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Banana pseudo-stem fiber yield and properties

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ABSTRACT

Banana is basically a fruit crop cultivated in all the tropical and sub-tropical countries. With increasing demand on eco-friendly materials, banana fibres are now used to make garments, ropes, mats, carpets, cushions, cushion covers, bags, baskets, table cloths and many more purposes. A research work was conducted on Banana pseudo stem (*Musa indica*) at the workshop of Farm Power and Machinery Department, Bangladesh Agricultural University, Mymensingh, Bangladesh. The main objectives of the study were to study the yield of fiber and its properties of Banana pseudo stem (*Musa indica*). Fermentation, mechanical extraction method (Scraping for stem fiber) was conducted to extracted fiber from Banana pseudo stem. The percent of elongation at break, tensile strength and diameter of banana pseudo stem fiber decreased with the increase of period of fermentation. Fiber percent was 2.66% and the estimated fiber production of banana pseudo stem, was 197 kg/ha.

INTRODUCTION

Banana is one of the important fruit and vegetable crop plants and belongs to the genus Musa. All the parts of this plant, for example, fruit, peel, leaf, pseudo-stem, stalk, and inflorescence (flower), can be utilized (Li et al, 2010 and Aziz et al, 2011). They are used in several food and nonfood-related applications, for example, as thickener, colorant and flavoring, macro and micro-nutrient source, livestock feed, fibers, bioactive compound source, and organic fertilizers (Padman et al, 2014). The banana leaf is frequently used in food processing (in some countries, e.g., Indonesia), food esthetic, food packaging, etc. The banana fruit itself is one of the most popular fruits and important diet due to its high nutritional content thus it becomes a valuable commodity all around the world. Other well-known species are abaca (*Musa extilis*) and other wild banana plants used as a source of fibers for the paper and cordage industries (P.T. Franco, 1981 and Saikia, 1997).The banana pseudo-stem has also been considered for use as pulp and paper raw material, fiber for textiles, and filler or structural reinforcement in composites materials (Paul et al, 2008. Bilba et al, 2007). Additionally, all parts of the banana plant have some medical added values, such as the flower can be cooked and consumed by diabetics, bronchitis, dysentery, and ulcer patients. The banana pseudo-stem sap can be orally taken or externally applied for stings and bites. The pseudo-stem of banana plant is the stem of banana plant that provides and transports nutrients from the soil to the fruits. This pseudo-stem will be cut and become waste biomass after the banana fruit is ripe and harvested, because the banana plant is unusable for the next harvest (Abdullah et. al. 2014). In addition to fruit production, huge quantity of biomass (pseudo stem, leaves, suckers etc.) is generated (Reddy et al, 2005 and Sakthivel et al, 2013). Banana pseudo stem has been known as a potential cellulose source, though usually discarded as agricultural waste in many countries. The composition of banana pseudo stem obtained by elemental analysis, as determined by Bilba et al. (2007). Banana fiber may be extracted from the pseudo

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stems of the Banana after the harvest. A wide range of eco-friendly items can be made out of Banana fiber, being a natural fiber it easily blends with other fiber such as jute and mesta. Products like, doormats, carpets, yarn, rope, geotextiles, travelites, luggage carriers and interior decorative items can be made out of this banana fiber. Banana fiber is a major alternative to pulp industry (Iyer et al. 1995). The banana fiber industry will create enough opportunity for labour employment. Fiber may be extracted manually from banana waste. Due to the relatively high cost of synthetic fibers and health hazards, it becomes necessary to explore natural fibers. Banana Fiber is a good alternative to this.

Different major fiber producing plants are available in our country with their commercial importance. Besides that fiber plants, there are many minor fiber crops present which are not used for producing fiber. So, it is needed to be thoroughly searched out. The main objective of this work was to study on fiber yield and properties of banana pseudo stem.

MATERIALS AND METHODS

The study was conducted at the workshop of Farm Power and Machinery Department, Bangladesh Agricultural University, Mymensingh, Bangladesh.

