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Extraction, Treatment and Characterization of Banana Pseudo-Stem Fibers as Potential Utility in Textile Industry

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ABSTRACT

Extraction, treatment and characterization of banana pseudo stem fibres was achieved. The study revealed that water retting is the best way to extract fibers, however the gummy materials bending fibres together must be weakened by boiling the fibres rich material prior to retting where the fibres were able to be extracted at 14th day of retting. The fibers were treated using NaOH for scouring while bleaching was carried out using H_2O_2. The treatment of fibers was conducted to get rid of fat, wax and other impurities as well as undesired colors bonded to fibers that could not be removed through water retting. The best scouring concentration of NaOH was found to be 17.5 % while the best bleaching concentration of H_2O_2 was found to be 2 %. More so, FTIR was carried out for both treated and untreated fibers and it was shown that wax, fat and other impurities can be removed by fibres' scouring and bleaching. This was further confirmed by the use of Soxhlet to extract ethanol-benzene extract from both treated and untreated fibres, where untreated fibres showed a considerable weight loss while the treated fibers did not show any weight loss. Thereafter, mercerization was carried out and it was found out that the best mercerization concentration of NaOH is 15%. Furthermore, the quantitative analysis of the banana pseudo-stem fibers revealed that the fibers have, ethanol-benzene extractives of 4.2 %, pectin content of 3.07%, Lignin content of 18%, cellulose content of 68.3% and ash content of 4.2 %. The fibers showed a water, oil and vapor absorption of 71%,59 % and 8% respectively. Also, the thermal analysis showed that the degradation temperature is 370 ^{0}C while the fibers started to display thermal instability at 290 ^{0}C. Moreover, SEM and XRD analysis showed that the treatment of fibres participated in removal of wax and oil as well as other gummy materials, which also is in line with FTIR results obtained.

Keywords: Extraction, Banana Pseudo-stem Fibers, Scouring, Bleaching, Mercerization, Characterization, Textile

INTRODUCTION

The textile industry is spread globally generating around 1 trillion dollars and contributes 7 % to the total world export with an employment of 35 million workers around the globe. Despite its contribution to the economy of the world, textile industries are among the biggest global polluter due to use of synthetic fibres in production of textile products which is the major source of microplastics in the oceans and the ecosystem as a whole [1]. On the other, hand the agricultural activities result in tons of wastes which contribute to the increment of greenhouses gas in the atmosphere, thus increased global temperature [2]. For example, after harvesting banana, the stems remain unused and farmers do get rid of them by burning them or depositing them in moist area [3]. The globe produces 72.5 million tons of banana fruit per year [4], this generates large amount of waste as the banana tree produce a fruit once in its lifetime. This has attracted the attention of researchers to think about how the banana fruits trees can be used. As result of the research, it was found out that banana tree is one of the fibres rich plants which can be used in textile industries to replace synthetic fibres in production of items such as carpets, hand bag among others. The natural fibres present advantages over synthetic fibres such as low density, environmentally friendly and low cost [5]. Natural fibres are extracted either mechanical using a sharp tool such as knife or a machine called decorticators or the extraction of fibres can be done using a retting method which can be done with the use of chemicals [6], water [6] or dew [7]. This research is aimed in extraction, treatment and characterization of banana pseudo stem fibres and study of its potentiality to be used in textile industry.

MATERIALS AND METHOD

Extraction of Banana Pseudo-stem Fibers

Banana pseudo-stem fibers were extracted using water renting process. The sorted, cleaned matured banana pseudo-stem trunk obtained after harvesting banana was used. The part of the trunk used during this research is the below part of 40 cm above the ground, after cutting the part of interest from the main banana pseudo-stem trunk, the part was cut into small pieces of 10-15 cm of length and 2-3 cm of width. Thereafter, those pieces were put in the pot and water was added which was followed by heating it to boil for 30 minutes. Thereafter, the heated banana pseudo-stem pieces were put in a basin and cool and clean water was added to it until they all emerge in water for retting. After the manual extraction of the fibres, the fibres were washed with running water to remove gum materials so as to have pure fibers [8]. To ensure the completion of the reting process, the extracted fibres were dried and its weight was recorded, thereafter soaked in water for 5 days. Afterward, the fibres were removed from the water washed with running water and dried where the fibres showed insignificant weight loss and therefore, it was concluded that the renting step of fiber treatment was accomplished. The extracted banana pseudo-stem fibres were then kept in nylon for next steps, scouring.

Treatment of Fibres

After renting, the obtained banana fibres appear with oils, fats, waxes, impurities and unpleasant colors which need to be removed to create fibres of good quality with a good dye affinity. This is achieved through two processes namely scouring and bleaching.





Scouring

Dried eight bunches of banana pseudo-stem fibres of which each has 5 gm were weighed, this was followed by the preparation of 0.25 %, 0.5 % 0.75%, 1 %, 1.25 %, 1.5 %, 1.75 % 2% of NaOH solutions in different 200 ml beakers. Afterward, each bunch of fibre was put in each beaker of NaOH solution heated using heating mantle at 100^{0}C for 30-40 minutes. While heating the fibres, a stirring rod was used to turn the fibres for uniform reaction. Then, the fibre bunches were removed from the beaker, washed with running water to neutralize NaOH and sun dried for 48 hours where its weights were recorded after drying [9]. The following formula was used to find out the percentage of weight loss of the fibres bundle due to scouring.

Weight Loss Percentage of the Sample= {(Wi-Wf)/ Wi} x 100%

Where Wi and Wf is initial weight before scouring and after scouring respectively.

Bleaching

A bunch of 30 gm of banana pseudo-stem fibres was measured. The bunch of fibres was scoured using 1.5 % NaOH at 100 ^{0}C for 30-40 minutes to remove no cellulosic materials. Thereafter, the fibres were rinsed with running water and sundried for 48 hours. After, drying the bunch of fibres was divided into various small seven bunches of fibres weighing 3 gm. Thereafter, various solution of Hydrogen Peroxide (H_2O_2), a bleaching agent, were prepared in 200 ml beakers. 1 %, 2 %, 3 %, 4 %, 5 %,6 % and 7 % solutions of H_2O_2 were prepared. Afterward, the scoured bunch of 3 gm of fibers were put in the beakers, heat at 100 ^{0}C for 25-30 minutes. Then, the fibre bunches were removed from the beakers, washed with running water and sun dried for 48 hours where its weights were recorded after drying [10]. The following formula was used to figure out the percentage of weight loss of the fibres bundle due to bleaching process. Weight Loss Percentage of the Sample= {(Wi-Wf)/ Wi} x 100%

Where Wi and Wf is initial weight before bleaching and weight after bleaching respectively.

Banana Pseudo-stem Fiber' Bundle Tension Force Testing After Bleaching

The tension force was measured in the mechanical engineering laboratory, Moddibo Adama University, Yola. The treated fibres were formed into a fibres bundles of 15 cm weighing 5 gm [11]. The fibres bundle was held by a grip and loads of known weigh

were applied till failure occurred. The tension force was calculated using the following formulae:

$F=m*g$

Where m is mass of the load applied until failure occurred and g is the standard gravity constant of 9.8 m/s^2.This was done so as to find the effect of increases of H_2O_2, a bleaching agent, concentration on the strength of the fibres.

