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PRODUCTION OF PARTICLEBOARD PANELS FROM WOOD OF *Ochroma pyramidale*

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Resumo

Produção de painéis aglomerados da madeira de Ochroma pyramidale. O objetivo do trabalho foi avaliar a utilização da espécie *O. pyramidale* para a produção de painéis aglomerados. As árvores, com idade de 6 anos, foram provenientes do Município de Mira Estrela/SP. Os toretes foram descascados e processados em um picador industrial para obtenção das partículas. Foram realizados oito tratamentos, variando os teores na emulsão de parafina (0, 1, 1,5 e 2%), e os teores de adesivos de ureia formaldeído (10 e 12%). As partículas passaram pelo processo de secagem até atingir 4% de umidade. Para a prensagem dos painéis foram utilizados os parâmetros temperatura de 160°C, pressão específica de 30 kgf/cm² e tempo de 10 minutos. Os painéis foram testados pelos testes físicos e pelos testes mecânicos, todos seguindo os procedimentos das seguintes normas: D-1037 (ASTM, 2006) para densidade, absorção de água e inchamento em espessura e ligação interna; DIN 52362 (1982) para flexão estática paralela. Como resultados, observou-se que o aumento da adição de parafina nos painéis resultou em uma melhoria na sua estabilidade dimensional. O tratamento que foi adicionado 12% de adesivo uréia formaldeído e 1,5% de parafina alcançou resultados superiores nas propriedades mecânicas, equivalente a 10390,91kgf cm^{-2} para módulo de elasticidade, 101,46kgf cm^{-2} para módulo de ruptura. Os painéis aglomerados de *O. pyramidale* alcançaram os valores mínimos de 1,4 kgf/cm² para ligação interna e de 56 kgf/cm² para módulo de ruptura requeridos pela normativa CS 235-66 (1968), tornando-se assim uma espécie potencial para a produção de painéis aglomerados.
Palavras-chaves: Pau de Balsa, Rápido Crescimento, Potencial, Painel de Madeira.

Abstract

The objective of this work was to evaluate the use of the species *O. pyramidale* for the production of particleboards. The trees, aged 6 years, came from the Municipality of Mira Estrela/SP state. The logs were peeled and processed in an industrial chopper to obtain particles. Eight treatments were carried out, varying the levels of paraffin emulsion (0, 1, 1.5 and 2%), and the levels of urea formaldehyde adhesives (10 and 12%). The particles went through a drying process until they reached 4% moisture. For pressing the panels, the parameters temperature of 160°C, specific pressure of 30 kgf/cm² and time of 10 minutes were used. The panels were tested by physical tests and mechanical tests, all following the procedures of the following standards: D-1037 (ASTM, 2006) for density, water determination and thickness increase and internal connection; DIN 52362 (1982) for parallel static bending. As a result, it was concluded that the increased addition of paraffin to the panels resulted in an improvement in their dimensional stability. The treatment that added 12% urea formaldehyde adhesive and 1.5% paraffin achieved superior results in mechanical properties, equivalent to 10390.91kgf cm-2 for the separation modulus, 101.46kgf cm-2 for the rupture modulus. The *O. pyramidale* particleboards reached the minimum values of 1.4 kgf/cm² for internal bonding and 56 kgf/cm² for the modulus of rupture required by CS 235-66 (1968), thus becoming a potential species for the production of particleboard panels.
Keywords: Balsa Wood, Rapid Growth, Potential, Wood Panel.

INTRODUCTION

Wood panels can be defined as products composed of wood elements such as: sheets, battens, particles and fibers, obtained from the reduction of solid wood, and reconstituted by means of adhesive bonding (WEBER; IWAKIRI, 2015). Wood panels are divided into three large groups: plywood, chipboard and compressed fiber panels.

Brazil has excellent conditions for developing the production of particleboard panels. In 2021, the Brazilian consumption of particleboard panels was 8.256 million m³, resulting in an increase of 15.43% compared to the previous year (IBÁ, 2021). The experience in managing fast-growing forests, which is widespread and associated with soil and climate conditions, makes it possible to optimize the use of forest resources. Most of the raw material used for the production of reconstituted wood panels in Brazil comes from forest plantations.

Currently in Brazil, wood from planted forests, mainly from pine and eucalyptus genera, is the most used by industries in the production of particleboard panels (PIERRE *et al.*, 2014). To meet the high demand for wood, it is necessary to increase the area planted with these species or diversify the types of raw materials used to produce particleboard panels (GUIMARÃES JÚNIOR *et al.*, 2013).

