Trends in

Applied Sciences Research

ISSN 1819-3579

Academic
Journals Inc.

www.academicjournals.com

Trends in Applied Sciences Research, 4 (2): 116-125, 2009
ISSN 1819-3579

Some Chemical and Morphological Properties of Juvenile Woods from Beech (*Fagus orientalis* L.) and Pine (*Pinus nigra* A.) Plantations

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Abstract: In this study, carefully selected test materials were taken from juvenile wood *Pinus nigra* and *Fagus orientalis* growing naturally in Turkey. The aim of this research is to determine the chemical and morphological properties of the wood fiber of the *Pinus nigra* and *Fagus orientalis* and the suitability of these properties for pulping. Eight sample trees were taken as four pieces for each species which were collected from Duzce-Dariyeri-Yaylagol region. The test samples were taken from certain parts of tree stems. In these tests, fiber length, fiber diameter, lumen dia cell wall thickness were measured. The felting power, elasticity coefficient, rigidity coefficient, Runkel's proportion, Muhlsteph's proportion and F-ratio were calculated from the wood fiber morphological properties and the effects of these properties on pulp strength properties were investigated. According to the results of this study, it was found that the pine and beech are/aren't suitable for pulping.

Key words: Juvenile wood, mature wood, chemical properties, morphological properties

INTRODUCTION

Fagus orientalis extends beginning from Balkans on the West to Crimea in the North upon Anatolia, Caucasia and Northern Persia. General geographical expansion is Bulgaria, Turkey, Caucasia and Persia. In our country it has the broadest expansion and the best development on the Black sea region. It establishes pure and mixed forests on Northern oriented sides of middle and higher parts of the mountains extending parallel to Black sea coast from Demirkoy to Hopa. It is seen on Marmara region and Anatolia occasionally. It exists locally in Pos forests of Adana, Amanos Mountains and Maras-Andirin location on the Southern Anatolia (Yaltirik, 1993). It establishes broad pure or mixed forests with fir, spruce, pinus and oak. In our country there are 713.842 ha of groves and 1.555 ha of timber beech forests. *Fagus* capable of reaching heights up to 40 m have smooth and cylindrical stem.

Pinus nigra has a broad area of expansion. Its general geographical expansion is Asia Minor, Crimea, Southern Carphatia, Balkan Peninsula and Cyprus. On the inner sides of Northern Anatolian Mountains; Northern sides of South Anatolian and Western Anatolia, Mountains (especially Taurus), it establishes mixed forests with *Pinus brutia*, *Pinus sylvestris*, Cedar, Juniper, Fir and Oak taxons or pure forests (Yaltirik, 1993). There are 2.527.685 ha of pure *Pinus nigra* forests in our country. It differs from other pinus species with thickness of its stem and branches, grey and deep cracked crust and dark grey color of needle leaves. It is capable of reaching to 30-35 m tall.

As known, wood is the major material for paper production and its chemical and morphological properties are definitely effective on paper properties. Sheet strength properties are dependent upon process variables e.g., fiber orientation and bond formation between fibers-investigations on softwood species clearly showed that sheet strength was influenced most by the original properties of the pulp fiber (Horn, 1974).

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It is apparent from the literature that opinions differ on the relative importance of particular fiber properties and their practical effects on paper properties (Dinwoodie, 1965; Wangaard, 1962). Researches on the effect of fiber properties on paper strength (Barefoot *et al*., 1964) led to the general belief that paper with desirable strength properties could only be made from long-fibered wood species i.e., softwood pulps. Other studies have shown that fiber length possibly is not the overriding factor in producing paper with acceptable strength (Alexander and Marton, 1968; Horn, 1974). On the other hand, morphological properties of some poplar species and rhododendron (*R. ponticum* L.) were studied in recent studies (Kar, 2005; Akgul and Camlibel, 2008).

