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RESEARCH ON THE PRODUCTION OF THE COMPOSİTE PANELS FROM SOME AGRICULTURAL RESIDUES

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Abstract
One of the important reasons for environmental pollution is fast depletion of forest resource as a raw material. While many industries utilise forest products as a raw material and uneconomical use of these resources cause extinction of forest. It is really necessary to find alternative raw material source in order to reduce forest consumption. For this reason it is important to study suitability of annual plants fibres or agricultural residues for panel production. This will aid protection of environment and as well as development of environmental friendly technologies. The aim of this study is to investigate the potential utilization of licorice root, hazelnut and peanut husks, corn and cotton stalks in composite panel production.

Composite panels are produced in a lab 20mm thick and targeted to 600 and 700 (kg/m³) densityWater absorption and thickness swelling of the panel were measured. Specimens were also tested for modulus of rupture (MOR) and modulus of elasticity (MOE), and for internal bond strength (IB) also were tested water absorbtion and thickness swelling. The results of this study showed that it was possible to produce composite panel utilizing agricultural residues on lab scale. Results indicated all produced boards met the minimum requirement of the particleboard standard TS-EN 312.

Key words: *agricultural residues; composite panel; physical and mechanical properties.*

INTRODUCTION

The demand for wood in the forest industry has been growing, but the production of industrial wood from the natural forests continues to decline. The decline in forest resources in developing countries is due to the depletion of the resources and in developed countries due to the withdrawal of forest areas from industrial production for other uses such as recreational areas. Also, there is a significant pressure on standing forest resources as a result of higher demand for wood in forest industry due to the increasing population and new application areas. Consequently, there is a need for alternative resources to substitute wood raw material. This will aid protection of environment and as well as development of environmental friendly technologies (Bektas et al. 2005).

Utilisation of agricultural fibers as a raw material does not only bring solution for raw material deficit in the particleboard industry, also brings some reduction in consumption of forest. The use of agricultural residues as a raw material in the forest industry is not new and it dates back to 1900s for panel industry. Today panel products using wheat straw and other crop residues are being commercially manufactured in a number of countries including Turkey. Several countries utilized agrofibers for the production of particleboard or other composite panels. So far there are at least 30 plants that utilize agricultural waste materials in the production of particleboards around the world (Guler 2015). The observed problems with industrial usage of agricultural residues in the forest industry are the high cost of collecting, transporting, and storing the residue material. Some of these problems could be overcome by building local, small scale mills close to the rural areas.

In Turkey the total wastes biomass resources potential reaches 56 240 000 ton/year (Table 1), of while are 36 million ton wheat straw, 2.5 million ton corn stalk, and 3 million ton cotton stalk, and 2.5 million ton sunflower stalk 1 and 1.3 million ton grape residues and the others 940.000 ton. Due to the expected applications of the efficient new modern technologies on the available biomass resources this contribution effect will be increased in the future (Akgul et al. 2005).

Table 1

Turkey's annual plant stalks production (ton/year) (Akgul et al. 2005)

Annual plant	Production (estimate)
Wheat straw	36.000.000
Barley stalk	8.000.000
Corn stalk	2.500.000
Cotton stalk	3.000.000
Grape residues	1.300.000
Rice straw	200.000
Rye	240.000
Tobacco	300.000
Hemp	2.000.000
Reed	200.000

In recent studies (Barbu et al. 2014); cotton stalks (Guler and Ozen 2004), cotton carpel (Alma et al. 2005), hazelnut husk (Guler et al. 2009), Oil palm (Ratnasingam et al. 2008), bamboo chips (Papadopoulos et al. 2004), kenaf core and kenaf stalks (Xu et al. 2004; Kalaycioglu and Nemli 2004), date palm branches (Nemli et al. 2001), Eggplant stalks (Guntekin and Karakus 2008), wheat straw and corn pich (Wang and Sun 2002), peanut hull (Guler and Buyuksari 2011), sunflower stalks (Khristova et al. 1998; Bektas et al. 2005; Guler et al. 2006) have been investigated.

