RESEARCH ARTICLE (Open Access)

The solubility of Turkey Oak (*Quercus cerris l.*) wood in water

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Abstract

Albania has an area of 28,748 km^2 where forest cover occupies an area of 1.5 million hectares. Coppice forests dominated by oaks occupy an area of 623,799 hectares. There are many types of oak in Albania, but the species that have the greater spread and the largest area are: Turkey oak (*Quercus cerris.* L) and Hungarian oak (*Quercus frainetto* Ten). Now days, turkey oak is being used in many wine barrels in Albania. The main components of wood parts, soluble in cold water, consist of carbohydrates, proteins, and inorganic salts. Tannins and some polyoses are soluble in hot water. The study was carried out in six sites along longitudinal gradient. Three stem discs from the bole R1, middle R2 and top R3 of the stem were taken from each tree. For solubility in cold water, the extraction conducted at 23 ± 2°C with constant mixing for 48 hours. For solubility in hot water a reflux condenser was attached to the flask and the apparatus was placed in a gently boiling water bath for three hours. The amounts of water-soluble components differed significantly in different parts of the same tree. Average values of wood solubility, in cold water (SCW %), on discs at the base of the trunk (R1), for the analyzed samples, from all stations, resulted Mean of SCW = 7.0 ± 1.83%, while for solubility in hot water (SHW %) resulted Mean of SHW= 9.68 ± 2.57%.

Keywords: turkey oak, solubility, extractives, wood, stem.

1. Introduction

Albania has an area of 28,748 km^2 where forest cover occupies an area of 1.5 million hectares. Coppice forests dominated by oaks occupy an area of 623,799 hectares. The genus *Quercus* is one of the most important clades of woody angiosperms in the Central and Western Europe, in terms of species diversity, ecological dominance, and economic value [8]. The genus *Quercus* in Albania is mainly represented by Turkey oak (*Quercus cerris* L.), Italian oak (*Quercus frainetto* Ten.), pedunculate oak (*Quercus robur* L) and sessile oak (*Quercus petraea* Liebl.). *Q.cerris* and *Q.frainetto* are the most widespread species in Albania, covering 132910 ha (30.8 % of overall forest area)[1].

In Albania, there are few studies related to this species focused on silvicultural aspects [3], but less investigated for the chemical composition and in particular for theirs extractives content.Besides the main structural component of the cell wall (cellulose, hemicelluloses and lignin) in wood was found a large group of compounds (which in oak constitutes a substantial part) called extractives. Wood extractives are non-structural compounds of low molecular weight that can relatively easily be separated from the wood using different solvents. This group of substances, which have different physical properties, chemical and biological weapons presents numerous incentives to use forest products.

They include primary metabolites, which usually are described as substances that are basic chemical units of plant living cells, such as nucleic acids, proteins and polysaccharides, and secondary metabolites which often are defined to be anything else that body produces but it is not a structural compound (polysaccharide or lignin). The structure, composition and content of extractives vary greatly between species and even within a single tree, where they are generally more abundant in the bark, branches and knots. Factors of these varieties include: differences within a tree, tree age, growth rate, soil and climate in the region, and most importantly, genetic differences between different species. The extractives play a role in protecting the plant from disease and pests, as well as in growth regulation. Tannins that are known to form complexes with metal ions and be involved

in oxidative reactions that can cause degradation of cellulosic materials, known as ink corrosion [2; 9; 10], constitute 5-10% of oak wood. The sensory impact of oak tannins is widely assumed to have an impact on astringency and mouth feel of a wine. In oak wood, hydrolysable tannins consist mainly of gallotannins and ellagitannins where the galloyl- and hexahydroxydiphenic acid (HHDP) moieties, respectively, are esterified to a core molecule, generally glucose [4; 7; 11].

The aim of this work was the gravimetric determination of hydrophilic extractives content into Turkey oak (Quercus cerris L.), since in now days, turkey oak is being used in many wine barrels in Albania. In general, the wood does not contain many organic compounds soluble in water, although higher amounts of tannin and arabino-galactane are presented in some species. Tannins are soluble in hot water, as well as some polioses of hardwood are soluble in water. The main components of wood parts, soluble in water, consist of carbohydrates, proteins, and inorganic salts. Water moves inorganic compounds from wood with the extraction step.

