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INVESTIGATING THE USE OF VINE PRUNING STALKS (*VITIS VINIFERA* L. CV. *SULTANI*) AS RAW MATERIAL FOR PARTICLEBOARD MANUFACTURING

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ABSTRACT

The aim of this study was to investigate the suitability of vine pruning (*Vitis vinifera* L. cv. *Sultani*) in Turkey as an alternative raw material for particleboard production. In Turkey, there are 484.000 hectare areas for vine cultivation. Annually, approximately 2.420.000 ton vine pruning parts residues remained. Every season, large quantities of vine prunings remain as by-products in the field, and unfortunately not utilized properly in related industries. In this study, vine pruning and wood (Scots pine) particles in various proportions were used as the raw material for three-layer flat pressed particleboards. A commercial urea-formaldehyde (UF) resin was used as binder. Small size experimental panels (56 × 56 × 2 cm) were manufactured. Some physical ((thickness swelling (TS), water absorption (WA)) and mechanical ((modulus of rupture (MOR), modulus of elasticity (MOE), internal bond (IB) perpendicular screw-holding (PSH, ⊥) and lateral screw-holding strengths (SHS, //)) properties of panels were determined. Results indicated that the bending strengths of A, B, C and D panels met the minimum bending strengths value (11.5 $N.mm^{-2}$) required in TS-EN 312-2 (1999) standard for general purpose particleboards.

KEYWORDS: Agricultural residue, particleboard, vine pruning parts.

INTRODUCTION

The increased demand for wood and agricultural land and the forest fires because of population expansion leads to a permanent decline in forest areas. Growing social demands for various wood products and especially wood-based panels leads to the continuous effort of finding new wood resources as an alternative to forest wood (Ntalos and Grigoriou 2002). Many political, economic, social, geographic and environmental factors determine the availability and end use of natural, renewable resources throughout the world. Due to environmental movement, landfill regulations, recycling trends, green movement, the available supply of wood is becoming scarce in the developed countries. Developing countries have already poor resources of wood for particleboard manufacturing. As a result, non-wood fibers play a major role in providing the balance between supply and demand.

Within the last four decades, in the forest products industry, especially in products generally referred to as particleboards, many the successful developments have been reported (Nemli et al. 2002). A wide range of agri-residues and annual fiber crops could potentially be used for manufacturing composites such as particleboard (Papadopoulos and Hague 2003). Agricultural residues are plentiful, widespread, and easily accessible. Aside from their abundance and renewability, utilization of agricultural residues has advantages for economy, environment, and technology (Çöpür et al. 2007).

Researchers have worked on a wide variety of crops from many different regions of the world. Some of these plants are sunflower stalks (Bektaş et al. 2002), vine prunings (Ntalos and Grigoriou 2002), hazelnut husk (Çöpür et al. 2007), kenaf stalks (Kalaycıoğlu and Nemli 2006), almond shell (Gürü et al. 2006), wheat straw (Mengeloğlu and Alma 2002), wheat straw and corn pith (Wang and Sun 2002), cotton carpel (Alma et al. 2005), coconut shell (Almeida and Teixeira 2002), castor stalks (Grigoriou and Ntalos 2001), rice husks (Vasisth and Chandramouli 1975), peanut shells (Jain et al. 1967), bamboo (Rowell and Norimoto 1988), waste tea leaves (Örs and Kalaycıoğlu 1991, Yalınkılıç et al. 1998), cotton stalks (Güler et al. 2001), kiwi prunings (Nemli et al. 2002), and flax shiv (Papadopoulos and Hague 2003).

One other lignocellulosic agricultural residue which could replace wood as the raw material for particleboard production is vine prunings. Turkey has approximately 484.000 hectare total area for vine cultivation (TSI 2007). The average pruning yield per hectare is approximately 5 tons, which is higher than the average wood yield of temperate forests (Ntalos and Grigoriou 2002). Therefore, approximately 2.420.000 tons of vine pruning residues are produced annually in Turkey. Large quantities of lignocellulosic prunings remain in the fields every year in early spring after pruning.

