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Production of particleboards from licorice (*Glycyrrhiza glabra*) and European black pine (*Pinus Nigra* Arnold) wood particles

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In this study particleboards were manufactured from mixtures of licorice (*Glycyrrhiza glabra*) and European Black Pine (*Pinus nigra* Arnold) wood particles at several ratios. The suitability of licorice (*Glycyrrhiza glabra*) chips for particleboard production was examined. Urea formaldehyde resin was used as a binder in 3-layers particleboards. The manufactured boards were tested according to European (EN) standards. The licorice and European Black Pine wood particles were mixed at ratios 25, 50, 75 and 100% respectively. Produced panels were tested for certain mechanical and physical properties. Experimental results indicated that increase in licorice chips in the mixture generally diminished the mechanical and physical properties. The produced boards can be utilized for general purposes as well as furniture for interior environments and the results obtained showing that licorice could be an alternative raw material for particleboard industry.

Key words: Particleboard, licorice (*Glycyrrhiza glabra*), physical and mechanical properties, European black pine (Pinusnigra).

INTRODUCTION

In recent years the utilization of agricultural waste and annual fibers for particleboard or other composite board production is going popular. Particleboard is one of the most important products of forest products industry known. Throughout the years, the production coast of particle board has increased while the quality of product reduced.

Agricultural waste materials and annual plants have become alternative raw materials for the production of particleboard or fiber composite materials. 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 for particleboard production. This will aid protection of environment and as well as development of environmental friendly technologies. The most frequently referred alternative non-wood materials are flax, bagasse, hemp, reed and cereal straws such as rice and

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Table 1. Properties of the UF adhesive.

Properties	UF[a]
Solid (%)	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, sec.)	20-40

[a]Urea formaldehyde.

Table 2. Experimental design.

Board type[a]	Raw material	
	Licorice roots	Pine chips
A	100	-
B	75	25
C	50	50
D	25	75
E	-	100

[a]The density of the boards made from licorice and European Black Pine wood chips was 0.70 g/cm^3.

wheat straw (Younquist et al., 1994). Today, chemical pulp and panel products using wheat straw and other crop residues are being commercially manufactured in a number of countries including Turkey (Copur et al., 2007). There is still an outgoing research interest to find alternative sources of raw materials for composite manufacturing.

In recent studies; sugarcane bagasse (Silva 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 (Nemliet 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) and pepper stalks (Guntekin al., 2008) have been investigated.

The problems of the industrial usage of agricultural residues in particleboard industry refer to the high cost of collecting, transporting, and storing of the residue materials. Some of these problems could be overcome by building local, small scale mills, close to the rural areas.

In Turkey licorice, 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.

One of the agricultural residues, licorice (*Glycyrrhizaglabra*L.), is produced by former USSR, Spain, Turkey, Syria, Iraq and Afghanistan. Most of the commercial supply comes from wild sources and only a limited amount is cultivated. In addition to its medicinal use, licorice has been industrially utilized in chocolates, beverages and tobacco (Copur et al, 2007). However, in utilization of licorice fibers, there is almost no literature in the particleboard industry.

Eastern Anatolia in Turkey is covered with licorice plant about 4 million acres. Utilization of licorice in particleboard industry might produce economic benefits and contribute to environmental sustainability. Therefore, this study focuses on the potential use of licorice roots as a source of board making raw material.

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MATERIALS AND METHODS

Licorice roots obtained from the Mediterranean region of Turkey were cleaned from dust and dirt. Licorice roots and pine wood were coarsely chopped. The particles were sifted by utilizing a horizontal position sieve. 3 to 1.5 mm average size particles were used in the core section of particleboard while 1.5 to 0.8 mm average size particles were utilized in the shell layers.

All particles used in this study were dried at 100 to 110°C in a technical oven until 3% MC is reached. Urea formaldehyde (UF) resin is the most common applied on wood panels (Silva et al., 2013). The resin was applied at 9% for the core layer and 11% for the shell layers based on oven dry weight. The properties of the UF resin are given in Table 1. As a hardener, 33% of ammonium chloride solution was used for all of the UF resin boards. Panels with a target density of 0.70 g/cm^3 were manufactured using 0, 25, 50, 75 and 100% licorice chips in the mixture. Experimental design are given in Table 2. The dimensions of the produced particleboards were 50×50×2 cm in pressing and after edge trimming the final dimensions of the particleboards were 47×47×2 cm. The pressing conditions were as follows; press temperature: 150°C; press time: 7 min; pressure: 2.4-2.6 N/mm^2 and production parameters of boards used in this study are shown in Table 3.

