Studies on the tensile properties of Banana stalk fibres from Njombe – Penja –Cameroon

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Abstract
This work is aimed at characterizing and comparing the mechanical properties of the unbleached and bleached banana stalk fibres, namely the Cavendish William variety. Banana tree belongs to the Musaceae Family and has a high fibrous potential, particularly in the stalk. In this work, the stalks collected were sectioned into different sections(A, B, C) and zones (Peripheral, Inter media, and Center) located on the longitudinal and cross sectional part respectively. The fibres were extracted through retting process. After extraction, the fibres underwent tensile test using the Universal testing tester. The results obtained in the case of unbleached fibres showed that, elongation vary from 1.63% to 3.06%; breaking force from 1.78 N to 3.45 N; tenacity from 0.11 N / Tex to 0.23 N / Tex; and initial modulus vary from 2210 N / Tex to 4235 N / Tex. The strength of initial modulus increases from the center to the periphery. The results of the tensile properties of bleached fibres are similar to that of unbleached fibres and followed the following trend, elongation vary from 1.76% to 3.61%; breaking force from 1.56 N to 2.61N; the tenacity from 0.13 N / Tex to 0.34 N / Tex and initial Young modulus varies from 2306 N / Tex to 3250 N / Tex and increases from the center to the periphery. It is noted that the elongation of the banana stalk fibreis similar to that offlax and ramie.

Keywords: *Banana stalk Fibres; Retting Tensile properties, Initial Young Modulus.*

1. Introduction

Natural fibers have played a crucial role in alleviating daily needs. But in recent years, the arrival of synthetic products has dominated over natural fiber, due to the low cost. Several authors have been interested in the characterization of banana fibers, these include: [1] who worked on the processing and evaluation of the mechanical properties of banana fiber reinforced by polymer composites. Their results showed that banana fibers have excellent mechanical properties and the maximum values obtained are 112.58 MPa as tensile strength, 77.21 MPa as flexural strength. The mechanical properties of banana fibres were also studied by Taiwo et al, 2016. The length of banana stalk and the banana leaf fibres were studied [2]. The results showed that the banana stalk and the banana leaf have an average fibre length of 1.27 mm to 0.88 mm respectively. The tensile properties and water diffusion of longitudinal and the cross section of raffia viniferafibres [3] was also studied. Vishnu Prasa et al, 2014 studied the effects of fibre configuration on the mechanical properties of bananas reinforced with polypropylene fiber. Their results show that the reinforced PP / Banana composites have a tensile strength of 355 MPa, a Young's modulus of 33.8 GPa; an elongation at break of 5.3% and a density of 1300kg/m^3. Since little have been studied on banana stalkfibre, we will focus on the mechanical characterization of William specie of banana stalk fibres grown in Cameroon. The effect of chemicals on mechanical properties of the fibre will be studied as it was done on sidarhombifolia [5].

II. Materials and methods

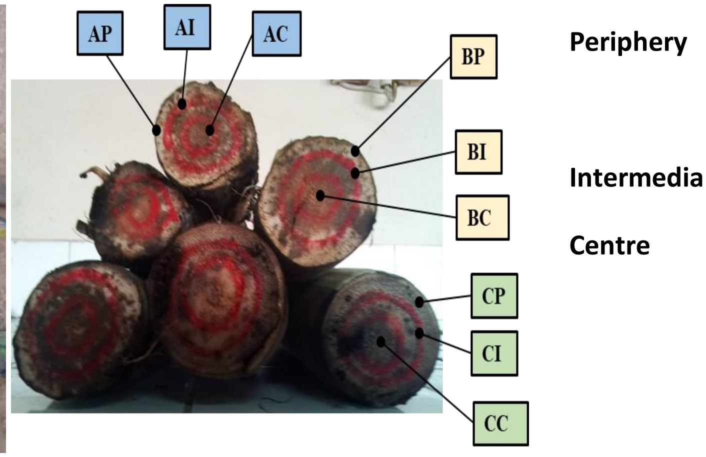
A. Materials

The banana stalks that we used for our study come from a plantation of the PHP of Njombe-Penja located in the Littoral region of Cameroon. The study is limited to the William specie. Electronic balance Machine was used to assist in the determination of linear density (Tex). Tensile Testing machine was used for determination of tensile properties of the fibre.

