

# A Comprehensive Review of Banana Based Paper

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**Abstract.** This paper reviews the process, product and future applications of banana-based paper. The utilization of bark tree to produce paper has been practiced for centuries. Unfortunately, deforestation can cause climate change, desertification, soil erosion, fewer crops, flooding, increased greenhouse gases in the atmosphere and a host of many environmental problems. As alternatives, many raw materials based on plant were produced for paper and banana stem is one of them. Banana stem is easily collected from banana trees after collection of banana fruits. It is the flower stalk of the banana plant. The rough and hard outer layers are removed to reveal the stark white. Once they are removed and dried, they are boiled, shredded and rinsed to create pulp. The pulp was put into mold and pressed into sheets of paper. This product gave a huge promising as viable product especially in commercialization, cost structure, paper superior properties and positive environmental benefits. Nowadays, the market of paper is overwhelming because it can be used to make a variety of products that helps world economy and have wide scope to create new market.

## INTRODUCTION

Paper can be made from any types of fiber, from wood or non-wood fiber and from your old cloth to the grass clippings [1]. Paper can be made from fibers of cellulose or from the recycled paper and the chemical substances depends on the material that are using [2]. In year 2009, global paper and paperboard production reached 367.8 million [3]. Traditionally, paper is made from wood by deforestation. As a result, huge amount of tree need to be cutting down to meet the supply of wood fiber of the industry as the paper are technically produced for the wrapping, packaging, drawing and writing [2].

As the deforestation increased every year for making paper, it increased the environmental pollution and the global warming where this is not good to earth [4]. The deforestation give bad effects to environment and it is important to find new fiber either wood fiber or non-wood fiber, or new type of plant to make paper without cutting of tree. The cost to produce paper from the wood fiber is higher than the non-wood fiber [5]. The debate over logging and opting for non-tree fiber rest controversial from years to years. In sight of the shortage of conventional supplies for pulp production, non-wood plants and agricultural residues appealed renewed interest [6].

Natural fiber such as banana fiber content many advantage such as low density, high in stiffness and high disposability and renewability [7-8]. For making paper, only some of banana species which have high cellulose content of pseudostem is used in papermaking and pulping industry since 60's [9]. Usually non-tree fibers come from agricultural residues for examples fruit seeds, peels and leaves, while natural growing plants consist of banana and bamboo and nonwood crop residues which are cotton stalks, rice straw and cereal straw [10].

Over an area of 48 lakh hectares, with an annual production of 99.99 million tons, banana plant is one such valuable bioresource which is distributed in more than 120 countries as banana is replace for biomass resource with very few higher value-added product markets [11]. Thus banana farming generates huge quantities of biomass most of which goes as waste due to non-availability of suitable technology for its commercial utilization. Good quality of fibers can be extracted from this farming residues along with numerous other plant components (juice) with bioconversion potential [12].

## BANANA PAPER

In Malaysia, the second most consumed fruit is banana. Every year, to reach the request in Malaysia, around 10 million banana tree need to be cutting down, however the banana trees are left to rot after the fruit is taken and the methane gas from the rotten process is released to the environment and this will affect the greenhouse [13]. The sustainable production of banana paper shall contribute to reduce the stress on natural forest resources [6]. Banana plant is not only a tree, but also, a high herb that grows 2-8m long with leaves of 3.5m in length [14]. From developing to industrial countries, bananas are the most traded fruit worldwide primarily [15].

Banana or in the scientific name call *Musa Paradisiaca*, *Musa Sapientum*, *Musa Cavendishii* and *Musa Chinensis* are all the types of banana species which can make paper from the banana fiber as the fiber have various strength, color and discrete length [16]. As one of the important fruit and vegetable crop plants, banana belongs to the genus *Musa* or other well-known species are abaca (*Musa textilis*) and other wild banana plants used as a source of fibers for the paper and cordage industries [17].

Banana tree is non-wood fiber and it is an alternative way to find the new renewable raw material to make paper without harmful the environment, banana is a good choice, in the meantime it also helps in increase the national economic growth [18]. The natural fibers have three types of grouped which are seed hairs, bast fibers and leaf fibers depends on its source [19]. For examples, cotton for seed hairs, ramie, jute and flax for bast fibers and sisal and banana for leaf fibers. The banana pseudostem and fruit-stem bunch can be found in tropical and subtropical countries in very large scale and this can show a major income source in countries and communities [20].

In the banana field, the banana plant can only be harvested once and this make the pseudostem and the unused part will be fell and this will make the stem attack by the fungi [5]. Usually the residue of the banana plant will become organic matter after being left on the field [21]. Plant that are left behind without any removal usually become a place for a disease vector for examples place for mosquitoes and fruit flies, it will also enhance pest's proliferation for rats and snails and lastly, it will bring bad aesthetic. A massive organic waste is produced because the banana stems cannot be used as an animal feed or other alternative and the waste is then causes of emission of toxic gases including CO<sub>2</sub> which can affect the environment [4].

## **BANANA PLANT**

The part of the plant starts from the roots to the point of its emergence from the covering of the false stem is composed of an exceptionally fine fibres which are white in color. The fruit stems contain fibres of a rough quality while the midribs of the leaves can produce a fibre which remarkable strength and durability if correctly processed [22]. However, in the banana plant, pseudostem is the main part as it serves three main function in tree which are to hold the glass, transport water and mineral and act as food storage [23]. The pseudostem containing cellulosic fibers that can be exploited in a paper mill. The study of the fiber was made to make the fiber can work in pulp and subsequent evaluation of its suitability and paper. The chemical and mechanical process are used to make the study success and this prove that the banana fiber can be used in pulp and paper industry for paper making. This make the banana fiber as an annual fiber, similar with sugar cane bagasse [24].