2. Material and Methods

The study was focus in the specie Turkey oak (Quercus cerris L.), that together with the Hungarian oak (Quercus frainetto Ten.) are the most common types of oak in Albania. They are found in the same habitat forming mixed forests with other species.

2.1. Research Locations

The study was carried out in six sites along longitudinal gradient (Tab 1). In the northeast part our sampling sites were Kukes (KU) and Diber (DI), in the northern central part of Albania we chose Ulza (UL) and Rreshen (RR), while from southern-central Albania we took samples from Graceni (EL) and Belsh (BE). All studied sites represent the natural habitats of mixed forest stands of Turkish oak (*Q. cerris* L.) and Macedonian oak (*Q.frainetto* Ten.) managed intensively as coppice for a long time. The study sites are located in different exposition and in a broad altitudinal range from 240 m until 692 m a.s.l (Table 1). Natural understory vegetation consists of common hornbeam (*Carpinus betulus* L.), common juniper (*Juniperus communis* L.), common hawthorn (*Crataegus monogyna* Jacq.) and herbaceous vegetation. These forest stands are grown on brown soils formed on limestone bedrock. Such soils have medium thickness with a sub-clay structure.

Table 1. Sampling sites location

	Sampling sites location			
Nr	**Sampling sites**	**Longitude**	**Latitude**	**Altitude (m. a.s.l)**
1	Kukes (KU)	20° 23' 35" E	42° 05' 01" N	365
2	Diber (DI)	20° 23' 46" E	41° 45' 07 " N	616
3	Rreshen (RR)	19° 53' 10" E	41° 48' 09 " N	240
4	Ulez (UL)	19° 54' 07" E	41° 39' 28 " N	241
5	Elbasan (EL)	19° 57' 51" E	41° 08' 58 " N	692
6	Belsh (BE)	19° 56' 47" E	40° 54' 09 " N	136

2.2. Samples preparation

Three stem discs from the bole R1, middle R2 and top R3 of the stem were taken from each tree. The stem discs were air dried and sanded until the tree-ring patterns were perfectly visible. Tree-ring width (TRW) was measured to the nearest 0.001 mm using a linear table, LINTAB (Frank Rinn S.A, Heidelberg, Germany) and the TSAP-Win program. For each sampled tree, height (H) was measured with Vertex, while diameter at breast height (DBH) with caliper. Discs are cleaned from the bark and any possible knock. Using a chainsaw, do some cutting, collecting necessary sawdust. In each case, we took care to remain unchanged correct proportion of sapwood and heartwood. Sawdust is riddled collected and stored fraction that runs the sieve 40mesh (0.400mm) and remains 60mesh sieve (0.250mm). When was needed was grinding in a hand- driven grinding mill [13]. For each sample previously determined the moisture according TAPPI 264 [14]

2.3. Cold- water Solybility

We weighted about 2grams (with an accuracy of 0.0001g) of wood meal, we placed sample in a plastic bottle of 500 ml and added slowly 300 ml of distilled water, so that the wood meal got all wet, to avoid the tendency to float. Extraction conducted at 23 ± 2 ° C with constant mixing for 48 hours. (Samples were placed in an electric shaker which makes continuous and uniform mixing). After extracting we filtered the extract, we used it in a vacuum filtration system, transferring the material to a glass medium tare filter which was previously dried to constant weight at 105 ± 3ºC. We rinsed samples with 200ml cold distilled water and filter together with the extracted wood meal and we dried it to constant weight at 105 ± 3ºC temperature. After cooling in a desiccator, we weight the filter and residues accurately to 0.0001g.

2.4. Hot-water Solubility

A two-gram sample was oven-dried and placed into a 250 mL Erlenmeyer flask with 100 mL of distilled water. A reflux condenser was attached to the flask and the apparatus was placed in a gently boiling water bath for three hours. Special attention was given to insure that the level of the solution in the flask remained below that of the boiling water. Samples were then removed from the water bath and filtered by vacuum suction into a fritted glass crucible of known weight. The residue was washed with 100 ml of hot water before the crucibles were oven-dried at 103±2ºC. Crucibles were then cooled in a desiccator and weighed until a constant weight was obtained. For to calculation the wood solubility in cold and hot water used the following equation [2]. S% = [(C-D)*100]/C [2] where: S= Solubility %, C = first weight of oven dry tested specimen (grams). D= weight of oven dry specimen, after extraction (grams), (with cold or hot water). (SCW % for solubility in cold water and SHW % for solubility in hot water)

3. Results and Discussion

Average values for solubility of timber in cold water TUF (%), in basimetrical disks (R1), for the analyzed samples from all stations resulted Mean of TUF = 7.0 ± 1.83%.

