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EFFECTS OF JUVENILE WOODS ON SOME PHYSICAL AND MECHANICAL PROPERTIES OF PARTICLEBOARDS MANUFACTURED FROM BLACK LOCUST (*Robinia pseudoacacia* L.)

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Abstract

In this study, Black Locust (*Robinia pseudoacacia* L.) one of the fast-growing trees in Black Sea Region of Turkey was investigated for manufacturing particleboard. The other purpose of this study was to determine if juvenile and mature woods adversely affects the thickness swelling (TS), water absorption (WA), static bending (SB) and internal bond (IB) strength properties of particleboards. Particleboards made from juvenile wood had lower static bending, internal bond, water absorption and thickness swelling values than those of board made from mature wood. Results showed that particleboard produced at 0,70 g cm^{-3} density had the requirements of IB and SB according to the EN standards. However, WA and TS values were higher than the required levels of the standard. The hydrophobic substance was not used in the production of particleboard. For this reason, additional work is needed to improve the physical properties of particleboard produced from Black Locust (*Robinia pseudoacacia* L.).

Keywords: Juvenile wood, particleboard, black locust

1. INTRODUCTION

Due to environmental reasons, landfill regulations, recycling trends, green movement, the available supply of wood is becoming scarce in the developed countries. Owing to the poor resources of wood for particleboard production in the developing countries such as Turkey, the fast-growing wood species will play a major role in providing the balance between supply and demand. For this reason, researches in Turkey have been carried out on a wide variety of fast-grown raw materials: i.e., *Pinus pinaster* (Kalaycıoğlu, 1991), *Eucalyptus camaldulensis* Dehn. (Nacar, 1997) e.g. Over the last decades, fast-growing plantations have steadily spread worldwide and their number, for softwood and hardwood, will continue to increase until they become predominant. Fast- grown *Robinia pseudoacacia* L. is a common hardwood species in Black Sea Region of Turkey, its usage has recently increased greatly. This mainly used for erosion control.

Juvenile wood exists in every tree. It is classified as that portion of the xylem, surrounding the pith in a cylindrical column that the cells have not fully matured. Compared to mature wood,

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the juvenile wood is characterized by lower specific gravity, shorter tracheids, larger fibril angle, lower transverse shrinkage, lower strength, lower percentage of late wood, higher moisture content, thinner cell walls, larger lumen diameters, and less cellulose but higher lignin content (GEIMER and others. 1997). It can be either sapwood or heartwood (KRAHMER 1986). Juvenile wood generally has lower mechanical properties than mature wood. Researchers generally agreed that the juvenile core occurs in the first 5 to 20 growth rings, depending mostly upon species (ERICSON/ARIMA, 1974; SHIOKURA 1982).

In this study, Black Locust (*Robinia pseudoacacia* L.) one of the fast-growing trees was investigated for manufacturing particleboard. The purpose of this study was to determine if juvenile and mature woods adversely affects the thickness swelling, water absorption, static bending and internal bond of particleboard.

2. MATERIALS AND METHODS

The wood used in this study was obtained from 23-year-old *Robinia pseudoacacia* L. grown in Black Sea Region of Turkey, Trabzon. Juvenile (defined in this study as the first 10 growth rings), mature (10+ growth rings) and sound (juvenile+mature) woods were used for the manufacturing particleboard.

First, the bark was removed. A hacker was used to first chipping. Then, a knife ring flaker was used to reduce the hacker chips to particles. After these processes, particles were dried to 3% moisture content and separated by the vibrating horizantal screen.

For the blending, as an adhesive urea formaldehyde 8% and 10% of the oven dry weight of particles in the core and face layers, respectively, as an hardener 30% of ammonium chloride solution which was 1% of the oven dry weight of particles, were used for the manufacturing of particleboards. The solid content of urea formaldehyde was 60%. The boards were pressed by the single daylight press at 150°C temperature for 5 min. under 2.5 N/mm^2 pressure. After pressing, particleboard was conditioned at a temperature of 20°C and 65% relative humidity. Three panels were made for each group. The dimensions of the panels were 56.5 x 56.5 x 2 cm.

