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Chemical Properties of Greek Stump Chestnut (*Castanea sativa* Mill.)

Konstantinos V Kakavas[1*], **Marina Chavenetidou**[2] **and Dimitris Birbilis**[1]

[1]*Department of Wood and Furniture Design and Technology, Laboratory of Chemical Technology and Biotechnology, Technological Educational Institute of Thessaly, 11 V. Griva Karditsa, Greece*

[2]*Laboratory of Forest Utilization, School of Forestry and Natural Environment, Aristotle University of Thessaloniki, Greece*

[*]**Corresponding author:** Kakavas KV, Department of Wood and Furniture Design and Technology, Laboratory of Chemical Technology and Biotechnology, Technological Educational Institute of Thessaly, 11 V. Griva Karditsa, Greece, Tel: +302441064736; E-mail: kakavas@teilar.gr

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Abstract

This paper deals with the investigation of chemical properties (electrical conductivity, pH, buffer capacity, minerals) of the species *Castanea sativa* Mill. The quantitative determination of the extracts soluble in hot water and dichloromethane was conducted using a Soxhlet device and according to the American Standards ASTM D 1110-84 and ASTM D 1108-84, respectively. The results showed that Greek Chestnut is rich in nutrients and organic chemical compounds, which can have pharmaceutical applications, and can be used in food technology, cosmetics, natural health or skin care products. This is the first attempt to record the chemical characteristics of Greek Chestnut.

Keywords: Chestnut; Extractives; Electrical conductivity; Acidity; Ash; Heartwood; Sapwood

Introduction

Extractives are mainly organic compounds (polyphenols, gum, fats, resins, oils, alkaloids, tannins, essential oils, etc.), found in wood cells, but do not participate in its structure. As a result, they can be removed by using various solvents, without alternating the wood structure. Nowadays, these substances, due to their properties, are extensively used in food and beverages and in the pharmaceutical industry for their positive effects on human health [1]. The proportion of extracts in each species ranges from less than 1% to 30% or more showing a great variation in different parts of a tree. Their presence results in an increase of wood density and reduces wood shrinkage and swelling. Furthermore, their increase of the physical endurance of the timber, prevents the entry of dopant materials and adversely affects wood adhesives used for wood bonding [2-4]. Wood discoloration can also be observed in species, rich in soluble extracts, when the wood is exposed to highly relative humidity or in contact with water, due to the washing of the extracts [5,6]. Corrosion of metal objects which are in contact with the wood can be caused by the weak organic acids contained in it [7,8]. Minerals (ash) contained in the wood affect the heating value, the consumption of chemicals during the production of wood pulp and the electrical conductivity. Moreover, they are associated with pollutants emitted during the combustion of wood or from the disposal of combustion residues and this is an index of removing nutrients from the soil.

The aim of this paper-study was the quantitative determination of chestnut wood extractives, as well as of the chemical characteristics and properties of Greek chestnut (*Castanea sativa* Mill.) for better utilization. It is the first time that such an effort is attempted.

Materials and Methods

Specifications of the above properties were made on samples taken from the base (codes: 1/1c, 3/1c, 5/1c, 9/1c and 10/1a-five chestnut logs) and top (codes 1/8c, 3/8c, 5/7c, 9/7c and 10/7c- five chestnut logs) chestnut logs from North Greece. From each disc the bark, the heartwood and the sapwood were initially separated. From the resulting material of the bark, sapwood and heartwood small wood particles with longitudinal sections were taken, which were then crumbled to a small crusher (mill) of Willey and converted into wood powder. The wood powder of bark, sapwood and heartwood was collected separately and used for the specifications a) of the extract, b) the electrical conductivity, c) acidification, d) buffering capacity and e) minerals.

From each tree disk the bark, sapwood and heartwood were separated, to be treated apart from one another. All samples were cut mechanically by hand with a sharp blade and then were trimmed with a mill (Wiley's mill), to create particles with approximately the same dimensions. For the extractions, a glass Soxhlet type device with the appropriate size was used, so as a 2 g specimen and glass filter with medium porosity to be fit. The extractions were conducted according to ASTM standards. The wood dust specimens were used for the determination of electrical conductivity, acidity and ash.

