Brazilian Journal of Experimental Design, Data Analysis and Inferential Statistics

Federal University of Rio de Janeiro

BJEDIS, Rio de Janeiro, Special Edition, v. 01 (2), 2021

DOI: https://doi.org/10.55747/bjedis.v1i2.48357

ISSN: 2763-6925

Special Edition **Received 02/03/2021. Revised 03/17/2021. Accepted 03/30/2021. Published 07/01/2021.**

Production of Handmade Paper from the Sugar Cane Bagasse Pulping

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Abstract: Nowadays, Brazil is considered the leading country, worldwide, in the production of sugarcane. Therefore, it is also the largest producer of residual biomass: the sugarcane bagasse. This is produced in different activities, such as biofuel, beverage, and sugar production. As all conventional waste, if improperly disposed of it can impact the environment and therefore, it is necessary to use methods to recover this biomass so that it can be returned as a consumer good. Thus, this work aims to use sugarcane bagasse from pastry shops in Duque de Caxias, RJ, to produce paper using homemade techniques. In this sense, the pulping method was performed by cooking the fibers in a pressure cooker in alkaline medium, washing and drying. Subsequently, the fibers obtained were molded on an A4 screen. Two sheets and three replicas were produced. The results obtained showed that the paper production was efficient and the physical measurements, grammage, area, mass, thickness, height and width, calculated by ANOVA and Tukey's Method showed equal values in each case, which indicates the quality of the production. In addition, the physical characteristics classified them as Kraft type paper, which can be used in craft activities.

Keywords: recycling, residual biomass, sugarcane bagasse, paper, statistical analysis

Adherence to the BJEDIS' scope: This article presents statistical results by ANOVA and Tukey's method, thus verifying the veracity of the results obtained, as well as the significant differences in the analytical data. This is a fundamental step in chemical analysis, in this case, the statistical were primordially to know the efficiency of paper production.

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1. INTRODUCTION

The market for pulp continues to grow across the around the world. The explosion in the paper production has shown no signs of decrease, due to population growth. It is expected that the demand for raw material would surpass the supply of pulp, from highly limited forest resources. This has led the market and the researcher to look for suitable additional non-woody material resources for pulp and paper manufacturing. Thus, to search for new raw materials, biodegradation of lignocellulosic has been steadily stressed (1).

Sugar cane is a plant that can reach up to 6 meters in height, is thin and has large leaves. It is not known for sure when it was discovered, but it is believed that it was first found in the subcontinent of India approximately 2500 years ago. Previously, it was widely used in medicines, as well as luxury items, but over the course of use, sugar was then produced. This was produced in China, but only became known in 1493 on Columbus' second voyage. So, with the knowledge of the properties of sugar cane, it was introduced in the preparation of food and drinks (2, 3).

Sugarcane bagasse is a residue generated by the agricultural industry, its current applications range from the biofuels industry(4), even in the growth of microorganism cultures (5). The main producers are divided globally, being Brazil with, approximately, 181 million metric tons year, Mexico with 15 million metric tons year -1, and Colombia with 7 million metric tons year (6). In these three countries alone, the total is 203 million metric tons per year, but its improper disposal causes serious damage to the environment. In this sense, there is a need to use this material for new applications.

The processing of one ton of sugarcane, for any purpose, produces on average two hundred and fifty kilos of bagasse as a by-product (7). Between 60 and 90% of this material is used by the sugar-alcohol industry itself as fuel to generate energy and heat, which meets 98% of its energy demand. However, there is still a surplus that generates numerous environmental and storage problems (8, 9).

In terms of the constitution of the residue, it has three main fractions (cellulose, hemicellulose and lignin), which together make up more than 90% of the total mass (10).

Sugarcane bagasse can be used with high technological gains, especially when working with the isolated parts of the components that make up this biomass, such as cellulose, hemicellulose and lignin (11).

When performing a bibliographic survey taking into account the Capes Platform (2020), searching for the topic "Sugarcane Bagasse", 14,503 journals were found indicating the use of sugarcane bagasse for various applications. However, highlighting the theme "Sugarcane Bagasse Paper", 6,649 journals were found with different methods of using sugarcane bagasse for paper production. When performed the search for a more noble use as the production of biofuels were found 3,329 journals. For the use of sugarcane bagasse to produce microorganism cultures, 1,797 journals were found. Besides these, sugarcane bagasse can be used as a catalyst, being 1,923 journals found for this topic. This research shows that the sugarcane bagasse is a raw material with great potential for application and, this shows the importance of reusing, recovering and recycling this material (12–16).

