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Potential Utilization of Empty Fruit Bunch (EFB) for Paper Making

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Abstract

The oil palm tree waste has had its use for broom making and temporary roofing (thatch houses). The aspects of its waste in context are the palm fronds and the Empty fruit bunch (EFB). The EFB which houses the oilseed has no documented use despite its high cellulosic content which is a major requirement in papermaking. Therefore, this work aimed to evaluate the suitability of using EPB for paper pulping. In this experiment, EPB was shredded and pulped to remove the lignin. The delignified pulp was loosened for fibre separation and subsequently dispersed in a water-containing corn starch solution before sheet formation. The sheeted paper obtained was evaluated for, grammage, abrasion, tensile strength, and tear strength. Results obtained reveal 80% abrasion resistance, 180g/m grammage while tensile strength and tear strengths were 0.638kg/cm and 34.578 respectively. These are pointers to its suitability for packaging papers such as cartons and cardboard.

Keywords: Empty Palm Bundle, Pulping, Paper Making, Grammage, Abrasion, Tear and Tensile Strength

I. INTRODUCTION

Paper is comprised of connected fibers usually wood pulp which is obtained from softwood coniferous trees such as pine. In terms of appearance, it is a thin sheet of white or coloured material fashioned by mechanical and/or chemical processing of Cellulose [1]. Noah Webster also defined paper as a constituent made in the form of thin sheets or leaves from wood, rags, straw, bark, or any other fibrous material for various uses Fibers obtained from several raw materials which has cellulose contains These materials include agricultural waste, grasses and other easier assessable fibers which contains cellulose. In retrospect, non-wood was primarily the source of the first paper made since 1700 but now with wood being of a larger percentage of the conventional paper and pulp production non-wood is being referred to as the alternate material [2]. Papermaking involves the dispersion of cellulosic fibres in water, after which the water is drained through a fine mesh and leaving the dispersed fiber evenly distributed on the mould surface followed by pressing and drying into flexible sheets [3]. Papermaking process for long has chiefly used wood for pulping but due to environmental degradation, climate change and waste accumulation alternate source of raw material are being utilized recently for paper products which are referred to as non-wood material. Paper utilization is dominant in the documentation of information and data, advertising and communication, sanitation, packaging, and educational purposes[4,5]. Oil palm is a single-stemmed tree that was originally harvested for palm fruits and used in the production of palm oil for both cooking as well as soap making [6,7]. They produce palm fruits that grow in large bunches. After the fruits are harvested, the empty fruit Bunch is discarded. EFB fibre Empty fruit bunch is a type of woody biomass formed during the production process of oil palm with a calorific value of 4,400 kcal/kg-dry and is considered as a non-toxic and promising biomass resource for industrial and farming applications including pulp and paper manufacturing [8]. The EFB is 23% of the weight of a fresh fruit bunch and an oil mill with a capacity of 60 tones of fruit bunches per hour produces more than 54,000 tones of empty fruit bunches per year[9]. EFB has little commercial value and poses a discarding problem due to its bulky nature. Usually, it is burnt, disposed of in landfills, or composted to organic fertilizer. However, the burning of EFB is no longer commended as it results in air pollution. For that reason, there is a need to optimize the use of EFB so as to resolve these problems and improve its judicious use in the production of composites, textiles, cellulose, and paper[9]. The use of EFB as an alternative raw material for pulp and paper provide added value and contribute to the zero-waste approach to the palm oil industry[10]. Therefore, this work aims at investigation its potential utilization for paper making.

II. MATERIALS AND METHODS

2.1 Materials

The EFB fibre as a residue oil palm tree was obtained from Ebonyi State, Nigeria., while Lab grade Corn Starch and Caustic Soda were obtained from Tunex laboratory Lagos State, Nigeria.