Water absorption and thickness swelling according to the EN 317 (1993), static bending according to the EN 310 (1993), internal bond EN 319 (1993) and water absorption according to the ISO 819 (1975) were conducted. All specimens were conditioned to equilibrium at a temperature of 20°C and 65% relative humidity. Thirty specimens were used for the tests. Table 1 shows the experimental design of the study.

Data for each test were statistically analyzed. Multifactor analysis of variance was used (alpha=0,05) to test for significant difference between factors and levels. When the variance analysis indicated a significant difference among factors and levels, a multiple comparison of the means was done employing a Duncan test to identify which groups were significantly different from other groups.

Table 1: Experimental Design
Tablo 1: Deneme Düzeni

Type Tipi	SGB* Yoğunluk (g/cm³)	JW*	MW*	SW*
1	0,60	+	-	-
2	0,60	-	+	-
3	0,60	-	-	+
4	0,70	+	-	-
5	0,70	-	+	-
6	0,70	-	-	+

*SGB- Specific gravity of the particleboard, JW-Boards made from juvenile wood, MW-Boards made from mature wood, SW-Boards made from sound wood (Juvenile+Mature , Usage ratio:1/3)

3. RESULTS AND DISCUSSION

Static bending (SB) data ranged from 10,17-15,61 N/ mm². The SB requirs of 11,5 N/ mm² for general purpose boards,: 13 N/mm² for interior fitments (including furniture), 15 N/mm² for load-bearing and 18 N/mm² for heavy duty load-bearing boards by EN 312-2 (1996), EN 312-3 (1996), EN 312-4 (1996) and EN 312-6 (1996), respectively. Except for particleboards produced from juvenile wood (Type 1) and juvenile wood+mature wood (Type 3) at 0,60 g/cm³ specific gravity, all of the boards had higher SB than the requirements for general purpose. Particleboard at 0,70 g/cm³ specific gravity produced from mature wood had higher SB than the requirements for load-bearing boards. The particleboard at 0,70 g/cm³ specific gravity can be used for interior fitments (including furniture). The average static bending (SB), internal bond (IB), water absorption (WA) and thickness swelling (TS) were showed in Table 2.

Table 2: The Average Values of SB, IB, WA and TS.
Tablo 2: Eğilme Direnci, Dik çekme Direnci , Su Alma ve Kalınlığına Şişmenin Ortalama Değerleri

Board Type Levha Tipi	SB Eğilme direnci (N/mm²)	IB Dik çekme direnci (N/mm²)	WA-2 h Su Alma (%)	WA-24 h Su alma – (%)	TS-2h. Kalınlığına şişme (%)	TS 24 h. Kalınlığına şişme (%)
1	10,17	0,296	23,12	48,32	13,13	18.22
2	12,34	0,350	25,68	51,25	15,74	21,14
3	11,28	0,332	24,53	50,57	14,45	20,45
4	13,39	0,403	19,81	52,21	9,94	22,18
5	15,61	0.481	22,46	54,74	12,58	24,66
6	14.56	0,455	21,18	53,55	11,13	23,46

The range of data in IB was from 0,296 N/mm² to 0,481 N/mm². The IB requires of 0,24 N/mm² for general purpose boards, 0,35 N/mm² for interior fitments, load-bearing boards and 0,50 N/mm² for heavy duty load bearing boards by EN 312-2 (1996), EN 312-3 (1996), EN 312-4 (1996) and EN 312-6 (1996), respectively. All of the particleboards produced from Black Locust had IB higher than the requirement for general purpose. Except for 1 and 3 types of the boards, the other boards had higher IB than the requirements for interior fitments and load bearing. Multifactor analysis of variance relating effects of specific gravity, juvenile wood and soaking time on the mechanical properties of particleboard are given in Table 3.