B. Methods

The stem was cut into 3 sections in a longitudinal direction (figure 1) and the sections werecut into cross sectional direction (figure 2). The cross sectional was divided into 3 zones (periphery, intermedia and the centre (Figure 2 B)

A) Longitudinal view of raw stalk



B) Cross section of the raw stalk

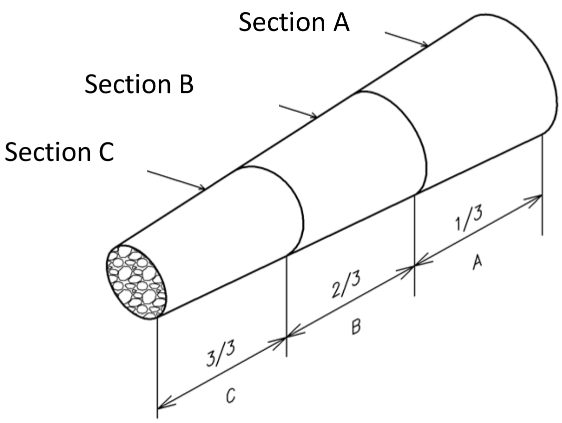


Figure 1: Longitudinal view of the banana stalk

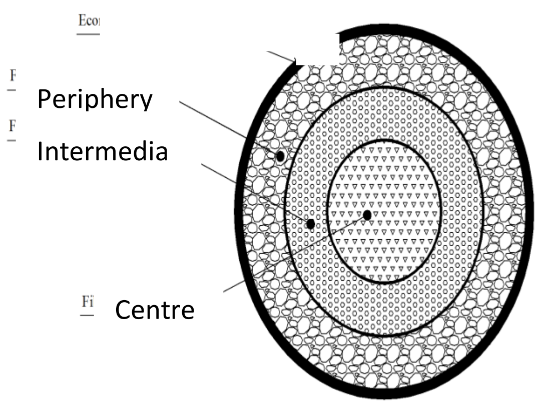


Figure 2: Cross sectional View

a) Extraction of the banana stalk fibers

For the fiber extraction phase, we used the following materials:
Certain extraction methods have been developed by certain researchers [6]. According to the literature,

Retting method(Figure 3) was chosen to extract the fibre. This method does not have adverse effects on the mechanical properties of the fibre. Fibres were extracted from different sections and different zones.

a) Banana stalk in Water

b) Extracted Fibres

Figure 3. Retting process of banana stalk fibre

b) Fiber treatment

Once the fibers were extracted, they were weighed on the electronic balance. The fibres extracted from different sections and zones were bleached in standard water bath apparatus. Hydrogen peroxide was used as the main bleaching agent. The duration of bleaching was 4- 5mins only, giving that Sodium Hydroxide (a reagent of H_2O_2 bleaching) is very aggressive to banana stalk fibre. The table summarizes the standard recipes used for bleaching

Table 1: Standard Recipe for Bleaching

Section	Chemical Products	Quantity (g)	L:R	Temperature (°C)	Duration (Min)
A	Sodium Hydroxide	0,175	1 : 30	30	5 min
	HydrogenPeroxide	2,922			
	Sodium silicate	4,383			
B	Sodium Hydroxide	0, 770	1:30	30	5 min
	HydrogenPeroxide	1,284			
	Sodium Silicate	1,926			
C	Sodium Hydroxide	0, 522	1:30	30	5 min
	HydrogenPeroxide	0, 870			
	Sodium Silicate	1, 305			

C. Tensile Properties of the Fibre

The tensile properties such as the breaking force, the specific stress, the elongation and the Young's modulus were determined on raw fibres and bleached fibres. The tensile test was carried out in accordance with ASTMD 3039 standards.

Linear densities of unbleached and bleached fibers was equally determined (eqn 2.5).