Extractives

The quantification of the extractives that are soluble in hot water and dichloromethane was done according to the American standards ASTM D 1110-84 and ASTM D 1108-84, respectively. For the extractions a glass type Soxhlet apparatus with a proper size was used, which can accommodate a sample of about 2 g wood dust and glass fiber filters with mean porosity. Before each extraction, the absolute dry weight of the wood powder and the filter weighing was determined, after drying them in an oven at 103 ± 2°C for 24 hours. Extraction with each extractor should be at a rate such that the siphon functions four times per hour. After a 4 hours extraction (the extract and into the pipette tube of the extraction device is "colorless") the filters are removed from the extractor and freely exposed to air for 24 hours, then placed in the oven at 103 ± 2°C for 24 hours until the complete drying of the wood powder and the filter and are weighed to

determine the absolute dry weight of the wood powder after the removal of the extracts.

Electrical conductivity

The term electrical conductivity refers to the ease of the passing of the electric current through a material and, in the case of wood it is associated with the presence of ions in the extracts. The electrical conductivity was determined in a mixture (wood powder water suspension) in a ratio of 1:10 (2 g wood powder: 20 ml water) 24 hours after mixing at a temperature of 250°C. The specifications were performed on samples before and after extraction with hot water.

Acidity (pH)-regulatory capacity

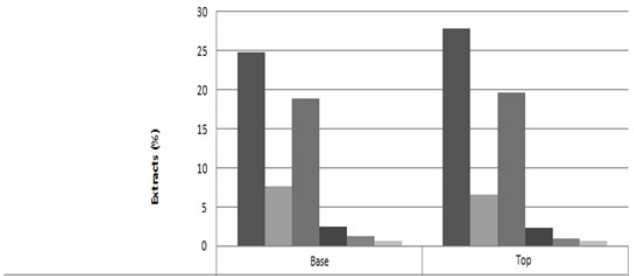
For the determination of acidity (pH) and buffer capacity the amount of 2 g dry wood dust in the air was used which was mixed with distilled water 40 ml in a small glass vessel (1:20). The mixture of wood powder-water was stirred and maintained at room temperature for 48 hours. The pH measurement is done with the electronic pH meter digital assistance 0.01 and then over 1 min by immersion of the electrode in the suspension. The acidity was determined in samples before and after extraction with hot water. Buffer capacity was determined in the same samples that were used to determine the acidity before the extraction with hot water. In the wood-water slurry which was used to determine the initial pH, with the aid of a metering pipette, small quantities by 0.5 ml NaOH solution 0.05 N were sequentially added and corresponding indications as pH and a pH=8 [9] were recorded. The buffering capacity (equivalent in acid) from the initial pH to pH=8 was determined by the relationship ml NaOH × 0.05 N NaOH to the amount (ml) of the extract (40 ml) [9].

Minerals (ash)

The quantitative determination of the minerals contained in the wood was done according to the American standards ASTM D 1102-84 under which dry burning of about 2 g of dry wood dust in the air (absolute dry weight of which) in a muffle furnace at 580-600°C up to stabilizing weight (complete combustion, incineration). The minerals (quantitatively and qualitatively) were determined before and after extraction with hot water. Qualitative analysis was made after quantifying the minerals used and the entire amount of ash created by the burning of the dry wood powder of each sample separately. Each sample was moistened with 3 drops of distilled water and then the ash was completely dissolved by the action of 3 ml HCl solution in water (1.1 vol) and modern heating in a water bath at 60°C for about 30 min. The solution was filtered with distilled water of a final volume of 50 ml [10]. The elements Ca, K, Mg, Na, Mn, Fe, Cu and Zn were determined by atomic absorption and P calorimetrically.

Results and Discussion

The content of chestnut bark, sapwood and heartwood extractives soluble in water and dichloromethane is shown in Figure 1. As shown in Figure 1, the content in water-soluble extractives was higher in the bark, followed by the heartwood and then the sapwood. The content of soluble in dichloromethane was also higher in the bark but a reverse tendency between heartwood and sapwood was observed, with the sapwood having a larger amount of dichloromethane soluble extracts than the heartwood. The sapwood showed greater concentration of water soluble extractives and soluble in dichloromethane at the base of the logs compared to the content at the top. The electrical conductivity of the bark, sapwood and heartwood, as determined before and after extraction in warm water, is shown in Figure 2.

