Cuban Journal of Forest Sciences

CFORES

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Original article

Analysis of wood preferences for furniture production in Pinar del Río and Artemisa, Cuba

Análisis de las preferencias de madera para la producción de muebles en Pinar del Río y Artemisa, Cuba

Análise das preferências de madeira para a produção de móveis em Pinar del Río e Artemisa, Cuba

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ABSTRACT

The objective of this study was to determine the main preferred woods for the furniture manufacture in the provinces of Pinar del Rio and Artemisa. The method used to measure the preferences of the specialists was the so-called Hierarchical Analysis Process through the application of a survey to 350 individuals related to the consumption of wooden articles. The results obtained allowed us to define that the most preferred woods for the production of furniture are *Swietenia mahagoni* (L.) Jacq., *Cedrela odorata* L., *Cordia gerascanthus* (L.) Moldenke, *Hibiscus elatus* L. y *Tectona grandis* Sw*.* From the application of the hierarchical analysis of the species selection process, it is stated that the most accepted species is *Swietenia mahagoni,* presenting an acceptance range of 100 %. Respondents also state that the attributes associated with quality aspects have a great impact on the preference of the product over the designs, when the furniture is made of solid wood. Based on the forest management project of the Costa Sur (Artemisa), Pinar del Río and Macurije (Pinar del Rio) agroforestry companies, it was defined that *Pinus caribaea var caribaea, Eucalyptus saligna, Samanea saman, Gmelina arborea y Acacia mangium* have the potential to be used in the furniture industry based on their volumes and permanence in the forest heritage of the companies studied.

Keywords: Wood; Species; Processing; Quality; Existence.

RESUMEN

El objetivo del presente estudio fue determinar las principales maderas preferidas para la elaboración de muebles en las provincias de Pinar del Río y Artemisa. El método utilizado para medir las preferencias de los especialistas fue el denominado Proceso de Análisis Jerárquico mediante la aplicación de una encuesta a 350 individuos relacionados con el consumo de artículos de madera. Los resultados obtenidos permitieron definir que las maderas de mayor preferencia para la producción de muebles son *Swietenia mahagoni* (L.) Jacq., *Cedrela odorata* L., *Cordia gerascanthus* (L.) Moldenke, *Hibiscus elatus* L. y *Tectona grandis* Sw. A partir de la aplicación del análisis jerárquico del proceso de selección de las especies se expone que la especie de mayor aceptación es *Swietenia mahagoni* (L.) Jacq., al presentar un rango de aceptación del 100 %. Los encuestados también exponen que los atributos asociados a los aspectos de calidad tienen un gran impacto en la preferencia del producto sobre los diseños, cuando el mueble está hecho de madera sólida. A partir del proyecto de ordenación forestal de las Empresas agroforestales Costa Sur (Artemisa), Pinar del Río y Macurije (Pinar del Río), se definió que *Pinus caribaea* var*. caribaea, Eucalyptus saligna, Samanea saman, Gmelina arborea y Acacia mangium,* cuentan con potencialidades para ser utilizadas en la industria del mueble a partir de sus volúmenes y permanencia en el patrimonio forestal de las empresas estudiadas.

Palabras clave: Madera; Especies; Procesamiento; Calidad; Existencia.

RESUMO

O objetivo deste estudo foi determinar as principais madeiras preferidas para a produção de móveis nas províncias de Pinar del Río e Artemisa. O método utilizado para medir as preferências dos especialistas foi o chamado Processo de Análise Hierárquica por meio de uma pesquisa com 350 indivíduos relacionados ao consumo de artigos de madeira. Os resultados obtidos permitiram definir que as madeiras mais preferidas para a produção de móveis são Swietenia mahagoni (L.) Jacq., *Cedrela odorata* L., *Cordia gerascanthus* (L.) Moldenke, *Hibiscus elatus* L. e *Tectona grandis* Sw. A aplicação da análise hierárquica do processo de seleção das espécies mostra que a espécie mais aceita é *Swietenia mahagoni* (L.) Jacq. com uma taxa de aceitação de 100%. Os respondentes também afirmam que os atributos associados aos aspectos de qualidade têm um grande impacto na preferência do produto em relação aos designs quando os móveis são feitos de madeira maciça. Com base no projeto de manejo florestal das empresas agroflorestais Costa Sur (Artemisa), Pinar del Río e Macurije (Pinar del Río), foi definido que Pinus caribaea var. caribaea, *Eucalyptus saligna, Samanea saman, Gmelina arborea e Acacia mangium*, têm potencial para serem utilizados na indústria moveleira devido ao seu volume e permanência no patrimônio florestal das empresas estudadas.