In this study density and spacing maintenance residues were used in order to determine utilizability of both species juvenile woods. As it is known, usage of younger woods in industry is becoming popular against increasing raw material requirement. In recent years, breeding species which grow quickly, provide more biomass and known as rapid growing wood in the market are highly considered.

But at this point, knowing the effects of juvenile wood fibers on paper properties is distinctly important. Individual fibers which constitute pulp have important effect on the pulp quality. Because of this, length, width, lumen space and cell wall thickness of the fibers forming the pulp, effect physical properties of paper and several criterions occurring from interrelations between these properties provide an idea about if that fiber can be used on paper production or not.

In this study, some chemical and morphological properties of junevile beech and pine woods were determined and it is researched if both wood species are suitable for fiber producing or not.

MATERIALS AND METHODS

Materials

This study was conducted at Duzce University Forest Faculty laboratories in August 2006-September 2007.

Twenty years old *Fagus orientalis* and *Pinus nigra* juvenile wood samples were taken from subsidiary of Duzce Forest Management Directorate, Dariyeri Management Chieftaincy divisions No. 19 and 20 of Yaylagol location.

On the other hand, circular cross sections which don't have heights less than 6 cm were taken from bottom, middle and peak parts of juvenile trees. Samples were mixed ensuring that they are equal and obtaining homogeneous mixture is tried. Afterwards these parts were cut as little match stick length and experiment samples by which fiber morphology was determined were prepared.

Method

For chemical tests, specimens were prepared according to Tappi T 257 om-85. Hollocellulose contents were determined according to the chloride method (Browning, 1967). The following tests were performed to determine the lignin (Tappi T 222 om-98) and ash (Tappi T 211 om-93) contents. Solubility properties were also determined based on alcohol-benzene (Tappi T 204 cm-97), cold and hot water (Tappi T 207 om-93) and 1% NaOH (Tappi T 212 om-98).

As length, width, lumen dia and cell wall thickness properties of fibers included in juvenile woods morphological parts are important in terms of paper manufacturing. Schultze (mazeration) method was used (nitric acid and potassium chlorate) on preparing preparations for making fibers individual.

Zeis monocular light microscope and vizopan (Reichard) was used for determining microscopic properties. Ocular is 6x and objectives are 40 and 90x magnifying and measurements were done by means of a special measurement scale attached on ocular. The values on measurement scale as micron are as follows: 6 ocular, on 40 objective 1 unit = 4 micron; -6 ocular, on 90 objective 1 unit = 1.9 micron.

Morphological properties were determined with these formulas:

Felting power = Fiber length/fiber width

Elasticity coefficient = Lumen dia×100/fibre width

Rijidity coefficient = Cell wall thickness/fiber dia×100

Runkel's proportion classification = Cell wall thickness×2/lumen dia

Muhlsteph's proportion = Cell wall area/fiber breadth cross section area×100

F Factor = Fiber length/cell wall thickness×100

RESULTS AND DISCUSSION

The results of chemical studies made on juvenile beech and pine specimens taken from subsidiary of Duzce Forest Management Directorate, Dariyeri Management Chieftaincy divisions No. 19 and 20 of Yaylagol location are given in Table 1.

The chemical results show that juvenile pine wood had lower holocellulose and higher lignin content than mature pine wood. Also alcohol-benzene and hot water solubility of juvenile pine wood were lower while the 1% NaOH solubility was higher than mature pine wood (Table 1). When the chemical composition of juvenile and mature beech wood was compared, juvenile beech wood had lower holocellulose and higher lignin content than mature beech wood. Also the alcohol-benzene solubility of juvenile beech wood was higher than mature beech wood (Table 1).

