Evaluation of the quality of wood from naturally fallen tree for the development of products in Design

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Abstract

The sustainable use of forest resources in the Amazon is one of the precautions attributed to Conservation Units of sustainable use, and among them, the RESEX Auati-Paraná stands out in this study. In this area, a large volume of naturally fallen trees of various species belonging to different diametric classes were inventoried, with a higher incidence of trees with small diameter. Therefore, it is important to highlight the potential use of this raw material for development high value-added products as a sustainable income generation opportunity for community members. Thus, the objective of this research was to assess the quality of naturally fallen species through the development of products with a fine finish through technical design projects. For this, was used, defining the types of products and species (Micrandropsis scleroxylon and Simarouba amara) for the study, characterizing them, surveying the cultural aspects of the RESEX, manufacture of physical products prototypes and analyzing the quality of the wood workability during machining processes. The results obtained through the design projects, demonstrated the quality and feasibility of using wood from naturally fallen trees for the manufacture of products, being able to be explored as a sustainable alternative to generate economic benefits to the community through the valorization of such natural resources of the Amazon rainforest.

Keywords: Amazonian timber, Sustainability, Wood technology, Machining, Product Design, Traditional community

1. Introduction

In order to promote the preservation of forest areas in Brazil, especially in the Amazon, there are demarcations of territories legally protected and, among the management policies at the federal level, are the Conservation Units for Sustainable Use (UC), having as one of its constituent categories the Extractive Reserves (RESEX) (ROCHA, 2010). Such areas used by traditional extractive communities have as basic objectives "to protect the livelihoods and culture of these populations, and to ensure the sustainable use of the unit's natural resources" (BRASIL, 2000) such as forestry.

Among the communities, the RESEX Auati-Paraná in the municipality of Fonte Boa stands out, in which community training projects were developed on the use of wood in the areas of mechanical processing, machining and marquetry, such contents being taught by the laboratory servers of Wood Artifacts Engineering (LEAM) of the National Institute of Amazonian Research (INPA) which, with the support of the INCT Madeiras da Amazônia / PRODERAM / ICMBio project, also promoted the construction of a School Workshop, containing basic machinery and tools joinery (CALEGARE et al, 2014). In this scenario of sustainable exploitation of forest resources by RESEX Auati-Paraná community members, the possibility of using wood from naturally fallen trees stands out. In general, naturally fallen trees are forest residues that consist of trees considered dead due to their fall caused by natural factors such as storms, lightning, windstorms, diseases or old age (NASCIMENTO et al., 2010).

In a study carried out by Rocha (2010) at Resex Auati-Paraná, a high volume of naturally fallen trees per hectare with a diversity of species was observed, and most of the inventoried individuals were contained in diametric classes in the range of 20–50cm, demonstrating the potential use of these woods from the point of view of available stock.

In this perspective, research that explored the use of naturally fallen tree wood (ROCHA, 2010; VIEIRA et al, 2020) emphasizes the importance of using these forest resources as a catalyst between the conservation and sustainable use of wood.

In the scope of the RESEX Auati-Paraná communities, in view of the little used stock of this timber resource, the opportunity of its sustainable exploitation for the development of artifacts (furniture, decorative items, etc.) and small objects stands out (POM) as an alternative for better use and valorization of the raw material. In addition, it can also become an economic activity of generating income for community members through their performance in the wood product market with high added value, as highlighted by Nascimento et al (2010), Rocha (2010) and Higuchi (2013).

In this sense, it is worth mentioning the relevant participation of Design with the helper in the development of products with technical, aesthetic and functional quality. Thus, the importance of the integration between the technical knowledge of Design and the scientific of wood is emphasized, as the sustainable use of this raw material is linked to technological research that promotes its best application (NASCIMENTO, CRISTIANO et al., 2018).

Thus, in order to provide subsidies for the useful destination of these raw materials that are not used in RESEX Auati-Paraná, it is important and necessary the continuous development of studies that generate information on the technological potential and technical viability of wood from trees of course, above all, applied research that practically emphasizes the quality and possibility of using them for processing

products with added value.

Therefore, the major objectives of the research was to assess the quality of naturally fallen tree species through the development of products with a fine finish through technical design projects.