Prior to testing, the boards produced were conditioned at 65 ± 5% Relative Humidity (RH) and 20 ± 1°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 (2012) standards. Mechanical and physical properties were tested 10 and 20 specimens respectively.

The analysis of variance (ANOVA) was applied using randomized complete design to find out the statistical differences in the physical, mechanical and dimensional properties of the particleboard. A Duncan multiple range test at 5% level of probability was conducted to study the significance of the

Table 3. Production parameters of particleboards.

Parameter	Value
Press temperature (°C)	150
Pressing time (min)	7
Peak pressure (N/mm^2)	2.4-2.6
Thickness (mm)	20
Dimensions (mm)	500×500
Outer layer (Whole of board %)	35
Middle layer (Whole of board %)	65
Number of board for each type	2

Table 4. The mechanical properties of particleboards made from licorice rootand European Black Pine andthe test results of ANOVA and Duncan's mean separation tests.

Mechanical properties	Board type	Mean [a]	Std. deviation	Std. error	X_{Min} [b]	X_{Max} [c]	p [d]
	A	12.02^{p}	0.986	0.916	9.36	13.32	*
	B	13.50^{s}	1.589	0.758	10.89	15.77	*
MOR (N/mm^2)	C	13.83^{su}	1.649	0.980	10.90	16.58	*
	D	14.78^{u}	2.214	0.654	12.37	18.24	*
	E	16.42^{v}	1.485	0.508	13.41	19.65	*
	A	2142.21p	185.532	61.576	1983.00	2286.00	*
	B	2242.36^{ps}	145.541	58.196	1958.00	2372.00	*
MOE (N/mm^2)	C	2358.16^{su}	198.588	68.617	2101.00	2680.00	*
	D	2487.52^{u}	212.122	75.357	2125.00	2784.00	*
	E	2582.62^{v}	202.310	48.986	2234.00	2625.00	*
	A	0.33^{p}	0.154	0.080	0.23	0.48	*
	B	0.45^{s}	0.109	0.089	0.35	0.54	*
IB (N/mm^2)	C	0.49^{u}	0.106	0.071	0.32	0.65	*
	D	0.52^{uv}	0.154	0.045	0.35	0.68	*
	E	0.55^{v}	0.136	0.023	0.41	0.69	*

[a], Mean values are the average of 10 specimens; [b], minimum value; [c], maximum value; [d,] significance level of 0.01 (for ANOVA); [p,s,u,t,v], values having the same letter are not significantly different Duncan test). MOR, Modulus of rapture; MOE, modulus of elasticity; IB, internal bond strength.

differences among species using Statistical Analysis System.

RESULTS AND DISCUSSION

Table 4 indicated results for the mechanical properties of the produced particleboard**.** Results indicated that licorice root ratios used in particleboard production significantly affect modulus of rupture, modulus of elasticity and internal bond of the product. The highest MOR and MOE values of 16.42 and 2582.62 N/mm^2 were observed when only pine wood was utilized in the manufacture of the particleboard (E), respectively. On the other hand, the lowest MOR and MOE values of 12.02 and 2142.21 N/mm^2 were obtained produced panels with licorice root ratio of 100%. It can be easily seen that mechanical properties of particleboards were reduced with the increase of licorice root ratio in the panels. The standard method TS-EN 312 (2012) recommends a minimum modulus of rupture (MOR) and modulus of elasticity values of 11 and 1600 N/mm^2 for the particleboards manufactured for general propose-use as well as furniture for interior environments respectively. The findings in this study showed that all panel 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 0.55 N/mm^2 was observed with the particleboard produced using 100% pine wood. The lowest IB value of 0.33 N/mm^{2}was obtained produced panels with licorice ratio of 100%. Figure 1 shows the IB strengths of the particleboards.

