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Properties of MDF manufactured with mixtures of wood from paricá plantations and wood waste from native Amazonian species

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ABSTRACT

Brazil stands out as one of the largest manufacturers of MDF (medium density fiberboard) in the world. The industries are concentrated in the south and southeast of the country and are primarily based on the use of *Pinus* and *Eucalyptus* wood, which are available in extensive planted areas. In the northern region, there is only one MDF industrial plant. Despite an abundance of potential raw materials in this region, there is a lack of studies on native species wood and their industrial waste utilization for MDF production. The present study aimed to evaluate the properties of MDF manufactured from a mixture of cultivated paricá (*Schizolobium amazonicum*) wood and wood waste from native Amazonian species. The study assessed the isolated effects of different proportions of the raw materials and panel thicknesses on MDF properties. Panels were produced, and samples were obtained for testing. Using standard procedures, the following properties were determined: density, water absorption, thickness swelling, internal bonding, static bending, and resistance to screw withdrawal. The results revealed a significant impact of the analyzed variables on some physical and mechanical properties of MDF. With the exception of internal bonding, all other properties of the evaluated MDF panels met the specified regulatory requirements for use in furniture manufacturing. It is concluded that mixtures of the assessed raw materials have great potential for MDF production in the furniture industry. However, adjustments in the production process are recommended to improve the internal bonding property.

KEYWORDS: *Schizolobium amazonicum*, wood-based panels, tropical wood species, industrial wood processing

Propriedades de painéis MDF fabricados com misturas de madeira de plantações de paricá e resíduos de madeira de espécies nativas da Amazônia

RESUMO

O Brasil se destaca como um dos maiores fabricantes de MDF (*medium density fiberboard*) do mundo. As indústrias concentram-se nas regiões Sul e Sudeste do país e baseiam-se no aproveitamento das madeiras de *Pinus* e *Eucalyptus*, disponíveis em extensas áreas plantadas. Na região Norte há apenas uma planta industrial de MDF. Embora haja abundância de matéria-prima potencial nesta região, há carência de estudos sobre madeiras de espécies nativas e seus resíduos industriais para aproveitamento na produção de MDF. O presente estudo teve como objetivo avaliar as propriedades de painéis MDF fabricados a partir de misturas de madeira cultivada de paricá (*Schizolobium amazonicum*) e resíduos de madeira de espécies nativas da Amazônia. Foram avaliados os efeitos isolados de diferentes proporções de mistura entre as matérias-primas e da espessura dos painéis sobre as propriedades do MDF. Os painéis foram produzidos e deles retiradas amostras para ensaios. Utilizando normas padrão, as seguintes propriedades foram determinadas: densidade, absorção de água, inchamento em espessura, tração perpendicular, flexão estática e resistência ao arranque de parafusos. Os resultados mostraram efeito significativo das variáveis analisadas sobre algumas das propriedades físico-mecânicas do MDF. Com a exceção da resistência à tração perpendicular, todas as demais propriedades dos painéis MDF avaliados atenderam aos requisitos normativos especificados para uso na fabricação de móveis. Conclui-se que as misturas das matérias-primas avaliadas possuem grande potencial para a fabricação de MDF para aplicação na indústria moveleira, porém, são recomendadas adequações no processo de produção a fim de melhorar a propriedade de tração perpendicular.

PALAVRAS-CHAVE: *Schizolobium amazonicum*, painéis à base de madeira, espécies de madeiras tropicais, processamento industrial da madeira

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INTRODUCTION

Brazil was the second largest producer of MDF/HDF (medium density fiberboards/high density fiberboards) in the world in 2021, with production nearing 6 million m³ (FAO 2022). Out of this total, 4.9 million m³ were consumed in the Brazilian domestic market, resulting in a 15.7% growth compared to the previous year's consumption (IBÁ 2022). The primary source of raw material for this product is wood, either in the form of logs or waste generated from other processes (Iwakiri et al. 2005). MDF finds its most common application in the furniture industry (Ayrilmis et al. 2017).