The linear density of a fiber is the ratio between the mass and the length . Its formula is as follows:

$$\Rightarrow \quad d_L = \frac{m}{L} \qquad (1)$$

Table 2: Summary of linear densities of unbleached and bleached fibers of the banana stalk

Fibre	LinearDensity **(g /km)**
UnbleachedFibres	13,33 - 17,33
BleachedFibres	9,33 - 14,66

It is noticed from the table that the linear densities of the bleached fibers have decreased due to the pretreatment (bleaching).

Strain

It is the modification which a body undergoes under the effect of the force which it undergoes and it is expressed as:

$$Strain = \frac{Length}{Initial\ Length} \qquad (2)$$

The specific Stress

The term specific stress is used to determine the initial modulus of fibre since the cross section of natural fibres varies along its length.

The specific stress is the ratio between the applied force and the mass per unit oflength. This term was coined by [7]. Its formula is as follows:

$$Specific\ Stress = \frac{Force}{Mass/unit\ Length} \quad (3)$$

The unit of the specific stress is expressed as $N / Tex = N / (g / km)$

The initial Young's modulus(E)

The initial Young's modulus is the relationship between stress and strain. It characterizes the rigidity of the material.

$$Initial\ Modulus = \frac{Specific\ \ Stress}{Strain} \quad (4)$$

2-5 Results and Discussion
2-5-1 Fiber extraction

The fibres were obtained after 168 hours by the method of retting with standing water; the fact that the fibres retain the mechanical properties is a good reason of chosen the method.

2 5-2 Fiber treatments

It takes 5mins to bleach fibres in the peripheral and intermedia areas of the banana stalk unlike thefibres in the central areatook 3minsmaximum to bleach.

2-5-3Tensile Properties

The results of the mechanical properties of the different samples were evaluated and the different parameters were determined. Figure 1.2 showed the behaviour or raw fibres from different sections of the banana stalk.