The pruning consists of three distinctive fiber types, the outer bast fiber, the woody core and the inner pith. After pruning, the prunings are, to some extent, utilized as fuel but the larger quantities remain unused on the fields. For this reason, a possible utilization of this by-product by the wood industry would be welcomed by the cultivators (Ntalos and Grigoriou 2002).

The chemical composition of vine stalks (Ntalos and Grigoriou 2002) and softwoods (Çöpür et al. 2007) are listed in Tabs. 1 and 2. Some basic characteristics and properties of vine prunings are shown in Tab. 3. The mean values of dry density of prunings ranged between 0.56 and 0.64 g.cm^{-3} (Ntalos and Grigoriou 2002). A comparison between these values shows that the vine stalks have lower lignin and higher hot water extractives and very high ash content than the softwood which is preferred for fire retardancy.

Tab. 1: Acidity, lignin, extracts and ash content of vine stalks (Ntalos and Grigoriou 2002).

pH	5.13
Lignin	21.07 (%)
Hot water extracts	13.27 (%)
Ethanol-benzene	2.76 (%)
Dichlomethane	2.14 (%)
Wood free of extracts	16.33 (%)
Ash	2.82 (%)

Tab. 2: Chemical composition of softwoods (Çöpür et al. 2007).

Hollocellulose (%)	63-70
α-cellulose (%)	29-47
Lignin (%)	25-35
Ash (%)	0.35
Solubility (%)	
Alcohol–benzene (2/1)	2-8
1 % NaOH	9-16
Hot water	3-6
Cold water	2-3

Tab. 3: Weight proportion and density of bark, core and pith of the vine stalks in three positions (Ntalos and Grigoriou 2002).

	Base	**Middle**	**Top**
Density (g.cm^{-3})	0.642 (0.047)	0.598 (0.029)	0.566 (0.045)
Weight proportion (%)			
Bark	11.97 (1.9)	10.6 (1.7)	9.7 (1.6)
Woody core	83.80 (2,3)	83.12 (2)	83.11 (2.2)
Pith	4.22 (0.9)	6.21 (1.3)	7.19 (1.4)

Standard deviation in parenthesis.

This paper presents the results of a study on the assessment of the suitability of vine pruning stalks (*Vitis vinifera* L. cv. *Sultani*) from the Aegean region of Turkey. This natural and abundant source should be utilized as the raw material for particleboard manufacturing.

MATERIAL AND METHODS

The raw material for this study consisted of vine pruning (*Vitis vinifera* L. cv. *Sultani*) and Scots pine (*Pinus sylvestris* L.). Vine prunings were collected from Manisa /Sarıgol region in Turkey. Scots pine was procured from a local supplier. The vine pruning stalks and wood were chipped by a universal chipper then the particles were dried to 3 % moisture content. Dusts in the chips are removed by an electrical fan. Prior to blending, vine pruning and industrial wood particles were screened by a screening apparatus through meshes with 3, 1.5 and 0.8 mm apertures to remove oversize and undersize particles and separate the core and surface layer particles (Nemli et al. 2002). No water-repelling agent was used during the board construction. The mat configuration was three-layer and formed by manual distribution after adhesive application in blender. The proportion was 35 % for surface and 65 % for core layer.

A commercial liquid UF-resin that was purchased from the local supplier was used. The UF-resin was applied to particles by spraying into a rotating drum that designed and built for this study. Based on oven dry particle weight, 8 and 10 % UF-resin were applied for the face and core layers, respectively. The mat configuration was formed by hand distribution in a template after resin application. The mat has been pre-pressed than the template removed and pressing process started. The particleboards were pressed at a maximum pressure of 25 kg.cm^{-2}, 150°C, for 7 min. The target dimensions of panels were 56 × 56 × 2 cm. and density for all board types was 0.70 g.cm^{-3}. Various mixtures of vine prunings (VP) particles and pine wood (PW) chips were used as furnishes for three-layer particleboards. All layers consisted of various proportions of mixed VP and PW (Tab. 4). For each mixed model, three experimental panels were manufactured. After pressing, panels were conditioned at a temperature of 20°C and 65 % relative humidity, edge trimmed to 55 × 55 cm.