2. Material and Methods

For the development of this research, the product design methodology proposed by Munari (2008) was used, also adopting complementary techniques by Bonsiepe (1984) to assist in the design data analysis stage, which are: morphological analysis; structural analysis; requirements and parameters.

2.1 Design problems

From the major objective of the research, the definition of the design problem and its components was made, in order to highlight, delimit and facilitate the understanding of the aspects that should be taken into consideration during the development of the Design project.

Therefore, the development of products inspired by the RESEX Auati-Paraná, based on the use of naturally fallen tree wood, was a project problem. As for its structuring into components, the following points were highlighted as relevant to the delineation of the problem:

Table 1. Highlighting and detailing the components of the problem and its aspects.

Components of the problem	Features
A - material	Selection and characterization of two Amazonian species of naturally fallen tree for study
B - concept	Investigation and search for references in the regional aspects of RESEX Auati-Paraná.
C - product	Research and selection of product typology for the development of prototypes.

2.2 Collection and analysis of design data

For the stage of data collection and analysis, the aspects of the components of the problem were based. From the data derived from the analysis of such questions, the Requirements and Design Parameters were established. In addition, the selection and characterization of the species of naturally fallen tree was made to make the prototypes.

2.2.1 Material: selection and characterization of the Amazonian woods of the research.

To define the two species of Amazonian wood in the study, a query was made to the database of the Laboratory of Engineering of Wood Artifacts (LEAM) of the National Institute of Research of the Amazon (INPA), about the species from naturally fallen trees with volume enough timber available in the laboratory for development products.

Then, the characterization of the species was done through bibliographic research through consultations of articles, books, dissertations and theses, with the objective of getting to know the species

better and thus obtaining a better basis for analyzing their quality during the machining of the products.

2.2.2 Product: Definition and typological analysis

In order to better direct the creative design process of design projects, the product category was delimited in decorative luminaires, and the specific types of pendant lamp and table lamp (candle table lamp / candle holder) were also selected.

Then, through consultations on the website of two design product stores, the study of typologies was made using the techniques of structural and morphological analysis proposed by Bonsiepe (1984).

In the structural analysis, it was possible to understand and outline the basic composition of the selected luminaire typologies regarding their components (parts) and subsystems. In the morphological analysis, the main formal structures were observed regarding the geometric composition (shapes) of the products.

Such schemes (figure 1) collaborated in the stage of generating product alternatives, serving as a basic guide for understanding the typologies.

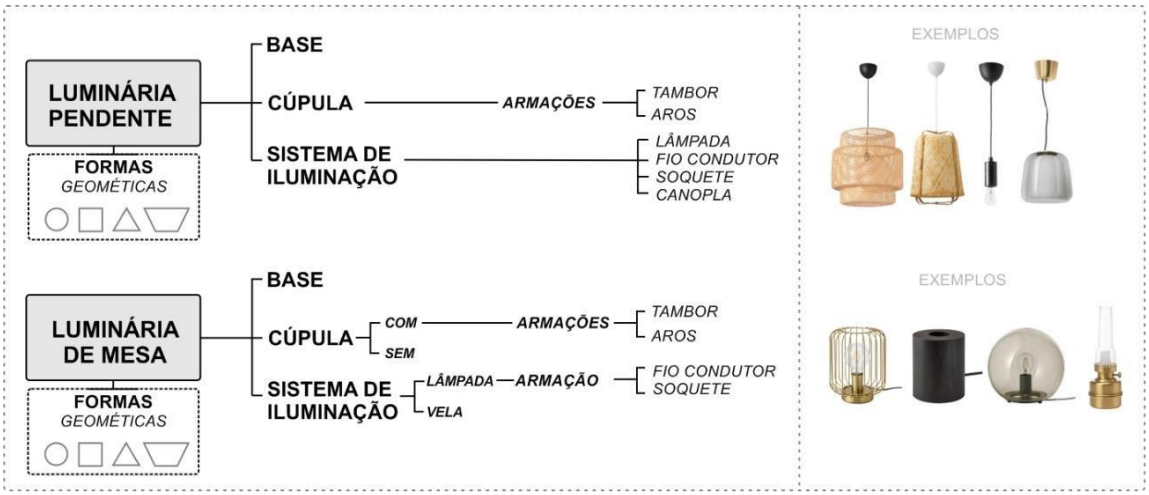

Figure 1. Analysis of the types of luminaires represented graphically in tree diagrams.