The knowledge of new species as a source of raw material in this sector is promising. Along with the study of new species for the production of panels, the aim has been to achieve improvements in their quality, both for physical and mechanical properties. With this in mind, the species *O. pyramidale* emerges as an alternative and promising species as a raw material for particleboard panels, due to the fact that it has desirable characteristics, such as rapid growth and mainly because it has a low specific mass.

One of the challenges for the production of particleboard panels is related to dimensional stability, which generally results in high water absorption and swelling in thickness. This phenomenon occurs because wood and its products have free hydroxyl groups (OH-), mainly in the amorphous region of cellulose and hemicelluloses. From the moment the wood is transformed into particles, its surface area is increased. This means there is greater contact between the wood and water, which generates high water absorption and thickness swelling values in the particleboard panels.

There are some methods that can be used to improve the dimensional stability of particleboard panels. One of these methods is the addition of paraffin to the treatments, which, when added to the production process, has the purpose of increasing their dimensional stability, reducing their hygroscopicity. This occurs because paraffin is a nonpolar alkane that is characterized by hydrophobicity, that is, it has no affinity with water. Thus, this substance acts by forming a protective film on the particles, making them waterproof. This improves the physical properties of the panels, especially with regard to liquid water, although the same is not true for water vapor (WEBER; IWAKIRI, 2015).

The *O. pyramidale tree* has a high growth rate, reaching up to 25 meters in height and approximately 71 cm in DBH at 7 years of age. In Brazil, especially in the states of Mato Grosso and São Paulo, some producers decided to invest in the species, with the "promise" of rapid growth. The growth rate of the species is fast and the density of its wood is very low (VERA *et al.* 2020). The species reaches heights between 1.8 and 4.5 m at the end of the first year, and can reach 11 m at the end of the second year (FRANCIS, 2000). Ecuador is traditionally the world's largest producer of balsa wood, supplying 89% of global markets, followed by Papua New Guinea at 8%. Some trees of the species reached 23 m in height and 50 cm in diameter at 6 years of age, and the final height can reach between 25 and 30 m and a diameter of up to 1 m (KOTLAREWSKIE *et al.* 2016).Furthermore, according to Daniels (2017), the species has low-density wood (120 kg/cm³ to 200 kg/m³) and can reach mechanical properties of 8000 MPa for modulus of elasticity and 70 MPa for modulus of rupture in static bending (BORREGA *et al.*, 2015).

However, there is still no consolidated market to absorb the wood from balsa wood plantations and the price per cubic meter is low compared to the world market, which sells around 150 thousand m³/year of wood of this species, generating around US$ 71 million, with the main buyers being the United States (50%), China, India, among others (DANIELS, 2017).

To this day, little is known about the potential use of this wood in the production of particleboard panels, as well as the best paraffin and adhesive contents for making these composites. Thus, the objective of this study was to evaluate the use of *O. pyramidale wood* in the production of particleboard panels, testing different paraffin and adhesive contents.

MATERIAL AND METHODS

The wood was supplied by the Balsa-Brasil project. Three six-year-old trees of the *Ochroma pyramidale* species were supplied and underwent the process of obtaining particles for the production of particleboard panels. The particles were generated by a Hombak "Chipper", model U-74. The adhesive used was urea formaldehyde (UF), together with the addition of paraffin emulsion for the production of particleboard panels.

The panels were produced according to the treatments described in Table 1, consisting of eight treatments, with four repetitions each, totaling 32 homogeneous panels. Different levels of paraffin emulsion and adhesive were tested.

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Table 1. Experimental design.
Tabela 1. Delineamento experimental.

Species	Adhesive (%)	Paraffin (%)	Adhesive (%)	Paraffin (%)
O. pyramidale	10	0	12	0
		1		1
		1,5		1,5
		2		2

For the urea-formaldehyde adhesive and paraffin, both in liquid form, the following parameters were analyzed: solid content according to standard NBR 8877 (ABNT, 2015); viscosity according to standard D-1037 (ASTM, 2006), gel time D2471-99 (ASTM, 1999) and pH determined with the aid of a digital pH meter calibrated in buffer solution 4.0 and 7.0 with the reading recorded after six minutes of contact with the electrode to the solution.

The particle dimensions were obtained using a digital caliper. The variables measured were length, width and thickness. In total, 150 particles of *O. pyramidale* material were randomly collected.

The *O. pyramidale* particles were dried in the open air and in an oven at a temperature of 80°C until they reached a moisture content of approximately 4%. They were then placed in sealed plastic bags to homogenize and maintain moisture, and then kept in a climate-controlled room with a constant temperature of 20±2°C and relative humidity of 65±3% until the panels were manufactured.