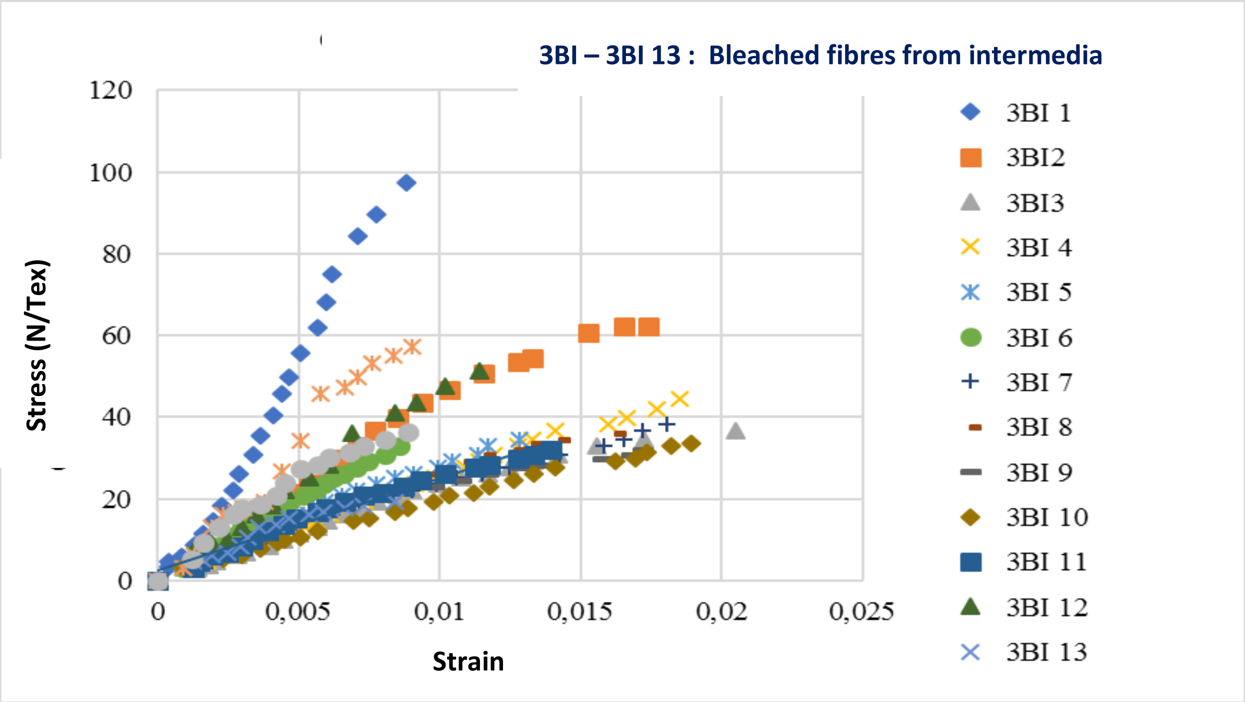


Figure 4: Stress / strain curves of the 3BI Section

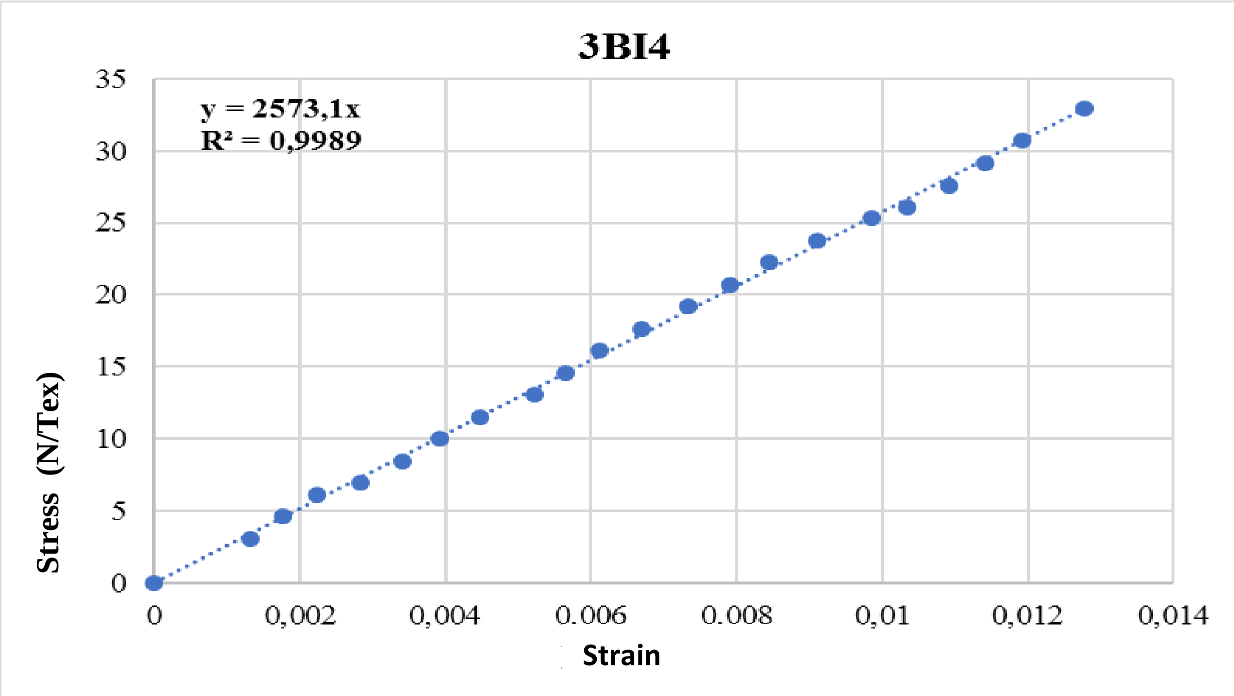


Figure 5: Selected curve from intermedia section

The curve in Fig 5 is one of the curves selected from Fig 4 and it can be used to determine the initial Modulus of the fibre by determining the gradient of the curve.

Tensile test was equally carried on the bleached fibres extracted from the center (BC) of the stalk and the curves are presented on figure 6. A single curve was equally singled out to determine the gradient which will serve as the initial Young Modulus (Figure 8).