Palavras-chave: Madeira; Espécies; Processamento; Qualidade, Estocagem; Existência.

INTRODUCTION

The global trend to use forest products or sub-products, especially those from natural forests, is motivating the introduction of species with high productive potential, hence the need to adapt the forestry industry to meet this growing demand (Valdés *et al*., 2019).

On the other hand, the great variability between forest species must also be considered, as well as their different technological properties. Among them, those that indicate possibilities of using wood for the most diverse purposes, counting among them, the furniture manufacture and the levels of customer satisfaction based on the well-being provided by wood (Lipovac and Burnard 2021).

It is significant to state that color is one of the most important characteristics for the identification, classification and suggestions of wood usage, mainly when it is associated with aspects related to its texture and design in final uses with greater added value (Valverde *et al*., 2020), mostly in the decoration, joinery and furniture industry.

In Cuba, although there are important technological advances in the sector, the level of knowledge in the area of workability properties of wood still needs to be improved (Valdés *et al*., 2018). Therefore, despite the existence of high volumes of wood in the forest heritage of provinces like Pinar del Rio and Artemisa, little is known about their workability properties, which makes them species of little use in the wooden furniture industry.

The objective of this study is to determine the main preferential woods for the furniture manufacture in the provinces of Pinar del Rio and Artemisa.

MATERIALS AND METHODS

Characterization of the study area

The Agroforestry Company "Costa Sur" is located to the west of the province of Artemisa, which is bordered to the north by the Atlantic Ocean, to the south by the Caribbean Sea, to the east by the province of Havana and to the west by the province of Pinar del Rio. The area, covered by forests with respect to the total assets of the company, is located mainly towards the coastal areas, so its spatial distribution is negative, of which 88 % are natural forests with high levels of degradation (SEF 2020).

The Agroforestry Company "Macurije" is located in the westernmost region of the Pinar del Rio province, covering parts of the territories of the Guane and Mantua municipalities. It limits to the north with the coastline from Baja to Garnacha coves; to the east with the municipality of San Juan y Martinez, belonging to the Pinar del Rio Agroforestry Company; to the south with the municipality Sandino Empresa Agroforestal Guanacahabibes (EAF) and to the southeast with the coast of the Gulf of Mexico. Pinar del Rio Agroforestry Company is located in the central and southern part of the province of the same name, which includes the municipalities of San Juan y Martínez, San Luis, Pinar del Rio and Consolacion del Sur, bordered to the north by the municipalities Minas de Matahambres and Viñales, to the south with the Caribbean Sea, to the east with the municipality of Los Palacios and to the west with the municipality of Guane (Valdes *et al.*, 2019).

Determination of sample size and sampling intensity

To determine the size of the sample (people to be surveyed), the survey method was applied through the questionnaire technique, personnel related to the consumption of wooden items (Anguita *et al.* 2003). The individuals were contacted in specialized stores, tourist facilities, sawmills, carpentry, construction works. Even professors of the Forest Engineering career at the University of Pinar del Rio were interviewed. The respondents represent a universe of 350 individuals.

The variable used was: years of experience of the respondents related to the processing and marketing of wood, which gave the possibility of developing stratified sampling which will provide an increase in the precision of population estimates (Cochran 1963).

To determine the number of people to survey, the population was stratified based on 5 years of experience or more, so three strata were formed:

- Stratum 1 — 5 to 9 years of experience with a total of 112 individuals;

- Stratum 2 — 10 to 14 years of experience with 186 individuals; and

- Stratum 3 — with more than 14 years of experience with 52 individuals.

