



## Chemical and Morphological Properties of Apricot Wood (*Prunus armeniaca* L.) and Fruit Endocarp

Ayhan GENÇER<sup>1</sup>, Ufuk ÖZGÜL<sup>1</sup>, S. Murat ONAT<sup>1\*</sup>, Gökhan GÜNDÜZ<sup>1</sup>, Barbaros YAMAN<sup>2</sup>, Hikmet YAZICI<sup>3</sup>

<sup>1</sup> Bartın University, Faculty of Forestry, Department of Forest Industry Engineering, 74100, Bartın

<sup>2</sup> Bartın University, Faculty of Forestry, Department of Forest Engineering, 74100, Bartın

<sup>3</sup> Bülent Ecevit University, Caycuma Vocational School, Zonguldak

### Abstract

This study examined some of the chemical and morphological properties of apricot wood (*Prunus armeniaca* L.) and fruit endocarp. According to results, the holocellulose, alphacellulose, and lignin ratios of apricot wood were found to be 79.50%, 42.33% and 16.43% respectively. The holocellulose, alphacellulose, and lignin ratios of the apricot fruit endocarp were determined to be 79.33%, 28.65%, and 36.22%, respectively. In morphological terms, the apricot fruit endocarp has not been found to be suitable for paper manufacturing but it can be used for board manufacturing. And also, apricot wood is similar to the hardwood species that have industrial value, so it is a convenient raw material for pulp production.

**Keywords:** Apricot wood (*Prunus armeniaca* L.), apricot fruit, chemical properties, morphological properties

## Kayısı (*Prunus armeniaca* L.) Odunu ve Meyve Endokarpının Kimyasal ve Morfolojik Özellikleri

### Öz

Bu çalışmada kayısı (*Prunus armeniaca* L.) odunu ve meyve endokarpının bazı kimyasal ve morfolojik özellikleri incelenmiştir. Araştırma sonuçlarına göre, kayısı odununun holoselüloz, alfa selüloz ve lignin içerikleri sırasıyla %79.5, %42.33 ve %16.43 olarak bulunmuştur. Aynı şekilde meyve endokarpının oranları sırasıyla %79.33, %28.65, ve %36.22 olarak tespit edilmiştir. Morfolojik olarak ele alındığında meyve kabuklarının kâğıt üretimine uygun olmadığı fakat levha üretiminde kullanılabilceği tespit edilmiştir. Bunlara ilaveten kayısı odununun diğer endüstriyel değeri olan yapraklı ağaç odunlarıyla benzer özellik gösterdiği ve bu nedenle kâğıt hamuru üretimi için uygun bir hammadde olduğu belirtilmiştir.

**Anahtar Kelimeler:** Kayısı odunu (*Prunus armeniaca* L.), kayısı meyvesi, kimyasal özellikler, morfolojik özellikler.

### \*Sorumlu Yazar (Corresponding Author):

Saadettin Murat ONAT (Dr.); Bartın Üniversitesi, Orman Fakültesi, Orman Endüstri Mühendisliği Bölümü, 74100, Bartın-Türkiye. Tel: +90 (378) 223 5099, Fax: +90 (378) 223 5062, E-mail: [smuratonat@bartin.edu.tr](mailto:smuratonat@bartin.edu.tr), ORCID: 0000-0003-1749-0619