The application of the urea formaldehyde adhesive and paraffin emulsion was carried out on a rotating drum gluing machine, programmed to rotate at a constant speed of 20 rpm. The gluing machine is equipped with a spray gun activated by an air compressor and coupled to a container for depositing the liquids, in this case, the adhesive and paraffin emulsion, in order to apply them to the wood particles.

Regarding the production, homogeneous panels measuring 40cm x 40cm and 16mm thick were produced, with a density equivalent to 0.6g/cm³. After its formation, the mattress was subjected to cold pre-pressing in a manual press with a specific pressure of approximately 5kgf/cm2 to accommodate the particles and then, hot pressing was done. The parameters used in the hot pressing were a specific pressure of 35kgf/cm2, for 8min, at a temperature of 160ºC in a hydraulic press with automatic control of the variables. Then, the panels were acclimatized in the laboratory with a constant temperature of 20±2oC and relative humidity of 65±3%. The panels remained in an air-conditioned room until reaching a constant mass and were later squared to remove the test specimens.

After the production of the particleboard panels, they were subjected to marking following a specific layout (Figure 1). After marking, the panels were squared on a circular saw to remove the test specimens and subsequently determine their physical and mechanical properties. In this process, the edges were disregarded, as they significantly interfere with the properties analyzed in the panels.

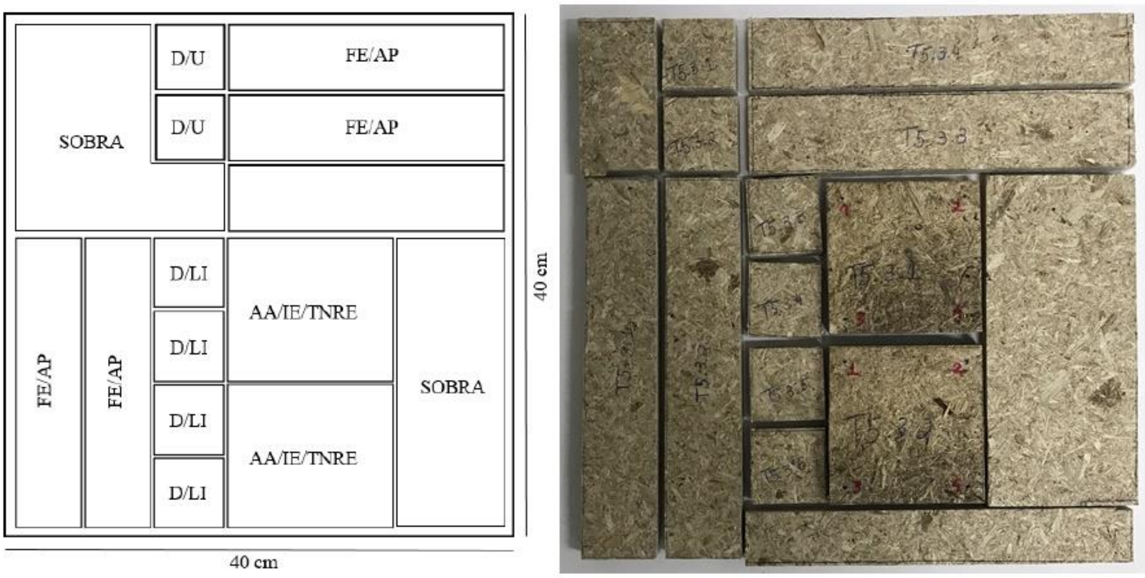

Figure 1. Layout used in the particleboard squaring process.
Figura 1. Layout utilizado no processo de esquadrejamento dos painéis aglomerados.

The dimensions of the test specimens, as well as the execution of the physical and mechanical tests, were carried out in accordance with the following standards: D-1037 (ASTM, 2006) for density, water absorption and swelling in thickness and internal connection; DIN 52362 (1982) for parallel static bending. The EMIC DL-300 kN universal testing machine was used for the mechanical tests. The data analysis was performed in a 4x2 factorial, considering the different paraffin contents (0, 1, 1.5 and 2%) and the different adhesive contents (10 and 12%).

The data adhesion and the normal distribution were tested by the Shapiro Wilk test, and to assess the homogeneity of variance, the data were subjected to the Bartlett test. Furthermore, the comparison of the means was given by the Scott-knott test. After meeting the statistical assumptions and the data sets, a statistical analysis was performed on all the experiment data sets, using the Completely Randomized Design (CRD). All tests were performed with 95% significance, using the software Sisvar 5.3 Build 77, developed by Ferreira (2011) and the Action platform of the Excel program.