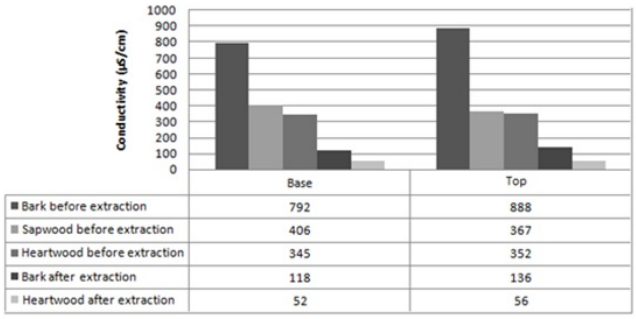


	Base	Top
Extracts with hotwater from bark	24,76	27,9
Extracts with hotwater from sapwood	7,66	6,49
Extracts with hotwater from heatrwood	18,81	19,62
Extracts with dichloromethane from bark	2,5	2,36
Extracts with dichloromethane from sapwood	1,24	0,93
Extracts with dichloromethane from heartwood	0,58	0,58

Figure 1: Bark, sapwood and heartwood extracts soluble in hot water and dichloromethane from the base and the top.

The electrical conductivity of the bark at the base and the top of the logs before and after extraction with hot water was found (Figure 2) higher (approximately twice) than that of the sapwood and heartwood. The extraction resulted in a strong decrease of conductivity in all cases. The conductivity of the sapwood before extraction was more than that of the heartwood, whereas after the extraction the conductivity of the heartwood was greater than that of the sapwood. The acidity and buffer capacity (equivalent in acid) of the bark, sapwood and heartwood of chestnut wood are shown in Figure 3. The acidity of the heartwood was found (Figure 3) higher than that of the bark and sapwood acidity, as well as the bark acidity was found greater than that of the sapwood. Heartwood acidity (pH=3.58) appeared to be greater than sapwood acidity (pH=4.29) by Malaban et al. as well [11]. Chestnut (*C. sativa* and *C. dentata*) sapwood and heartwood acidity was found to range from pH=3.2 to pH=4.29. The buffering capacity of the sapwood was higher compared to the buffering capacity of the bark and heartwood. The differences between the bark and heartwood were very small (Figure 3). The quantification of minerals contained in the bark, sapwood and heartwood of chestnut wood and the effect of water-soluble extracts are shown in Figure 4. Qualitative analysis of inorganic components is shown in Figures 5 and 6. Qualitative analyses of the main minerals contained in the ash are shown in Figure 5. Ash content appeared to be higher in the bark than in the sapwood and heartwood (Figure 4). The relatively small increase in minerals observed in the bark after extraction with hot water should be attributed to the higher percentage of inorganic components in bark and are not removed along with the water-soluble extracts. As far as the inorganic components content is concerned. Figure 5 shows that in all cases a reduction of the content (larger in the bark) was observed after extraction, except for the case of the iron (Fe) and zinc (Zn) content, which was found slightly larger in the heartwood. The minerals contained in bark ash, sapwood and heartwood were found to rise or to fall after extraction with hot water (Figure 6). In brief, the values of chemical properties in bark, sapwood and heartwood chestnut wood are shown in Figures 1, 2 and 4. Reference to bark and sapwood wood properties was made for comparative purposes only and is associated with the use of chestnut logs with bark, intended for

shredding. Bark and sapwood are removed during sawing of logs; therefore the chemical chestnut wood properties mainly comprise heartwood. The differences in the properties between the base and the top are very small and practically do not affect the use of wood. As shown in Figures 1, 2 and 4 chestnut wood contains a high proportion of water-soluble extracts. The removal of the extracts resulted in a decrease of minerals and conductivity.



	Base	Top
Bark before extraction	792	888
Sapwood before extraction	406	367
Heartwood before extraction	345	352
Bark after extraction	118	136
Heartwood after extraction	52	56

Figure 2: Conductivity of bark, sapwood and heartwood at the base and the top before and after extraction with hot water.

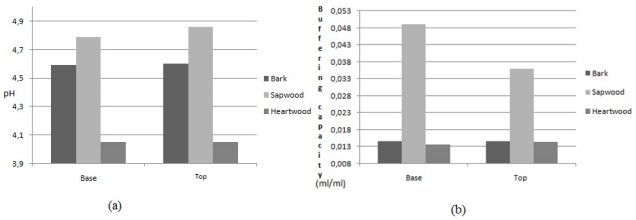
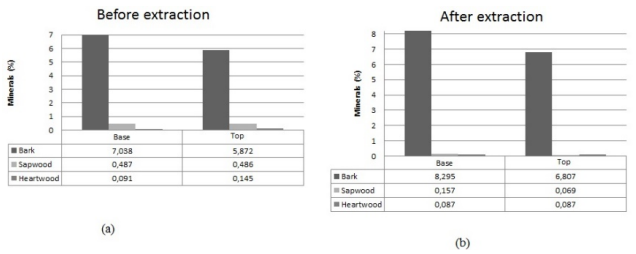


Figure 3: Acidity (pH), and Buffering capacity (equivalent in acid) in the bark, sapwood and heartwood at the base and the top.