Table 3: Multifactor Analysis of Variance Relating Effects of Specific Gravity, Juvenile Wood and Soaking Time on the Physical and Mechanical Properties

Tablo 3: Fiziksel ve Mekanik Özellikler Üzerine Yoğunluk, Genç Odun Ve Suda Bekleme Süresinin Etkisine İlişkin Çoğul Varyans Analizi

Tests Deney	SV Varyans kaynağı	SS Kareler toplamı	d.f. sebestlik derecesi	MS Ortalama kareler	F-Ratio F-Oranı	SL Önem seviyesi
SB	A (Yoğunluk)	1045,80	1	1045,80	674,23	***
	B (Genç odun)	1873,42	2	936,71	587,61	***
IB	A	16,25	1	16,25	175,68	***
	B	22,18	2	11,09	142,48	***
WA	A	123145,62	1	123145,62	425,16	***
	B	245684,32	2	122842,16	647,46	***
	C(Suda bek. süresi)	165436,45	1	165436,45	885,63	***
TS	A	16454,36	1	16454,36	245,12	***
	B	35689,45	2	17344,72	312,56	***
	C	28964.78	1	28964.78	569.46	***

Note: ***= p≤ 0.001, SV= Source of Variation, SS= Sum.of Squares, MS=Mean Square, SL=Significant Level, A= Specific Gravity, B=Juvenile Wood, C= Soaking Time

Tests showed that particleboard made from mature wood had better strength properties than particleboard made from juvenile wood. This can be explained that compared to mature wood, the juvenile wood is characterized by lower specific gravity, shorter tracheids, larger fibril angle, lower strength, lower percentage of latewood, thinner cell walls, larger lumen diameters, and less cellulose (GEIMER/1997). Tensile strength, modulus of rupture, and modulus of elasticity of juvenile wood are inferior to therefore mature wood because of high fibril angle, short tracheid length, and low specific gravity (PANSHIN/ZEEUW 1980; SMITH/BRIGGS 1986). Reduction in selected mechanical properties of parallel laminated veneer made from larch containing juvenile wood was reported by JO et all. (1981). For these reasons, particleboards made from juvenile wood had poorer strength properties than board made from mature wood. The similar results were found by STEFANIAK (1985), GEIMER (1986), and WASNIEWSKI (1989).

The maximum TS (24 h) requires of 15% for load-bearing boards and 14% heavy duty load-bearing boards by EN 312-4 (1996) and EN 312-6 (1996), respectively. The thickness swelling values of particleboard produced from Black Locust were very poor (high). This may be due to not using a hydrophobic substance in the production of boards. As a consequence, boards require additional treatments such as coating of particleboard surfaces with melamine impregnated papers or laminates (NEMLI 2000) to became stable product. According to the variance analysis, specific gravity, soaking time and juvenile wood were found to be effective on the physical properties of particleboard (p≤ 0.001). Increasing board specific gravity from 0,60 g/cm^3 to 0,70 g cm^3 improved the WA and TS values for 2 h. soaking. This may be due to low porosity and difficult diffusion on the high board density (ÖZEN 1981). The similar results were found by AKBULUT (1995).

However, particleboard at 0,70 g/cm^3 specific gravity had higher WA and TS than those of board in 0,60 g/cm^3 for 24 h. soaking. The similar results were found by AKBULUT (1995). This is due to high amount of wood material in the board produced at 0.70g/cm^3 specific gravity (MALONEY 1977). WA and TS values statistically are less for particleboard made from juvenile wood compared to board made from mature wood.

This may be due to low specific gravity, thinner cell walls, larger lumen diameters and less cellulose of the juvenile wood. These properties will tend to offset the above mentioned advantage of juvenile wood (GEIMER and others. 1997). Our study showed that thickness swelling and water absorption were lower in particleboards made of juvenile wood. The similar results were found by STEFANIAK (1985), WASNIEWSKI (1989).

