Manufacture of a non-woven using bamboo cellulose base *(angustifolia)* as a filter medium for the manufacture of masks

1st Willam Esparza, 2nd Wilson Herrera, 3rd Luis Chamorro
Technical University of the North, Faculty of Engineering in Applied Sciences, Textile Career, Ibarra, Ecuador
email1: wresparza@utn.edu.ec, email2: waherrera@utn.edu.ec, email3: lachamorro@utn.edu.ec

Abstract

The purpose of this study was to produce a non-woven, using a base of bamboo cellulose (angustifolia) with a particle size of 1mm, and it begins with the weighing of 100 g bamboo cellulose, which is mixed with a bath ratio bamboo / water 1:10 in a mixer grinder, placing 1 liter of water mixes and forms a viscous solution, this solution is placed on a frame stretched with polyester woven mesh and another frame without mesh, once the layer is formed, it is remove the upper frame without mesh and compress it manually with a sponge, removing excess water and drying in the room at a temperature of 20 ^{0}C for 8 hours, evaporated the moisture from the bamboo cellulose (angustifolia) and dried, separated from the frame and a laminated nonwoven (filter) was obtained. Finding that the breaking strength and its elongation in thickness of 0.3mm is 2.73 N and 0.895 mm respectively and thickness of 5mm is 31.2 N and 1.01 mm. The resistance and extension is very low in the two cases, and there are no statistically significant differences between their sample medians (p> 0.05). It can be concluded that when using bamboo cellulose base with a particle size of 1mm, and forming the non-woven with thickness of 0.5mm and 3mm, it has low resistance and extension, finding that if the raw material has an influence on the conformation of the non-woven.

Keywords: Bamboo, non-woven, filter

1. Introduction

The research focuses on the elaboration of a filter based on bamboo cellulose *(angustifolia)* intertwined between its fibers known as non-woven, taking advantage of the fact that bamboo is a cellulosic non-timber forest resource found in nature, since 1990 The need for the environment arises and promotes bamboo research, in conjunction with several international donors, creating the International Network on Bamboo and Rattan (INBAR) with the support of the International Center for Development Research (IDRC), (FAO , 2017). In order to benefit from its properties and characteristics, it can be used from food for human and animal consumption, beverages, clothing, medicine, coal, paper, soaps, cleaning products among others. (BAMBUCYT, 2018), Because it is a grass, it has properties that can be used as a fiber with particular and natural antibacterial, bacteriostatic and deodorizing functions, bamboo has a unique bioagent against bacteria and bacteriostasis called "Bamboo Kun". This molecular substance is hermetically found all the time during the process of being produced in bamboo fiber. (Bambro textile Co., 2017).

Silman, details that there are in the south west Amazon of Peru large areas of bamboo covering an area of 180,000 km^2 and dominate the largest areas of tropical virgin lands on the planet. (Nelsón 1994 citado en Saatchi et al 2000 citado en Miles R. Silman, 2015). With its different properties according to the cultivation site, as expressed in the Technological University of Pereira on the physical characteristics of Guadua angustifolia fiber bundles in: percentage of moisture content, percentage of water absorption, average apparent density, shape and texture (Universidad Tecnológica de Pereira, 2007). In addition, in the National University of Colombia in 2002, I developed an investigation on the taxonomy of the two classes of bambusoideae existing in America, on the anatomy of the leaf blade and culm, emphasizing preservation methods. (Universidad Nacional de Colombia, 2002).

Until now, the behavior of the material when subjected to mechanical characterization tests is not adequately known. In this work, it was sought to evaluate bamboo (Guadua angustifolia) specimens subjected to the simple compression test (Antonio Ludovico Beraldo, 2007). In addition, the bamboo fiber (cut) guadua angustifolia, at the National University of Colombia conducted the study to determine the resistance to compression parallel to the fiber and the modulus of elasticity. (Universidad Nacional de Colombia, 2007), developing a construction manual for anti-seismic earthen houses, through the use of bamboo as an alternative method, where the vertical reinforcements of the mud wall are placed with 2.5 to 5 cm thick bamboo canes (Universidad de Kassel, Alemania, 2005). Where, through this fiber, the publication of the optimization of the production of activated carbon from bamboo (Bambusa vulgaris striata) was made (Revista Mexicana de Ingeniería Química, 2010), Research was carried out on the characteristics of bamboo fibers (Dendrocalamus giganteus), in their anatomical, chemical, and physical-mechanical compositions, according to the ABNT and EN standards. (Universidad Tecnológica Federal Do Paraná , 2012).