Fiber length, fiber dia, lumen width and cell wall thickness of beech and pine woods are given, respectively in Table 2 and 3 and 30 measurement was carried out for determining each property. According to that, maximum fiber length of beech wood was found as 1.14 mm and minimum fiber length was found as 0.48 mm. Maximum fiber dia value indicated as width was found as 47.60 μ and

Table 1: Chemical composition of juvenile black pine and beech (% of o.d wood) and mature pine (Usta, 1993) and beech (Yildiz, 2002)

Component	*Pinus nigra* (juvenile)	*Fagus orientalis* (juvenile)	*Fagus orientalis* (mature)	*Pinus nigra* (mature)
Holosellullose	64.70±0.10	67.30±0.15	78.90	72.20
α-cellulose	35.50±0.15	42.90±0.23	-	-
Lignin	33.00±0.23	29.20±0.27	22.30	28.50
Ash	0.90±0.10	0.40±0.10	-	-
Solubility				
Alcohol-benzene (2/1)	2.51±0.27	3.50±0.11	1.79	6.07
1% NaOH	19.00±0.11	17.50±0.11	13.80	12.20
Hot water	2.25±0.15	2.50±0.18	2.07	4.71
Cold water	3.88±0.11	1.00±0.23	-	-

Mean values are the average of duplicate measurements

Table 2: Findings obtained from studies on beech (*Fagus orientalis*) wood

Variables	Fiber length (mm)	Fiber width (μm)	Single cell wall thickness (μm)	Lumen width (μm)
N	30.00	30.00	30.00	30.00
Average	0.67	17.94	4.64	8.66
Max.	1.14	47.60	8.40	42.00
Min.	0.48	11.20	2.80	2.80
SD	0.15	6.24	1.83	6.76
Variance	0.02	38.88	3.34	45.70

Table 3: Findings obtained from studies on black pine (*Pinus nigra*) wood

Variables	Fiber length (mm)	Fiber width (µm)	Single cell wall thickness (µm)	Lumen width (µm)
N	30.00	30.00	30.00	30.00
Average	1.21	36.12	4.95	26.23
Max.	1.67	70.00	8.40	53.20
Min.	0.71	25.20	2.80	14.00
SD	0.26	9.90	1.90	8.87
Variance	0.07	98.05	3.61	78.66

Table 4: Values belong to morphological properties of fibrous beech and black pine juvenile woods

Species	Felting power	Elasticity	Runkel	Muhlsteph	Rigidity	F-factor
Beech (*Fagus orientalis*)	37.17	48.29	1.07	76.68	25.85	140.38
Black pine (*Pinus nigra*)	33.62	72.61	0.38	47.28	13.70	240.55

minimum was 11.20 µ for beech wood. And maximum single cell wall thickness named as single cell wall was found as 8.40 µ and minimum was 2.80 µ for beech wood. In addition, highest lumen dia value for beech wood was found 42.00 µ and minimum lumen dia value was 2.80 µ.

According to that, maximum fiber length was found as 1.67 mm and minimum fiber length was found as 0.71 mm for black pine. In Table 3, the column given with width name shows fiber dia. According to this, maximum fiber dia was found as 70.00 µ and minimum fiber dia was found as 25.20 µ for black pine wood. The column named as single cell wall in Table 3 shows single cell wall thickness. When this cell wall is multiplied by 2, average cell wall thickness is found. For black pine wood, maximum single cell wall thickness was found as 8.40 µ and minimum value was found as 2.80 µ. Additionally, for black pine wood, maximum lumen dia value was found as 53.20 µ and minimum value was found as 14.00 µ.

Values belong to morphological properties of fibrous cells are given in Table 4. Today, just as long fiber and short fiber pulp concepts are widely used in paper industry, measurement of fibers constituting pulp and accordingly relations between pulp properties also become important. For example, increase in fiber length affects resistance properties of the paper positively but causes to malformation on paper obtained (Kirci, 2000).

Fiber cell wall thickness also affects the strength of individual fibers. It is known that paper made from a pulp constituted of very thin cell wall fibers have very low tear resistance. And very thick cell wall fibers provide low resistance and big volume papers because they don't flatten properly on forming sheet (Kirci, 2000).

