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The Effect of Finishing Material on Some Selected Physical Properties of C. lusitanica Grown at Arsi Forest Enterprise, Munesa District - Oromia – Ethiopia

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Abstract
Basic wood density (D) and initial moisture content (MC) are the two important wood properties for solid timber applications; especially structural timber application is strongly related to wood density. Other physical properties which are highly affect the basic density such as; dimensional stability, water absorption ability (WAA), and anti-swelling efficiency (ASE) are the dominant wood properties for the utilization of wood in different way. There are many technological factors that determine the quality and aesthetic values of the finished woodworking products. Finishing technology is among the factors that play a great role in determining the durability and visual value of the end product. In this study the effect of wood finishing materials were studied on the above listed physical properties of *C. lusitanica* species grown at Arsi Forest Enterprise- Munesa District – Ethiopia. A total of 10 trees from *C. lusitanica* stand were felled and a replicates of green sample discs having a dimension of about 3cm thick were taken from the butt, middle and top portion of the tree, to investigate moisture and density variation along the tree height. In addition to these discs, a total of 90 specimens from 10 trees (i.e. 3 specimens from each tree, 1 specimens from one portion of the tree) having a dimension of about [2 x 2 cm (cross section) and 3 cm long] were prepared from three trees were prepared for shrinkage, WAA and ASE analysis. The Statistical Analysis Software (SAS) were used to analyze the data using analysis of variance (ANOVA) procedure and a least significant difference (LSD) method were used for mean comparison at $P \leq 0.05$. All variables were evaluated along the tree height and among two different finishing treatments. Among all studied properties a significance difference exists in basic wood density wood shrinkage and water absorption ability among the three different tree portions and among the treatments. Basic wood density showed an increasing trend as the tree height increases, unlikely both tangential and radial shrinkage decreases as the tree height increases. Water absorption ability showed a less value in varnish treatments. In the other way, the initial moisture content and the anti-swelling efficiency of the species were revealed a significant difference along the tree height and different finishing materials.
Keywords: Finishing material, tree position, wood physical properties, *Cupressus lusitanica*, Ethiopia.

1. Introduction

The choice of the right strategy that could bring about rapid and sustainable development is still a controversial issue in policy analysis discourse (Girma Gebrehiwot, 2006). Man depends on forest products specially wood and wood products for several purposes (Zobel, *et al*., 1987). The increase in population, urban settlement and consequently increase in demand of different kinds of wood products results in swelling of small and large scale woodworking enterprises.

At present, based on the availability of a big range of woody species in Ethiopia there are a number of wood and wood based product industries running and on establishing in different level. Yet, having a wide range of species does not ensure the quality of end products in both sectors (i.e. wood and wood based industries). To select the best wood for a particular purposes calls for an accurate knowledge of the qualities required and reliable information as to the woods possessing those qualities. In fact, there is a very considerable variation among timbers both in appearance and their properties. (Gemechu Wirtu, 2008).

The important technical features usually concerned in this regard are: anatomical structure, shape & size of the trees, specific gravity, strength, hardness, flexibility, elasticity, toughness, adaptability or otherwise to seasoning, natural durability and adaptability to preservative treatment, color, grain, figure and similar characteristics, freedom from defects, adaptability to working with tools and on machines.

Even though, the above listed technical characteristics are considered, there are many other technological factors that determine the quality and aesthetic values of the finished woodworking products. Finishing technology is among the factors that play a great role in determining the durability and visual value of the end product. The word finish in woodworking usually describes some final surface treatment that protects the wood and enhances its appearance. (R. Bruce Hoadley, (2000), Wikipedia, the free encyclopedia, (2012), William R. Sam, (2004)).

Finishing materials are available in different type, size, instruction, and application method. There are a number of finishing materials; varnish, stain, lacquer, paint are among the very common finishing materials used in woodworking sectors. These materials have their own properties (advantages and disadvantages) in the quality and visual appearance of the finished product and on the workers' as well.

Understanding the characteristics of wood finishing materials is therefore very important so as to produce sound and resistant products for external factors, well decorated and durable furniture and structural members and not only in regard of wood and wood based products, but also for the well-being of carpenters and users as well. However, no or a few studies have been made so far regarding the effect of wood finishing materials in the field of woodworking. The assessment on the effect of finishing material on the species *Cupressus lusitanica* is valuable for wood workers, instructors, finishing material suppliers as well as for students in the area. The current study is therefore; focus on the investigation of the effect of wood finishing materials on some selected physical properties of *Cupressus lusitanica* wood species grown at Arsi Forest Enterprise, Oromia – Ethiopia.

1.1. Objectives of the study

The general objective of this study is to investigate the effect of wood finishing materials on some selected physical properties of *Cupressus lusitanica* wood species grown at Arsi Forest Enterprise, Oromia – Ethiopia. More specifically the study had the following objectives;

- ✓ To determine the initial moisture content and basic density of the species,
- ✓ To determine the water absorption ability of the species,
- ✓ To evaluate the anti-swelling efficiency of *Cupressus lusitanica*.
- ✓ To assess the dimensional stability namely tangential and radial.

