mixture of fibre and palm nuts. Kernel recovery is the separation of the palm kernel nuts from the fibre by hand in the small scale operations. The sorted fibre is covered and allowed to heat, using its own internal exothermic reactions, for about two or three days. The fibre is then pressed in spindle press to recover second grade (technical) oil that is used normally in soap making [11]. Nut drying is the removal of moisture from the kernel nuts, palm kernel nut cracking is the breaking of the palm kernel nuts to release the kernels through which the shell is gotten.

The sequence of extraction is shown in Fig. 1, adapted by Food and Agricultural Organization, FAO.

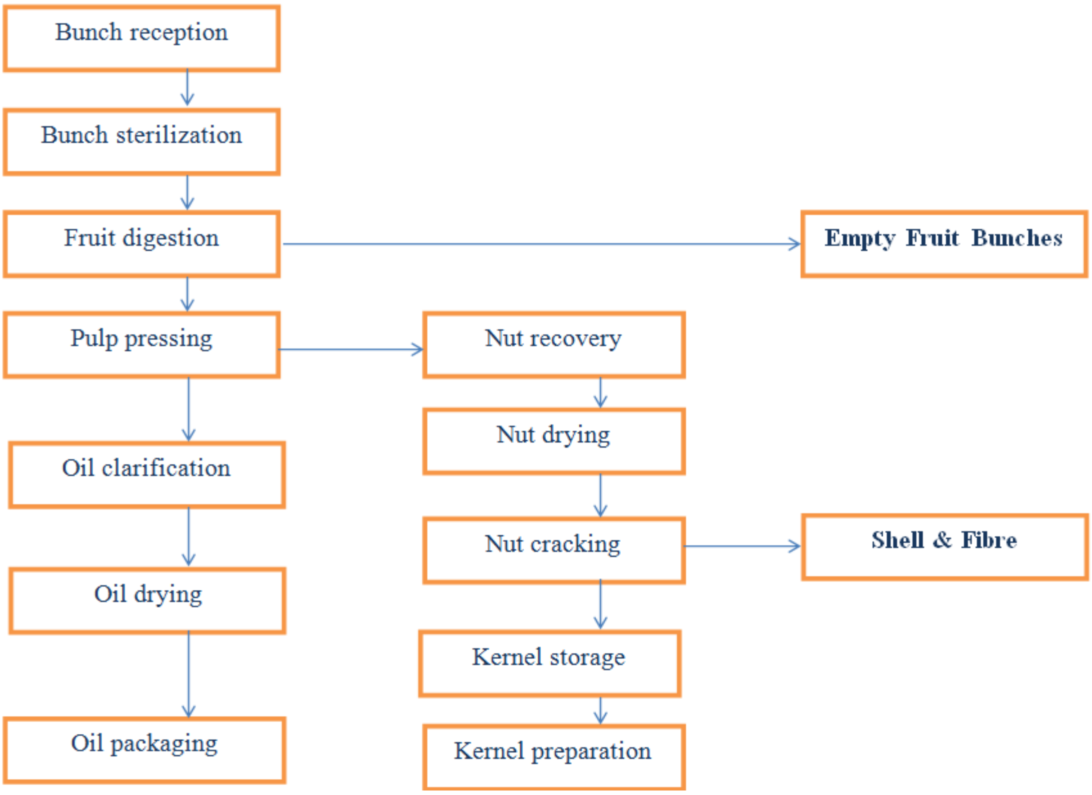

Fig.1. Flow diagram for palm oil processing Source:[11]

V. Materials & Method

Sample collection

The oil palm residues were collected from Nigeria Institute for Oil Palm Research, NIFOR.