RESULTS

Adhesive characterization

Table 2 presents the solid content values of the urea formaldehyde adhesive and paraffin used in all treatments, together with the gel time, viscosity and pH values for the adhesive only.

Table 2. Results of the adhesive properties and paraffin solids content used in the production of the panels.
Tabela 2. Resultados das propriedades do adesivo e teor de sólidos parafina utilizados na produção dos painéis.

Properties	**Values**
Solids Content – Urea Formaldehyde (%)	67
Solids content – Paraffin (%)	49
Gel time (s)	523
Viscosity (cP)	332,25
pH	7,8

Where: s: seconds; cP: centipoise.

Physical properties

Figure 2 presents the results of the physical properties, such as density (A), compaction ratio (B), moisture content (C), rate of non-return to thickness (D), swelling at 2 hours and 24 hours (E, F) and water absorption at 2 hours and 24 hours (G, H) of the panels manufactured for the different paraffin and adhesive contents.

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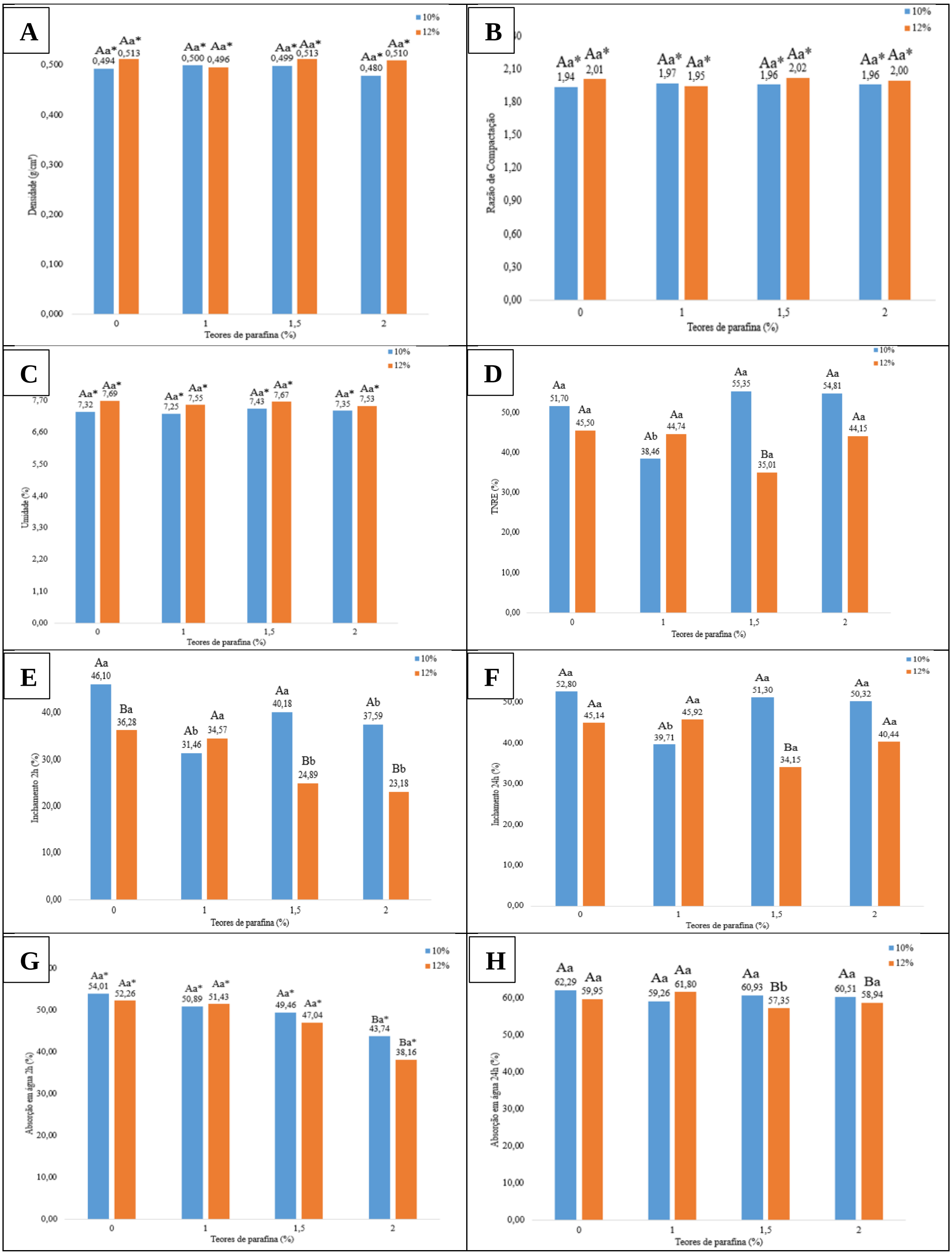

Where: 10% (blue) and 12% (orange) percentages of the amount of urea-formaldehyde adhesive. Means followed by the same letters do not differ from each other by the Scott-Knott test at 5% significance. Capital letters consider the adhesive content, while lower case letters analyze the paraffin content. *Variable in which the interaction between the adhesive x paraffin factors was not significant at the 5% significance level.