2.2.3 Concept: regional aspects of RESEX

For the collection of information about the regional characteristics of RESEX Auati-Paraná, consultations were made on the works of Higuchi (2013), Calegari et al (2014) and ICMBio (2011), focusing on the contents regarding the geographical aspect (hydrography), architecture and lifestyle related to the general daily life of the community regarding transportation and work.

From the main characteristics raised about these aspects, two were selected to compose the conceptual basis of the products, which are:

(a) Transport: boats or canoes;

(b) Hydrography: External river with muddy color and internal water bodies with dark color.

2.2.4 Requirements and Design Parameters

To guide the stage of creative product development, a Requirements and Parameter table was generated containing the main points of orientation to the design process, as indicated by Bonsiepe (1984).

Table 2. Defined requirements and design parameters

Requirements	**Parameters**
Must present simple forms	Use of basic geometric shapes
Must present regional identity	Conceptualization based on the characteristics of RESEX Auati-Paraná
Must generate little mechanical processing waste	Cutting planning for the best use of timber pieces
Must have productive facility	Use of basic joinery machinery and processes.
It must value the aesthetic characteristics of the wood	Use of heartwood and sapwood
	Aesthetic composition using marquetry techniques

2.3 Product design

The generation of product alternatives was initiated through manual sketches on paper as they allow greater freedom and speed in the graphic representation of products. At the end, the two proposals that best fit the requirements and design parameters framework were selected.

Then, three-dimensional digital prototypes were made using the 3D solid modeling CAD software, *Solid Edge ST6*, in which the product's actual volumetric reference was obtained, enabling the improvement of proposals in terms of format, dimensions, construction details and assembly, avoiding possible waste of material both in these processes of evaluation and adaptation of the idea and in the final production of the prototype.

Finally, after making adjustments to the digital prototypes, their technical details were made, which are extremely important to guide the process of making the physical prototypes.

2.4 Materials and technology

For the manufacture of physical prototypes, boards of the species *Simarouba amara* (marupá) and *Micrandopsis scleroxylon* W. Rodr (piãozinho), from a naturally fallen tree, were used. For the latter species, it is noteworthy that pieces of wood derived from a shaft considered to be of small diameter were used.

In order to facilitate the production process of the products, basic machinery was used, which can be found in small and medium-sized joiners. In summary, the following equipment, finishing materials and construction techniques were used:

- Machinery: Band saw, circular saw, surface planer machine or a jointer-planer (trowel), planer thicknesser, milling machine (routing cutting), drill and sander;
- Finishing materials: sandpaper for wood, sealer and wax;
- Techniques and processes: Marquetry, cutting, planing, gluing, sanding and drilling.

2.5 Experimentation: manufacture of products

The physical prototypes were executed in the joinery of the Laboratory of Engineering and Wood Artifacts (LEAM-INPA) with the support of the responsible technician.

The planing process with a jointer-planer / thicknesser was used for the initial preparation of use of the boards, obtaining pieces with flat surfaces on all their faces and reaching the ideal thicknesses for the pieces

of the products.

For straight cuts and obtaining initial pieces with general dimensions, a circular bench saw was used. The cuts of pieces with sinuous shapes and straight or rounded details were performed with the band saw. To obtain parts with large rounded cutouts in its center, the milling machine (routing cutting) was used for the cutting process.

The bench-top circular sander was used for roughing parts details using Nº 60 sanding paper. For finishing, the parts were sanded with machine and manually using sandpaper Nº 120, 150, 180, 220, 360, 400, 600, 1200 and 1600 in order to achieve a fine finish on the wood surfaces. Finally, two layers of sealer were applied and then one of natural wax, polishing with flannel to obtain a shine.

It is noteworthy that for making the Candle Holder, residual pieces generated from the mechanical processing of the pendant lamp were reused, thus promoting the maximum use of the wood.

Figure 2. Wood machining processes in the manufacture of physical products prototypes.