2. Materials and Methods

2.1. Description of the study area

Arsi Forest Enterprise owns forest plantations in two zones (eastern Arsi and western Arsi) of Oromia National Regional State, at about 240 km South of Addis Ababa, located at 6 º 50" – 7º 38" North latitude and 38º 30" – 39º 06" East longitude, along the eastern escarpment of the rift valley. The total concession area of the enterprise (former) is estimated to be 21,384 ha of which 6230 ha is plantation forest and the rest (15,154 ha) is natural forest. The entire forest area is divided into three forest districts, namely Munessa, Gambo and Shashemene. This study was conducted at Munessa District also named Degaga site. The altitude of the study sites ranges from 2100m – 2450 m. a.s.l (Kedir Nino, 2009).

The climatic condition of the forest area is fairly typical of the Ethiopian plateau, with a main wet season in the period i.e. from July to October and a less well-defined rainy period usually occurring between March and June. The dry season extends from November to February (Chafey 1978). The forest area has a bimodal rainfall: namely, the main rainy season which extends from the end of May to September, and short rainy season is from February to April.

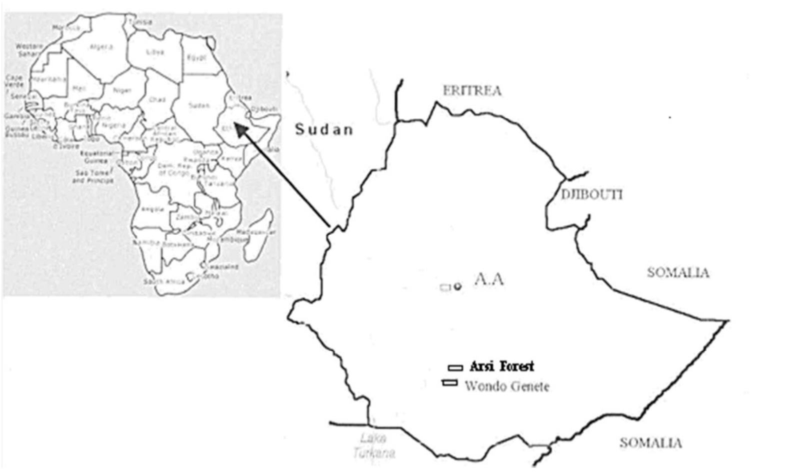

Fig. 1. Map of the study area.

The mean annual rainfall of the area is 1,250 mm .The maximum temperature of the area is 25ºC and the minimum is 7ºC, which occurs in November, where the maximum is in May. In general, rainfall in the area increases with altitude but the pattern is considerably modified by local topography (Kedir Nino, 2009).

The same author described the rocks as volcanic, principally ignimbrite but with basalt in the north and lava near the southern extremity of the forest. The soils are derived from parent rock and are reddish in color, freely draining and of medium texture. Lundgren described them as ferrisoils and his analyses showed that the levels of available chemical nutrients present in the soils are high with the exception of phosphorus (Kedir Nino, 2009). Besides the natural vegetation, plantations constitute a major proportion of the Arsi Forest vegetation. The first plantations were established in the 1950's around degaga sawmill. During the 1960's and subsequent decades planting was conducted on large scale mainly with C. lusitanica, several Eucalyptus spp. and very few indigenous species.

At present, the main plantation species of the enterprise are exotics such as *C. lusitanica, P. patula, Eucalyptus globulus, E. saligna, E. grandis and E. riminalis*. In recent years, some efforts have been made to further encourage the planting of the major indigenous species that include *Juniperus procera, Olea africana and Podocarpus falcatus*. Friis (1992) described the natural vegetation of the area as "undifferentiated afromontane forest"; including various upland forests with *Podocarpus*.

For this study, a compartment number 22 called Dalelae of C. lusitanica stand were selected. The stand was established in 1988. The stand covers about 8.6 hectare and 1600 trees were planted per hectare by 2.5m initial spacing. Slashing and spotting were carried two times in a year until the plantation grows up to three years. Besides, slashing and spotting different silvicultural treatment were taken during the growth period of the stand such as access pruning when the stand is at 5 years access pruning can be done during 4 – 6 years of the stand. First pruning and first thinning were taken simultaneously after 4 years of that the access pruning was ended. In the first thinning a total of 600 trees or 37% from the hectare were thinned out. In the second thinning treatment about 400 trees per hectare were taken out at the age of 12 years i.e. after three years of the first thinning.

2.2. Methodology

2.2.1. Selection and preparation of sample trees

Prior to data collection, reconnaissance survey were made in the C. lusitanica stands. The reconnaissance survey was covering all visual observation of the stands in relation with the site, diameter and height of the plantation. Sample trees were obtained from compartment No. 22 plantation of C. lusitanica from Arsi Forest Enterprise - Munesa distrct; the growth condition for stand was uniform with that of other compartments. The sample trees were selected randomly from 12m x 12m rectangular plot area, which is meant for research purposes (Zziwa, et al, 2006). Trees were selected primarily due to their very similar characteristics. Non-defective stems were considered in selecting trees of good form and that were free from visible defects (Zziwa, et al, 2006). Accordingly, sample trees having minimal lean, relatively straight stems, and with relatively few external defects were chosen with the intent of minimizing tree-to-tree variation.

