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Proximate and physicochemical composition of oil palm empty fruit bunch

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Abstract

Agro-waste management generates worries to most developing countries and the menace needs to be curbed to reduce pollution. This study investigated the Proximate and Physicochemical composition of Oil Palm Empty fruit bunch. Samples collected were oven dried, grinded and analytical methods were carried out adopting AOAC 2005 (Association of official Analytical Chemists) test methods. The proximate analysis of the EFB revealed it to be a poor source of lipid (3.75 ± 0.01) but with a high fibre content (67.0 ± 1.19). The results showed concentrations of ash (6.87 ± 0.11), carbohydrate (12.3 ± 0.95), moisture (5.13 ± 0.24) and protein (4.87 ± 0.01). The physicochemical characteristics of oil palm empty fruit bunch is reported that pH had mean of 5.81±0.22, while temperature, total suspended solid, electrical conductivity, total dissolved solid, salinity, nitrate and sulphate had mean of 28.14 ± 0.02, 5.09 ± 0.02, 53.15 ± 0.03, 26.61 ± 0.015, 19.97±0.03, 14.65 ± 0.05, and 4.94 ± 0.02 respectively. More so, phosphate had mean of 17.55 ± 0.04, while ammonia, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, magnesium and calcium had mean of 0.04 ± 0.01, 2.86 ± 0.01, 1.58 ± 0.02, 2.55 ± 0.02, 1.05 ± 0.01 and 3.77 ± 0.01 respectively. The Proximate and Physicochemical composition of the Oil Palm Empty Fruit Bunch in this study demonstrates the efficiency of utilizing and application of this byproduct in various processes to help combat waste management issues in the environment.

Keywords: Oil Palm Empty Fruit Bunch; Proximate; Physicochemical; Agro-waste

1. Introduction

The African oil palm *Elaeis guineensis* (the species name guineensis referring to its country of origin guinea) is the principal source of palm oil. It is native to west and southwest Africa [1]. Mature palms are single-stemmed and can grow well over 20m (66ft) tall. The leaves are pinnate and reach between 3–5 m (10–16 ft.) long. The flowers are produced in dense clusters; each individual flower is small, with three sepals and three petals. The palm fruit is reddish, about the size of a large plum, and grows in large bunches. Each fruit is made up of an oily, fleshy outer layer (the pericarp), with a single seed (the palm kernel), also rich in oil [2].

Oil Palm belongs to the Kingdom: Plantae, Order: Arecales, Family: Arecaceae, Subfamily: Arecoideae, Tribe: Cocoeae, Genus: Elaeis, Species: Guineensis [3]. The processing intermediates from fresh fruit bunch (FFB) of oil palm are chaff, palm kernel press fibre (PPF), nut and palm kernel shell (PKS). The by-products include palm kernel cake, palm pressed fibre, palm oil mill effluent, empty fruit bunches chaff and decanter cake [4]. In a typical palm oil mill, empty fruit bunches are abundantly available as a fibrous material of purely biological origin. It is one of the lignocellulosic materials, which has great relevance since a large quantity of the biomass is generated by oil palm industries [5]. The empty fruit bunches are considered as unwanted waste mainly because of their storage, transport, distribution and treatment cost. In the oil extraction process, the fruits or nuts are first stripped from fruit bunches, leaving behind the

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empty fruit bunch as waste. EFB contains neither chemical nor mineral additives, and depending on proper handling operations at the mill, it is free from foreign elements such as gravel, nails, wood residues, waste etc [6]. This research is aimed at evaluating the nutritional, physical and chemical composition of oil palm empty fruit bunches.

2. Material and methods

2.1. Collection of Oil Palm Empty Fruit Bunch and Processing

Oil palm Empty Fruit Bunch which was collected in a sterile bag from a local oil palm mill company in Aluu community, Rivers State, Nigeria. They were oven dried at 60°C for 24 h, and then grinded into fine particles (<500 mm) and then transported to the laboratory.

2.2. Proximate Analysis of Empty Fruit Bunch

Proximation of the oil palm waste was done to ascertain the nutritional content. The following analysis was done adopting [7].

2.2.1. Moisture Content

The sample's moisture content determination was performed gravimetrically by drying about 30g of the sample in a crucible in a hot air oven at 120°C to a constant weight. After cooling the sample to room temperature in desiccators, the final weight was recorded.

$$\text{Moisture}(\%) = \frac{WF - WD}{WU} \times \frac{100}{1} \tag{2.1}$$

where WF is weight of fresh sample, WD is weight of dried sample and WU is weight of sample used.

