Application of Talo Palmeira do Buriti (*Mauritia Flexuosa*) for Production of Sustainable Design

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***Abstract*— *Environmental problems are a matter of concern in all areas of knowledge. Pollution, disposal and degradation are part of the vocabulary and daily life of contemporary life. The systems of manufacture, recycling and pollution index generated by industries are in constant debate all over the world, for the search for alternatives that will solve these problems. The amount of disposal of non-degradable materials in the environment has increased steadily, and product packaging is a large part of this problem, mainly due to inappropriate disposal. In this context, the present work aims to extract nanocrystals (Poly lactic acid) from cellulose of the buriti petiole with potential for the technological production of sustainable design. To extract the dust from the buriti petiole, dry material was used, which was cut into small cubes and soaked in running water for twenty four hours. Next, the lactic acid poly (powder) was bleached, the color of the visual aspect was characterized under a microscope and the degree of water absorption was evaluated, the morphology and thermal properties of the lactic acid poly of the buriti petiole were characterized. . From these results, different sustainable packaging prototypes were generated. In addition, from the buriti petiole, cellulose nanocrystalswere extracted, with the potential for the development of bio-based nanocomposites for application in the environmentally correct innovative packaging design. After this stage, mechanical tests were performed by visual inspection and traction of the biocomposites and biodesing and evaluated the biodegradation result of the biocomposites in soil and water. Therefore, the designer the technology and use in materials makes it possible to generate new options and uses of fibers, adding greater importance to the sustainability process, collaborating with the environment and better exploring the alternatives for using a certain material.*
***Keywords*— Petitol of buriti. Nanocomposite. Biodegradable design. Nanocrystals.**

I. INTRODUCTION

Environmental problems are one of the main concerns of contemporary society. The manufacturing, recycling and pollution indexes generated by industries are constantly being discussed all over the world, in search of alternatives that will solve these problems. Social innovations need to be effective in this process to create more conscious consumption by the consumer, mainly focused on actions of sustainable practices. (VEZZOLI; MANZINI, 2008).

Product packaging is part of the pollution problem, as the incorrect way of disposal causes the inability to reuse its materials. However, it is possible to reduce this impact using, for example, advanced materials research methods. (SANTOS; AGNELLI; MANRICH, 2004).

The sustainable design produced by the PLA (lactic polyacid) of the Mauritia flexuosa petiole can help reduce the impact caused on the planet through sustainable alternatives, generating demands, channeling technologies, or producing innovative materials such as biodegradable compounds, which better fit this reality, as the substitution of materials, methods and energies for cleaner production. In addition, the use of nanoscience and nanotechnology in the development of packaging has provided an improvement in physical and functional characteristics, in

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addition to adding better value to the packaging. (MOORE, 2009).

An example of this proposition that fits these parameters was the study by Abdul khani et. al (2014), who used aggregated cellulose nano particles are poly (lactic acid) to generate a more resistant material with a higher rate of degradation. Azeredo (2009) also used nano particles as a resource to generate improvements in packaging in several aspects. The author points out that properties such as antimicrobial activity and the ability to immobilize enzymes, among others, can be incorporated into packaging using nano particles and benefit the use mainly in food packaging.

Developing alternatives that better contribute to the use of packaging becomes less aggressive to the environment is the challenge of the current design, in addition to combining methods and techniques that make this process possible throughout the life of these packaging. By using a biodegradable material in his product whose raw material is derived from a renewable source, the designer will bring better consequences for the post-use of this packaging in his project. (PEREIRA; SILVA, 2010).

The need to design packaging that is less aggressive to the environment has generated research and exploration in the field of materials and techniques to build a different concept in the application of these materials in the final production of this type of product. For this reason, we opted in this work to use biopolymers and natural lignocellulosic fibers. Biologically active polymers are polymers produced from raw materials derived from renewable sources such as corn, sugar cane, cellulose, chitin and others. (BRITO et al., 2011).

The biodegradation of these polymers occurs when they are used as a nutrient by a certain set of microorganisms (bacteria, fungus, algae) (BRITO et al., 2011). For this reason, biologically active polymers are more sensitive to biodegradation than conventional petrochemical polymers, although biodegradable synthetic polymers are found.

Poly (lactic acid) (PLA) is an example of this type of polymer widely used in various sectors of the industry in the manufacture of products, due to its structural characteristics, its biodegradability and excellent mechanical properties (HAMAD et al., 2015).

PLA is a thermoplastic polyester, has clarity, shine and UV stability (ALMASI et al., 2015). PLA is also applied in several studies serving as a matrix in composites, together with natural fibers and other materials, making it more resistant and more effective in specific applications. (ALMASI et al., 2015).

According to Pereira et al. (2015), lignocellulosic fibers are considered an innovation in the search for new materials because they have low cost, biodegradability, recyclability and because they are not abrasive during processing. The use of nanoscale fibers has also become attractive for the replacement of synthetic fibers, mainly in the creation of nanocomposites from these fibers. Much research has been directed towards creating high-performance packaging through them. (KHALIL; A.F; YUSRA, 2013).

