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Textile Palm Fibers from Amazon Biome

Lais Gonçalvez Andrade Pennas[1,a], Ivete Maria Cattani[1,b], Barbara Leonardi[1,c], Abdel-Fattah M. Seyam[2,d], Mohamad Midani[2,3,e], Amanda Sousa Monteiro[1,f], Julia Baruque-Ramos[1,g*]

[1]University of Sao Paulo, School of Arts, Sciences and Humanities, Av. Arlindo Bettio, 1000; 03828000, Sao Paulo, SP, Brazil

[2]North Carolina State University, College of Textiles, 1020 Main Campus Drive, Raleigh, NC 27606, USA

[3]German University in Cairo, College of Engineering and Materials Science, Al Tagamoa Al Khames, Cairo, Egypt

[a] laiis_s@hotmail.com, [b] ivetecattani@me.com, [c] leonardi.ba@gmail.com, [d] aseyam@ncsu.edu, [e] msmidani@ncsu.edu, [f] amandasousamont@gmail.com, [g] jbaruque@usp.br

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Abstract. There are several species of Amazon palm trees from which can be obtained: food and oils (fruits and seeds), medicinal products, construction material (logs and leaves), handicraft, textiles, etc. Taking in account textile fibers, three palm origins stand out: tucum (*Astrocaryum chambira* Burret), buriti (*Mauritia flexuosa* Mart.) and tururi (*Manicaria saccifera* Gaertn.). Tucum fibers, obtained from grown leaves, are used in the manufacture of fabrics, handicrafts, nets, yarns and fishing nets. Buriti presents multiple uses, especially for handicraft products. A soft fiber ("linen") and another harder and rougher ("draff") are removed from the young leaves of the buriti palm, both being used. Tururi is the sac that wraps the fruits of the Ubuçu palm tree. The material is constantly used by the Amazonian riverside population and by artisans for handicrafts, fashion items and other products for tourism. In a joint project of the North Carolina State University (USA) and University of São Paulo (Brazil), multilayer composite materials were developed and characterized in 3D structure with quite promising results in terms of resistance and aesthetic finish similar to wood. Thus, the traditional and innovative uses of native vegetable fibers are ways of valuing the regional product and preserving their respective ecosystems.

Introduction

The Amazon biome comprises an area of 410 million hectares and is formed by three types of forests: dry land, wet land and flooded area. It encompasses extensive areas of “cerrados” (kind of savannas) and meadows. The Amazon biome develops around the Amazon basin and is present in eight countries of South America [1]. There are several species of palm trees from the Amazon biome, from which can be obtained: food or oils (fruits and seeds), biodiesel, medicinal and cosmetic uses, construction material (logs and leaves), handicraft material, including fibers for textile purposes, etc. Some examples are [2]: Açai (*Euterpe precatoria*); Cocao (*Attalea tessmanii*); Inaja (*Attalea maripa*); Jaci (*Attalea butyraceae*); Jarina (*Phytelephas macrocarpa*); Murmuru (*Astrocaryum murumuru*); Paxiubao (*Iriartea deltoidea*); Paxiubinha (*Socratea exorrhiza*); and Pataua (*Oenocarpus bataua*). The incentive for the employment of native vegetable fibers as an alternative textile material can increase local productivity and improving the income of the populations. Another point is that there is enormous creative potential. Aiming

at technology, there is growing international interest in the use of these vegetable fibers, especially as non-conventional materials for the manufacture of composites instead of those made with wood or synthetic materials [3]. Taking in account the obtainment of textile fibers, three palm origins stand out: tucum buriti and tururi. A briefing enrolling the obtention of fibers, processing and manufacture of final products in shown in Figure 1.

Figure 1. Tucum: (a) Obtention from grown palm leaves [4]; (b) Processing of obtained fibers [4]; (c) Macrame fabric [4] [5]. Buriti: (d) Obtention of "linen" and "draff" fibers from the young leaves [1] [6] [7] [8]; (e) Dyeing of fibers [1] [6] [7] [8]; (f) Working in manual looms [1] [6] [7] [8]. Tururi: (g) Sac covering the fruits in the palm and after collection [9] [10]; (h) Drying of tururi mats after dyeing [9] [10]; (g) Mat, bags and composite made from tururi [9] [10] [11].