From 1997 to 2002, Brazilian MDF production was characterized by the exclusive use of woods from the *Pinus*. In 2003, *Eucalyptus* spp woods were introduced, and they have since shown a growing trend in production participation (Belini 2007). Currently, depending on the region of the country, one genus or the other predominates.

MDF production is concentrated in the southern and southeastern Brazil, accounting for approximately 70% of the total area planted with *Eucalyptus* spp. and *Pinus* spp. in the country (IBÁ 2022). Geographically, wood-based panel industries are strategically located near furniture centers or in locations with logistics that favor the efficient flow of production to customers (Vidal and Hora 2014).

In 2010, an MDF industry was established in northern Brazil, in the state of Pará, using wood from *Schizolobium amazonicum* Huber ex Ducke (paricá) and *Eucalyptus* spp plantations as raw materials. The introduction of this industry was an innovative initiative and marked the beginning of decentralizing MDF production in Brazil, as well as the utilization of non-traditional raw materials in this industrial segment. Among these potential raw materials are the wastes generated from the mechanical processing of wood from native Amazonian species, which are abundant in Pará.

The use of waste from processing native wood, from sawmills and veneer factories in the Amazon region, can be an interesting alternative for the particleboard industries (Iwakiri et al. 2012). However, few studies have been conducted on this topic, including research on industrial or laboratory-scale MDF production using residues from the mechanical processing of native Amazonian wood (but see Araujo et al. 2021).

Paricá wood has a low density, ranging between 260 and 420 kg m^{-3} (Vidaurre et al. 2012; Melo et al. 2013). However, most native Amazonian species used in mechanical processing consist of medium to high-density woods (Martini et al. 1998). Low-density woods are preferred for the production of medium-density panels because they result in an appropriate compaction ratio (CR ≈ 1.3), which is determined by the relationship between panel density and wood density. High-density wood cannot be adequately compressed to achieve the required compaction ratio for medium-density panels without compromising bonding. A partial solution for using high-density woods is to blend them with low-density woods, creating a mixture of raw materials that achieves the appropriate density for proper compaction (Maloney 1977).

There are numerous studies on the quality of MDF produced from the blending of different types of wood and/or other lignocellulosic materials, seeking alternative raw materials and their suitability for the production process (e.g., Belini et al. 2010; Köse et al. 2011; Ayrilmis et al. 2017; Rahman et al. 2019; Araujo et al. 2021). In addition to the raw material, various production variables of MDF, such as density and adhesive content (Eleotério et al. 2000; Hong et al. 2017; Rahman et al. 2019; Rockwood et al. 2022), as well as panel thickness (according to NBR 15316-2; ABNT 2009b), influence the product's properties. However, there are limited studies that specifically address the effect of panel thickness (e.g., Valcheva and Savov 2016).

The primary aim of the present study was to assess the properties of MDF panels produced using a combination of paricá wood and wood waste from native Amazonian species. The specific objectives included examining the isolated effects of the blend ratio between raw materials and of the thickness of the panels on the properties of the MDF.

MATERIAL AND METHODS

Experimental design

The experimental design consisted of three independent experiments, each designed to analyze the isolated effect of a production variable on the properties of the MDF panels manufactured in an industrial production line. The density of the panels was intentionally kept constant across treatments within each experiment because its variation could mask the effects of the variables tested in each experiment on the properties of the panels. In Experiment I, the targeted density for the panels and panel thickness was kept constant, and the analyzed variable was the fiber blend ratio (FBR) used in the panel manufacturing process, tested with three treatments. In Experiments II and III, both density and FBR were kept constant, and different treatments of panel thickness were tested. The detailed setup of each experiment is presented in Table 1. For each treatment, three panels (replicates) were used.

Raw materials

In this study, we used wood sourced from *Schizolobium amazonicum* in the form of logs (SAL) and wood veneer waste (SAV), along with a blend of wood waste resulting from the mechanical processing of various Amazonian native species (MIX). The SAL material originated from eight-year-old plantations, SAV and MIX (lacking species identifications)

Table 1. Setup of experiments I, II, and III (Exp) to evaluate the isolated effect of fiber blend ratio (FBR) and panel thickness on the properties of MDF produced with *Schizolobium amazonicum* wood and wood waste from native Amazonian species.