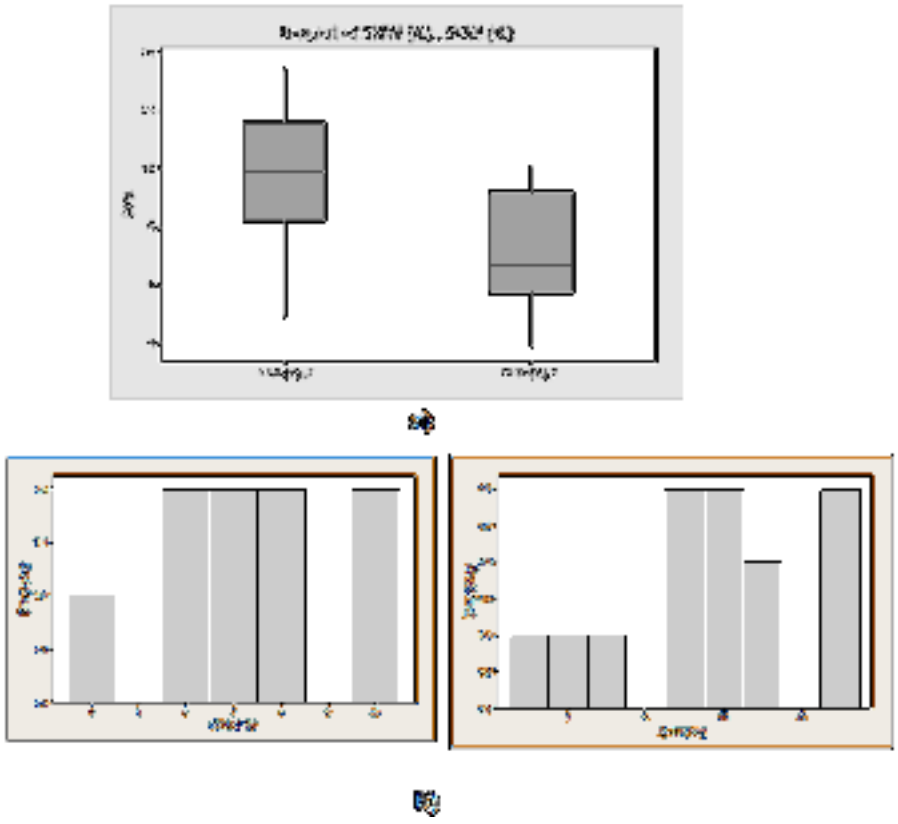


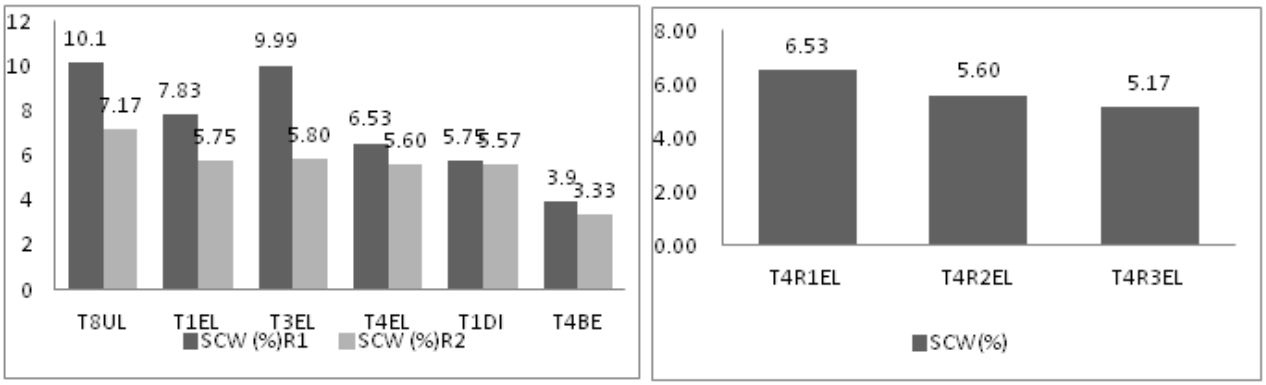
Figure 1. a) Boxplots of SHW (%) and SCW (%) for solubility of R1, b) their Histograms