From the analyzes carried out by China Textile Supervision National Testing Center, with the support of Bambrotex, a company related to the production of Bamboo fibers, finding that bamboo has good physical, chemical and biological properties (Bambro textile Co., 2017). Especially applied in new fields due to their resistance, such as the aeronautical industry that replaces carbon fiber, fiberglass, and kevlar, which due to their favorable aspects during the period of use work against the moment of their degradation (Lucena, Suarez, & Zamudio, 2009). Its use has been aimed exclusively at construction, such as the research carried out in the Canton Bucay Ecuador on the benefits of Guadua angustifolia with a scientific analysis on the amount of water in stems and woody tissues of the stems, (Dávila, 2013).

Cellulose is renewable, biodegradable and biocompatible, it can be used as a raw material in packaging materials. Due to its immiscibility, it is usually converted into derivatives to make it more processable such as: cellulose ethers such as methylcellulose (MC), carboxymethylcellulose (CMC), hydroxypropylcellulose (HPC), hydroxypropylmethylcellulose (HPMC) (Camacho et al, 2011). These advantages are taken advantage of in the shaping of medical-sanitary tissues due to its action to prevent allergic phenomena and skin infections, drapery due to its antibacterial and permeability functions (Observatorio Industrial del sector textil/confección, 2015).

Advantages that can be exploited with an analysis of the best option in the fiber production stages, as indicated (Rosero, Rosero, Esparza, & Esparza, 2018), it is necessary to carry out physical and / or chemical treatments to the bamboo cellulose. The bamboo cellulose is extracted using the alkaline method with sodium hydroxide flakes. This process is carried out at a temperature of 150 ° C, with a time of 6 hours and a 1:10 bath ratio (bamboo / water), the yield is in the order of cellulose 11.39%, 41.61% and 44.8%. In addition, lignin was removed in 88.6, 58.39 and 51.2 percent respectively (Esparza W. , Rosero, Chamorro, & Herrera, 2018). Meanwhile, another procedure for obtaining cellulose was optimized by varying the time, temperature and concentration of sodium hydroxide. In addition, the best cellulose yield was obtained after the entire process and a reaction percentage of 44.05% cellulose was achieved after 5 hours of extraction (Jiménez & et al, 2011) . And applying the study of vulcanized elastomeric mixtures composed of natural rubber NR and styrene butadiene rubber SBR. They are two of the most widely used elastomers on a global scale for different industrial applications (Mansilla, 2012), achieving the formation of a polymer. These compounds are mixed components, they improve the physical and thermal properties of elastomers.

2. Methodology

The nonwoven (filter) elaboration process was using bamboo cellulose (angustifolia), with a particle size of 1 mm. Obtained from the separation process with lignin using the alkaline method as indicated (Esparza W. , Rosero, Chamorro, & Herrera, 2018) at a temperature of 150 0C, 6h and bath ratio (bamboo / water) 1:10 as variables the alkali and the alkali / bath ratio, the cellulose yield 11.39, 41.61 and 44.8%. Furthermore, lignin was eliminated in 88.6, 58.39 and 51.2% respectively.

2.1 Materials

The following materials were used to form the nonwoven:

• Balance
• Tray
• Frame tensioned with mesh
• Frame without mesh
• Mixer crusher
• Canvas
• Sponge

2.2. Process

The particle size of the bamboo cellulose base (angustifolia) used was 1mm, and it begins, with the weighing of the bamboo cellulose 100 g (c) which is mixed with a ratio of bamboo / water bath 1:10 in a mixer grinder (b) placing 1 liter of water, mixing and forming a viscous solution (d), this solution is placed on the frame stretched with mesh and the frame without mesh (e), once the bamboo layer is formed, Remove the upper frame without mesh (f) and compress it manually with a sponge (g), removing excess water to dry at room temperature at 20 °C for 8 hours (i) as shown in graph 1.

Graph 1. Process for obtaining non-woven (filter) from bamboo cellulose

Compressed, the moisture evaporated from the bamboo cellulose (angustifolia) and dried, the non-woven that was on its frame was separated (h), a laminated non-woven (filter) of 0.5 and 3 mm thick (i), with a smooth characteristic on the surface, of a beige and rigid color. Resistance and extension tests were carried out on the elaborated nonwoven, in order to determine the properties acquired in the formation process by means of the Titan 5 universal Strength Tester dynamometer equipment, using the ISO 13934-1: 2013 STANDARD as shown in graph 2.