Tab. 4: Experimental design and composition of the core of three-layer particleboards.

Board type	**Raw material usage (%) (Vine pruning: wood)**	**Pressure time (min)**	**Density (kg.m^{-3})**	**Adhesivee type**	**Adhesive (%)**		**Proportion (%)**	
					Surface	**Middle**	**Surface**	**Middle**
A	100:0	7	700	UF	10	8	35	65
B	75:25	7	700	UF	10	8	35	65
C	50:50	7	700	UF	10	8	35	65
D	25:75	7	700	UF	10	8	35	65
E	0:100	7	700	UF	10	8	35	65

Test samples were cut from the boards and the following properties were determined in accordance with appropriate EN and TS standards: EN 322 (1993), EN 319 (1993), EN 317 (1993). TSI (2007). All results were statistically analyzed by using the analysis of variance (ANOVA) and Tukey's mean separation tests.

RESULTS AND DISCUSSION

Tab. 5 and Tab. 6 presents the hygroscopic and mechanical properties of three-layer boards containing various proportions of Scots pine wood and vine pruning particles.

The static bending strength values of all experimental panels varied from 7.96 to 13.36 N.mm^{-2}. The bending strengths of all panels met the minimum bending strength value (11.5 N.mm^{-2}) required in TS-EN 312-2 (1996) standard for general purpose particleboards with the exception of the E (100 % wood) type panels, having density of 0.706 g.cm^{-3}. The highest bending strength value (13.36 N.mm^{-2}) was measured for the particleboard having density of 0.700 g.cm^{-3}, the lowest one (7.96 N.mm^{-2}) is for board having a density of 0.706 g.cm^{-3}, thus showing that density is not a clear factor on the bending strength. The reduction in bending strength for the E type board that constructed from 100 % wood is probably attributable to manufacturing parameters which is consistent but incomparable to standard particleboard manufacturing. The negative effect of vine particles on board bending strength is partially attributable to their lower length to thickness (slenderness) ratio in comparison to wood particles. The negative effect of vine pruning particles was not only evident on bending strength but on all mechanical properties which is probably because of the fact that they incorporate certain amounts of pith particles. According to a previous research, vine pruning particles were) characterized by higher bulk density and lower slenderness ratio than industrial wood particles (Ntalos and Grigoriou 2002).

Tab. 5: Density and hygroscopic properties of three-layer particleboards made from various mixtures of Scots pine wood and vine pruning particles.

Hygroscopic properties	**Board type**	**N**	**Mean**	**S.D.^{w}**	**S.E.x**	**X min^{y}**	**X max^{z}**	**p**
Density (kg.m^{-3})	A	18	646.90^{b}	67.15	15.82	476.21	733.92	*
	B	18	723.94^{a}	60.34	14.22	552.16	790.37	
	C	18	735.68^{a}	37.56	8.85	662.48	796.74	
	D	18	700.06^{ab}	76.35	17.99	485.23	798.14	
	E	18	706.66^{a}	21.68	5.11	673.20	756.66	
Thickness swelling 2 h (%)	A	24	18.33^{a}	7.76	1.58	10	40	*
	B	24	31.13^{d}	4.19	0.86	23	42	
	C	24	35.33^{de}	5.58	1.14	25	47	
	D	24	23.42^{b}	4.15	0.85	16	32	
	E	24	38.50^{e}	6.16	1.26	27	52	
Thickness swelling 24 h (%)	A	24	22.79^{a}	5.79	1.18	12	32	*
	B	24	34.29^{b}	4.43	0.90	25	43	
	C	24	37.04^{b}	5.61	1.14	28	48	
	D	24	25.63a	3.39	0.69	19	34	
	E	24	41.00^{c}	6.11	1.25	30	53	
Water absorption 2 h (%)	A	5	115.40^{d}	2.6077	1.1662	112.00	118.00	*
	B	5	96.00^{b}	3.1623	1.4142	93.00	101.00	
	C	5	86.80^{a}	1.4832	0.6633	85.00	89.00	
	D	5	104.00^{c}	5.2440	2.3452	99.00	112.00	
	E	5	99.20^{bc}	3.5637	1.5937	94.00	104.00	
Water absorption 24 h (%)	A	5	133.23^{c}	2.8281	1.2648	130.00	137.00	*
	B	5	121.40^{b}	3.2863	1.4697	119.00	127.00	
	C	5	105.60 a	2.0736	0.9274	103.00	108.00	
	D	5	124.40^{b}	5.5498	2.4819	117.00	131.00	
	E	5	121.40^{b}	3.2094	1.4353	117.00	125.00	