1. Empty Fruit Bunch, EFB
2. Palm Fibre and
3. Palm Kernel Shell

These residues are shown in Fig. 2

Fig.2. Oil Palm Residues

Determination of moisture content

Each sample of mass 10g were measured and placed in the porcelain separately. The porcelain and its content were then oven dried at 110^{o}C to a constant weight for 3 hours. The percentage wet and dry basis moisture content was analysed in the laboratory and calculated using the equation (1) and (2):

For wet basis:

$$x_{ow} = \frac{W_1 - W_2}{W_1} X\ 100 \quad (1)$$

Where: X_{ow} = Moisture content on wet basis
W_1 = Initial mass of sample
W_2 = Final mass of sample after drying

For dry basis:

$$x_{od} = \frac{W_1 - W_2}{W_2} \text{X } 100 \quad (2)$$

Where: X_{od} = Moisture content on dry basis
W_1 = Initial mass of sample
W_2 = Final mass of sample after drying

Determination of calorific value

After the evaluation of the moisture content, about 1g mass of each fuel sample was accurately weighed into the crucible and a fuse wire (Nickel, whose weight is known) was stretched between the electrodes. It was ensured that the wire was in close contact with the fuel. To absorb the combustion products of sulphur and nitrogen, 2 ml of water was poured in the bomb. Bomb was then supplied with pure oxygen through the valve to an amount of 25atm. The bomb was then placed in the weighed quantity of water, in the calorimeter. The stirring was started after making necessary electrical connections, and when the thermometer indicates a steady temperature, the fuel was fired and temperature readings are recorded after 1/2 minute intervals until maximum temperature was attained. The bomb was then removed; the pressure slowly released through the exhaust valve and the contents of the bomb were carefully weighed for further analysis. The heat released by the fuel on combustion was absorbed by the surrounding water and the calorimeter. The gross heat of combustion of each residue was analysed in the laboratory with the bomb calorimeter and calculated using equation (3) (www.parrinst.com).

$$CV = \frac{C\Delta T - (e_1 + e_2 + e_3)}{m} \quad (3)$$

Where,
C = heat capacity of the bomb calorimeter = 15kJ/^{o}C
ΔT = change in temperature variation
m = mass of sample (g)
e_1 = Correction of heat of formation of nitric acid [however, flushing the bomb with oxygen prior to firing, displaces all nitrogen, thereby eliminates nitric acid formation, hence, e_1 = 0]
e_2 = Correction of heat of formation of sulphuric acid [% of sulphur in sample x 57.54(J/g) x mass of sample (g)]
e_3 = Correction of heat of formation of fuse wire [length of fuse wire consumed in (cm) x 9.66(J/cm)]

VI. Results & Discussion

Experimental result of moisture content of each residue

Equations (1& 2) were used to calculate the percentage wet and dry basis moisture content. From the processed data result, it shows that palm kernel shell has a much lesser moisture content than fibre and empty fruit bunch. This indicates that it would combust more effectively and sustainably than others. The result is shown in Fig. 3.

Experimental result of calorific value of each residue

The gross heat of combustion of residues was calculated from the experiment carried out with the bomb calorimeter using Equation (3). The Palm kernel shell has a calorific value of 23,604.71kJ/kg; the Palm fibre has 14, 511.961kJ/kg, while the Empty fruit bunch has 17,854.807kJ/kg. This result is shown in Fig.4. From the analysis, it shows that the calorific value of the palm kernel shell will combust more effectively and sustainable.