Banana Pseudo-stem Fibres' Mercerization to Enhance fibres'dye absorption

The banana pseudo-stem fibres that underwent treatment (Scouring with 1.75 % NaOH and bleaching with 2% H_2O_2) were mercerized with 10 %, 15 % and 25% NaOH in a water bath at 15°C for 10 min. The samples were being turned with a glass rod to ensure an even treatment. The samples were rinsed in tap water. The water absorption of samples was recorded before and after mercerization to find out which Concentration of sodium hydroxide that increase fibres' water absorption [12].

Banana Pseudo-stem Characterization

Fourier Transform Infrared Spectroscopy for Treated and Untreated Banana Pseudo-stem Fibres

FTIR was carried out to figure out the functional group of fibres. The FTIR analysis was conducted for both treated and untreated fibres. The analysis was conducted at American University of Nigeria, Chemistry Laboratory.

Quantitative Analysis of Fibres' Constituents

i. Ethanol-Benzene Extractives Content (E_B)

A Soxhlet extraction of 1.9 g of banana pseudo-stem fibres was carried out using benzene and ethanol (1:2 v/V). The cartridges of fibres were removed from Soxhlet after the extraction was completed, dried in woven at 105° C [13]. The level of ethanol-benzene extractives (Resins, Oil fats and Waxes) was determined using the equation below.

$$E_B = \frac{m_o - m_1}{m_0} \times 100\%$$

where, m_1, the mass of the dry residue I extracted after evaporation of Ethanol-Benzene solvent and m_0 the mass of the sample before extraction.

Pectin Contents (E_P)

A mass of 1.3 g of residue I was introduced into a flask of 250 ml and 50 ml of 2% HCl solution was added. The mixture was heated under the reflux by stirring in a water bath at 80°C for 2 hours. Residue II was retained by filtration, and it was washed with distilled water and dried in the oven at 150°C until dried and its weight was recorded after cooling. The Pectin content was determined using the following formulae [14].

$$E_P = \frac{m_1 - m_2}{m_1} \times 100\ \%$$

Where m_2 is the dry mass of Residue II while m_1 is the dry mass of residue I.

Lignin Contents (EL)

A mass of 0.2 gram of residue II was treated with 5 ml of 72 % concentration Sulfuric Acid for one hour in water bath at 30°C to hydrolyze the polysaccharides. The mixture was then diluted to the acid concentration of 3 % by addition of 120 ml of distilled water, and brought at 120° C in an oil bath for 2 hours. Afterward, the sample was cooled in a cool water bath and filtered using a Buchner system. The residue that was made up by insoluble lignin was dried at 150°C and its weight was recorded [14].

The lignin contents (E_L) were calculated by the following equation:

$E_L = m_L / m_3 \times 100\%$

where m_L is the mass of extracted Lignin, m_3 the mass of Residue II.

Cellulose Content (E_C)

A mass of 1 g of Residue II was introduced into a beaker containing 50 ml of 5 % NaOH for two hours. The flask was heated in water bath for one hour at 50°C. The residue was washed with running water to get rid of lignin and hemicellulose removed by NaOH. The residue obtained was dried at 105 °C for 5 hours cooled and weighed [15].

The Cellulose content was determined using the following equation:

$E_C = (m_c/m_2) \times 100\ \%$

where m_c and m_2 are mass of cellulose and mass of Residue II.

Fibres' Ash Content

2g of fibres were placed in a porcelain crucible and then calcined at 1000^{0}C in furnace for 2 hours. The ash content was measured via mass balance where the crucible was weighed with the material before and after calcination [16]. The ash content was measured according to [14] using the following formulae.

$$A.C = (m_a / m_f) \times 100\%$$

Where m_a is the mass of ash obtained while m_f is the mass of fibres.

Fibres' Water , Moisture and Oil Absorption Test

Water absorption test was carried out according to [11] fibres specimens were placed in oven at 150 ^{0}C for 1 hours to drain all captured moisture. Thereafter 1 g of each fibers was measured and immersed in water at room temperature for 2 hours. After, the sample fibres were removed and patted dry with a lint free cloth, and weighed using an electronic weighing balance.

The percentage water absorption was determined using the following formulae

$$\% W.A = \{(W_f - D_f)/ D_f\} \times 100\%$$

Where W_f and D_f stand for wet and dried fibres respectively.

Oil and moisture absorptions test were carried out like water absorption test by changing absorption medium with Soya beans Oil and water vapor respectively. The water vapor was created by heating water bath at 85^{0}C and the fibers were hanged on 13 Cm above the level of water in the water bath for 2 hours.

Thermal Analysis

Thermal analysis which involves the techniques that study the properties of materials as they change with temperature. Thermal analysis was conducted at Ahmed Bello University, Zaria. Both Thermogravimetric Analysis (TGA) and Differential Thermal Analysis (DTA) of the fibres were carried out. TGA measures change in weight in relation to change in temperature while DTA involves the measurement of temperature difference between a substance and a reference materials [17].

Morphology Analysis

Morphology of banana pseudo-stem fibres was studied with using scanning electron microscopy (SEM).

Crystallinity Analysis

Crystallinity analysis of banana pseudo-stem fibres was studied with X-Ray Diffraction (XRD)

RESULTS AND DISCUSSION

Extraction of Banana Pseudo-stem Fibers

The extraction of Pseudo-stem fibres was carried out using water retting. During retting, it was observed that the banana stem did not get retted easily as it was soaked in water and could not get retted for up to 30 days, but rather, the stem was changing colour from green-white to black-brown. Therefore, the pectin and other gummy materials that bond the fibres had to be weakened by boiling the banana fibre-rich material to facilitate retting. After boiling, the banana fibre-rich material was soaked in water, and the fibres could be extracted in 14 days. Also, an attempt to extract banana fibres using NaOH was made. However, it was observed that the concentration of NaOH and time needed to conduct retting have to be well studied as the extraction with NaOH resulted in the obtainment of very weak fibres depend on the concentration used. Also, the part of the banana trunk from which fibres are extracted must be specific. During this research, a lower part (40 cm above the surface) was used as a source of pseudo-stem banana fibres. This is because a different trunk part presents fibres with different strengths.

Treatment/Purification of Banana Pseudo-Stem fibres

i. *Scouring*

The figure 1 below presents the various concentrations of Sodium Hydroxide used in scouring banana pseudo-stem fibres and recorded weight loss of the samples at various concentrations. The concentration ranges from 0.25% to 2.5 % with an interval of 0.25 % which resulted in the obtainment of 10 samples. The highest weight loss of 11.2 % was recorded at the concentration of 2.5 %, while the lowest weight loss of 0.8 % was recorded at 0.25 %. The exercises revealed that the sample scoured 1.75% concentration of NaOH has 8 % weight loss, which falls within the range of the standard weight loss of 7-8% of scoured fibres [18]. Therefore, the best NaOH concentration for scouring pseudo-stem banana fibres is 1.75 %, giving a weight loss of 8 %. The weight loss graphs show that the increase in NaOH concentration is directly proportional to the increase in fibre weight loss. That is to say, the weight loss of fibres increases with the increased concentration of NaOH and vice versa.