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## 1. Introduction

As the population around the world increases, so does the demand for new sources of raw materials. This demand is grouped under health, sheltering, education, defense, and particularly nutrition. Therefore, utilizing raw material sources from convenient areas is important. Industrial organizations and governments are continuously conducting research to determine the feasibility of using various alternative sources of raw materials to supplement or replace the conventional sources. Turkey produces 20% of the apricot wood in the world; there are about 12 million apricot trees in the country (Gezer, 1999). The production of dried apricot wood in Turkey has been a traditional practice since ancient times. Usually, old trees and prunings are burned. In addition, a significant amount of fruit endocarp is produced as a byproduct of the production of dried apricot wood. Presently, most of the apricot fruit endocarp is burned. In an earlier study conducted with different apricot fruits, it was found that the fruits could be a source of oil and that they have high concentrations of Ca, K, Na, and P, giving them a high nutritional value (Gezer et al., 2011). The chemical and morphological characteristics of a raw material are the most important factors for determining the properties of paper to be manufactured using lignocellulosic material. In general, the lengths of the fibers in hardwood species vary from 0.6 to 1.9 mm (Pakhala, 1993), and the average is just above 1 mm (Hale, 1969); thus, they are classified in the “short-fiber group”. Woods in this group are known to produce high-quality writing and printing papers that have high opacity and smoother surfaces (Karlsson, 2006). The length of the fibers in wood is an important factor, because a minimum length is required to provide enough bonding surface to give a satisfactory stress distribution in the sheet. Paper made from woods with shorter fibers will have insufficient common bonding areas between the fibers; as a result, there will be weak points for transferring stress within the sheet, and the strength of the paper will be low (Panshin and deZeeuw, 1970). According to another study, using plum stem and branch wood (*Prunus domestica*) for pulp and paper production may solve the raw material problem because of having desired fiber and chemical properties and being similar to other hardwood species (Kiaei et al. 2014). In this study, the chemical and morphological properties of the wood from apricot trees and apricot fruit endocarps were examined. The suitability of apricot wood for use in paper production was investigated based on the results that were obtained.

## 2. Material and Method

Wood and the endocarps of the fruits from the apricot tree (*Prunus armeniaca* L.) were examined chemically and morphologically in this study. The apricot wood was obtained from the orchard of the Malatya Apricot Research Institute in Turkey. The type of apricot used in the study was Hacihaliloglu. The endocarps of the fruits of the same type of apricot tree were supplied by a private enterprise. After the apricot wood was chipped, the samples were stored in a laboratory environment and air dried. Fruit endocarps were selected by hand and cleaned to remove impurities. Samples were ground in a Wiley mill according to the TAPPI T 11 os-75 standard and sieved; the samples that remained on the 60 mesh sieve were used for chemical analysis. The TAPPI T 203 os-71 standard was used to determine the alpha cellulose content of the fruit endocarps, and the TAPPI T 222 om-02 standard was used for lignin analysis; holocellulose determination was conducted according to Browning (1967). The TAPPI T 207 cm-99 standard was used to determine the solubility of the fruit endocarps in cold and hot water, and the TAPPI T 204 cm-97 standard was used to determine their solubility in alcohol. The apricot wood and endocarp samples were individualized via the maceration (chlorite) method. Using a glicerine-gelatine solution, permanent preparations were prepared from the macerated samples. The following equations were used to identify the fiber-dimension relationships:

Runkel ratio = Peripheral thickness of the fiber x 2/Lumen Diameter

Felting ratio = Fiber length/Fiber width

Elasticity ratio = Lumen Diameter x 100/Fiber width

Rigidity coefficient = Wall thickness of the fiber x 100/Fiber width (Kırcı, 2003)

Defining the density from geometric shapes for pitted materials could lead to misleading results. Therefore, Archimedes law was used in finding the specific weight (Hacke et. al., 2000). After the weights of the oven-dried samples were calculated, the apricot heartwood and sapwood samples were cut into cubic shapes (1 x 1 x 1 cm), attached to a pin, immersed in boiling paraffin, and then removed from the paraffin. As was done for the wood samples, after the complete dry weight of the apricot fruit endocarps was calculated, 10 g of oven-dried apricot fruit endocarps were immersed in the boiling paraffin and then removed from it. Subsequently, the wood and fruit endocarp samples were immersed in a beaker that had been filled with water, and the volume of the water that overflowed from the beaker was determined. According to the  $d = m/V$  formula, the specific weight of apricot wood was calculated in  $g/cm^3$ .

### 3. Results and Discussion

Some of the chemical components of apricot wood and fruit endocarps are given in Table 1.