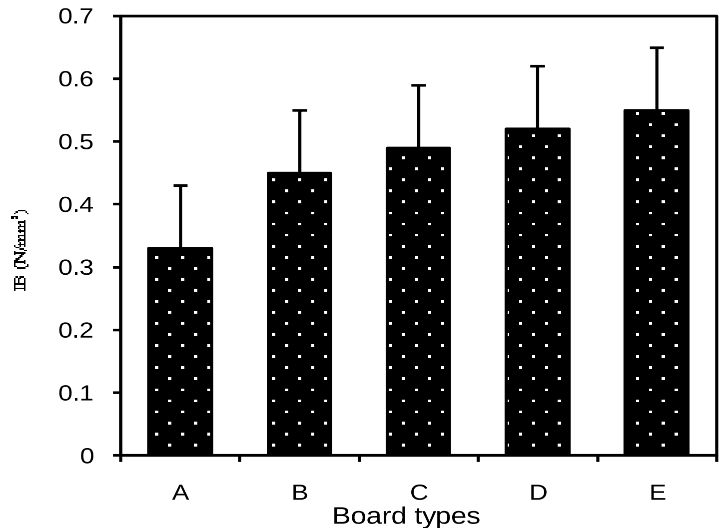

Figure 1. The internal bond strength of the particleboards.

Table 5. Thickness swelling (TS) and water absorption (WA) test results of ANOVA and Duncan's mean separation tests ofparticleboards produced from licorice root and European Black Pine wood particles.

Physical properties	Board type	Soaking time (2 and 24 h)	Mean (%)[a]	Std. deviation	Std. error	X_{Min}[b]	X_{Max}[c]	p[d]
Thickness swelling (TS)	A	2	17.12^{p}	1.118	1.012	12.36	24.26	*
	B	2	15.54^{s}	1.251	1.131	11.95	25.30	*
	C	2	15.14^{s}	0.546	1.560	09.52	23.02	*
	D	2	14.21^{u}	0.654	0.658	22.31	24.11	*
	E	2	$13,25^{v}$	1.284	1.092	21.48	22.54	*
	A	24	20.19^{p}	1.451	0.100	12.21	24.99	*
	B	24	20.68^{p}	1.547	0.481	12.14	22.36	*
	C	24	19.32^{ps}	1.874	0.222	14.15	23.20	*
	D	24	18.36^{s}	1.687	0.130	27.43	28.50	*
	E	24	17.65^{u}	1.548	0.461	13.52	20.23	*
Water absorption (WA)	A	2	48.25^{p}	2.487	1.018	39.41	57.65	*
	B	2	44.26^{s}	2.683	1.985	30.31	55.62	*
	C	2	38.39^{u}	2.248	1.358	28.43	56.68	*
	D	2	38.01^{uv}	2.658	1.654	32.57	42.25	*
	E	2	39.07^{v}	2.952	1.462	28.50	48.74	*
	A	24	59.69^{p}	1.254	0.100	42.99	72.48	*
	B	24	59.26^{ps}	2.547	0.654	45.58	85.64	*
	C	24	57.29^{s}	2.654	0.588	51.39	88.40	*
	D	24	55.25^{u}	1.852	0.165	43.14	75.17	*
	E	24	54.90^{uv}	1.927	0.187	40.81	74.40	*

[a], Mean values are the average of 20 specimens; [b], minimum value; [c], maximum value; [d], significance level of 0.01 (for ANOVA); [p,s,u,v,], values having the same letter are not significantly different (Duncan test).

Particleboards met the IB requirement of 0.35 N/mm^2 for general purpose end-use as well as furniture for interior environments expect for A type. This finding is compatible with previous results reported in literature (Goker et al, 1993, Bektas et al., 2005; Guler et al., 2006).

Table 5 shows the results of ANOVA and Duncan's mean separation tests for water absorption and thickness