Figure 2. Physical properties of the panels.
Figura 2. Propriedades físicas dos painéis.

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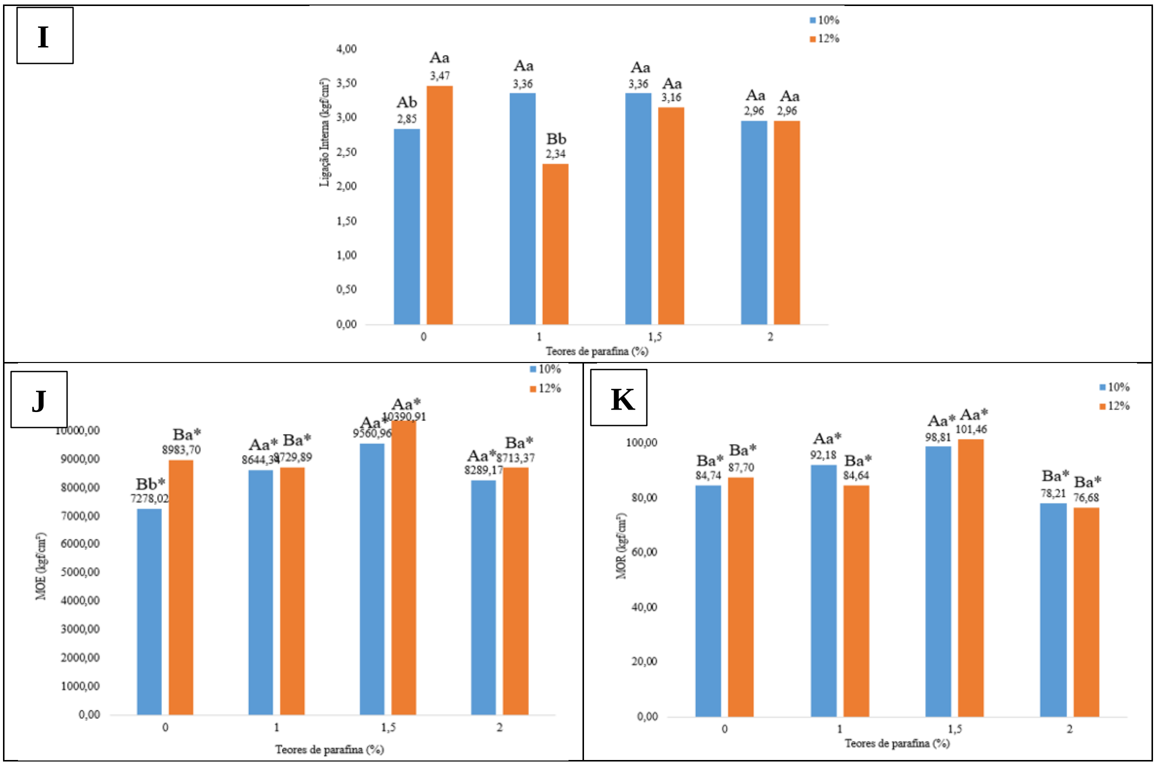
Mechanical properties

Figure 3 shows the results of the mechanical properties, such as internal connection (I), modulus of elasticity (J) and modulus of rupture (K) of the panels manufactured for the different paraffin and adhesive contents.



Where: 10% (blue) and 12% (orange) percentages of the amount of urea-formaldehyde adhesive. Means followed by the same letters do not differ from each other by the Scott-Knott test at 5% of significance. The capital letters consider the adhesive content, while the lower case letters analyze the paraffin content. *Variable in which the interaction between the adhesive x paraffin factors was not significant at the 5% of significance level.

Figure 3. Mechanical properties of the panels.
Figura 3. Propriedades mecânicas dos painéis.

DISCUSSION

Regarding the density of the panel and the compaction ratio (Figures 2A and 2B), when evaluating the different paraffin contents (0, 1, 1.5 and 2%) and adhesive contents (10 and 12%), the averages obtained did not show significant differences, that is, they were equal to each other.