2.6 Verification: analysis of the performance of forest species

For the analysis of the quality of the wood in the manufacture of fine finishing products, the final result of the physical prototypes was observed, as well as the surface quality of the wood pieces photographed during the machining processes, taking as reference the ASTM D-1666-11 standard adapted and made more flexible to the particularities of this research, that is, served as an evaluation parameter of the results obtained. Therefore, the validation of the species was done through the assessments of the wood surfaces in the processes, prototypes and additional pieces of rectangular shape, with straight edges and with simulation of split fittings typically used in furniture.

3. Results and Discussion

3.1 Technological characterization of the studied species

- ***Micrandropsis scleroxylon* (Piãozinho)**

Scientific Name: *Micrandropsis scleroxylon* W.Roch
Family: Euphorbiaceae
Common names: Acapuri, Piãozinho, Peãozinho, Seringarana.

Additional information: Initially, studies by Rodrigues (1971) described the species under the binomial *Micrandra scleroxylon* W. Rodr., Including it among the species of Micrandra. However, in 1973, with the realization of new studies, the same author updated it for the new genus of the Euphorbiaceae family, naming *Micrandropsis* Rodr.

Figure 3. View of the cross section of the trunk (A); contrast between heartwood and sapwood (B); macroscopic aspect in cross section (C).

Source: Barros (2016) - A; Araújo (2019) - B; Rodrigues (1971) - C.

Table 3. Features of the species *Micrandropsis scleroxylon*

Features	bibliographic survey data
General features	The tree of this species has great occurrence in the Amazonian firm ground forest in the state of Amazonas [(1)] with records also Roraima and Pará [(2)], in addition to Amapá, Tocantins, Acre, Rondônia and Maranhão [(3)]. It is considered small, with a shaft with a diameter at chest height (DBH) predominantly between 25-34 cm, but it can also be found in a smaller quantity with 35-44 cm and 45-54 cm, more rarely in this last diameter class [(1)]. Corroborating, another study [(4)] registered trees with PAD within these ranges, presenting 44.8–36.2–31.2–30.5 (cm). As for the height, it reaches around 25-28 m with the crown [(1)] [(5)] and commercial height approximately between 10.4-17.9 m [(6)]. Regarding its organoleptic characteristics, it is a wood that is heavy, hard and compact; it presents a great contrast due to the color distinction between the uniform dark brown / dark brown heartwood and yellowish / cream sapwood; glossy surface with smooth appearance; receives a neat finish and excellent polishing [(1)]. It has a fine texture [(1)] to medium [(6)] [(7)] and a right grain [(1)] [(7)] to the right for interlocking [(6)]. Growth rings difficult to visualize; it has an indistinct smell and taste [(1)], but it can exhibit an unpleasant smell when freshly cut [(6)].
Workability	Not very difficult to machine [(1)], presenting flat surfaces with little roughness when planing and especially after sanding [(7)].
Main uses	It is little known despite the relative regional abundance, and is eventually used for stakes, posts, posts, with suggestive use for parquet floors, sleepers, parquet, civil and naval construction, etc. [(1)]; considered to have timber potential [(3)].
Physical properties	Basic density values are recorded as: 0.91 g / cm3 [(8)], 0.82-0.90g / cm³ in the sapwood and 0.93-0.97 g / cm³ in the heartwood [(6)]; 0.645g / cm³ [(9)]. In relation

	to apparent density (12% U), 1.176 g / cm³ [9] are recorded. Thus, it is classified as high density wood. Regarding dimensional stability through the anisotropy coefficient, values between 1.29-1.78 are shown, thus presenting dimensional variations considered stable to normal [6].

Sources: [1]Rodrigues (1971); [2]Lisboa e Rodrigues (1994 apud ARAÚJO, 2019); [3]Cardozo and Vale Junior (2012); [4]Medeiros et al (2017); [5]Aparecido et al (2019); [6]Barros (2016); [7]Araújo et al (2019); [8]Nascimento et al (2017); [9]Araújo (2019).

- ***Simarouba amara* (Marupá)**

Scientific name: *Simarouba amara* Aubl.
Family: Simaroubaceae.
Common name: Marupá, caixeta.