This is attributed to unscoured fibres containing various impurities that cannot be removed during retting, such as waxes, fats, that when unremoved, cause the fibres to be non-absorbent to the dye. The scouring process removes all fat/oil and wax materials, and the hydrophobic character of fibres is removed from the fibres with alkali, such as sodium hydroxide. During scouring, saponifiable oils and free fatty acids convert into soaps, pectose and pectin change into soluble salts of pectic acid, proteins hydrolyze into soluble degradation products, and the unsaponifiable oils and waxes are emulsified by the soaps formed from saponification. Saponification is the reaction in which insoluble and water-immiscible materials convert into water-soluble products, and its reaction is as oil + caustic soda + water = soap +glycerin. Removing the non-cellulosic materials leads to the weight loss of the fibres [19].

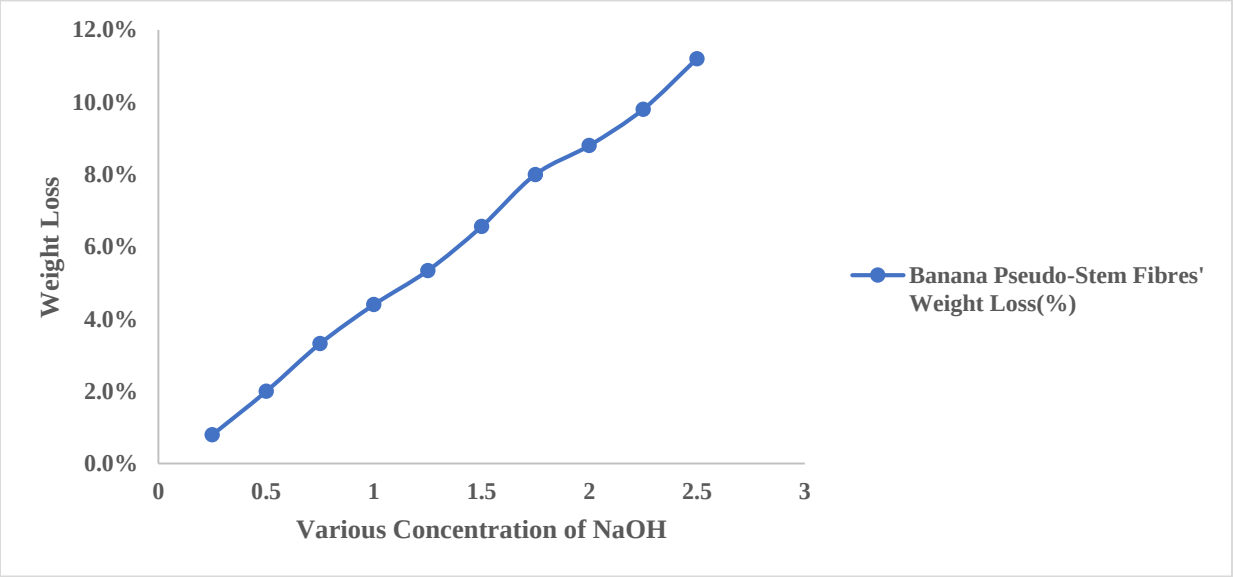


Figure 1: Effect of NaOH concentration on weight loss of banana pseudo-stem fibres

Bleaching

The figure 2 below present various concentrations of H_2O_2 used in the bleaching of banana pseudo-stem fibres. The concentration ranged from 1-7 %, and the highest weight loss of 14.23 % was obtained at a concentration of 7 %, while the lowest weight loss of 2 % was obtained at 1 %. According to [20] the weight loss of cellulosic fibres due to bleaching has to fall within the range of 2-3 %. Therefore, the best concentration of H_2O_2 to bleach banana pseudo-stem fibres is 2 %. Moreover, it was noticed that as the concentration of the bleaching agent, H_2O_2, increases, the weight loss increases. This is because, during bleaching, the cellulosic fibres lose a trace of any impurities that were not removed during scouring and help remove any colour on the fibres to produce white fibres, which are more affinity to the dye [21]. The bleaching with H_2O_2 occurs due to the per hydroxyl ion (HO_2) obtained when H_2O_2, a weak acid, is ionized in water [22]. On the other hand, figure 5 below presents the data on fibres' tension forces obtained at various concentrations of H_2O_2. It was observed that the tension forces of fibres decrease as the concentration of H_2O_2 increases and vice versa. This is because as the bleaching occurs, some amorphous part of the fibres reduces; thus, the increase of H_2O_2 damages the cellulose chain in fibres, decreasing the fibre's mechanical strength and thus reducing tension force [23].

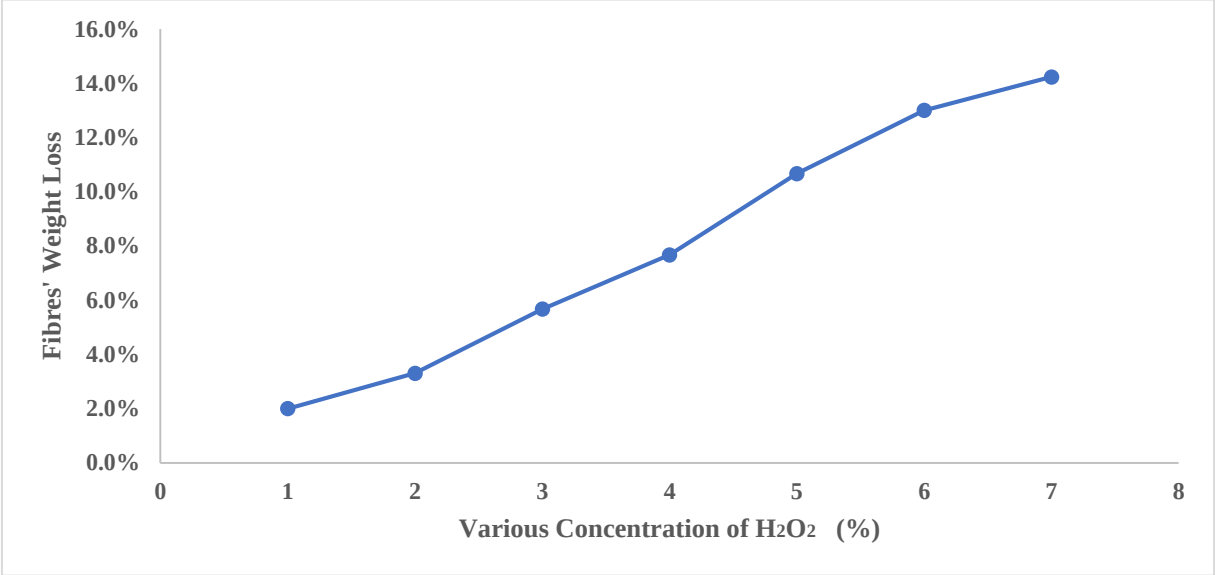


Figure 2: Effect of H_2O_2 concentrations on weight loss of banana pseudo-stem fibres

