

Manufacturing from Bagasse Fibers Particle Boards

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ABSTRACT

This work aimed to improve the mechanical and physical properties of particle board made from Bagasse fibers by adding different ratios of *Calotropis procera*, CP, wood particles, underutilized bush species in Sudan. Particleboards made from Urea formaldehyde (UF) (16%) based on the oven dry weight of the fibers and CP wood particles were added to Bagasse fibers. The panels were produced using 200°C pressing temperature, 190 %in two ratios 50% and 30 BAR pressure, and 7 min of pressing time with 0.65 g/cm³ target density. The produced panels were tested for their mechanical and physical properties and then evaluated using British Standards (BS EN). The results revealed that addition of 50% CP wood particle could improve the mechanical and physical properties as the best modulus of rupture (MOR) and modulus of elasticity (MOE) values (11.59N\mm² and 1609N\mm² respectively) and the lowest value of thickness swelling (TS) obtained was (22.10%). Therefore, the panels could be used for general uses. In addition, the panels made from Bagasse only showed reduction in the mechanical and physical properties compared to those made from 30% which has MOR and (MOE) values of 9.36 N\mm²and1485 N\mm² and were lower than the values specified by BSEN standards. As for the panels made from only CP, it has MOR and MOE slightly lower than standard. All panels made from Bagasse and CP in different ratios have unique internal bond, which well exceeded the performance level specified in BSEN standards for purposes in wet and dry conditions. The study concluded that the mechanical and physical properties for the panels made from Bagasse .fibers could be improved by the addition of 50% CP wood particles

Keywords: Particleboard, Bagasse, *Calotropis procera*, UF., UTM.

INTRODUCTION

Nowadays, there is a growing tendency towards using non-wood fibres and agriculture or forest residues for producing composite wooden products like particleboard. These alternative raw materials, therefore, can play a major role in the future of particleboard industry. Some studies on particleboard use of wood and agricultural residues include: Cotton stalks (Guler and Ozen 2004), hazelnut husk (Copuret *et al.* 2007), Kenaf (Kalaycioglu and Nemli 2006), palm branches (Nemli and Kalaycioglu2001), (Ghalehno *et al.* 2011), Roselle stalks (Ghalehno and Nazerian 2012) and Bagasse (Youngquist *et al.* 1997; Xu *et al.* 2009). Using of residues of agricultural products in production of particleboards is very profitable in economic and environmental terms regarding the fact that wood resources of the world are very limited (Mohammad Dahmardeh 2013). In Sudan, there are five operational sugar factories that utilize sugarcane located in different states. Some of these factories are generating electric power by using the sugarcane Bagasse fibres, and the rest is considered as wastes (Abdalla *et al* 2018).

For this study Bagasse fibers was used to produce particleboards in different combinations with Usher wood particles. Urea Formaldehyde (UF) was used as adhesives at the level of 16% based on the oven dry weight of the fibers.

The main objective of this study was to investigate the producing particleboards from Bagasse fibers and improved mechanical and physical properties with addition Usher particles.

Materials and Methods

Lignocellulosic materials

Bagasse and *Calotropis procera* (Usher) were collected from Gezira State. The Bagasse fibers and Usher wood were air dried and hammer milled into small particles using a laboratory hummer mill. They were then screened using different sieves. The particles retained on mesh size 20 (particle size - 1 mm) were blended with the adhesives. The Bagasse and Usher particles (initial moisture content was 13 and 5.4%) were then oven dried in an industrial oven to decrease the moisture content (MC %) to 2.88%. The moisture content was determined using a moisture meter. Different ratios (50:50 and 70:30 w/w) of Bagasse/Usher (B/U) were mixed and used for particleboard manufacturing.

Binding Materials:

Commercial urea formaldehyde (UF) resin was provided by Mansoura for resin and chemical industries (Egypt) grade E4 with concentration 60%, viscosity = 350-450 cps, specific gravity = 1.250 approximately and solid content = 60±2% was used in this investigation. Ammonium chloride 2% (NH₄CL) from the local market was added to Urea Formaldehyde resin as a hardener.

Particleboard preparation

Duplicate one layer laboratory particleboards of 340x310x10 mm dimensions were prepared by adding 16% of adhesive (UF) based on the oven dry weight of the particles. Higher levels of resin loading were needed to compensate for the lighter weight of the Bagasse particles, which increased their volume and may have decreased board density. The panels were manufactured using 0, 70, 50, and 100 % Bagasse fibers in the mixture.

The panels were pressed at a maximum pressure of 190 bars. The pressing temperature was 200 °C and the pressing time was 7 min. All the panels were targeted for density of 0.650 g/cm³.