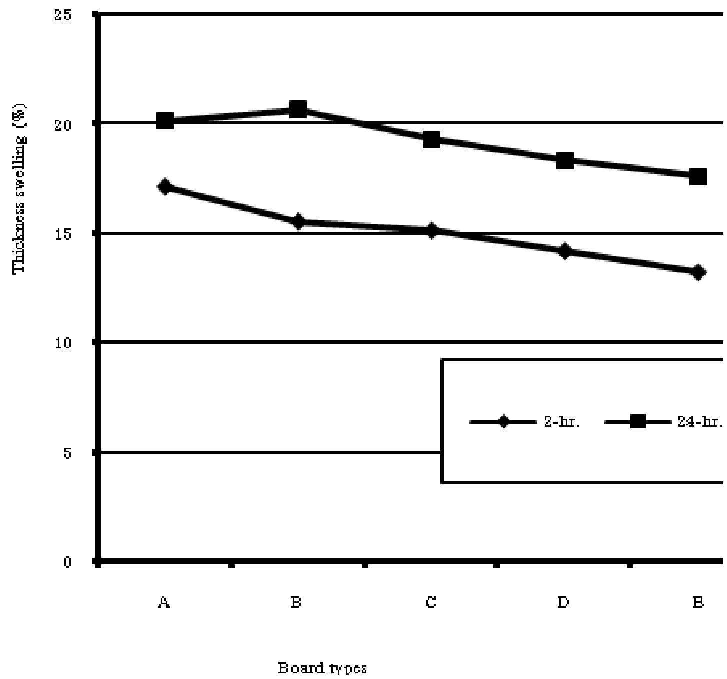

Figure 2. The effect of two different soaking times on thicknesses swelling of board types.

swelling for 2 and 24 h water immersion times. The highest water absorption (48.25 and 59.69%) and thickness swelling (17.12 and 20.19%) were observed with the particleboard (A) having 100% licorice root in the mixture for 2 and 24 h water immersion times, respectively. A diagram of the effect of two different soaking times on the TS of the boards is shown in Figure 2. Increase in licorice root percentage in the mixture resulted in a higher thickness swelling and water absorption for particleboards produced using licorice root and wood chip mixtures. The observed results indicated that the particleboards (A, B, C, and D) including licorice root in the mixture resulted in higher thickness swelling (more than 14%) required by TS EN 312 (2012) Standard. The values obtained with licorice rootwere found to be comparable with other agricultural residues investigated earlier in the literature: thickness swelling and water absorption values of 17 and 60% for tobacco, 29 and 70% for tea leaves (Kalaycioglu 1992), and 30 and 72% for cotton stalks (Gulerand Ozen, 2004) were reported for 24 h water immersion time, respectively. Utilizing water repellent chemicals, such as paraffin in the production may improve these properties.

Conclusions

This study investigated the possibility of using licorice root and European Black Pinewood mixture to manufacture three-layer particleboards. For this purpose, the mixture of particles produced from licorice root and black pine wood at certain concentrations (0, 25, 50, 75 and 100%) have been used. Five types of panels are produced and their mechanical and physical properties are evaluated. The results indicated that it is possible to produce particleboards from licorice root alone and from the mixture of licorice root and wood chips by using urea-formaldehyde adhesives.The produced boards can be utilized for general purposes as well as furniture for interior environments and the results obtained show that licorice could be an alternative raw material for particleboard industry. Even though increase in the concentration of licorice root particles in composite matrix reduces both the physical and mechanical properties of the particleboard, almost all the studied properties (that is, modulus of rupture, modulus of elasticity, intermal bond strength) of the produced panels comply with the minimum requirements in standards for general grade particleboards with the exception of thickness swelling and water absorption. As there are no hydrophobic additives used in these panels, these properties can be improved by the utilization of hydrophobic materials in the matrix. Overall, this study showed that licorice root could be utilized as a raw material in particleboard production by itself or in combination with European Black Pine wood mixture.

Conflict of Interest

The authors have not declared any conflict of interest.

REFERENCES

Alma HA, Kalaycioglu H, Bektas I, Tutus A (2005). Properties of cotton carpel-based particleboards Ind. Crops Prod. 22(2):41-149.

Bektas I, Guler C, Kalaycıoglu H, Mengenoglu F, Nacar M (2005). The manufacture of particleboards using sunflower stalks (*Helianthus annuus* l) and poplar wood (*Populus alba* L), J. Compos. Mater. 39:467-473.

Copur Y, Tozluoglu A, Karademir A (2007). Pulping of licorice (glycyrrhızaglabra): An alternatıve raw materıal to produce pulp Cellulose Chem. Technol. 41(2-3):155-159.

Goker Y, As N, Kalaycioglu H, Akbulut T (1993). Some of the technological properties of particleboard with Pinusbrutia and European birch Proceedings of International Symposium on Pinusbrutia, Marmaris, Turkey, pp. 692-699.

Guler C, Ozen R (2004). Some properties of particleboards made from cotton stalks (*Gossypium hirsitum* L) HolzRoh- Werkst 62:40-43.

Guler C, Copur Y, Buyuksari U (2009). Producıng particleboards from Hazelnut Coryllus Avellana L Husk And European Black Pıne Pınus Nıgra Arnold, Wood Res. 54(1):125-132.

