Diagnosis of the Practices and Methods for
the Development of New Products from
the Banana Fibers in the Department of Huila

Yessika Paola Sánchez Betancourth\textsuperscript{1}, Stephanie Paladínez Perdomo\textsuperscript{2} and Diego Fernando Suarez Cortes\textsuperscript{3}

\textsuperscript{1} Corporación Universitaria del Huila - CORHUILA, Neiva, Colombia
\textsuperscript{2} Corporación Universitaria del Huila - CORHUILA, Neiva, Colombia
\textsuperscript{3} Corporación Universitaria del Huila – CORHUILA, Neiva, Colombia

Copyright © 2018 Yessika Paola Sánchez Betancourth et al. This article is distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Abstract

The objective of this research is to characterize the current situation of the practices and methods used to create new products from the harvest and post-harvest processes of the banana crop. Bananas’ morphology is composed of a central stem, colines, flower, leaf in development, pseudostem, cluster, rachis and leaves. This article is aimed to identify the companies and / or people who are dedicated in the development of products from the banana fibers. It will also provide alternatives to take advantage of this waste, helping not only the environment but industrial development in the Department of Huila, hand in hand with environmental management.

Keywords: Waste, fibers, products, alternatives

I. Introduction

The use of waste is understood as all those successive phases of a process, which initially use a waste as raw material in order to add a value to obtain a usable product or by-product. Currently, worldwide there is a tendency to reuse and take advantage of different organic and inorganic waste for the creation of new products that impact
in a friendly way with the environment. To this can also be added the deficient normativity of government policies regarding the conservation of natural resources, as well as the inadequate final disposal of the different waste generated. Although the objective is not only to reduce the existing pollution generated by them, it is also necessary to generate new entrepreneurship opportunities from the generation of value to the different organic crops, allowing to reduce costs and collect new profits. In the Department of Huila, there is knowledge of the existence of a sustainable ecological project, located in the south of Huila, which from the transformation of the banana pseudostem waste it has managed to obtain fibers that are later transformed into packaging for all types of products. This has led to an important advance in the use of organic waste seeking to generate subproducts from the first to the last stage of the banana.

(Nación, 2016) [11]
The banana belongs to the Musaceae family, native from Southeast Asia, and includes two species: Musa Cavendish (bananas) and Musa paradisiaca (bananas). (Gob.Est. Colima, 2005), Musa textile Musa species (abaca, manila, hemp) are used to make clothes, cords, threads, interior linings of vehicles. The common fiber that is extracted from the dry petioles and the pseudo stem of the plant are used in the manufacture of certain papers. (Meneses, 2010) [9]. Fibers in Colombia are used to make handicrafts, and regarding the use given, there are textile fibers, the fibers to make brushes and brooms, fibers for braided fabrics, natural fabrics, and fibers to make paper. According to data presented by Artesanías de Colombia, Colombians use 114 plant species to extract plant fibers being the most important those of cotton and fique.

For this, the present investigation allows to make a diagnosis of the current situation from the point of view of methods and practices in which products are being developed from the fibers obtained from the banana, considering some aspects such as organizational, commercial, production and human factor.

(Artesanía, 2014) [2]

II. Theoretical development

Morphology of the banana

Picture 1 Morphology of the banana
Pseudostem

"The part of the plant that resembles a trunk is, in fact, a false stem called pseudostem, and is formed by a tight set of superimposed leaf sheaths. Although the pseudostem is very fleshy and consists mainly of water, it is quite strong and can support a cluster of 50 kg or more. As the leaves emerge, the pseudostem continues to grow upward and reaches its maximum height when the true stem - the floral stem that supports the inflorescence (see below) - emerges at the top of the plant.