On this point, when fiber lengths of beech and black pine juvenile woods are investigated, it is seen that obtained values are low. If it is taken into account that, compared to short fibers, long fibers increase tear resistance by expanding the tension on broader area, it is thought that papers obtained from both beech and black pine fibers will have less tear resistance. Also, short fibers may not make inter fibrous connection as good as long fibers, it is estimated that opacity values of papers will be less.

Investigating in respect of cell wall thickness, it takes attention that black pine juvenile wood fiber have thin cell wall and fibers of juvenile beech wood have thick cell wall. On this point, considering that volume density value (or specific weight) of black pine juvenile woods will be less than the volume density of juvenile beech woods, it will be inevitable to think that hammering properties of different fiber types will be different from each other. In such a way that, because the fibers obtained from low density value black pine juvenile wood easily flatten on screen, they will hardly release the water and so juvenile beech wood fibers will release the water quickly on screen.

Except from this, it is considered that black pine juvenile woods having low specific gravity are extremely suitable for mechanical pulp production on both paper mill and refiner. Its requirement of low energy for fibration makes it advantageous on this point. It is also thought that juvenile wood fibers of softwoods reduce the pulp output on the chemical pulp production, increases necessary chemical substance portion on boiling, its bleaching is difficult and black pine juvenile wood fibers are

Table 5: Fiber lengths, fiber widths, lumen widths and cell wall thicknesses of various hardwood species

Species	Fiber length (mm)	Fiber width (μ)	Lumen width (μ)	Cell wall thickness (μ)	Literature
Fagus orientalis	0.67	17.94	8.66	4.64	Current study
Populus euramericana	1.17	24.20	15.80	4.20	Bektas *et al.* (1999)
Plane	1.42	22.30	9.70	6.20	Bektas *et al.* (1999)
Hornbeam	1.49	21.93	10.22	5.85	Tank (1978)
Robinia	0.85	16.95	7.86	2.59	Liao *et al.* (1981)
Eucalyptus (13-14 years)	0.92	15.44	7.35	2.04	Hus *et al.* (1975)

Table 6: Fiber length, fiber width, lumen width and cell wall thickness values measured on various softwoods

Species	Fiber length (mm)	Fiber width (μ)	Lumen width (μ)	Cell wall thickness (μ)	Literature
Pinus nigra	1,21	36,12	26,23	4,95	Current study
Fir	3,9	40	28	6	Tank (1964)
Picea orientalis	3,4	22-26	15-18	3,5-4	Bostanci (1976)
Abies cilicia	3,8	41,6	30	5,3	Tank (1964)
Pinus sylvestris	2,9	36	22	7	Akkayan (1983)
Pinus brutia	4-5	45-52	25-34	9-10	Goksel (1984)

not suitable in terms of producing chemical pulp because forming pressure wood risk is higher (Bostanci, 1987; Kirci, 2000). On Table 5 various hardwood species fiber length, fiber width, lumen width and cell wall thickness are given.

On Table 5, when we look at fiber analyses of hardwoods, it is seen that fiber length value of the beech juvenile wood is lower. It is seen that fiber width of beech wood is more than robinia and eucalyptus wood fiber's fiber width and less than widths of *Populus euramerica*, plane and hornbeam.

It is seen that lumen width of beech juvenile wood is more than the lumen widths of robinia and eucalyptus and less than the lumen widths of *Populus euramerica*, plane and hornbeam wood lumen.

And beech juvenile wood cell wall thickness seems more than populus euramerica, robinia and eucalyptus cell wall thickness values and less than cell wall thickness values of plane and hornbeam.

On Table 6, when we look at the fiber analysis of softwoods, it seems that length value of black pine juvenile wood fiber width is low. It is seen that fiber width of black pine juvenile wood and fiber width of other softwoods are almost the same. Same condition is also seen on lumen width values. And it is seen that cell wall thickness are higher only than Pica Orientalis values and lower than values of other softwood species.

In respect of more objective approach, rather than fiber measurements, providing connections between evaluations of fibrous structured cells' morphologic properties and paper properties will give better information about utilization of wood fibers usage in paper industry.