Exp	Treat	Density (kg m^{-3})	FBR (%) SAL	SAV	MIX	SFBR	Thickness (mm)
I	T2	700	25	0	75	B	15
	T3	700	0	40	60	C	15
	T4	700	0	25	75	D	15
II	T1	800	15	15	70	A	12
	T5	800	15	15	70	A	15
III	T4	700	0	25	75	D	15
	T6	700	0	25	75	D	18

Treat = treatment code; Density = target density of the panels; SFBR = symbol of fiber blend ratio; SAL = *Schizolobium amazonicum* wood from logs; SAV = *Schizolobium amazonicum* wood from veneer wastes; MIX = wood waste from the mechanical processing of native Amazonian species.

materials were obtained from sawmills and veneer factories located in the municipalities of Paragominas, Dom Eliseu, and Ulianópolis.

The materials were processed into chips and subsequently into fibers within the facilities of a MDF manufacturing plant. The fibers were then used in the production of MDF panels in the same MDF plant, as detailed below.

Manufacture of MDF panels

Except for the variables described earlier in the experimental design, including the specific density planned for each experiment, all other production parameters of the MDF panels manufactured in the plant were kept constant, as described below.

The chips from the dosing silo, previously washed, classified, and mixed according to each fiber blend ratio (A, B, C, or D), were submitted to preheating with steam at a temperature of 90 °C for 8 minutes. Subsequently, the chips were transferred to the digester, where they were exposed to a temperature of 190 °C and a pressure of 0.85 MPa for 5 minutes. Then, the wood chips were defibrated in a double-disc refiner under a pressure of 0.95 MPa.

Upon exiting the defibrator, adhesive and paraffin emulsion were applied to the fibers. The adhesive used for fiber bonding was urea-formaldehyde (UF), with a solids content of 66% and a viscosity of 350 cP. The adhesive dosage was 13% solids, based on dry fiber mass. The paraffin dosage was 0.7% of solids, calculated similarly to the resin.

After receiving the adhesive and paraffin, the fibers were dried in a tube dryer, driven by a forced air current at a temperature ranging from 140 to 150 °C, achieving an average final moisture content of 10%. The fiber mattress was formed on a mobile mat, pre-pressed, cut, and then taken to a hydraulic press equipped with 12 plates for the final pressing. The press operated at a temperature of 194 °C, a maximum pressure of 2.1 MPa, and a total time of 189 seconds.

After pressing and cooling, one panel out of the 12 produced at a time was randomly selected, and a 600 x 600 mm sample was extracted from it, which constituted one treatment replication. This process was repeated for each new pressing and cooling cycle until three samples per treatment were collected, which were then used to obtain specimens for conducting the planned tests.

Basic density of the raw materials

Samples of wood chips from the raw material were collected at the MDF plant and taken to the Mechanical Testing Laboratory of Wood and Derivatives at Universidade de São Paulo - USP, where the basic density of SAL, SAV, and MIX wood chips was determined using the maximum moisture content method, as outlined by Smith (1954). Based on these data, the basic density of the chip mixtures that formed the fibers was estimated. The estimation procedures followed Surdi (2012) and Surdi et al. (2015), accounting for the percentage of each raw material's contribution to the mixtures.

Obtaining and testing specimens

The samples of panels (600 x 600 mm) produced in the MDF plant were also taken to USP for the experimental procedures. Test specimens were obtained from each panel sample using a circular saw and then conditioned at 22 ± 2 °C and 65 ± 5% relative humidity. These specimens were used to evaluate moisture content, density, water absorption (WA) and thickness swelling (TS) after 2 and 24 hours of immersion, internal bonding (IB), static bending (SB) to determine modulus of rupture (MOR) and modulus of elasticity (MOE), as well as resistance to screw withdrawal (RSW) on the top and face surfaces.