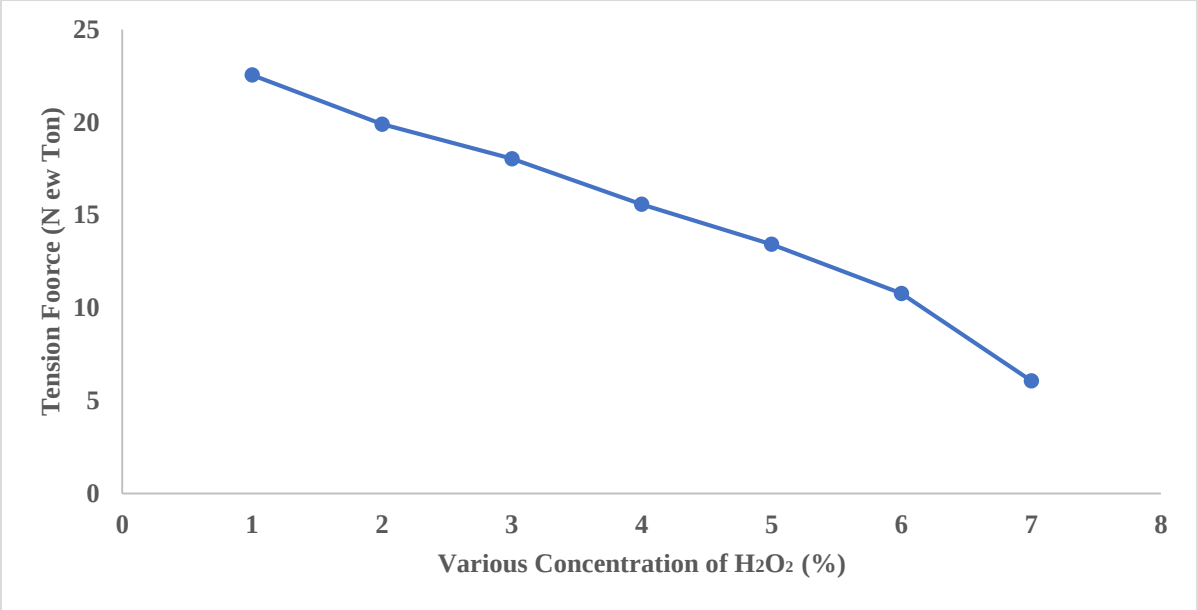


Figure 3: Effect of H_2O_2 concentrations on tension force of Banana pseudo-stem fibres

Mercerization

Figure 3 present the data captured during the mercerization of banana pseudo-stem fibres. The data show the water absorption percentage before and after the mercerization of fibres at NaOH concentrations of 10%, 15 % and 20 %. The statistical comparative data in Figure 8 below revealed that water absorption before mercerization is lesser than water absorption after mercerization. When cellulose is immersed in a concentrated caustic soda solution, water and alkali diffuse, and the material swells. The fibre hair quickly commences to untwist from its twisted ribbon-like form and tends to become more cylindrical due to deconvolution. Also, the higher the water absorption of cellulosic fibres, the higher the dye absorption on that fibre [24]. Therefore, the best NaOH concentration for banana pseudo-fibres mercerization is 15 %, showing a water absorption of 84.13 % after mercerization.

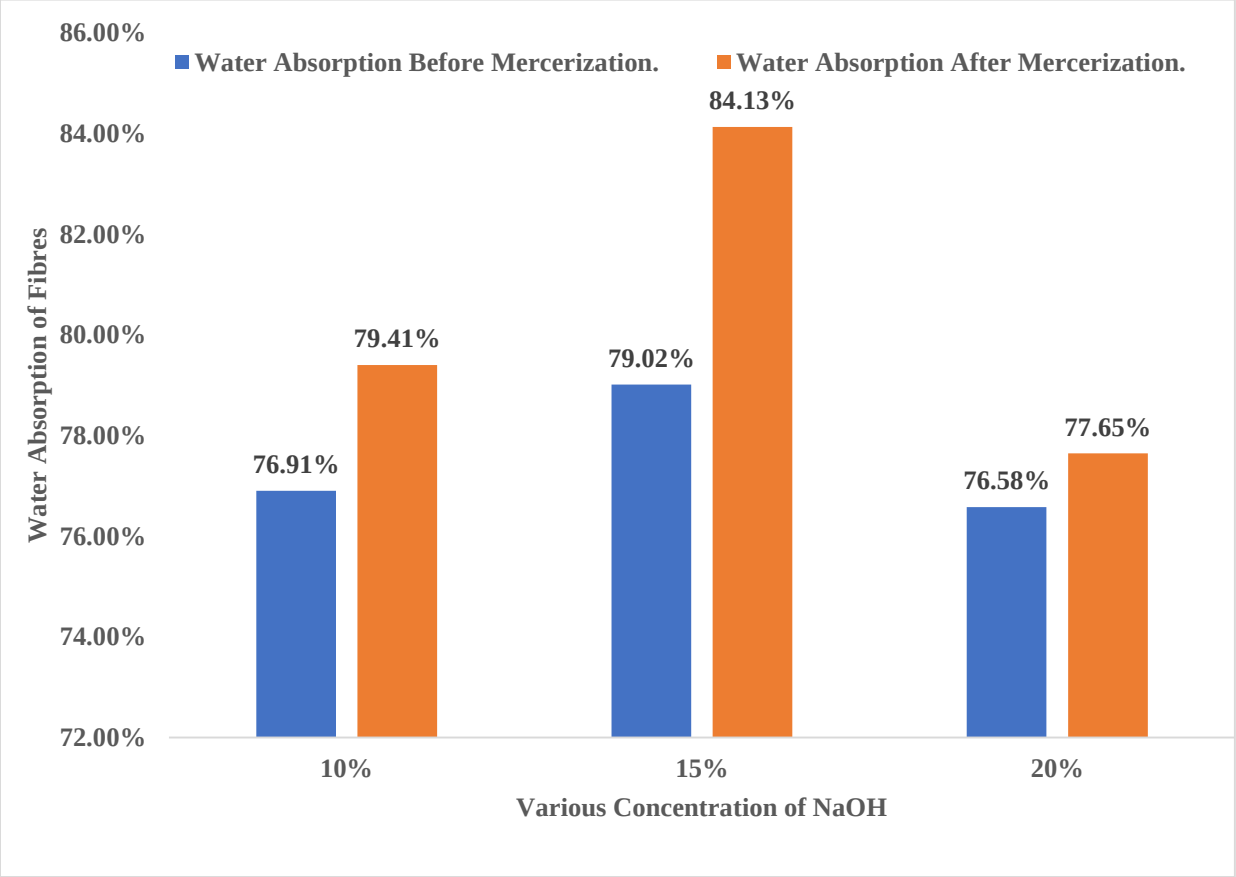


Figure 4: Effect of Mercerization with various high concentrations of NaOH on water absorption of banana pseudo-stem fibres