In the present study the main physical-chemical characteristics of these palm fibrous material were compared and for tururi also the characteristics of composite structures were presented.

Material and methods

The fibers were taken respectively from: (**i**) Grown leaves of tucum palm trees (*Astrocaryum chambira* Burret), in the Community Ecological Village of Jurua, municipality of Ipixuna, Amazonas State, Brazil, GPS 07°03′04″S and 71°41′43″W; (**ii**) Yong leaves of buriti palm trees (*Mauritia flexuosa* Mart.), located in Marcelino Village, situated on the bank of "Preguiça" river, Barreirinhas city, Maranhao State, Brazil, GPS 02°45'18,8101"S and 42°49'04,2782"W; (**iii**) Sacs of tururi (*Manicaria saccifera* Gaertn), in the cities of Sao Sebastiao da Boa Vista and Muana, Para State, Brazil, central GPS positions respectively S -1°23 '53.4156"W -49°38'14.9928" and S-1°20'40.3506 "W-49°17'45.3948". All locations are in comprised in Brazilian Amazon Forest biome and in all cases, the prospection radius was 5,000 m. It should

be noted that obtaining these specimens does not require authorization from IBAMA (Brazilian Institute of Environment) or any other federal or state environmental agency, since the material is usually collected and marketed and its purchase and possession has no legal restriction in any of the Brazilian states. Other fibers employed in the present study, originated from the leaf of following plants, are: i) curaua (*Ananas erectifolius*) provided by the Federal University of Amazonas, produced in that Brazilian state; and ii) sisal (*Agave sisalana*) purchased in Sao Paulo city, while originating from Bahia state (both Brazilian regions).

The assays were performed at 20^{o}C and 65% relative humidity (ABNT NBR ISO 139:2005) [12]. Cross microscopy structures were determined according to ABNT NBR 13538-1995 [13]. They were carried out on cross-sections of resin encapsulated fibers cut in rotational semi-automated microtome (Leica, RM 2245 model, Germany). The materials were analyzed in biological microscope (Leica, BME model, Germany) coupled to camera video digital imaging (Sony Color VideoCamera ESWAVEHAD, 55C-DC93-P model, China). All the obtained images were captured and processed by Video Analyzer 2000 system (Mesdan, Italy).

Tensile properties of the fibers (rupture load, elongation, tenacity and Young's modulus), from buriti and tucum fibers samples (obtained respectively from young and grown leaves) and fibers withdrawn from tururi sacs, were determined according to ASTM D 3 822-2001 [16] employing tester machine Instron (model 5569, Norwood, USA). Formerly, in order to determine tenacity (strength value shared by count number) fiber fineness (linear density or count number) was calculated in terms of TEX, defined as the weight in grams per 1,000 m of the fiber, by weighing a known length of the fiber. A gauge length of 25 mm, automatic pre-tension and crosshead speed of 50 mm/min and a cell of 1000 N were employed. The results are an average from at least twenty samples. The total length of the sample was approximately 100 mm, sufficient to allow the distance between the jaws of 25 mm.

The tenacity for fibers was determined by the presented in Equation 1 [14] [15]:

$$\gamma = \frac{F}{T_m} \qquad \begin{array}{l}\gamma = \text{tenacity (cN/tex);}\\ F = \text{breaking load (cN);}\\ Tm = \text{count number (tex).}\end{array} \qquad \text{(Eq.1)}$$

The Young's modulus (or textile initial modulus or module) of a fiber is determined by the slope of the tenacity-elongation curve in its initial linear part as presented in Equation 2 [15]:

$$\text{Young's modulus} = \frac{\gamma_1}{\varepsilon_1} \qquad \begin{array}{l}\gamma_1 = \text{Tenacity in the initial part of the tenacity-elongation curve (cN/tex)}\\ \varepsilon_1 = \text{elongation in the initial part of the tenacity-elongation curve (\%)}\end{array} \qquad \text{(Eq. 2)}$$