Among the various natural fibers, there is Buriti fiber, which is abundant in the Amazon region of Brazil and in countries in Latin America. (LAVORATTI et al., 2013).

Buriti fiber (Mauritia Flexuosa) is widely used to create handicrafts in traditional communities (SHANLEY & MEDINA, 2005).

However, it has very interesting characteristics in its composition, besides being very light, this fiber is easy to handle and also rich in antioxidant and antibacterial properties. (KOOLEN et al., 2013).

There are other properties, for this fiber that can be combined with other materials for different and technological applications, and for creating composites. The buritizeiro is a tall palm. It is possible to explore all parts of it, such as the root, the petiole and the fruit. (SAMPAIO & CARRAZA, 2012).

From cellulose, two types of nanoreforces can also be obtained, namely: cellulose nanofibers (NFCs) and cellulose nanocrystals (NCC) (REDDY et al., 2013).

The term cellulose nanocrystals (NCC) is used to designate elongated crystalline nanofibers similar to a rod, while the designation "micro / nanofibrils" should be used to designate long, flexible micro and nanofibers (NFCs) that consist of alternating chains of cellulose crystalline and amorphous cellulose. (TONOLLI, et al., 2012).

Nanocomposites are considered the materials of the 21st century, as they can add exclusive combinations, properties that cannot be found in common composites. (CAMARGO; SATYANARAYANA; WYPYCH, 2009).

In this context, the present research used the buriti petiole as a reinforcement of the poly lactic acid as a matrix to produce biobased composites generating environmentally friendly materials in the construction of sustainable packaging. For this purpose, it is proposed with this research, to extract nanocrystals (Poly lactic acid) from cellulose of the buriti petiole with potential for the technological production of sustainable design.

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II. METHODOLOGY

According to Almeida (1998), sustainability is: "meeting the needs of the present generation without affecting the ability of future generations to meet theirs". Some people today refer to the term "ecologically sustainable development" as a broad term, as it implies continued development, and insist that it should be reserved only for development activities. "Sustainability", then, today and used as a broad term for all human activities.

2.1 Research location

The research was carried out in the municipality of Imperatriz (figure 01), the second largest city in the state of Maranhão. It comprises an area with great biodiversity because it contains the dense rainforest of humid characteristics of the Amazon, stretches of savanna and pioneer formations, all marked by deforestation (SEMA, 2016).

Photos: Southwest Maranhão - Imperatriz
Source: SEMA – 2016

2.2 Materials

The petit of Buriti (PB) was acquired in the village Setor Agrícola, Municipality of Governador Edison Lobão, Maranhão - Brazil. Colorless green filament with a diameter of 1.85 mm of poly (lactic acid), natural coloring (figure 02).

Fig.2: Dry buriti leaf and petiole.
Source: Authors 2020.

Ten buriti petiole sticks were cut with a length of 2 meters, weighing 800g each, with an average diameter of 1.89mm of green stick. After cutting, the petiole was placed in the sun for 3 hours at an average temperature of 33 ° C. Afterwards, the outer layer (bark) was removed, leaving only the colorless filament with a diameter of 1.85mm (figure 23). Without the outer bark, the petiole was placed in the sun for another 10 days until completely dry, removing all the water.

2.3 Extraction of dust from PB and obtaining of bio-based composites (PLA / PB)

To extract the dust from the buriti petiole, the dry material was used, which was cut into small cubes and soaked in running water for 24 hours. Then it was ground using a Philips WalitaProblend Black with Gray liquifier. For the sieving of the powder, a 17 cm Jolly Plastic sieve was used, with an 18/20 mesh opening and a 0.22 wire gauge figure 03.

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Fig.3: Petiole cut into cubes, Petiole soaked in running water, crushed petiole and sieved powder Source: Zilmar Soares and Ana Beatriz de Castro.

2.4 Bleaching of the buriti petiole to obtain the PLA

500g of PB powder mixed in one liter of water was used, plus 60g of alkalizing anionic surfactant, 120g of sodium carbonate, 40g of ammoniumpersulfate, 300 ml of hydrogen peroxide. The mixture was homogenized for 05 minutes in a blender and put to rest for one hour. Then it was taken to the oven for four hours at a temperature of 35ºC.

After removal from the oven, the material was strained and washed with running water and taken back to the oven for five hours at the same temperature, this process was repeated three times. Figure 04 shows the PLA bleaching sequence process.

In this process, the result was the characterization of cellulose, a fibrous material that originated the foam used in the mixture of biocomposites.

Fig.4: PLA bleaching process.
Source: Ana Beatriz de Castro and Zilmar Soares

2.5 Caracterização da cor e aspecto visual do PLA

Para a caracterização da cor foi utilizado peróxido de hidrogênio, Pecarbonato de sódio,Tensoativo aniônico alcalinizante, Ammoniumpersulfato e 100 ml Laurimina óxido. O material ficou em estado de dormência por 48 horas em temperatura ambiente.