2.2.2. Ash content

The sample ash content determination was performed gravimetrically by taking about 30g of the sample in a clean pre-weighed crucible. This was slowly heated on a plate to complete carbonization. It was then placed in a furnace at 550°C for 24hrs to obtain white or grey ash. The crucible was placed in desiccators for cooling and weight of ash was recorded.

$$\text{Ash}\ (\%) = \frac{WA - WC}{WS} \times \frac{100}{1} \tag{2.2}$$

where WA is weight of crucible and ash sample, WC is weight of crucible and WS is weight of sample.

2.2.3. Protein Content

The first stage of the process is digestion. Empty fruit bunch of weight 0.1 was poured into a clean conical flask of 250 ml capacity, 3 grams of digestion catalyst was also added and the Empty fruit bunch was heated to digest the content from black to sky- blue colouration. The digest was cooled to room temperature and was diluted to 100ml with distilled water. The second stage involves distillation. Diluted digest of 20 ml was measured into a distillation flask and the flask was held in place on the electrothermal heater or hot plate. The distillation flask was attached a Liebig condenser connected to a receiver containing 10 ml of 2% boric acid indicator. 40mls of 40% of sodium hydroxide was injected into the digest became strongly alkaline. The mixture was heated to boiling and the distilled ammonia gas via the change from purple to greenish as ammonia distillate was introduced into the boric acid. For the third stage being titration, the distillate was titrated with a standard 0.1N hydrochloric acid solution back to purple from greenish. The volume of hydrochloric acid added to effect this change was recorded as titer value.

$$\text{Organic Nitrogen}(\%) = \frac{\text{Titre value} \times 1.4 \times 100 \times 100}{1000 \times 20 \times 0.1} \tag{2.3}$$

Calculation % Organic Nitrogen = (Titer value x 1.4 x 100 x 100)/1000x20x0.1

where

Titre value is the volume of HCL used in titrating the ammonium distillate, 1.4 is nitrogen equivalent to the normality of HCL used in the nitration 0.1N, 100 is the total volume of digest dilution, 100 is the percentage factor, 1000 is the conversion factor from gram to milligram, 20 is the integral volume of digits analyzed or distilled and 0.1 is the weight of sample in gram digested.

2.2.4. Crude Fibre

This was performed as acid-alkaline hydrolysis. This entails boiling 2g of the sample with 0.1 MF12804 and 0.1 M NaOH in a beaker and the content filtered through a Buchner funnel, dried and ashed at 550°C.

2.2.5. Crude Lipid

A filter paper containing about 2g of the sample was slotted into a Soxhlet extractor and was inserted into a pre-weight dried distillation flask. Then through the condenser end connected to the extractor, solvent (acetone) was introduced into the distillation flask. The condenser was attached to coolant with a continuous flow of cold water for the heated solvent chamber to be extracted by continuous refluxing until the lipid was visibly extracted completely from the sample. The lipid was concentrated by evaporating the solvent. The percentage of lipid was measured by drying the flask to constant weight and weighing.

$$\text{Lipid}\ (\%) = \frac{WFE - WEF}{WSE} \times \frac{100}{1} \tag{2.4}$$

where WFE is the weight of flask and extract, WEF is the weight of empty flask and WSE is the weight of sample extracted.

2.2.6. Carbohydrate Content

Using a weight balance 0.1g of sample, was weighted into a 25ml volumetric flask, 1ml distilled water and 1.3 ml of 62% perchloric acid was added and shake for a period of 20 minutes to homogenize completely. The flask was made up to 25 ml mark with distilled water and stopper. The solution formed was filtered through a glass filter paper or allowed to sediment and decanted. One milliliter (1ml) of the filtrate was collected and transferred into a 10ml test tube and diluted with distilled water. One millilitre (1ml) of working solution was pipetted into a clean test tube and 5ml anthrone reagent was mixed similarly and the whole mixture was read at 630 nm wavelength using the 1ml distilled water and the 5ml anthrone reagent prepared as blank. Solution glucose of 0.1ml was also prepared and was treated as the sample with anthrone reagent. The absorbance of the standard glucose was read and the value of carbohydrate as glucose was calculated using the formula below.

$$\text{CHO as glucose}\ (\%) = \frac{25 \times AB}{SG} \tag{2.5}$$

AB is absorbance of sample and SG is absorbance of standard glucose

2.3. Assay of Physicochemical Properties of the Empty Fruit Bunch Extract

The physicochemical properties of the samples were measured using the standard analytical procedure of [7]. The grinded oil palm empty fruit bunch underwent aqueous extraction and were analyzed for the following physiochemical parameters on getting to the laboratory: pH, chloride, nitrate, phosphate, sulphate, ammonia, total dissolved solids (TDS), conductivity, salinity, biochemical oxygen demand (BOD), chemical oxygen demand (COD), and DO.