Graph 2. Bamboo Nonwoven (Filter) Strength and Expansion Test

3. Results

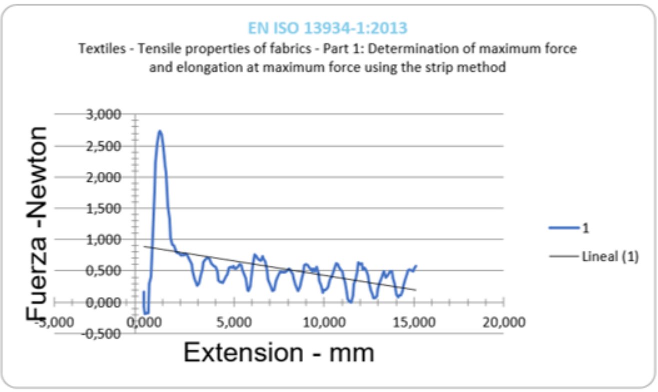
To determine the tensile strength and extension to breakage of paper and others, in the elaborated bamboo nonwoven, the strip method was used according to the ISO 13934-1: 2013 standard, the results and data found with the thicknesses of 0.5 and 3 mm were the following, indicated in table 1.

Table1. Results with 0.5 and 3 mm thick non-woven bamboo

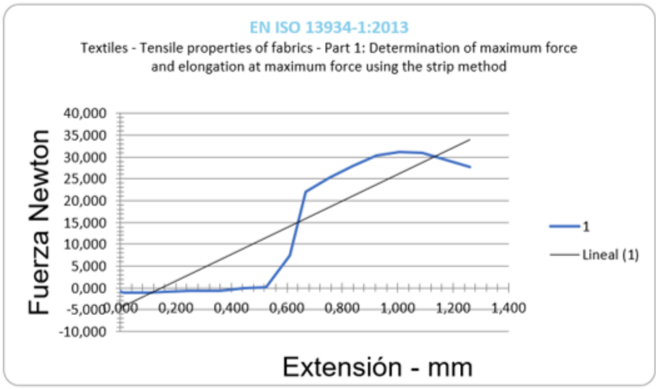
Reading Índex	Extension With thickness 0.5 (mm)	Force (N) With thickness 0.5 (mm)	Extension With thickness 3 (mm)	Force (N) With thickness 3 (mm)
1	-0,001	0,166	0,000	-0,627
2	-0,001	0,066	0,000	-0,797
3	-0,001	-0,076	0,000	-0,962
4	0,058	-0,184	0,012	-1,025
5	0,140	-0,180	0,101	-1,081
6	0,223	-0,173	0,165	-0,954
7	0,306	0,290	0,249	-0,781
8	0,391	0,403	0,360	-0,658
9	0,476	1,064	0,444	-0,173
10	0,559	1,752	0,526	0,041
11	0,644	2,231	0,612	7,443
12	0,727	2,542	0,668	21,957
13	0,811	2,711	0,755	25,177
14	0,895	2,730	0,838	28,006
15	0,978	2,685	0,922	30,314
16	1,062	2,465	1,007	31,197
17	1,146	2,163	1,090	30,926
18	1,228	2,064	1,175	29,250
19	1,313	1,531	1,259	27,622

3.1 Strength and extension with thickness 0.5 and 3 mm

According to graph 3a, with the data found from the dynamometer equipment, the resistance and extension were obtained, showing that the nonwoven (filter) made with bamboo cellulose with a thickness of 0.5 mm resists a maximum breaking force of 2.73 Newton and reached to obtain an extension of 0.895 mm indicating that it does not have a good resistance to breakage, in addition its extension is very low causing it to break with a minimum force with a tendency to decrease, while with a thickness of 3 mm, it was found that it resists a breaking force of 31.02 Newton and an extension of 1.01 mm with a tendency to increase according to figure 3b.