Density and moisture content were evaluated on the same test specimen. A similar process took place to evaluate WA and TS. The dimensions of the test specimens to evaluate SB were as follows: a length equal to 20 times the sample thickness, plus 50 mm, and a fixed width of 50 mm. The dimensions of the test specimens to evaluate all other properties were 50 x 50 mm and the thicknesses were 12, 15 or 18 mm. For each parameter evaluated, four measurements were taken per panel, totaling 12 measurements, considering that three panels (replicates) were used per treatment. The dimensions of specimens and testing procedures followed the NBR 15316-3 standard (ABNT 2009c), which is similar to the European standard series for MDF.

Data analysis

Initially, the normality and homogeneity of variance of the data were checked using the Shapiro-Wilk and Bartlett tests, respectively. The requirements for normality and homogeneity were met, and there was no need to transform the data for any of the analyzed variables.

The response variable in each experiment was compared among treatments using analysis of variance (ANOVA). When the ANOVA was significant, a Tukey test was used for pairwise comparison between the treatments ($\alpha = 0.05$). The average values of the assessed parameters were compared to the specifications outlined in the NBR 15316-2 standard (ABNT 2009b).

RESULTS

Density

The average basic density for the SAL and SAV chips did not differ statistically, as expected considering they were composed of the same source wood. The density of MIX chips was significantly higher than that of SAL and SAV (Table 2).

Table 2. Basic density of SAL, SAV and MIX chips, and of the fiber blend ratios (as defined in Table 1) used in the MDF panels produced with *Schizolobium amazonicum* wood and wood waste from native Amazonian species. Basic density values of chips are the mean of eight replicates.

Chips	SFBR	Basic density (kg m^{-3})
SAL	-	300 b
SAV	-	290 b
MIX	-	650 a
CV (%)	-	7.6
-	A	544
-	B	563
-	C	506
-	D	560

SAL = *Schizolobium amazonicum* wood from logs; SAV = *Schizolobium amazonicum* wood from veneer wastes; MIX = wood wastes from the mechanical processing of native Amazonian species; CV = coefficient of variation; SFBR = symbol of fiber blend ratio; Chip type means followed by different letters indicate statistically significant difference ($p < 0.05$) according to a Tukey post-hoc test.

Table 3. Moisture content, density and compression ratio of MDF panels used in three experiments to evaluate the effect of fiber blend ratio (FBR) and panel thickness on the properties of MDF produced with *Schizolobium amazonicum* wood and wood waste from native Amazonian species. Density and moisture content values are the mean of three replicates.

Experiment	Treatment	SFBR	Thickness (mm)	Moisture content (%)	Effective density (kg m^{-3})	CR
I	T2	B	15	8.4	730 a	1.3
	T3	C	15	8.7	710 a	1.4
	T4	D	15	8.7	710 a	1.3
CV (%)	-	-	-	-	1.0	-
II	T1	A	12	7.9	810 a	1.5
	T5	A	15	7.6	820 a	1.5
CV (%)	-	-	-	-	1.6	-
III	T4	D	15	8.7	710 a	1.3
	T6	D	18	8.5	710 a	1.3
CV (%)	-	-	-	-	2.4	-

CV = coefficient of variation. SFBR = symbol of fiber blend ratio; CR = compression ratio. Within each experiment, means followed by different letters differ statistically ($p < 0.05$) according to a Tukey *post-hoc* test.

The effective density of the panels within each experiment closely matched the planned density (target density), demonstrating that the panel production process was well-controlled. There were no significant differences among treatments in the effective density of the panels in any of the experiments (Table 3). Therefore, the fiber blend ratios (Experiment I) and panel thickness (Experiments II and III) did not have a significant influence on panel density.

Water absorption and thickness swelling

In Experiment I, there was no significant difference in WA and TS (both at 2 and 24 h) of the panels among treatments (Table 4), indicating that the fiber blend ratio did not influence these properties. In Experiment II, WA (at 2 and 24 h) and TS (at 24h) differed significantly among the treatments, indicating an effect of panel thickness (12 and 15 mm) on these variables. In Experiment III, TS (at 2 and 24 h) differed significantly among treatments, reinforcing the effect of panel thickness (15 and 18 mm, in this case) on thickness swelling.