a,b,c,d, e values having the same letter are not significantly different and vice versa (for Tukey test).

w Standard deviation.

x Sampling error.

y Minimum value.

z Maximum value.

* Significance level of 0.05 (for ANOVA)

Tab. 6: Mechanical properties of three-layer particleboards made from various mixtures of Scots pine wood and vine pruning particles.

Mechanical properties	Board type	N	Mean	S.D.^{w}	S.E.^{x}	X min^{y}	X max^{z}	p
Static bending (MOR) (N.mm^{-2})	A	18	12.38^{a}	2.2	0.52	10.29	17.65	*
	B	18	12.78^{a}	2.4	0.57	8.82	16.91	
	C	18	13.27^{a}	1.9	0.45	9.56	17.65	
	D	18	13.36^{a}	2.4	0.58	8.82	16.91	
	E	18	7.96^{b}	6.3	1.14	6.61	8.82	
Elasticity (MOE) (N.mm^{-2})	A	18	2841.88^{bc}	1421.44	335.03	1618.00	7845.00	*
	B	18	3336.61^{bc}	966.65	227.84	1949.00	5044.00	
	C	18	3927.05^{b}	1021.38	240.74	2351.00	6193.00	
	D	18	5252.88^{a}	1887.20	444.81	2464.00	8387.00	
	E	18	2409.11^{c}	624.18	147.12	1570.00	3924.00	
Internal bound strength (N.mm^{-2})	A	24	0.52^{bc}	0.27	0.05	0.14	1.06	*
	B	24	0.45^{c}	0.14	0.02	0.22	0.72	
	C	24	0.67^{ab}	0.21	0.04	0.33	1.10	
	D	24	0.79^{a}	0.24	0.05	0.28	1.20	
	E	24	0.21^{d}	0.05	0.01	0.12	3.13	
Screw holding strength⊥ (N.mm^{-2})	A	15	3.24^{abc}	0.98	0.25	0.58	4.21	*
	B	15	3.13^{bc}	0.58	0.15	2.64	5.00	
	C	15	3.44^{abc}	0.92	0.23	0.78	4.60	
	D	15	4.07^{a}	0.96	0.24	2.94	5.98	
	E	15	2.54^{c}	0.71	0.18	1.56	3.53	
Screw holding strength // (N.mm^{-2})	A	30	2.02^{c}	1.00	0.18	0.49	4.21	*
	B	30	2.3^{bc}	0.80	0.14	0.68	4.31	
	C	30	2.92^{ab}	0.82	0.15	1.47	4.90	
	D	30	3.47^{a}	2.11	0.38	0.49	12.05	
	E	30	0.93^{d}	0.43	0.08	0.39	1.66	

a,b,c,d, e values having the same letter are not significantly different and vice versa (for Tukey test).

w Standard deviation.

x Sampling error.

y Minimum value.

z Maximum value.