In addition, tururi fibrous material from sacs was tested in order to determine the values of tensile strength (testing the fibers withdrawn from these sacs and testing strips from the sacs that forms this material - *in natura* and after discoloration) and weight. Tensile properties of the surface fibrous material (rupture load, elongation, strength and Young´s modulus), from samples obtained from cut strips of the fibrous material from the sacs, were determined according to ABNT NBR 13041:1993 [17] employing tester machine Instron (model 5569, Norwood, USA), employing using a crosshead speed of 100 mm/min and a cell of 1000 N. The results are an average from at least twenty samples. The samples were 20 mm wide and 300 mm length. Jaws

of rubberized grips with dimensions of 3.8 x 5 cm were employed. The distance between the grips was 200 mm. The thickness of the samples was previously determined employing portable analogical thickness gauge (model 188F, Mesdan, Italy).

In order to define the weight of the surface of fibrous material, ABNT NBR 12984:2000 [18] standard was employed. A total of 20 samples of size 5.0 x 5.0 cm were tested. The samples were weighed on analytical balance (Sartorius, ED124S model, Germany). The weight calculation was calculated as g/m^2.

Regain determinations were performed according the method adapted from ISO/TR 6741-4: 1987 [19]. Percent Moisture Regain (or "Regain") is defined as the weight of water calculated as a percentage of dry weight. After acclimatization at 20^{o}C and 65% relative humidity [13] [14] [15] the samples were weighed on analytical balance (Sartorius, ED124S model, Germany). The drying was performed in an oven with forced air circulation (Binder FD Model 115, Germany) at 70°C for 24 h or more until constant weight and the sample was again weighed. Twenty repetitions of each group were analyzed.

For tucum fiber, DSC, TGA and XRD tests were performed. DSC (Digital Scanning Calorimetry) and TGA (Thermogravimetry Analysis) tests were carried out in Thermogravimetric Analyzer Mettler Toledo (model TGA/DSC 2, Netherlands), temperature from 30 to 1000°C, 10°C/min, 50mL/min nitrogen atmosphere and 70µL alumina crucible. For lignocellulosic materials, the events (peaks characterized by inflection points) in the DTG (Derivative Thermogravimetry) curves can be associated to processes that occur to the different constituents of the analyzed material. Thus, in many cases, the approximate composition of the analyzed lignocellulosic material can be estimated by comparing the DTG and TGA curves and compare those results with those obtained through chemical determination [20].

In addition, the XRD spectra were obtained at room temperature (25°C) with a diffractometer Rigaku Miniflex 300 (Japan), Cu X-Ray tube, Kβ filter, 30 kV and 15 mA. Dispersion ranged from 4° to 80°, 2°/min continuous scan, 0.020° sampling width and 2θ/θ scan axis.

The tucum, buriti, tururi, sisal and curauá fibrous materials were analyzed by FTIR in equipment Thermo (model Avatar 370 FT-IR) employing cell of ATR / Germanium (Ge) (Nicolet, USA). The interval was from 4,000 to 700 cm^{-1}, performing 32 scans with 2 cm^{-1} resolution. The data acquisition was performed by OMNIC software, version 4.1, 2011[21].

Results and discussion

Cross-sectional microscopies

The cross-sectional microscopies of fibers are presented in Figure 2. They match with other ones of recognized textile employability.

(a) **(b)** **(c)**

Figure 2. Cross microscopies: (a) Tucum: 1.280X magnification and 10 µm scale [original data]; (b) Buriti "linen": 1.280X magnification and 50 µm scale [1] [7] [22]; (c) Tururi: 640X magnification and 100 µm scale [3] [9].

Despite of the similarities in the cross sections of studied species here and that ones from fibers of recognized textile employability, it cannot conclude, only through microscopic examination of their cross sections, the possible type of application for certain fiber. For this purpose, there is the necessity of a combined analysis of results from other physical and chemical tests. However, examination of cross sections by optical microscopy also is useful to evaluate the integrity of fiber cellular structure and the adequacy of procedures for processing of the fibers. The damage to cellular structures is visible such as deformation of cell shape [23]. The tucum cell diameter average value (from 10 determinations) is 5.5±1.5 μm (CV=27%). For buriti "linen" is 8.5 μm and for buriti "draff", 7.2 μm. The tururi cell diameter average value (from 10 determinations) is 8.7±5.1 μm (CV=58.6%). This value is compatible with the values of species of recognized textile employability. According to Reddy and Yang[25], the unit cell size ranges from 12.0 to 25.0 μm for cotton, 5.0 to 76.0 μm for flax and from 15.0 to 25.0 μm for jute.