Static bending, internal bonding and resistance to screw withdrawal

In Experiment I, there were no significant differences in SB (MOE) and IB of the panels among treatments (Table 5), indicating that the fiber blend ratio did not influence these properties. However, SB (MOR) and RSW (top and face) of the panels differed significantly among the treatments. In Experiment II, SB (MOR and MOE) did not differ significantly among the treatments, indicating that there was no influence of panel thickness on static bending. However, IB and RSW (face) differed significantly among treatments. In Experiment III, SB and RSW differed significantly among treatments, indicating an influence of panel thickness (15 and 18 mm), except on IB.

Table 4. Water absorption (WA) and thickness swelling (TS) of MDF panels used in three experiments to evaluate the effect of fiber blend ratio (FBR) and panel thickness on the properties of MDF produced with *Schizolobium amazonicum* wood and wood waste from native Amazonian species. WA and TS values are the mean of three replicates.

Experiment	Treatment	SFBR	Thickness (mm)	WA2h (%)	WA24h (%)	TS2h (%)	TS24h (%)
I	T2	B	15	5.4 a	25.1 a	0.8 a	6.4 a
	T3	C	15	8.1 a	35.1 a	1.4 a	5.7 a
	T4	D	15	7.0 a	32.3 a	1.1 a	6.4 a
CV (%)	-	-	-	25.6	15.1	28.0	8.0
II	T1	A	12	11.1 a	26.1 a	2.5 a	9.2 a
	T5	A	15	7.8 b	21.2 b	1.4 a	6.6 b
CV (%)	-	-	-	7.3	2.7	22.3	5.9
III	T4	D	15	7.0 a	32.3 a	1.1 a	6.4 a
	T6	D	18	4.5 a	26.7 a	0.6 b	4.4 b
CV (%)	-	-	-	23.9	9.2	11.2	7.2

CV = experimental coefficient of variation; SFBR = symbol of fiber blend ratio; 2h and 24h = after 2 and 24 hours in water immersion, respectively. Within each experiment, means followed by different letters differ statistically ($p < 0.05$) according to a Tukey post-hoc test.

Table 5. Static bending (SB), internal bonding (IB) and resistance to screw withdrawal (RSW) of MDF panels used in three experiments to evaluate the effect of fiber blend ratio (FBR) and panel thickness on the properties of MDF produced with *Schizolobium amazonicum* wood and wood waste from native Amazonian species. SB, IB and RSW values are the mean of three replicates.

Experiment	Treatment	SFBR	Tickness (mm)	SB (MPa)		IB (MPa)	RSW (N)	
				MOR	MOE		Top	Face
I	T2	B	15	23.4 b	2501 a	0.47 a	834 a	1170 a
	T3	C	15	27.7 a	2882 a	0.38 a	682 b	1004 b
	T4	D	15	23.2 b	2423 a	0.33 a	709 ab	1005 b
CV (%)	-	-	-	6.3	7.9	15.8	7.8	2.8
II	T1	A	12	34.6 a	3237 a	0.48 a	*	1162 a
	T5	A	15	31.5 a	3465 a	0.32 b	-	871 b
CV (%)	-	-	-	8.9	5.8	11.3	-	6.9
III	T4	D	15	23.2 b	2423 b	0.33 a	709 a	1005 a
	T6	D	18	32.8 a	2900 a	0.31 a	641 b	821 b
CV (%)	-	-	-	27.9	5.1	20.1	8.9	8.9

CV = experimental coefficient of variation; SFBR = symbol of fiber blend ratio; MOR = modulus of rupture; MOE = modulus of elasticity; *The NBR 15316-2 standard (ABNT, 2009b) does not have a rule for testing RSW (top) on panels with a thickness of less than 14 mm. Within each experiment, means followed by different letters differ statistically ($p < 0.05$) according to a Tukey post-hoc test.

DISCUSSION

Basic density of raw materials

The values of basic density obtained in this study for wood chips derived from veneer residues and logs of paricá agree with values reported in the literature for 14-year-old paricá wood (average 310 kg m^{-3}) (Modes et al. 2020), for five to 11-year old wood (260 to 300 kg m^{-3}) (Vidaurre et al. 2012), and for wood veneers (average 310 kg m^{-3}) (Iwakiri et al. 2011). Melo et al. (2013) reported basic density values from 270 to 420 kg m^{-3} for paricá.