* Significance level of 0.05 (for ANOVA)

The internal bond strength values of experimental panels varied from 0.21 to 0.79 N.mm^{-2}. The minimum requirements in the standards are 0.24 N.mm^{-2} for general purpose, 0.35 N.mm^{-2} for interior fitments and for structural boards (EN 312-4: 1996) and 0.50 N.mm^{-2} for heavy-duty structural boards TS EN 312-6: 2005). Results indicated that panels A, C, and D were the three types that had higher IB strength than the requirement for general purpose, interior fitments, load-bearing boards and heavy-duty load bearing boards except for B an E boards. The B type panel, on the other hand, met only the minimum requirement for the interior fitments boards. E type didn't meet the minimum requirements for the interior fitments and for load-bearing boards. The reduction in IB for the E type board that constructed from 100 % wood is probably attributable to manufacturing parameters which is consistent but incomparable to standard particleboard manufacturing.

Tab. 6 demonstrates the results of mean perpendicular screw-holding (PSH, ⊥) and lateral screw-holding strengths (SHS, //) of experimental panels. None of the mean screw-holding strength values (ranging between 2.54 and 4.07 $N.mm^{-2}$) were higher than the minimum value of perpendicular screw-holding strength (7.2 $N.mm^{-2}$) required in BS EN 2684 (2004) standard for general purpose particleboards. According to Ntalos and Grigoriou (2002) the use of vine prunings particles as surface material should be rejected as it deteriorates. Low strength values can be enhanced by using some hardener. Meanwhile, ANOVA results showed that perpendicular screw-holding strength values of all types of panels are significantly different and higher than that of the lateral screw holding strength values. This observation is parallel to previous finding in literature (Alma et al. 2005, Güler et al. 2001, Ntalos and Grigoriou 2002, Bektaş et al. 2002).

The results indicated that all mechanical properties (bending strength, internal bond, elasticity and screw holding strength) generally decreased as the amount of vine pruning particles increased in the range from 25 to 100 %. Similar results had also been observed with previous studies on various raw materials and wood mixture by Papadopoulos and Hague (2003), Ntalos and Grigoriou (2002), and Nemli et al. (2002). Aside from the low slenderness ratio, another negative characteristic of vine pruning particles is probably the fact that they incorporate certain amounts of pith particles which is reported to reach approximately 7 % at the top according to Ntalos and Grigoriou (2002). Merev (1998) points out that as pith consists parenchyma cells, which are softer and shorter than the other cells, strength properties of these cells are low. Pith influences the hygroscopic properties negatively, too. The increase in density, as it was expected, improves the mechanical but not the hygroscopic properties. Among all mechanical tests, the D type (25 % VP/75 % W) board is observed to be an appropriate mixture.

The mean thickness swelling of experimental panels ranged from 22.79 to 41.00 % for 24 h. The thickness swelling of panels significantly differed as soaking time increased from 2 to 24 h for all panel types. It is apparent from the Tab. 5 that the mean thickness swelling of all the types of panels rapidly increases when increasing soaking time from 0 to 2 h and then slightly increase with further increment. For the soaking times of 2 and 24 h, the greatest mean swelling was observed with E type (100 % PW) particleboard having a density of 0.706 $g.cm^{-3}$, while the lowest value is for the A type (100 % VP) particleboards with a density of 0.646$g.cm^{-3}$. In general, thickness swelling of the boards was very high. This could be both due to lack of water repellent chemicals in mat mixtures and due to high amount of pith. The density of the particleboards had an effect on the mean thickness swelling of the particleboards. High mean thickness swelling observed for dense particleboards could be explained by the higher number of water attractive OH groups in the material (Çöpür et al. 2007). On the other hand, an additional factor is likely to be that the vine pruning material is more absorbent, which promotes more rapid uptake of water and hence increased swelling. The thickness swelling for 24 h was higher than the TS-EN 312 (2005) requirement (14 %) for all experimental panels manufactured in this study. It should be noted that thickness swelling ratios for crop based particleboards were typical such as 22 % for tobacco straw (Kalaycıoğlu 1992), 24 % for cotton stalks (Güler et al. 2001), 25 % for sunflower stalks (Bektaş et al. 2002), 25.8 % for vine pruning (Ntalos and Grigoriou 2002), 26 % for cotton carpel (Alma et al. 2005), 41.66 % for wheatgrass (Zheng et al. 2007), 42 % for sunflower stalks (Bektaş et al. 2002) and 62.9 % for flax (Papadopoulos and Hague 2003).