FTIR of treated and untreated Banana Pseudo-stem fibres

Untreated Banana pseudo-stem fibres

FTIR of treated banana pseudo stem fibres presented below was carried out to determine the type of functional groups present in the fibres. The FTIR spectra of the tested sample were registered in the spectral range of 4000–1000 cm^{-1}, as shown in Figure 10 below. The spectrums of banana pseudo-stem dye have different absorption bands and characteristics of functional groups. The band at 3458.15 cm^{-1} represents elongation of -OH from cellulose Lignin and Hemicellulose, while the band at 2908.71 cm^{-1} represents C-H present in cellulose and hemicellulose. The peaks at 2548.55, 2348.82 and 2015.31 cm^{-1} are associated with the presence of the alkyne group in 17-octadecenoic acid [25], stearolic acid and tartaric acid [26]. They occur in plants as triglycerides, a composition of three fatty acids esterified to a glycerol molecule, available in plant fat [27]. The peak at 1638.44 cm^{-1} is attributed to symmetrical aromatic elongation, C=C, in lignin [28]. The peak that appeared at 1450.36 cm^{-1} represents the bending of CH_2 in cellulose and a symmetric deformation of CH_2 in cellulose [29]. The peak at 1162.97 cm^{-1} is associated with C-O stretching vibration triacylglycerides [30]. The seventh 1087.99 cm^{-1} is attributed to C=C stretching of the symmetrical elongation present in Lignin [31]. The peak at 971.34 cm^{-1} arose due to the elongation of -OH and C=O cellulose bonds and the ester group in pectin and hemicellulose [30]. The peak at 784.68 cm^{-1} is assigned to the symmetrical stretching of C-H and O-H bonds of cellulose [29]. While the peak at 720.79 cm^{-1} corresponds to C–OH out-of-plane deformation in cellulose [32]. These results show that banana pseudo-stem fibres comprise Cellulose, Hemicellulose, Pectin, Lignin, fat and waxes. They are, therefore, similar to known plant fibres such as Sisal, Coconut, and Jute.

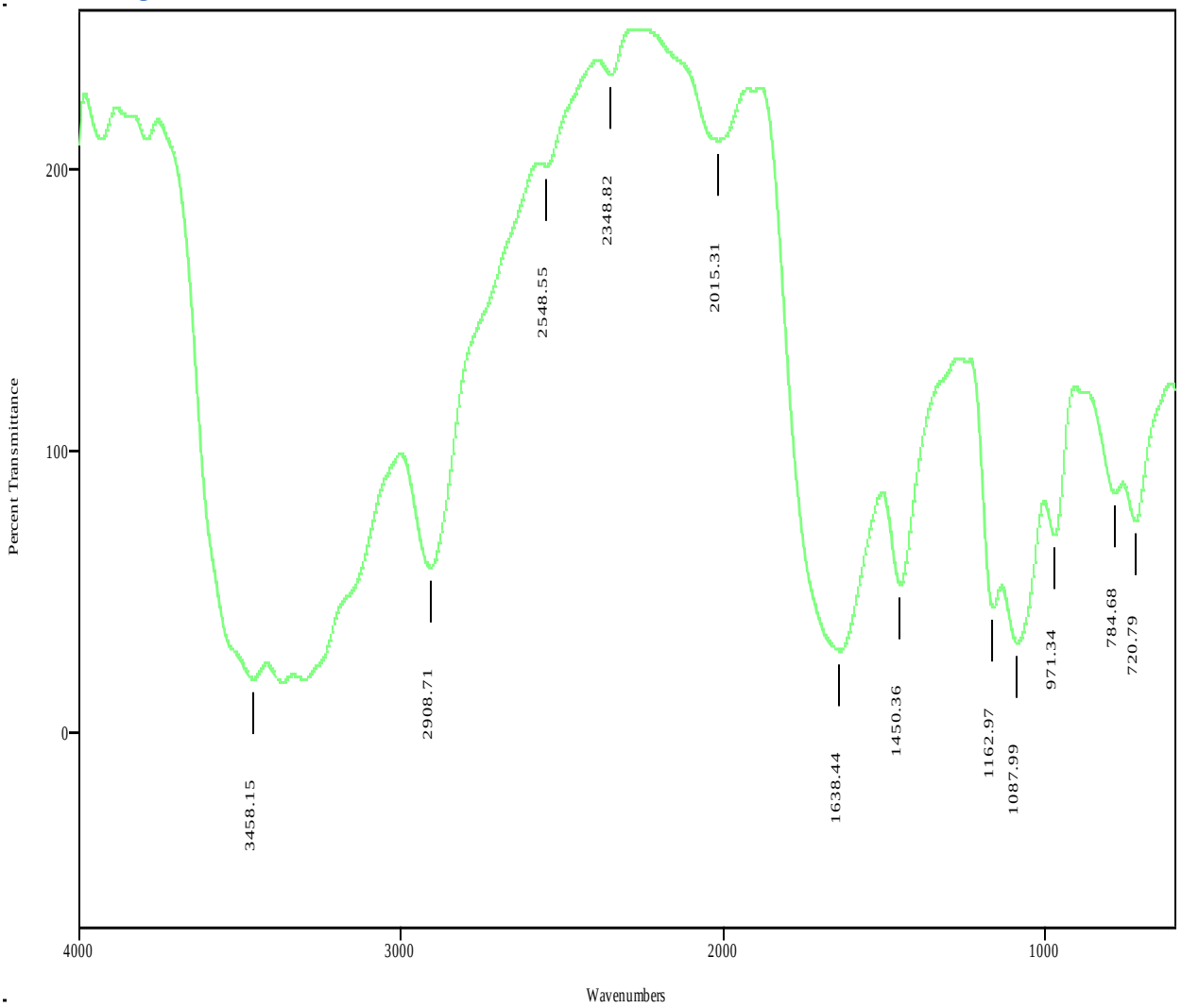


Figure 5 : FTIR of untreated Banana pseudo-stem fibres

Treated Banana Pseudo-stem fibres

The FTIR results of treated banana pseudo- stem fibres presented in figure 5 below shows that the peak at 2548.55 cm^{-1}, 2348.82 cm^{-1}, 2015.31 cm^{-1} and 1162.97 cm^{-1} have disappeared after treatment of fibres with NaOH and H_2O_2 to remove wax and fat substances and unwanted colours through scouring and bleaching to enable a good dyes absorption. This was also confirmed by the Soxhlet extraction of fibres using ethanol-benzene (1:2 V/V) solvent, where both treated and untreated fibres were extracted. The untreated fibres showed the presence of oil, wax and gum material, while treated fibres showed no sign of oil and wax materials. The peak that disappeared is the peaks at 2548.55, 2348.82 and 2015.31 cm^{-1} that, are associated with the presence of alkyne group in 17-octadecenoic acid [25], stearolic acid and tartaric acid [26]. They occur in plants as triglycerides, a composition of three fatty acids esterified to a glycerol molecule, available in plant fat [27].

