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The Effects of Machining Defects on the Lumber Quality of Cupressus lustanica (C. lusitanica) Grown in Arsi Forest Enterprise, Degaga, Ethiopia

Misganu Eba Belina
Arsi Unversity, Lecturer at College of Agriculture and Enviromental Science under Department of Natural Resource Mangement
Masters of Science in Prodcution Forestry (MSc.)
Arsi, Assela Ethiopia

Dr. Tsegaye Bekele
(PhD, Associate Professor and Lecturer at Hawassa University, Wonogent Forestry College) Hawassa Ethiopia

Dr. Seyoum Kelemwork
(PhD, Assistance Professor and Guest Lecturer at Hawassa University, Wondo Gent Forestry College and Full Time Senior Researcher at Ethiopian Forest Product Utilization Research Centre) Addis Ababa Ethiopia

Abstract
Machining defects are the important types of wood defects that reduce the lumber quality of most timber tree species. The purpose of this study was to evaluate the main machining defects of *C. lusitanica* grown in Arsi Forest Enterprise, Degaga District, and to recommend suitable harvesting age for the species based on the results obtained. Nine *C. lusitanica* logs representing 25, 30 and 35 years (3 trees from each age category) were used in the study. Sample trees with similar diameters (27-33 cm) at breast height and planted with an original similar stand spacing of 2.5m were collected. Sample discs obtained from bottom, middle and top portions were used to determine average initial tree moisture content (MC) and basic density. Then, the logs were transported to mobile saw mill of Arsi Forest Enterprise, Degaga and converted into 126 boards. The sawn boards were dried in the compartment kiln of the Forest Product Utilization and Research Center of Ethiopia by using seasoning schedule suggested for *C. lusitanica.* Thirty six boards were used for evaluation of machining defects from all the three age groups. Completely randomized design with factorial experiment was used to conduct this experiment. The statistical analyses were conducted considering three factors (3 age-groups, 3 heights and 2 tree diameter) to evaluate the effects of age, tree height and diameter on machining defects. The results showed that *C. lusitanica* lumber of all the age classes considered exhibit major machining defects like saw marks, chip marks, torn grain and woolly grain were observed on all age groups of lumber. Height variation (position from which the lumbers are taken along the stem) has significantly ($P < 0.05$) effected machining properties. On the other hand age variation also showed high significant ($P < 0.01$) effect on machining defects. In general, the machining properties, chip mark planing defects was high for the 25 year-old trees (4.66mm) than 30 and 35 year-old trees. Generally, the effects of age and height variation had high significant effects on the lumber quality of *C. lusitanica.* Based on the results harvest at 30 years of age is recommendable for the species to obtain the best lumber quality.
Keywords: Age variation, height variation, basic density, torn grain, chip mark, woolly grain.

Introduction
General Background
The wood machining is an integral part of the value-added process of wood products manufacturing industry, generally contributing almost 23% of the total production cost of such products (Hoff *et al*., 1997). Machining defects are one of main factors that affect the quality of timber. There are quite a few machining defects that may show up from time to time: knife burn, chip out, torn grain breakout, fuzzy grain, raised grain, loosened grain, edge splits and chip marks, and planer splits (Gene, 1998). When diagnosing machining defects in a wood workshop/joinery, frequently there are several contributing factors whose occurrence alone are not serious, but together are problems. If we machining wood properly, we can save money and energy including conservation of the forest on sustainable basis since wood is very durable if not attacked by micro organisms (Walker *et al.*, 1993; Desch and Dinwoodie, 1996). This study investigates the effects of seasoning and machining defects of *Cupressus lustanica* planted in Arsi Forest Enterprise at Degaga forest district. The defects of machining were investigated and recommendations made to minimize the defects of seasoning and machining of the species.

Machining defects are important problems that degrade lumber quality and lower its prices. Machining defects of *Cupressus lustanica* are among the visible factors that lead the lumber to degrade in its quality in general. The extent of such defects are known to vary with age, height variation with in a tree and between sap and heart wood. Harvesting at the right age as well as from the right portion of a stem can reduce these defects and contribute to higher quality. However, such studies are almost absent in Ethiopia. The outcome of this study will contribute towards reducing or minimizing these common defects that will ultimately reduce wood wastage, help use the forest resources on the sustainable base, acquire knowledge of machining for the species and increase the supply of quality lumber sawn from *Cupressus lusitanica* lumber. This study will also help researchers/ scientists as starting point to undertake further and in depth investigation on related research issues and to properly utilize this tree species on sustainable basis.