The results of this study showed that it was possible to produce boards utilizing agricultural residues in Turkey.

OBJECTIVE

The aim of this study is to investigate the potential utilization of hazelnut and peanut husks, and corn and cotton stalks, in tree-layer particleboard lab production as supplement and to alleviate the shortage of raw material in forest industry.

MATERIAL AND METHOD

Agricultural residues obtained from the Black sea and Mediterranean region of Turkey were cleaned from dust and dirt and were chipped. All particles used in this study were dried at 100-110^{0}C in a technical oven dry until % 3 MC to be reached. The urea formaldehyde resin was applied 8-9% for the core layer and 10-11% for the face layers based on oven dry weight. The properties of the UF resin are given in Table 2 and 3. As a hardener, 33% of ammonium chloride solution was used for all of the UF resin boards. Panels with a target density of 600 - 700kg/m^3 were manufactured. Experimental design was given in Table 2. The dimensions of the produced particleboards were 480x480x20mm in pressing and after edge trimming the final dimensions of the particleboards were to 450x450x20mm. The pressing conditions were as follows; press temperature: 150^{0}C, press time: 7min, pressure: 2.4-2.6N/mm^2 and production parameters of boards used in this study.

Table 2

Properties of the urea formaldehyde

Properties	UF[a]
Solidity (%)	55±1
Density (g/cm^3)	1.20
pH	8.5
Viscosity (cps)	160
Ratio of water tolerance	10/27
Reactivity	35
Free formaldehyde (%)	0.15
33% NH_4Cl content (max, %)	1
Gel point (100°C, sec.)	25-30
Storage time (25°C, max. day)	90
Flowing point (25°C, sn.)	20-40

Prior to testing, the boards produced were conditioned at 65 ± 5% relative humidity (RH) and 20 ± 1^{0}C in according to TS 642-ISO 554 (1997) Hardboard method. The samples were cut from the experimental boards to determine some physical and mechanical properties in accordance with TS-EN 310 (1999), TS-EN 317 (1999), TS-EN 319 (1999), and TS-EN 312 (2005) standards.

Table 3

Experimental design composite panels

Board types	Raw materials	Density (kg/m^3)	Resin ratio (%)		Pressure (N/mm^2)	Pressing time (min.)
			Outer layer	Core layer		
A	Hazelnut husk	700	10	8	2.4-2.6	7
B	Hazelnut husk	600	10	8	2.4-2.6	7
C	Peanut hull	700	11	9	2.4-2.6	7
D	Peanut hull	600	11	9	2.4-2.6	7
E	Cotton stalk	700	10	8	2.4-2.6	6
F	Cotton stalk	600	10	8	2.4-2.6	6
G	Corn stalk	700	10	8	2.4-2.6	6
H	Licorice root	700	10	8	2.4-2.6	6

Water absorption and thickness swelling of the panels were measured according to TS-EN 317 (1999). Specimens were also tested for modulus of rupture (MOR) and modulus of elasticity (MOE) TS-EN 310 (1999), and for internal bond strength TS-EN 319 (1999). A universal tester was used to assess particleboard mechanical properties; values represent the mean of 20 specimens. The TS-EN 326-1 (1999) standard was used to get panel samples. Following TS-EN 325 (1999), sample thickness and length were measured using a digital micrometer and compass having 0.01mm gradients.