A total of 10 trees were harvested for analysis. All selected sample trees were marked, measured, and segregated prior to felling and bucking them into saw logs. Diameter at Breast Height (DHB) and total height for each sample tree were measured. For sampling of stem a minimum of two disks must always be taken (Jeremy Ellis -Flower, 1996). Sampling from different heights enabled assessment of variation in wood properties with height. Three stem cross-sectional samples (discs) were taken from each felled tree at four meter interval from butt, middle and top part of the tree (Mulugeta L. and Tsegaye B. (2004)), so that a total of 30 sample discs were sawn using a chain saw.

Fig. 2. From the top left to down right; measuring the diameter of the tree (DBH), felling the tree using chain saw, coding the harvested sample tree, weighting the sample disc by sensitive balance, removing the disc sample from the oven dry for checking, and measuring the dimensional change in wood specimens.

2.2.2. Determination of Moisture Content

The density of wood can be considered once its moisture content has been defined. In physics the density of a material is defined as the mass per unit volume (kg m-3). The situation is not so simple with wood because changes in moisture content affect both its mass and volume. Therefore, it is necessary to specify the moisture content of wood as well as its density. Thus, a replicates of 30 green samples discs with dimension of about 3 cm thick were taken from the butt, middle and top log of the tree stem, to investigate the moisture variations within the tree heights. Moisture content was determined in accordance with ISO 3130 procedures (Zziwa, et al, 2006). All samples were weighed to obtain the green weight and then oven dried at a temperature of 103 ± 2 °C and weighed within 24 hrs intervals until constant weight is obtained to achieve the dry weight (Zziwa, et al., (2006), Panshin and de Zeeuw, (1980), Seyoum (2008). After cooling for 30 minutes in desiccators, the moisture content of each sample were calculated as follows:

$$MC = \frac{Wg - Wo}{Wo} \times 100\% \quad \text{……………………………..……………. Equation (1)}$$

Where; MC (%) = Moisture content, Wg = the green weight of the sample (g), Wo = the oven dry weight of the sample (g)

2.2.3. Determination of Basic Wood Density

The basic density of wood is obtained using green volume and oven dry weight of each sample discs. The basic density of wood were measured from fresh samples based on the most commonly used wood basic density measure, which is defined as the weight of any given volume of substance divided by the weight of an equal volume of water. Using displacement method the volume of all samples was obtained by immersing in water (Zziwa, et al., (2006), Panshin and de Zeeuw, (1980), Pérez and Kanninen, (2005), Seyoum (2008), Ülker USTA (1998).

Wood basic density is determined by taking samples of stem sections (2cm x 2cm x 3cm) (Perez and Kanninen, (2005). The volume of each sample was determined by water displacement method. The weight of water displaced from the beaker by the submerged sample was recorded. The test specimens were then oven dried at 103 ± 2 ^{o}C and weighed within 24 hrs interval until constant weight, and cooled in desiccators. They were then reweighed and the weights were record. Basic density in g/cm^3 was then calculated from the relationship:

$$\text{Basic density} = \frac{\text{oven dry weight of sample } (g)}{\text{weight of displaced water } (cm^3)} \quad \text{……………………….. Equation (2)}$$

2.2.4. Determination of Radial and Tangential Shrinkages

Furniture maker and designers rely on unit shrinkage information to build and design shrinkage/swelling allowances. Shrinkages were evaluated from samples at green stage and after drying up on constant weight. The specimens were prepared from bottom, middle and top portions of the tree. For the shrinkage study, a total of 90 specimens from 10 trees (i.e. 9 specimens from each tree, 3 specimens from one portion of a tree) having a dimension of about [2 x 2 cm (cross section) and 3 cm long] were prepared from three trees Shanavas and Kumar (2006) and Ilker and Arif, (1998). The three dimensional measurements in green condition were made for radial, tangential and longitudinal lengths and each experimental specimens were then weighed before the specimens were placed in an oven. The weight and dimension of all samples were weighing and measured at green level by using sensitive balance and digital Vernier caliper, respectively.

All the specimens were dried in the oven at 103±2 ^{O}C until constant weight is obtained. Weight and dimensional readings from the oven were made within 4 hours interval. Each specimen were consequently removed from the oven and immediately put back in the oven after weighing and measuring, and this continued until a steady weight is recorded. The percentage of shrinkage was then calculated by using the following formula; Ilker and Arif, (1998):

Sh (%) = [(Dg - Dod)/Dg] x 100 ………………..………………………. (Equation 3)

Where, Sh = percentage of the shrinkage (%), Dg = the green (original) dimension of the sample (mm), and Dod = the oven-dry dimension of the sample (mm).

2.2.5. Determination of volumetric swelling

For the swelling study, a first measurement was made of the dimensional lengths of an air-dried sample before each sample was fitted into a swelling jig; and the reading recorded before the sample was completely immersed in water. Readings from the swelling jig were taken one every 24 hours. Measurements were made until a steady weight was recorded Ilker and Arif, (1998). The percentage of swelling was then calculated according to the following equation:

Sw (%) = [(Ds-Dg)/Ds] x 100 …………….………………………………. (Equation 4)

Where, Sw = percentage of the swelling (%), Ds = the swelling dimension of the block (mm), Dg = the green (original) dimension of the block (mm).