The average density of the panels was 0.500 g/cm³, not reaching the nominal density of 0.600 g/cm³. The loss of material that occurs during the process was considered for the production of particleboard panels. However, this value was not achieved due to laboratory conditions, with situations occurring that cannot be controlled in the panel production processes, such as: lack of homogeneity in the distribution of particles in the mattress and lateral sliding of particles during pressing.

This behavior also occurred in the studies by Melo *et al.* (2015), evaluating the influence of specific mass on particleboards produced using different proportions of wood particles (*Eucalyptus grandis*) and bamboo (*Bambusa vulgaris*), where they found lower apparent density values than previously established.

Another explanation for this behavior would be a possible loss of particles and additives during the formation of the mattress, together with the return in thickness of the panels, after the removal from the hot press and packaging, with a consequent increase in the volume of the panels and reduction in the initial nominal density (JUNIOR *et al.*, 2016).

However, the average density value of the panels fell within the low density classification (<0.60g/cm³), according to the CS 236-66 standard (COMMERCIAL STAN-DARD-CS, 1968).

From figure 2B, it can be seen that there was no statistically significant difference in the compaction rate for either the paraffin content or the adhesive content. The averages presented for compaction ratio were statistically the same, ranging from 1.95 to 2.02.

According to Wechsler *et al.* (2013), the ideal compaction ratio range should be between 1.3 and 1.6 for adequate densification and consolidation of the panel to the desired final thickness. Therefore, lower density materials are the most recommended ones.

Furthermore, regarding particleboard panels, the same authors state that the higher the compaction ratio, consequently, the greater the amount of wood particles used during production, resulting in greater densification of the panels. The present study presented values above the ideal range proposed by Wechsler *et al.* (2013). With high panel densification values, the hygroscopic swelling property of the wood will also be high. This behavior occurs due to the release of compression stresses generated during the high-temperature pressing process.

The moisture content values of the mattress ranged from 7.25 to 7.69%, and did not present a statistically significant difference between the averages found (Figure 2C).

Weber and Iwakiri (2015) found an average moisture content value equivalent to 8.30% when evaluating the behavior of plywood, MDF and MDP waste for the production of particleboard panels. The average value found by the same authors was higher when compared to the one of the present study. The difference in values can be explained by the fact that the material was subjected to high temperatures during the panel manufacturing process, significantly contributing to the reduction of hygroscopic sites.

Mendes *et al.* (2014) point out that the equilibrium moisture content for reconstituted wood products is lower when compared to the one of solid wood, when exposed to similar temperature and humidity conditions.

Trianoski *et al.* (2014) states that the reduction in moisture content is due to the transformation of the wood into particles, subsequent mixing of adhesives, paraffins and the application of high temperatures and pressure during the pressing of the panel, causing them to lose the ease of stabilization with the environment.

For the non-return to thickness rate (TNRE) (Figure 2D), when 10% UF was used in the treatments, there was a significant difference in the 1% paraffin content, with values ranging from 55.35 to 38.46%. However, when 12% UF was used, there was no difference between the averages obtained in the different paraffin contents, the values ranging from 45.50 to 35.01%. There was no interaction between the adhesive x paraffin factors.

It is noted that with the increase of adhesive in the treatments, per surface area of particles, there was a decrease in water absorption, swelling in thickness and TNRE, except for the treatment that used 1% paraffin, causing an inverse behavior.

The decrease in the TNRE variable can be explained by the physical barrier that is larger in the glue line and also by the addition of paraffin to the treatments, since its function is to reduce hygroscopicity, resulting in the occupation of the hygroscopic sites of the wood (OH), leaving the panel with less affinity for water (MENDES *et al.*, 2003).

Furthermore, in relation to TNRE, it is seen that this variable is directly related to the swelling property in 24h. Therefore, the higher the IE24h, the higher the TNRE. This is due to the greater variation in thickness resulting from the release of compression stresses, which becomes partially unrecoverable (MENDES *et al.*, 2014).

It can be observed that for most treatments there was a significant reduction in the TNRE in the panels when the adhesive content was increased from 10% to 12%. The increase in the availability of adhesive per surface area of particles is the cause of the decrease in the non-return rate in thickness.

Mendes *et al.* (2014), when evaluating the quality of homogeneous particleboards produced with wood from Eucalyptus urophylla clones, found average values for TNRE of 29.08%.