2.3.1. pH Determination

The pH of the water samples was measured using a pH meter after standardizing and calibration with buffers 4.0, 7.0 and 10. The electrode was inserted into the extract ensuring the bulb of the electrode was not touching the bottom of the sample container to avoid crack of an electrode and then pH readings were recorded.

2.3.2. Chlorides

Method: Titration method

Procedure: the chloride concentration in the sample was determined by silver nitrate titration. A few drops of potassium chromate were added to five millilitres of the sample. After a colour change to yellow, it was then titrated with silver nitrate ($AgNO_3$). The tire value was recorded after a colour change from yellow to the end-point (orange).

2.3.3. Salinity

Method: Titration method

Procedure: the chloride concentration in the sample was determined by silver nitrate titration. A few drops of potassium chromate were added to five milliliters of the sample. After a color change to yellow, it was then titrated with silver nitrate ($AgNO_3$). The tire value was recorded after a colour change from yellow to the end-point (orange).

2.3.4. Nitrate

Method: Bruccine colorimetric method

Procedure: the nitrate concentration was determined using the Bruccine colorimetric method, where 0.5ml of Brucine solution was added to 1ml of the sample in a clean test-tube. The 2ml of concentrated sulphuric acid (H_2SO_4) was added. This was mixed and allowed to stand for 30 mins and 2ml distilled water was added and the absorbance read after 15-30mins at a 740nm wavelength (UV– 4 Unicam spectrophotometer).

2.3.5. Phosphate

Method: Ammonium Molybdate method

Procedure: some 50ml of the water sample was measured into a 500ml containing H2SO4 (37% v/v) and 5g ammonium sulphate and mixed well. This was placed on a hot plate (30ºC) until the volume was less than 30ml, cooled and washed with distilled water. About 4 drops of phenolphthalein indicator were added and sodium hydroxide was used to make up to 400ml. another 5ml of 37% H_2SO_4 and 5ml ammonium molybdate and 5ml amino solution was added. The mixture was mixed and allowed to stand for 10 minutes. The absorbance of the solution was read at 650nm using the UV – 4 spectrophotometers.

2.3.6. Sulphate

Method: Turbidometric method

Procedure: some 20ml sample was added to 4ml of buffer solution. The mixture was swirled. Then, added a spoonful of barium chloride crystals and stirred for 60 seconds. Turbidity was measured using the UV-4 unicam spectrophotometer at a wavelength of 470nm.

2.3.7. Ammonia

Method: Distillation and titration method

Procedure: 50ml of the extract was measured into a distillation flask and adjusted to a pH of 7.0. Sodium hydroxide solution (250ml) and 50ml of distilled water were added and mix. Few zinc granules were added to make boiling uniform and prevent cracking of flask. Boric acid (100ml), methyl red (2 drops) and 2 drops of Bromocresol green indicators were added. The mixture was placed in a distillation column and titrated against 0.20M NH_4Cl which changed from light green to pink.

2.3.8. Determination of Conductivity

An electronic conductivity meter was used to measure the conductivity of the waste-water. The probe was pre-calibrated with potassium chloride (KCl) for 15minutes by lowering probe (the sensitive part) into the KCl-solution, as described by the instructions of the manufacturer, to a ten milliliter (10ml) of the sample was brought to the required temperature of 25ºC by immersion in a water bath and the bottle stoppered. The electrode was immersed into the sample with the bridge balance and the resistance read off on the LCD of the equipment.

2.3.9. Biochemical Oxygen Demand (BOD)

This was done by pipetting 50ml of the extract into a 200ml BOD bottle and then diluted with 150ml of deionized water (Dilution water) to fill the bottle. The bottle filled to the brim was stoppered without entrapping of air bubbles. The

initial DO in the sample after 15mins at ambient temperature was determined using the blank dilution water and the sample was incubated at ambient temperature for 5 days. After 5 days, the amount of dissolved oxygen remaining in the incubated samples was determined. The BOD_5 was calculated as

$$BOD_5 = DO_0 - DO_5 \quad (2.6)$$

where DO_0 and DO_5 is initial dissolved oxygen and dissolved oxygen at the 5th day respectively.

2.3.10. Chemical Oxygen Demand (COD)

Twenty-five millilitres of the sample was added into 250ml conical flask and 10ml of 0.0125N $KMNO_4$ (Potassium permanganate) and 10ml of diluted H_2SO_4 were added to the water. The blend was altogether blended and brooded at surrounding temperature for 4 hours. The mixture was examined at intervals and a further 10ml of $KMNO_4$ was added to maintain a definite excess once the purple to pink colour of the permanganate tried to disappear. A blank was prepared by adding the same volume of the reagent used for the sample to 250ml distilled water and was incubated at ambient temperature for 4h. At the end of the 4h incubation, 1ml of 10% potassium iodide (KI) was added and the resultant solution titrated with 0.0125M sodium thiosulphate using starch as indicator. The titration proceeds until the blue colour disappeared to produce a colourless. The titration of the blank was repeated.