Theoretically, volumetric shrinkage and swelling should be equal to the sum of longitudinal, tangential and radial shrinkage and swelling in a piece respectively, when the values are expressed as percentages of the original green size (Zziwa, et al., (2006), Panshin and de Zeeuw, (1980), Pérez and Kanninen, (2005), and Ülker USTA (1998). Accordingly, the volumetric swelling was calculated as the summation of tangential, radial and longitudinal swelling as shown below;

Vsw = [Tsw + Rsw + Lsw] ………………………………………. (Equation 4.1)

Where, Vsw – volumetric swelling (mm), Tsw – tangential swelling (mm), Rsw – radial swelling (mm), Lsw – longitudinal swelling (mm)

2.2.6. Determination of water absorption (WA) & anti-swelling efficiency (ASE).

Sets of varnish – glue, varnish and untreated or control wood specimens (20mmx20mmx30mm width, thickness and length respectively) were placed in different beakers for the different test sample, filled with water. There was replacement of water absorption values and anti-swelling efficiency were calculated according to equation (5) and (6) after each water replacement, in line with procedure also adapted by Temiz et al (2006) as cited on Erakhrumen and Ogunsanwo (2009).

WA = [(W2 – W1)/W1] x 100 --- Equation (5)

ASE = [(Su – S) / Su] x 100 --- Equation (6)

ASE = [(Su – Svg) / Su] x 100 -- Equation (6.1)

ASE = [(Su – Sv) / Su] x 100 -- Equation (6.2)

Where, W2 – Wet weight of the specimens after soaking in water, W1 – Oven dry weight of the sample. S – Volumetric swelling of treated sample, Su – Volumetric swelling of untreated samples, Svg – Volumetric swelling of varnish-glue treated sample and Sv – Volumetric swelling of varnish treated samples.

2.3. Experimental Design and Statistical Analysis

The effect of finishing material on initial wood moisture content, basic wood density, water absorption, anti-swelling efficiency and shrinkage (both tangential and radial) analyzed using analysis of variance (ANOVA). The experimental design for analyzing these variables constitutes a complete randomized design (CRD) (Alexander, et al, 2008). The statistical analyses were conducted to evaluate the effects of finishing material on some selected physical properties of *C. lusitanica* tree species from Arsi Forest Enterprises, Oromia-Ethiopia. The Micro Soft Excel package of 2007 version were used to analyze the data using analysis of variance (ANOVA) procedure and a least significant difference (LSD) method was used for mean comparison at $P \leq 0.05$.

3. RESULT AND DISCUSSION

3.1. Initial Moisture Content

The result of this study shows that the initial moisture content of *Cupressus lusitanica* were not shown significant difference among the three tree portion. Relatively high initial moisture content was observed at bottom portion of a tree (135.94%) while 132.43% and 134.21% are registered in middle and top portion of a tree log, respectively. Similarly, Samuel M, (2010) and Zelalem G., (2010) founds that the initial moisture content of *P. patula* and *Juniperus excels* along a tree portions was not found significantly different along the tree height. The amount of water in a tree trunk varies from the cambium to the pith as well as along the tree trunk. At the same time, there are variations between trees of different species. As such, the moisture content in a length of freshly sawn timber may not be uniform throughout the tree stem (Can et al., 2005). Results of the ANOVA for testing the effect tree height/portion on the initial moisture content (MC), basic wood density and other parameters are presented in the Table 2.

Table 2: Stand characteristics of *C. lusitanica* as influenced by tree height.

Tree portion	MC (%)	Density (g/cm3)	WAA (%)	ASE (%)	TSh (%)	RSh (%)
Top	132.43	0.620	-	-	4.68	2.78
Middle	134.21	0.601	-	-	4.84	3.10
Bottom	135.94	0.573	-	-	4.86	3.14

Tree height was not found to significantly affect MC with (P - value = 0.2748) and mean square value of 169.349. The initial moisture content variation among portion of the tree stem might be due to the differences and changes in anatomical feature during its maturation period. The anatomical difference, structure and formation of the secondary xylem reflected in the higher density of the latewood compared with early wood (Nobuo Shiraishi, 2000 and Seyoum Kelemwork, 2008).

On the other hand, the narrowing nature of the tree towards the top portion results in a reduction of its inner portion with less parenchyma cells (a region in which more amount of moisture is found), and high number of fibers having small size. Another reason for this finding might be due to the gravitational force of the earth surface which results a movement of moisture from the top to the bottom portion of the tree stem.

However, in contrast with the finding of this author 2010 on the study of the effect of initial spacing and tree portion on selected physical properties of *J. excels*, initial moisture content of *J. excelsa* were showed significantly difference among the three tree portion (bottom, middle and top). The difference between these two results may be due to the difference in species, plantation site and the growth condition of the tree has its own effect on the result.

