Banana Plant Waste as Raw Material Using in Textiles

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Abstract

Banana is one of the rhizomatous plants and currently grown in 129 countries around the world. It is the fourth most important global food crop. Different parts of banana trees serve different needs, including fruits as food sources, leaves as food wrapping, and stems for fiber and paper pulp. Historically, banana stems had been used as a source of fiber with the earliest evidence around the 13th century. But its popularity was faded after other convenient fibers such as cotton and silk were made available. As fiber industry has been developing to increase production efficiency, new fibers were then developed to effectively respond the consumers' need, including the production of man-made fibers using petroleum to optimize the fiber properties. The chemical use inevitably causes contamination in every environmental medias - water, soil and air, which directly affects human wellbeing and environment. This research is to develop banana fiber from the plant that is available locally throughout the country of Thailand but rarely used as fiber source in textile industry. The focus of the study is to optimize the fiber producing processes of in an environmental friendly manner and decrease chemicals and toxic agents incurred. The findings were 25-30% yield for fiber collection and the mechanical process (fresh method) is an appropriate method of fiber extraction. The yarn spinning and knitting were experimented but the results have not been satisfied, yet. Further study should be developed. As banana fiber can provide a wide variety of uses in textile and paper industry, the study the application of this locally and widely grown plant species for the sustainable development would be beneficial.

Keywords: Banana, Fiber, textiles etc.,

Introduction

Banana fabric is a beautiful, animal-free textile that mimics real silk, and acts as a great vegan alternative. The fiber material comes from the stalk of the banana plant, and while it is certainly a unique idea, it is not new. It is an animal free, fully organic fiber with fantastic texture which we offer in plain weave as well as in different patterns. Kindly note that Banana fabric is one of the world's strongest natural bio degradable fiber and it comes from the stalk of the banana plant and it is incredibly durable, water resistant, soft, breathable, natural absorbent and recyclable. Banana fiber has a natural sheen, and the inner strands of the stalk are very fine, allowing it to replicate the hand of silk. But banana can be used as an alternative to other fabrics as well. Because the quality of the fibers inside the stalk varies, the types of textiles it can produce vary also. While the inner strands are smooth and fine, the outer strands are coarser. These fibers can be processed into a hand similar to anything from bamboo, to hemp, to linen. Some fibers are thick and coarse enough for basket weaving, which can be used in handbags.

Banana Fabric

Since the Japanese have been processing banana fibers for nearly 800 years, they have perfected the art of creating banana cloth. The finest fibers of the banana stalk are reserved for kimono dresses and kamishimo, a formal garment worn by the samurai. Nepalese artisans have also been creating beautiful and lavish rugs out of banana fibers, as their moisture-wicking properties make them the ideal floor coverings for tropical climates. Alongside these traditional uses, banana fibers are also used for interior purposes such as cushion covers, curtains, tablecloths, bags and even paper and journals. The International Institute for Environment and Development has even launched a program to educate women in Rwanda in making low cost and environmentally friendly sanitary pads out of banana fiber. The time and skill required to efficiently making strong and evenly spun yarns can take a lifetime to learn, however, the process of banana fiber production is nonetheless a sustainable one. Banana plants do not require pesticides or fertilizers when grown in the tropics, and are often cultivated by small farmers who own their land. The fibers are spun, dyed and woven by small artisan communities that continue to pass down their trades to younger generations, keeping age-old traditions alive. These communities often thrive as a whole on the work they accomplish, sharing the benefits equally among one another.

Banana Silk

Banana Silk is made from the pseudo-stem of the Banana Tree. The fibre is extracted from the stem then woven, dyed and expertly tailored into beloved garments. There are little to no chemicals used in the production. Amazingly, Banana Silk is also durable, moisture-absorbent and completely biodegradable. When thinking of fibers used in rug production, the majority assumes there are solely two categories: natural ones, like wool, cotton or silk, and entirely artificial, synthesized out of petrochemicals – such as polyester and nylon. ... Banana silk is obtained from wood pulp, so it is considered a recovered fiber.

Banana Fibre Processing and Weaving

The extraction of the natural fibre from the plant required certain care to avoid damage. In the present experiments, initially the banana plant sections were cut from the main stem of the plant and then rolled lightly to remove the excess moisture. Impurities in the rolled fibres such as pigments, broken fibres, coating of cellulose etc. were removed manually by means of comb, and then the fibres were cleaned and dried. This mechanical and manual extraction of banana fibres was tedious, time consuming, and caused damage to the fibre. Consequently, this type of technique cannot be recommended for industrial application. A special machine was designed and developed for the extraction of banana fibres in a mechanically automated manner. It consisted mainly of two horizontal beams whereby a carriage with an attached and specially designed comb, could move back and forth. The fibre extraction using this technique could be performed simply by placing a cleaned part of the banana stem on the fixed platform of the machine, and clamped at the ends by jaws. This eliminated relative movement of the stem and avoided premature breakage of the fibres. This was followed by cleaning and drying of the fibres in a chamber at 20o C for three hours. These fibres were then labeled and ready for lamination process.