A variação da coloração dos compósitos bio baseados em relação ao PLA puro foi medida com auxílio de instrumento de medida de cor portátil (Instrutherm, model ACR- 1023). As amostras foram ensaiadas e os resultados foram obtidos através de visualização figura 05.

O processo escolhido para a obtenção PLA branqueado do pecíolo do buriti foi o processo manual, fermentação e secagem natural (ao sol), também chamado comumente artesanal. Esta nanocelulose foi aplicada pelo método de compósito polimérico à base de uma emulsão de produtos caseiros e posteriormente, o compósito foi caracterizado PLA branqueado.

Fig.5: Pó (PLA) no processo de caracterização, em diferentes cores.
Fonte:Zilmar Soares e Ana Beatriz de Castro

2.6 Characterization of the color and visual aspect of the PLA

To characterize the color, hydrogen peroxide, sodium carbonate, alkalinizing anionic surfactant, ammonium dispersulfate and 100 ml laurine oxide were used. The material was dormant for 48 hours at room temperature.

The color variation of bio-based composites in relation to pure PLA was measured with the aid of a portable color measurement instrument (Instrutherm, model ACR-1023). The samples were tested and the results were obtained through visualization figure 05.

The process chosen for obtaining blanched PLA from the buriti petiole was the manual process, fermentation and natural drying (in the sun), also commonly called artisanal. This nanocellulose was applied by the polymeric composite method based on an emulsion of homemade products and later, the composite was characterized as bleached PLA.

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Fig.6: Powder (PLA) in the characterization process, in different colors.
Source: Zilmar Soares and Ana Beatriz de Castro

2.7 Extraction of cellulose fiber

For the extraction of the fiber it involved the purification of the petiole which consisted of the removal of the lignin. For this, 1g of sample was transferred to three bekers. To estebekers was added the solution 30 mL of 5% NaOH (w / v) for 4 hours. After that time, the sample was filtered and washed with distilled water. This procedure was repeated until the filtrate was neutralized.

The purified samples were transferred to three test tubes containing a mixture of a solution of aqueous sodium chlorite (1.7% NaClO2) and a solution of acetate buffer (27 g of NaOH and 75 ml of glacial acetic acid diluted in 1 L of water). The system was kept under reflux at 80ºC for 2 h. After this time, the pulp was filtered and washed until neutral. The procedure was repeated for two times and at the end the figure 28 was dried.

The residue was washed with 200 ml of deionized water, 20 ml of 20% acetic acid and again with 200 ml of deionized water. The sample retained in the filter was taken to the sterilization and drying oven (Nova ethics, Brazil) at 105 ± 2 ° C for 24 hours. After the period in the greenhouse, the sample was placed in the desiccator until it reached room temperature transformed into thin cellulose and hemicellulose, then it was weighed on a precision scale (Mcel) figure 06.

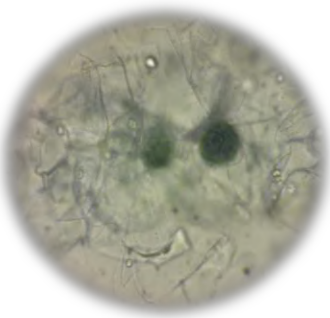

Fig.6: Sample visualized in electron microscopy of pure PLA.
Source: Ana Beatriz de Castro Silva.

To neutralize the pH over a period of 10 days, the nanocrystal particles were collected and stored in the refrigerator. To prevent the spread of fungi in the samples, three drops of sodium hiplochlorite were added to these. After this period, the buriti petiole nanocrystals (NCPB) were observed by Tecnai G2-12 transmission electron microscopy (CCENT / UEMASUL Microscopy Laboratory) using an acceleration voltage of 80 kV. A drop of the diluted suspension of the nanocrystal solution was deposited on a carbon-coated grid. The samples were stained with lugol solution and methylene blue figures 07.

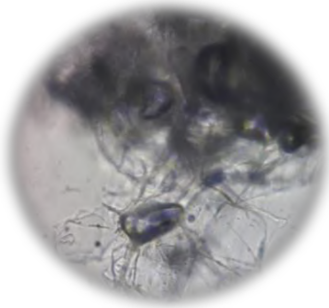

Fig.7: PLA / PB nanocrystals observed in electron microscopy.
Source: Ana Beatriz de Castro Silva.

2.8 Production of biodegradable designs

In this sense, composites were produced from the buriti petiole which was called PLA / PB95%, PLA / PB97%, PLA / PB98%, PLA / PB100%, PLA / PB99% respectively. The cooking of PLA for the production of composites was obtained by the conventional method at 100º C, for 5 min. Then it was placed on a flat tray for 20 minutes, after this time, the material was cooled and placed in a dormant state for three days figures 08 and 09. After this process the composites were molded in different designs. In order to arrive at a ready model and the correct formula, eight tests (experiments) were needed figures 10.