4. CONCLUSION

Statistical analysis showed that physical and mechanical properties of particleboard were affected by specific gravity and juvenile wood using. Particleboard made from juvenile wood had lower static bending, internal bond, water absorption and thickness swelling values than those boards made from mature wood. These relations were statistically significant in many cases. Increasing board specific gravity improved the mechanical properties of particleboard. For 2 h. soaking, water absorption and thickness swelling values of particleboard at 0,70 g/cm^3 specific gravity were found lower than those of board at 0,60 g/cm^3. However, in 24 h. soaking, increasing board specific gravity resulted in an increase in the water absorption and thickness swelling.

Particleboards produced from Black Locust (*Robinia pseudoacacia* L.) had the required levels of static bending and internal bond. Strong particleboard can be produced from this fast-grown raw material. However, the thickness swelling of the board was very poor (high). For this reason, additional work is needed to improve the physical properties of particleboard produced from *Robinia pseudoacacia* L.

YALANCI AKASYA (*Robinia Pseudoacacia* L.)'DAN ÜRETİLEN YONGALEVHALARDA GENÇ ODUNUN BAZI FİZİKSEL VE MEKANİK ÖZELLİKLER ÜZERİNE ETKİLERİ

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Özet

Bu çalışmada, hızlı büyüyen ağaç türlerinden biri olan ve Türkiye'nin Doğu Karadeniz Bölgesinde erozyon kontrolünde başarılı bir şekilde kullanılan Yalancı akasya (*Robinia pseudoacacia* L.) odununun yongalevha üretimine uygunluğu araştırılmıştır. Bu çalışmanın bir diğer amacı genç ve olgun odunların yongalevhanın su alma miktarı, kalınlığına şişme oranı, eğilme ve yapışma dirençleri üzerinde etkili olup olmadığının belirlenmesidir. Genç odundan üretilen yongalevhaların eğilme ve yapışma dirençleri ile su alma miktarı ve kalınlığına şişme oranı daha düşük bulunmuştur. Test sonuçlarına göre 0,70 g/cm^3 yoğunlukta üretilen yongalevhalarm eğilme ve yapışma direnci değerleri standartlarda öngörülen değerlerden yüksek bulunmuştur. Bununla birlikte, levhaların su alma miktarı ve kalınlığına şişme oranları oldukça yüksek çıkmıştır. Deneme levhalarının üretiminde hidrofobik madde kullanılmamıştır. Bu nedenle Yalancı Akasya'dan üretilen yongalevhalarınn fiziksel özelliklerini iyileştirmek için ek bir çalışmaya ihtiyaç duyulmaktadır.

Anahtar Kelimeler: Genç Odun, Yongalevha, Yalancı akasya

ÖZET

Lif-yonga odunu kullanan yongalevha ve liflevha endüstrilerinin hammadde ihtiyaçlarını karşılamak için genelde hızlı gelişen türlerden yararlanılmaktadır. Özellikle plantasyonlarda yetiştirilen bu türler normalden daha fazla genç odun içrmektedir.

Genç odunun anatomik, kimyasal ve fiziksel-mekanik özellikleri ergin odundan önemli ölçüde farklılık göstermektedir. Genç odunda; yoğunluk düşük, hücre boyları daha kısa, selüloz oranı az, lignin oranı fazla, mikrofibril açıları daha büyük, hücre çeperleri daha ince, yaz odunu katılım oranı daha düşüktür (GEIMER 1997, BOZKURT/ERDİN 2000).

Yukarıda belirtilen farklılıklardan dolayı gerek plantasyonlarda yetiştirilen hızlı gelişen türlerin yongelevha ve liflevha üretimine uygunluğu ve gerekse genç odunun levha özelliklerine etkisi ile ilgili çalışmalar yapılmıştır. Bu çalışmalar daha çok Çam, Kavak ve Okaliptus türlerinde yoğunlaşmıştır.

Bu çalışmada, Türkiye'de Karadeniz bölgesinde erozyon kontrolü amacıyla dikilen ve hızlı gelişen bir tür olan Yalancı Akasya (*Robinia pseudoacacia* L.) odunu kullanılarak, genç odun ve ergin odunun yongalevhanın önemli bazı özellikleri üzerine etkisi araştırılmıştır.