To determine the sampling intensity (sample size) of the stratified population, the following expression from Pellico and Brena (1997) was used for finite populations (Equation 1):

$$n = \frac{t^2 \left(\sum_{h=1}^{L} W_h\, s_h\right)^2}{E^2 + t^2 \sum_{h=1}^{L} \dfrac{W_h\, s_h^2}{N}} \qquad (1)$$

Where: n- total number of units sampled; h-size of the stratum t- percentile t for a given confidence (1-a) 100 %: E- margin of error willing to accept; N- potential total number of population units; L- number of strata; W $_h$ - proportion of the stratum in the total sample; stratum size; - variance of the strata

To determine the n-size of the sample in each stratum, the proportional distribution is used, meaning (Equation 2):

$$n_h = W_h * n \qquad\qquad (2)$$

Where: n $_h$ number of units sampled per stratum; W $_h$ proportion of the stratum in the population; n total number of sampled units in the population.

Analysis of wood preferences by the consumer through the Hierarchy Analysis Process (AHP)

The method used to measure the preferences of the specialists was the so-called Analysis Hierarchy Process (AHP), proposed by Saaty (1980), used by Scholz and Decker (2007), as well as Beltran *et al.* (2021), with the intention to analyze this decision problem through the hierarchical structure, based on the individual decision of the elements.

In this case, the AHP intends to evaluate the tendencies that certain segments of the population have in relation to their preferences for wood for making furniture, taking into account the different attributes that characterize wood and its effect on the psychological well-being that this important raw material provides.

For the hierarchy of the model, the problem must be broken down into its relevant components. When building this model, enough details should be included to describe the problem as thorough as possible.

The maximum limit of the hierarchy represents the objective of the decision problem (Species preference in the elaboration of furniture). This objective was characterized from a first level of attributes (Criteria), within which Design and Quality were set. They were subdivided into several levels of attributes (Subcriteria), such as style, individuality, surface finish, work complexity, type of construction, modern rustic, classic, surface finish, translucent, opaque, skill in prize, normal, type of construction, solid, veneers, translucent oiled, lacquered and grained and finally the alternatives; which will be the species that are identified as the favorite ones; in correspondence with the methodology proposed by Roche and Vejo (2005).

According to Beltrán *et al.* (2021), in the next stage the possibilities of the alternatives (the 5 species selected as the most preferred) are evaluated through binary comparisons (pairwise) for each of the criteria and subcriteria established, the decision maker expresses his preference by assigning a numerical value to each comparison. At each level of the hierarchy, comparisons were made between pairs of elements of that level,

based on the importance or contribution of each one of them to the higher-level element to which they are linked.

This comparison process will lead to a scale of relative measurement of priorities or weights of said elements. In both cases, the pairwise comparisons were made by means of preference ratios that were evaluated according to a numerical scale from 1 to 9.

Taking into consideration the work carried out by Berumen and Llamazares (2007), based on the results obtained, the following matrix was formed (Equation 3):

$$A = \begin{pmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{pmatrix} \tag{3}$$

Once these matrices were constructed, they were normalized, dividing each number in the column by the total sum of the column and thus the normalized matrix was obtained (Equation 4)

$$A_{normalizada} = \begin{pmatrix} \frac{1}{v1} & \frac{a_{12}}{v2} & \cdots & \frac{a_{1n}}{vn} \\ \frac{a_{21}}{v1} & \frac{1}{v2} & \cdots & \frac{a_{2n}}{vn} \\ \vdots & \vdots & \vdots & \vdots \\ \frac{a_{n1}}{v1} & \frac{a_{n2}}{v2} & \cdots & \frac{1}{vn} \end{pmatrix} \tag{4}$$

Subsequently, an arithmetic average was calculated for each line of the normalized matrix and the Priority Vector for the alternatives, criteria and subcriteria was obtained (Equation 5).

$$p = \begin{pmatrix} \frac{1}{n}\sum_{1}^{n} a_{1j} \\ \frac{1}{n}\sum_{1}^{n} a_{2j} \\ \vdots \\ \frac{1}{n}\sum_{1}^{n} a_{nj} \end{pmatrix} \tag{5}$$

In this case, the AHP tried to evaluate the tendencies that certain segments of the population have in relation to their preferences for wood for making furniture, taking into account the different attributes that characterize it. Therefore, data from pair comparisons were collected at the individual level through questionnaires applied to a

group of 25 specialists who were chosen based on the predetermined objective and according to the criteria set forth by Barba and Pomerol (1997). In these cases, a geometric average of all the opinions issued by the specialists was obtained, coinciding with Roche and Vejo (2005).

