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Extraction, purification and testing of vegetable fibres from *Poliostigma reticulatum*, *Grewia molus* and *Ciccus populnea*

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Abstract

Fibre from three different vegetable plant stems *Poliostigma reticulatum, Grewia venusta, Ciccus populnea* were extracted, purified and their mechanical properties determined. The pH of retting medium (H_2O) was observed to decrease as the retting time increases. This was ascribed to the activity of microorganisms on the non-fibrous matter of the bast thereby freeing the fibrous component. The fibres were also chemically retted using NaOH and NH_4OH at different concentrations, scoured, bleached and mercerized. The breaking load and percent elongation were measured. The strength of fibres was observed to decrease with increase in concentration of retting medium for all the vegetable plants. However, beyond 15% NaOH and 10% NH_4OH minimal decrease in strength was obtained. This was attributed to the breakdown of inter-bonds between the waxy matter and the gradual separation of the fibres. The hydroxides of Na and NH_3 could have dissolved the matrix of the bast there by exposing the fibres. However, the decline in strength of fibres at high chemical retting concentrations may be due to a combine effects (temperature and concentration), which degrade the intra-bonds of the freed fibres. NH_4OH retting produced cleaner, lustrous and stronger fibres than H_2O and NaOH respectively. These vegetable fibres could be close substitutes for use in carpet, mat, bags, furniture, apparels, sport equipment, and women's wear productions and in natural fibre based composites.

Keywords: Retting, Fibre, Microorganisms, Tensile Strength, Bast, Mucilaginous Matter

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1. Introduction

Different parts of vegetable plants have been utilized in many ways such as in medicine, food, building, furniture, cordage, textile, source of fuel, etc. Fibres have also been extracted from either stems of jute i.e. kenaf, ramie; banana, sisal leaves and cotton seed, coir. The continuous applications of vegetable fibres overtime have necessitated interest of scientists toward the improvement in the method of extraction, purification and modification of their properties (Ajayi et al., 2000; Dass, et al., 2002; Ezeribe, et al., 2009; Tarnongo, et al., 2009). Due to these renewed interest, bast of vegetable plants which were hitherto thrown away as waste are now being studied as possible replacement for some synthetic and other commonly used natural fibres. Also, the economy of some countries have greatly improved due the twin advantages of waste reduction and source of raw material for local industries. In this research, natural fibres were extracted from three different vegetable plants of *Poliostigma reticulum*, *Grewia mollis* and *Cissus populnea* in different retting media, purified and their strength determined.

2. Materials and methods

The samples were collected at two different places, *Poliostigma reticulatum, Grewia venusta* were collected at Garko hill Akko Local Government Area, Gombe State. *Cissus populnea* was collected from Yelwa-Tudu, Bauchi metropolis Bauchi State. Knife was used to remove the bark from the harvested stem because it is difficult to remove the bark after the stem was dried up.

2.1. Water retting

30 cm long and 100 g of each sample A, B and C were submerged in water of 20 litres for five (5) weeks. At intervals of 7 days small quantity from each sample were removed, washed with detergent and rinsed in overflowing water. This process removes ligneous, woody and mucilaginous matters and converts them to soluble product (Ajayi et al., 2000). The above procedure was then repeated for NH_4OH. 1 mg of 12 cm of the fibres were taken and the tensile strength measured. 1 ml of the retted media (water) was put in a beaker and the pH measured at interval of seven days.

2.2. Chemical retting

Five different beakers marked 1, 2, 3, 4 and 5 each contains 600 ml of NaOH at different concentration (i.e. 5%, 10%, 15% and 20%) respectively were prepared and used separately as a chemical retting agent 15.0 g of each sample A, B and C was submerged in solution and heated at 100^0C for 30 minutes in water-bath. The fibres were then rinsed in cold water (H_2O) to free fibres strands. The fibres were dried up overnight at room temperature to prevent oxidation of fibre macromolecules. The fibres were prepared to 12 cm and 1 mg each.