RESULTS AND DISCUSSION

Table 4 indicated results for the technological properties of the produced composite panels from agricultural wastes**.** Results indicated that agricultural residues used in composite panel production significantly affect modulus of rupture, modulus of elasticity and internal bond of the product. The highest MOR and MOE values of 15.67N/mm^2 and 2705N/mm^2 were observed when only cotton stalk was utilized in the manufacture of the composite panel (E), respectively. The lowest MOR and MOE values of 5.94N/mm^2 and 814N/mm^2 were obtained produced panels (600kg/m^3) with peanut hull 100%. The standard (TS-EN 312 (2012) recommends a minimum modulus of rupture (MOR) and modulus of elasticity values of 11N/mm^2 and 1600N/mm^2 for the particleboards manufactured for general propose-use including furniture (type 2), respectively. The findings in this study showed that A, E, F and H types particleboards met the minimum requirement for MOR and MOE.

In the case of IB, similar to the other mechanical properties, the highest IB value of 0.53N/mm^2 was observed with the particleboard produced using 100% cotton stalks (E type). The lowest IB value of 0.20N/mm^2 was obtained produced panels with corn stalk of 100%. All produced particleboards met the IB requirement of 0.24N/mm^2 for general purpose end-use expect for G type panels. This finding is compatible with previous results reported in literature (Goker et al. 1993, Akbulut. 1995, Kozlowski and Piotrowski 1987, Bektas et al. 2005, Guler et al. 2006).

Table 4 shows the results of tests for water up-take and thickness swelling for 24h immersion times. The highest water up-take (71.72%) and thickness swelling (30.36%) were observed with the composite panel (E) having 100% cotton stalk in the 24h immersion times, respectively. The lowest water absorption A type (hazelnut husk) panel (37%) and thickness swelling C type (peanut hull) panel (15%) were observed with the composite panel 100% agricultural residues in the 24h immersion times, respectively. The observed results indicated that the composite panels resulted in higher thickness swelling (more than 14%) required by TS EN 312 (2012) Standard (Type 3). Utilizing water repellent chemicals, such as paraffin in the production may improve these properties.

Table 4

Technological properties of composite panels *

Board type	Panel Density (kg/m^3)	Thickness Swelling 24h (%)	Water up-take 24h (%)	MOR (N/mm^2)	MOE (N/mm^2)	IB (N/mm^2)
A	700	19.6 (0.69)	37.0 (3.37)	11.9 (0.80)	1547 (108)	0.50 (0.08)
B	600	22.1 (2.13)	64.2 (9.35)	8.18 (1.04)	974 (89)	0.34 (0.15)
C	700	15.34 (1.79)	57.95 (3.63)	9.9 (1.04)	1276 (53)	0.31 (0.02)
D	600	13.09 (1.90)	71.72 (7.4)	5.94 (0.73)	814.4 (20.5)	0.24 (0.03)
E	700	30.36 (2.37)	72.17 (4.56)	15.67 (1.72)	2705 (317)	0.53 (0.11)
F	600	31.7 (1.68)	93.3 (5.53)	11.4 (1.46)	2004 (185)	0.35 (0.05)
G	700	25.55 (3.08)	63.39 (7.02)	9.13 (1.28)	1419 (114)	0.20 (0.05)
H	700	20.19 (1.45)	59.69 (1.25)	12.00 (0.98)	2142 (185)	0.33 (0.15)

*Values in parentheses are standard deviations.

CONCLUSIONS

This study investigated the possibility of using agricultural residues to manufacture three-layer particleboards. The results indicated that it is possible to produce particleboards from residues by using urea-formaldehyde adhesives. All the produced panels tested for mechanical properties complied with the minimum requirements in the standards for the general grade particleboards.

The produced hazelnut husk, peanut hull, cotton stalk, corn stalk and licorice root panels comply with the minimum requirements in standards for general grade particleboards with the exception of thickness swelling and water up-take. As there are no hydrophobic additives used in these panels, these properties can be improved by the utilization of hydrophobic materials in the panels.

As a result of the study it may be possible utilisation of agricultural residues as a raw material for panel production and investigated technological properties. Utilisation of agricultural wastes as a raw material does not only bring solution for raw material deficit in the composite panel industry, also brings some reduction in consumption of forest.

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