Tensile and regain results

The values for tensile and regain results on fibers of buriti, tucum and withdrawn from tururi sacs are presented in Table 1.

Table 1 - Tensile and regain results on fibers of buriti, tucum and withdrawn from tururi sacs. Values expressed by average, standard coefficient and variation coefficient.

Fiber		Count Number* (tex)	Rupture Load (N)	Elongation (%)	Tenacity (cN/tex)	Young's Modulus (N/tex)	Regain (%)	References
Tucum		320±127 (39.5%)	119±49 (41.0%)	**6.6**±0.4 (5.8%)	**37.4**±5.6 (14.9%)	**8.3**±1.0 (12.5%)	**10.0**±0.3 (3.4%)	[original data]
Buriti**	linen	**223**±77.7 (34.8%)	64.1±27.4 (43.6%)	**8.3**±0.5 (6.8%)	**28.4**±5.5 (19.6%)	**6.1**±0.8 (13.1%)	**8.5**±0.3 (2.6%)	[1] [22]
	draff	**228**±134 (47.7%)	52.2±35.1 (67.2%)	**5.0**±0.8 (15.5%)	**18.0**±6.3 (34.9%)	**6.0**±1.6 (25.9%)	**9.0**±0.8 (8.4%)	
Tururi		**98.4**±15.2 (15.5%)	17.7±4.2 (23.5%)	**10.5**±2 (20%)	**18.0**±3.2 (18%)	**3.4**±0.5 (14.4%)	**12.0**±0.5 (4.3%)	[3] [9]

*For buriti and tururi the expressed values represent the count number of single fibers. For tucum the expressed value represents the count number of fiber bundles employed in tests, since the single fibers are very thin (near 2.4 tex and 90±12 cm natural fiber length). **From buriti young leave two different fibers are obtained: one more flexible (popularly called "buriti linen") employed in woven or knitted fabrics for fine handcrafts, and another one more rustic ("buriti draff") employed for confection of basketry, sets of placemats, etc.

Table 2 – Tenacity, elongation and Young's modulus values for species of recognized textile employability. Values adapted from the indicated references.

Fiber	Elongation (%)	Tenacity (cN/tex)	Young's modulus (N/tex)	Regain (%)	References
Sisal	2 – 3	35.3 – 44.1	12.4	11	[15] [24] [26] [28]
Curaua	4.5 – 6	135 - 326	30-80	9	[24] [26] [27]
Cotton	3 – 7	26.5 – 43.3	5.3–6.2	8.5	[15] [24] [25]
Hemp	1.8	51.2 – 60.0	19.4	8-12	[15] [24]
Jute	1.7 – 2.0	26.5 – 51.2	17.9	13.8	[15] [24] [25] [26]

A comparison between the determined values (Table 1) and the properties of other vegetal fibers (Table 2) was performed. The tenacity of tururi fiber is lower in relation to other analyzed fibers. It is comparable to the lower limit of this parameter for cotton and jute. The tenacity values for the other analyzed fibers are comparable to sisal (leaf fiber), cotton (seed fiber) and hemp and jute (stem fibers). All the values are inferior to the curauá (leaf fiber). However, it is remarkable that despite of curauá is a leaf fiber, their general employment is for manufacture of composites instead of textile purposes.

The obtained values of regain (Table 1) are consistent with other ones of recognized textile employability lignocellulosic fibers (Table 2).

Tensile tests and weight on tururi fibrous material strips

The test was performed with 20 samples (cut strips of the fibrous material from the sacs of tururi) with dimensions of 20 x 200 mm and an average thickness of 0.71 mm. The results of the tensile test are shown in first line of Table 3.