Guntekin E, Uner B, Sahin HT, Karakus B (2008). Pepper stalks (*Capsicum annuum*) as raw material for particleboard Manufacturing. J. Appl. Sci. 8:2333-2336

Guntekin E, Karakus B (2008). Feasibility of using eggplant (*Solanumme longena*) stalks in the production of experimental particle-board Ind. Crops Prod. 27:354-358.

Guler C, Buyuksarı U (2011). Effect of production parameters on the physical and mechanical properties of particleboards made from peanut (*Arachis hypogaea* L) hull**,** *BioRes* 6(4):5027-5036.

Guler C, Bektas İ, Kalaycioglu H (2006). The experimental particleboard manufacture from sunflower stalks (*Helianthus annuus* L) and Calabrian pine (*Pinus brutia* Ten) Forest Prod. J. 56(4):56-60.

Kalaycioglu H (1992). Utilization of crops residues on particleboard production In Proc ORENKO 92, First Forest Products SympKaradeniz Technical Univ, Faculty of Forestry, Trabzon, Turkey, pp. 288-292.

Khristova P, Yussifou N, Gabir S, Glavche I, Osman Z (1998). Particleboards from sunflower stalks and tannin modified UF resin Cellulose Chem. Tech. 32:327-337.

Kalaycıoglu H, Nemli G (2006). Producing composite particleboard from kenaf (*Hibiscus cannabinus* L) stalks Ind. Crops Prod. 24:177-180.

Nemli, G, Kalaycioglu H, Alp A (2001). Suitability of date palm (*Phoenix dactyliferia*) branches for particleboard production HolzalsRoh- und Werkstoff , 59:411-412.

Ntalos GA, Grigoriou AH (2002). Characterization and utilization of wine pruning as a wood substitute for particleboard production Ind. Crops Prod. 16:59-68.

Papadopoulos AN, Hill CAS, Gkaraveli A, Ntalos GA, Karastergiou SP (2004). Bamboo chips (*Bambusa vulgaris*) as an alternative lignocellulosic raw material for particleboard manufacture, HolzRohWerkst 62:36-39.

Ratnasingam J, Nyugen V, Ioras F (2008). Evaluation of some finishing properties of oil palm particleboard for furniture application. J. Appl. Sci. 8(9):1786-1789.

Silva DAL, Lahr FAR, Pavan ALR, Saavedra YMB, Mendes NC, Sousa SR, Sanches R, Ometto AR (2014). Do wood-based panelsmade with agro-industrial residues provide environmentally benign alternatives? An LCA case study of sugarcane bagasse addition to particle board manufacturing. Int. J. Life Cycle Assess, 19:1767-1778.

Silva DAL, Mendes NC, Varanda LD, Ometto AR, Lahr FAR (2013). Life Cycle Assessment of Urea Formaldehyde Resin: Comparison by CML (2001), EDIP (1997) and USEtox (2008) Methods for Toxicological Impact Categories, Re-engineering Manufacturing for Sustainability, pp. 529-534.

TS-EN 317 (1999). Particleboards and fiberboards, determination of swelling in thickness after İmmersion Turkish Standard Institute, Ankara.

TS-EN 310 (1999). Wood based panels, determination of modulus of elasticity in bending and bending strength Turkish Standard Institute, Ankara.

TS-EN 319 (1999). Particleboards and fiberboards, determination of tensile strength perpendicular to plane of the board Turkish Standard Institute, Ankara.

TS 642-ISO 554 (1997). Standard atmospheres for conditioning and/or testing; Specifications Turkish Standard Institute, Ankara.

TS-EN 312 (2012). Particleboards-specifications-part 2: requirements for general purpose boards for use in dry conditions, Turkish Standard Institute, Ankara.

Xu J, Sugawara R, Widyorini R, Han G, Kawai S (2004). Manufacture and properties of low-density binderless particleboard from kenaf core J. Wood Sci. 50:62-67.

Wang D, Sun XS (2002). Low density particleboard from wheat straw and corn pith Ind. Crops Prod. (15):47-50.

Youngquist JA, English BE, Scharmer RC, Chow P, Shook ST (1994). Literature review on use of non-wood plant fibers for building materials and panels General Technical Report FPL-GTR-80 Forest service, Forest Products Laboratory Madison, Wisconsin.