As the banana pseudostem is fast growing and has yield high of biomass, we can used it as a new raw materials for making of paper [25]. For mechanical properties in bast fibre, high content of cellulose and low microfibril angle impart are important. In the lignocellulosic material, lignin and hemicellulose play an important role in the natural decay resistance. This can be seen through the composition of banana pseudostem in element analysis [26]. The banana plant contributes various polymers such as cellulose, hemicellulose, pectin and lignin. The polymers are the one which provide fiber with strong mechanical properties. As the fiber are important for the paper making, the fiber need to be firm and strength [27].

In the banana pseudostem, the high content is amount of ash approximately 16%, which is common for annual plants. The ash content is important for industry processing, as the ash in banana is high, it make banana pseudostem is easy to make paper. The low amount of lignin which approximately 15% and banana pseudostem consist of hollocellulose where hollocellulose is a collective term referring to the entire polysaccharide portion of wood [28]. The cell wall structure, the chemical composition, anatomy and lignin distribution of banana stem fiber. The fiber of banana pseudostem has high Young's Modulus and higher water absorption capacity. Banana pseudostem is a new raw material for paper due to its high tensile strength and stiffness [29].

The banana fiber consists of rich fiber cellulose, its cellulose fraction is not easily accessible to the enzyme digestion because of the lignocellulosic nature of banana pseudostem and this make the banana paper is high in resistance in digestion than the paper from the wood [30]. For sources like wood, it will be difficult to separate and

highly toxic chemical substances are needed, but for the banana fiber as the lignin is low in content, easy to remove and separate the lignin, no chemical substances are used and this makes the banana paper environmental friendly [31].

## PROPERTIES AND STRUCTURE OF BANANA PAPER

In the manufacture of paper and paperboard, one of the most major component of abundant raw material which is predominantly used is pulp, other than paper and paperboard, pulp also important in textile industries, food or packaging material and also in pharmaceutical products which all the items related to cellulose where the cellulose and the fibers of the paper are important for the structure and properties of items [32].

The raw material such as banana and the manufacturing method are important to determine the mechanical properties and the cellulose structures of the papers. The durability and resistance towards environmental stress of the paper are largely independent on the mechanical properties of paper. The tensile strength of the paper is related to the ability of the paper to endure the tension condition [33]. The paper that is made from handmade, has higher extent of crosslinking and cellulose polymerization [34].

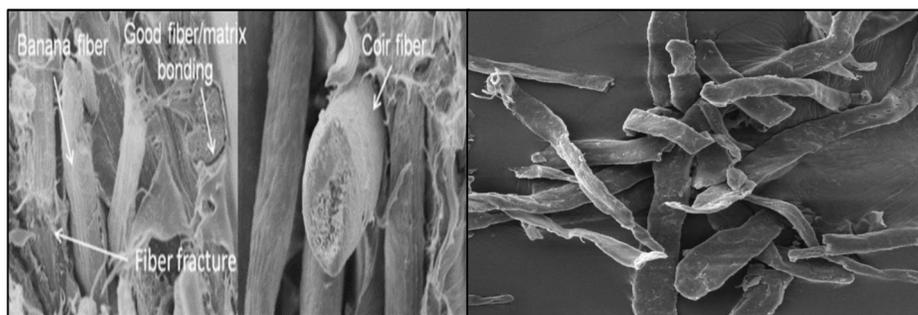
In India, the fibers of banana plant not only use for the paper, but also can used for handicrafts, ropes and textiles. There is limitation for the agro-based fiber to produce a product by using bio fiber, as the fiber is high in moisture absorption of the natural fibers, making it difficult for the hydrophobic fibers and hydrophilic polymers to bond together and for the paper, this will make the structure and the surface of the paper is not smooth like the paper from the wood mill [35].

The nanostructured cellulosic material significantly increases interfiber bonding which leading stronger and denser papers, and also has been reported this incorporation increase in more than twice the life span of paper products [36]. Wood pulp fibres are unique reinforcing materials that offer numerous advantages. They are non-hazardous, renewable, and readily available at relatively low cost compared to other commercially available fibres and this make banana paper is different from recycled paper [37]. Lignocellulose-based fibres or particles are the most widely used as biodegradable reinforcing elements or partial replacement of binder or filler for composite materials. In addition to the above-mentioned advantages, these materials possess interesting mechanical and physical properties to the paper [38].

### Banana Surface Morphology and Structure

The general relationship between fiber morphology and paper strength properties has been studied for various wood species [17]. The plant materials, fiber dimensions, and their derived values which are consist of slenderness ratio, flexibility coefficient, and runkel ratio on pulp and paper mechanical strength is important to determine the surface of paper either rough or smooth. The structure of banana paper is observed, the amount of lignin in the banana paper is low and this makes the banana paper is a new raw material which is worth in pulp and paper industry [18].

The thin cell wall of the latter structures will break if there is mechanical decortication in the machine that is used to make the paper and this will make varying dimension of the fiber bundles released. On the surface of the fiber bundles, patterns of the imprints of the neighboring cell will remain on the surface as there is residual in cell wall fragments [39]. Figure 1.1 and 1.2 show the image of the banana paper under scanning electron microscope which there is fiber fraction and good fiber matrix bonding which increase the interaction between the fiber in the paper [40].



**FIGURE 1:** Banana Paper under scanning electron microscope

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