Fig.8: Cooking of composites using the conventional method. Figure 09: Material dormancy process before the designs are produced. Figure 10: Ready design. Source: Ana Beatriz de Castro Silva

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2.9 Mechanical testing of PLA in bio composite based on visual inspection

This step was followed by the advisor and co-supervisor. The main tool used in the visual rehearsal was the eyes, therefore, to assist in the analysis were used electronic magnifiers with zoom model LEZ 1080, microscopes Trinocular E200 LED Nikon achromatic flat objectives of 4.10.40 and 100x 10x field of 20mm Automatic bivolt and templates and comparator (comparator cylinder) 3x100 mm for plasticity limit tests.

2.10 Mechanical tensile test (EM)

The strain-strain strain curves were obtained with the aid of a universal testing machine EMIC DL 2000 equipped with a 20 N load cell and using a speed of 10 mm min-1. For each material, five tests were performed with different samples and the reported result was the average of the results of such tests with the respective standard deviations.

2.11 Tests with the materials produced to check the degradation time in water and soil.

Tests to verify the degradation process compared to traditional plastics, two environment models were created. The first model was characterized by an aquatic environment. The second environment was characterized by the terrestrial environment. The tests (experiments) were monitored daily, with the degradation processes between the two environments being noted and transformed into statistical data.

2.12 Evaluation of the material resulting from the biodegradation of biocoposts in garden plants.

The biocomposites used were introduced in a mini composting system, in plastic boxes with a capacity of 30 dm3, under screen conditions. The basis for preparing biocomposites consists of 98% and 95% buriti petiole powder with the additive tapioca gum at 2% and 5%.

During the elaboration period, which extended for 100 days, the biocomposites were irrigated every two days and were revolved every 30 days, days to maintain temperature, humidity and microbial activity. The biocomposites differed according to the application of percentage of additives (tapioca gum) in the growth process of plants isolated from native fungi of cerrado soil, dry leaves of vegetable were added next to the soil in which the experiment was applied.

III. RESULT AND DISCUSSION

Few studies show the potential of the buriti petiole, addressing the possibility of replacing synthetic fibers. Santos et al., (2010), investigated the microstructure and mechanical characterization of buriti fiber for use as reinforcement in polymeric composites. It obtained values of tensile strength of 684 MPa and Modulus of Elasticity of 36.26 GPa that are close to the values found in other fibers as shown in table 01.

The buriti fiber showed a density lower than the water density 0.770 g / cm3 which resulted in specific values of resistance and modulus under tension. These values are consistent with those cited by Mueller et al., (2003), for Jute fibers, flax fibers, sisal fibers. The values found by Santos et al (2010), obtained in the tensile tests, as well as the specific values, are consistent with those found in the literature for vegetable fibers most used as reinforcement in composites.

Tensile test values, as well as specific values, found in the literature for buriti fibers. Source: Santos et al. (2013).

	Buriti
Tensile strength (Mpa)	684
Elastic modulus (GPa)	36,26
Specific resistance	97,7
Specific module	5,18

Thus, the mechanical properties, surface morphology and microstructure of buriti fibers present values similar to those found in the literature for other plant fibers. The specific values obtained for the buriti fibers are interesting and justify the use for bio based composite.

Making a comparison between the composites, it is observed that the composites of materials such as aramid carbon and fiberglass dominate the aerospace, civil construction, automotive and sports industries. Glass fibers are the most used to reinforce plastics due to their low cost (compared to aramid and carbon) and reasonably good mechanical properties. However, these fibers have serious drawbacks, as shown in Table 02.

Table 02: Comparison between buriti fiber and glass fibers.

	Buriti fiber	Fiberglass
Density	Low	Double buriti fiber.
Cost	Low	Low, but superior to the buriti fiber.
Renewable	Yes	Not
Recyclable	Yes	Not
Energy consumption	Low	High
CO2 neutral	Yes	Not
Abrasion for machine	Not	Yes

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Health risk when inhaled	Not	Yes
Elimination	Biodegradable	Non-biodegradable

Source: LABG / UEMASUL - 2020.

3.1 PLA with the composition of foam, and tapioca gum, colored with natural dyes.

The morphological aspects of the structure of the composition surface of the buriti PLA, in cooking, show the characteristic microstructure of the material. Through these images it is possible to observe that the fibers are composed of different types. Figures 11 and 12 illustrate the photographs of the bio-based composites, obtained from colored PLA, with the combination of the buriti powder petiole matrix in composition with the foam (fiber) and tapioca coma.

Fig.11 and 12: Bio composites based on different proportions of PLAS. Source: Ana Beatriz de Castro and Zilmar Soares

Buriti PLA fibers are elongated structures with hollow and rounded cross sections, distributed throughout the plant and can be classified according to anatomical origin such as stem fibers, leaf fibers, wood fibers and surface fibers. The petiole fibers occur in the phloem that is located in the stem's stem (CAETANO et al., 2004).

In these films it is also possible to distinguish a reinforcement phase, usually in the form of foam (fiber), and another binder (the matrix), which allows efforts to transfer throughout the entire composite working in an integrated manner.

