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Utilization of Common Hazelnut (*Corylus avellana* L.) Prunings for Pulp Production

Upotreba biomase nastale orezivanjem stabala običnog lješnjaka (*Corylus avellana* L.) za proizvodnju celuloze

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ABSTRACT • *For the purpose of this study, pulp and handseet were produced from common hazelnut (Coryllus avellana L.) wood by using Kraft methods. Chip/solution ratio was chosen as 1/5, cooking temperature was 170°C and time for reaching the maximum temperature was 90 minutes. Screened yield was found best in 20/26 active alkali/sulfidity ratio with 47.59 %. With increased active alkali/sulfidity ratios, screened yield was decreased. The best beating degree has been identified as the 50 SR°. According to cooking parameters, while NaOH/Na2S ratio was 20/26 %, tearing index, breaking length and burst index were reached to the maximum value of 3.83 mN · m*^{2}*/g, 43.23 N · m/g and 1.87 kPa · m*^{2}*/g, respectively. These values were used for selecting the optimum cooking parameters.*

Key words: *common hazelnut wood, Kraft pulp production, paper, wood pruning*

SAŽETAK • *Za potrebe istraživanja kraft metodom proizvedena je celuloza od drva običnog lješnjaka (Coryllus avellana L.). Omjer između iverja i otopine bio je 1 : 5, temperatura kuhanja bila je 170 °C, a vrijeme postizanja maksimalne temperature iznosilo je 90 minuta. Najbolji prinos celuloze dobiven je pri omjeru lužine i sulfida 20 : 26 i iznosio je 47,59 %. S povećanjem omjera lužine i sulfida smanjivao se prinos nakon prosijavanja. Pokazalo se da je najbolji stupanj mljevenja 50 SR°. Pri različitim parametrima kuhanja i pri omjeru NaOH/Na*$_2$*S od 20 : 26 % indeks cijepanja, duljina lomljenja i indeks pucanja postigli su maksimalne vrijednosti od 3,83 mN·m*^{2}*/g, 43,23 N·m/g i 1,87 kPa·m*^{2}*/g. Te su vrijednosti upotrijebljene za odabir optimalnih parametara kuhanja.*

Ključne riječi: *drvo običnog lješnjaka, proizvodnja kraft celuloze, papir, drvo od rezidbe*

1 INTRODUCTION
1. UVOD

Hazelnut (*Corylus*) from *Betulaceae* family has natural distribution throughout Balkans, Asia, Iran and northern Turkey, and covers 10 species (Yaltırık and Efe, 2000). Having the highest commercial value in the world, *Corylus avellana* L. (FAOSTAT, 2011) is the widest species in our country (Sarıbaş, 2012). The total hazelnut farming area in Turkey was 6.678.649 ha in the year 2010 (TMO, 2013). *Corylus avellana* L. is the most important among them from the commercial aspect (FAOSTAT, 2011).

The yield of hazelnut is higher in north and east exposures in eastern Black Sea region at altitudes of 250-1000 m, and it has natural distribution at altitudes

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of 0-2500 m (Aydınoğlu, 2012). Although almost 70 % of the world's hazelnut production is provided by Turkey (TMO, 2013), the hazelnut wood could not have industrial use in our country. When cutting old trees with decreased yield, most of them are burnt. Some of their parts are used in traditional handworks such as production of wicker chairs, baskets, and barrel rings (TEMA 2004). However, since the interest in these handcrafts has decreased and not all of pruning residuals are suitable for use in these areas, the hazelnut wood cannot be utilized properly.

In a study, González *et al*. (2011) showed that the prunings from orange trees can be used to obtain soda pulp of acceptable quality with yields from 34.10 to 51.81 %. In another study, Gencer (2015) studied the utilization of kiwi pruning waste for kraft paper production and the effect of the bark on paper properties. According to the results, pulp making should then be decided based on an economic analysis. Pruning waste obtained from the kiwi plant is a sustainable fiber source since the plants are pruned annually. This waste should be utilized in the pulp and paper industry in order to provide income for growers.