Leaf

The leaf is the main photosynthetic organ of the plant. Each leaf emerges from the center of the pseudostem as a rolled cylinder (see below, leaf cigar). The distal end of the lengthening leaf sheath contracts to form a petiole, more or less open depending on the growing. The petiole becomes the central rib, which divides the limbus into two middle sheets. The upper part of the leaf (beam) is called the adaxial surface (lower) while the lower part is called the adaxial surface. The first rudimentary leaves produced by a growing child are called flakes. The leaves in mature state, which are called true leaves, consist of pod, petiole, central vein and limbus. In the sheets, the ribs run in parallel in a long s-shape, from the midrib to the margin. As they do not branch, the leaves tear easily.
**Rachis**

The rachis is the stem of the inflorescence, which goes from the first fruit to the male bud. It may be bare or covered with persistent bracts. The scars on the spine, which indicate where the bracts were attached, are also known as nodules.

**Stem**

The true stem is a large, starchy, underground rhizome, which is crowned with buds and develops once the plant has blossomed and fructified. As each rhizome pacifier reaches maturity, its terminal bud becomes an inflorescence when pushed up from the inside of the soil by the lengthening of the stem, until it emerges above the pseudostem.
Flower

Yellowish flowers, irregular, and with six stamens, of which one is sterile, reduced to petaloide staminode. The gynoecium has three pistils with inferior ovary. The whole of the inflorescence is the "rule" of the banana tree. Each group of flowers arranged in each bract is a gathering of fruits called "hand", containing from 3 to 20 fruits. A regime cannot be more than 4.

Calceta

The Calceta of banana fiber, the use of which is very different to the sock of banana split into ribbons, was discovered in the 1980s by an artisan of Huila, who took off the fibers, the bark of the banana stem, spinning it and her weaving on a loom of likewise for the sisal. The result was the origin of a new material which are currently the same products that are traditionally done with fique." (Vezina, 2016) [19]

Agro-ecological conditions for the cultivation of banana

Altitude: It is a condition that determines the banana growing season in accordance with the variety, adapting itself in a wide range that goes from zero meters to 2000 meters above sea level.
Temperature: It is a factor that determines the frequency of the leaves and it depends on the period of the plant to be longer or shorter.

Precipitation: The banana cultivation requires for its normal development and good production, well distributed rainfall during the year.

Winds: It is not recommended to set the crop in areas of strong winds in excess of 20 kilometers/hour, because they can cause damage to the leaves as bending or breakage, affecting production.

Relative Humidity: The relative humidity of the environment should be adequate (75-80 %), given that high humidity conditions could favor the presence of diseases caused by fungi.

Brightness: Must be good amount of daylight, so plants are developed properly (leaves, clusters, buds or side shoots). Otherwise, the low availability of light slows down production and affects the fruit quality.

Soil: Banana requires soil surveying undulating to flat, deep, well drained, fertile and good amount of organic matter of middle and loose texture (sandy to loamy-clayey and sandy soils). (DANE, 2014) [4]

**Harvest and post-harvest**

Harvesting is done by picking bunches of bananas between 70 and 100 days after flowering, when they are fully developed; that is, in a Green State, with full, rounded fruits and without sharp edges. The collection begins with the Puja of the pseudo stem so the plant double slowly, avoiding that cluster hits the ground; is cut from the plant and is transported in the shortest time to the site's benefit without abusing it or expose it to the Sun. (García, 2017) [6]

Regardless of the target market, the benefit seeks always to improve the presentation, which can be in clusters or packed in boxes or bags; extend the time of greenery, and avoiding the attack of fungi in stalk. In the case of packaged in boxes or bags, must be the bathtubs below the dark line that connects the fingers with stem, looking for bananas falling loose to the tank of weaning, in where you remain submerged for a few minutes in a mixture of Water-Alum - merteck. Bananas are packaged in boxes of 25 kg; These are arranged on pallets protected indoors.

**Regulations or legal ligaments in banana material.**

At the national level we find the Federation Fedeplacol, of bananas from Colombia, created on July 10, 2010, in the city of Pereira. This entity has issued a number of manuals, magazines including counting with the support of ICA (Colombian Agricultural Institute) for the publication of the following documents:

• Certification BPA. (Good Agricultural Practices)

On the other hand, we find the Colombian Institute of technical standards and certification, ICONTEC, National Agency for Standardization, 1993 Decree 2269,
1190, speaking about requirements that must be met by bananas intended for consumption standard.