The water absorption values of experimental panels ranged from 86 to 133 % and significantly different depending on the board type, and water immersion time (2-24 h). On contrary to thickness swelling, vine pruning particles affected the water absorption negatively. This is due to high porosity and easy diffusion on the low board density and could be due to lack of using water repellent chemicals during panel manufacturing. Addition of water repellent chemicals such as paraffin could easily reduce the rate of thickness swelling and water absorption. Similar results for water absorption were found by Ntalos and Grigoriou (2002), Alma et al. (2005), Güler et al. (2001), and Çöpür et al. (2007). Water absorptions that observed by other researchers are 65.6 % for vine pruning (Ntalos and Grigoriou 2002), 93.6 % for cotton stalks (Güler et al. 2001), 153 % for cotton carpel (Alma et al. 2005), and 95 % for sunflower stalks (Bektaş et al. 2002).

The evaluation of the mechanical and hygroscopic properties of experimental panels showed the following results. In general, partial substitution of wood by vine pruning negatively affects the board properties. The particleboards A, C, and D were the three types that met the minimum requirement for the heavy duty load bearing boards. But the E - type particleboards resulted in lower bending and internal bond strength values. Based on all mechanical tests, the D type (25 % VP/75 % W) board is to be an appropriate mixture.

The particleboards manufactured utilizing vine pruning gave relatively high thickness swelling and water absorption values. Adding water repellent chemicals such as paraffin during the board production could easily reduce the rate of thickness swelling and water absorption.

For enhancing the properties of vine pruning particleboard, as Ntalos and Grigoriou suggested (2002), further research should be carried out in order to find appropriate methods for pith separation from the whole stalk. In addition, properties of vine pruning particleboard can be enhanced by alternative resins, such as isocyanates, and/or a reduction in furnish particle size, or involvement of plastic, fiber and or other materials in panels during manufacturing.

The results indicated that it is possible to produce particleboard from the chips of vine pruning stalks (*Vitis vinifera* L. cv. *Sultani*). When the amount of the waste material is considered, it is always reasonable to strive to convert vine prunings to a valuable raw material for composite particleboard production.

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REFERENCES

1. Alma, M.H., Kalaycıoğlu, H., Bektaş, I., Tutuş, A., 2005: Properties of cotton carpel-based particleboards. Industrial Crops and Products 22(8): 141–149.
2. Almeida, R.R., Teixeira, D.E., 2002: Utilization of the coconut shell oDel M C Hf babachu (*Orbignya* sp.) to produce cement-bonded particleboard. Bioresource Tech. 85(2): 159-163.
3. Bektaş, I., Güler, C., Kalaycıoğlu, H., 2002: Manufacturing of particleboard from sunflower stalks (*Helianthus annuus* L.). Using urea-formaldehyde resin. Kahramanmaraş Sütçü İmamUniversity, J. Sci. Eng. 5(2): 49-56.
4. Çöpür, Y., Güler, C., Akgül, M., Taşçıoğlu, C., 2007: Some chemical properties of hazelnut husk and its suitability for particleboard production. Building and Environment 42(7): 2568-2572.