In this study, in order to have preliminary information about the usability of hazelnut wood in pulp production, morphological properties and chemical components of the wood have been determined. Based on these properties, it can be concluded whether it is suitable for pulp production. In pulp production, the Kraft method was preferred. Kraft method was selected for its shorter cooking duration, high-resistance of its pulp, and the fact that it is suitable for all wood species (Casey, 1980). When applying the Kraft method, 6 times of cooking were performed in order to determine Na_2S and NaOH ratios,. While producing paper from any pulp, many of the paper characteristics are determined by beating. In other words, paper is produced in a beater. For this reason, in order to determine the characteristics that the paper will gain at different beating degrees, the most appropriate beating level was determined in our study by producing paper from unbeaten pulp and pulps beaten at beating degrees of (18±2), 35 and 50 SR°.

The aim of this study was to investigate the possibility of use of the hazelnut wood residues, not used industrially for any products, in the pulping and paper industry, and also to determine the anatomical and chemical properties of the hazelnut wood.

2 MATERIALS AND METHODS
2. MATERIJALI I METODE

The common hazelnut (*Corylus avellana* L.) wood used in this study was obtained from north-west exposure at 35-60 m altitude at coordinates of 41°36′ N, 32°19′ E. After being cut into 5 cm parts in longitudinal direction, shredding process was executed manually. The branches and the other parts of the tree were also used in this study. NaOH and Na_2S used in pulp production were obtained from MERCK Darmstadt, Germany. Wood samples were macerated by chloride method (Wise and Jahn, 1952), and the preparations were evaluated from the aspect of their fiber lengths by their measurement.

Elasticity ratio = (*Lumen diameter* x 100) / *Fiber width*.

Runkel ratio = (*Fiber sheath thickness* x 2) / *Lumen diameter*

Felting ratio = *Fiber length* / *Fiber width*

Solidity coefficient = (*Fiber wall thickness* x 100) / *Fiber width*

Holocellulose was determined by Wise's chloride method (Wise and Jahn, 1952), and alpha cellulose (Rowell, 2005), lignin (TAPPI T 222 om-02), ash (ASTM D 1102-84), solubility in alcohol (TAPPI T 204 cm-97) and solubility in cold- and hot-water (TAPPI T 207 cm-99) were also determined. Chip/solution ratio (1/5), time for reaching maximum temperature (90 min.) and duration of cooking at maximum temperature (60 min.) were taken as constant for pulping. In determining the cooking temperature, kraft cooking temperature (170 °C), which was accepted to be ideal by İstek and Özkan (2006), was taken as constant. NaOH (%) - Na_2S (%) ratios were taken as 18-28, 20-26, 22-24, 24-22, 26-20 and 28-18, and six different cooking procedures were executed. Kappa number of pulps was determined according to TAPPI T 236 om-99, while viscosity of pulp was determined according to SCAN-CM 15-62 standards. 13 replicates were produced in accordance with different beating conditions. In all papers dealing with beating at (18±2º SR°), 35±2º SR° and 50±2º SR°, opacity and brightness, tearing index, break index, and burst index values were determined in accordance with TAPPI T 519 om-02, TAPPI T 525 om-02, TAPPI T 414 om-98, TAPPI T 494 om-01 and TAPPI T 403 om-02 standards, respectively. SPSS 16.0 package software was used for assessment of data.

According to Gençer and Şahin (2015), the highest values of breaking length, brightness, burst index, tearing index, opacity and whiteness were taken into account, as well as the values at which the difference between those values was not statistically significant at 5 %, and a scoring table (Tab. 5) was developed in order to determine the optimum conditions. Moreover, the highest values and the value(s) at which the difference between those values was not statistically significant at 5 % were each graded as 1, while all of the remaining values were graded as 0.

3 RESULTS AND DISCUSSION
3. REZULTATI I RASPRAVA

When loading chips into cooking boiler for pulping production, the higher the oven-dry density value of the wood, the higher is the yield obtained from the unit volume of that chip. Therefore, the boiler capacity changes proportionally to the density of wood species. The high density of the hazelnut wood has an important advantage compared to species of wood with low density. Oven-dry density of *Corylus avellana* L. wood was determined to be 0.67 g/cm³., This value of *Corylus colurna* from the same family, grown in our country, is 0.699 g/cm³ (Korkut *et al*., 2008), while that of *Corylus colurna* L. grown in the Czech Republic is

Table 1 Comparison of fiber lengths with *Corylus avellana* L. wood
Tablica 1. Usporedba duljine vlakanaca različitih vrsta drva i drva lješnjaka (*Corylus avellana* L.)