According to Bryan Harris, 1999 because of wood properties vary among species, between trees of the same species, and between pieces from the same tree, solid wood cannot match reconstituted wood in the range of properties that can be controlled in processing (Bryan Harris, 1999, Zhang & Morgenstern, E.K. 1995, Zziwa A., et al (2006) and Seyoum Kelemwork, 2008).

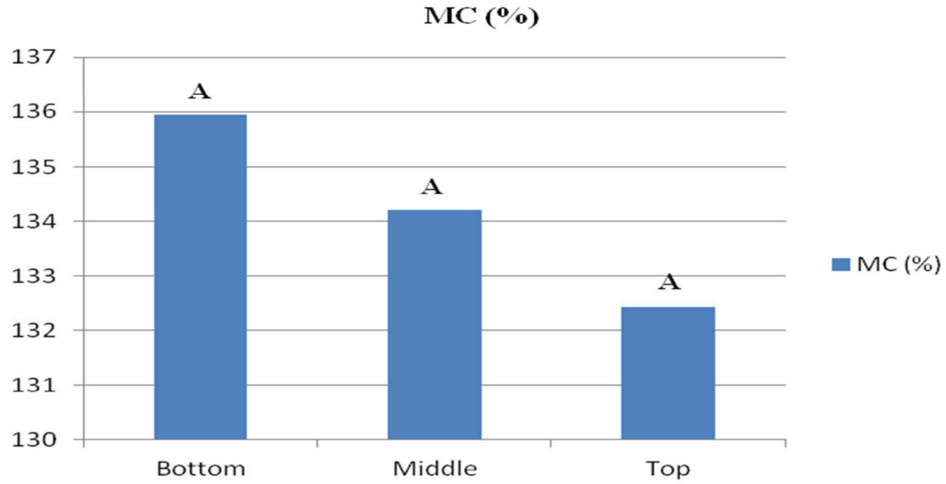

Fig. 3. Initial moisture content of *C. lusitanica* among different tree portion. Mean having the same letter was not significant difference at $P \leq 0.05$.

3.2. Basic Wood Density

The basic density of *Cupressus lusitanica* was found significant difference in the three portion of tree stem at (P-value = 0.0064). The mean basic wood density of the three portions of tree ranged between 0.620 g/cm3, 0.601 g/cm3 and 0.573 g/cm3, top, middle and bottom, respectively with the mean square value of 0.09486968. The basic wood density decreases from the top to the bottom part of the tree (See Fig 3).

Significantly higher basic wood density (0.620 g/cm3) was found in the top parts of the tree. Wood basic density was found to be higher at high stand density and on top parts of the tree (Perez and Kanninen, (2005)). The increase in basic density in top portion of the tree might be due to the higher proportion of latewood and juvenile wood impacts are more difficult to anticipate, but lower proportion of juvenile wood lead higher wood basic density in closer spacing (John, 2004). Alexander et al., (2008) also stated that, there is high percentage of moisture content in the juvenile wood and this leads to lower basic density because of their inverse proportionality between moisture content and basic wood density. The result of basic wood density obtained in this study also reported by earlier researchers (Alexander et al., 2008, Bruce Zobel, 1992, John, 2004, and Perez and Kanninen, 2005, Samuel M., 2010).

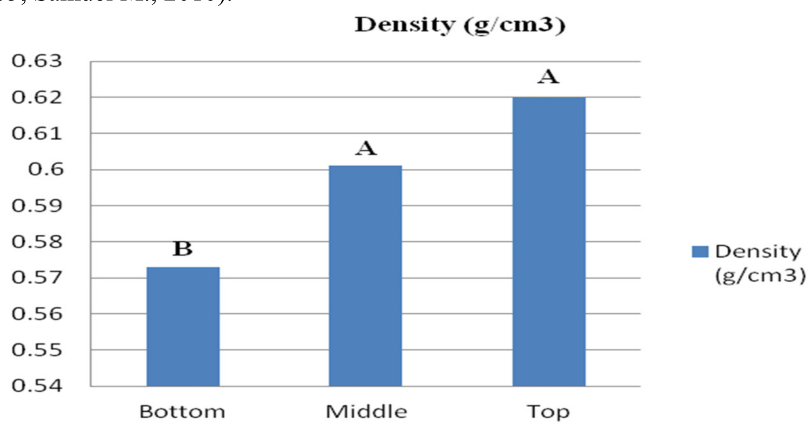

Fig. 4. Basic density of *C. lusitanica* among different tree portion. Mean having the same letter was not significant difference at $P \leq 0.05$.

3.3. Tangential and Radial Shrinkage

Tree height was shown a significant difference among the two direction of shrinkage studied. The mean value for tangential and radial shrinkage ranged between 2.78% and 4.86% (Table 3). Results of the ANOVA for testing the effect of tree height on radial and tangential shrinkages are presented in Table 3.

Table 3: Tangential and radial shrinkage of C. lusitanica as influenced by tree height.

Tree Position	TSH (%)	RSH (%)
Bottom	4.86	3.14
Middle	4.84	3.10
Top	4.68	2.78

In both aspects, the bottom part of the tree had shown the highest mean value of shrinkage, while the lowest mean value of shrinkage was observed in top part of the tree see (Fig. 4, 5 and 6). The mean value for tangential shrinkage increased slightly from top to bottom parts of the tree, ranging from 4.68 % to 4.86 %, in the same way, the mean value for radial shrinkage also increased from top to bottom parts of the tree height, ranging from 2.78 % to 3.14 % in bottom part of the tree.