Levy Neto and Pardini (2006) make the following definition: A composite material is a set of two or more different materials, combined on a macroscopic scale, to function as a unit, aiming to obtain a set of properties that none of the components individually presents.

The basic characteristic of composite material is two types of phases: the matrix that has the purpose of protecting its structure and the other phases against the action of the environment and, particularly, corrosion and abrasion, and the reinforcement that alters the properties of the matrix, being able to provide greater resistance (BLEDZKI AND GASSAN, 1999 & BROUTMAN, 1990).

3.2 Water absorption tests

The behavior of water absorption by PLA (powder) and foam (vibrates) can be seen in Figure 13. As expected, due to its hydrophilic characteristic, the presence of the fiber increased the tendency for water to be absorbed by the foam. In general, the higher the fiber content (CP), the greater the absorption of graphical water 01.

Fig.13: two experiments to observe the water absorption of bio-based in relation to PLA and foam. Source: Ana Beatriz de Castro and Zilmar Soares

To analyze the water absorption process, the PLA / PB 100% composite in natural color and fibrous foam was used. Analyzing the results, it can be seen that there was an increase in the volume of PLA (powder) by 8% due to the elasticity of the crystals, since the fiber has greater capillarity in relation to water, the volume increase was 4%, graphical 01. This difference between the powder and foam is related to the removal of the PLA after sifting. Another aspect observed that the presence of water increased the color of both PLA and foam, this chemical reaction occurred due to the presence of hydrogen in the water compound.

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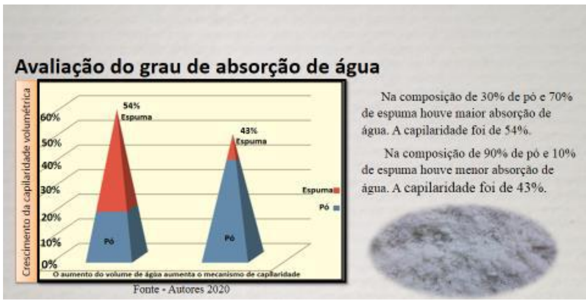

Source - Authors 2020

It is worth mentioning that the water absorption test was carried out with two samples (powder and fiber). The sample of the PLA (powder) obtained the lowest absorption of H2O, where the foam was more on the surface due to the greater amount of fibers. Thus, it can be said that increasing the amount of fibers increases the absorption of H2O. Foam (fiber), on the other hand, showed greater water absorption. According to Sousa (2016), this phenomenon occurs because the capillarity mechanism facilitates water molecules to flow along the matrix-fiber interface.

With this experiment it can be said that the bio composite produced with PLA without the fiber, becomes more elastic and increases flexibility, thus facilitating the production of bio design.

3.3 Chemical characterization of BP.

The chemical characterization of the Buriti Petiole (PB) allowed the quantification of its main constituents in table 03. Although the chemical composition of ligninocellulosic fibers varies according to the age of the wood and its place of cultivation Fengel & Wegener, (1989), the sample of petiole of buriti studied presented levels of α-cellulose, hemicellulose and lignin close to the values found by Barbosa, (2011) which were 51.29%, 18.80% and 16.37%.

Table 03: Chemical characterization of the buriti petiole (PB).

Matter	Teor (%)
Cellulose	55,4
Hemicellulose	15,5
Total Lignin	18,2
Holocellulose	76,1
Ashes (minerals)	3,0

Source: Ana Beatriz de Castro and Zilmar Soares

3.4 Bleaching of BP

The evolution of the bleaching process of PB was observed through the discoloration of the fiber using homemade chemical products figure 14.

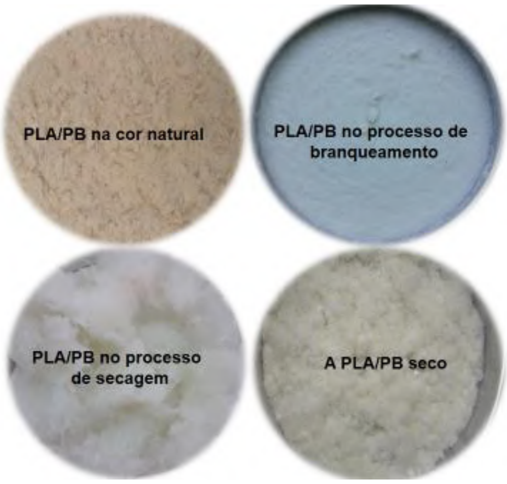

Fig.14: artisanal bleaching process.
Source: Zilmar Soares.

Figure 15 illustrates the evolution of the visual aspect of the buriti petiole (PB) during the bleaching stages. The dark coloration of BP can be attributed to the presence of lignin (ROBLES et al., 2015).

Fig.15: Photo illustrating the visual aspect of PB during the bleaching stages.
Source: Ana Beatriz de Castro

Figure 15 shows the presence of fibrous material, dispersed in a solid and homogeneous, non-fibrous matrix. After chemical treatment for fiber extraction, the material showed fibrillar morphology, with long fibers and an average diameter of less than 24 micrometers.