Wood species *Vrsta drva*	**Fiber length** *Duljina vlakanaca* mm	**Fiber width** *Širina vlakanaca* µm	**Lumen width** *Širina pore* µm	**Wall thickness** *Debljina stijenke* µm
Corylus avellana L.(1)	1.04	22.2	13.66	4.3
Corylus avellana L.(2)	1.06	23.8	14.08	4.8
Betula verrucosa (3)	1.10	20.0	-	1.9
Eucalyptus globus (3)	1.00	13.0	-	1.6
Fagus silvatica var. *purpurea* (3)	1.03	19.0	-	7.5
Qercus robur (3)	1.10	21.0	-	6.0
Fraxinus excelsior (3)	1.05	16.0	-	3.8

Key/*Legenda*: 1 – authors' finding, 2 – Merev, 1998, 3 – Rydholm, 1965

0.627 g/cm^3 (Zeidler, 2012). The fiber morphology of the raw material plays a decisive role for the characteristics of the paper to be produced. For this reason, Table 1 presents morphological characteristics of some important hardwood trees from literature compared with fiber lengths of *Corylus avellana* L. wood.

According to IAWA (1989), the trees with mean fiber lengths between 900 and 1600 µm are considered as "medium length" fiber group. As can be seen in Tab. 2, it was determined that *Corylus avellana* L. wood is in this group with its 1.04 mm fiber length. Merev (1998) has determined the fiber length, fiber width, lumen width, wall thickness, and trahe length of *Corylus avellana* L. wood to be 1.05 mm, 23.76 µm, 14.08 µm, 4.80 µm, and 599.98 µm, respectively. Merev's determinations show similarities with the values obtained in our study. They are the same as *Taxus brevifolia* and *Quercus stellate*, and have similarities with *Carya cordiformis* and *Ulmus alata* (0.66 g/cm^3) (Miles and Smith, 2009).

Elasticity coefficient, rigidity coefficient, Runkel ratio, and felting ratio of hazelnut wood are 61.53, 19.23, 0.63, and 46.90, respectively, and these values show similarity with those of kiwi (Yaman and Gençer, 2005) calculated to be 61.99, 19.00, 0.61, and 44.03. When the relationship between specific weight and fiber lengths of hazelnut wood was examined, it could be seen that elasticity coefficient was 61.53 and specific weight was 0.67 g/cm^3. The woods with elasticity coefficient of 50-75 and weight of 0.55-0.70 g/cm^3 are classified into this group. The woods in this group provide papers with good resistance characteristics, because they are partly grinded since their lumen gaps are wide although wall thicknesses are a little bit high (Bostancı, 1987). With such characteristics, *Corylus avellana* L. is classified into elastic fiber class, and it has advantages in paper production compared to species having fibers with thick and thin wall. Since thick-walled cells do not collapse, the potential contact area decreases. Consequently, the burst resistance depending on fiber connection also decreases. On the other hand, since the individual fiber strength of thin-walled fibers is low, their tearing resistance is also low (Panshin and de Zeeuw, 1970).

The rigidity coefficient has been found to be 19.23. The physical resistance characteristics of papers made of fibers having high rigidity coefficients are affected negatively and not enough inter-fiber connection can be established (Yaman and Gençer, 2005). High rigidity coefficient means low physical resistance qualifications, especially the low level of burst and breaking resistances. Runkel ratio has been calculated to be 0.63. If the Runkel ratio is less than 1, it is classified into thin-walled fiber class. Except the tearing and folding resistance, all of the characteristics of paper made of these fibers show improvement. Felting ratio has been found to be 46.93. Although the fibrous raw materials having felting ratio less than 70 are considered to be invaluable in terms of paper production, since it has been revealed that the physical characteristics of pulps obtained from the fibers of hardwoods having felting ratio less than 70 are good, it can be stated that this ratio does not indicate a systematical relationship with various physical characteristics of paper but indicates the relationship only with tearing resistance of the paper (Bostancı, 1987). According to these results, hazelnut wood can compete with forest trees having significant place in pulp production (Table 1) from the morphological aspect. *Corylus avellana* L. and *Corylus colurna* L. are two important hazelnut species in Turkey. Some physical and chemical characteristics of these wood species are presented in Tab. 2.