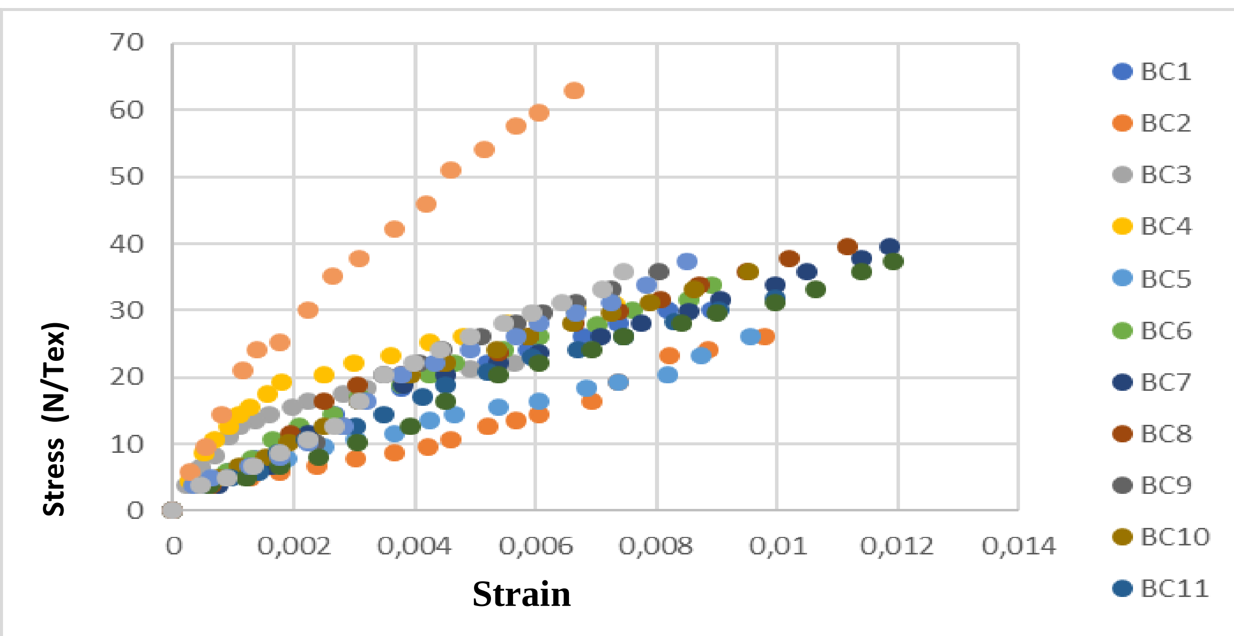


Figure 6: Bleached Stress / Strain curves of the BC Section

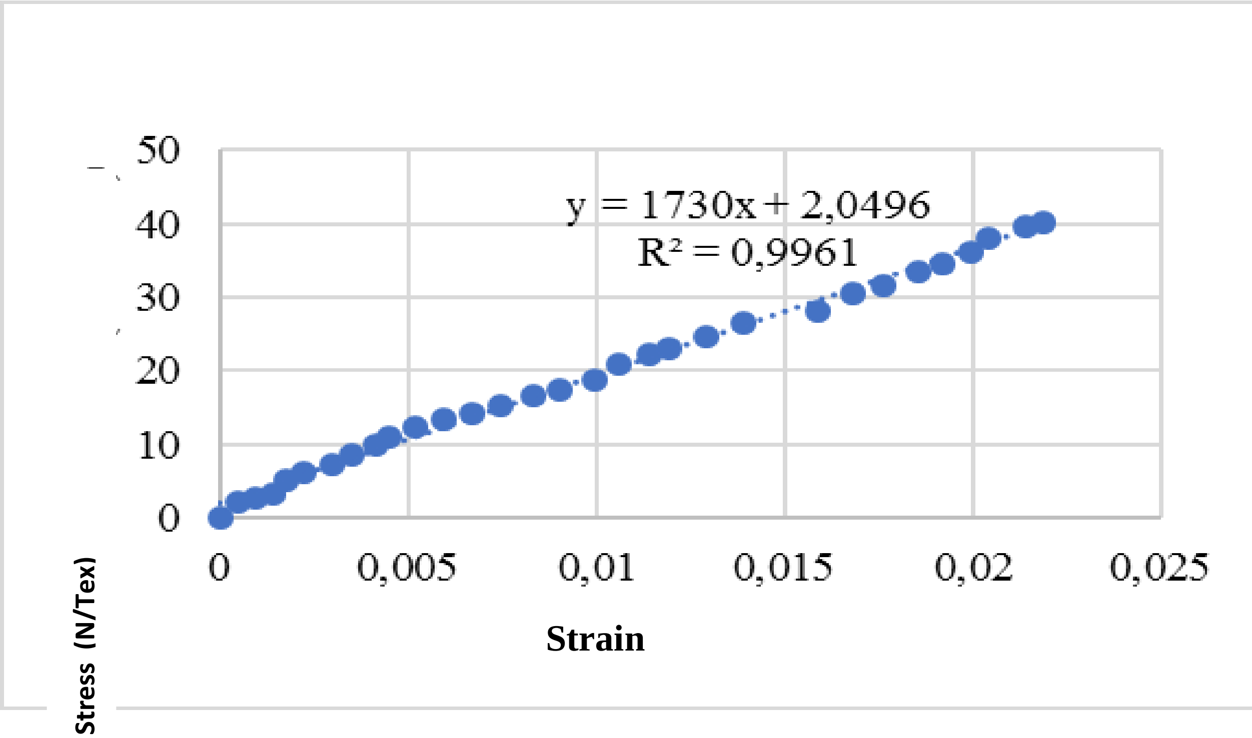


Figure 7: Selected curve from Center of the stalk.

Figure 8 presents the overall results of initial modulus of rawfibres extracted from different sections (A, B and C) and from different zones (c, i and p). It is noticed from the figure that initial modulus increases from the centre (c) to periphery (p). This also indicates that the strength of the fibre reduces from the periphery to the centre.