The maximum limit of the hierarchy represents the objective of the decision problem (preference of species in the furniture manufacture). This objective was characterized from a first level of attributes (Criteria), within which the following were set:

Design and Quality. They were subdivided into several levels of attributes (Subcriteria), among which are: style, individuality, surface finish, work complexity, type of construction, modern rustic, classic, surface finish, translucent, opaque, skill in prize, normal, type of construction, solid, veneers, translucent oiled, lacquered and grained and finally the alternatives; which will be the species that are identified as the preferred ones; in correspondence with the methodology proposed by Roche and Vejo (2005).

In the next stage, the possibilities of the alternatives (the 5 species selected as the most preferred) were evaluated through binary comparisons (pairwise) for each of the established criteria and subcriteria, the decision maker expresses his preference by assigning a value numerical to each comparison.

At each level of the hierarchy, comparisons were made between elements of that level, based on the importance or contribution of each of them to the higher-level element to which they are linked (Beltrán *et al.*, 2021).

This comparison process leads to a scale of relative measurement of priorities or weights of those elements. In both cases, the pairwise comparisons are made by means of preference ratios that are evaluated according to a numerical scale from 1 to 9 proposed in Table 1.

Table 1. - Fundamental scale of comparisons

Worth	Definition	Comments
1	Equal importance	Criterion A is just as important as Criterion B
two	Intermediate importance	Intermediate value for when it is important to compare
3	Medium importance	Experience and judgment slightly favor Criterion A over Criterion B.
4	Intermediate importance	Intermediate value for when it is important to compare
5	High relevance	Experience and judgment strongly favor Criterion A over Criterion B.
6	Intermediate importance	Intermediate value for when it is important to compare
7	Very high importance	Criterion A is much more important than Criterion B
8	Intermediate importance	Intermediate value for when it is important to compare
9	Extreme importance	The greater importance of Criterion A over Criterion B is beyond doubt.

Example: If criterion A is of great importance compared to criterion B, the notations would be as follows:

Criterion A vs. Criterion B 5/1
Criterion B vs. Criterion A 1/5 (reciprocal of the above)

Source: Saaty (1980) and Berumen and Llamazares (2007)

With these results, the following matrix is formed: (Equation 6), according to Berumen and Llamazares (2007) (Equation 6):

$$A = \begin{pmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{pmatrix} \tag{6}$$

Subsequently, an arithmetic average is made for each line of the normalized matrix and the Priority Vector is obtained for the alternatives, criteria and subcriteria (Equation 7)

$$p = \begin{pmatrix} \frac{1}{n}\sum_{1}^{n} a_{1j} \\ \frac{1}{n}\sum_{1}^{n} a_{2j} \\ \vdots \\ \frac{1}{n}\sum_{1}^{n} a_{nj} \end{pmatrix} \tag{7}$$

Analysis of the consistency of the opinions expressed

Bearing in mind that respondents can make poor judgments when comparing some of the elements, an analysis of the consistency of the results obtained was carried out. For each line of the pair comparison matrix, a weighted sum is determined based on the sum of the product of each value of the same by the priority of the corresponding alternative (which arises from the priority vector). By averaging the results obtained, a λ_{max} (Berumen *et al.,* 2007) (Equation 8) was obtained:

$$\lambda_{max} = n = \sum_{i=1}^{n} \lambda_i \tag{8}$$

Once it is obtained, the Consistency Index (Equation 9) is calculated (Moreira and Ortega (2021):

$$IC = \frac{\lambda_{max} - n}{(n - 1)} \tag{9}$$

With this index, a measure of consistency was already obtained. But it should not be used because according to the AHP a certain value of this index is tolerable in an array of a certain dimension, but it is not tolerable in another of a different dimension. Because of this, Saaty (1980) developed a random consistency measure, uniform for all matrices (Table 2).