Average values for solubility of timber in hot water SHW (%), in basimetrical disk (R1), for the analyzed samples from all stations resulted mean of SHW 9.68 ± 2.57%. Descriptive statistics parameters per variables such as diameter; number of annual ring (age); tree-ring width (TRW) and SHW showed in tab. 2. In figure 1 show boxplots and histagrams for datas of the wood solubility in cold and hot water, respectivly;

Table 2. Descriptive statistics parameters for SHW

Variable	N	Mean	Standart error of mean	Standard Deviation	Median
Samples diameter	14	12.79	1.83	6.83	11.35
Number of annual ring (age)	14	20.29	2.05	7.68	20
Tree-ring width (TRW)	14	2.465	0.247	0.92	2.341
Solubility in hot water SHW (%)	14	9.679	0.687	2.57	9.925

There was no correlation found between solubility in water and variables such as the cutting diameter, age and width of annual rings (TRW) on samples of Turkey oak. We also analyzed the solubility differences in hot water between disks of the base and the middle of trunk. Solubility in cold water, SCW, the basimetrical disks were significantly higher than those in R2 disk Fig 2. a) . The values of solubility in cold water, SCW (%), are falling further towards the top gasket Fig 2. b).



a) **b)**

Figure 2. a) Differences for SCW (%) between R1 and R2 b) Differences for SCW (%) in relation to the vertical position, of the sample in the tree (T4EL).

Solubility in hot water in basimetrical disk SHW were lower than those in R2 disk. Fig. 3.a). For trees T1EL and T7DI determination solubility in hot water for the top gasket (R3). The figure 3. b) shows differences of SHW for R1, R2 and R3. As for values SHW for top disks, R3, they are lower than the values of middle disk and comparable to those of basimetrical disk of R1.

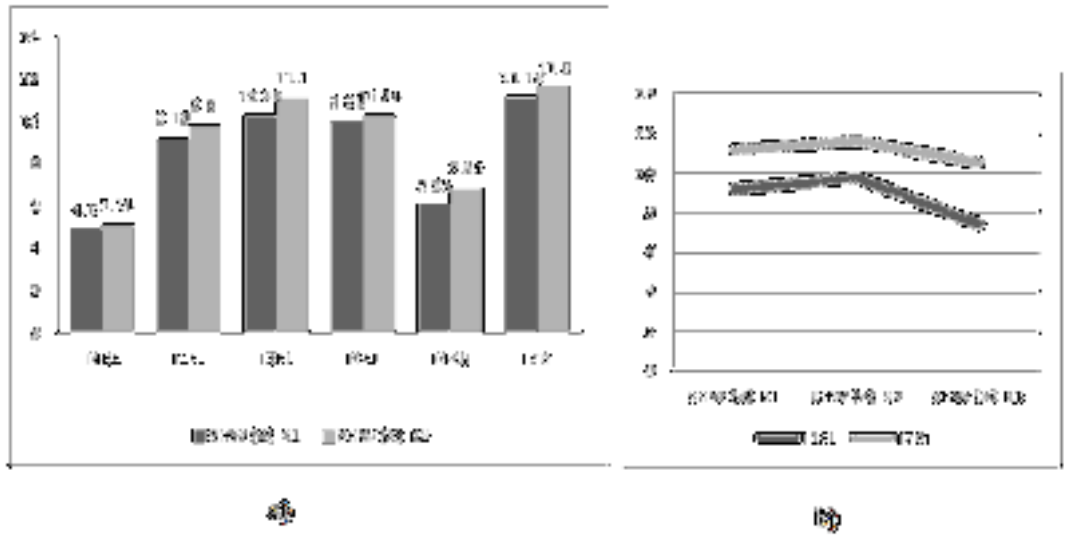


Figure 3. a) Variability of solubility in hot water between R1 and R2 b) Differences for SHW (%) in relation to the vertical position, of the sample in the tree (T1EL and T7DI).

Solubility in hot water in basimetrical disk SHW were lower than those in R2 disk. Fig 3. a) As for values SHW for top disks, R3, they are lower than the values of middle disk and comparable to those of basimetrical disk of R1 Fig 3. b). Hillis [5] has shown that extractive components in wood tend to be higher in hardwood. The heartwood size decreases by the level of starting the crown. Consequently, the wood of the top contains less heartwood and less extractable than the trunk. However, this decrease in the direction of the tree top depends on the species. Results for the bark solubility were much higher than those in the entire cross section of the trunk wood without bark.