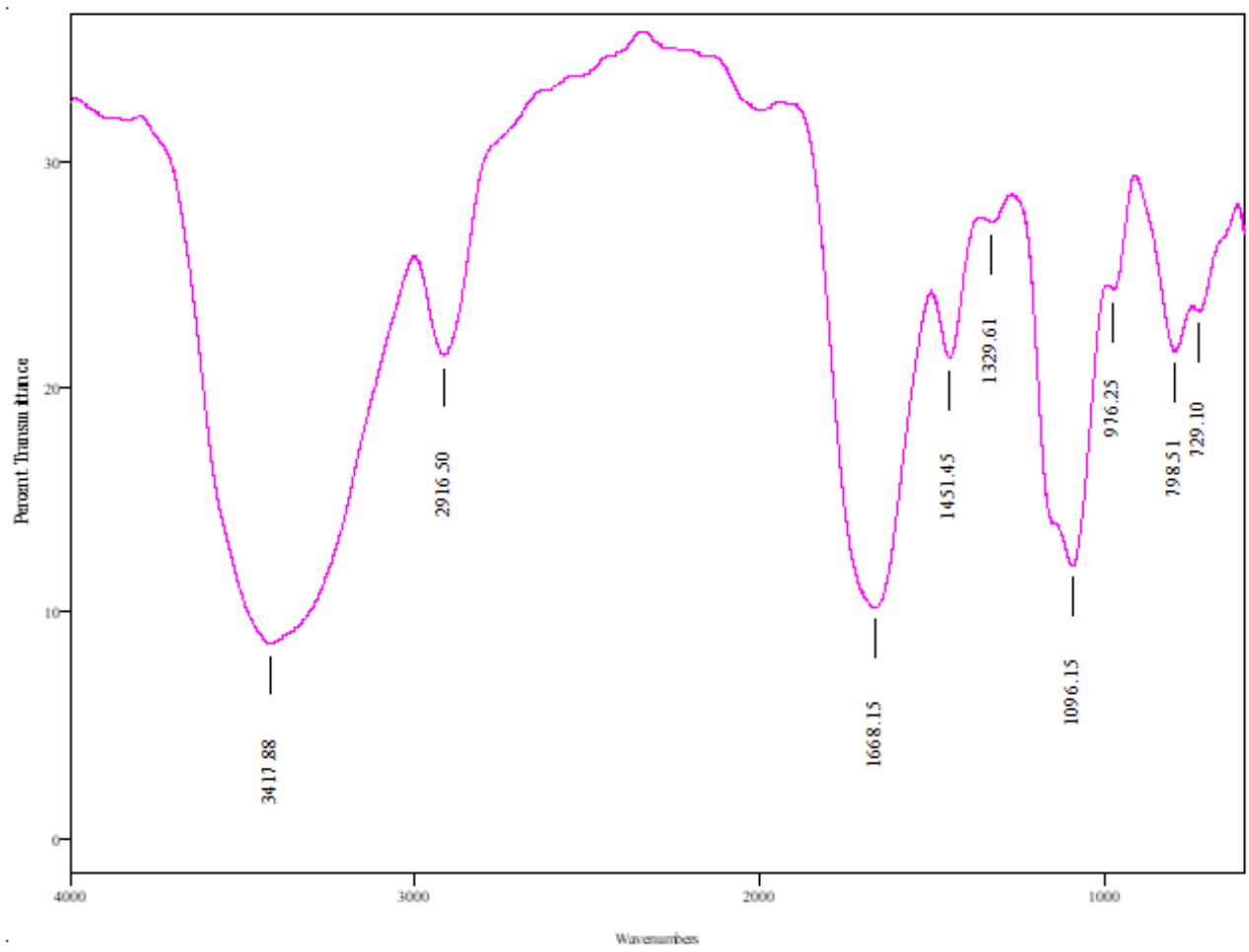


Figure 6: FTIR of treated Banana pseudo-stem fibres

Quantitative analysis of fibres' constituents

Ethanol-Benzene Extractives Content (E_B)

During ethanol-benzene extractives content of treated Banana pseudo-stem fibres showed no change in weight loss, while untreated fibres showed a change in weight loss where the weights of untreated fibres were recorded to be 1.82 g which resulted in an E_B of 4.2 %. The absence of Resins, oil fats, Waxes and other impurities on treated is results of fibres treatment using NaOH for scouring and H_2O_2 for bleaching, where all oil, wax, fat and other impurities and undesired colours were removed, resulting in no sticking but whitish fibres.

Pectin Contents (E_P)

The study revealed that the fibres have pectin content of 3.07%.

Lignin Contents (E_L)

The study revealed that the fibres have lignin amount of 0.036 g leading to E_L 18%.

Cellulose *Content (E_C)*

The study revealed that the fibres have cellulose content of 0.63 g which account for E_C of 68.3 %.

Ash Content (AC) of Treated Fibres

The study revealed that banana pseudo-stem fibres have 0.084 g of ash. When the formulae to calculate AC was applied, it was shown that banana pseudo-stem fibres have AC of 2.15 %.

Water, Oil and Moisture Absorption Test

Figure 7 shows the result of banana fibres' water, oil and moisture absorption test Banana pseudo-stem fibres have a water absorption of 71%. Cellulosic fibres absorb water due to their hydrophilic nature resulting from H-bonds of -OH groups between macromolecules of their cell wall When the fibres come into contact with water/moisture, H-bond breaks and -OH groups create new H-bonds with

water molecules; thus, the higher the cellulose content, the high-water absorption [33].Oil absorption was carried out like a water absorption test by changing the absorption medium to Soya beans Oil. The oil absorption percentage was 59 % for banana pseudo-stem fibres.

It is noticed that the oil absorption percentage is lower than that of water oil absorption. This is attributed to oil being less dancer than water, making it float on the surface of the fibres [34]. Also, the results showed that banana pseudo-stem fibres have a moisture absorption of 8 %.

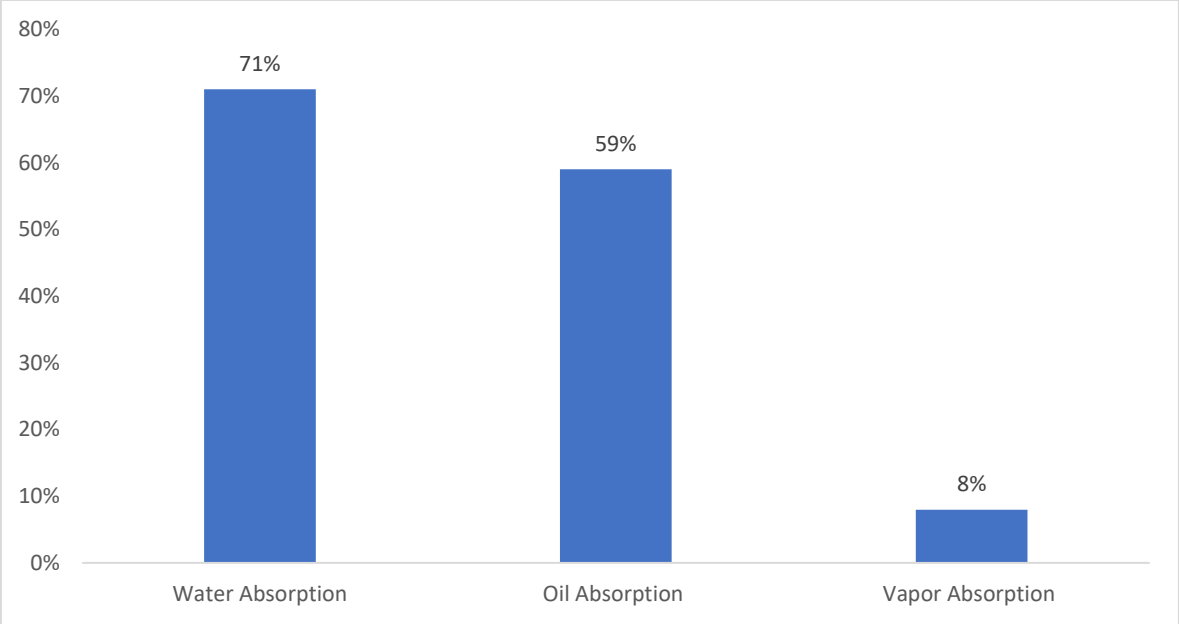


Figure 7: Statistical Comparison of fibres' Water, Oil and Vapor Absorption

Thermal Analysis of the plant banana pseudo-stem fibres (TGA and DTA)

The TGA curve below shows that the fibres understudy broke down into six phases, marked with blue inked dots. According to [35], this thermal behaviour is typical of plant fibres. The first change occurred at 100 ^{O}C and ended at 180 ^{O}C. This is due to the evaporation of moisture and molecules structure rearrangement due to exposition of fibres to heat. Another noticeable change occurred from 350 ^{O}C to 410 ^{O}C, which due to the loss of CO gas. Also, at 470 ^{O}C to 620 ^{O}C, and 690 ^{O}C, a negligible change in weight of sample, occurred due to the formation of CO_2 gas. Beyond 690 ^{O}C, the fibre's weight loss became slow, forming a stable residue. However, the sample presented a thermal instability with a sharp decreases in weight at the 290 ^{O}C to 470 ^{O}C. The DTA figure 9 shows that banana fibres' degradation temperature occurred at 370 ^{O}C.