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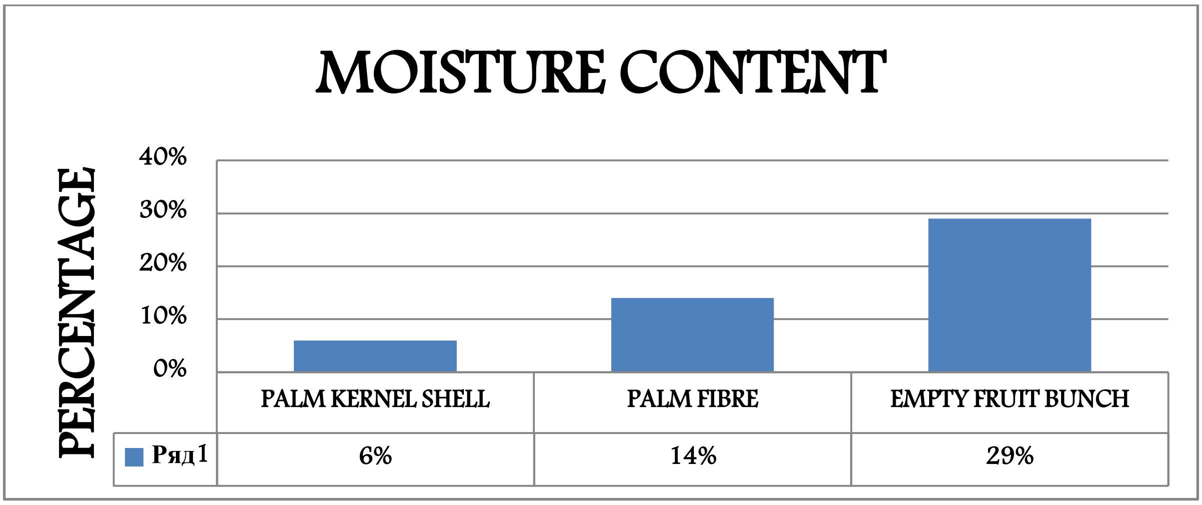

Fig.3. Moisture content of each residue

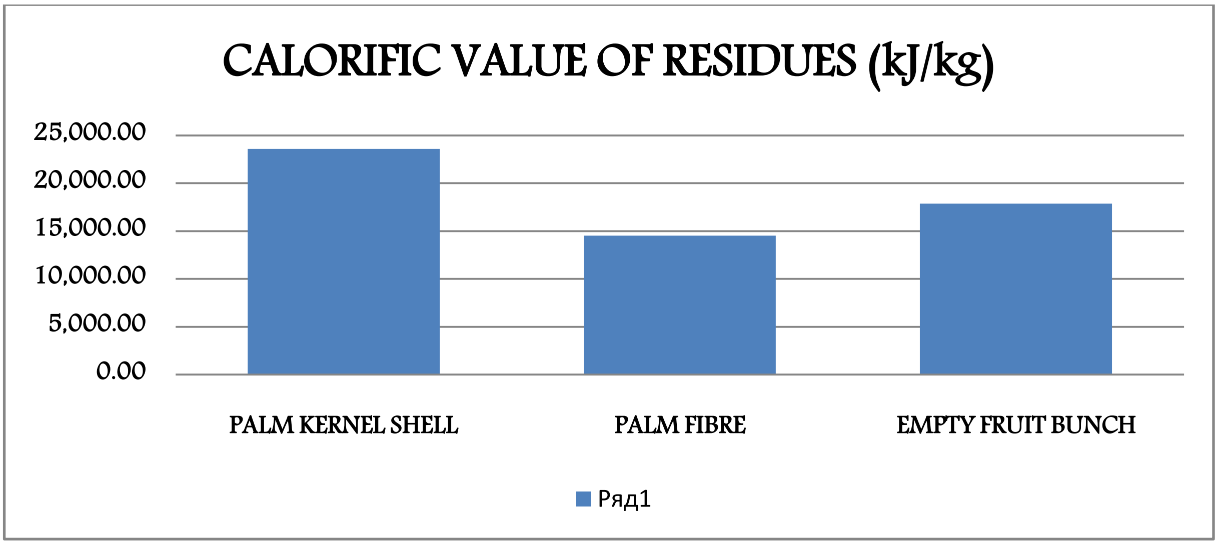

Fig.4. Calorific value of residues

VII. Conclusion

The combination of increasing energy prices, irregular electricity supply for a population of about 180 million Nigerians from the national grid, and concern over the impacts of carbon emissions associated with the combustion of fossil fuels energy have increased pressure to utilise renewable energy resources. Base on the results from the experiment, it means that there is a lot of potential heat energy from the palm oil residues that can be utilise as an alternative to the fossil fuel energy for the purpose of combustion. Finally, oil palm residues could serve as an alternative energy source that could significantly and sustainably contribute to the Nigeria energy mix.

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