Table 2 Some physical and chemical characteristics of *Corylus avellana* L. and *Corylus colurna* L. woods
Tablica 2. Neka fizikalna i kemijska svojstva drva *Corylus avellana* L. i *Corylus colurna* L.

Characteristics *Obilježje*	***Corylus avellana* L.** (Findings)	***Corylus colurna* L.** (Korkut *et al.,* 2009)
Extractive matter, % / *ekstraktivne tvari, %*	2.83	7.42
Cold-water solubility, % / *topljivost u hladnoj vodi, %*	2.90	6.30
Hot-water solubility, % / *topljivost u toploj vodi, %*	3.70	7.40
Holocellulose, % / *holoceluloza, %*	82.07	68.80
α-cellulose, % / α-celulo*za, %*	41.33	43.50
Lignin, % / *lignin, %*	15.89	23.60
1 NaOH solubility, % / *topljivost u lužini, %*	18.48	25.50
Ash content, % / *sadržaj pepela, %*	0.72	0.30

Table 3 Screened yield, screenings, total yield, Kappa number, and viscosity of pulps obtained from *Corylus avellana* L. wood
Tablica 3. Prinos prosijavanja, prosijavanje, ukupni prinos, Kappa broj i viskozitet celuloze proizvedene od drva *Corylus avellana* L.

$NaOH-Na_2S$ %	**Screened yield** *Prinos prosijavanja* %	**Reject** Škart %	**Total yield** *Ukupni prinos* %	**Kappa number** *Kappa broj*	**Viscosity** *Viskozitet* cm^3/g
K1/ 18-28	45.72	0.20	45.92	17.25	778.26
K2/ 20-26	47.60	0.05	47.64	17.35	947.01
K3/ 22-24	45.06	0.13	45.19	15.25	697.17
K4/ 24-22	43.55	0.07	43.62	14.65	685.47
K5/ 26-20	40.67	0.06	40.73	14.55	680.39
K6/ 28-18	38.21	0.06	38.27	14.45	607.48

K - Kraft pulping / *priprema kraft pulpe*

When physical and chemical properties of *Corylus avellana* L. wood, presented in Table 2, are compared with those of *Corylus colurna* L. wood, it can be concluded that solubility values, α-cellulose, and lignin contents are low in *Corylus colurna* L. wood, while holocellulose and ash content values are high in *Corylus avellana* L. wood .

3.1 The effect of active alkali/sulfidity ratio on pulp yield
3.1. Utjecaj omjera lužine i sulfida na prinos celuloze

Some characteristics of Kraft pulp obtained from *Corylus avellana* L. wood, such as screened yield, total yield, Kappa number, and viscosity, are presented in Table 3.

When producing paper from pulp, many characteristics of the paper depend on the beating degree. Beating mainly affects the physical characteristics. With beating, primary fiber wall is shivered, fiber length decreases, elasticity increases, and outer specific area of fiber increases. As the duration of beating increases, the breaking and burst indices increase, tearing index of paper sheets increases rapidly and then these properties decrease. Opacity and brightness of paper sheets decrease. Similar results are generally determined due to beating (Gencer and Sahin, 2015).

When examining Table 4, it can be seen that the same letters in the same columns indicate that the differences are statistically non-significant at confidence level of 95 %. When examining the effect of different active alkali/sulfidity ratios on opacity, it can be seen that the highest opacity in papers produced from non-beaten pulps has been measured to be 99.93 % at active alkali/

Table 4 Some physical, optical, and mechanic characteristics of sample papers obtained from *Corylus avellana* L. wood and Duncan test
Tablica 4. Određena fizikalna, optička i mehanička svojstva uzoraka papira proizvedenih od drva *Corylus avellana* L. i rezultati Duncanova testa