a. Strength and extension thickness 0.5mm

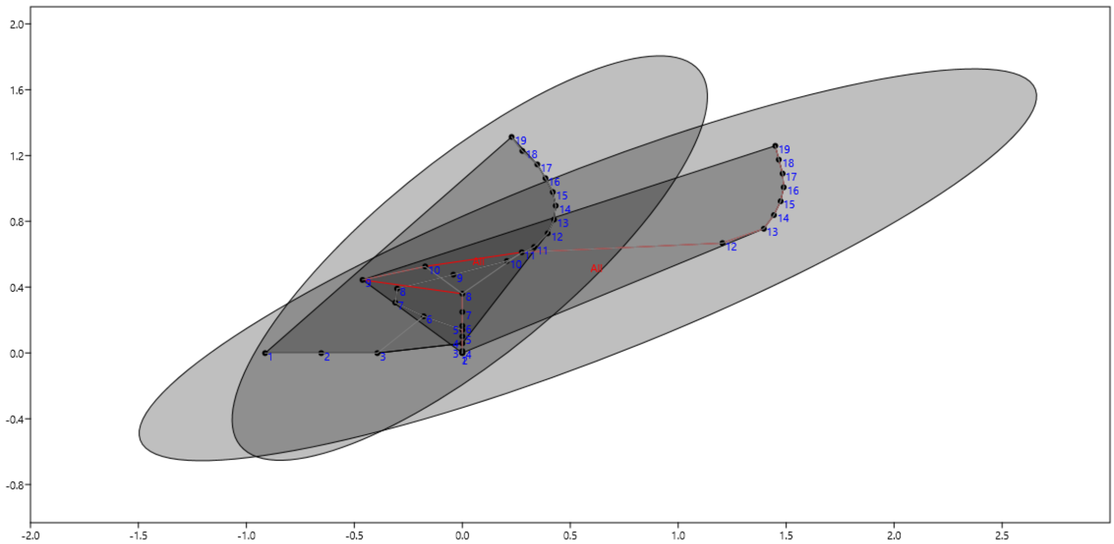


b. Strength and extension thickness 3mm

Grph3. Strength and extension thickness 0.5 and 3 mm

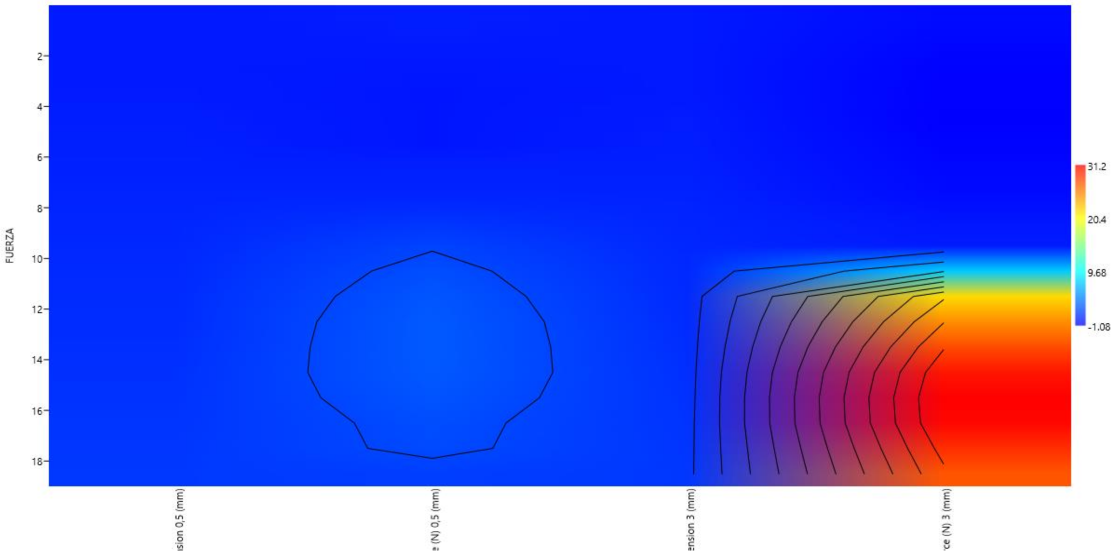
4. Discussion

In the graph in x, y past, it can be observed that all the data are within the eclipse with a reliability of 95%, there are data that are concentrated in the center indicating that they are uniform and have correlation between them and few data are a little distant in group from their correlation, expressing that all the data obtained are reliable as shown in graph 5.