	Base	Top
Bark	7,038	5,872
Sapwood	0,487	0,486
Heartwood	0,091	0,145

	Base	Top
Bark	8,295	6,807
Sapwood	0,157	0,069
Heartwood	0,087	0,087

Figure 4: Minerals (ash) of the bark, sapwood and heartwood at the base and the top before and after extraction with hot water.

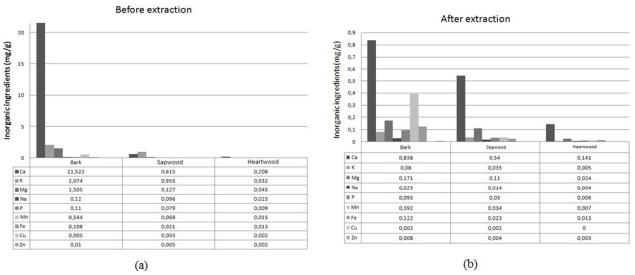


Figure 5: Content of inorganic ingredients of bark, sapwood and heartwood chestnut wood before and after extraction with hot water.

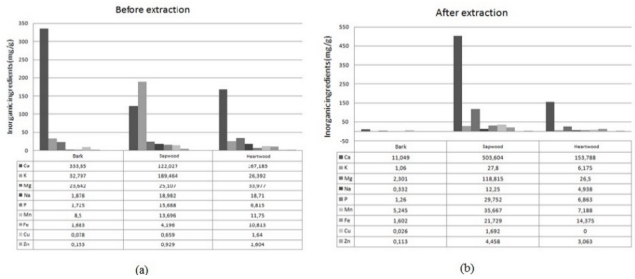


Figure 6: Content of inorganic ingredients contained in chestnut wood ash before and after extraction with hot water.

Conclusion

The content in soluble extracts was higher in the bark (26.33%) compared to the heartwood (19.22%) and very little in the sapwood (7.08%). The average content in extractives soluble in dichloromethane was 2.43%, 1.09% and 0.58% for the bark, sapwood and heartwood respectively. In both cases, bark appeared to have the largest number of extractives of all, when heartwood exceeded compared to sapwood. The electrical conductivity of the bark was found to be approximately 840 mS/mm, sapwood 387 mS/mm and heartwood 349 mS/mm, almost double compared to heartwood and sapwood. The extraction resulted in severe reduction of electrical conductivity in all cases. The conductivity of sapwood before the extraction was higher than that of heartwood, whereas after the extraction the opposite fact was observed. The acidity (pH) of the bark was 4.60, 4.83 of the sapwood and 4.05 of the heartwood, showing that bark has the highest acidity of all, whereas the acidity of heartwood was higher than that of sapwood. This fact agrees with the findings of Malaban et al. [11], even though the acidity (pH) was determined with different methods. The buffer capacity (equivalent of acid) was 0.0146 ml/ml for the bark, for the sapwood 0.043 ml/ml and the heartwood 0.014 ml/ml, showing that sapwood has the highest buffering capacity of all, whereas differences between heartwood and bark were very small. Minerals (ash) were 6.46% in the bark, 0.487% to 0.118% in the sapwood and heartwood. After extraction with hot water, conductivity decreased significantly and was 127 mS/mm, 38 mS/mm and 54 mS/mm for the bark, sapwood and heartwood respectively [12]. As it seems, bark had the highest percentage of minerals compared to all types of specimens. The removal of water-soluble extracts resulted in a reduction of minerals in

sapwood and heartwood (0.113% and 0.087%, respectively), while a small increase was observed in the bark (7.551%). This small increase is supposed to be due to the largest percentage of inorganic components, which are found in the bark and are not removed along with the water-soluble extractives. Extraction with hot water resulted in the reduction of mineral content (Ca, K, Mg, Na, P, Mn, Cu and Zn), except for iron (Fe) content, which was observed to increase.

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