III. Field work

The development of this research project, was held in the city of Neiva, located in Huila Department. To determine the index of banana crops, we went to the Secretary of agriculture and mining in the government of Huila, where shared us information of the livestock evaluation of the sown hectares of banana single and sandwiched in the areas of North, West, Central, and South of the Department, which is updated annually. In the following charts, you will find the amount of single and sandwiched banana, which is in the Department, while quantities of acres that we find by municipality.

Figure 1 Only Banana - Ministry of Agriculture and Mining in the province of Huila 2018

Figure 2 Interleaving Banana – Secretary of Agriculture and Mining in the province of Huila 2018
Figure 3 Center of Huila - Secretary of Agriculture and Mining in the province of Huila 2018

Figure 4 North of Huila - Secretary of Agriculture and Mining in the province of Huila 2015
On the other hand, was an investigation of the platforms of the library of the University Corporation of Huila - CORHUILA, to identify companies or individuals to the development of new products based on banana fiber; where found was a variety of companies that manufacture products based on banana fiber or support artisans who work with this, as it is C. I. SOEXIMCOL LTDA,. Seeking a balanced and fair community development by applying human talent to serve the community through the democratization of opportunities and resources. Which should generate employment and encourage integral human development. Its activity is the recovery, collection of paper waste tending by non-spam, focusing on environmental services and file artisan training, requiring the community to enjoy better conditions of life. So they should operate in the company with the proactive conviction of its partners in terms of efficiency and accountability, appropriate to offer products which meet their quality expectations to its distinguished clientele. Thus they will consolidate the leadership in the sector and will generate the resources needed for the achievement of social objectives through a solidarity approach that constitutes our company name. Their products are made of natural fibres such as banana stem, shell peas, pineapple fiber, amero of corn, onion fiber or fiber of garlic.(LTDA, s.f.) [8]

Also, an instrument of checklist was used for the people of Palermo-Huila and San Agustín - Pitalito, where it was found the company Libertejidos S.A., which is a company dedicated to the manufacture of products based on banana fiber. Once identified the companies, were to carry out field visits to the municipalities where you could buy accurate information of the current status of waste and its use, by means of direct observation. Finally, to complement the diagnosis, some samples to fibers were made in order to have more precise information about the components of this; this process was conducted in the laboratory.
IV. Results Discussion

Based on the bibliographic review, some characteristics were initially identified, and the uses that have been carried out in the world in relation to the different uses that can be obtained from the waste generated by the Harvest and Postharvest of the banana. The products found are the following:

<table>
<thead>
<tr>
<th>Part of the plant</th>
<th>Obtained product</th>
<th>Place of investigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pseudostem</td>
<td>Paper</td>
<td>Ecuador</td>
</tr>
<tr>
<td>leaf</td>
<td>Dishes and wraps</td>
<td>Medellín, Colombia</td>
</tr>
<tr>
<td>Raquis</td>
<td>Flour</td>
<td>Cuba</td>
</tr>
<tr>
<td>Stem</td>
<td>Paper</td>
<td>Caldas, Colombia</td>
</tr>
<tr>
<td>Flower</td>
<td>Food products</td>
<td>Madrid, España</td>
</tr>
<tr>
<td>Stocking</td>
<td>Prints and crafts</td>
<td>México - Colombia</td>
</tr>
</tbody>
</table>

Once the different products and companies that are currently transforming the bananas waste into new products are identified, it was determined in the Department of Huila what is the current situation in relation to the management of the waste generated by the harvest and post-harvest of the banana, as well as the methods of the fibers extracted from the residues of the banana.