Table 2. - Random Consistency Index (ICA)

Number of items being compared	1	2	3	4	5	6	7	8	9	10
Random Consistency Index (ICA)	0	0	0.58	0.89	1.11	1.24	1.32	1.40	1.45	1.49

Source: Berumen and Llamazares (2007)

For these purposes, the Consistency Ratio was determined from the following equation (Moreira and Ortega 2021):

Where: RC- consistency ratio; IC consistency index; ICA- Random consistency index

From the point of view of the AHP, it is desirable that the consistency ratio of any pairwise comparison matrix be less than or equal to 0.10 (Moreira and Ortega 2021).

Finally, the contribution of each element to the elements of the immediately higher level of the hierarchy was evaluated and the global contribution of each alternative to the main objective or goal was calculated. Excel was used as a tool to facilitate data processing. In the case of selecting the species preferred by wood consumers, a priority vector is defined for each sub-criterion and criterion, as well as for all the alternatives evaluated.

Analysis of the stock volumes of the preferred species in the furniture market and substitution alternatives

Finally, an analysis is made of the stock volumes in the forest estates of the species preferred by the respondents and the timber species with the greatest existence in the forest estates with the aim of proposing them as alternatives in the furniture sector in Pinar del Rio and Artemisa.

RESULTS AND DISCUSSION

Determination of the woods preferred by consumers

As a result of the applied survey, it was obtained that the five favorite species by consumers for the manufacture of furniture are *Swietenia mahagoni* (100 %), *Cedrela odorata* (98 %), *Cordia gerascanthus* (66.8 %), *Hibiscus elatus* (51.2 %) and *Tectona grandis* (39.2 %).

These results coincide with those of Valdés *et al*. (2014), where the perceptions of wood consumers identified the same species as the most preferred, resulting in *Swietenia mahagoni* the most precious of them.

When carrying out an analysis of the main criteria exposed by consumers referring to: quality of the wood, possibility for new designs, difficulty for being worked and characteristics of its surface finish, the respondents state that the wood used for the production of furniture has to be analyzed in its entirety because there are many factors that affect a correct selection, these approaches coinciding with the criteria issued by Laina *et al.* (2017), who point out that wood has a strong impact on customer preferences when it is analyzed the product as a whole.

The magnitude of the irregularities that are formed in the woodworking process depends on several interrelated factors, as well as the anatomical structure and physical properties of the wood. These elements must be taken into account when selecting the wood to use for making furniture.

There are several factors that influence the process of secondary transformation of wood and that participate in the formation of surfaces and in their final quality, among them are mainly the orientation of the grain, the moisture content, and the density of the wood; corroborating the approaches of Hazir and Koc (2018), in relation to the quality of wood and its derivatives.

Another of the results obtained from the surveys carried out in the research phase regarding the work complexity, refers that the quality of the surface finish depends to a great extent on the little knowledge of the industrialists, of the most suitable combinations for the processing of the wood; coinciding with the approaches of Singer and Ozçahin (2020).

When the number of blades and the speed of rotation of the head increase, a better surface finish is obtained (without quantifying the increase) in the piece, which coincides with Valdés *et al*. (2019), when establishing that the surface roughness is affected by different variables, for example, in woodworking and rotational speed, where an increase in rotational speed produces less rough surfaces.

Respondents also state that the attributes associated with quality aspects have a great impact on the preference of the product over the designs, when the furniture is made of solid wood, in this way the carpenters prefer *Swietenia mahagoni,* both in the classic product lines and in the country-style ones, which still have a stable market in the areas under study.

Use of Hierarchical Analysis in the process of selecting the preferred species based on the attributes of the wood

From the materialization of the proposed methodology, results were obtained related to the normalized matrix that defines the importance of each of the species in consumer preferences (Table 3).