It was possible to observe that the use of sugarcane bagasse for paper production has gained prominence, this occurs because the process involved in the treatment of fibers, known as pulping, is simple to handle, facilitating this application. In this sense, this work aims to use home-made techniques to make handmade paper produced by sugarcane bagasse pulping. The results obtained showed that it was possible to produce the Kraft paper (17).

2. MATERIALS AND METHOD

2.1. Sugarcane bagasse pulping.

The sugarcane bagasse samples were collected in a free market near the Federal Institute of Education, Science and Technology of Rio de Janeiro campus Duque de Caxias, according to the methodology recommended by NBR 10.007 (18). The material was collected in a pile at 10 am and had been processed less than 2 hours before (Figure 1). Due to the homogeneity of the physical aspect of the waste material, four simple samples were taken from the top, middle and bottom around the pile/mountain of the waste. These were mixed to obtain a composite sample. The solid material of the composite sample was fractionated into pieces of approximately 1 cm

size to obtain uniform fragments, giving rise to a homogeneous sample. Figure 1 shows the cane before and after liquid extraction. This is popularly known as sugarcane bagasse.

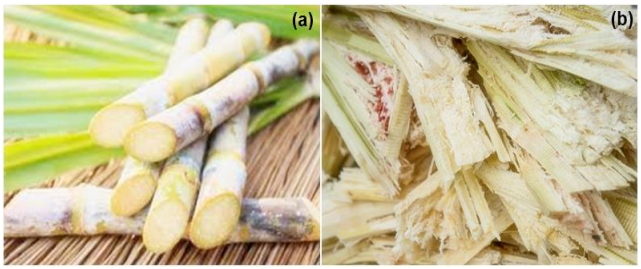

Figure 1. (a) Sugarcane and (b) Sugarcane bagasse.

For the preparation of the pulp, a stainless-steel pressure cooker (7L), scissors, spatula, 500 g C.E. scale (Certificate of Verification-ISO 9001), pH measuring tape, gloves, 1,500 mL measuring cup, sodium hydroxide (NaOH), water, sack cloth, stove, and canvas (opening: 1 mm, weight: 45g/m²) were used. After the separation of these materials, production started with the sugar cane bagasse already cut. 500 grams of bagasse, 2 L of water, and 20 grams of sodium hydroxide were used, in a 1:4 ratio, placed in a stainless pressure cooker and mixed these materials. It was left to stand for 15 minutes for the sodium hydroxide to react with the bagasse and for the mixture to reach room temperature (30°C). After this period, the pot was covered and cooked over medium heat (approximately 150°C). After the pot reached pressure, the material was left to cook for 40 minutes. After this period the pressure was removed from the pot and the final material was a pulp. In addition, the pH of the pulping residual water was measured, and the residual water was stabilized before disposal. Finally, it was stored in a plastic container and placed in the refrigerator.

2.2. Paper production

The paper production was done in three steps: The first stage consisted in the separation of the materials that would be used, being these, blender to grind the pulp, a large pot, to store the pulp, newspaper to put the paper to dry, glue, water and A4 canvas.

The second was to separate the pulp into four parts, each part was beaten separately, in 700 mL of water for 15 seconds, and then stored in a jar. This was done with the four parts of pulp. Then, 2 grams of glue was added to each 20 grams of pulp, to bind the fibers together and facilitate the formation of the paper sheet after drying. Then, the A4 fiber mesh was immersed in the pot of water and fibers and lifted up, so that the fibers were retained in the mesh and the sheet was formed. The part with the fibers was left on top of the newspaper and, with the help of a sack cloth, the back of the screen was dried in order to loosen the fibers in the newspaper. Then, it was placed to dry and waited for the paper to be obtained. After the fibers were dry, they were detached from the newspaper and, thus, the handmade paper was already obtained.

The third step consisted in cutting the leaves obtained, because some leaves had flaws due to the lack of fiber or even because they stuck to the newspaper. This occurred because it was obtained by manual method. Thus, the leaves obtained had an average size of 195 cm. Two blades with three replicas each were used.

2.3. Physical characterizations

To characterize a sheet of paper, some factors are taken into consideration, the mass (g) of the paper, the thickness that was measured using a digital caliper, the area (mm) and the grammage (g/cm^2) (19). All these are obtained through mathematical calculations:

2.3.1. Weight (g):

$$Mm = \frac{m\ (g)}{Qt} \quad \textbf{(1)}$$

Where:

Mm= average weight (g)

m(g)= mass of the papers weighed on scales.