2.3. Purification of fibres

Retted fibres were scoured in 22% NaOH solution for 30 minutes at $100^{O}C$ according to Dass, et al. (2007). The fibres were then soaked in soap solution and quickly rinsed with tap water to avoid the reaction between hot scoured fibres and air which may lead to degradation. Dry scoured fibres were measured and submerged in a solution of H_2O_2 to remove any colouring matter and white fibres were obtained. 1.0 g of bleached fibre was added and warmed at 50 ^{0}C for 20 minutes. Then the fibre was washed with detergent and rinsed properly and neutralized with acetic acid to remove excess alkali and prevent degradation. The fibre was then dried up in the laboratory overnight. The fibres were arranged based on the physical observation of cleanliness Ajayi, et al. (2000).

2.4. Tensile strength measurement

The bundle test described in ASTM D2524 was used. The Shirley testometric tester model 220D was used. Prior to test, the machine was calibrated to a nominal gauge length of 50 mm pulling champs move at 10 mm/min. 3 tests were carried out for each bundle and the average values recorded. The tensile strength was calculated using the formula:

$$\text{Tensile strength (Psi)} = \text{Breaking load (gf)} \times 4.733 \times 10^{-2} / \text{Mass (g)}$$

3. Results and discussion

Figure 1 is a plot of the pH of retting medium (H_2O) against time in days. The retting time increases as the acidity decreases up to a minimum then flattened. The microorganisms release enzymes, which digest the pectin material, surrounding the fibres bundles, thus free the fibres. No appreciable decrease in strength of fibre was observed as from the 5th week of retting. This may be due to increase in acidity of the medium as the microorganisms continued to act on the mucilaginous substances. Furthermore, increase in pH could have been due to microbes' accessibility to the soluble mucilaginous matter thereby increasing their secretion of enzymes even when the fibrous portion have been separated. Dass, et al. (2002) supported this assertion when they showed increase in total acidity, pH even after fibres have been completely loosened from the stalk. The decrease value of BL and BE both suggested that the action of microbes on ligneous matter which is tightly bounded to cellulose and makes separation difficult and prolong.

Figure 2, 3 and 4, gives the effect of time and chemical retting on the strength of fibres using water, NaOH and NH_4OH solutions as the retting medium. Both media show similar pattern of behaviour in that as the time and concentration of the medium increases the strength of the fibre decreases to a minimum. However, in curve C the decrease in fibre strength then remain constant even as concentration of medium increases. Several researchers have reported that the possibility that separation of non-fibrous substances from the fibres is the result of the dissolution of carbohydrates, glycosides, tannin and some nitrogen compounds in solution. The research noticed various organic acids and gases were produced and solution becoming turbid during the retting.