Table 3 – Tensile tests on cut strips of the tururi fibrous material. Values expressed by average, standard coefficient and variation coefficient.

Rupture Load (N)	Elongation (%)	Strength (MPa)	Young's modulus (MPa)	Weight (g/m^2)	References
213± 93 (43%)	**5.9**±1.0 (17%)	**17.6**±7.8 (44%)	**552**±288 (52%)	**182**±18 (10%)	[3] [9]
391	-	-	1,800-2,400	366-583	[29]
432	9.35	-	-	204.7	[30]
558.3	-	12.27	-	246.37	[31]

The values presented in Table 3 are similar (within the same order of magnitude). In the same way, for the weight values, but it is worthy of mention that for many tururi applications, it is stretched and the weight decreases in the proportion of its nonwoven structure opening.

There was no significant statistical variation between the tensile characteristics of the fibrous material in the natural condition (brown color) and after discoloration with hydrogen peroxide and solar illumination [3] [9].

Evaluation of cellulose, hemicellulose and lignin contents and crystallinity index

The values of cellulose, hemicellulose and lignin contents and crystallinity index for all fibers, excepted tucum fiber, were obtained in literature as presented in Table 4.

Table 4. Estimation of the concentrations of holocellulose and lignin in the tucum fiber through the analysis of the TGA and DTG curves. Other values were obtained from literature.

Fiber	Holocellulose (wt%)		Lignin (wt%)	Pectin (wt%)	Waxes	Extractives (wt%)	Crystallinity Index* (%)	References
	Cellulose (wt%)	Hemicellulose (wt%)						
Tucum	68.4		21.7	-	-	-	80.25	[original data]
Buriti	65–71		21–27	-	-	5.4–6.0	71.2	[32]
Tururi	74.1	12	31.1	-	-	0.5	60.6	[29] [30]
Sisal	65–67	12	9.9	2-10	2-10	0.3-2	57.3	[32]
Curaua	71-74	9.9-21	7.5-11	-	0.79-0.9	2.5-2.8	43.5	[32]

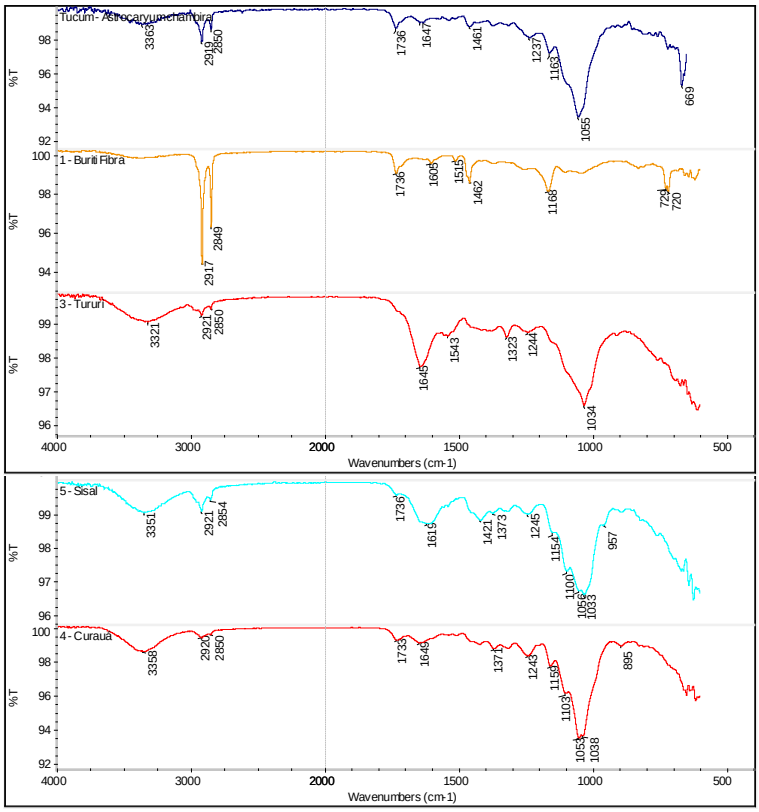
*Calculated according empirical method proposed by Segal et al. in 1959 [33]

According the results shown in Table 4 the obtained values are close. However, Segal's method [33] must be used with care, since it cannot able to reflect the real degree of biomass crystallinity, but instead provide a parameter for comparison. Even little variations in their compositions or cellulose crystallinity are expressive in order to determine differences in mechanical and thermal properties, being that higher tensile strength and higher thermal stability are obtained for fibers that contain more crystalline cellulose [32].