The reason for increasing the mean value of both directions shrinkage as tree height increases might be highly due to the amount of moisture content in the trees. Wood's dimensions and mechanical, elastic, and thermal properties depend on the moisture content (Roger M. Rowell, 2005 and Wanli Cheng, et al, 2007). Wood is also anisotropic, which means that its properties vary according to its growing direction (longitudinal [vertical or length direction], tangential [parallel to annual growth rings], and radial [perpendicular to the annual growth rings]). (Roger M. Rowell, 2005 and Wanli Cheng, et al, 2007). As investigated above even though there is no significant difference in the initial moisture content, the bottom part of the tree showed the highest amount as compare to the middle and top part of the tree.

Therefore, the reason for high amount of shrinkage in the bottom part is highly related with the amount of moisture content found in the steam, because the highest moisture content implies the larger cell cavities in the tree thus the larger cell cavities shrinks more as compare to the smaller cell cavities. Because of high amount of moisture removal from the tree leads to high dimensional reduction – shrinkage Wanli Cheng, et al, 2007. The reason for less amount of shrinkage in both tangential and radial direction is due to the higher density in the top part of the tree. Because the tree nature itself which is the narrowing nature as the tree height increases makes the wood fiber to bind together very closely, results for high dens wood. Thus, the higher density shrikes less and have smaller cell cavity.

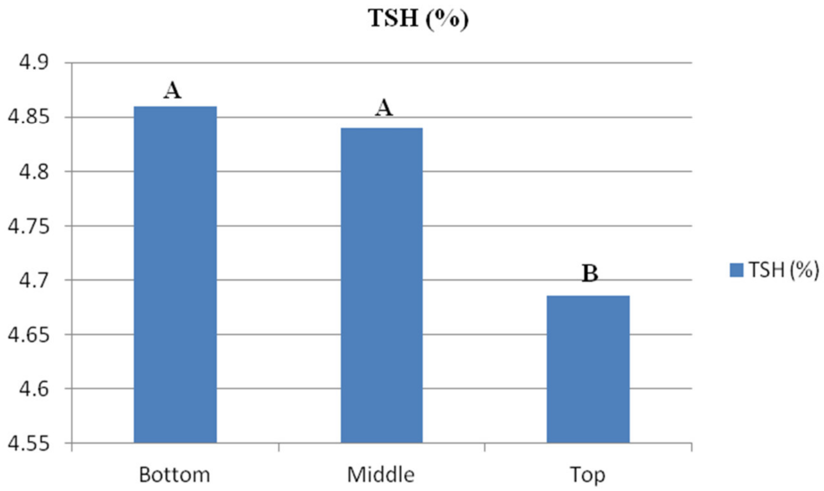

Fig. 5. Tangentail shrinkage of C. lusitanica among different tree portion. Mean having the same letter was not significant difference at $P \leq 0.05$.

As shown in the figure clearly the mean value of tangential shrinkage was found high than that of radial shrinkages, in all parts of the tree steam. Radial shrinkage is perpendicular to the growth rings. It is shrinkage in the direction towards the center of the tree. This might causes radial shrinkage to partly restrained by rays (fibers that run perpendicular to the growth rings). However, tangential shrinkage is in the direction parallel to the growth rings. It is always a little larger than the shrinkage in the radial direction (Roger M. Rowell, 2005).

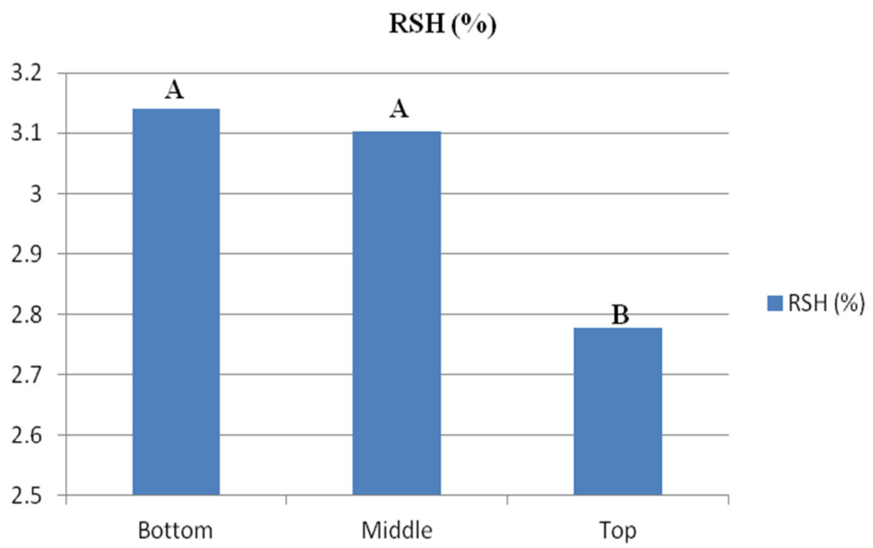

Fig. 6. Radial shrinkage of C. lusitanica among different tree portion. Mean having the same letter was not significant difference at $P \leq 0.05$.