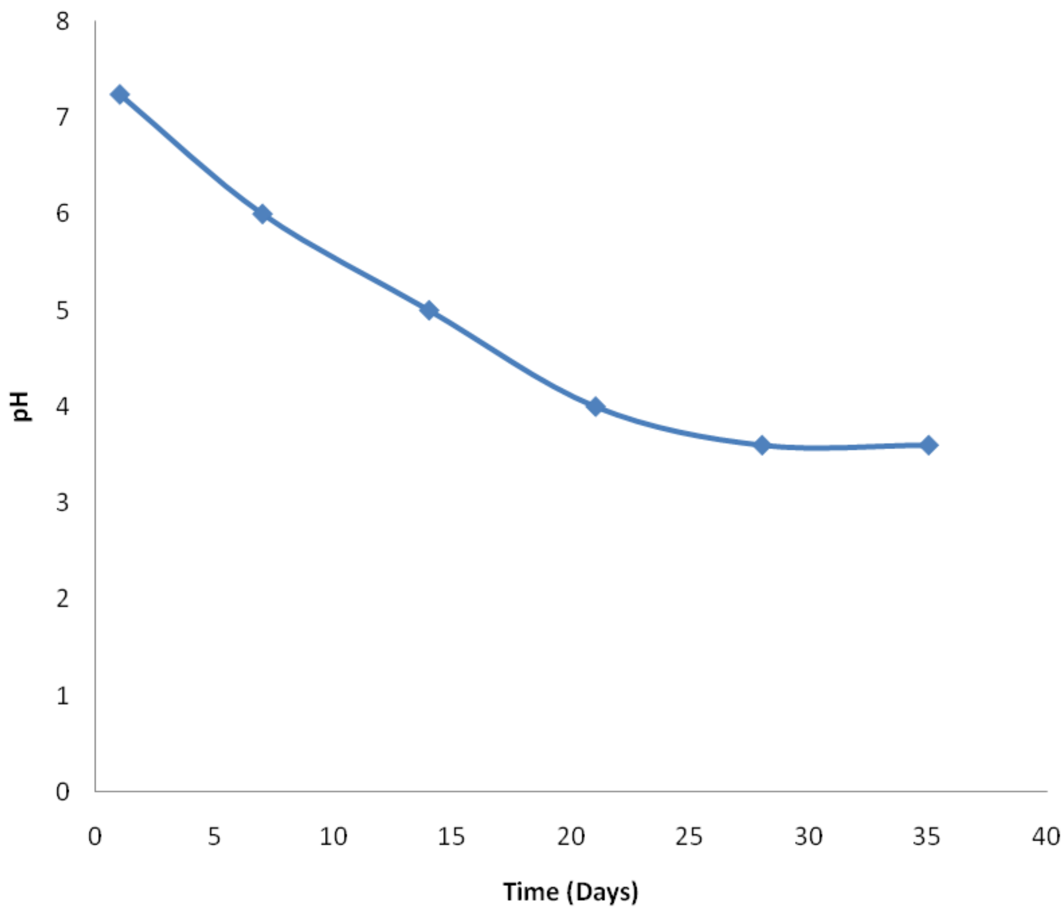

Figure 1. pH of H_2O against retting time (days)

From the Figure 4 breaking load in kg/f against concentration of NH_4OH (%), NH_4OH is a better retting agent than NaOH as shown because it gives clearer and soft to touch fibres that suggested complete retting. And at 5% NH_4OH solution the fibres were completely retted whereas looking at Figure 2 it does not completely retted at 5% NaOH signifying that much of the pectin could have been removed, the hemicellulose and lignin remain attached to the fibres (Cerchiara et al., 2010). Sample A & C show similar pattern to that of sample B in NH_4OH solution retting. 15% NH_4OH was considered to be the best of the concentration for retting of these bast fibre. From Figure 2 the result shows that at 28 days samples, B and C have been completely retted. The time taken was also strong factor considered in retting of bast. 28 days was observed as maximum time for water retting of these bast. However, the maturity of plant and position on the stem of bast taken were noticed to have strong effects on the water retting time.