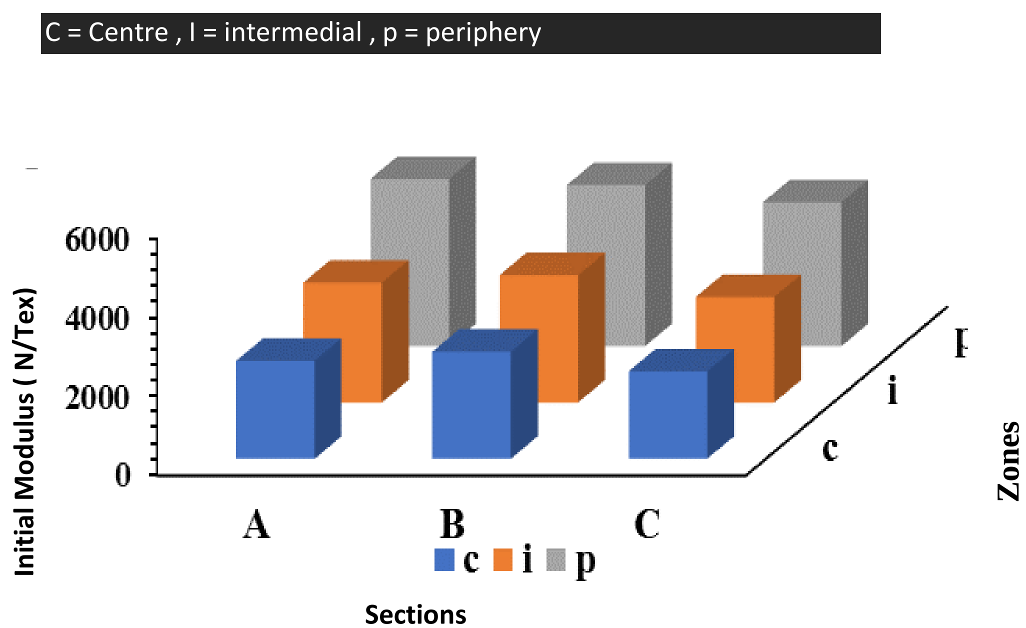


Figure 8 The initial modulus of raw fibres

Similarly figure 9 present the results of the initial modulus of bleached fibres. The initial modulus increases from the centre (I) to the periphery (p).It is noticed that there is no significant difference of initial modulus of fibres extracted from the 3 sections (A,B C). But there is a significant difference of initial modulus of fibres extracted from the periphery, intermedia and the centre of the banana stalk fibres.