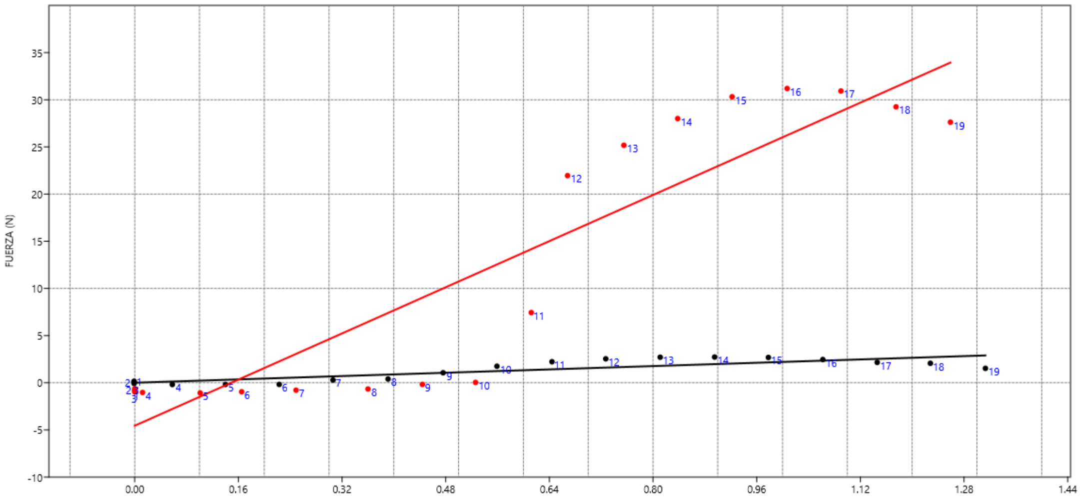
Graph4. Correlation between thicknesses of 0.5 and 3 mmm

While in the Matrix Plot graph, it is possible to distinguish the similarity between strength and extension of the nonwoven with a thickness of 0.5 mm, concentrating little data on its extension, while in the 3mm thickness it is observed that, initially both its strength and extension They are similar to that of 0.5 mm with a tendency to increase in resistance as its extension increases, indicated in graph 6.



Graph 5. Correlation of 0.5 and 3 mm thicknesses

On the other hand, in the One –way Ancova graph, it is shown that using the bamboo cellulose base with a particle size of 1 mm, as we increase the thickness of the bamboo non-woven from 0.5 to 3 mm respectively, the resistance increases. And the extension as detailed in figure 7.



Graph6. Trends according to thickness 0.5 and 3 mmm

When using the raw material with a particle thickness of 1 mm for the elaboration of the bamboo nonwoven, it was found that, with the two thicknesses obtained of 0.5 and 3mm, the resistance and the extension are very low in both cases, and not there are statistically significant differences between their sample medians ($p > 0.05$). Taking into account the bamboo with its culm they are more resistant as indicated (Lucena, Suarez, & Zamudio, 2009) its lightness and high modulus of rupture (from 9000 to 10100 N / mm2) and elasticity (84 to 126 mm) make bamboo an ideal material for construction greater than steel. While the non-woven analyzed, with a thickness of 0.5mm, it was found that the breaking strength and its elongation is 2.73 N and 0.895 mm respectively and with a thickness of 3mm it increased to 31.2 N and 1.01 mm.

This low resistance and elongation in the analyzed laminated nonwovens is possibly due to the particle size of 1 mm used as raw material, as determined (Esparza , Rosero, Herrera, & Chamorro, 2018) with a particle size between 20 to 0.05 mm. The result found was a cellulose base with a higher yield of 44.845% using an intermediate particle of 15 mm. It was found that the smaller the bamboo particle, the lower the percentage of cellulose base separated from the lignin. That is, if the particle size used in the formation of laminates has an influence, the longer the fiber obtained in the cellulose has more resistance as indicated (Noé, 2016) The pulp mixes bagasse and pulp from Kraft 70-30 bags presents the highest amount of long fiber. This material forms a closed and not very porous structure, which prevents the long fiber fraction from working optimally.

5. Conclusion

It can be concluded that when using bamboo cellulose base with a particle size of 1mm, and forming the nonwoven elaborated with thickness of 0.5mm and 3mm, it has low resistance and extension, finding that if the raw material has an influence on the conformation of the no tissue. With this finding, it is necessary to carry out more studies with different cellulose particle sizes to show that it improves its properties.

6. Recognition

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7. References

Antonio Ludovico Beraldo, D. A. (02 de 10 de 2007). Técnica de Moiré aplicada al análisis de esfuerzos de compresión en el bambú guadua. concepción, Brasil: Madera, Ciencia y Tecnológia.