Justification on the Selected Species

Cupressus lusitanica is native to Mexico and Guatemala and Honduras, where it is widely found in the central mountain ranges from 1800 to 2600m elevation and Mexican cypress (*C. lusitanica*) is now widely planted at high elevations throughout the tropical world (Tiruneh Kide, 2002; Farjon, 2005**;** Negash and Hubert, 2006). It is a large evergreen conifer that grows up to 35m long and 1.2m breast height diameter with a straight trunk, generally conical but not regular in shape, crown broadly pyramidal, in older trees broad with pendulous and wide spreading branches (Vidakovic, 1991; Farjon 1993; Tiruneh Kide, 2002; Negash and Hubert, 2006). The heartwood is yellowish, pale brown, or pinkish, with occasional streaking. The texture is fine and uniform, and the grain is usually straight. Bark thick, reddish-brown, with longitudinal fissures. Shoots quadrangular, pendulous, forming flattened foliage sprays. Seeds about 75 to a cone, brown, with resin glands, about 4 mm long together with a narrow wing (Vidakovic, 1991; Farjon 1993). It grows fast on good sites and moderate on poorer sites. It requires weeding during early establishment.

Cupressus lusitanica is one of the most important industrial plantation timber trees in Ethiopia. It was introduced to Ethiopia probably before 1950 (Pukkala and Pohjonen, 1993; Negash *et al*., 1995). Gradually, it was extended in different places of the country through reforestation programs. Arsi Forest Enterprise (the former Munessa Shashemene) is among the areas where this species has been planted widely as timber tree and it is considered an ideal tree for sawn boards. Currently, more than half of lumber available to saw millers come from plantations consisting mostly of *C. lusitanica.* Next to eucalyptus tree species, *C. lustanica* is fast growing tree throughout the country (FAO, 2003). Due to its easily workable properties, *C. lustanica* can be used as raw material for various applications such as construction material and furniture materials including panel products such as face veneer, core-stock and cross bands in plywood, and chips for wafer board and pulpwood (Web *et al*., 1984). However, lumber products produced from this tree have various seasoning defects such as knife burn, chip out, torn grain breakout, fuzzy grain, raised grain, loosened grain, edge splits and chip marks, and planer splits (Gene, 1998).

Machining Defects

The surface quality of wood has a strong influence on its further manufacturing processes, such as adhesive jointing and finishing. The resultant surface quality from the machining process of wood is affected by the interaction between the work piece characteristics, machine parameters and tool factors (Kilic *et al*., 2005). A number of defects which may or may not be related to improve seasoning or storage, but which become evident during fabrication or manufacturing process of wood are known as machining defects. Some of the more common machining defects are raised grain, loosed grain, fuzzy grain, torn grain and chip marks (Ratnasingam, 2008).

Raised grain is one of the common machining defects of lumber. It is uneven surface on the a piece of wood resulting from the hard, higher-density summer wood being raised above but still adhering to the soft, lower-density spring wood (Williston, 1988).

According to Panshin and deZeeuw, (1980), raised grain defects occur mainly in lumber machined at a moisture content of more than 12 percent. This defect is a problem most often found in woods that have large differences in density within an annual ring. The surface appears as a corrugated or washboard surface rather than smooth with the bumpiness associated with the annual rings. Generally, it is caused by the dense summer wood being pressed into the soft spring wood by feed rolls, a tight pressure bar, dull knives, excessive heel or improper cutting angle (**Gene, 1998**).

Loosened grain is another machining defect that occurs during machining lumber for some intended purpose. Loosened grain occurs when the bond between the summer wood and springwood is broken (Williston, 1988). It is a loosening of the tips and edges of annual rings on flatsawn lumber. It results because of a weakening and failure of the soft springwood cells due to the pounding action of the knives. The term loosened grain also refers to separation and curling of tips of growth rings on the surface of flat- grained lumber (Panish and deZeeuw, 1980). This defects primarily to the pounding action of the planer knives, or to pressure in sanding sufficient to crush the early wood in one or more growth rings under a layer of late wood exposed on the face of a board (Gene, 1998). Loosened grain boards are difficult during machining and painting.