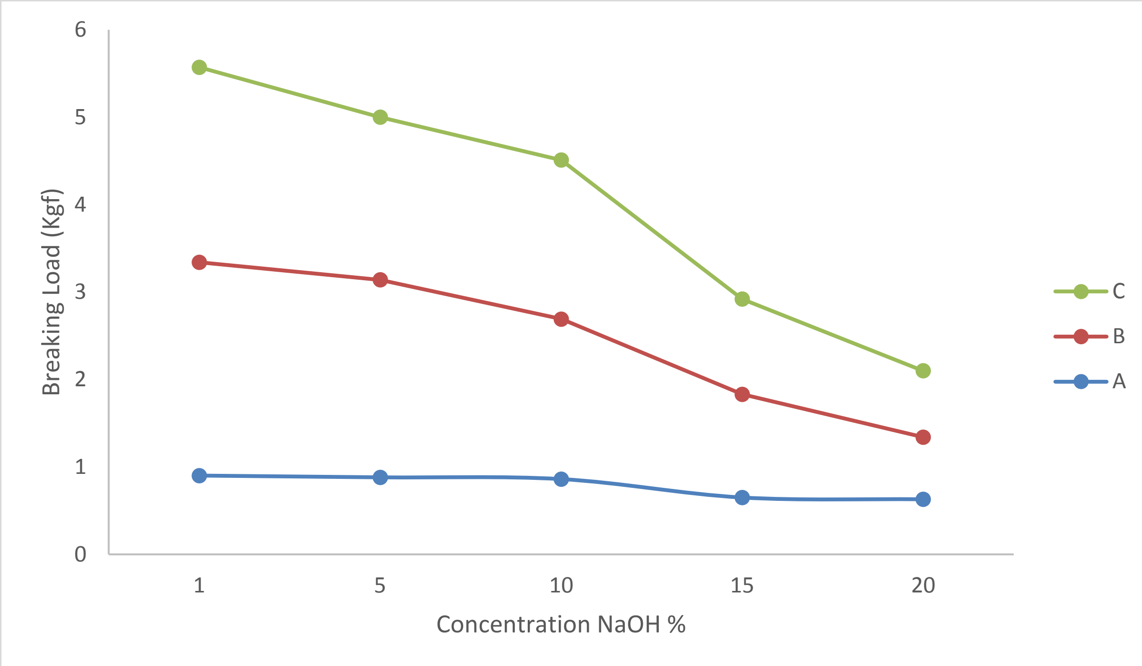

Figure 2. Breaking Load (BL) against Concentration of NaOH (%)

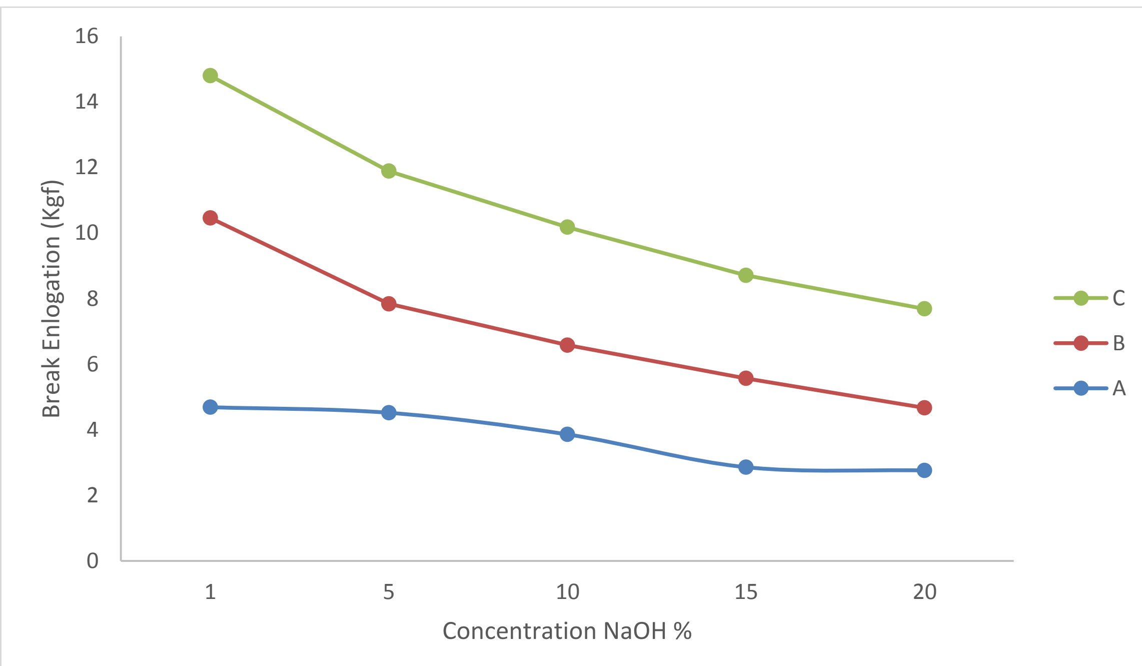

Figure 3. A plot of Break Elongation (BE) against concentration of NaOH (%)