Table 3. - Normalized matrix from the hierarchical analysis of the process

Species						VP
Swietenia mahagoni	0.52	0.52	0.61	0.40	0.30	0.479
Hibiscus elatus	0.10	0.10	0.06	0.24	0.20	0.149
Cedrela odorata	0.15	0.31	0.20	0.24	0.20	0.228
Tectona grandis	0.10	0.03	0.06	0.08	0.20	0.090
Cordia gerascanthus	0.10	0.03	0.06	0.024	0.06	0.054

From the results obtained, an arithmetic average was determined for each line of the normalized matrix and the priority vector for the alternatives, criteria and subcriteria was obtained (Figure 1).
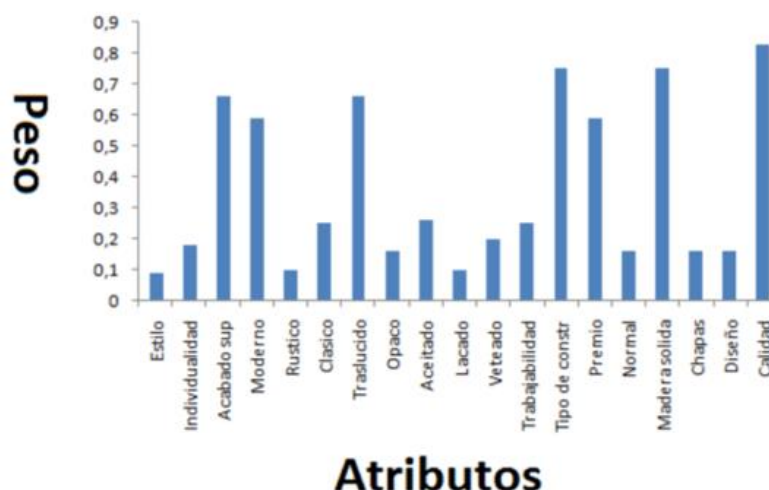

Fig. 1. **-** Overall contribution of each alternative to the main objective or goal

In the case of selecting the species preferred by wood consumers, a priority vector is defined for each sub-criterion and criterion, as well as for all the alternatives evaluated. The final result of the hierarchical analysis of the species selection process shows that the species with the highest acceptance globally is mahogany, presenting an acceptance range of 54 %, as shown below:

- *Swietenia mahagoni* = 0.52 *0.83+0.50*0.16+0.39*0.14 = 0.54*100 = 54 %

- *Cedrela odorata* = (0.23*0.83) + (0.16*0.16) + (0.25*0.14) = 0.245*100 = 24 %

- *hibiscus elatus* = (0.10*0.83) + (0.10*0.16) + (0.17*0.14) = 0.12 * 100 = 12 %

- *Tectona grandis* = (0.06*0.83) + (0.056*0.16) + (0.11*0.14) = 0.06*100 = 6 %

- *Cordia gerascanthus* = (0.03*0.83) + (0.056*0.16) + (0.07*0.14) = 0.04*100 = 4 %

Availability of the five species preferred by the furniture industry

An analysis of the volumetric and surface existence of the four species preferred by wood consumers in the management projects of the Macurije, Pinar del Rio and ''Costa Sur'' Agroforestry Companies is shown in Table 4.

Table 4. - Availability of preferred timber species by the furniture sector

Especies valoradas	EAF Macurije		EAF Pinar del Rio		EAF Costa Sur		Totales	
	ha	Vol.(m³)	ha	Vol.(m³)	ha	Vol.(m³)	ha	Vol.(m³)
Swietenia mahagoni	28,7	834,3	13,4	1003,7	85,7	3556,5	127,8	5394.5
Cedrela odorata	30,2	906	0,2	11	54,6	2730	85	3647
Hibiscus elatus	89,1	4975,2	65,1	7055	206,5	18998	360,7	31028.2
Tectona grandis	19,5	935	31,1	3243	38	1710	88,6	5888
	167,5	7650,5	109,8	11312,7	384,8	26994,5	662,1	9535

Source: State Forest Service (SEF)-Ministry of Agriculture (2020)

Cordia gerascanthus is not included in this table because at present it is in a state of sapling given the overexploitation, so no volumes of wood are reported by any of the three companies under study.

As can be seen from the table, the largest existence in surface and volume for the four species belong to the AFC Costa Sur followed by the AFC Macurije and the AFC Pinar del Rio, where the species in descending order that occupy the largest surface area and the largest volume of existence are *Hibiscus elatus* followed by *Tectona grandis, Swietenia mahagoni* and finally *Cedrela odorata.*

These results correspond to the areas of plantations prioritized by the companies due to the rapid growth for the cases of *Hibiscus elatus* and *Tectona grandis* and the vulnerability of *Swietenia mahagoni* and *Cedrela odorata* for *Hypsipilla grandella's* attackand for the use of *Cedrela odorata* to a greater extent for the manufacture of tobacco boxes, being a priority in the Pinar de Rio province (SEF 2020), which requires intensive management for both species.