Fuzzy grain occurs when the fibers are not cleanly cut off by knives. Surface fuzzing develops when individual fibers or small groups of fibers become loosened in large number on the surface of a board (Panish and deZeeuw, 1980). It may also occur on very fibrous and low density woods. It is common in hardwoods such as aspen, basswood, cottonwood, and willow, with cells called gelatinous fibers in abnormal wood called tension wood. Apparently, these cells are not strong enough to stand up while being cut, so they bend over and are not cut. It is also objectionable because of the difficulties experienced in obtaining a smooth surface when this condition prevails. Control is obtained by using low moisture contents and sharp knives (Gene, 1998).

Chipped grain (chip mark) is a broadly visible surface irregularity caused when particles are chipped or broken off below the line of cut (Williston, 1988). It is scooped out or chipped by the action of cutting tools and occurs when the knives are cutting against the grain, often occurring around knots (Gene, 1998).

Torn grain is a type of sever chipped grain that usually occurs around knots and other locations where grain angle abruptly changes, dives or is short (Williston, 1988). The occurrence of chipped grain and torn grain defects may be due to the dullness and setting of knife, the rate of feed of the stock into the machine, or the slope and variation in the grain of the wood.

Density

Density is one of the fundamental properties of wood as it indicates the amount of substance present in a unit volume of wood. Like any highly porous cellular material, wood properties depend on the amount of empty and full space in a given sample (Michel, D., *et al*., 1999). The amount of moisture in wood must be indicated or specified with a density figure (Siau, 1984), and wood density is thus usually expressed in one of the following ways: green (with the same moisture content as in the living tree), oven-dry (after heating in an oven at 103 $\pm$2° centigrade until constant mass is achieved), or air-dry (at equilibrium with ambient conditions or other specified conditions) (Siau, 1984; Skaar, 1972 cited in Ilker , 2003).

Wood strength is directly related to density of wood, (Bendtsen 1978 cited in Willcocks and Bell, 1994). According to the study conducted by Chudnoff (1980), the mean basic density of conifers species are 460 kg/m^3 for all trees is within the range of 340 to 680 kg/m^3. The age of the material studied by Chudnoff (1980) is, however, not indicated. It is known that generally in conifers density varies directly with age (Panshin *et al.,* 1964 cited in Khiari S. K. & Iddi S., 1989). Wood density varies from below 0.1 to above 1.0 g/cm^3, and correlates with breaking strength (Niklas, 1992).

Michel, *et al*., (1999) stated that the mean cypress density, as in other conifers, varies widely with a reference value of density at 12% moisture content is approximately 0.5 gm/cm^3. They also discussed that how this puts cypress in the average density class for conifers, but also lighter wood and slightly heavier woods can also be found.

Materials and Methods

Description of the Study Area

Location

Arsi Forest Enterprise or the former Munessa Shashemene Forest Enterprise is lies with in 6^o 50'' – 7^o 38'' North latitude and 38^o 30'' – 39^o 06'' East longitude, 240 km away from Addis Ababa to the south. This area is a forested part in the Rift Valley of the south-eastern highlands of the Ethiopian plateau, lying with in the administrative zone of Arsi and its small fraction in east Shoa administrative Zone (Chaffe, 1979). The total concession area of the enterprise (the former Munessa Shashemene Forest) is estimated to be 21,384 ha of which 6230 ha is plantation forest and the rest 15,154 ha is natural forest (Kedir Nino, 2009). The total forest area owned by Arsi Forest Enterprise alienated into three large forest districts, namely Degaga, Gambo and Shashemene forest district. The study was conducted in the *C. lusitanica* plantation forest of the Degaga forest district. The altitude of the study sites ranges from 2100m – 2600 m asl (Tesfaye Teshome, 1996).