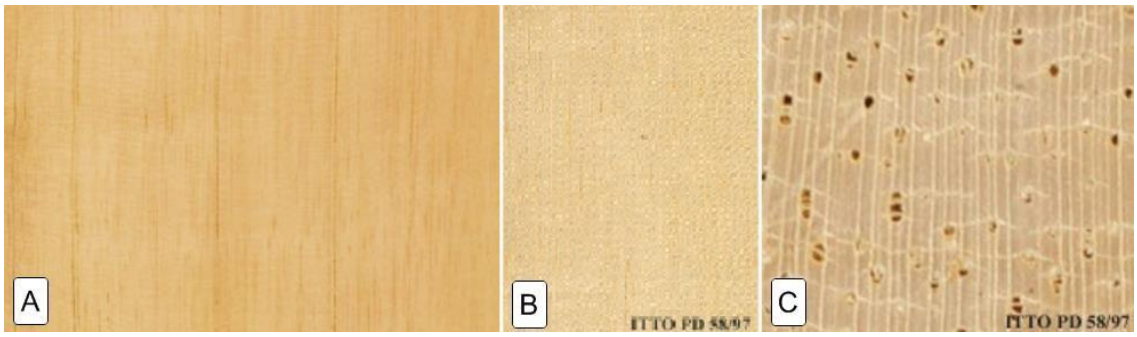

Figure 4. Aspect of the wood on the tangential side (A); View of the radial face (B); macroscopic aspect in cross section (C).

Sources: IPT [2020] – A; ITTO[2020] – B e C.

Table 4. Technological characteristics of the species Simarouba amara

Features	bibliographic survey data
General features	Occurrence recorded in the states of Pará, Amazonas, Acre, Mato Grosso and Rondônia [1]. It is a large tree, with a circular straight shaft with diameters up to 90 cm; Light wood; indistinct heartwood and sapwood of a bright yellow color that changes over time to yellowish-white; right grain; medium texture; absent figure; indistinct smell; imperceptible to slightly bitter taste [2] [3] [4]. Growth ring limits are not very distinct; absent figure; moderate brightness on longitudinal surfaces [4]; soft to manual cutting [3] [4]; smooth surface to the touch [3]. Suffers the action of staining fungi [1].
Workability	It is easy to saw, plan, nail, screw and receive a good finish [2]. Thus, it is easy to work with manual or mechanical tools, with a superficial finish, it is excellent in sandpaper, drill and planer, but poor in the lathe, in addition it presents good bonding [1].
Main uses	Furniture, general carpentry, joinery and finishing works, boxes, crates,

	compensating, cutlery, musical instruments [(2)], frames, broom handles, matchsticks, plywood, laminates, among others (1).
Physical properties	Basic density with values of approximately 0.34 g / cm³ [(3)], 0.35 g / cm³ [(2)] and 0.37 g / cm³ [(1)] being classified as a light wood. As for the apparent density, it presents 0.37 g / cm³ [(3)]. Regarding the anisotropy coefficient, values such as 1.54 [(2)] and 1.58 [(3)] are reported, classifying wood with good to normal dimensional stability.

Sources: [(1)]Souza et al (2002);[(2)]INPA/CPPF (1991); [(3)]Costa (2017); [(4)] Ribeiro (2017).

3.2 Visual characteristics of the samples used

The visual organoleptic characteristics regarding the color and figure of the species were observed on planed boards for better visualization. In general, the visual aspects observed are in accordance with the literature, however, additional descriptive information was generated regarding the aspect of the wood used in the research.

Figure 5. Wood used used to manufacture the products.

The species *Micrandropsis scleroxylon* (Piãozinho) has distinct heartwood and sapwood. The heartwood was dark brown in color with the presence of fine fine bands of tone close to black. The sapwood exhibited uniform yellowish color with the occasional presence of some thin grayish streaks. In general, the figure is absent, however, such variations of linear shades in some pieces attribute additional visual elements to wood.

The species *Simarouba Amara* (Marupá) showed no distinction between heartwood and sapwood, showing a yellowish-white color or straw shade and an absent figure. In the pieces used there was the presence of a staining fungus, attributing to the wood black linear figures with curvilinear shapes, giving the pieces an aesthetic aspect not characteristic of the species.

3.3 Behavior of wood in the manufacture of products

From the observation and evaluation of the workability of the species in the machining processes, it was possible to analyze the quality and potential of use in products with higher added value.

