Sunflower Stalks as An Alternative Source of Raw Material in Composite Panel Production

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***Abstract*— Composite panels were produced from mixtures of sunflower stalks (*Helianthus annuus* L.) and some industrial wood chips at various ratios. Urea-formaldehyde adhesive was used as a binder. The sunflower stalks and wood chips were mixed at the ratios of 25:75, 50:50, and 75:25. All boards were tested for physical properties (thickness swelling and water absorption) and mechanical properties (internal bond strength, modulus of elasticity, modulus of rupture). The properties of all the panels manufactured met the minimum requirements for general grade panels. This study showed that the renewable sunflower stalks and wood particles can be used at different ratios in the production of composite panel and the resulting panels can be utilized for general purposes as well as furniture for interior environments. This result may prove that sunflower stalks can be an alternative raw material for the manufacture of composite panels.**

***Keywords*— Sunflower stalks, composite panel, agriculture, raw materials**

I. Introduction

Agricultural residues as a raw material in the manufacture of composites was one of the solutions that came to the minds of many researchers. The use of these materials may benefit both the environment and socioeconomic development [1]. Several countries utilize annual fibers 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.

In Turkey sunflower, rice, wheat, straw, sugar cane and cotton are produced for vegetable oil fiber or food industries. The waste products of these agricultural plants are consumed for animal feed fertilizer or heat production.

Sunflower (*Helianthus annus* L.) is one of the most important industrial plant in Turkey, and mainly cultivated for oil production. Sunflower a dried or semi-dried climate, likes deep moist soil rich in organic materials.

Today, sunflower is utilized in forest products industries as well as paper, plastic, paint, soap and cosmetic production [2].

Agricultural residues are the renewable resources that can be utilized as raw materials for composite panel production [3].

Turkey also faces the problem of lack of woody raw material since most of its forested areas are unproductive. However, approximately 700 ha field is being utilized for sunflower farming in Turkey generating roughly 3–3.5 million tons of waste sunflower stalks every year [1]. The utilization of such a raw material in combination with other woody species available in the country could benefit both environmentally and economically.

In recent studies; wheat cereal straws [4], bamboo [5], bagasse [6], Cotton stalks [7], sunflower stalks [8] cotton carpel [9], hazelnut husk [10], kenaf core and kenaf stalks [11]-[12], corn and cotton stalks [13], peanut hull [14], sunflower stalks [1]-[15] have been investigated.

In this study, cost reduction and suitability of sunflower stalks for the composite panel production were examined. For this purpose, sunflower stalks were mixed with industrial wood particles. The utilization of sunflower stalks in panel production will also reduce the wood demand and deforestation in Turkish forest.

The basic aim of this study is to evaluate the suitability of sunflower stalks for particleboard production. This will also create a new raw material resource for lingo-cellulosic board industry.

Annual plants for using lignocellulosics from agricultural residues to replace wood as raw materials for panel products has received considerable attention in recent yerars [16]. The improvements in the production technology also eliminate the some previous problems in utilization of annual plants for the composite panel production.

In this study, suitability of sunflower stalks for panel production were examined. For this purpose, sunflower stalks were mixed with industrial wood particles.

II. Material and Method

The raw materials for this study consisted of Sunflower stalks gathered were cleaned from husks and other impurities, and then chipped and screened. Industrial wood chips were collected from some plant in Turkey.

All particles used in this study were dried at 100-110 0C in a oven until % 3 moisture content. Urea formaldehyde resin (UF) was applied 9 % for the core layer and 11 % for the face layers based on oven dry weight.

As a hardener, 33 % of ammonium chloride solution was used for all of the UF resin boards. Properties of UF and the panel production parameters were also displayed in Table 1 and 2. Experimental design composite panel was showed in Table 3.

Manuscript received May. 23, 2017. This work was supported in part by the Duzce University.

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TABLE I: PROPERTIES OF THE UREA FORMALDEHYDE.

Properties	UF
Solidity (%)	55±1
Density (g/cm3)	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

TABLE II: PRODUCTION PARAMETERS OF PARTICLEBOARDS.

Parameter	Value
Press tem;erature (0C)	150
Pressing time (min)	7
Peak pressure (N/mm^2)	2.4-2.6
Thickness (mm)	20
Dimensions (mm)	560x560
Outer layer (Whole of board %)	35
Middle layer (Whole of board %)	65
Number of board for each type	2

TABLE III: EXPERIMENTAL DESIGN COMPOSITE PANELS

Board typea	Raw material ratio Sunflower stalks:wood particles (%)
A	100:0
B	25:75
C	50:50
D	75:25
E	0:100

[a]The density of the board made from sunflower stalk and wood particles were 0.70 g/cm^3

The sampling performed from panels according to TS-EN 326-1 [17]. The water absorption and swelling in thickness of materials were determined according to TS-EN 317 [18]. The boards are also tested for bending strength and modulus rupture in accordance to TS-EN 310 [19] and internal bond strength in accordance to TS-EN 319 [20].