It is noteworthy that the basic density for the FBR used in the study (A, B, C, D) fell between those of SAL/SAV, which contained only paricá, and MIX, which contained wood waste from other species and had significantly higher density than SAL/SAV. Thus, it is evident that the wood blending was effective in achieving suitable basic density values, which can promote a favorable compression rate (1.3 to 1.5) for good consolidation of the panels in our study.

Density, moisture content and compaction ratio

The Brazilian standard (NBR 15316-1; ABNT 2009a) classifies panels with densities between 650 kg m^{-3} and 800 kg m^{-3} as "Standard MDF". Therefore, the panels from all treatments can be included in this class, including the panels in Experiment II even though their density slightly exceeded the ABNT upper limit, as up to 5% of variation is acceptable.

The moisture content of the panels in all experiments ranged from 7.6% to 8.7%, remaining within the range of 4% to 11% established by the NBR 15316-2 standard (ABNT 2009b). Likewise, the compression ratios of the panels in the experiments ranged from 1.3 to 1.5 and were therefore above or equal to the minimum value of 1.3 indicated to ensure good fiber-to-fiber contact during mattress pressing, providing conditions for proper bonding (Maloney 1977).

Water absorption and thickness swelling

In Experiments II and III, a trend of decreasing WA and TS values with increasing panel thickness was observed, agreeing with the trend observed in MDF panels produced with a density of 850 kg m^{-3} and six thicknesses from 4 to 14 mm (Valcheva and Savov 2016) and MDF panels produced with a density of 770 kg m^{-3} and three thicknesses from 6 to 19 mm (Krzysik et al. 2001).

The NBR 15316-2 standard (ABNT 2009b) does not specify values for WA (2 and 24 h) and TS2h, but it does establish a maximum value of 12% for TS24h for MDF panels with thicknesses between 12 and 19 mm. The TS24h values of the MDF panels in our experiments ranged from 4.4% to 9.2%, below the maximum value and thus complying with the standard. In another study of MDF panels produced by blending eucalyptus fibers (70%), paricá (20%), and sawmill residues (10%) bonded with UF resin, and densities ranging from 651 to 800 kg m^{-3}, panels were collected every two hours during a production shift and TS24h values ranged from 11.2% to 15.6%, and exceeding the maximum requirement stipulated by the Brazilian standard in 80% of the collection times (Araujo et al. 2021).

Static bending, internal bonding and resistance to screw withdrawal

In Experiment I, a reduction in the amount of MIX fibers led to a significant increase in MOR values. A slight increase in the compression ratio of these panels may have favored the increase in MOR, and could benefit the mechanical strength of the panels (Maloney 1977). The significantly higher RSW (top and face) values in T2 may be related to the IB of the panels in T2, which tended to be higher, though not significantly, from the values in the other treatments.

In Experiment II, the thinner panels had significantly higher IB and RSW (face) compared to the thicker panels, suggesting that IB and RSW (face) are positively related. Our IB values are consistent with those obtained by Krzysik et al. (2001) for panels with thicknesses of 6, 12 and 19 mm, equivalent to 1.12, 0.87 and 0.66 MPa, respectively, demonstrating that increasing the thickness led to a reduction in IB.

In Experiment III, MOR and MOE were significantly higher in the thicker panels, while RSW (top and face) was significantly higher in the thinner panels. Krzysik et al (2001) also reported that thickness, MOR and MOE were directly related, i.e., that MOR and MOE increased with panel thickness. According to the normative rule, in the preparation for the RSW (face) test, the screw must penetrate 15 mm into the sample. In the 15 mm thick panels, the screw practically traversed its entire thickness. On the other hand, in the 18 mm thick panels, the screw only penetrated the outer layer of one face and reached the inner layer, where it remained anchored. It is presumed that, in the RSW test, due to the fact that the screw passed from face to face through the 15 mm specimens, the resistance offered was greater compared to the 18 mm specimens.