Bu amaçla, Trabzon'da 23 yaşındaki bir Yalancı Akasya (*Robinia pseudoacacia* L.) ağacı kesilerek özden itibaren ilk 10 yıllık odun kısmı genç odun, diğer kısmı ise ergin odun olarak ayrılmıştır.

Genç ve ergin odunlardan aynı laboratuar şartlarında yongalevha üretimine uygun yongalar hazırlanarak %3 rutubete kadar kurutulmuştur. 0.60 ve 0.70 gr/cm^3 yoğunluklarda olmak üzere 3 grup levha üretilmiştir. Birinci grup levhalar genç odundan, ikinci grup levhalar ergin odundan, üçüncü grup levhalar ise genç+ergin odun karışımından (1:3) yapılmıştır. Bütün levha gruplarının üretiminde yüzey tabakalarında %10, orta tabakalarda ise %8 oranında Üre-formaldehit tutkalı, sertleştirici olarakta %1 oranında Amonyum klorür (% 30'luk) kullanılmıştır.

Her bir grup için 3 adet olmak üzere 56.5x56.5x2 cm boyutlarında toplam 18 adet levha üretilmiştir. Levhaların üretiminde pres sıcaklığı 150°C, pres basıncı 2.5 N/mm^2 ve presleme süresi 5 dakika olarak uygulanmıştır.

Üretilen levhalardan alınan örnekler üzerinde EN 317'ye göre kalınlığına şişme, ISO 819'a göre su alma, EN 310'a göre eğilme direnci ve EN 319'a göre yüzeye dik çekme direnci deneyleri yapılmıştır. Her bir deney, hava kurusu hale getirilmiş 30'ar örnek üzerinde yapılmıştır.

0.60 ve 0.70 gr/cm^3 yoğunluklarda genç odun ve ergin odunun levha özelliklerine etkisini ortaya koymak için çoğul varyans analizi yapılmış, sonucun anlamlı çıkması halinde Duncan testi ile aritmetik ortalamalar karşılaştırılarak birbirinden farklı ve eşit gruplar belirlenmiştir.

Bütün levha gruplarına ait deneylerden elde edilen sonuçların aritmetik ortalamaları aşağıdaki tabloda topluca verilmiştir.

Table 4: Levhanın Özellikleri

Levha Tipi	Eğilme direnci (N/mm^2)	Dik çekme direnci (N/mm^2)	Su alma – 2 saat (%)	Su alma 24- saat (%)	Kalınlığına şişme-2 saat (%)	Kalınlığına şişme-24 saat (%)
Genç odun 0.60 gr/cm^3	10,17	0,296	23,12	48,32	13,13	18,22
Ergin odun 0.60 gr/cm^3	12,34	0,350	25,68	51,25	15,74	21,14
Karışım 0.60 gr/cm^3	11,28	0,332	24,53	50,57	14,45	20,45
Genç odun 0.70 gr/cm^3	13,39	0,403	19,81	52,21	9,94	22,18
Ergin odun 0.70 gr/cm^3	15,61	0,481	22,46	54,74	12,58	24,66
Karışım 0.70 gr/cm^3	14,56	0,455	21,18	53,55	11,13	23,46

Yukarıdaki tablonun incelenmesinden görüldüğü gibi eğilme direnci ve yüzeye dik çekme direnci açısından her iki yoğunlukta da genç odunun kullanıldığı levhalar daha düşük değerler vermiştir. Bu iki direnç açısından en iyi sonucu ise ergin odundan üretilen levhalar vermiştir. Su alma ve kalınlığına şişme bakımından genç odundan üretilen levhalardan daha iyi sonuçlar elde edilmiştir. Genç odunda liflerin daha kısa ve selüloz oranının daha az olması bu sonuçların elde edilmesine neden olabilir.

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