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Pulp and papermaking potential of Palmyra fruit fibre *Borassus flabelifar*

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ABSTRACT

The pulp and papermaking potential of Palmyra palm fruit fibre was investigated in both acidic and alkaline media and was found to be an alternative raw material for cellulosic pulp for paper making. The chemical compositions of the fibre strands from the Palmyra palm fruit such as cellulose, moisture content, lignin and extractive were also investigated in accordance to standards. The pulp yields obtained from the raw material were below 40% in both media studied. The physical properties of the paper produced (both in acidic and alkaline media) such as bulk yield (Kg/m^3), caliper thickness (mm), pulp yield (Kg/m^3), fibre width (mm), fibre length (mm), water absorption, colour and the mechanical properties such as tensile, tear strength and folding endurance were also investigated.

INTRODUCTION

Papermaking is known to have been traced back to China about 105CE, when *Cei hun*, an official attached to the imperial court during Han Dynasty (202BC – 220CE), created a sheet of paper using mulberry and other blast fibres along with fish net, old rags and hampster wastes[1]. But with progression in the 8th century in the Islamic world, papermaking changed from an art into major industrial work through the use of machines to design and manufacture bulk of papers.

The introduction of raw material of non-wood fibres such as various species of palm fibres, rice straw, bagasse, bamboo etc which are processed into paper have tremendously improved the production rate of paper making industries worldwide. Palmyra palm *Borassus flabelifer* is a native plant found in the western part of Africa and Asia. It belongs to the Palmae family having similar characteristics with palm oil nut and coconut; it's parts such as the trunk, fronds and husk are utilized in pulp industries for papermaking [2]

Paper , a material sheet which has been of high demand due to it's ubiquitous use for writing and packaging is basically made up of cellulosic fibres, which is normally produced by separating wood using mechanical or chemical process [3]. These isolated fibres are subsequently rearranged and randomly distributed into sheet-like structures.

Originally, wood pulp was the major resource used in the production of paper. In recent times, non-wood pulp constitute a major contribution to total pulp as to bridge the insufficient wood supply for the growing demand of paper which has caused the industries to search for alternative wood sources (the non-wood fibres) such as rice straw, baggasse etc [4]. Also, the act of deforestation and continuous rise in the price of wood chips, have resulted to the increase in the utilization of non-wood resources for production of better paper quality. Hence the pulping and

paper making potential of Palmyra palm fruit fibre, a non-wood resource was examined in order to ascertain its potentials.

MATERIALS AND METHODS

Material

Palmyra palm fruit fibre used for this research was sourced from palm trees located in the vicinity of Nnamdi Azikiwe University, Awka and was duly identified by a taxonomist Dr. Mbaekwe of Botany Department, Nnamdi Azikiwe University, Awka.

Methods

The pulping method used was the semi-chemical methods [4, 7and 9] where 150g each sheath cooked fibre of the Palmyra palm fruit was first ground, sieved and emmersed in 200ml i.e 1M, 2M and 3M concentrations of NaOH (Alkaline) and HCl (acid) respectively at 155 to 160^{o}C using a gas cooker.

The pulp were then bleached with hypochlorite, filled with white corn starch and bound (sized). The pulp were then cast into various moulds,pressed and allowed to dry in the oven at 70^{o}c to a constant weight.

Paper Testing: Physical, mechanical and chemical tests were conducted on the product, paper to ascertain their quality.

The Physical and Mechanical Quality

The physical and mechanical of both the fruit and fibre pulp and the paper produced included: pulp yield, colour and bulk yield for pulp. Water absorption, moisture content, fibre width, caliper thickness, tearing strength, tensile strength, folding endurance for the fruit fibre. These tests were all conducted according to literature [5- 6 and 9 - 14].

Chemical Test

The chemical tests include Ash content, moisture, cellulose content, lignin and the extractives conducted on the fruits fibre according to literature [5, 7 and 8].