Felting Power

Direction criterion has not a clear effect on fiber length. Fibers lengths were measured shorter in close areas to core and longer in the wood zones far from core. It was found that summer wood fibers are longer than winter wood fibers. There is a linear relationship between tree age and fiber length. Fiber length increases from juvenile period to old period. In terms of fiber length, wood zones can be indicated respectively by short to long as juvenile wood, ripe wood and old wood.

One of the criterions that control suitability of wood material to paper production is felting power calculated by comparing fiber length to dia. Depending on this, because fiber length affects the proportion positively, felting of pulp having long fibers will be easier.

This power is an important factor having positive effect on strength, tear, burst, breaking off; double folding resistance according to physical test results of the paper and it is wanted to be between 70-90 for softwoods and 40-60 for hardwoods. This rate was measured as 75.68 for wheat stem (Eroglu, 1980) and 59.6 for tobacco stem (Tank, 1980).

According to this, when felting power is 37.17 for juvenile beech wood, this value was found as 33.62 for black pine. On other studies done about hardwoods, felting power was found as 63.30 for plane (Bektas *et al*., 1999), 52.08 for eucalyptus (Hus *et al*., 1975), 72.30 for *Carpinus orientalis* (Tank, 1978) and 50.33 on robinia (Liao *et al*., 1981). Comparing to other trees, felting coefficient of juvenile beech was found very low. And on other studies about softwoods, felting power was found as 78.30 for *Pinus sylvestris* (Akkayan, 1983), 89.25 for *Pinus brutia* (Bektas *et al*., 1999), 119.46 for *Picea orientalis* (Bostanci, 1976) and 45.64 for *Pinus pinaster* (Bektas *et al*., 1999). Examining these given values, it seems that felting rate for black pine is very lower than other species.

When we examine all these values, because felting power is low parallel to the low fiber lengths of both beech and black pine juvenile woods, it is estimated that resistance property of paper will also be lower. But when taller fibers are used alone, it breaks the regular fiber distribution and forms a drawback because it forms balls during production of paper (Bostanci, 1987). Because of this, it is thought that using short fiber pulps beside long fiber pulps during paper production will be more convenient.

Elasticity Coefficient

Elasticity coefficient which is also referred as Istas coefficient is formulated as lumen dia X 100/Fiber width and it is related with individual elasticity of fibers. According to elasticity rate there are 4 groups of fibers (Istas *et al*., 1954; Bektas *et al*., 1999):

- High elastic fibers having elasticity coefficient greater than 75
- Elastic fibers having elasticity ratio between 50-75
- Rigid fibers having elasticity ratio between 30-50
- High rigid fibers having elasticity less than 30

According to this, elasticity coefficient of juvenile beech wood fibers is 48.29 so it is included in rigid fibers group, and elasticity coefficient of black pine juvenile wood fibers is 72.61 so it is included in elastic fibers groups. On other studies about hardwoods, elasticity coefficient was found as 43.30 for plane (Bektas *et al*., 1999), 45.20 for eucalyptus (Hus *et al*., 1975), 41.00 for *Carpinus orientalis* (Tank, 1978) and 46.37 for robinia (Liao *et al*., 1981) and it was found that beech juvenile fibers are in uniformity with other hardwoods in terms of elasticity coefficient. On studies about softwoods, elasticity coefficient was found as 60.02 for *Pinus sylvestris* (Akkayan, 1983), 62.71 for *Pinus brutia* (Bektas *et al*., 1999), 66.92 for *Picea orientalis* (Bostanci, 1976) and 63.32 for *Pinus pinaster*. Examining this information given, it seems that black pine juvenile wood fibers are included in elastic fibers like other softwoods.

Depending on all of these, it is possible to say that black pine juvenile wood fibers will be more preferable than juvenile beech wood fibers in terms of paper production. Because rigid fibers don’t have efficient elasticity, they aren’t suitable for paper production and they are used more on fiber plate, rigid cardboard and cardboard production. In addition, if it is considered that this coefficient reduces as tree age rises, it should be considered that using juvenile woods will be more advantageous.