Abundant species, but little used by the furniture industry

Other species that have ample existence in plantations and in volumes of wood within the forest heritage of the Macurije, Pinar del Rio and Costa Sur companies are shown in Table 5.

Table 5. - Availability of abundant species, but little preferred by the furniture sector

Especies valoradas	EAF Macurije		EAF Pinar del Rio		EAF Costa Sur		Totales	
	ha	Vol. (m³)	ha	Vol. (m³)	ha	Vol. (m³)	ha	Vol. (m³)
Pinus caribaea	27275,7	3218532.1	5328.9	808657	419.13	35626	33023.7	4062815.1
Eucaliptus saligna	8153.2	823473.2	1162.2	128995	192.7	14452.5	9 508.1	966920.7
Samanea saman	--------	---------	2.2	158.1	57	3705	59.2	3863.1
Acacia mangium	123.5	13214.5	281.0	18873.1	136.0	9520	540.5	41607.1
Gmelina arborea	--------	---------	14.6	938.4	115.3	10377	129.0	11315.4

Source: State Forest Service (SEF)-Ministry of Agriculture (2020)

The species with the largest volume and area planted in the companies studied is the *Pinus caribaea* var*. caribaea* followed by *Eucalyptus saligna, Gmelina arborea, Acacia mangium* and *Samanea saman* in that order. The first two are prioritized in reforestation plans due to their uses and rapid growth, and the last two are one of recent introduction (*Acacia mangium* and *Samanea saman)* existing only in natural forests.

Comparing the results presented in Tables 4 and 5, in terms of surface area of the cited species, it can be seen that the *Pinus caribaea* var*. caribaea, Eucalyptus saligna, Acacia magnium, Gmelina arborea and Samanea saman* (all of relatively low preference in the furniture industry), are the species with the largest volume of existence, resulting, on the other hand, that the ones with the smallest amount in the area under study are *Swietenia mahagoni, Cedrela odorata* and *Tectona grandis,* which are together with *Hibiscus elatus* those preferred by consumers.

It is noteworthy that in the case of *Hibiscus elatus* despite being one of the preferred species, and therefore overexploited for furniture manufacturing, its abundance is currently relatively high, even higher than *Samanea saman.*

In the Forest Economy Organization and Development Projects of the three companies there are coincidences in that the volumes of wood of high-demand species are detrimental. That coincides with Valdés *et al*. (2014), who attributes that the existence of precious wood species is affected by the high existing demand, which causes an imbalance in the development classes of these species and their use. Hence, there are few usable individuals and in the case of *Swietenia mahagoni and Cedrela odorata* a low recruitment in the natural forest, which provokes a decrease in surfaces.

That is why, from the analysis of the high volumes of little-known wood species in the furniture industry, its use is recommended because reduces the current impact made on the wood species preferred by consumers.

It is also significant to define that the woods with the greatest existence in the production systems and the forest heritage that support them, are mostly characterized by presenting light tones that exert a marked influence on the psyche and the psychological well-being of the consumer. Which defines that color is one of the preferred factors when selecting a product derived from wood (Bello *et al.,* 2020).

CONCLUSIONS

The most preferred species for furniture production in Pinar del Rio and Artemisa are *Swietenia mahagoni*, *Cedrela odorata*, *Cordia gerascanthus*, *Hibiscus elatus* and *Tectona grandis.*

The most widely accepted species globally is *Swietenia mahagoni* presenting an acceptance range of 54 %, as shown below.

The attributes associated with quality aspects have a great impact on the preference of the product over the designs, when the furniture is made of solid wood, *Pinus caribaea* var. *caribaea, Eucalyptus saligna, Samanea saman, Gmelina arborea* and *Acacia mangium* have the potential to be used in the furniture industry, taking into consideration their respective volumes and permanence in the forest heritage of the companies studied.

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Conflict of interests:
The authors declare not to have any interest conflicts.

Authors' contribution:
The authors have participated in the writing of the work and analysis of the documents