The shrinkage values show considerable differences among different directions, i.e. tangential shrinkage (perpendicular to the grain and parallel to the growth rings) is always greater than radial (perpendicular to growth rings), and longitudinal shrinkage (along the grain) is considered negligible. The shrinkage values observed at the end of the experimental time (30 minutes) were significantly greater in the tangential direction (8.40 %) than either the radial (4.06 %) or longitudinal (0.58 %) directions Ilker and Arif, (1998).

Similarly (Ilker and Arif, 1998) in his experiment stated that the swelling values show considerable difference among different directions, i.e. tangential swelling is always greater than radial, and longitudinal swelling is considered negligible. According to (Ilker and Arif, 1998) the reasons for the difference between radial and tangential swelling are not clear. This is partly attributed to the presence of rays, which (due to their radial orientation) exercise a restraining influence on the radial swelling. Ilker and Arif, 1998 also stated two different reasons for the variation between the two directional shrinkages. The first is that wood has passages running from the core to the bark; these are called rays and are fairly numerous. If the fibers are joined to the rays, they anchor the fibers in place. The rays do not hinder but help swelling in the tangential plane. Another possible reason for the different amounts of swelling in the radial and tangential plane could be the different swelling abilities of early wood and latewood.

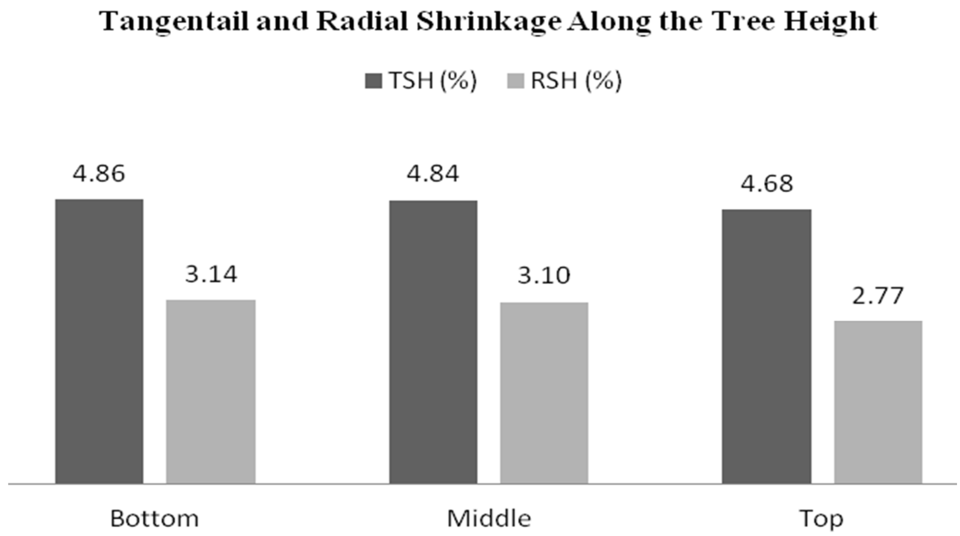

Fig. 6. Tangentail and Radial shrinkage of C. lusitanica among different tree portion.

3.4. Water Absorption and Anti Swelling Efficiency

Results of the analysis for testing the effect of finishing material on water absorption and anti-swelling efficiency are presented in Table 4 and 5. Finishing material was not found to significantly affect the anti-swelling efficiency, however it was found to significantly affect the water absorption ability between the two different

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treatments see (Fig. 6 and 7). Of course, water absorption ability in both treatment and in control group increases as the tree height decreases, ranging from 142.14 in the top part of the tree to 169.20 in the bottom part of the tree in control group samples. Although there was not shown a significant difference of the anti-swelling efficiency the percentage value increases slightly in similar manner that the way water absorption increases for example in VarGlue treatment ranging from 29.32 % to 43.37 % top and bottom part of the tree, respectively.