Mechanical and physical testing

The pressed boards were trimmed and kept in a conditioning room (humidity 65% and 20 ± 5 °C) for 2-3 days prior to testing. Test specimens were prepared according to BS EN (326: 1994). The mechanical properties were investigated in accordance with appropriate BS EN standards: modulus of rupture (MOR) and modulus of elasticity (MOE) – EN 310, 1993, and internal bond (IB) strength – BS EN 319, 1993. Physical properties, namely thickness swelling (TS) and water absorption (WA) were determined based on EN 317 (1993). Samples were immersed in distilled water for 2 and 24 hrs. before thickness measurements. The tests were carried using Computerized Universal Testing Machine; Model WDW-100 and minimum number of specimens used for each test were four.

RESULTS AND DISCUSSION

Mechanical Properties

The results of the mechanical tests are summarized in Table 1. It has been observed that the addition of CP particles significantly improved the mechanical properties of the produced panels. The best MOE, MOR values (11.59N/mm² and 1609N/mm²) were achieved when 50% of CP was added to Bagasse fibers. The result indicated that the mechanical properties increased with addition of proportion of usher. Addition of 30% usher particles to Bagasse produced panels with 9.36 N/mm² MOR and 1485N/mm² MOE respectively and they were lower than the ones obtained by addition of 50%. However, these values are higher than the ones produced from Bagasse alone and, slightly lower than the standard values for panels used for general purposes and interior fitments (including furniture).

Table 1 Mechanical properties of board produced using 16% resin

Test	MOR N\mm ²	MOE N\mm ²	IB N\mm ²	Density g\cm ³
Lignocellulosic Material				
Bagasse	7.83	1169	0.41	0.645
Bagasse: procera 70:30	9.36	1485	0.61	0.639
Bagasse :procera 50:50	11.59	1609	1.32	0.629
C. procera	8.60	1452	1.8	0.632

-EN BS standard value of MOR (BS EN) =11.5 N\mm² , MOE 1600N/mm² , IB 0.28N/mm² , TS 25%,WA 15% for general uses and the BS EN standards values for interior fitments (furniture) are 13 for MOR, 1600 for MOE and 0.4 for IB.

Addition of wood particles such as CP to the agricultural residues such as Bagasse could reduce the huge volumes of these fibers due to their light weight. Hence lower % of adhesives could be used and in turn it reduces the cost of manufacturing. In addition to this, it improves the mechanical and physical properties. This may be explained by the lower density of Bagasse, which requires a larger volume of particles to produce a panel of predetermined density, which reduces the amount of adhesive per particle, and thus decreases the bond among particles. As a result, an increase in the ratio of percentage of Bagasse and peanut shells was decreasing the mechanical properties.

Decreases in MOE and MOR trend with increases in the proportion of agricultural wastes mixed with wood for particleboard production have already been reported by Guleret al. (2016) who found that, the mechanical properties of particleboards were reduced with the increase of corn stalks ratio in the panels made from corn stalks with industrial wood chips.

A decrease was noted in values of MOE and MOR with increasing Bagasse fibers percentage in panels. This decreasing tendency was also observed by Mendes et al. (2010) when they evaluated the values of MOE and MOR as a function of increasing percentages of coffee husk in particleboard panels.

Scatolino *et al* (2013) evaluated the properties of particleboard panels in which agricultural wastes mixed with wood were associated in different ratio, and found values of MOE and MOR decreasing with increases in the proportion of agricultural wastes.

The IB values of the panels in Table 1 were ranged between 0.41-1.8N/mm². The minimal requirements of internal bond strength for general purpose, furniture manufacturing and load-bearing are 0.28, 0.40 and 0.35N/mm², respectively.

According to the results of IB and BSEN specifications, the panels had a unique IB values and they could be used for all purposes in dry condition.

IB values decreased with the increasing the Bagasse fibers content in the panels. This is probably attributed to lower adhesive content per surface area of Bagasse fibers in comparison to wood particles. This is due to the fact that Bagasse was wider and considerably thinner, and consequently has a much larger surface area than wood particles. This finding is also compatible with previous researches (Azizi et al 2011, Kord et al 2016). The panels produced from Calotropis procera particles had IB value was higher than all of the EN requirements.

Generally, according to the specifications, particleboard made from Calotropis procera wood particles and UF adhesive have unique internal bond, they could be used for all purposes in wet and dry conditions.