The bleaching of buriti fibers presents a behavior similar to that observed by Clough et al.,

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(1996) who observed a visible fibrous material in composites and polymers, using increasing doses of NaOH, checking long diameters and changing color for higher doses of Chemicals.

Changes in the chemical structure of the fibers can be presented as the sum of the individual components, that is, cellulose, hemicellulose and lignin. However, cellulose is more sensitive to changes than lignin (FREITAG & MORRELL, 1998).

The results showed that the increase in the chemical dosage modifies the buriti fiber making it less resistant. For higher doses of gamma irradiation in buriti fibers, the fibers become less flexible.

3.5 Nanocrystals of the buriti petiole (NCPB)

Figure 16 shows the dispersion of nanocrystals of the buriti petiole (NCPB) in different light phases. (A) Low dispersion of light. (B) Average dispersion of light. (C) concentration of light in the central part of the material. In phase (D) The effect occurred when there was a high dispersion of light by colloidal particles. In this case, it was possible to visualize the path that light takes, as these particles disperse the light rays. This observation indicates the presence of nanostructures in the dispersion. Graph 02 shows the diffractogram of dispersed nanocrystals (NCPB).

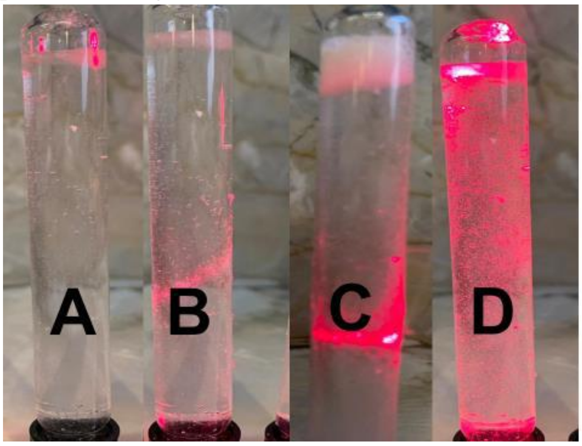
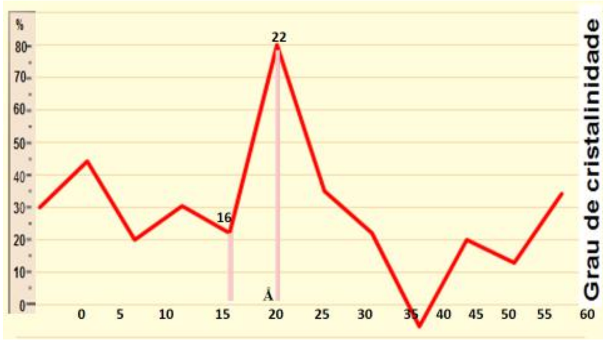


Fig.16: Dispersion of nanocrystals obtained from the buriti petiole (NCPB).
Source: Ana Beatriz de Castro and Zilmar Soares



Graph 02: Diffractogram of nanocrystals obtained from the buriti petiole (NCPB). Source: Zilmar Soares LABG / UEMASUL

The value found for the crystallite size was 22 Å, slightly less than the value found by Robles et al. (2015) which was 34 Å. The crystallinity result obtained from the diffractogram of graph 2 was 80% (degree of crystallinity). This value was within the expected for a morphology characterized as nanocrystal. Getting close to 60% found by (ROBLES et. Al., 2015).

From the cellulose of PB it is possible to obtain two types of nano particles: nanocrystalline cellulose and nanofibrilated cellulose. The nanofibrilated cellulose is arranged in parallel bundles organized "like spaghetti noodles", while the crystalline cellulose (or nanocrystals) with the appearance of tiny crystalline rods "resembles needles or grains of rice, but about 200 thousand times smaller in thickness", VALDEIR & ARANTES (2017).

Nanocellulose, with its high performance and versatility, is an alliance between nanotechnology, biotechnology and renewable raw material figure 17.

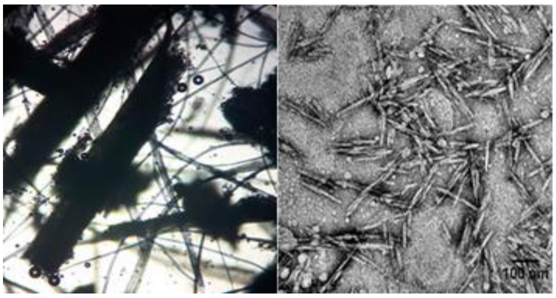


Fig.17: Presents the two nanocrystalline structures of PB. Source: Zilmar Soares

3.6 Production of PLA / PB composite biodesign by cooking

The bio based composites PLA / PB98% was used to produce the prototype of biodesign. For this, the cooking process was chosen, which consists of heating the material for four minutes at 100 ° C. After this process, the

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material was placed on a flat surface for cooling for three days. After cooling the material was transformed into different utensils, figures 18 and 19.