RESULTS AND DISCUSSION

The results presented in Tables 1, 2 and Figures 1 to 7 below show the potential of palmyra palm fruit fibre in pulp and paper making owing to the relevance of the tests conducted and methods used.

Table 1: Physical and mechanical Quality characteristics of the pulp and paper

Properties	**Concentrations of NaOH and HCl**					
Physical properties	**1M NaOH**	**1M HCl**	**2M NaOH**	**2M HCl**	**3M NaOH**	**3M HCl**
Pulp yield %	33.10	34.93	30.50	32.06	30.00	30.08
Bulk yield kg/m^3	5.60	5.55	5.40	5.30	5.40	5.30
Caliper thickness (mm)	0.50	0.55	0.55	0.54	0.67	0.70
Water absorption (%)	59.90	53.29	60.70	61.30	64.90	63.18
Colour	Fairly white	Brown	Fairly white	Brown	White	White
Mechanical Properties	**1M NaOH**	**1M HCl**	**2M NaOH**	**2M HCl**	**3M NaOH**	**3M HCl**
Tearing strength N/m^2	1.09	1.80	2.33	2.20	2.60	2.40
Tensile strength N/m^2	3.22	3.45	3.49	3.45	3.62	3.50
Folding endurance g/m^2	747.13	736.46	1151.63	1486.27	2074.47	2083.33

Table 2: Physical and Chemical property of The Fruit Fibre

Parameters	**Quantity**
Moisture content (Wt %)	4.200
Cellulose (Wt %)	4.100
Lignin (Wt %)	17.900
Extractives (W%)	6.600
Ash (Wt %)	4.300
Fibre width (mm)	0.014
Fibre length (mm)	1.250