Material and Methods

Banana fibres were extracted from the stems of banana plant. Longitudinal slices were prepared from stems and fed to fiber extracting machine. The fiber extracting machine, also known as a mechanical decorticator, consists of a pair of feed rollers and a beater. The slices were fed to the beater between the squeezing roller and the scrapper roller, following which the pulp gets separated and fibers are extracted and air dried in shade.

Conditioning

Specimens were conditioned, at 65% RH and 210 C for a day to ensure environmental equilibrium, prior to testing.

Fiber linear density

Fibre diameter was evaluated from optical observations under microscope as the average of five diameter measurements taken at different locations along the fiber with a range of standard deviation from 0.05 to 0.1. Based on the diameters of the fiber, the whole fiber samples were divided into four broad categories. The diameter of the fiber was then measured at 100 different places along the length of four fibers. 100 fibers were also taken at random from the sample and their diameter measured at 10 different places. The tex of the fiber was calculated assuming the density of banana fibers to be 1.4g/cc, determined using a density gradient column prepared from xylene (0.865 g/cm3) and carbon tetrachloride (1.595 g/cm3) by Kumar et.al.18 Figure 2, which is the cross section of a fractured banana fiber, shows the circular nature of the fiber, along with the presence of some protruding fibrils. Thus for a circular cross section of the fiber, the tex of the fiber, defined as the weight in grams of 1000m of the fiber, would be related to the volume as Tex = Volume (cc) x 1.4 x 1000 …..

Single fiber tensile test

Fibres were carefully manually separated from the bundles. Fibre ends were glued onto a paper frame according to the preparation procedure described in ASTM D3822-07 Standard. A Hounsfield tester was used to test the fibers. A load cell of 100 Newton was used for fiber testing. Due to variability of natural fibers, 20 samples were tested and the average value reported along with the variability of the data.

Characteristics of banana fibre

The physical and chemical properties of banana fibre are considered below:

The chemical composition of banana fibre is cellulose (50-60%), hemicelluloses (25- 30%), pectin (3-5%), lignin (12-18%), water soluble materials (2-3%), fat and wax (3- 5%) and ash (1-1.5%).Its appearance is similar to that of bamboo and ramie fibre; however banana fibre has better fineness and spin ability. It has shiny, appearance depending upon the extraction and spinning process. It has very strong fibre with 3% elongation and light weight. Its average fineness is 2386 Nm, average strength is 3.93 cN/dtex and average length is 50 ~ 60 mm (or 38mm) It absorbs and releases moisture easily. It can be spun by different methods like ring spinning, open-end spinning, bast fibre spinning, and semi-worsted spinning. It is bio-degradable and has no negative effect on environment and thus can be categorized as eco-friend fibre.

Properties of Banana Fibers

Tenacity	29.98 g/denier
Fineness	17.15
Moisture Regain	13.00%
Elongation	6.54
Alco-ben Extractives	1.70%
Total Cellulose	81.80%
Alpha Cellulose	61.50%
Residual Gum	41.90%
Lignin	15.00%

Banana Fiber Extraction Processing, Yarn Spinning & Weaving

The extraction of the natural fiber from the plant required certain care to avoid damage. In the present experiments, initially the banana plant sections were cut from the main stem of the plant and then rolled lightly to remove the excess moisture. Impurities in the rolled fibers such as pigments, broken fibers, coating of cellulose etc. were removed manually by means of comb, and then the fibers were cleaned and dried. This mechanical and manual extraction of banana fibers was tedious, time consuming, and caused damage to the fiber. Consequently, this type of technique cannot be recommended for industrial application. A special machine was designed and developed for the extraction of banana fibers in a mechanically automated manner. It consisted mainly of two horizontal beams whereby a carriage with an attached and specially designed comb, could move back and forth. The fiber extraction using this technique could be performed simply by placing a cleaned part of the banana stem on the fixed platform of the machine, and clamped at the ends by jaws. This eliminated relative movement of the stem and avoided premature breakage of the fibers. This was followed by cleaning and drying of the fibers in a chamber at 200 C for three hours. These fibers were then labeled and ready for lamination process. After fiber is collected, the process goes to yarn spinning. The researcher investigated the traditional process, which use the filament yarns in weaving banana fabric. The finding showed that the convention process was very time-consuming, thus not appropriate for today's use. Therefore, this research explored open-ended spinning process for yarn development. The fiber was cut in to 3-centimeter length for spinning process.