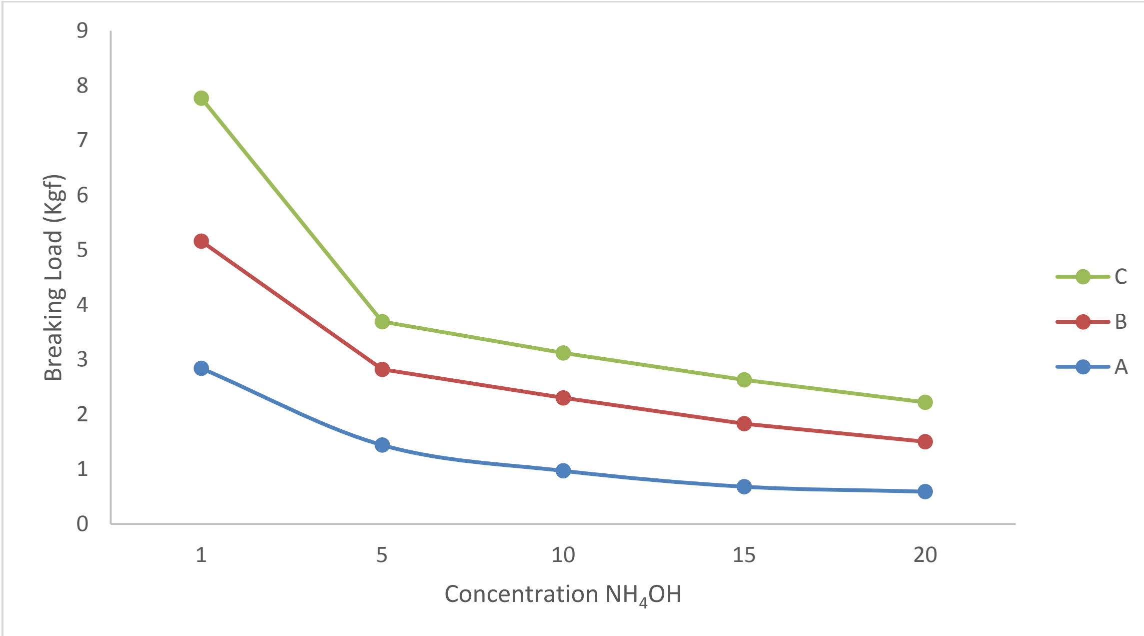

Figure 4. Breaking Load (Kgf) against concentration of NH_4OH %

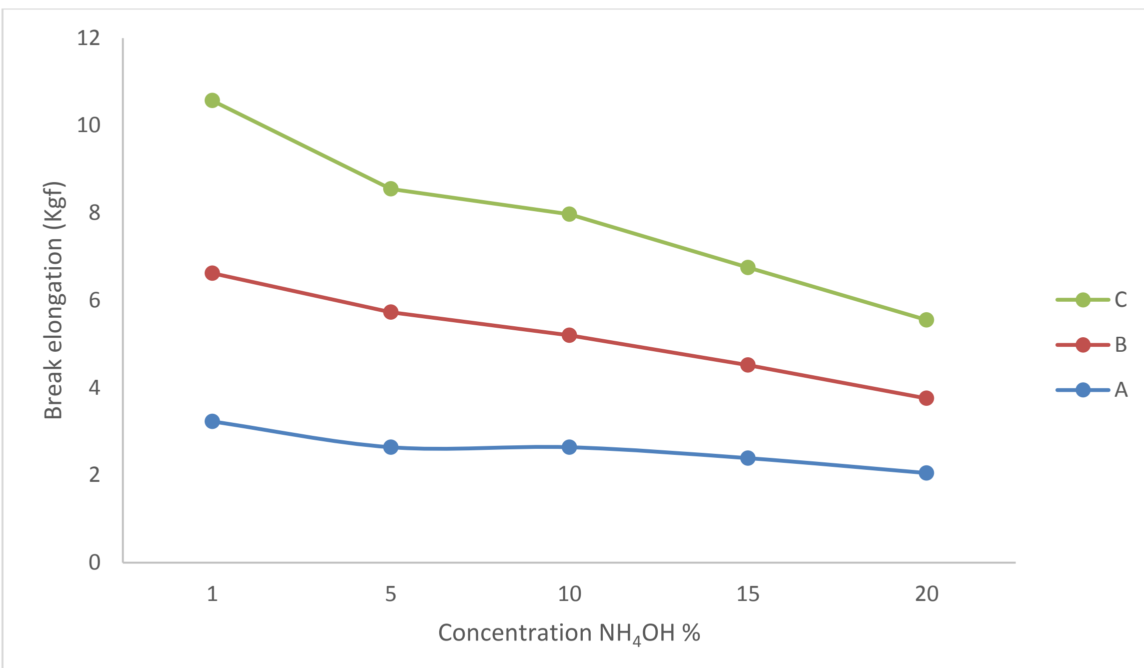