SR°	**No**	**Optical characteristics** *Optička svojstva*		**Mechanic characteristics** *Mehanička svojstva*		
		Opacity *Neprozirnost* %	Brightness *Sjajnost* %	Tearing index *Indeks cijepanja* $mN·m^2/g$	Breaking index *Indeks lomljivosti* N·m/g	Burst index *Indeks pucanja* $kPa·m^2/g$
18±2	K1	99.88 G	25.18 H	2.93 BCD	34.86 C	1.51 D
	K2	99.89 G	25.39 I	3.83 I	43.23 D	1.87 E
	K3	99.92 G	26.05 K	2.64 ABC	34.69 C	1.30 C
	K4	99.93 G	26.99 M	2.60 AB	29.71 B	1.37 C
	K5	99.85 F G	29.38 O	2.41 A	29.57 B	1.11 B
	K6	99.79 F G	32.17 P	2.34 A	24.41 A	0.95 A
35±2	K1	99.21 C	19.50 C	3.86 I	80.66 I	4.62 K
	K2	98.44 B	19.33 C	3.63 GHI	83.29 I	5.01 L
	K3	99.70 EF	21.69 F	3.70 HI	76.91 H	4.04 I
	K4	99.69 EF	20,19 G	3.61 FGHI	70.03 F	3.80 H
	K5	99.69 EF	25.67 J	3.49 FGHI	69.36 F	3.41 G
	K6	99.59 E	28.68 N	3.43 FGH	62.61 E	3.33 FG
50±2	K1	98.51 B	17.75 A	3.39 FGH	86.29 J	4.63 K
	K2	97.87 A	18.26 B	3.34 EFGH	87.86 J	5.19 M
	K3	99.37 D	20.07 D	3.26 DEFG	81.16 I	4.16 J
	K4	99.41 D	21.23 E	3.23 DEF	73.78 G	3.81 H
	K5	99.38 D	23.19 G	2.99 CDE	67.52 F	3.43 G
	K6	99.16 C	26.31 L	2.89 BCD	62.12 E	3.25 F

After one-way analysis of variance (ANOVA), the Duncan test was used to determine the difference between groups. Important differences between groups were marked by the letter A, B, C…, etc. The letter means the difference between the groups. / *Nakon jednosmjerne analize varijance (ANOVA) primijenjen je Duncanov test kako bi se odredile razlike između skupina podataka. Značajne razlike među skupinama prikazane su slovima A, B, C itd. Različita slova označuju značajne razlike među skupinama.*

Table 5 Scoring the optimum pulp production conditions and beating degree
Tablica 5. Bodovanje optimalnih uvjeta proizvodnje celuloze i stupnja mljevenja

Properties / *Svojstvo*	**K1 x/y/z**	**K2 x/y/z**	**K3 x/y/z**	**K4 x/y/z**	**K5 x/y/z**	**K6 x/y/z**
Opacity / *neprozirnost*	1/0/0	0/0/1	1/1/1	1/1/1	1/1/1	0/1/1
Brightness / *sjajnost*	0/0/0	0/0/0	0/0/0	0/0/0	0/0/1	1/1/1
Tear index / *indeks cijepanja*	1/1/0	1/1/1	0/1/0	0/1/0	0/1/0	0/1/0
Breaking index / *indeks lomljivosti*	0/1/0	1/1/1	0/0/0	0/0/0	0/0/0	0/0/1
Burst index / *indeks pucanja*	0/0/0	1/1/1	0/0/0	0/0/0	0/0/0	0/0/0
Pulp yield / *prinos celuloze*	0/0/0	1/1/1	0/0/0	0/0/0	0/0/0	0/0/0
Kappa number / *Kappa broj*	0/0/0	0/0/0	0/0/0	0/0/0	0/0/0	1/1/1
Viscosity / *viskozitet*	0/0/0	1/1/1	0/0/0	0/0/0	0/0/0	0/0/0
Total point x/y/z / *ukupan broj bodova x/y/z*	2/2/0	5/5/6	1/2/1	1/1/1	1/2/2	2/4/4

x – 18±2 SR°, y – 35±2 SR°, z – 50±2 SR°

sulfidity ratio of 24/22. It can be seen that opacity of paper sheets decreased in all samples as the beating duration was increased. When examining the effect of different active alkali/sulfidity ratios on brightness in non-beaten pulps, it can be concluded that the highest brightness value was 32.17 % at active alkali/sulfidity ratio of 28/18. This value was decreased in all of the samples as the duration of beating was increased.