As for the ease of machining, the species *Micrandropsis scleroxylon* (Piãozinho) showed slight resistance to thinning due to the hardness of the wood.

In the planing process with a planer and thicknesser, it presented excellent surfaces without apparent defect and with a smooth and glossy aspect. (figure 7-A and B)

In the cuts with the circular saw, band saw and milling machine, the results obtained on the surfaces and edges of the wood were excellent, with no considerable breakage or chipping of fibers (fluff) (figure 7-C to H).

As for the drilling process with a flat drill, it showed excellent edges, with a defect (tearing of woody material) only at the bottom of the hole when not passing through. With the helical drill it also presented excellent edges, with the occasional presence of slight fibrous chills in some slits made by the successive drilling method (mortising), however, they are easily corrected with sanding or with a blade (figure 7 - I to K).

In the sanding process there was no difficulty in obtaining a smooth and glossy surface, considering that the planing process already generates an excellent finish on the parts. The use of sandpaper with granulometry 120, 150, 180, 220 and 360 was sufficient to achieve an excellent result with evident shine. It is noteworthy that the use of sandpaper 400 and 600 collaborated with the accentuation of the chandelier, being complementary those of grain size 1200 and 1600 to guarantee maximum brightness, however visually no great differences were noticed (figure 5 - L).

Regarding the bonding with white PVA glue, it presented an excellent result in the marquetry technique with joining in pieces of other timber (*Simarouba amara*), showing no detachment tendency when used in the saw cut and flat drill hole processes. Glued together, it presented a good result, but it is advisable to reinforce it with screws in top fittings for larger products, such as furniture.

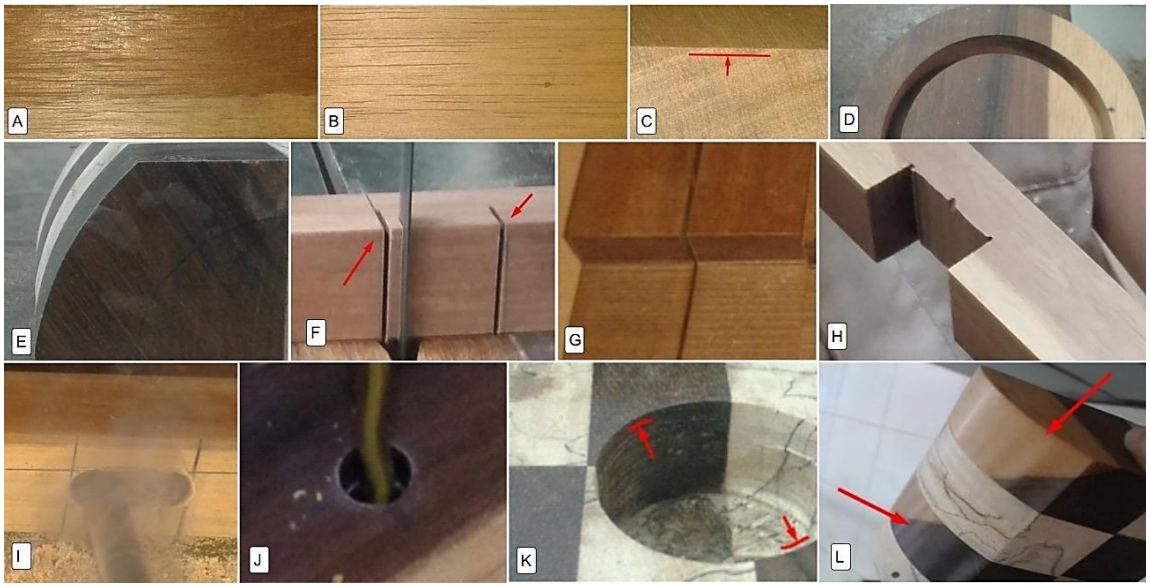

Figure 6. Finishing the surfaces of Piãozinho wood in machining processes

The species *Simarouba amara* (Marupá) presented good surfaces resulting from the planing process with the thicknesser and jointer-planer, however, chips were observed in some points on the board surface (figure 6-A)

As for the cut with a circular saw and a band saw, it showed a good result in terms of the edge finish (figure 8 - D and E), with the presence of fibrous chills being uncommon (figure 8 - B and C). Regarding

the cutting process with milling (routing cutting), it obtained surfaces with excellent finish (figure 8 - H).