2.2 Methods

2.2.1 Raw Material Preparation

The raw material being EFB fibre was obtained locally and then washed to remove impurities such as sand, dust, and dirt. The bunch was then manually shredded using a cutlass to obtain the fibrous part. This fibrous part was washed with distilled water repeatedly and then sun-dried for 48 hours. The dried fibre was then weighed.

2.2.2 Pulping

The dried fibre obtained above was pulped using Lab grade sodium hydroxide (NaOH) as the pulping agent such that 30% by weight of the fibre mass was used to prepare the pulp bath. The Pulping was done between a temperature of 90^oc to 100^oc for a duration of 7hrs. The pulp yield was 63.6%.

2.2.3 Preparation of Paper

The pulp was beaten with the aid of a mortar and pestle to loosen the pulp fibre. The paper was prepared by the mixture of pulped fibre and starch solution at a ratio of 1:1. The double boiler method was employed in the formation of the paper. In this experiment, a cold starch solution was heated at 100 ^oC for about 5 minutes to obtain a starch paste. The cold starch paste was then mixed with pulped fibre and then further beaten. This mixture was further diluted with water and stirred for proper dispersion of fibres in the vat. The paper was fabricated with the aid of a mold and deckle such that the mold is dipped vertically into the pulp/starch mixture vat and then made horizontal and lifted off the vat. On lifting, fibre mass is already on the mesh surface. The sheet is then transferred onto cotton fabric for drying. The sheet placed on the cotton fabric was left to dry for 24hrs after which the paper is pulled from the cotton surface and ironed to straighten the paper.

2.3 Properties Evaluation of Paper

2.3.1 Abrasion Test

The paper samples were cut to the machine size sample preparation. Laboratory Martidale Abrasion Tester was used to carry out the abrasion resistance in accordance with ASTM D4886-18.

2.3.2 Tensile and Tear Strength Test

The Tensile and Tear strengths of the paper sample were determined with the aid of a Tensile Testing Machine Model- HD-A5l2, China. with a maximum force of 200kg (20 kN) following ASTM D2261

2.3.3 Grammage Test

Grammage test was carried out in accordance to BS ISO 536, the sample area dimension used in this experiment is 10cm by 10cm ($0.01M^2$). The grammage was calculated using equation 1

$$\text{Grammage} = \frac{weight}{length \times width} \quad \text{………………………………….. Eq I}$$

III. RESULT AND DISCUSSION

3.1 Abrasion Resistance

The results obtained from the abrasion resistance test at an abrader speed of 200 rev/min is shown in Table 1, four (4) test runs were carried to minimize error

Table 1: Abrasion Resistance of EFP based Paper

Specimen	Initial Weight(G)	Final Weight(G) @ 200 Rotation	Mean	Loss of Weight	% Abrasion Resistance
A	0.1322	0.1080	0.0242	18.31	81.69%
B	0.1598	0.1270	0.0328	20.53	79.47%
C	0.1991	0.1709	0.0282	14.16	85.84%
D	0.1253	0.1055	0.0198	15.80	84.20%
Average	0.1541	0.1279	0.0262	17.00	83.00%

From the above table, the abrasion value can be evaluated concerning the fibre weight loss. The above test was carried out using the Martindale abrasion tester after the sample was prepared with the sample cutter giving the same dimension all through. With a loss in weight of 0.02625 after 200 rotations by the abrasion machine with a weight of 9kg. It can be concluded that the paper has a good enough rubbing resistance to be utilized for paper production. With the average % abrasion result being 83%, it means that the paper is 83% resistant to rubbing under the condition of weight 9kg and a rotation of 200. An increase in abrasion resistance might be achieved with a stronger fibre to fibre bond within the paper

Note: the varying weight of the specimen within the same sample is because the paper sample is handmade with a mould which resulted in an uneven fibre distribution across the paper length with some points having more fibre concentration than others.