When examining the effect of different active alkali/sulfidity ratios on tearing index, it can be seen that the tearing index of paper sheets obtained from different active alkali/sulfidity ratio of 20/26 was 3.83 mN·m^2/g for non-beaten pulp and 3.86 mN·m^2/g for pulp beaten at 35 SR°. As the duration of beating increased, this value also increased in all samples initially, and then it decreased in all of them at 50 SR°. Breaking index value at active alkali/sulfidity level of 20/26 has peaked in non-beaten pulp and pulps beaten at 35 SR° and 50 SR°, and it increased with beating. It was found to be 43.23, 80.66 N·m/g and 87.86 N·m/g, respectively. When evaluating the effects of different active alkali/sulfidity ratios and beating on burst index, it can be seen that, with 20/26 active alkali/sulfidity ratio, the sample papers made of unbeaten pulp and pulp beaten at 35 SR° and 50 SR° had the highest values, and namely 1.87, 5.01 and 5.19 kPa·m^2/g, respectively. Burst and tearing index values obtained from *Corylus avellana* L. wood at similar Kappa number and SR° levels are higher than those obtained from papers made of *Olea europaea* wood (Requejo *et al.,* 2012).

According to Tab. 5, the most ideal beating conditions were determined by giving 1 point to the best value and to the values having statistically non-significant difference from the best value at confidence level of 95 %. When interpreting the columns of Table 4, all 3 freeness or schopper degrees were taken into consideration. However, while scoring in Table 4, by evaluating each beating value at 18±2 SR°, 35 SR° and 50 SR° beating levels, *x*, *y* and *z* columns were created. This was done with the aim of determining the best beating degree.

When evaluating the pulp, high yield and viscosity values and low Kappa number are desired. The aim of the assessment was to determine the highest yield and viscosity and the lowest Kappa number. Since these values are the properties related to pulp, they are the same for every beating degree. Table 5 presents the scoring used to determine the optimum conditions.

According to Tab. 5, the paper made of K2 pulp gained the highest scores at every beating degree, and peaked when beaten up to 50 SR° degrees. According to these results, the cooking conditions of common hazelnut wood can be considered as 20/26 active alkali/sulfidity, cooking temperature of 170 °C, 1/5 chip/solution ratio, 90 min. for reaching the maximum temperature, 60 min. of cooking at the highest temperature, and beating degree of 50 SR°. In our study, pulp has been produced from Common Hazelnut (*Corylus avellana* L.) wood by Kraft method, and the best beating degree has been determined. However, in order to achieve an exact judgment, we believe that other pulp production methods should also be investigated.

4 CONCLUSION
4. ZAKLJUČAK

The fibers of the Hazelnut wood presented in Tab. 1 were determined to be similar to the fibers of the hardwoods commonly used in the wood products industry. Therefore, it can be said that the paper produced from hazelnut wood can be an alternative to commonly used hardwood species. Hazelnut wood has a high α-cellulose ratio and a low lignin ratio, hence it can easily be used in an alternative pulping process.

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5 REFERENCES
5. LITERATURA

1. Bostancı, Ş., 1987: Kâğıt Hamuru Üretimi ve Ağartma Teknolojisi. Karadeniz University, Faculty of Forestry, Karadeniz University Press, General Publication Nr. 114, Faculty Publication Nr. 13, Trabzon.
2. Casey, J. P., 1980: Pulp and Paper Chemistry and Chemical Technology, Vol. 1, Third Edition. Wiley Interscience Publisher Inc., New York, 409.