3. Results

3.1. Proximate Composition of Oil Palm Empty Fruit Bunch

Table 1 depicts the findings for proximate composition of Oil Palm Empty Fruit Bunch (EFB). Indicating it could be an important source of energy.

Table 1 Proximate Composition of Oil Palm Empty Fruit Bunch

Parameters	Mean ± Std. error
Moisture	5.13±0.24
Ash	6.87±0.11
Fat/lipid	3.75±0.01
Crude Protein	4.87±0.01
Crude Fiber	67.0±1.19
Carbohydrate	12.30±0.95

3.2. Physicochemical Composition of Oil Palm Empty Fruit Bunch.

Table 2 shows the findings for the physical and chemical composition of Oil Palm Empty Fruit Bunch (EFB).

Table 2 Physicochemical Composition of Oil Palm Empty Fruit Bunch

Parameters	Mean ± Std. error
pH	5.81±0.22
Temperature (°C)	28.14±0.02
TSS (ppm)	5.09±0.02
Electrical Conductivity (µS/cm)	53.15±0.03
TDS (ppm)	26.61±0.02
Salinity (ppm)	19.97±0.03
Nitrate (ppm)	14.65±0.05

Sulphate (ppm)	4.94±0.02
Phosphate (ppm)	17.55±0.04
Ammonia (ppm)	0.04±0.01
DO (ppm)	2.86±0.01
BOD (ppm)	1.58±0.02
COD (ppm)	2.55±0.02
Magnesium (ppm)	1.05±0.01
Calcium (ppm)	3.77±0.01

4. Discussion

The experiment was conducted to examine the proximate and physicochemical of oil palm empty fruit bunch. The empty fruit bunch was locally produced, oven dried, grounded and stored in a cool dry place.

The moisture content of any substate is an index of its water activity [8] and is used as a measure of the stability and susceptibility to microbial contamination [9]. This implies that EFB may have a long shelf life due to its low moisture content. The moisture content of EFB (5.13 ± 0.24). Protein composition is vital for biosynthesis of active enzymes and co-enzymes, comparatively protein content is needed for functional system and supplementation [10]. The protein content for EFB is (4.87 ± 0.01), Carbohydrate composition is a significant nutritional constraint for organism growth [11]. EFB had carbohydrate level of (12.30 ± 0.95) which will favor the growth of organism. It has been pragmatic that about 80% of the entire cost of production in microbial cultivation is carbon substrate [12]. These carbohydrates synthesized are amalgamated into the cell wall as a prospective feedstock for citric acid production.

The grinded oil palm empty fruit bunch underwent aqueous extraction and was analyzed for their physicochemical properties. [13] recounted a huge amount of organic and inorganic nutrients tied to agro waste materials which serve as reservoir of nutrients. The pH of the oil palm empty fruit bunch was (EFB=5.81 ± 0.22). The pH affects the bioavailability of nutrients and its availability to target microbial populations, but extreme pH conditions may impede the growth of organisms. Biochemical Oxygen Demand (BOD) refers to the quantity of dissolved oxygen that would be consumed by aerobic organisms to break down organic material present in a given sample at certain temperature over a specific time period if all the organics in one liter of water were oxidized by bacteria and protozoa [14]. When BOD levels are high, dissolved oxygen (DO) levels decline because the oxygen that is accessible in the water is being disbursed by the bacteria. Since less dissolved oxygen is available in the water, aquatic organisms may not survive [15]. The extract BOD (ppm) (EFB=1.57 ± 0.02) and DO (ppm) (EFB=2.86 ± 0.01). Sulphate and nitrate content; Sulphate (ppm) (EFB=4.94 ± 0.02) and Nitrate (ppm) (EFB=14.65 ± 0 0.05). According to [16], these ions are essential to enhance growth of organisms. Nitrogen constitute the basic part of cell proteins, capable of inducing the formation of pellets in filamentous fungi and other organisms. Therefore, this substrate will play a significant role in the production processes. Furthermore, studies have demonstrated that the type of nitrogen source employed in production usually influences the yield of organic acids [17]. This is in agreement with [18] who worked on Improvement of production of citric acid from oil palm empty fruit bunches.

5. Conclusion

This study investigates Proximate and physicochemical composition of oil palm empty fruit bunch, serving as a guide for the nutritional, physical and chemical content, proving it can be used as a renewable alternative and inexpensive substrate for industrial use, which is an eco-friendly agro-waste management method.

Compliance with ethical standards

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Disclosure of conflict of interest

Authors have declared that no conflict of interest exist

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