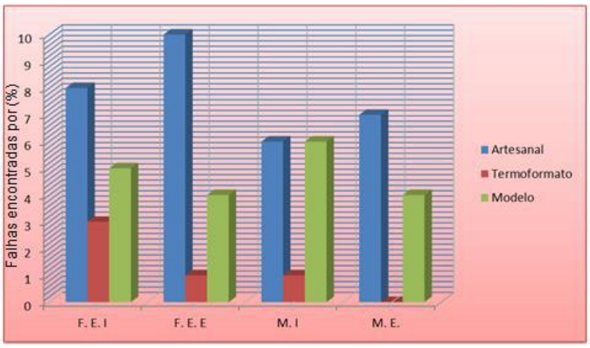
Fig 18 and 19, It presents the biodesigns produced in an aertesanal way with the PLA of PB.
Source: Zilmar Soares and Ana Beatriz de Castro.

In this way, by processing and improving natural or composite raw materials, it is then possible to design eco-sustainable products. (MORAES, 2010).

Also according to Twede & Goddard (2010), it is possible to apply different materials to replace others. Another alternative would be to reduce the amount of material used in the manufacture of biodesign, or even make modifications to the material, creating structural combinations to improve and generate the expected performance in these products.

3.7 Mechanical testing of PLA and bio-based composite by visual inspection

Simple techniques were used to detect surface flaws and distortions in the structure, and the degree of finish and shape of the pieces. The main tool used in the visual test was the eyes, therefore, to assist in the analysis were used magnifiers, microscopes, optical projectors, templates and comparators. The result is shown in graph 3.

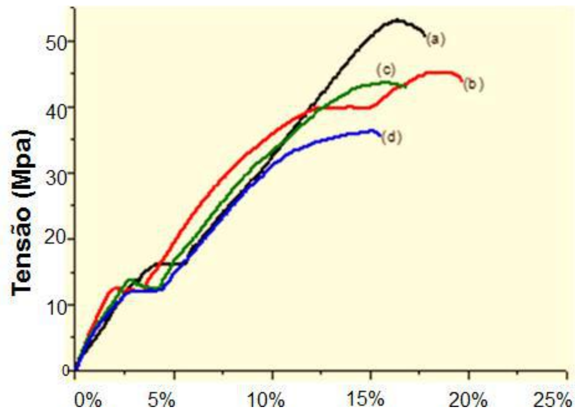


Graph 03: Present the flaws found in biodesign with the industrial model. F.E.I.:Failure in the internal structure. F.E.E .: External structure failures. M.I .: Internal molding. M.E .: External molding. Source: Ana Beatriz de Castro

The failures were necessary to improve the mechanical properties and hydrophobicity of cellulose nanostructures. According to Spinella et al., (2015), this result occurs due to the formation of a non-polar covalent bond between the coupling agents and the free hydroxyls of the cellulose, also improving the dispersion inside the matrix during the processing by both cooking and cooking. by thermoforming.

3.8 Mechanical testing (EM) of PLA and traction-based bio composite

The Mechanical Tensile Test is widely used to collect basic information about the strength of materials and as a material acceptance test that is done by comparing the properties determined by the test and specified adjustments in bio based composites. Graph 03 shows the curve of the tensile test of the buocomposites according to the concentration of matrix and assets. And the values are specified in table 04



Graph 03: Traction test curves: (a) pure PLA, (b) PLA / PB98% (c) PLA / PB95% and (d) PLA / PB90%. Source: Authors

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Table 04 - Values of mechanical properties in traction and degree of crystallinity (DRX) for pure PLA and bio based composites.

Samples	Voltage (MPa)	Along (
PLA Puro	54,12	18
PLA/BP98%	45,00	20
PLA/BP95%	43,09	16
PLA/BP90%	35,63	15

Source: Ana Beatriz de Castro

The limit of the tensile strength found for the naturally colored PLA filament was reported as 57 Mpa by Wittbrodt & Pearce, (2015). This value is very close to the value found in the present study (54,12). The elongation value, however, is well above the value found by such authors (2.35%), which reinforces the hypothesis that plasticizer was added to the filament used in the present study.

Regarding bicomposites, the tendency observed to reduce the tensile strength and reduce the elongation with the increase in the CP content is typical of composites with a weak interaction between the fiber (foam) and the matrix, which can be explained by the fact that PB did not receive any surface treatment to improve adhesion with the matrix (PORTELA et al., 2010).

Among the results reported in the references, is the increase in tensile strength and modulus by the factors of 1.45 and 1.75 respectively in PLA reinforced with synthetic cellulose fibers. With the reinforcement of burit fibers, the modulus and tensile strength were increased by the factors of 2.40 and 1.20 respectively.

Graupner et al. (2009), described the production through compression molding of PLA composites reinforced with 40% by weight of cotton fibers, hemp, kenaf (Hibiscus cannabinus) and synthetic cellulose (Liocel). In general, the results in terms of mechanical properties fell far short of those calculated using the mixtures rule.