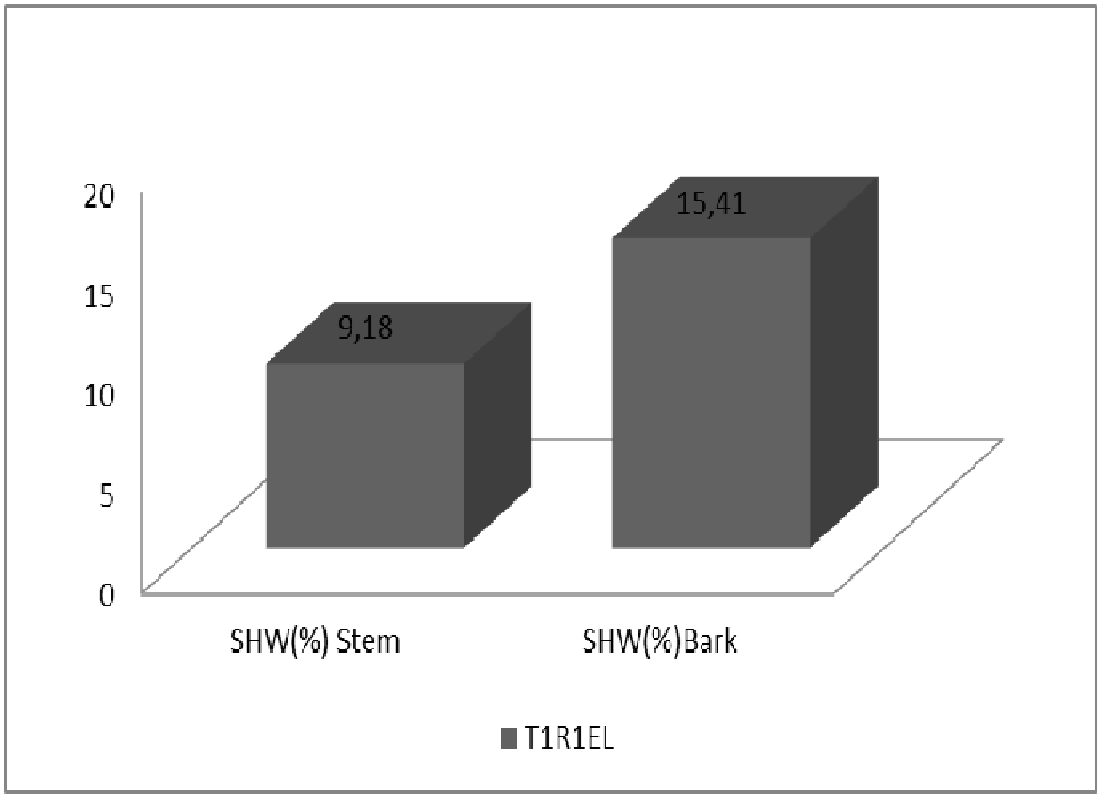


Figure 4. The bark solubility in hot water for T1R1EL

Interestingly were relatively high differences between SCW (%) and SHW (%) values for gaskets taken in the middle of trunk (figure 5).