Qt= Number of papers tested.

2.3.2. Area (mm^2)

$$Am = \frac{b * h}{Qt} \quad (2)$$

Where:

Am= average of the paper areas in millimeters

b= base of the paper in millimeters

h= height of the paper in millimeters

Qt= Quantity of paper tested.

2.3.3. Grammature (g/cm^2)

$$Gm = \frac{Am}{Mm} \quad (3)$$

Onde:

Gm= average weight ing/ cm^2

Am= average area in centimeters

Mm= average mass in grams

2.4. Statistical analysis:

The means of the variables obtained in the blades (mass, thickness, height and width, grammage and area) were compared using Tukey's test at 5% probability using the SigmaPlot 12.5 program (20).

3. RESULTS AND DISCUSSION

The paper obtained was shown in Figure 2.

Figure 2. Paper obtained from sugarcane bagasse pulping.

The results of the masses, area, thickness, weight, height and width of the leaves are shown in table 1. It was possible to obtain a pattern of mass, thickness, area, weight, height, and width in each case. The results obtained were satisfactory, taking into consideration the possibility of producing the papers with homemade techniques. This allows us to infer that even though it is a homemade technique to produce the leaves, it was possible to obtain a standard in these samples, which allows the uniformity of the production. No significant differences were observed between the blades. However, the manufacturing process is practically the same as conventional production, what changes is the extraction of cellulose, which comes from sugarcane bagasse. The paper produced has the same quality as ordinary paper with the advantage of not requiring the addition of chemicals and the consumption of as much water as recycled browns (21).

Table 1. Means values of paper physical analyses made with sugarcane bagasse.

Blade	Average weight (g)	Average tickness (mm)	Average height and width (mm)	Average area (mm²)	Average grammature (g/cm²)
1	3,42[a]	0,95[b]	139,67[c]	19553,17[d]	175,12[e]
2	3,54[a]	0,97[b]	139,33[c]	19553,33[d]	158,06[e]

Means followed by the same lowercase letter in the collumm do not differ from each other according to Tukey's test at 5% probability.

Additionally, the bagasse it satisfes requirements for a successful papermaking fiber better than any other crop fiber. This material, has been normally used in south China as fibers for paper production (22). There are several recommendations for using cellulosic waste materials for paper production. Pego et al (2019) have been showed bamboo and sugarcane bagasse as lignocellulosic materials that have potential to be used in pulp and paper industries in Brazil (23).

This shows that people can produce in their homes and make this production a source of income. The characteristics presented here define Kraft paper, which is widely used for craft applications, such as making invitations, gift wrapping, and party items with a rustic theme. Additionally, it can be used to prepare each of printing and writing paper, Bristol board, tissue, glassine and greaseproof paper, duplex and triplex paper, corrugating medium, linerboard, wrapping and bag papers, and newsprint (24).

4. CONCLUSÃO

Through the results obtained, it was possible to conclude that, the homemade techniques performed were efficient for the production of the pulps from sugar cane bagasse. Moreover, the glue was a good binding agent, because it allowed the molding of the fibers and after drying the paper was obtained. Due to the manual production, it was possible to identify some flaws, such as the agglomeration of the fibers in some parts of the paper, as well as the cutting of the sheets that influenced the size of the paper area. However, these factors did not harm the quality of the paper. Therefore, this work was of great importance, because it allowed the recycling of sugarcane bagasse, showing that it was possible to obtain a new product.

ACKNOWLEDGMENTS

This research was supported by the National Council for Scientific and Technological Development (CNPq-304500/2019-4, Coordination for the Improvement of Higher-Level Personnel (CAPES - Financial Code 001), Carlos Chagas Filho Foundation for Research Support of the State of Rio de Janeiro (FAPERJ).

Sample CRediT author statement

Fabíola da Silveira Maranhão: Conceptualization, Methodology, Data analysis, and Writing-Original draft preparation. **Sérgio Thode Filho**: Conceptualization, Supervision, Reviewing and Editing. **Fernando Gomes de Souza Junior**: Data analyses and Reviewing, **Daniela O. Gaspar:** Reviewing. **Cintia Patrícia Santos da Paixão**:

Reviewing and Editing. **Thuanny Moraes de Almeida:** Reviewing and Editing. **Emanuele Nunes de Lima Figueiredo Jorge:** Reviewing, Editing and Validation. **Ana Carolina Valle da Silva:** Reviewing.

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