Banana Fibers Chemical Treatment

Alkali treatment increases surface roughness resulting in better mechanical bonding and the amount of cellulose exposed on the fiber surface. This increases the number of possible reaction sites and allows better fiber wetting. The possible reaction of the fiber and Sodium Hydroxide (NaOH) is represented in Equation. The banana fibers were cleaned and immersed in 6% NaOH solution for 2 h at room temperature as shown in Figure 2, and then thoroughly washed by immersion in a clean water tank to remove the non-reacted alkali until the fibers were alkali free. They were next rinsed under running water and filtered. The filtered fibers were then dried in an oven at 80 °C for 24 h.

Specimens Preparation

Dry soil, including sand and clay to be used for GCEB production were run through a manual sieve with a 3.40 mm2 (0.00527 in2) mesh size to remove lumps. The samples produced consisted of 10 plain CEBs (control) and 60 banana-fiber-reinforced GCEBs. Based on the typical CEBs mix ratios, GCEBs are formed using a mixture (by weight) of sand (35%), 5 mm aggregate (30%), clay (35%), cement (7%), and water (10%). With the exception of fiber length, all the identified factors were kept constant in all mixes to allow for observation of the influence of fiber length on strength of tested specimens. The development of strength properties of soil-cement-fiber mixes mostly depends on the formation of fiber-matrix adhesion, matrix-matrix cohesion and fiber-fiber cohesion. These identified bonds can be affected by dimensions, surface conditions and the quantity of fiber present [9]. Previous studies have recognized that reinforced CEB with 0.4% of the Polypropylene fibers recorded the highest compressive strength; also, these studies prove that increasing fiber content more than 0.4% reduces the strength significantly.

Advantages

Banana fiber is natural fiber. Natural fibers present important advantages such as low density, appropriate stiffness and mechanical properties and high disposability and renewability. Moreover, they are recyclable and biodegradable. Biodegradable, the natural fibre is made from the stem of the banana tree and is incredibly durable. Banana fibre can be used to make a number of different textiles with different weights and thicknesses, based on what part of the banana stem the fibre was extracted from. One traditional use of the coarse abaca fibers, which range up to 3 meters in length and have very high tensile strength, was as cordage, especially for ship's rigging. Today, most abaca is pulped and processed into tea bags, vacuum bags, a casing for sausages, banknotes, cigarette papers and high-quality writing paper. Recently, research engineers patented a novel mixture of polypropylene thermoplastic and abaca yarn for use in automobile components, including external panels. Once a favored source of rope, abaca shows promise as an energy-saving replacement for glass fibers in automobiles. The fiber was originally used for making twines and ropes as well as the Manila envelope; now most Abaca is pulped and used in a variety of paper–like products including filter paper and bank notes. It can be used to make handicrafts like bags, carpets, clothing, and furniture. Some of the fine inner fibers from the abaca leaf–stalk is used directly, without spinning, for making delicate, lightweight, yet strong fabrics. These fabrics are used in the Philippines for clothing, and for hats and shoes. Some abaca is used for carpets, table mats, etc. In South India lot of Banana, cultivation is found which has helped the local people to extract fiber from the leaves of the banana plant which is being used in making banana yarn and blended with cotton, and synthetics and various lightweight fabrics are produced. It has to be popularized further in India similar to the Philippines. A very alternative way to save wood because banana tree fibre is extremely long and strong and can produce excellent paper. Once it is made, it will sell very well because paper is used in great amount. There is a great flexibility in choice whether what to make out of the banana paper. There is a great variety to choose from greeting cards to other crafts. With the100 million tones of banana waste worldwide each year, this has a huge potential both economically, and in terms of its sustainability impact.

Disadvantages

When banana leaves are cut off from the tree, they start to die and wither, so the banana leaves has to be processes to assure the durability, stability and endurance of the banana leaf product. There should be another way to maintain the freshness of the leaves. People have to learn and get used to the ways to weave the leaves and weaving takes up so much time. To make the banana leaf to a paper, it has to go through numerous processes which involve chemicals. Poor people might have a hard time buying and obtaining these chemicals. These have to go through mass production in order to obtain real solid profit. The process of making glass out of banana fibers is not very known to many, and the process may be hard and complicated for average Filipinos. There needs to be machines that make these glasses.

Conclusion

Fiber extraction, the mechanical extraction should be employed. The mechanical process was appropriate for fiber collection since the color of fibers is lighter than biological process. The yarn spinning and knitting were experimented. Banana fibers, and suggests applications that reflect concerns for the environment. The environmental benefits of utilizing left-over products have offered options instead of using new fibers, where it could increase the demand of new natural material and high energy consumption. It also promotes awareness of environmental issue on excessive chemical in textile industry from using synthetic and petroleum-based fibers.

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