Rigidity Coefficient

As the rigidity coefficient calculated by cell wall thickness divided into dia and multiplying by 100 increases, physical resistance properties of paper weaken. Height of this rate effects tensile, tear, burst and double fold resistance of paper negatively (Hus *et al*., 1975).

According to this, when rigidity coefficient for juvenile beech wood was found as 25.85, it was 13.30 for black pine juvenile wood fiber. As hardwood fibers generate thick wall fibers, their rigidity coefficient is mostly bigger (Hus *et al*., 1975). On other studies about hardwoods, rigidity coefficient was found as 27.80 for plane (Bektas *et al*., 1999), 27.66 for eucalyptus (Hus *et al*.,1975), 42.00 for

Carpinus orientalis (Tank, 1978) and 15.28 for robinia (Liao *et al*., 1981). Parallel to these information obtained, it is seem that rigidity coefficient for beech juvenile wood fibers have a value between other species' values and they are more advantageous especially than *Carpinus orientalis*, eucalyptus and plane. Rigidity coefficients regarding softwoods were found as 19.97 for *Pinus sylvestris* (Akkayan, 1983), 20.00 for *Pinus brutia* (Bektas *et al*., 1999), 16.24 for *Picea orientalis* (Bostanci, 1976) and 17.82 for *Pinus pinaster* (Bektas *et al*., 1999). Depending on that information given, it considered that black pine juvenile wood fibers rigidity coefficient is so lower compared to other softwoods and with this feature, it is thought that it may affect resistance effect of papers obtained positively.

Bearing upon all these, because rigidity coefficients are found very low for both juvenile wood examples, it can be told that they are convenient for producing high quality writing and printing paper. Also as rise on tree age will increase this effect; it is thought that using juvenile woods in paper industry will be more suitable.

Runkel's Proportion

By dividing cell wall thickness by lumen dia, Runkel classification value is obtained. When Runkel's proportion is greater than 1, it is assessed as fibers having thick wall and cellulose obtained form this type fibers is least suitable for paper production; when it is equal to 1, cell wall have medium thickness and cellulose obtained from this type fibers is suitable for paper production, when the rate is less than 1, cell wall is thin and cellulose obtained form these fibers is most suitable for production of paper. Decrease in this rate affects other physical resistance properties such as burst and tensile except from tear resistance connected with fiber length, positively (Eroglu, 1980).

According to this, runkel value of the beech juvenile wood is 1.07 and it is included in thick wall fibers group and black pine wood runkel value is 0.38 and it is involved in thin cell wall fibers group. In studies about hardwoods, runkel value was found as 1.30 for plane (Bektas *et al*., 1999), 1.22 for eucalyptus (Hus *et al*., 1975), 1.41 for *Carpinus orientalis* (Tank, 1978) and 0.66 for robinia (Liao *et al*., 1981). Also these values are similar to other wood species for beech juvenile wood fibers. In other studies about softwoods, runkel value was determined as 0.66 for *Pinus sylvestris* (Akkayan, 1983), 0.60 for *Pinus brutia* (Bektas *et al*., 1999), 0.48 for *Picea orientalis* (Bostanci, 1978) and 0.36 for *Pinus pinaster* (Bektas *et al*., 1999). Examining these values, it seems that black pine juvenile wood fibers are in uniformity with other softwood fibers.

Except from this, it was found that fibers having runkel's proportion less than 1 are included in flexible fibers category and these fibers are easily flattened during paper production and give stronger inter fibrous connections (Kirci, 2000). On this point, because of black pine juvenile wood fibers runkel value is quite low an idea stating that they will enable stronger paper production appears. Also, as the tree age increases, this value will also increase so utilization of juvenile woods in paper industry will be more convenient.