FTIR

The Fourier transform infrared spectroscopy (FTIR) from 4,000 to 500 cm^{-1} in equipment Thermo (model Avatar 370 FT-IR) employing cell of ATR / Germanium (Ge) (Nicolet, USA) comparing the spectra of three palm fibers from: (i) grown leaves of tucum (*Astrocaryum chambira* Burret); (ii) young leaves of buriti (*Mauritia flexuosa* Mart.); and (iii) sacs of tururi fibrous material (*Manicaria saccifera* Gaertn.); and two leaf fibers from: (i) curaua (*Ananas erectifolius*) and (ii) sisal (*Agave sisalana*) - is shown in Figure 3.

Figure 3. FTIR from 4,000 to 500 cm^{-1} in equipment Thermo (model Avatar 370 FT-IR) employing cell of ATR / Germanium (Ge) (Nicolet, USA) - Transmittance from 96.4 to 99.8%. From top to down: tucum (dark blue line), buriti (orange line), tururi (red line), sisal (light blue line) and curauá (red line). The overlap of FTIR spectra of 'linen' and 'draff' of buriti indicate a strong similarity between their chemical characteristics.



Taking in account the informations available by Stuart [34], an interpretation for the assignments of each fiber correspondent peak is presented in Table 5.

Analyzing the findings in Figure 3 and Table 5, it is possible to notice the great similarity in two wavenumber regions, near 3000 cm^{-1} and near the 3500 cm^{-1}, indicating the presence of CH and OH respectively [35]. These are the major bands observed in the graphic, which was expected, since all analyzed materials have vegetal origin. It is still possible to compare the bands obtained around 1000 cm^{-1}, in the region so called "fingerprint" of FTIR spectrum [34].

The characteristic absorption bands (cm^{-1}) for cotton are: 3450-3250; 2900; 1630; 1430; 1370; 1100-970; 550. These bands have similarity with the fibers analyzed in present study. Near the 1750 cm^{-1} band there is an area which indicates the presence of carbonyl group (C=O). The angular deformation between 3339 and 3564 cm^{-1} indicates the presence of hydroxyl groups which, in the cellulose chain are able to interact with each other, forming hydrogen bonds of two types: intramolecular (between the hydroxyl groups of the same chain), which are responsible for the stiffness of the chains, and intermolecular (between the hydroxyl groups of adjacent chains) are responsible for the formation of the supramolecular structure [36].

Thus, by FTIR analysis, considering the similarities and differences between the spectra (Figure 3 and Table 5), denoting different compositions and/or molecular structures and the presence of cellulose, hemicellulose and lignin in the fibers analyzed in present study.

Table 5. Infrared bands determined for tucum (Astrocaryum chambira), buriti (Mauritia flexuosa), tururi (Manicaria saccifera), sisal (Agave sisalana) and curaua (Ananas erectifolius) and their respective assignments.

Wavenumber (cm^{-1})					Assignment***
Tucum*	**Buriti***	**Tururi****	**Sisal****	**Curaua****	
3363	-	-	3351	3358	3700-3200 O-H stretching
-	-	3321	-	-	3700-3200 O-H stretching
2919	2917	2921	2921	2920	---
2850	2849	2850	2854	2850	2900-2700 C-H aldehyde stretching
1736	1736	-	1736	1733	1740-1720 C=O aliphatic aldehyde stretching
1647	-	1645	-	1649	1680-1600 C=C stretching
-	1605	-	-	-	1680-1600 C=C stretching
-	-	-	1619	-	1680-1600 C=C stretching
-	1515	-	-	-	---
,-	-	1543	-	-	---
1461	1462	-	-	-	---
-	-	-	1421	-	---
-	-	-	1373	1371	---
-	-	1323	-	-	---
1237	-	1244	1245	1243	1300-1100 C-O stretching
1163	1168	-	1154	1159	1300-1100 C-O stretching
-	-	-	1100	1103	1100 C-O-C stretching
1055	-	-	1056	1053	---
-	-	1034	1033	1038	---
-	-	-	957	-	1000-600 =C-H out-of-plane bending
-	-	-	-	895	1000-600 =C-H out-of-plane bending
-	729	-	-	-	1000-600 =C-H out-of-plane bending
-	720	-	-	-	1003-600 =C-H out-of-plane bending
669	-	-	-	-	1004-600 =C-H out-of-plane bending