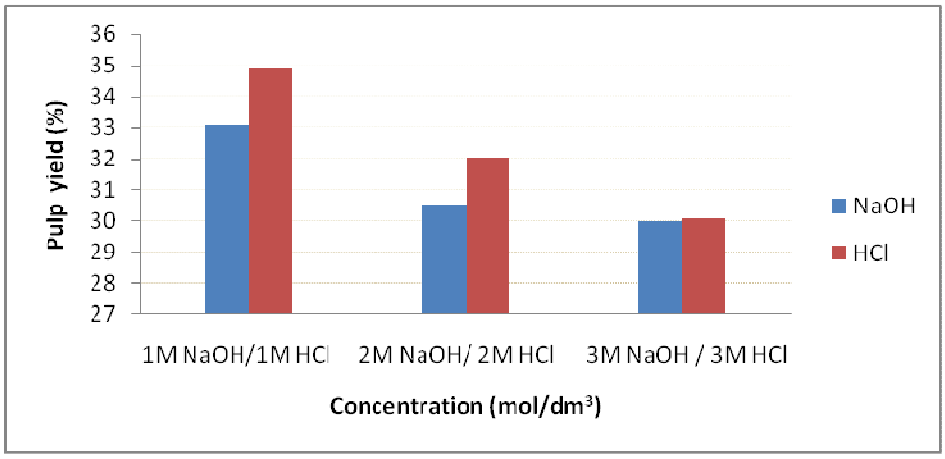

Fig. 1: Effects of varied concentration of NaOH and HCl on percentage pulp yield

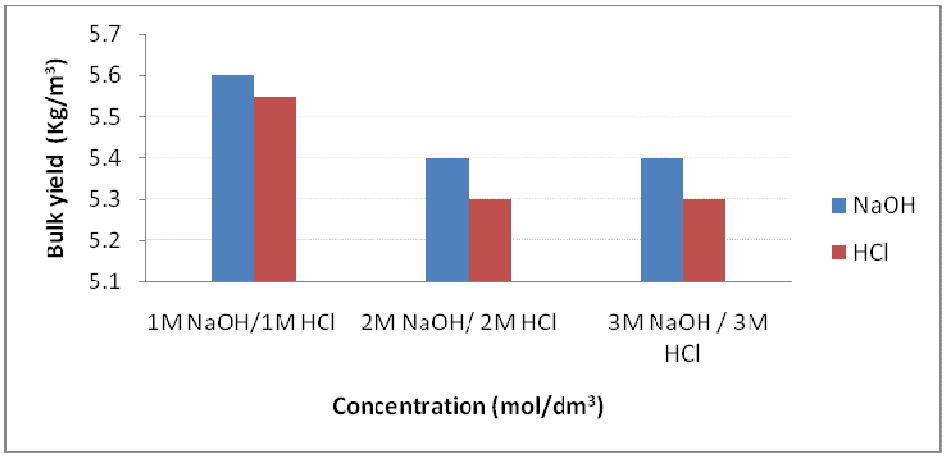

Fig. 2: Effects of varied concentration of NaOH and HCl on bulk density

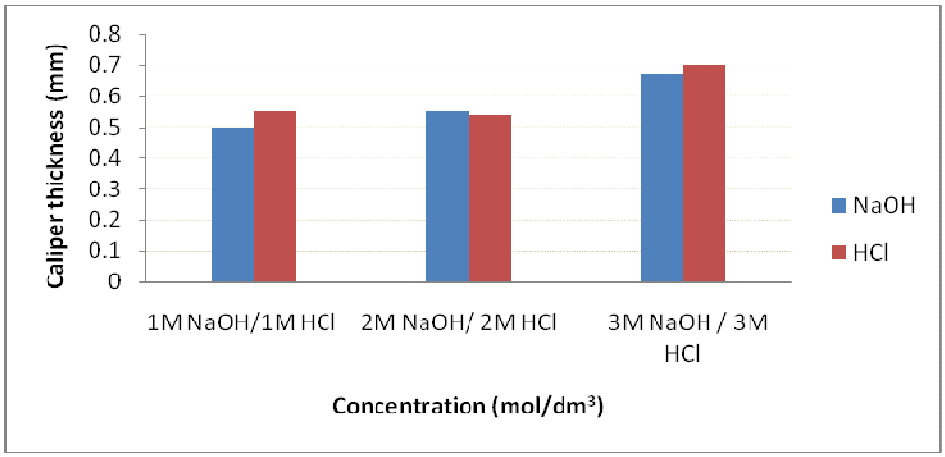

Fig. 3: Effects of varied concentration of NaOH and HCl on caliper thickness

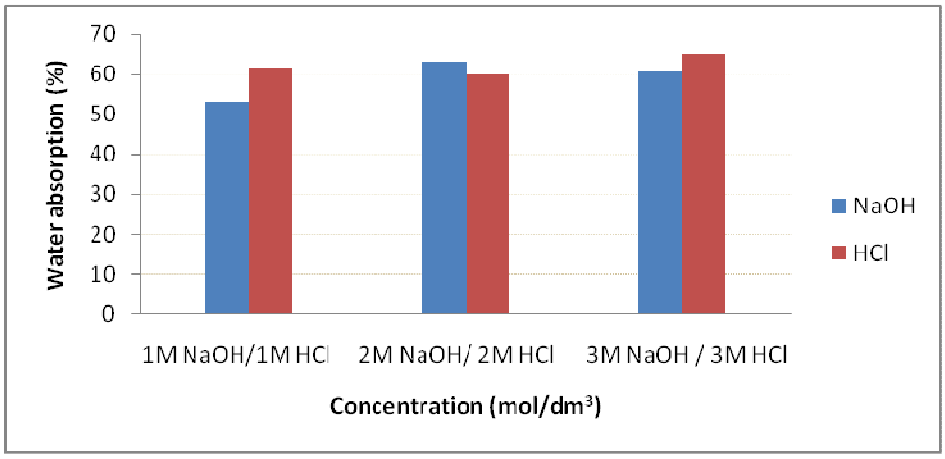

Fig. 4: Effects of varied concentration of NaOH and HCl on water absorption

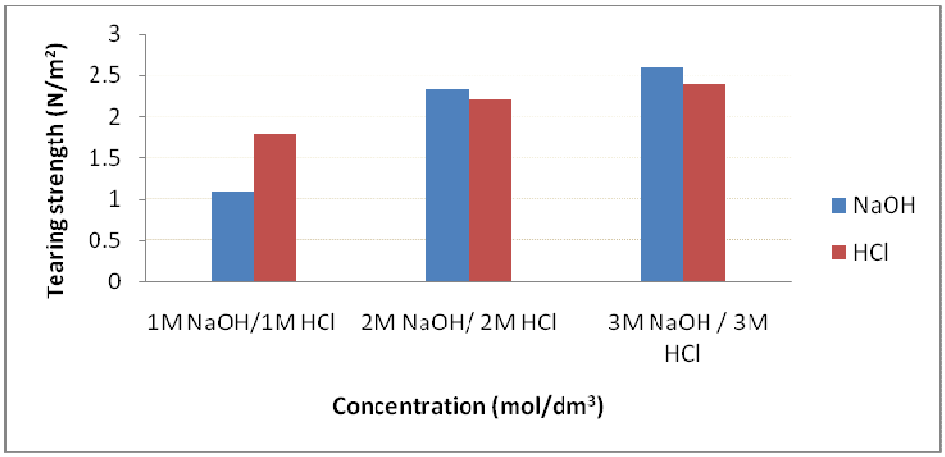

Fig. 5: Effects of varied concentration of NaOH and HCl on tearing strength

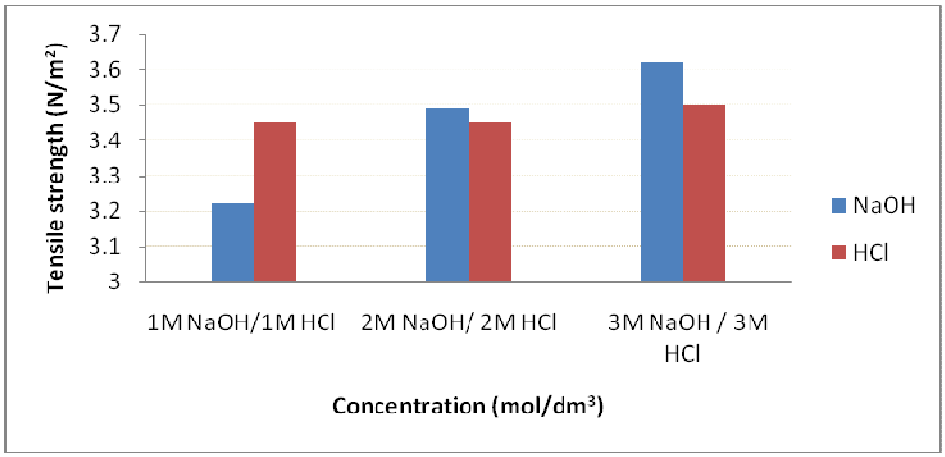

Fig. 6: Effects of varied concentration of NaOH and HCl on tensile strength

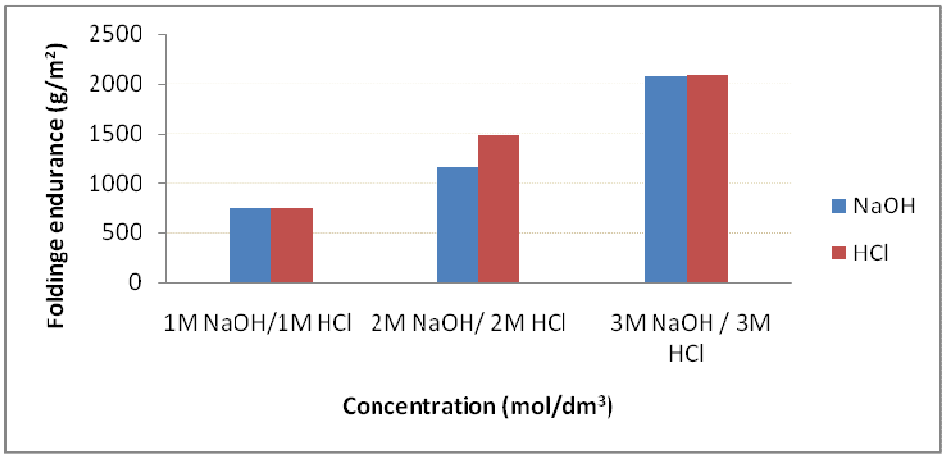

Fig. 7: Effects of varied concentration of NaOH and HCl on folding endurance

DISCUSSION

Table I showed the physical properties of the pulp from both acid and alkaline methods of pulping. Pulp yield from NaOH and HCl, pulps in Table 1, Figure 1 indicated that the yield the pulp yield decreased with increased concentrations of NaOH and HCl respectively. The pulp yield from NaOH treatment was lower when compared to that from HCl due to the greater removal of lignin and other substances. The pulp yield was within the range reported for semi-chemical pulp and soda alkaline pulp [15 - 20].