Table 2 Physical properties of board produced using 16% resin

Test Lignocellulosic Material	Thickness Swelling 2hours	Thickness Swelling 24hours	Water Absorption	Density g/cm ³
Bagasse	25.99	43.89	80.66	0.645
Bagasse :procera 70:30	22.55	35.44	82.75	0.639
Bagasse :procera 50:50	22.10	34.24	81.9	0.6288
C. procera	23.63	32.26	83.81	0.632

-EN BS standard value of TS= 25%for general uses

Table 2 shows a decreasing tendency as the proportion of Usher particles increased in the panels. It has been noticed that there was an increase in the mean values of absorption after 2hr. and 24hr. as the percentage of Bagasse fibers increased. The higher water absorption (WA) value was obtained by the panels with a higher percentage of Bagasse fiber can be explained by a larger volume of particles is required, to reach the required weight in order to obtain the same apparent density of the board, resulting in a larger exposed surface, which generates more water sorption sites. Similar results were obtained by Guler *et al* (2016) who reported that increase in corn stalks percentage in the mixture resulted in a higher TS and WA for particleboards produced using corn stalks and wood chip mixtures. The highest WA (58.3 and 63.39 %) and TS (24.61 and 25.55 %) were observed with the particleboard having 100 % and that having 75% corn stalks in the mixture for 2 hrs. and 24 hrs. water immersion times.

The addition of usher particles to the Bagasse was found to decrease the TS values; it is a compatible result with Kowaluk and Kadziela (2014) who reported that, the addition of hazelnut

shells particles to the particleboard structure in the range of 0-50% significantly improves the properties of these panels when subjected to soaking. The swelling in thickness decreases with hazelnut particles content increase.

In general, panels did not satisfy the thickness swelling requirement for general uses. This may be due to no hydrophobic additives used in these panels manufacturing. As a consequence, the panels require additional treatments such as the coating of particleboard surfaces with melamine-impregnated papers or laminates usage to become a more stable product, reported by Ashori and Nourbakhsh (2008).

Guler et al (2016) reported that, Utilizing water repellent chemicals, such as paraffin in the production may improve these properties. The addition of CP was found to improve the thickness swelling for 2 and 24hrs.

CONCLUSIONS

The study concluded that:

- There is a great potential of using Bagasse fibers in manufacturing particle board panels
 - Bagasse fibres do not need costly pretreatment in manufacturing particle boards
 - Any underutilized wood particles such as *Calotropis procera* CP. can be added
- The produced panels could be used for general uses according to the British Standards (BSEN).

ACKNOWLEDGMENTS

The authors would like to thank the Ministry of higher education and Scientific Research, Khartoum, Sudan, for providing the fund for this research study.

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تصنيع الاخشاب المضغوطة من الياف البقاس

الملخص

يهدف هذا العمل إلى تحسين الخواص الميكانيكية والفيزيائية للأخشاب المضغوطة المصنوعة من ألياف البقاس بإضافة نسب مختلفة من خشب CP وهي الانواع الخشبية غير المستغلة في السودان. تم تصنيع الواح الاخشاب المضغوطة من اليوريا فورمالدهايد (16٪) بناءً على الوزن الجاف للألياف تمت إضافة جزيئات خشب CP (Calotropis procera) إلى ألياف البقاس بنسبتين هما 50% و 30٪. تم إنتاج الألواح باستخدام درجة حرارة 200 درجة مئوية للضغط ، و 190 بار بضغط ، و 7 دقائق من وقت الضغط بكثافة 0.65 جم / سم³. أجريت الاختبارات الميكانيكية والفيزيائية للألواح المنتجة ثم قيمت الألواح باستخدام المواصفات القياسية البريطانية. أظهرت النتائج أن إضافة 50٪ من جسيمات الخشب CP يمكن أن تحسن الخواص الميكانيكية والفيزيائية كأفضل قيم لمعامل التمزق ومعامل المرونة (11.5 نيوتن/مم² و 1609 نيوتن/مم²) على التوالي. تم الحصول عليها مع الألواح المصنوعة من البقاس والعشر بنسبه 50٪. وادني القيم عند الغمر بالماء كانت (22.10%). و يمكن استخدام الألواح للاستخدامات العامة. بالإضافة إلى ذلك، أظهرت اللوحات المصنوعة من الياف البقاس فقط انخفاضاً في الخواص الميكانيكية والفيزيائية مقارنة بتلك المصنوعة من 30٪ والتي تحتوي على قيم لمعامل التمزق، معامل المرونة بقيمة 9.36 نيوتن/مم² و 1485 نيوتن/ وهي أقل من القيم المحددة في المواصفات القياسية البريطانية. اما بالنسبة للألواح المصنوعة من CP فقط فلديها قيم لمعامل التمزق ومعامل المرونة أقل قليلاً من المعيار. خلصت الدراسة إلى ان الخواص الميكانيكية والفيزيائية للألواح المصنوعة من ألياف البقاس يمكن ان تحسینها بإضافة جزيئات العشر. جميع الألواح المصنوعة من البقاس وخشب CP بنسب مختلفة لها رابطة داخلية فريدة ، والتي تجاوزت مستوى الأداء المحدد في معايير BSEN للاستخدام في الظروف الرطبة والجافة. وخلصت الدراسة إلى أنه يمكن تحسين الخواص الميكانيكية والفيزيائية للألواح المصنوعة من ألياف البقاس بإضافة 50٪ من جزيئات الخشب CP.