III. RESULT AND DISCUSSION

Water Absorption and Thickness Swelling; results are shown in Table 4. It was found that the panel type A was the weakest against the water penetration. In general, it was found that the extent of water absorption and level of thickness swelling of the boards made of sunflower stalks are higher than that of made from woody materials. It is thought to be mainly due to the cell properties of the annual fiber. The cells of sunflower stalks a porous structure hence shows lower density.

The experimental values of the thickness swell test (2 h and 24 h) in water immersion are given in Table 4. The A type panels were showed the greatest thickness swell and water uptake while the E type particle panel were showed the lowest. While the amount of wood chips in mixture was increased the thickness swell amount was decreased.

TABLE IV: RESULTS OF WATER ABSORPTION AND THICKNESS SWELLING OF THE PANELS.[A]

Board types	*n*	Water Absorption (%)		Thickness swelling (%)	
		2-hr.	24-hr.	2-hr.	24-hr.
A	30	65.42 (3.55)	83.12 (2.87)	19.19 (1.87)	26.20 (0.58)
B	30	56.54 (1.47)	76.11 (2.47)	16.77 (1.24)	22.90 (0.68)
C	30	54.52 (1.89)	73.23 (2.74)	15.99 (1.54)	23.40 (0.73)
D	30	51.62 (2.78)	68.58 (2.38)	14.16 (1.41)	20.25 (1.54)
E	30	39.52 (2.44)	48.30 (2.49)	12.20 (1.26)	16.85 (0.69)

[a]Uses in parentheses are the standard deviations of the means; *n* denotes sample size.

According to Kalaycioglu [21], the particleboards manufactured from residues of tobacco and tea leaves are also reported to have 37.48 % and 60.71 % water uptake values for 2h and 24 h immersion respectively. Guler [22] fount that cotton stalk particle boards represented 18-35 % thickness swelling for 24 h.

In general panels manufactured from sunflower stalks showed relatively higher water uptake and thickness swelling values due to their high porosity. Another reason for the higher thickness swelling result might be the low temperature drying of sunflower stalks due to fire danger in dryer. In addition, application of hydrophobic chemicals and paraffin may reduce the thickness swelling and water uptake values of sunflower stalk particleboards.

Results of the mechanical properties of the particleboard were illustrated in Table 5. The density and resin using amount in particleboard directly affects the bending strength of the product. EN 312 [22] recommends that particleboards manufactured for general propose must show a minimum of 11 N/mm^2 Modulus of rupture (MOR). According to this study while A type boards showed the lowest MOR (14 N/mm^2), the E type boards represent the greatest (19.3 N/mm^2). The Modulus of rupture (MOE) is increased as the amount of wood particles increased in the mixture. The lowest MOE was in A type board (1789 N/mm^2) while the E type boards presented an average (3241 N/mm^2) MOE value.

The range of data in IB was from 0.43 to 0.71 N/mm^2 (Table 5). The IB requirements of 0.24 N/mm^2 for general purpose boards, 0.35 N/mm^2 for interior fitments. All of the particleboards were requirements standards. In this case, data reported in this study show agreement with the previous literature [1]- [8]- [24].

TABLE V: RESULTS OF THE MECHANICAL PROPERTIES OF THE PANEL.[A]

Boards types	MOR (N/mm^2)	MOE (N/mm^2)	IB (N/mm^2)
A	14.52 (2.54)	1789 (254)	0.43 (0.072)
B	16.65 (2.42)	2314 (245)	0.44 (0.042)
C	17.85 (2.01)	2615 (202)	0.52 (0.081)
D	19.50 (1.87)	2826 (198)	0.53 (0.075)
E	19.35 (1.45)	3241 (234)	0.71 (0.087)

[A]Values in parentheses are the standard deviations of the means; *n* denotes sample size: 20; average MC at test was 10.5 percent.

IV. CONCLUSION

This study showed that sunflower stalks can be utilized as a raw material in particleboard manufacturing by itself or in combination with industrial wood chips. Even though increase in mixture of wood and sunflower stalks particles in composite increased both physical and mechanical properties of the particleboard, almost all the studied properties of the produced panels complied with the minimum requirements in standards for general grade particleboards with the exception thickness swelling and water absorption. Since there were no hydrophobic additives were used in these panels, these properties could be improved by the utilization of hydrophobic materials sach as parafin in the matrix.

Consequently, particleboard panels from sunflower stalks if a chemical or mechanical (lamination) surface coating is applied on to the particleboards the end products can become much more dimensionally stable composite material.

Sunflower stalks will offer a high-quality particleboard raw material in many parts of the world. Using sunflower stalks for manufacturing of particleboards would be a new solution to the raw material shortage in the industry.

The utilization of sunflower stalks in the particleboard industry can also be considered a renewable income for the produces and farmers of this annual crop.

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