According to the authors, it was demonstrated that high values of tensile strength in composites will only be achieved by increasing the fiber / matrix interaction. For this, the composites must have adhesion promoters, coupling agents or plasticizers.

3.9 Process of degradation of the bio-based composite

The recipe for the PB powder-based biocomposite gives a brownish color to the final product. Or natural dyes to obtain other shades in the final products. Only with bleached PB it has a slight transparency. However, all composites produced in this research and the additives included in the formulation, are natural and non-polluting.

The samples were stored in different systems (water and soil) that were collected for periods of 2, 4, 6, 8, 10 and 12 weeks, with each system containing different samples of each composition. The system was formed by basins with a capacity of 600 mL where the soil prepared with pure PLA plates with composition was added. The materials were placed (glass vats) randomly in the LAB / BG - UEMASUL (for bacteriological culture with air circulation and refrigeration) maintained at a temperature of 32 ° C and the systems were removed after two, four, six, eight, ten and twelve weeks, when the degradation process was observed, figures 20 and 21.

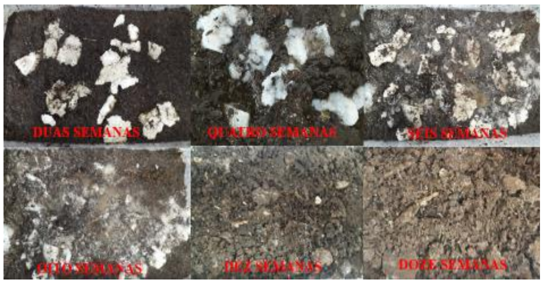

Fig.20: Process of biodegradation of composites in weeks (soil).
Source: Ana Beatriz de Castro and Zilmar Soares

Fig.21: Biodegradation process of composites in weeks (water).
Source: Ana Beatriz de Castro and Zilmar Soares.

The 8-week effect on the biodegradation process in the flexible biocomposite occurred faster in the water due to the matrix and the PLA / PB / additive composites are illustrated in Figure 621. Considering the experimental errors, the incorporation of the load and the additives (coma of tapioca) did not change the rigidity of the systems. However, the effect of biodegradation on the elastic module is very significant. According to Álvaro (2017), the presence of natural additives does not change

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the properties in biodegraded composites, but contributes to the biodegradation process.

According to Almasi, (2014). Biodegraded composites in water practically lose their ability to resist tensile stresses. The elongation at break is less affected than the tensile strength with the addition and formation of composites, however the effect of biodegradation is severe, where the additive composites present three times less elongation than the pure PLA biodegraded in soil.

Marcia et. al (2010) states, the growing concern with the environment has been trying to develop biodegradable polymers as one of the solutions to the problem of discarding the large volume of polymeric material. In this sense, it is worth emphasizing the importance and applicability of biodegradable polymers that can be used pure, in polymeric mixtures or in composites with natural fibers.

3.10 Evaluation of the bi-compound bi-post material used as fertilizer in garden plants.

After the completion of the process of biodegradation of cups in the soil, an experiment was carried out under greenhouse conditions to evaluate the effect of adding the compounds to the soil on the vegetative development of different species. The resulting soil was a dark, sandy texture clay (22 g kg-1 of clay and 871 g kg-1 of sand)

The fertilization with organic compounds from the biodegradation of the biobased compounds did not affect the plants, on the contrary, it improved the quality of the green of its leaves. These results may suggest that the cultivated plants extracted from the soil most of the readily available nutrients of the compounds, resulting in similarity in the vegetative development of the plants grown in normal soil.

Fertilization under the organic paradigm assumes that soil fertility must be maintained or improved, using natural resources and biological activities. As far as possible, natural resources should be used, as well as organic by-products that provide the supply of nutrients, in a wide and diversified way, and should prioritize nutrients through decomposition residues, compounds and organic residues. (LIMA et al., 2011).

Decomposition materials of organic matter is the best strategy for the use of these residues, since it facilitates the handling, reduces the volume of residues and the loss of nitrogen. A well-made compost presents organic matter transformed into humus and acts on the soil, improving its structure and providing it with conditions to store more water, air and nutrients, which will feed the plants (LUCON & CHAVES, 2004

IV. CONCLUSION

The designer as a mediator of the application of the material is necessary so that new options of use are designed in products, services and technologies. Bearing in mind that each and every product, needs to pass several tests in which prove its effectiveness as well as its efficiency. The material proposed in this project was developed and had its properties evaluated to prove the possibility of use in new technologies.

Therefore, the designer the technology and use in materials makes it possible to generate new options and uses of fibers, adding greater importance to the sustainability process, collaborating with the environment and better exploring the alternatives for using a certain material. It is concluded in this research that the diverse characteristics found in the petit of buriti, makes it an innovative material and with great possibilities of new proposals of use in the industry and in the market. Because it is a material with low environmental impact and its performance appropriates differentiated values, contributing to a new type of more conscious consumption.

The data collected and presented by the buriti petiole are tools that can be used by other designers to create new product designs that meet the complex and current demands of the market, product and sustainability.

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