Figure 5. Breaking elongation (Kgf) against concentration of NH_4OH (%)

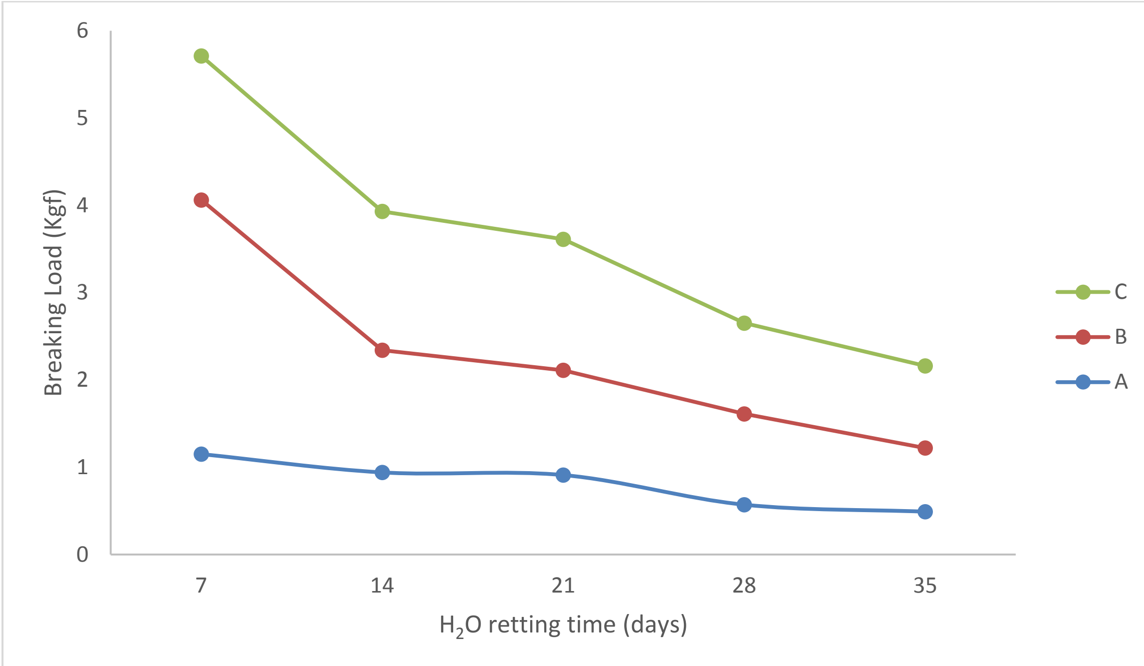

Figure 6. Breaking Load (Kgf) against H_2O retting time (days)