3. Gençer, A., 2015: The utilization of kiwi (*Actinidia deliciosa*) Pruning waste for kraft paper production and the effect of the bark on paper Properties. Drewno, 58 (194): 103-113.
http://dx.doi.org/10.12841/wood.1644-3985.084.08.
4. Gençer, A.; Şahin, M., 2015: Identifying the conditions required for the NaOH method for producing pulp and paper from sorghum grown in Turkey. BioResources, 10 (2): 2850-2858.
http://dx.doi.org/10.15376/biores.10.2.2850-2858.
5. Gonzáles, Z.; Rosal, A.; Requejo, A.; Rodríguez, A., 2011: Production of pulp and energy using orange tree prunings. Bioresource Technology, 102 (19): 9330-9334. http://dx.doi.org/10.1016/j.biortech.2011.07.088.
6. Korkut, D. S.; Korkut, S.; Bekar, I.; Budakçı, M.; Dilik, T.; Çakıcıer, N., 2008: The effects of heat treatment on the physical properties and surface roughness of Turkish hazel (*Corylus colurna* L.) wood. International Journal of Molecular Sciences, 9: 1772-1783.
http://dx.doi.org/10.3390/ijms9091772.
7. Merev, N., 1998: Odun Anatomisi Cilt 1. Doğu Karadeniz Bölgesindeki Doğal Angiospermae Taksonlarının Odun Anatomisi, General Publication Nr. 189, Faculty Publication Nr. 27, Karadeniz Technical University Press, Trabzon.
8. Miles, P. D.; Smith, W. B., 2009: Specific gravity and other properties of wood and bark for 156 tree species found in North America. Res. Note NRS-38. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northem Research Station. 35 p.
9. Panshin, A. J.; deZeeuw, C., 1970: Textbook of Wood Technoology, 3rd ed. New York: McGraw-Hill; 705 p., Vol. 1.
10. Requejo, A.; Rodriguez, A.; Colodette, J. L.; Gomide, J. L.; Jimenez, L., 2012: Optimization of ECF bleaching and refining of kraft pulping from olive tree pruning. Bioresources, 7 (3): 4046-4055.
11. Rowell, R. M., 2005: Wood Chemistry and Wood Composites. CRC press, USA.
12. Rydholm, S. A., 1965: Pulping processes. Vol. 1, 1st Ed., Interscience Publishers, California, 1269 p.
13. Sarıbaş, M., 2012: Dendroloji II Angiospermae. Kapalı Tohumlular Angiospermae (Amentifeare), Bartın University Publication Nr. 7, Faculty of Forestry Publication Nr. 5, Bartın.
14. TEMA 2004: Ağaçlar, Doğa Severler İçin Rehber Kitap, Marmara Bölgesi Doğal-Egzotik Ağaç ve Çalıları. 3. ed., TEMA Foundation Press, Pub. Nr. 39, Turkish Foundation of Foresting, Protecting Natural Assets and Struggle with Erosion, İstanbul.
15. TEPGE 2011: Durum ve Tahmin Fındık 2011/2012. TEPGE Yayın No. 1918, ISBN: 978-975-407-338-6, ISSN: 1306-0260. Agricultural Economy and Policy Development Institute, Ankara.
16. TMO 2013: Hazelnut Industry Report of Year 2012. General Directorate of Turkish Grain Board, Ankara.
17. Ververis, C.; Georghiou, K.; Christodoulakis, N.; Santas, P.; Santas, R., 2004: Fiber dimensions, lignin and cellulose content of various plant materials and their suitability for paper production. Industrial Crops and Products, 19 (2004): 245-254.
http://dx.doi.org/10.1016/j.indcrop.2003.10.006.
18. Wise, L. E.; Jahn, E. C., 1952: Wood Chemistry. 2nd ed., Vol 1-2. Reinhold Publication Co. New York, U.S.A, 1330.
19. Yaltırık, F.; Efe, A., 2000: Dendrology Handbook, Gymnospermae-Angiospermea. Faculty of Forestry Publication, Istanbul University Publication, Istanbul, Turkey.
20. Yaman, B.; ve Gençer, A., 2005: Trabzon koşullarında yetiştirilen kiwi (Actinidia deliciosa (A. Chev.) C. F. Liang & A. R. Ferguson) nin morfolojisi. Süleyman Demirel University, Journal of Faculty of Forestry, A (2): 149-155.
21. Zeidler, A., 2012: Variation of wood density in Turkish hazel (*Corylus colurna* L.) Grown in the Czech Republic. Journal of Forest Science, 58 (4): 145-151.
22. *** 2011: FAOSTAT. http:/faostat.fao.org/site/567 DesktopDefauH.aspx?PageID=567
23. *** 1989: IAWA list of microscopic features for hardwood identification IAWA Bulletin n.s., 10: 219-332.

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