The swelling values at 2 hours in relation to the paraffin contents are shown in figure 2E. When 10% UF was added, it can be observed that the treatment that did not require the addition of paraffin and the treatment that required 1.5% paraffin presented higher swelling values after 2 hours, equivalent to 46.10% and 40.18%, respectively, resulting in equal averages that did not differ from each other. When 12% UF was added to the treatments, the highest averages for this variable were equal to 36.28% (0% paraffin) and 34.57% (1% paraffin), statistically equal averages. This behavior is common, since the paraffin and resin have the function of giving the panel repellency to water in a liquid state. This reduction in hygroscopicity promotes an improvement in the swelling property in thickness, making the panel less reactive to water (WEBER; IWAKIRI, 2015). Therefore, the greater the amount of paraffin applied, the lower the swelling in thickness of the panel.

By adding 2% paraffin to the treatments, it was possible to observe a decrease in swelling in the thickness of the panels, resulting in a reduction of 18.45% (10% UF) and 36.10% (12% UF). According to Guimarães Júnior *et al.* (2013), the addition of 1% paraffin in the production of particleboard panels results in a reduction of approximately 11% in the thickness swelling.

For swelling in thickness in 24h (Figure 2F), there was also an interaction between the adhesive x paraffin factors. Furthermore, there was a significant difference between the paraffin contents when 10% UF was used. The values ranged from 52.80% to 39.71% when 10% UF was used and from 45.92 to 34.15% using 12% UF.

In treatments using 12% UF, it was observed that when increasing the paraffin content there was a decrease in thickness swelling after 2 hours. The values obtained for all treatments in thickness swelling after 2 and 24 hours were higher than the maximum value required by standard CS 235-66 (1968), equivalent to 30%, that is, they did not meet the standard.

It can be stated that the particles that received 1.5% paraffin and 12% urea-formaldehyde adhesive showed less swelling, which possibly occurred due to the reduction of hydroxyl groups available for water adsorption in cell wall constituents. Guimarães Junior *et al.* (2013), studying the influence of different paraffin contents on the physical and mechanical properties of *Pinus oocarpa* particleboards, observed that there was a decreasing linear relationship between the swelling in thickness in 2 hours and the percentage of paraffin used in the production of the panels. While for the swelling in thickness in 24 hours, a maximum swelling value was observed for a percentage of approximately 0.5% paraffin. Gorski *et al.* (2015), analyzing the production of oriented particleboards from Eucalyptus benthamii Maiden et Cambage and Pinus spp. wood in different combinations between layers, they achieved lower results when compared to the study, ranging from 9.0 to 20.6% for swelling in thickness 2 hours and from 32.1 to 42.50% for swelling in thickness 24 hours.

Trianoski *et al.* (2014), evaluating the production of *Toona ciliata* particleboards produced with different densities and resin contents, concluded that the application of a greater amount of adhesive provided an improvement in the stability property, a behavior verified in the present study.

For the variable of water absorption in 2h (Figure 2G), there was no interaction between the factors analyzed (adhesive x paraffin). It is noted that there was a decrease in the averages when increasing the paraffin contents, both for the treatments using 10% UF and for the other treatments using 12% UF. The values ranged from 38.16% to 54%.

The treatments that did not receive paraffin were those that absorbed the most water, both in 2h and in 24h. This behavior can be explained by the large amount of empty spaces between the particles, which were possibly filled by water. Another factor is the abundant presence of pores of the *O. pyramidale* species and also by the greater amount of particles in the panels with a high compaction ratio.

The variable water absorption after 24 hours (Figure 2H) showed interaction between the factors (adhesive x paraffin). Furthermore, there was a statistical difference between the paraffin contents when 12% UF was used. The highest absorption value was 62.29%, observed in the treatment that led to the addition of 10% UF and no amount of paraffin, with no significant difference when compared to the other values for the different paraffin contents. When 12% UF was added, the highest absorption value was 61.80% observed in the treatment that received 1% paraffin. It is noted that for most treatments, when a greater amount of adhesive was added, water absorption decreased; this behavior was observed at 2 and 24 hours. The significant difference occurred for the variable water absorption at 24 hours between the treatments of 10% and 12% UF when the 1.5% paraffin content was added. The standards for marketing low-density particleboard panels do not establish limits for water absorption after 2 and 24 hours.

Guimarães Junior *et al.* (2013) observed higher water absorption values when paraffin was not added to the treatments, equivalent to 116.05% (2 hours) and 120.47% (24 hours), while the lowest values were found in the treatments that had a higher paraffin content, equivalent to 2%; the averages obtained in the study were 19.75% (2 hours) and 64.69% (24 hours).

The internal bonding variable (Figure 3I) showed a significant difference in the interaction between the adhesive x paraffin factors. When 10% UF was used, there was no significant difference between the paraffin contents, while when 12% UF was used, the 1% paraffin content was statistically different from the other contents. Furthermore, the internal bonding averages ranged from 2.34 to 3.47 kgf/cm².