Table 1. Chemical analysis of apricot wood and fruit endocarp

Properties (%)	Apricot wood	Apricot fruit endocarp
Cold water solubility	6.75	6.09
Hot water solubility	8.94	9.07
Holocellulose ratio	79.50	63.33
Alpha Cellulose ratio	42.33	28.65
Lignin ratio	16.43	36.22

The extractive substance ratio of apricot wood and fruit endocarp were found as 9.02% and 6.76%, respectively, while the solubility in cold and hot water were as 6.75% and 8.94%, respectively. These values were close to the cold and hot water solubility of durmast oak (*Quercus petraea*), i.e., 7.36 and 9.54%, respectively (Alkan, 2004). The ratio of holocellulose of apricot wood was 79.50%. This value was close to holocellulose ratio of *Acer campestre* (78.53%) (Alkan, 2004), and the ratio of lignin was about 16%, which was close to the lignin value of Holm oak (16.3%) (Alaejos et al., 2008). The average value of the lignin content of hardwood species is around 20% (Suchsland and Woodson, 1986). The main target in chemical pulping is to remove lignin located in middle lamella. In general, hardwood species have more cellulose, hemicelluloses, and less lignin than softwood species, and they can be bleached with fewer chemicals (Karlsson, 2006). Because apricot wood has a low lignin content, fewer chemicals would be consumed during delignification in the chemical pulping process than for hardwood species. In one study, the lignin content of hazelnut husks was reported as 35.1%, so it was found to be suitable for particleboard production (Çöpür et al., 2007). The amount of lignin in apricot fruit endocarp was about 36%, which was similar to the amount of lignin in hazelnut husks. Using apricot fruit endocarp can increase chemical consumption because of its high lignin content, so it should be used in other board products. The alpha cellulose content of wood is directly proportional to pulp yield. Alpha cellulose ratio of apricot wood was found to be about 42%, which was similar to the content of *Quercus ilex* L. (42.9%) (Alaejos et al., 2008). It can be expected that the pulp yield of apricot wood would be high. Some of the morphological properties, fiber-dimension relationships, and specific weight values of apricot wood and fruit endocarp are given in Table 2.

Table 2. Some morphological properties, fiber-dimension relationships, and specific weight values of apricot wood and fruit endocarp

Properties	Apricot wood		Apricot fruit endocarp
	Heartwood	Sapwood	
Fiber length (mm)	0.717	0.694	0.210
Fiber width (µm)	13.75	12.08	17.32
Lumen Diameter (µm)	6.05	5.69	3.52
Wall Thickness (µm)	3.85	3.19	6.9
Elasticity Coefficient	50	50.37	20.32
Rigidity Coefficient	25	24.81	39.84
Runkel Ratio	1.0	0.99	3.92
Felting ratio	46.22	55.09	12.14
Specific Weight (g/cm <sup>3</sup> )	0.54	0.63	1.09

In general, the average length of the fibers of hardwoods is a little more than 1 mm (Panshin and deZeeuw, 1970). However, the resistance values of paper made of very short fibers are generally low (Eroğlu, 2003). The short hardwood fibers enhance the paper printability, especially the opacity (Pakhala et al., 1993). Extremely long fibers cause formation defects in paper production (Eroğlu, 1990). The lengths of apricot fibers in the heartwood and sapwood were found to be about 0.72 and 0.69 mm, respectively. In an earlier study, the average fiber length of bigleaf maple (*Acer macrophyllum*) was found to be 0.77 mm (Panshin and deZeeuw, 1970). Our experimental values for apricot wood were very close to this reported value for bigleaf maple wood. The specific weight of apricot heartwood and sapwood, i.e., 0.54 and 0.63 g/cm<sup>3</sup>, respectively, were similar to many industrially-valued hardwood trees in Turkey. The length of the fibers in the apricot fruit endocarp was found to be 0.21 mm. The density of apricot fruit endocarp was determined to be about 1.1 g/cm<sup>3</sup>. In an earlier study of apricot fruit endocarp, the specific weight was given as 1.023 g/cm<sup>3</sup> (Gezer et al. 2011). So, our experimental value was very close to this reported value. Elasticity coefficient depends on the individual elasticity of fibers. This coefficient