Bambro textile Co., L. (20 de Enero de 2017). *Bambrotex.* Obtenido de recuperado el 20 de enero de 2017: http://www.bambrotex.com/second/bc_nab.htm

BAMBUCYT. (2018). Propagación manejo y silvicultura. (F. Morocho Galarza, & G. Gutiérrez Tejada, Edits.) *1*(1), 36.

Dávila, P. R. (2013). Percepciones locales versus evidencia científica sobre la relación entre el bambú y el agua en el Cantón Bucay, Provincia del Guayas, Ecuador. *Tesis de Maestria no publicada*. Cuenca, Azuay, Ecuador: Universidad de Cuenca.

Esparza , W. R., Rosero, E., Herrera, W., & Chamorro, L. (2018). Influencia del tamaño de la partícula de bambú angustifolia en la obtención. En U. T. Norte, *Memórias del VI congreso UTN* (pág. 346). Ibarra: UTN.

Esparza, W., Rosero, E., Chamorro, L., & Herrera, W. (2018). Obtención de celulosa a partir del bambú (angustifolia) para materia prima en la fabricación de fibra textil. En UTN, *Tendencias Tecnológicas Aplicadas a la Ingeniería* (pág. 263). Ibarra, Imbabura, Ecuador: UTN.

FAO . (2017). *Red internacional del bambú.* Beijing: FAO.

Jiménez , G., & et al. (Diciembre de 2011). Obtención de carboximetil celulosa usando lemna como materia prima. *Revista Iberoamericana de polimeros, 12*(6). Recuperado el 25 de Mayo de 2017, de http://www.ehu.eus/reviberpol/pdf/DIC11/genire.pdf

Lucena, M. P., Suarez, A., & Zamudio, I. (29 de Julio de 2009). Desarrollo de un material compuesto a base de fibras de bambu para aplicaciones aeronauticas. Cartagena de Indias, Colombia: Universidad de San Buenaventura.

Mansilla, M. A. (2012). Influencia de la microestructura en las propiedades mecánicas y térmicas de mezclas de caucho natural y caucho estireno butadieno. *Tesis doctoral. Universidad de Buenos Aires. Facultad de Ciencias Exactas y Naturales*. Buenos Aires, Argentina. Recuperado el 13 de Agosto de 2020, de https://bibliotecadigital.exactas.uba.ar/download/tesis/tesis_n5117_Mansilla.pdf

Nelsón 1994 citado en Saatchi et al 2000 citado en Miles R. Silman, E. J. (2015). *Los bosques de bambú en la amazonía occidental.* Reynolda Station, NC 27109-7325 USA: Departamento de Biologia, Wake Forest University.

Noé, A. R. (2016). Pulpa de bagazo de caña con alto índice de fibra larga. *Revista Técnica de la Facultad de Ingeniería Universidad del Zulia, 39*(2).

Observatorio Industrial del sector textil/confección. (2015). *Materias primas para el sector textil/confección. Opciones de futuro.* FEDIT.

Revista Mexicana de Ingeniería Química. (2010). Optimización de la producción de carbón activado a partir de bambú. *Revista Mexicana de Ingeniería Química*, 359-366.

Rosero, E., Rosero, P., Esparza, W., & Esparza, D. (2018). Procesos de obtención de fibras textiles regeneradas celulósicas orientado al bambú: revisión de literatura. En U. T. Norte, *II Jornadas Internacionales de Investigación Científica* (Vol. II, pág. 884). Ibarra, Imbabura, Ecuador: UTN.

Universidad de Kassel, Alemania. (2005). *Manual de construcción para viviendas antisísmicas de tierra.* Alemania: Universidad de Kassel, Alemania.

Universidad Nacional de Colombia. (2002). *Distribución, morfología, taxonomia, anatomia, silvicultura y usos de los bambues del nuevo mundo.* Santafé de Bogotá: Universidad Nacional de Colombia.

Universidad Nacional de Colombia. (Enero-Junio de 2007). Resistencia a la compresión paralela a la fibra de la guadua angustifolia y determinación del módulo de elasticidad. *Universidad Nacional de Colombia, 11(1)*, 89-103.

Universidad Tecnológica de Pereira. (2007). *Estudio de las características físicas de haces de fibra de guadua angustifolia.* Pereira- Colombia: Universidad Tecnológica de Pereira.

Universidad Tecnológica Federal Do Paraná . (2012). *Características das fibras Do bambu (Dendrocalamus gigantueus) e potencial de aplicacao em paineis de fibra de media densidade (MDF).* Curitiba: Universidad Tecnológica Federal Do Paraná .