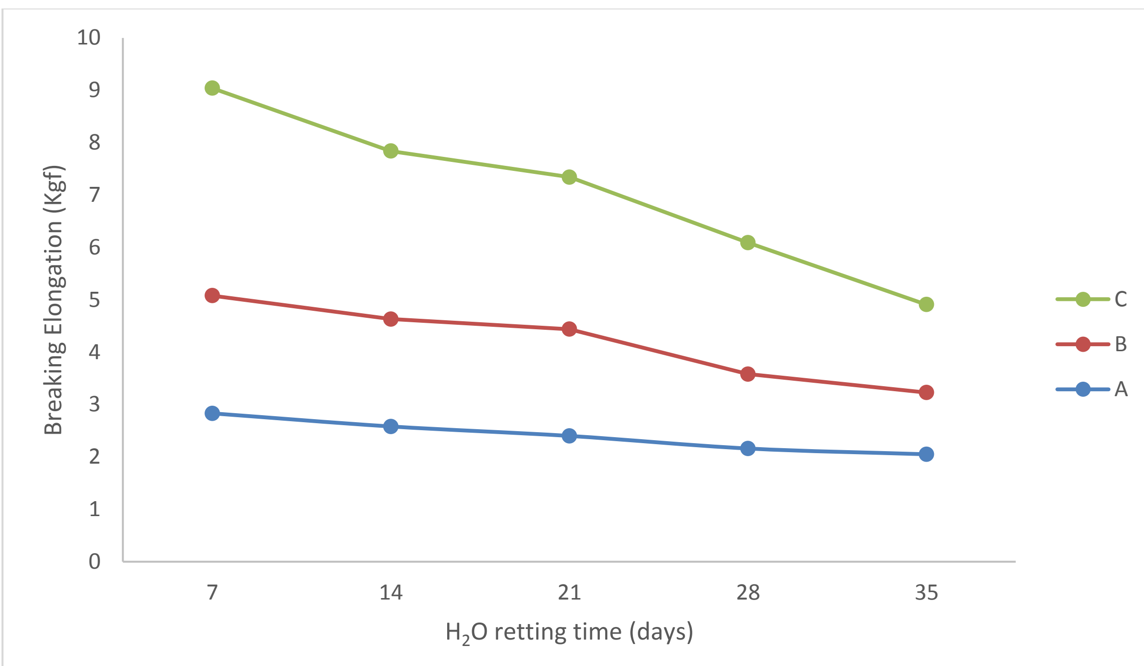

Figure 7. Breaking elongation (Kgf) against H_2O retting time (days)

Figures 5, 6 and 7 give the effect of chemicals and retting time on the breaking elongation of fibres using water, NaOH and NH_4OH solutions as the retting media. Both medium show similar pattern of behaviour, in that as the concentration of the medium increases the breaking elongation decreases to a minimum then remain constant (Tarnongo et al., 2008). This could be ascribed to the gradual freeing of the fibres from the bundles. Since the stem is made up of fibre bundles each containing individual fibre cells or filaments. The filaments are made up of cellulose and bonded together by a matrix hemicellulose which can be lignin or pectin. The removal of hemicellulose reduces its ability to absorb moisture and the breaking of lignin which cements fibre cells also may have contributed to weaken the fibres and consequently its ability to extend (Tarnongo et al., 2009). Therefore, it may be inferred that strong alkali, higher temperature and long period of time of retting have adverse effects on bast fibres.

4. Conclusion

From the study the following conclusions can be drawn: retting and other purification processes improved the properties of fibres such as strength. All retted fibres except those with NaOH are clearer and lustrous. All retted fibres experience drop in tensile strength with increase in concentration of retting liquor. NH_4OH was found to be better retting medium because it is a weak alkali. The fibre obtained from this research should be further purified and tested to ascertain it favourability or otherwise for use in manufacture of carpet, mat, bags, furniture, apparels, sport equipment, women's wear, etc.

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