is related to the density of the wood from which the fibers came (Kırcı, 2003). The hardwood and sapwood elasticity coefficients of apricot were 50.0 and 50.4, respectively. Such fibers are in the flexible fibers group and are preferred for paper manufacturing. Flexible fibers with an elasticity ratio of 50-70 are obtained from woods with a specific weight range of between 0.5–0.7 g/cm<sup>3</sup>. The specific weight of apricot wood is 0.54 g/cm<sup>3</sup> in hardwood and 0.63 g/cm<sup>3</sup> in sapwood. These results support the relationship between elasticity coefficient and density. The strength of individual, very flexible fibers is lower than that of the flexible fibers used in paper manufacturing, and this has a negative effect on the tear resistance of the paper. This situation results from the thinner walls of the fiber's cells. This issue can be solved by adding some pulp that has long, rigid fibers. In terms of elasticity coefficient, apricot wood is a convenient raw material for pulp. In terms of individual fiber strength, fiber plaque is appropriate for the production of cartons and boards. The elasticity coefficient of apricot fruit endocarp is 20.3. Such fibers are very rigid and are not suitable for use in paper manufacturing. Thus, they can be used for board production. In order to determine whether a source of plant fibers is suitable for pulp production, the Runkel ratio classification is used. Smaller values indicate that the fibers are more suitable for paper production (Lessard and Chouinard, 1980). Runkel ratios of apricot hardwood and sapwood were found to be 1.00 and 0.99, respectively. This group of fibers has a medium-thickness cell wall. They are more easily collapsed during paper manufacturing than fibers with a thick cell wall and that produce more inter-fiber connections. When apricot hardwood and sapwood were evaluated by the Runkel classification, they qualified as a suitable raw material for paper manufacturing. The Runkel ratio of apricot fruit endocarp was found to be 3.92, and such fibers have a very thick cell wall and cannot be used in pulp manufacturing. It would be better to use them in board production.

The felting ratio of many hardwood species and straw fibers is below 70, which indicates that the resistance properties of the paper will be diminished (Bostancı, 1987). However, having a felting ratio below 70 does not mean that paper cannot be manufactured from this raw material. The felting ratios of apricot hardwood and sapwood were determined to be 46 and 55, respectively. Similarly, the felting ratio of kiwi wood has been found to be 44.03, and that wood has been deemed to be suitable for paper production (Yaman and Gençer, 2005). The presence of short fibers can cause decreases in tear strength. However, it can be solved by controlled beating by taking fibers at the beginning of beating. Because fibrillation and tear strength increase at first stage and before begin to decrease again (Eroğlu, 1990). And if high tear strength paper is intended to be produced, the pulp can be mixed with pulp having long fibers. With these values, it can be said that apricot heartwood and sapwood can be used for pulp production. The felting ratio of apricot fruit endocarps was found to be 12. Therefore, it would be very difficult to use them in pulp manufacturing. Rigidity coefficient in softwood trees is lower than that in hardwood trees. In an earlier study, the rigidity coefficient of *Carpinus orientalis* Miller was found to be 42 (Tank, 1970). The rigidity coefficients of apricot heartwood and sapwood were found to be 25 and 24.8, respectively. The rigidity coefficient is directly proportional to thickness of the fiber wall. Under this condition, it is difficult for the fibers to collapse. Therefore, necessary bonds are not formed, and this has an adverse effect on the physical resistance of the paper (Akkayan, 1983). With 25 and 24.8 rigidity coefficients, apricot heartwood and sapwood are more suitable for paper manufacturing than hornbeam (*Carpinus orientalis* Miller). However, the rigidity coefficient of apricot fruit endocarp was about 40, which showed that it would be a suitable raw material for paper manufacturing. However, the high rate of stone cells and some unidentified impurities of the endocarp make it less suitable for paper manufacturing.

#### 4. Conclusion

Apricot wood has chemical components, physical properties, and fiber dimensions that are comparable to the hardwood trees that are preferred for paper manufacturing. Therefore, it is believed that the pulp produced from apricot wood would be similar to the wood pulp derived from typical hardwood trees. No significant differences were found in the morphological properties of sapwood and heartwood, so it is concluded that using these two sources together for pulp manufacturing should not cause any problems. Short fiber apricot wood is found suitable for the production of writing and printing paper. Future studies should investigate the possibilities of producing wood pulp using different methods and raw materials. As for fruit endocarps, the results indicate that they can be used for board manufacturing rather than paper production.

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