According to the information collected, the municipalities to be visited were selected, where the first visit was to the farm of the president of the Plataneros and banana association ASOPOBLAB, Mr. Alfonso Achury, of the vereda La Lindosa, located in the municipality of Palermo and the municipality of Gigante, who explained the banana growing process, each part that composes the plant and its final disposal in the post harvest. At the same time, the following findings were determined:

The farm has 3 hectares of mixed cultivation, distributed between hartón Dominican banana and coffee; currently between 300 and 650 kilograms are collected weekly, with a total of 8 tons per month. The farmer states that during the harvesting process no fertilizers or germinators different from what is used for planting coffee crops are used, and the seed that has been used for many years is used. When he was asked if he had knowledge about the use that was currently being given to the residues from the harvest and post-harvest of the banana, he said he had no knowledge, but he has observed that it is used in crafts.
As a leader of the Association of Plátano Growers, he expressed that the support of the departmental government is very limited, and that, due to lack of training and technical advisory in the sector, farmers have been unaware of the different product/sub-product alternatives that can generate based on the Fibers or other parts of the Banana Plant, which, if possible, the sector is stuck and leads to the deterioration of its competitiveness. Similarly, he mentioned that the generated waste is only used as composting for the same crop.

The monitoring of pests and diseases in the cultivation areas is very important for the sector since the quality of the plátano depends on that in a large extent, the farmer indicates that the crops are mostly kept clean which helps to reduce or maintain little presence of pests in crops, this has led to little chemical products being used which are also environmental pollutants.

According to the producer at present the commercialization of the product has been achieved directly from the producer to the marketer with the collection centers that exist in the municipality, or in the local market. The reasons why farmers have chosen this crop as their agricultural activity are initially to maintain the tradition of the area, which is currently dedicated to the production of Plátano for being one of the foods in the family basket. Second, for the facility of handling that is given to the crop. (Achury, 2018) [1]

The conclusions of the investigation in general must be clear and conclusive, taking into account that they are the results of the entire research process and that is the contribution to the scientific community in the researched area.

![Picture 8 Business practice in Palermo](image-url)
The company Libertejidos S.A.S, is a company dedicated to the elaboration of handcrafted products in fiber of banana. It is located in the Strait of Magdalena River in the municipality of San Agustín, south of Huila; where its founder, Mrs Lisbina Becerra, entrepreneur, told us: "the process we have had has been very important, since we have had enough knowledge of different topics. I thank to the entities, particularly the Chamber of Commerce of Neiva for having us in mind in this process. "This innovative company produces packaging, crafts such as bags, hats, paper, wallets and have as an initiative, the manufacture of clothing with plátano fiber waste as an added value. Lisbina added: "My mother was the one who made the discovery of plátano fiber and since then, it was the legacy that she left us and we wanted to take it forward. With these resources we will seek to further enhance this process through laboratories, so that foreigners and their own know how to develop the packaging and the process with fiber."

Once the companies and/or people dedicated to the use of the waste were determined, we proceeded to verify the conditions of the raw material and the operations of the different processes for this is taken into account the concepts applied within the academic formation as industrial engineering, in aspects such as security, planning of production, organization and methods, innovation and development, we will use worksheets.

**Current process for obtaining products from banana fiber**

It was found that in the company Libertejidos, the procedure for the creation of the products is described with a series of tasks carried out in each area and under what conditions they are found.
1. Reception of raw material: This task is carried out within the storage area, where it lasts approximately 15 to 30 minutes depending on the amount of raw material needed for the process. This is linked to the production per order.

2. Embroidery: This activity is a little complex, since if, for example, it is about making a 10x10 cm doll, it takes approximately 25 minutes and this job consists of a worker, a Rimax ® chair and a table where there are her implements and working tools.

3. Spinning: This area consists of a Rimax ® chair, a spinner, which separates the fibers and a worker, who is in a position inclined by the height of the spinner.

4. Assembling: This activity involves interlacing the threads, where the worker has a chair by her working table.

5. Weaving: This area is where the work force concentrates the most and consists of 3 people. It lasts about 1 hour to make between 15 to 20 cm of tissue.