The raw materials of banana pseudo stems were collected for extracting fiber from different places. Banana pseudo stem is the rejected portion of banana plant. As a result, it can found any market where banana is selling. So, the pseudo stem were collected from different market places (Jolchotro Banana Bazar, Modhupur Bazar and Sesh Moar of BAU campus (Figure 1) at different times of research. The unnecessary portion was separated by cutting then the weight of the stem was taken before they are processed through the fermenter. Before through the fermenter, the pseudo stem was weighed by the spring balance. After weighed the samples were binding tightly by using plastic rope. A specific identifier was added with the rope for identification of different samples. The fermenter was filled up by water. The amount of water is depends on the amount of samples which need to ferment.

Figure 1: Collection field of Banana from local market

Figure 2: Banana pseudo stem after retting

Figure 3: Cleaning the fiber after retting

The samples were taken for fermentation with four treatments: i) aerobic fermentation ii) anaerobic fermentation iii) fermentation with urea and iv) fermentation with CaO. Banana pseudo-fiber is attached with its stem. The fiber is needed to

separate from the stem for further using. Retting process was used for extracting the fiber from Banana pseudo stem (Figure 2). Extracted fibers were washed in clean water (Figure 3). Removed all the unnecessary parts from fiber, because this portion decrease the demand and price of fiber in market. Since, the extracted fiber contained some moisture, so, the fiber is needed to squeeze by hand for removing this moisture. After squeezing excess water the fibers were spread on the railing for sun drying for 2-3 days.

Moisture content determination of dried fiber and stick

After drying and before weighing all the extracted dried fiber and dried stick were needed to measure its moisture contents. That is why; the extracted fiber and stick were dried by using oven dry method. By this process the moisture was measured content of extracted dry fiber and stick for finding the actual percentages of fiber and stick.

The moisture content can be calculated simply, as follows:

$$\text{Moisture Content (\%)} = \frac{\text{Initial weight} - \text{Oven dry weight}}{\text{Oven dry weight}} x100 \dots\dots\dots\dots\dots\dots (i)$$

Determination of percentages of fiber and stick:

Fiber percentage is considered as an essential pre-requisite in breeding programme. It is also assumed to be an index of fiber yielding capacity of a particular variety. Different methods are followed to find out the fiber percentage of jute and allied fibers.

Fiber percentage on green weight basis

In this method, stems along with total foliage are weighed just after harvest and then ratted for fiber extraction. Then, percentage of dry fiber is calculated on the basis of green weight.

$$\text{Fiber \%} = \frac{\text{Weight of dryfiber after extraction (gms)}}{\text{Weight of stem along with total foliage (gms)}} x100 \dots\dots\dots\dots\dots\dots (ii)$$

$$\text{Fiber \%} = \frac{\text{Weight of dryfiber after extraction (gms)}}{\text{Weight of stem along with total foliage (gms)}} x100 \dots\dots\dots\dots\dots\dots (ii)$$

$$\text{Stick \%} = \frac{\text{Weight of drystick after extraction (gms)}}{\text{Weight of stem along with total foliage (gms)}} x100 \dots\dots\dots\dots\dots\dots (iii)$$

This method gives us a ready-made idea about the possible yield of fiber of a particular area before extraction.

Fiber percentage on stripped weight basis

In this method, leaves and branches are stripped off just after harvest and weighed immediately. The stripped plants after weighing are sent for retting. The fiber % is calculated on the basis of stripped weight.

$$\text{Fiber \%} = \frac{\text{Weight of sun dryfiber (gms)}}{\text{Weight of stripped stem (gms)}} x100 \dots\dots\dots\dots\dots\dots (iv)$$

$$\text{Stick \%} = \frac{\text{Weight of sun driedstick (gms)}}{\text{Weight of stripped stem (gms)}} x100 \dots\dots\dots\dots\dots\dots (v)$$

Fiber percentage on dry weight basis

In this method, fiber percentage is calculated on the basis of total dry weight of fiber and stick after extraction.

$$\text{Fiber \%} = \frac{\text{Weight of sun dryfiber (gms)}}{\text{Weight of (strick + fiber) (gms)}} x100 \dots\dots\dots\dots\dots\dots (vi)$$

$$\text{Stick \%} = \frac{\text{Weight of sun dried stick (gms)}}{\text{Weight of (strick + fiber) (gms)}} x100 \dots\dots\dots\dots\dots\dots (vii)$$

Determination of various physical properties of extracted fiber

Hounsfield UTM 10KN (H10KS) was used for test of tensile and flexural strength, compression shear and other mechanical and physical properties of materials.