The hole with a flat drill obtained a good finish on the edge, with the occasional appearance of fibrous chills, but with pullout on the bottom surface of the non-through hole (figure 8- F).

The finishing of the sanded parts had excellent surfaces and was easily hand-machined, reducing the process time. In order to promote a smooth appearance and avoid a fuzzy touch, sandpaper of granulometry nº 120, 150, 180, 220, 360, 400 and 600 were used, where the use of sandpaper 1200 and 1600 was optional for straightening, without showing relevant differences. As for the surface luster, little glare was noted on the absent one (figure 8 - I).

As for gluing, it showed excellent performance in the marquetry technique when glued together with the species *Micrandropsis scleroxylon* (Piãozinho) and also with pieces of the same species.

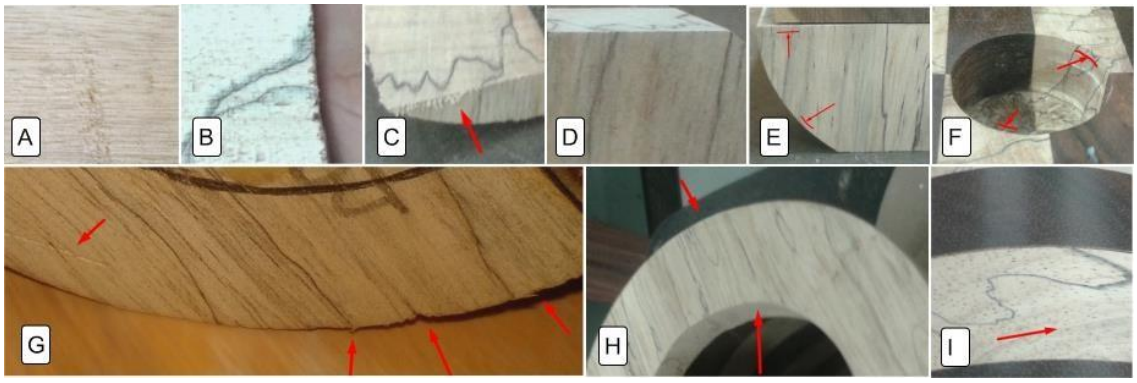

Figure 7. Finishing the surfaces of Marupá wood in machining processes

3.4 General results of workability

In general, it was found that both species showed positive results in terms of surface quality in the machining and finishing processes, the evaluation of which is summarized in table 5.

Table 5. Evaluation of machining tests

Machining processes	**Species and classification**	
	Micrandropsis scleroxylon (Piãozinho)	*Simarouba amara* (Marupá)
Cutting	Excellent	Good
Milling cutting (routing cutting)	Excellent	Good
Planing	Excellent	Good
Sanding	Excellent	Good
Drilling - Flat Drill	Excellent	Good
Drilling - Helical Drill	Excellent	-
Collage	Excellent	Excellent

The species presented different facilities regarding the thinning of the wood material by manual machining and with machinery, with Marupá being more easily worked than Piãozinho. Such behavior can

be explained by the density, since high density woods have greater hardness and consequently less ease in terms of workability (BURGER and RICHTER, 1991; MADY, 2000).

The hardness of the wood also influenced the susceptibility of the surfaces to suffer markings by impacts with sharp objects, and it was observed that Marupá, a low density wood, showed easier to acquire marks (figure 8 - G) compared to Piãozinho, of high density , which demonstrated good resistance.

According to Araujo et al (2019), studies on the roughness of the wood surface indicate that it suffers a relevant influence from the density it has, having been observed through the analysis of species of medium and high density that, in general, woods of greater density have less rough surfaces, that is, with less irregularities and consequently more flat and smooth.

Such behavior was observed in this research through the excellent results achieved on the machined surfaces of Piãozinho, going against what was found by Araújo (2019) in his study on its roughness. The author pointed out that this high density species showed low roughness on the planed surface without sanding as well as good performance in reducing this roughness with the use of sandpaper 120 and 180, obtaining smooth surfaces.