The standard NBR 15316-2 (ABNT 2009b) establishes that, for MDF panels with a thickness from 12 to 19 mm intended for furniture manufacturing, the minimum values for MOR and MOE are 20 MPa and 2200 MPa, respectively. The panels from all our experiments exhibited average MOR and MOE values above the established minimums, thus fully satisfying the normative requirements.

None of the panels reached the minimum value required for IB, stipulated at 0.55 MPa (NBR 15316-2; ABNT 2009b), intended for furniture manufacturing. On the other hand, according to the same standard, MDF panels with IB values greater than 0.30 MPa can be used as ceilings and walls. Therefore, our panels, which had IB values between 0.31 and 0.48 MPa, could be used for those purposes.

There are reports in the literature indicating that MDF panels do not always meet the regulatory requirements of European (EN 622-5; CEN 2006) and Brazilian (NBR 15316-2; ABNT 2009b) standards, of a minimum value of 0.55 MPa for IB. MDF panels manufactured with eucalyptus and a density of 756 kg m^{-3} collected from an industrial production line in Brazil had an average IB of 0.30 MPa (Torquato et al. 2010). The same authors obtained MDF panels made from pine wood from industrial production lines in four other Brazilian factories, with densities ranging from 693 to 736 kg m^{-3}, and they had an average IB ranging from 0.35 to 0.53 MPa. In all cases evaluated, the authors found IB values below the European standard. MDF panels produced with a mixture of eucalyptus fibers (70%), paricá (20%), and sawmill residues (10%) had IB values ranging from 0.42 to 0.62 MPa and did not meet the minimum established by the Brazilian standard in 80% of the collection time (Araujo et al. 2021).

There is no definition of minimum values for RSW (top and face) in the NBR 15316-2 standard (ABNT 2009b). MDF panels manufactured from *Pinus taeda* wood fibers glued with resin based on UF, with a nominal density of 700 kg m^{-3} had average values of 778 N for RSW (top) and 972 N for RSW (face) (Ferreira 2010). MDF panels produced with *Eucalyptus grandis* fibers bonded with UF and a nominal density of 700 kg m^{-3}, had average values of 1334 N and 1206 N for RSW (top) and RSW (face), respectively (Belini and Tomazello Filho 2010). MDF panels produced with a mixture of eucalyptus fibers (70%), paricá (20%), and sawmill residues (10%) had RSW (top) values ranging from 468 N to 931 N and RSW (face) values ranging from 837 N to 1343 N (Araujo et al. 2021). The RSW (top) and RSW (face) values found for the panels in the present study ranged from 641 N to 834 N and from 821 N to 1170 N, respectively, being more compatible with the values reported by Ferreira (2010) and Araujo et al. (2021).

CONCLUSIONS

There was a significant effect of the fiber blend ratio favoring MOR and RSW (top and face) of MDF panels produced with *Schizolobium amazonicum* wood and wood waste from native Amazonian species, with particular emphasis on the ratios 40SAV:60MIX and 25SAV:75MIX, respectively. A significant effect of MDF thickness was observed for IB and RSW (face), with positive highlights for the 12 mm thick panels; and for WA (2 and 24 h) and TS24h for 15 mm thick panels, both produced with a fiber blend ratio of 15SAL:15SAV:70MIX. MDF panels produced with a fiber blend ratio of 25SAV:75MIX and a thickness of 18 mm showed better performance in TS (2 and 24 h) and SB (MOR and MOE), while the 15 mm panels had better RSW performance (top and face). Except for IB, all other properties of the evaluated MDF panels met the specified regulatory requirements for use in furniture manufacturing. The results indicate that mixtures of *Schizolobium amazonicum* (paricá) wood and wood waste from native Amazonian species, have great potential for MDF manufacturing for use in the furniture industry, but adjustments to the production process are recommended to improve IB. To achieve this, we suggest improving the pressing cycle, increasing the adhesive (UF) content applied to the inner layer fibers of the panels, and reinforcing this adhesive with the addition of melamine (MUF), either individually or in combination.

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