When assessing the adhesive content of the panels, a significant difference was observed in the treatment that used 1% paraffin. In the remaining treatments, the averages were statistically the same (Figure 3I). The CS 236-66 (1968) standard stipulates minimum values for internal bonding of 1.4 kgf/cm². Therefore, all panels produced with different paraffin and adhesive contents met the minimum required.

The lowest averages for internal bonding were found when a larger amount of paraffin was applied, equivalent to 2.34 kgf/cm². The values obtained for internal bonding in the present study may have been influenced by the geometry of the particles, which is directly associated with the compaction ratio value. The particles were obtained using an industrial chipper, with blade angles adjusted to cut *Pinus* sp. wood, a species that also has low density. The factor that may explain this behavior is that *O. pyramidal* wood is anatomically distinct when compared to *Pinus* sp. wood, resulting in particles with larger-than-expected geometries, i.e., short and wide particles. When subjected to the internal bonding test, it can be seen that the glue breaks in the presence of larger particles.

Some authors conclude that the internal bonding variable is related to the compaction ratio. Studies by Gorski *et al.* (2015) found that the highest average value of the internal bonding test (0.68 MPa) was obtained by the panels that presented the highest compaction ratio (1.52).

Figure 3J shows that the MOE averages did not show any interaction between the adhesive x paraffin factors. The values ranged from 7278.02 to 9560.96 kgf/cm² when 10% UF was used in the production of the panels and from 8713.37 to 10390.91 kgf/cm² when 12% UF was used. The highest MOE values for both UF adhesive contents of 10% and 12% were observed when 1.5% paraffin was added.

With the presentation of these results, it can be seen that adding a greater amount of paraffin to the treatments resulted in an improvement in the mechanical properties to a certain extent. In this study, it was possible to observe that adding the paraffin content up to 1.5% resulted in a higher MOE value.

The values obtained by the panels produced did not reach the minimum required by the CS 236-66 (1968) standard, equivalent to 10500 kgf/cm², that is, they presented values lower than the standard for modulus of elasticity.

Guimarães Junior *et al.* (2013), studying the effect of the influence of different paraffin contents on the physical-mechanical properties of *Pinus oocarpa* particleboards, achieved a higher MOE value in treatments that included 2% paraffin, equivalent to 1380.87 MPa.

For the MOR variable (Figure 3K), the same behavior occurred in relation to the MOE variable, where the highest averages for both 10% and 12% UF were observed at a paraffin content of 1.5%. There was no significant difference between the averages when evaluating the different adhesive contents, indicating that with the increase in adhesive in the particleboard production process (between 10 and 12%), there was no change in their flexural properties. There was also no interaction between the adhesive x paraffin factors. In relation to the provisions of the CS 236-66 (1968) standard, with regard to MOR, the minimum value required is 56 kgf/cm², therefore, all treatments complied with the standard.

The study by Guimarães Junior *et al.* (2013) found the highest MOR average when they added 2% paraffin to the treatments, equivalent to 168.55 kgf/cm². Trianoski *et al.* (2014) assessed that between treatments with the same nominal density and different resin levels, there was a tendency for improvement in the mechanical properties for MOE and MOR.

Furthermore, according to Laskowska and Maminski (2018), mechanical properties such as flexural strength and rigidity and internal bonding strength are influenced by the geometry of the particles that compose them.

CONCLUSION

Based on the results obtained with the agglomerated panels of O. *pyramidale*, the following conclusions can be presented:

- By adding paraffin up to 1.5% to the panels using 12% UF, it was possible to verify the reduction in swelling and water absorption in 2h, improving the dimensional stability of the panels.
- The particleboard panels produced with 12% adhesive content and 1.5% paraffin content resulted in higher values for mechanical properties, such as modulus of elasticity and rupture for static bending tests.
- The different treatments with UF adhesive and paraffin contents achieved the minimum values required by the CS 235-66 (1968) standard for the internal bonding properties and modulus of rupture of particleboards. However, for the modulus of elasticity, swelling and thickness after 2 and 24 hours, none of the treatments achieved the standard.
- Wood from the *O. pyramidale* species showed satisfactory results for mechanical properties in the production of particleboard panels when 1.5% paraffin and 12% urea formaldehyde were added. It is recommended to test and apply new treatments to achieve better results regarding the physical properties of the panels and consequently reach the minimum required by the regulations. Furthermore, new research should be carried out regarding the loss of material during the particleboard production process.

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