Muhlsteph's Proportion

Muhlsteph's proportion indicated as dividing cell wall by cross-section area determines effects of cell wall on physical properties of paper. Thin wall fibers are easily crushed on paper production so this affects either paper density and resistance properties positively (Casey, 1961).

According to this, while it was found that when muhlsteph value is 76.68 for juvenile beech wood, it is found as 47.28 for black pine wood. Mulsteph values related with other studies were found as 61.2 for *Pinus brutia* (Bektas *et al*., 1999). Lower value obtained from black pine juvenile wood fibers shows that it consists of thinner cell wall fibers. Because using thin wall fiber is more suitable in paper industry, black pine juvenile wood is more suitable than juvenile beech wood.

F Factor

Bigger F factor (flexibility) calculated by dividing fiber length into wall thickness determines that flexibility of papers obtained from these type fibers will be good.

Table 7: Relations between fibrous cells morphological factors and physical resistance properties of paper (Bostanci, 1987; Dadswell and Watson, 1962)

Relations	Burst resistance	Tear resistance	Double folding resistance	Density of paper (*)
As fiber length rise	+	++	+	-
As cell wall thickness rise	-	+	--	--
As cell wall thickness decrease	+	-	++	++
As fiber length /width increase			+	
As fiber curls increase	-	+	+	-

*: Porosity, air permeability, water holding capacity and volumeness re inversely proportional to density; +: Positive effect was determined; ++: Absolutely has positive effect; -: Negative effect was determined; --: Absolutely has negative effect

According to this, while F factor for beech juvenile wood was found as140.38, it was found as 240.55 for black pine juvenile wood. On studies about hardwoods, F factor was found as 235.92 for *Populus euramericana* and 206.78 for *Populus tremula* (Kar, 2005). On other studies related with softwoods, F factor was found as 606.66 for *Pinus brutia*, 410.34 for *Cedrus libani* (Erdin, 1985), spring wood radial for *Pinus pinaster* (Izmit, land, Bonitet-1) was determined as 745.40, spring wood tangent as 695.81, summer wood radial as 603.9 and summer wood tangent as 493.20 (As, 1992).

Considering these data belong to hard/softwoods, F-values were low on both black pine juvenile wood and beech juvenile wood. It is thought that being low fiber length on both juvenile wood species affect these values.

On evaluations made in earlier study, it has seen that there is a very tight relation between resistance properties of papers and morphological structure of wood. Especially, fibrous cells on the wood have very important functions. In Table 7, the relations between some physical properties of paper and wood fibers having effects on these properties are compared.

By analyzing Table 7, it is seen that rise in fiber length and decrease in cell wall have an important effect of physical resistance of paper. Although, on this point, however black pine and beech juvenile woods having short fibers are seen as forming disadvantage, their low wall thicknesses remove this disadvantage in some extend.

CONCLUSIONS

The chemical properties of both juvenile woods were determined and the results showed that all the chemical results of both juvenile woods were close to mature soft and hardwoods.

Fiber cells' length, width, lumen space, wall thickness values play an important role on density of wood and consequently effecting physical properties of paper. Several criterions appearing as a result of these relations between themselves may give an idea about if that fiber may be used paper production.

Fibrous properties of black pine juvenile woods are approximately resemble to other softwoods properties. Generally, relations between several rates about fiber measurements and paper properties are extremely important. As it may be seen by comparing with earlier studies, values except from fiber length are in the same frequency. Therefore, black pine juvenile woods can be easily used on the areas about fiber and paper production.

Fiber analysis values of beech wood are approximately in the same ranges as wood fiber analysis of hardwoods found in earlier studies.

Looking at both species' fibrous properties, it seems that juvenile woods can be used in the areas especially in which hard/softwoods are used. It seems that short fibers especially smooth the formation and can be used by mixing with long fiber types in certain rate. In addition to that, it is obvious that juvenile woods can be used on fiber board production.

As a result, utilization of juvenile woods on fiber production, even if little, can have contribution on raw material supply.

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