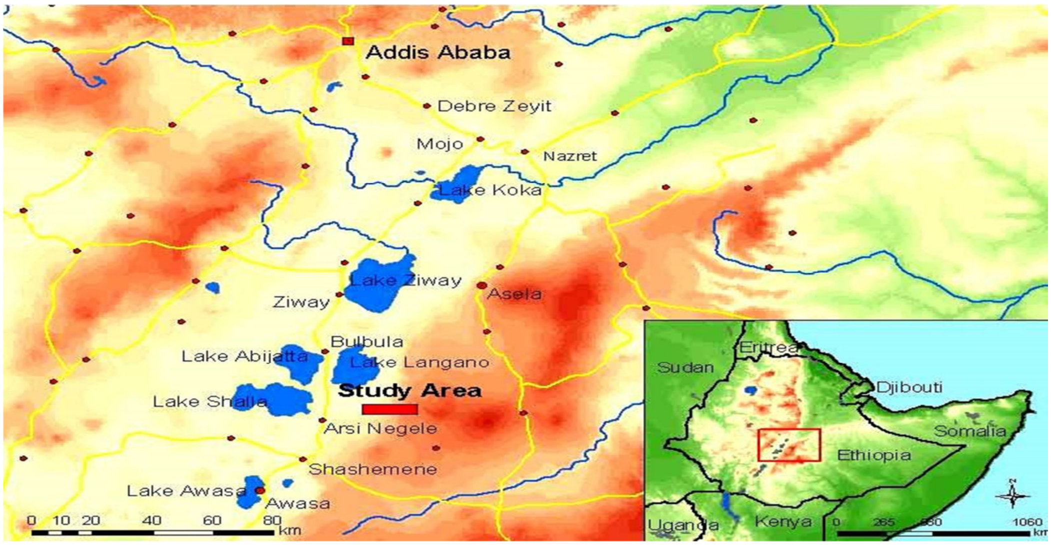

Figure 1: Map of the study area, (source Ormsby (2001), modified by Rückcamp)

Topography and Soil
Geographically, the study area is largely associated with the Wonji belt of faults and craters run roughly NNE-SSW (Chaffey, 1979). According to Lundgren (1971) ash and lava cover the bottom of the rift valley, which is late Tertiary origin (Anonymous, 1988). 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 colour, freely draining and of medium texture. Lundgren (1971) described the soils as ferrisols and his study show that the levels of readily available chemical nutrients present in the soil area all high with the expectation of phosphorus, for which is markedly deficient.

Climate
The study area is located with in the Woyina Dega and Dega climatic zone, which are characterized by high rainfall during rainy season (Anonymous, 1990). The climatic zone of the forest area is fairly typical of the Ethiopian plateau, with a main wet season between July to October and a less well-defined rainy period usually occurring between March and June (Kedir Nino, 2009). The enterprise areas have bimodal rainfall distribution, i.e., with a main wet season in the period of July to October and less well defined rainy period usually occurring between March and June and the dry season extends from November to February , December being the driest month (Chafey, 1979). The mean annual rainfall of the area was estimated to be 1,250 mm, and the mean annual maximum temperature which occurs in November, where the maximum is in May is about 25^{o}C and the mean annual minimum was about 7^{o}C (Chafey, 1979; Kedir Nino, 2009).

Vegetation and Wildlife Resources
Arsi forest enterprise area has a bulk of natural vegetation, and plantations forest vegetation. According to Chaffe, (1979) and Lundgren (1971) the dominant tree both in size and frequency from natural forest is *Podocarpus falcutus* and other large trees are *Celits africana, Olea hochstetteri and Prunus africana. Angeria adolfi-friedic, Apodytes dimidiata, Ficus sur, Schefferelra abyssinca, and Syzygium guinease* are among the less common trees. The first plantations were established in the 1950's around sawmills (Kedir Nino, 2009).

Cupressus lusitanica, *P. patula*, *Eucalyptus globulus*, *E. saligna, E. grandis* and *E. riminalis are* the major plantation species of the enterprise at hand. *C. lusitanica* is one of main plantation species for timber tree in the enterprise. The major types of vegetation are high forest from approximately 2100 to 2450m, bamboo coppice from 2450 to 2650 and low forest and woodland at the edge of and on plain above the steep slopes occupied by bamboo (Kebede Seifu, 1998; Kedir Nino, 2009).