*original data; **[3] [9]; ***Assignments according the interpretation of informations by Stuart [34].

Tururi composite development

In a joint project of the North Carolina State University (USA) and University of Sao Paulo (Brazil), multilayer composite materials were developed and characterized in 3D structure with quite promising results in terms of resistance and aesthetic finish similar to wood. The goal of this research was to develop and characterize multilayer 3D green composites from Tururi fibrous material and identify applications based on their performance. A total of 12 composite samples were fabricated using Vacuum Assisted Resin Transfer Molding Technique (VARTM) to study the effect of the structural parameters, namely, number of Tururi fibrous layers, fiber orientation, and fiber volume fraction on the tensile and impact behavior of the final composites. It was found that increasing the % stretch of the Tururi sac, and using an angle-ply stacking arrangement significantly reduced the anisotropy of the produced composite, and resulted in a quasiisotropic material. In the 0°/90° arrangement, the tensile breaking load for 0% stretch was the same in the sac and cross directions, whereas in the 100% stretch it was random. Moreover, the breaking load of 100% stretch was generally higher than the 0% stretch. Additionally, when

the breaking load was normalized by the preform areal density, it was found that composites with higher number of layers have lower normalized breaking load. Finally, increasing the stretch improved the resin penetration and increased the normalized breaking load. In the 0°/45°/-45°/90° arrangement, the tensile breaking load for 100% stretch was the same in the sac and cross directions, whereas in the 0% stretch it was different. Moreover, the breaking load of 100% stretch was generally higher than the 0% stretch. Additionally, when the breaking load was normalized by the preform areal density, it was found that the number of layers and % stretch have negligible effect on the normalized breaking load. It was found that a proper stacking sequence, can produce composites from tururi fibers with quasi-isotropic tensile behavior, and with the proper combination of number of layers, and stretch %, the tensile properties of the produced composite can be optimized [11].

Furthermore, the impact properties of these composites were characterized in light of structural variables, namely, number of layers, fiber orientation, and % stretch. It was found that the number of layers had the most significant effect on the impact resistance of the tururi composites, followed by the % stretch, whereas the preform orientation had a slight significant effect on the normalized impact energy; moreover, it significantly affected the failure mechanism. Thus, in order to design composites from tururi fibers with high impact resistance, the first factor to be considered is the number of layers which should not exceed a certain threshold after which the resin penetration becomes impaired. The second factor is the % stretch, which should be minimized to maintain higher fiber volume fraction. Finally, the fiber orientation should be random to improve the impact resistance, failure mechanism, and the damage tolerance of the structure [37].

The results are promising and indicate that tururi fibers are good candidate for the reinforcement of polymer composites. Natural fiber composites from tururi fibers exhibit a natural wood grain appearance; therefore, it can be used as a wood alternative in applications like floor laminates, counter tops, and indoor and outdoor furniture [11] [37].

Conclusion

The analyzed palm fibers (tucum, buriti and tururi) have employment potential in different kind of products, handcrafts or composites, which could generate articles such as utensils, furniture, flooring or construction. On the other hand, it is very important to preserve the palm species present in Amazon Forest biome, from which they are extracted in a sustainable way from local communities. Thus, more studies are necessary in order to know about the availability of this material thinking in an industrial scale. On the other hand, the work of local communities and craft cooperatives, which employ this material, could be stimulated respecting social and cultural aspects. The employment of natural fibers, in a sustainable context, bring implications of great importance to society, such us the environmental care, incoming generation and the possibility of qualifying the products produced by these communities adding technical and design attributes.

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