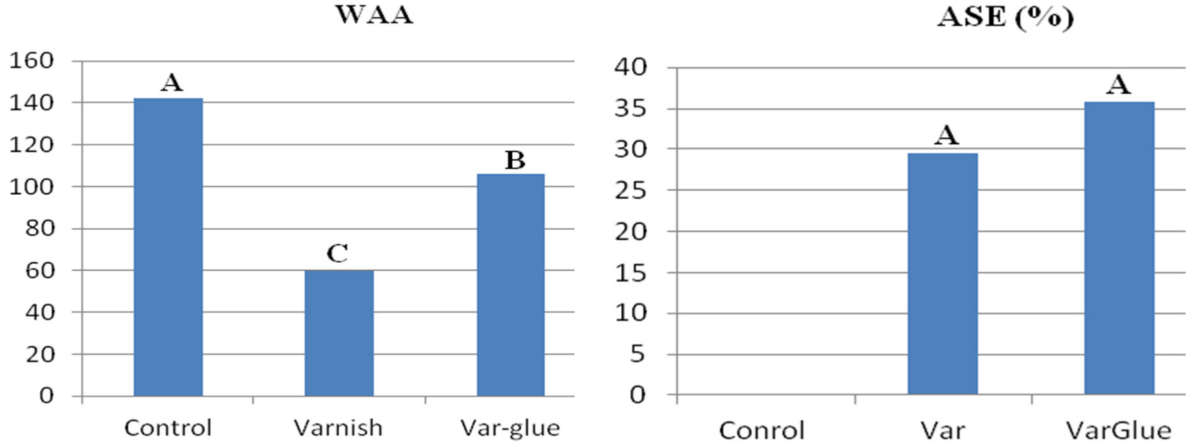

Fig. 7. Water absorption ability (left) and Anti swwelling efficiency (right) of *C. lusitanica* among different finishing materials. Mean having the same letter was not significant difference at P ≤ 0.05.

The graph revealed that all the control, varnish and varglue treatment samples absorbed water at different quantity, although more water is absorbed by the control samples as compare to that of varnish and varglue treated samples. This observation might be as a result of the capability of natural oils found in PVA and varnish to prevent water uptake by lignocellulosic material, as also observed by Sailer et al as cited Andrew A. Erakhrument and Olukayodi Y. Ogunsanwo, (2009).

Samples treated by varnish absorbed the least amount of water absorbed, while those for the control experiment had the highest absorption, followed by samples treated by varglue. Low value of water uptake for the varnish samples (60.05%) may be attributed to the thermal degradation of hemicelluloses, which is the most hygroscopic polymers in the lignocellulosic cell wall as also observed in other studies, e.g Tjeerdsma et al 1998 and Temiz et al 2006 as cited on Andrew A. Erakhrument and Olukayodi Y. Ogunsanwo, (2009). It was observed that WA ability was more in untreated (control) samples as compare to both finishing treated samples this might be nothing will restrain the uptake of moisture in control group because of the hygroscopic nature of the wood.

Table 4: The effect of finishing material of C. lusitanica WAA and ASE as influenced by tree height. .

	WAA (%)			ASE (%)		
Tree Portion	Control	Varnish	VarGlue	Control	Varnish	VarGlue
Bottom	169.20	45.06	123.05	-	33.33	43.37
Middle	157.90	41.21	114.20	-	30.49	33.92
Top	142.14	38.88	101.94	-	23.24	29.32

The anti-swelling efficiency for the control group indicates zero reading; this is because of the mathematical formula relation see Equation 6 on page 31. The reason for slight difference on anti-swelling efficiency of VarGlue finishes may be highly related with the property of PVA glue in relation with dimensional stability. Therefore, to state the reason in depth further investigation needs to be carried out on the characteristics of PVA ingredients and the structure of the wood cell as well.

The result of ASE test revealed that samples treated by VarGlue had higher value of 35.74% the implication of this result is might be as a result of modification of cell wall substances responsible for water absorption in this reisn material as stated earlier. The result of this study proves that, water absorption and anti-swelling efficiency are the two different physical properties of the wood. When the water absorption ability of the species becomes high it does not assure better the anti-swelling efficiency.

Table 5: The effect of finishing material of *C. lusitanica* WAA and ASE as influenced by tree height. .

Treatment	**WAA (%)**	**ASE (%)**
Control	142.42	-
Only Varnish Finish	60.05	29.44
Varnish and Glue Finish	106.03	35.74

4. Conclusion and Recommendation

The two different direction shrinkage and wood basic density had a significant different on portion of the tree height. Similarly water absorption ability showed a significant difference among the three experiment group (control, varnish and VarGlue treatment). While the initial moisture content and anti-swelling efficiency of the species exist not a significant difference in both tree height and finishing material treatments experiment. Another conclusion was that I did not find hardly any difference between the anti-swelling efficiency property in sample treated with varnish, comparing to the samples treated with varglue. In case of tree portion analysis, the higher basic density was observed at the top part of the tree. Unlike the trend of basic density both tangential and radial shrinkage was decreases as the tree height increase. Based on this study, the less value of water absorption ability was observed in Varnish treated samples followed by Varglue and the control or untreated samples. Taking into account the result of these tests, it can be said that wood samples treated with varglue finishing had slightly better water resistance and dimensional stability as compared to samples treated with varnish only and high as compare to the control group. This implies application of glue before varnish finishing material largely contributed to improve the water resistance and dimensional stability in finished wooden articles. Besides the water resistance and dimensional stability glue can add a better glossy or shine effect for the aesthetic value of the finished product. Since, the highest wood basic density properties was observed in the top part of the tree, the author recommend the top part of the tree for floor and other construction which needs wood strength, because wood strength is highly correlated with the basic wood density. Also the trend of applying water mixed glue before any finishing should be encouraged with the proper ratio of water and glue, for the better water resistance and dimensional stability of the end product. Moreover, the top part of the tree and varglue finishes has slightly larger dimensional stability than bottom and varnish finishes relatively. Therefore, for making outdoor furniture and furniture which will use in environment with fluctuating atmospheric condition the top part and the varglue finishes are preferable. Further studies are necessary to ascertain the performance of glue and varnish finishes in different physical and mechanical properties by varying the ratio of glue and water during the mixture of the finishing material.

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