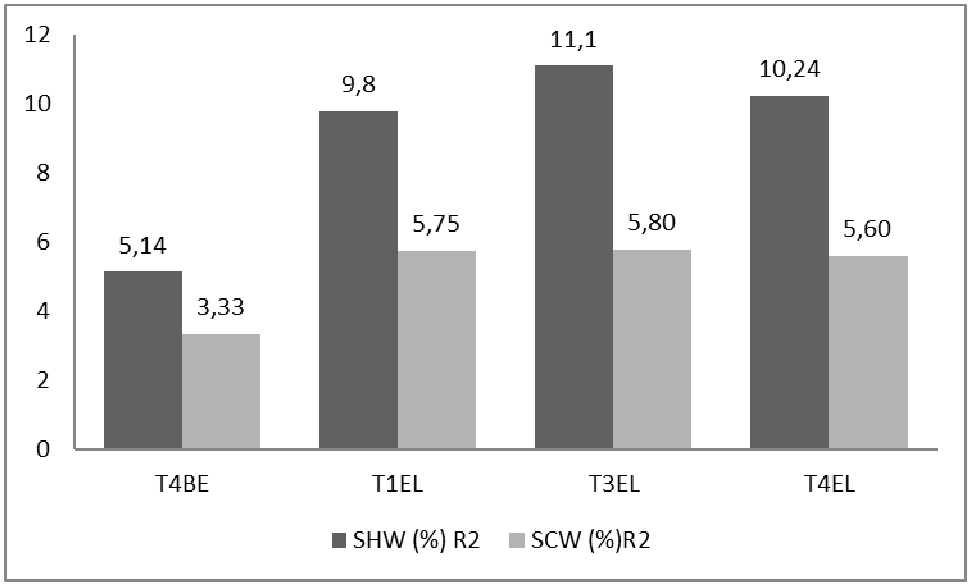
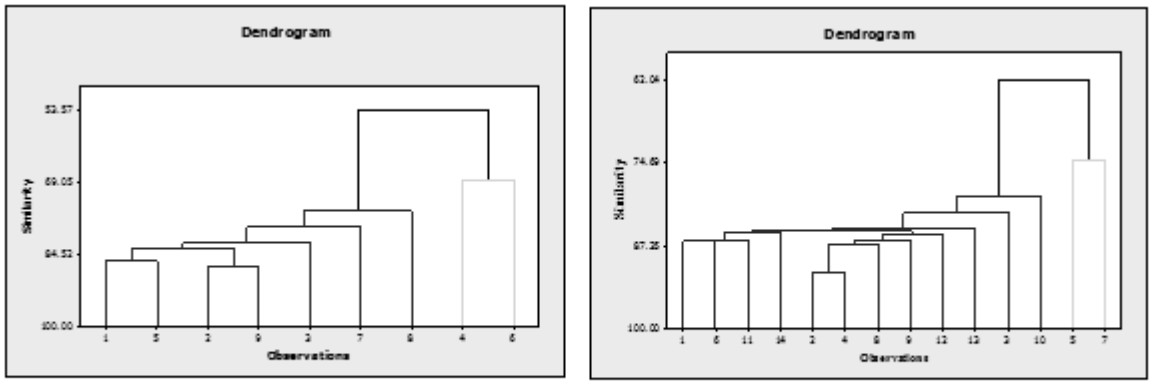


Figure 5. Values of SHW (%) and SCW (%) for middle gaskets R2.

From Kozlowski and Keller [6] it is known that soluble carbohydrates and starch are in a dynamic balance with others, with photosynthesis and the needs of the metabolic processes in different parts of wood. Consequently concentrations vary throughout the year, depending on the plant's wood. Based on this we can reason why the extractives amount in hot water were higher in the R2 disk then in R1 because in this part occurs the accumulation of reserve materials. According Sjôstrôm [12], hot water soluble substances are simple phenols, tannins, sugars with low molecular weight and polymers such as arabinogalactan. So the big differences between SHW and SCW values resulted due to the starch which does not dissolve in cold water but is well digested in hot water and it is the main reserve for hardwoods. The lowest values achieved at the Belsh station can be related to the fact that samples were taken in Febrary, when the reserve materials are the least likely, whereas for others in November. To see how the samples were grouped based on the similarity to water solubility we used the Euclidean Distance method. For the cold solubility resulted that the samples were grouped in two clusters, in first cluster samples: T8R1UL (1), T11R1RR (2), T4R1BE (3), T3R1EL (5), T1R1DI (7), T4R1KU (9) and T7R1DI (8), while in second samples T1R1EL (4) and T4R1EL(6) from Elbasan zone (Figure 6).



a) **b)**

Figure 6. a) The dendrogram created by HFC for solubility in cold water SCW (%) of R1 disks. b) The dendrogram created by HFC for solubility in hot water SHW (%) of R1 disks.

For the hot solubility in first cluster samples: T8R1UL (1), T9R1UL (2), T4R1BE (3), T6R1BE (4), T3R1EL (6), T1R1DI (8), T2R1DI (9), 7R1DI (10), T4R1KU (11), T6R1KU (12), T4R1RR (13) and T11R1RR (14), while in second the samples T1R1EL (5) and T4R1EL (7) of Elbasan station. Separation of the samples from the Elbasan

area can be influenced by two factors; firs the samples ages from this area as a consequence and the diameters were larger as well as from other areas; secondly this area is governed not as coppice.

4. References

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