Percent elongation at breaking Test

Elongation recorded at the moment of rupture of the specimen, often expressed as a percentage of the original length. It corresponds to the breaking or maximum load.

Laid the fiber sample across the table of machine. Measure the length of fiber samples to be tested. Using two pair of needle-nosed pliers, grasp the sample at each end. Hold one end of the sample at

"0" on the yard stick. Slowly stretch the other end of the sample as far as it will stretch, until the sample breaks.

Using the formula below, calculated percent elongation at the point of breaking

$$(\%)\ \text{Elongationat break} = \frac{\text{Elongation at break}}{\text{Original length}}\ x100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (viii)$$

Fiber dimension Test

Micro hardness tester machine (HMV-2 series) was used to measure the diameter of the fiber (Fig. 3.41). The measuring range of this machine was .01 µm -500 µm.

RESULT AND DISCUSSION

Banana pseudo were collected from different field for measuring the various parameters which are shown in Table 1. The result of Table 1 shows that, Banana pseudo stem contained, average 2.66% Fiber (green wet basis) and Fiber yield/pseudo 59.11 gm.

The obtained fibers of banana pseudo stem shown in Figure 6.

Figure 4: Obtained fiber from banana pseudo stem

Effect on percent Fiber for different treatment

It was observed that, for Banana pseudo stem, maximum 2.67% Fiber was found after 20 days of aerobic fermentation; 2.68% Fiber after 15 days of anaerobic fermentation; 2.68%Fiber after 10 days of fermentation with urea and 2.4%Fiber after 30 days of fermentation with CaO (Figure 7).

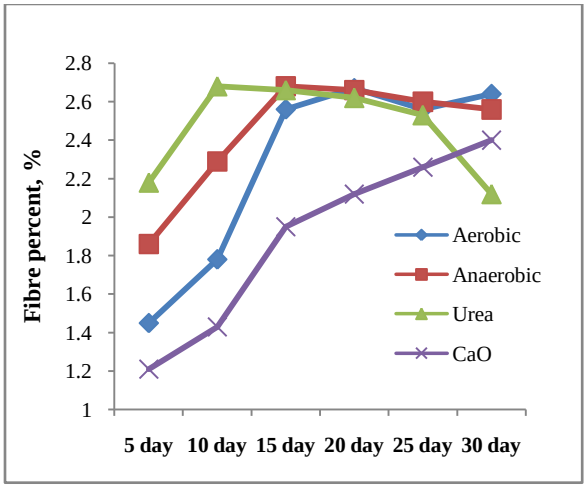

Figure 7: Effect on percent Fiber of Banana pseudo stem for different treatments

Effect on Fiber strength for different treatment

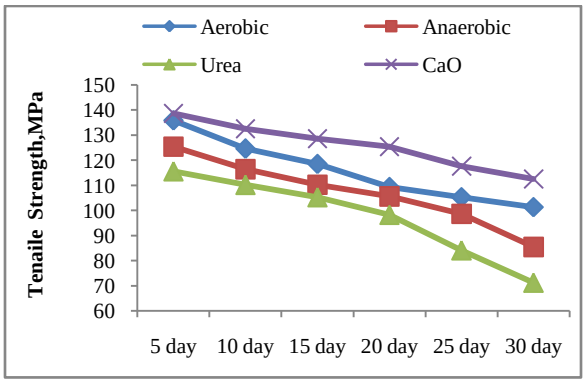

Figure 8: Effect on Fiber strength of banana pseudo stems fiber for different treatments

Figure 8 showed that, for Banana pseudo stem, 109.41 MPa strength was found after 20 days of aerobic fermentation; 110.3 MPa strength after 15 days of anaerobic fermentation; 110.2 MPa strength after 10 days of fermentation with urea and 112.53 MPa strength after 30 days of fermentation with CaO. Above result showed that, tensile strength of Fiber decreased with the increase of period of fermentation.