5. EN 322, 1993: Wood based panels, determination of modulus of elasticity in bending and bending strength.
6. EN 317, 1993: Particleboards and fiberboards, determination of swelling in thickness after immersion.
7. EN 319, 1993: Particleboards and fiberboards, determination of tensile strength.
8. EN 312-2, 1996: Particleboards-specifications. Part 2. Requirements for general-purpose boards for use in dry conditions.
9. EN 312-3, 1996: Particleboards-specifications. Part 2. Requirements for boards for interior fitments (including furniture) for use in dry conditions.
10. EN 312-4, 1996: Particleboards-specifications. Part 4. Requirements for load-bearing boards for use in dry conditions.
11. Grigoriou, A., Ntalos, G.A., 2001: The potential use of *Ricinus communis* L.(Castor) stalks as a lignocellulosic resource for particleboards. Industrial Crops and Products 13(3): 209-218.
12. Güler, C., Özen, R., Kalaycıoğlu, H., 2001: Some properties of particleboards made from cotton stalks (*Gossypium hirsutum* L.). Kahramanmaraş Sütçü İmamUniversity, J. Sci. Eng. 4(1): 99-108.
13. Gürü, M.S., Tekeli, B., Bilici, I., 2006: Manufacturing of urea–formaldehyde-based composite particleboard from almond shell. Mater Design 27(10): 1148-1151.
14. Jain, N.C., Gupta, R.C., Jain, D.K., 1967: Particleboard from groundnut shells. In: Proceedings of the 11th Silviculture Conference. May 1967, India. Pp 141-147.
15. Kalaycıoğlu, H., 1992: Evaluation of plant residues in particle board manufacturing. "ORENKO 92" (Bitkisel atıkların yongalevha endüstrisinde değerlendirilmesi. “ORENKO 92” Ulusal. Orman ürünleri endüstri kongresi, Trabzon. Bildiri metinleri. 1. cilt.) Pp : 288-292 (in Turkish).
16. Kalaycıoğlu, H., Nemli, G., 2006: Producing composite particleboard from kenaf (*Hibiscus cannabinus* L.) stalks. Industrial Crops and Products 24(2): 177-180.
17. Mengeloğlu, F., Alma, M.H., 2002: The usage of wheat straw in the production of composite panels. Kahramanmaraş Sütçü İmamUniversity. J. Sci. Eng. 5(2): 37-48.
18. Merev, N., 1998: Anatomy of the angiospermae woods in Black Sea region of Turkey. Faculty Publication 1(27): ISBN 975-6983-04-03 (in Turkish).
19. Nemli, G., Kırcı, H., Sedar, B., Ay, N., 2002: Suitability of kiwi (*Actinidia siensis* Planch) prunings for particleboard manufacturing. Industrial Crops and Products 17(1): 39-46.
20. Ntalos, A.G., Grigoriou, A.H., 2002: Characterization and utilization of vine prunings as a wood substitute for particleboard production. Industrial Crops and Products 16(1): 59-68.
21. Örs, Y., Kalaycıoğlu, H., 1991: Using of waste tea leaves on the particleboard industry. Turk. J. Agric. For. 15: 968-974.
22. Papadopoulos, A.N., Hague, J.R.B., 2003: The potential for using flax (*Linum usitatissimum* L.) shiv as a lignocellulosic raw material for particleboard. Industrial Crops and Products 17(2): 143-147.
23. Rowell, R.M., Norimoto, M., 1988: Dimensional stability of bamboo particleboards made from acetylated particles. Mokuzai Gakkaishi 34(7): 627-629.
24. TS-EN, 312-6, 2005: Particleboards-specifications. Part 6: Requirements for heavy duty load bearing boards for use in dry conditions.
25. TSI, 2007: Statistical indicators 1923-2007.
26. Wang, D., Sun, X.S., 2002: Low density particleboard from wheat straw and corn pith. Industrial Crops and Products 15(1): 43-50.

27. Yalınkılıç, M.K., Imamura, Y., Takahashi, M., Kalaycıoğlu, H., Nemli, G., Demirci, Z., Özdemir, T., 1998: Biological, physical and mechanical properties of particleboard manufactured from waste tea leaves. International Biodeterioration and Biodegradation 41(1): 75-84.
28. Zheng, Y., Pan, Z., Zhang, R., Jenkins, M.B., Blunk, S., 2007: Particleboard quality characteristics of saline jose tall wheatgrass and chemical treatment effect. Bioresource Technology 98(6): 1304-1310.
29. Vasisth, R.C., Chandramouli, P., 1975: New panel boards from rice husks. FAO background paper. FO/WCWBP/75, New Delhi, India.

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