Still with regard to the good quality of the wood finish in the machining processes, the type of grain and texture are also indicative of the positive result achieved, as woods with straight grain and fine texture tend to have a greater facility in obtaining a good surface finish in the processes (MADY, 2000). Thus, according to the data collected on the organoleptic characteristics, both species are identified as having the right grain and have a texture classified between fine and medium, thus indicating factors that contribute to the good performance observed.

Regarding the use of heartwood and sapwood, with an emphasis on Piãozinho wood, it is noteworthy that no distinctions were noted regarding the quality of the woody material during the processing of the pieces, that is, they presented similar performance with excellent finish.

Regarding the presence of staining fungi in the pieces of Marupá, they did not show any negative influences on the machining of the wood or the final result of the product, contributing positively to its aesthetics. It is reported that, in general, the presence of staining fungi does not significantly alter the mechanical strength of wood, affecting mainly its aesthetics (MORESCHI, 2013). For artifacts or small wooden objects, pieces with a similar look to the one used in this research can be a positive point, as seen in the products generated, thus indicating the importance of evaluating the possibility of using stained wood for use in product projects along the way. instead of discarding them soon.

It is also noteworthy that during the manufacturing processes as well as after the finalization of the products, the wood did not show dimensional changes, indicating good stability. Such a result was expected due to the anisotropy coefficient reported in the literature for these species, with dimensional variations considered stable to normal according to classification based on Galvão and Jankowsky (1985 apud COSTA, 2017).

3.5 Manufactured products

The two products produced showed technical feasibility, aesthetic and functional quality, meeting the demands of the market for the design of wood products with a fine finish. The concepts generated for the creation of the products sought to represent aspects of the Resex Auati-Paraná as well as to value the

aesthetic beauty of the woods. Through the technique of marquetry, the contrast between the colors of the wood was evidenced, making reference to the different shades between the waters found in the surroundings and interior of RESEX Auati-Paraná.

The suspended luminaire named "Rio" used as inspiration for the thematic concept the beauty and movement of the rivers, represented in the side cutouts that are highlighted in the product through internal lighting.

Figure 8. Prototype of the suspended luminaire finished and in use.

For the table lamp, a lamp was developed characterized as a modular table support for 36mm réchaud candles, named "Modulare", having as conceptual inspiration lamps used as one of the lighting means, where the candle represents the points of light seen at night in the darkness. In addition, its frontal shape alludes to the canoes used for locomotion in the RESEX. As it is a modular part, it allows several configurations by joining several units in different arrangements.

Bearing in mind that the "Modulare" luminaire was made from the waste generated during the production of the "Rio" luminaire, the importance of the Design project is realized, which, through technical planning of the product, enabling a higher yield of the due to the reduction in the production of waste pieces during the beneficiation process.

This advantage was also observed through the use of the sapwood of Piãozinho wood, a part that is usually discarded. With the manufacture of the products, it was demonstrated that this woody part can also be used in the manufacture of products with a fine finish, enabling the increase of the wood yield, as highlighted by Fróes et al. (2019). In addition, the use of pieces of the Piãozinho species derived from a shaft considered to be of a small diameter, it has been shown that trees naturally fallen within smaller diametric classes can also be used by the community to manufacture products.

Figure 9. Prototype of the table lamp, with candle, finished and in use.

4. Final consideration

It is noteworthy that, given the results exposed through the product design and machining analysis projects, it contributed to the strengthening of technical-scientific information about the quality and viability of sustainable use of wood from naturally fallen trees for the manufacture of products with added value, thus providing subsidies to Organs managing bodies of RESEX Auati-Paraná regarding the possibility of using these forest resources by the local community.

5. Conclusion

The wood of Amazonian tree species of naturally fallen trees performed well in the machining and finishing processes, proving technically feasible for processing in products with high added value.

The species *Micrandropsis scleroxylon* showed excellent machinability in wood from both heartwood and sapwood and can be used for the development of products with a fine finish.

The development of technical design projects proved to be important for the good planning of products, collaborating with the maximum use of wood through the reduction of waste generated during processing.

Finally, it is concluded that the use of these forest resources for the production of products is an alternative that can be explored as a sustainable opportunity for income generation of RESEX Auati-Paraná community members.

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