Bulk density of paper made from NaOH and HCl, from Table 1, figure2, showed that the bulk density of handmade papers produced decreased with increased concentrations of NaOH and HCl. But in comparism to both treatments, paper made from HCl gave a higher bulk density compared to that made from NaOH.

Water absorption of papers made from HCl and NaOH, from Table 1, Figure 3, it could be seen that the water absorption of the locally handmade paper produced from Palmyra palm fruit using varied concentrations of NaOH and HCl increased concentration of NaOH and HCl. The paper made from NaOH had a greater water of absorbability than the paper made from acid pulping (HCl) was due to low size content used during production [7, 21-22]

The tearing strength of paper produced using different NaOH and HCl concentrations presented in Table 1, Figure 4, indicated that strength of handmade paper produced from Palmyra palm fruit using varying concentrations of NaOH and HCl decreased with increased concentrations, however, the result showed that handmade paper from HCl had a greater tearing strength when compared to that from NaOH at each various concentrations.

Tensile strength of handmade papers form Table 1, Figure 5, showed that the tensile strength of the papers increased with increased concentrations of NaOH and HCl solution, the tensile strength of NaOH was greater than that of the paper made from HCl.

Folding endurance of the paper from Table 1, Figure 6 showed that the folding endurance varied with concentrations of NaOH and HCl. It increased with increase in concentrations of NaOH and HCl, whereas in relation to both, paper made from NaOH had a higher folding endurance compared to that made from HCl. Caliper thickness of paper NaOH and HCl, from Table 1, Figure 7, indicated that the caliper thickness increased with increase in concentrations of NaOH and HCl. Whereas in comparism to both, paper made from NaOH, gave a higher caliper thickness than that made from HCl.

Colour: Both CID and base gave variance in colour, as the concentration of the acid or NaOH increase, the colour intensity increased.

CONCLUSION

From the tests and results obtained from this work, it could be concluded that Palmyra palm fruit grown in south-east Nigeria is fairly good for pulp and papermaking.

At the varied concentrations of NaOH and HCl, pulp yield decreased as the concentrations of NaOH and HCl increased in both. But pulp yield from NaOH gave a lower yield compared to that of HCl acid, which were all below 40%. The NaOH treatment gave a better paper compared to that of HCl acid at the varied concentrations, it also gave a better results in almost the properties compared. It can now be said that paper made from NaOH are better than that from HCl acid; owing to the relevance of the tested properties carried out, its pollutant effects to the environment, economical effectiveness and quality of paper produced to bridge scarcity and demand.

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