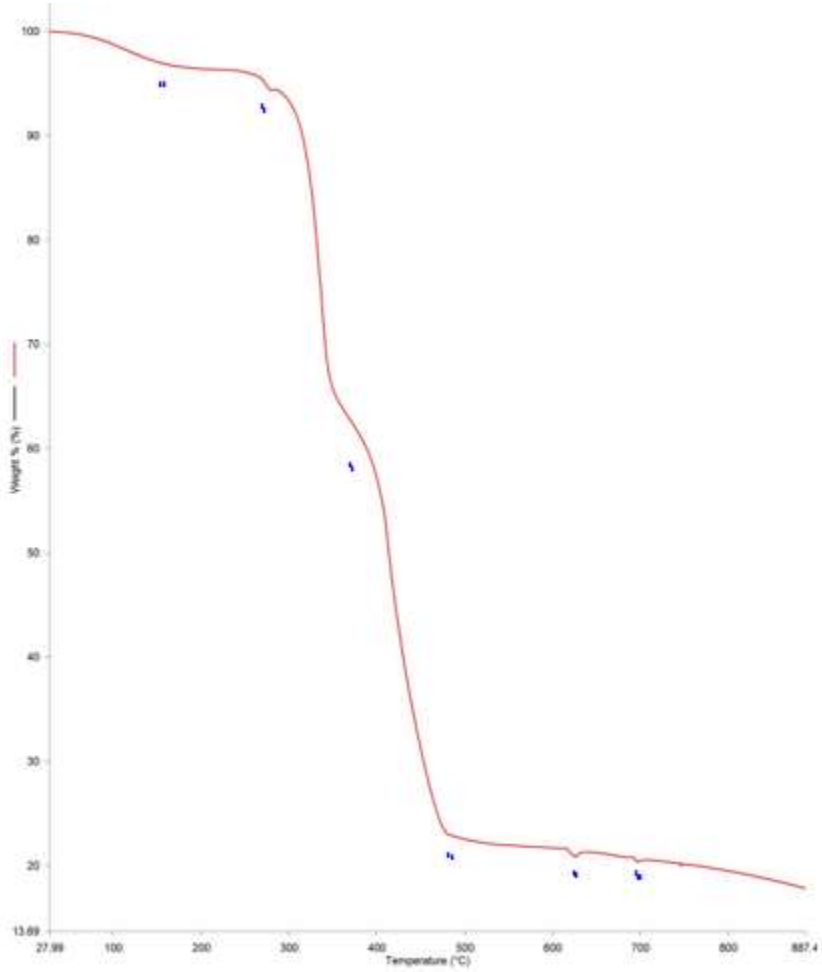


Figure 8: TGA of Banana Pseudo-stem Fibres

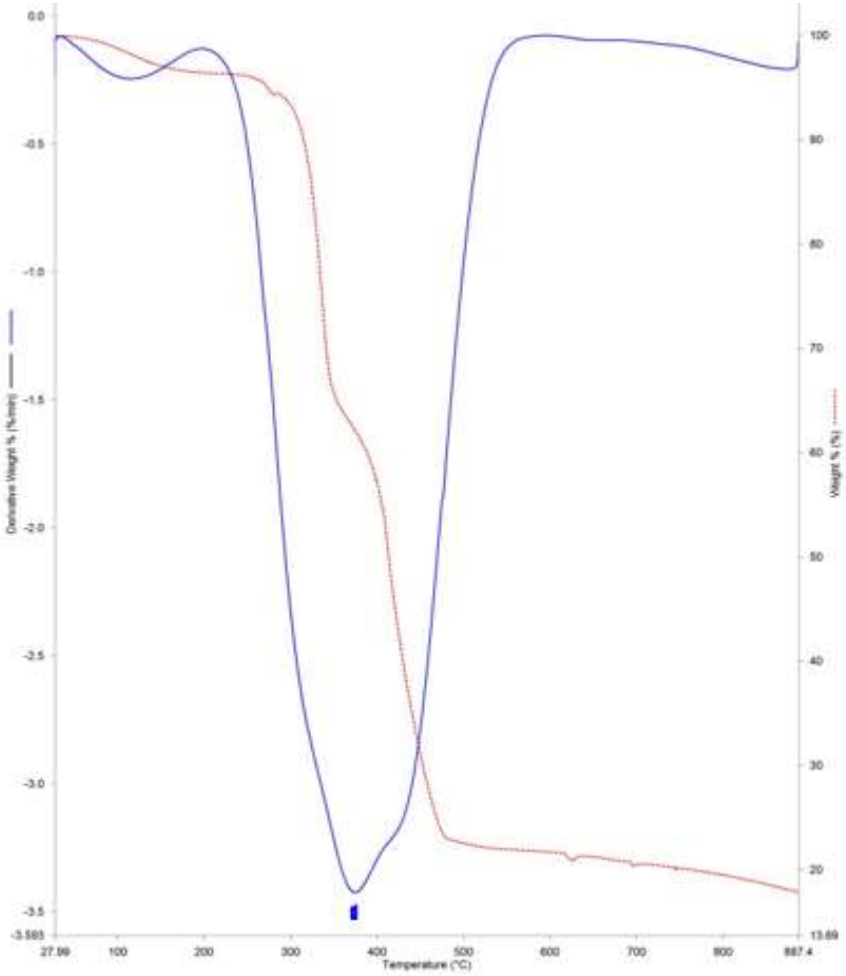


Figure 9: DTA of Banana Pseudo-stem Fibres

Scanning Electron Microscopy

Scanning electron microscopy was carried out with the aim of studying change in morphology of banana pseudo stem fibres as a result of scouring and bleaching. Figure 10 below clearly shows significant change in the physical appearance of the fibres surface. Right SEM image revealed that the surface of untreated fibres appears rough due to the presence of wax, fat and other unpleasant colors. However, the left SEM image revealed that after treatment of the fibres with sodium hydroxide and hydrogen peroxide, all wax, fat and unpleasant color disappeared. This is in line with the results presented by FTIR where peaks that represent wax, fat on the fibres disappeared.