6. Dyeing: This task is completely manual and open, that is, it is performed by 2 people, who must work standing up and sometimes in a squat style, when soaking the fibers in dye. The dyes are sometimes natural, extracted from the coffee husk, flowers, among others.

The final products made with this fiber range from decorative type, to personal and domestic use, creating tablecloths, placemats, coasters, hats, clothing, handbags and a wide range of accessories. These objects are exhibited in the different handicraft points in the municipality of San Agustín and in this way the banana fiber is integrated into the local economy through artisanal work, to become the livelihood for many families that are complemented by the agricultural activities of the population.

Picture 10 Production of Libertejidos Company
SWOT Analysis

Table 2 SWOT Analysis – Palermo and Gigante

<table>
<thead>
<tr>
<th>MUNICIPALITIES OF PALERMO AND GIGANTE</th>
<th>STRENGTHS (S)</th>
<th>WEAKNESSES (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Use of the scion as organic composting for the banana crop.</td>
<td>• There are no alliances between department and municipality.</td>
</tr>
<tr>
<td></td>
<td>• Interest of the people for the acquisition of technical knowledge.</td>
<td>• Lack of knowledge about the use of banana waste.</td>
</tr>
<tr>
<td>OPPORTUNITIES (O)</td>
<td>• Presence of companies that take advantage of banana waste.</td>
<td>• High demand for input prices.</td>
</tr>
<tr>
<td></td>
<td>• Higher demand in the plantain crop.</td>
<td>• High demand for quality in the products.</td>
</tr>
</tbody>
</table>

Table 3 SWOT Analysis - San Agustin

<table>
<thead>
<tr>
<th>MUNICIPALITY OF SAN AGUSTIN</th>
<th>STRENGTHS (S)</th>
<th>WEAKNESSES (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Accessibility to raw material.</td>
<td>• They do not have trained personnel.</td>
</tr>
<tr>
<td></td>
<td>• Innovation in products.</td>
<td>• Lack of productive processes.</td>
</tr>
<tr>
<td>OPPORTUNITIES (O)</td>
<td>• Government support with the FONDE EMPRENDE.</td>
<td>• Lack of capital for investment.</td>
</tr>
<tr>
<td></td>
<td>• Market opening.</td>
<td>• Elevation in taxes.</td>
</tr>
</tbody>
</table>

Finally, some samples of the banana fiber from the municipality of Palermo were taken to make a comparison between this fiber and other similar fibers, which were cotton fiber and nylon. In this comparison, it was intended to check the physical and chemical properties of each of them. In the SENA Servicio Nacional de Aprendizaje (The National Training Service), tests were carried out to establish the physical properties such as the measurement of thickness and tension property, both for banana fiber and nylon. According to the results, it can be observed that their characteristics tend to be similar under the same environmental conditions.
In the company Engineering and Laboratory Services, physicochemical testing applications were carried out, where the characteristics of humidity and ash are established, under the gravimetric test method, as well as, oxidizable organic carbon and/or organic matter under the volumetric test method, which is found in the NTC 5167. Finally, the requested test of the fiber by means of the alkaline method.

V. Conclusions

In the results obtained from the visits to the municipalities, it was possible to determine that the current destination of these wastes is not good, since they are not taking advantage of them just as in Palermo and Gigante, where there is little information about the management and technification of waste. On the other hand, it was found that in the municipality of San Agustín, they do have the knowledge to use the waste from the banana plant and they are currently investigating and innovating products such as hats, bags, paper, among others. Finally, it was found that, in the department of Huila, there is a high availability of raw material (banana crop waste) for the creation of new products. Likewise, there is a high level of ignorance about the use of this. Through this research study, it is desired to disseminate the information obtained so that entrepreneurship programs are run through this alternative, which could be the creation of textile fabrics, wood, paper, among others to be able to contribute with the economic growth of the department.

References


Received: July 25, 2018; Published: August 22, 2018