3.2 Grammage

The result of grammage test is presented in Table 2

Table 2: Grammage of EPB

Specimen Number	Weight (g)	Sample Area (m^2)	Grammage (g/m^2)
1	1.5874	0.01	158.74
2	1.5757	0.01	157.57
3	1.5733	0.01	157.33
4	2.1062	0.01	210.62
5	1.9325	0.01	193.25
6	1.8675	0.01	186.75
7	2.0754	0.01	207.54
8	1.6872	0.01	168.72
9	2.0152	0.01	201.52
10	1.5263	0.01	152.63
Average	1.7947	0.01	180 g/m^2

The grammage of a paper also referred to as the area density is the mass per unit area of the paper. Results revealed average grammage of 180 g/m^2. Papers for office use usually have their values around 80 to 180 g/m^2. However, this value of 180 g/m^2 obtained for EFP based paper can best be used for packaging papers which generally have a grammage value of between 120g/m^2 to 300g/m^2 [11]

3.3 Tensile Strength and Tear Strength of Paper

The result obtained from tensile and tear strengths of EPF is presented in Table 3.

Table 3: Tensile Strength and Tear Strength of Paper

Sample	Tensile Strength (kg/cm^2)	Tear Strength (Nm^2/kg)
1	0.68	15.80
2	0.62	15.76
3	0.60	15.73
4	0.65	15.78
Average	0.64	15.76

The tear strength of paper refers to the resistance of a paper sheet to tearing force while tensile strength is the maximum strength to break a strip of paper. As shown in Table 3, the best tensile strength of the paper produced from EPF is 0.68kg/cm^2 while tear strength gave a value of 15.76Nm^2/kg. The results are consistent with that obtained by [12]. While the figures are low, it is enough to solidify the claim of EFB fibres being useful for paper production and due to its similar physical characteristics with wood. From the results, the paper has a low tensile and tear strength as compared with conventional writing paper which has a tensile strength of 3.56Mpa or 3.60kN/m for its tensile strength. It must, however, be noted that The tensile strength value is dependent on the machine type used for the test. The poor tensile and tear strength of the sample could be because the conventional paper has a finer fibre mass than EFB paper as well as a more open fibre structure due to mechanical beating action. It is also because hardwood generally has a better elongation value than EFB fibre even after prolonged digestion time.

IV. CONCLUSION

From the tests carried out on the EFB paper produced, it can be concluded that oil palm empty fruit bunch can be utilized in the production of packaging paper in the place of wood thereby reducing the rate at which trees are lost as well as protecting the environment by controlling the release of toxic gases into the atmosphere from the burning of empty fruit bunches. Commencing the tests carried out on the EFB paper such as the abrasion test it has been observed that the paper can withstand a level of rubbing without being damaged. The abrasion test was carried out on the Martindale abrasion tester using a weight of 9kg at 200 rotations with the average difference in weight of the sample after the abrasion test being 0.0262 with an 83% resistance to abrasion. The tensile and tear test carried out using a tensile tester of Model HD-A512 was good for paper utilization but did not give a very good value when compared with conventional writing paper in terms of paper tensile and tear strength and as a result of this, the durability of the paper while in use might be affected. The grammage value of the paper is 180g/m^2 which is within the range of paper board grammage value. EFB fibres are hard and brittle making them a bit difficult to pulp. After pulping with caustic soda for a duration of 7hrs I got a pulp yield of 63.6% which is lesser than that of wood pulp. This is one of the downsides of EFB fiber as it requires more fibre mass than wood for paper production and is harder to pulp than wood. EFB can be beaten both manually and mechanically but gives a paper product that is coarse by touch making it better suited for packing paper than writing paper. The coarse nature of the paper produced is also because the paper was manually pulped with the use of mortar and pestle. With the paper gotten from the pulping of oil palm empty fruit bunch, the paper can be used in the production of packaging papers such as cartons as well as for the fashioning of paper egg crate. The use of EFB paper for the making of paper egg crates will reduce the rate of plastic usage, therefore, reducing the accumulation of waste.

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