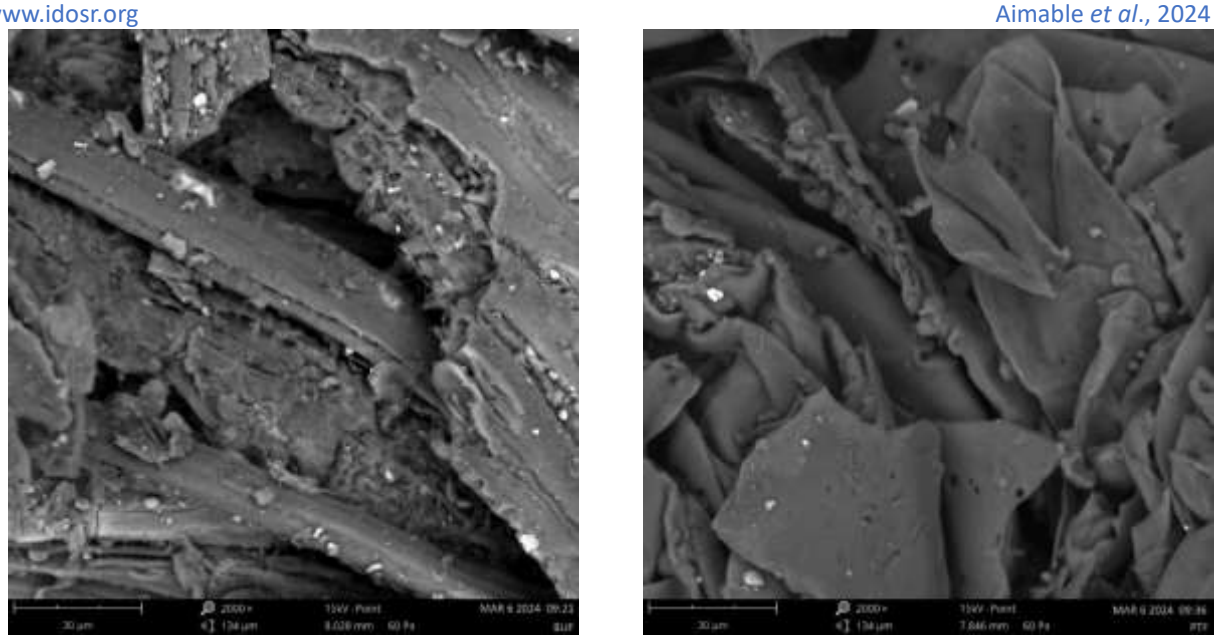
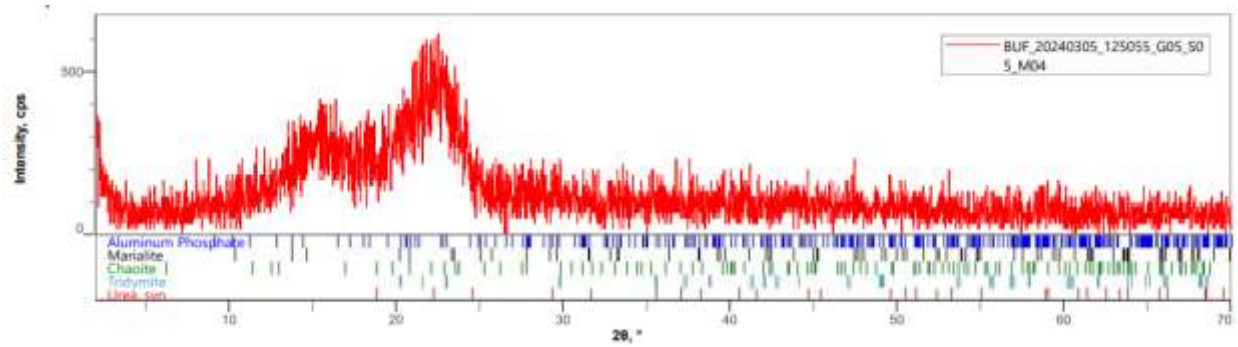


Figure 10: SEM of untreated Banana Pseudo-stem fibres (Left) and SEM for treated Banana Pseudo-stem fibres (Right)

X-Ray Diffraction

The result of X-ray diffraction plots the intensity of the signal for various angles of diffraction at their respective two theta positions. The greater the intensity of the peak, the greater the amount of crystals or molecules with that distinct spacing. The width of the peaks is inversely proportional to the crystal size. A thinner peak corresponds to a bigger crystal. A broader peak means that there may be a smaller crystal, defect in the crystalline structure, or that the sample might be amorphous in nature. The peaks intensity of XRD are related to crystallinity of the sample and it is used to determine the crystallinity index (CI) of a sample. The intensities of XRD peaks are directly proportional to the crystallinity of the sample. Higher peak intensity indicates higher CI and vice versa. Generally, if you get a very broad humped peak, then the material will be amorphous with short range ordering. If you get a sharp peak in the XRD pattern, then the sample is crystalline. From the expression given above, we can conclude that banana pseudo stem fibres treatment has enhanced its crystallinity as the peaks obtained after fibres treatment have high intensity compare to the peaks obtained for untreated fibres. This is because of the realignment of celluloses molecules in the crystal lattice and removal of lignin and hemicellulose which form amorphous region of the fibres [36].



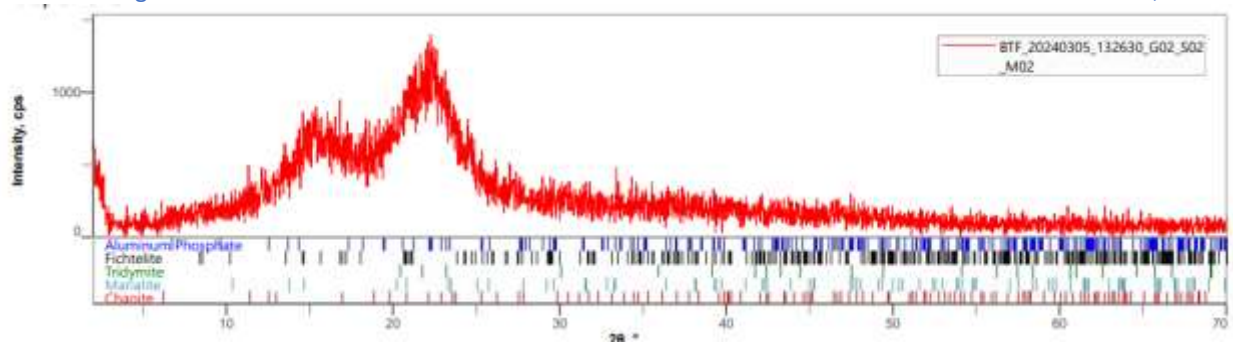


Figure 11: XRD for untreated (above) treated (below) banana pseudo stem fibres.

CONCLUSION

The aim of this research which was to extract, treat and characterize fibres from banana pseudo-stem was achieved. This study showed that, it is possible to get fibres from banana pseudo stem trunk which is actually considered as a waste after the banana fruits is harvested. However, the fibres have to undergo treatment to remove gummy, oil and other unpleasant color that might be present on the fibres. This is done in two processes namely scouring and bleaching. Also, another step to further increase the absorption of dye by fibres known as mercerization has to be performed. The extracted fibres can be used to produce a yarn which can further be used to produce some other items such as carpets, hand bags, ropes, keyholders and sacks through weaving and/or knitting depends on the product desired. Also, the produced fibres can be used in the production of non-woven fabric in which the fibres are bonded together to create a fabric. The fibres can be bonded chemically, mechanically or thermally. Nonwoven fabric is of great important ranging from medical and healthcare to civil engineering.

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