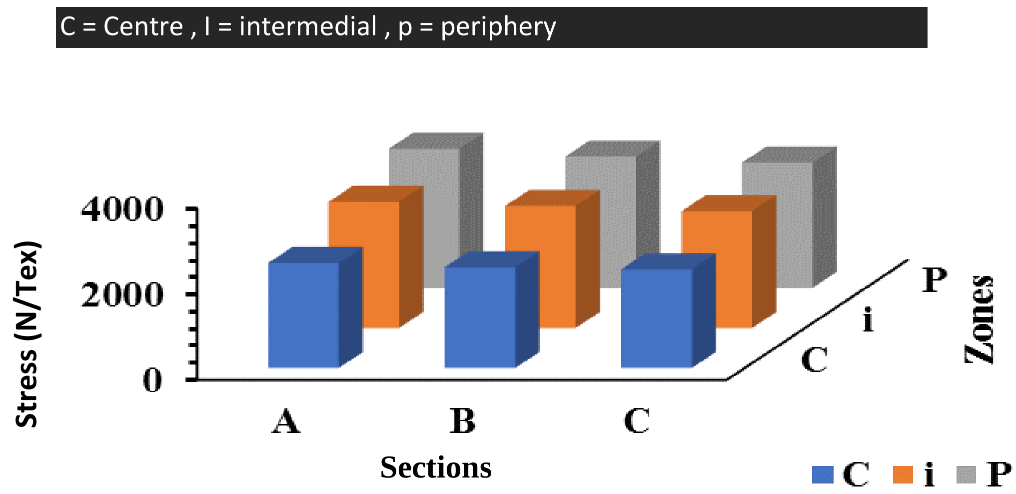


Figure 9: The initial modulus of bleached fibres

A summary of the tensile properties of banana stalk is presented on Table 5. It is noticed that bleaching has an effect on the mechanical properties of banana stalk fibres. This effect is more noticed on the initial modulus of the fibre. Bleaching has no adverse effect on the elongation of the banana stalk fibres especially when the right concentration of caustic soda is used. This phenomenon is common with all natural fibres. Chemical treatment has no effect on the mechanical properties of synthetic fibres [9].

Table 5: Summary of the mechanical properties of unbleached and bleached fibers

Banana stalk fibre	Elongation (%)	Breaking Force (N)	Tenacity (N/ Tex)	Initial Modulus(N/Tex)
Raw Fibres	1,63 – 3,06	1,78 – 3,45	0,11 – 0,23	2210 –4235
Bleached Fibres	1,76 – 3,61	1,56 – 2,61	0,13 – 0,34	2306 – 3250

One can noticed on Table 6 that some tensile properties (Elongation and Tenacity) of banana stalk fibres are similar to that of bastfibres (jute hemp and linen) [10].

Table 6: Mechanical tensile properties of some bast fibers

Fibres	Elongation (%)	Tenacity (N/Tex)
Cotton	7 – 8	0,14- 0,43
Jute	1,5 – 1,8	0,12 -0,24

Linen	2,7 – 3,2	0,17– 0,55
Hemp	1,6	0,14
Ramie	3,6 – 3,8	0,24 -0,24
Banana stalk fibres bananier	***1,63 - 3,61***	***0,11 - 0,34***

Conclusion

The study has shown that banana stalk fibre can be successfully extracted through retting process. Fibres extracted from different sections of the stalk have proven to have same tensileproperties; On the other hand, fibres extracted from different zones, ie from the periphery to the centre of the stalk, do not have same tensile properties. The strength or initial modulus of the fibres increase from the centre part of the stalk to the peripheral part. Bleaching of banana stalk fibrestakes very short duration (3-5mins) compare to other bastfibres whose bleaching duration ranges from 60-90mins. The results of the tensile properties have proven that banana stalk fibres can be of great potential use in the textile industry.

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