Table 1: Various parameters for Banana Pseudo stem

Sample No.	**Length of pseudo, (cm)**	**Area of whole pseudo (cm^2)**	**Green wt. before retting, (gm)**	**extracted Fiber wt. (gm)**	**%Fiber (wet basis)**	**Wt. Loss, gm**	**% Loss**
1	56	2480.41	1800.00	45.60	2.53	1754.40	97.47
2	54	2039.08	1400.00	35.62	2.54	1364.38	97.46
3	120	4872.24	3014.00	84.39	2.80	2929.61	97.20
4	115	4854.70	3142.00	84.35	2.68	3057.65	97.32
5	143	5702.74	4037.79	100.28	2.48	3937.51	97.52
6	68	2629.91	1552.00	48.62	3.13	1503.38	96.87
7	53	1913.62	1354.93	35.12	2.59	1319.81	97.41
8	78	2581.72	1827.98	46.25	2.53	1781.73	97.47
9	82	2830.75	2004.30	49.82	2.49	1954.48	97.51
10	94	3399.85	2251.00	62.54	2.78	2188.46	97.22
11	89	3054.34	2162.61	57.64	2.67	2104.97	97.33
Mean	**86.55**	**3305.40**	**2231.51**	**59.11**	**2.66**	**2172.40**	**97.34**
Standard Deviation	**29.55**	**1268.90**	**838.53**	**21.58**	**0.19**	**817.29**	**0.19**

Effect on Fiber thickness for different treatment

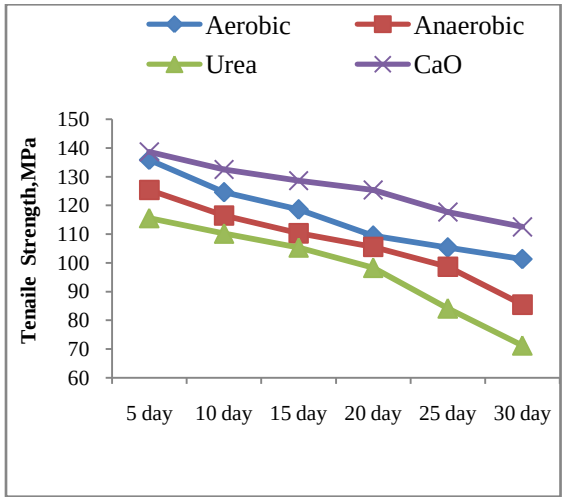

Fig. 9: Effect on Fiber thickness of Banana pseudo stem Fiber for different treatments

Figure 9 showed that, for Banana pseudo stem, 0.222 mm diameter was found after 20 days of aerobic fermentation; 0.223 mm diameter after 15 days of anaerobic fermentation; 0.224 mm diameter after 10 days of fermentation with urea and 0.231 mm diameter after 30 days of fermentation with CaO. Above result showed that, diameter of Fiber decreased with the increase of period of fermentation.

Effect on Fiber elongation break for different treatment

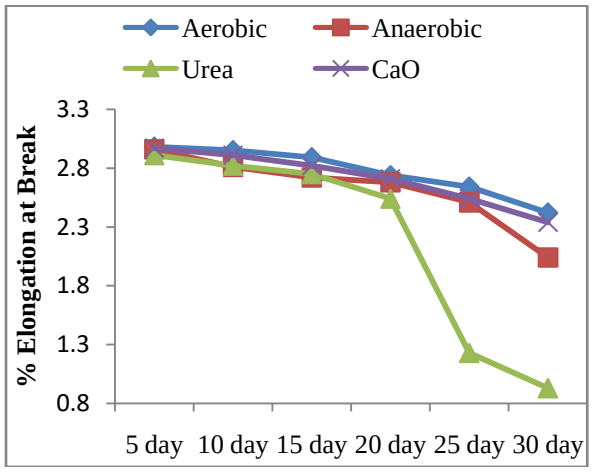

Figure 10: Effect on elongation break of banana pseudo stem fiber for different treatment

Figure10 showed that, for banana pseudo stem, 2.82% elongation break was found after 20 days of aerobic fermentation; 2.825 % elongation break after 15 days of anaerobic fermentation; 2.82 % elongation break after 10 days of fermentation with urea and 2.12 % elongation break after 30 days of fermentation with CaO. Above result shows that, % elongation at break of Fiber decreased with the increase of period of fermentation.

CONCLUSION

The percent of elongation at break, tensile strength and diameter of banana pseudo stem fiber decreased with the increase of period of fermentation. Fiber percent was 2.66% and the estimated fiber production of banana pseudo stem was 197 kg/ha. However there is scope for further research to completely characterize and economic feasibility of the banana fibers and facilitate proper applications in natural fiber reinforced composites.

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