The area is among the Arsi-Bale mountain ridge, which is known for its wildlife resource. Accordingly, there are many wild animals found in the area including endemic ones. It is also frequent to see several bird species of different habitats (forest and water bodies). Moreover, Arsi Forest is known as a controlled hunting area and contributes to the national economy through hard currency income. The major wild animals are *Tragelaphus buxtoni* (Mountain Nyala), *Panthera pardus* (Leopard), *Tragelaphus scriptus Meneliki* (Menelik's bushback) and there are also common ones such as warthog, hyena, and different monkeys (Chaffe, 1979).

Methods

Sample Collection

Nine *Cupressus lusitanica* logs from plantation stands representing 25, 30 and 35 years of age (three trees from each age class) were used for this study. The trees were obtained from plantation forests of Arsi Forest Enterprise, Degaga District. The study was conducted on the test material logs obtained from three compartments, Dalele 10B, Dalele 2 and Kuke 26, with age variation from 25, 30 and 35 years, respectively. Trees were selected primarily due to their very similar characteristics except their age variation. Sample trees with similar diameters 27-33 at breast height and which has similar stand spacing 2.5m, minimal lean, relatively straight stems, and with relatively few external defects were chosen with the intent of minimizing tree-to-tree variation. All selected sample trees were marked, measured, and segregated according to their age-groups, prior to bucking them into saw logs. Then each tree was cut and divided into three portions (bottom, middle and top) at 4m intervals or based on the merchantable length.

The nine *Cupressus lusitanica* plantation tree logs from three different age groups were flatsawn into 108 lumbers with a dimension of 2.5 x 0.125 x 0.025 m.

Determination of Basic Density

The basic density of *Cupressus lustanica* was determined 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. Replicated samples of 3-cm long sample disk were cut from the bottom, middle and top parts of the log. Using displacement method the volume of wood samples was obtained by immersing in water (Panshin and De Zeus, 1980). The volume of each piece was determined by water displacement method are the weight of water displaced from the beaker by the submerged sample were recorded. The samples were dried at 103 ± 2 °C and the oven dried sample was followed with the intervals of 24 hrs until constant weight (Siau, 1984). The constant weight of the samples was obtained after 80 hrs.

The basic dry density of the samples is calculated according to (ISO 3131 1975(E) from the following formula:

$$Basicdensity = \frac{oven\ dry\ weight\ of\ sample\ (g)}{weight\ of\ displaced\ water\ (cm^3)}$$ Equation 1: Basic density

Data Collection

The sample was processed on the machines and the machining defects were observed, graded and measured. The machining defects observed on both cross cutting and ripping by using table saw are saw mark and wooly grain defects were observed and for planning defects by using thicknesser plane machines with the depth of 1, 2, and 3 mm and the defect observed were torn grain and chip mark defects. The machining defects from each bottom portion and age-group were measured, graded and recorded.

Experimental Design and Statistical Analysis

Completely randomized design (CRD) with factorial experiment was used to conduct this experiment. The statistical analyses were conducted considering three factors (3 age-groups, 3 heights and 2 tree section) to evaluate the effects of age (juvenility), tree height and diameter on machining defects. Statistical Analysis Software (SAS) was used to analyze the data using analysis of variance (ANOVA) procedure and further analysis of the means were carried out by mean separation using least significant difference(LSD) method at $P < 0.05$ (Seyoum *et al.*, 2008).

Results and Discussion

Basic Density

The statistical analysis of variance (Table 1) shows the effects of age and tree height basic density of *C. lusitanica*. As depicted in (Table 1), the interaction effects of age and height shows insignificant effect ($P > 0.05$).

Table 1: Mean square and statistical significances of Summary of ANOVA on basic density

Source of variation	DF	Mean square and statistical significances
		Density (g/cm^3)
Age	2	255.46**
Height	2	2.22 ns
Age x Height	4	14.08 ns

Note: ns- not significant at $P < 0.05$, * significant at $P < 0.05$, ** highly significant at $P<0.01$

On the other hand age shows high significant effect ($P < 0.01$) on basic density of *C. lusitanica,* while tree height and the interaction effects of age and height had insignificant effects ($P > 0.05$) on basic density.

Table 2: Basic density of *C. lusitanica* of the three age groups

Age	**n**	**Mean value**
		Density(g/cm3)
25	9	0. 519_b
30	9	0. 584_a
35	9	0. 479_c

Note: means having the same letter are not significantly different at $P < 0.05$,
n- is number of observation

The basic density shown in the (Table 2) is described by Figure 4 and 5.

In (Table 2), the 0.519 g/cm^3, 0.584 g/cm^3 and 0.479 g/cm^3 basic density mean values are depicted for 25, 30 and 35 year-old trees.

Wood strength is directly related to density of wood and as density increases the strength of the wood and wood quality also increases (Bendtsen 1978; Willcocks *et al*., 1994). Thus, from the age 25, 30 and 35 *Cupressus lusitanica* tested in this study, the 30 year-old had high density. Therefore, this high density of age 30 indicated that how this age group had a good wood quality since density is an indicator of strength, stiffness and quality (Bendtsen 1978; Willcocks *et al.,* 1994; John, 2005).

According to Michael, *et al*., (2008) the average basic density of *C. lusitanica* is 0.457 gm/cm^3 (457 kg /m^3) and also they described the *P. radiata* has 0.407 gm/cm^3 and that how the density of *C. lusitanica* is significantly exceeded that of *P. radiata* by 12% (0.457 versus 0.407 g/cm^3). The average basic density recorded in this study is 0.519 g/cm^3, 0.584 g/cm^3 and 0.478 g/cm^3 for age 25, 30 and 35 years *C. lusitanica* tree species respectively.

From this result it is clear that high density is an indicator of strength and stiffness and the denser wood has high quality and recommendable for some furniture and construction work (John, 2005). According to the result obtained in this study the 30 year-old *C. lusitanica* is recommendable for harvesting age than 25 year-old and 35 year-old *C. lusitanica* to have high quality timber for furniture construction and some other easy construction work.

The result shows that the density of *C. lusitanica* was showed increasing trend as the age of tree increases from 25 to 30 year-old trees. But it showed a decreasing trend on the 35 year-old trees. Wood density can be changed by silvicultural practices and genetic manipulation between age difference and sites (Rozenberg and Cahalan, 1997). Silvicultural practices may result in rapid tree growth but concerns exist about possible effects on wood quality (Rozenberg, and Cahalan, 1997). The decreasing trend density showed on 35 year-old *C. lusitanica* it might be due to silvicultural treatment difference (pruning, thinning etc.) between the three ages.

A comparison of mean density among three age groups of *C. lusitanica* grown in Ethiopia has an important implication for determination of lumber qualities produced from this tree for various applications. Therefore, it's very important to distinguish that for *C. lusitanica* age is better predictor of variation in mean density than tree height. More dense wood has high strength and stiffness and recommendable for high quality furniture and construction application (John, 2005).

Machining Defects

In this section the result of machining defects namely cross cutting, ripping and planing are presented.

Cross Cutting and Ripping Defects

The summary of the analyses of variance (Table 3) shows as age variation had high significant ($P < 0.01$) effects on saw mark and woolly grain cross cutting defects while it had insignificant ($P > 0.05$) effects on saw mark and woolly grain ripping defects.

Table 3: Summary of ANOVA table on Cross cutting and ripping defects of *Cupressus lusitanica*

Source of variation	DF	Mean square and statistical significances			
		Cross cutting defects		Ripping defects	
		Saw mark (mm)	Woolly grain (mm)	Saw mark (mm)	Woolly grain (mm)
Age	2	0.86**	0.69**	0.08 ns	0.08 ns
Tree diameter	1	0.25ns	0.03ns	0.11 ns	0.19 ns
Age x Tree diameter	2	0.08ns	0.03 ns	0.19 ns	0.19 ns

Note: ns- not significant at $P < 0.05$, * significant at $P < 0.05$, ** highly significant at $P < 0.01$

The tree diameter (both sap and heart section) had insignificant ($P > 0.05$) effects on the saw mark and woolly grain cross cutting and ripping machining defects. On other hand, both age and tree diameter variation did not show significant effects on ripping defects.

The average ripping defects of *C. lusitanica* of the three age groups observed in this study were shown in the (Table 4).

Table 4: Average ripping machining defects of *C. lusitanica* of the three age groups

Age	n	Mean value of ripping machining defects of *C. lusitanica*	
		Saw mark (mm)	Woolly grain (mm)
25	36	4.17a	4.83a
30	36	4.1a	4.92a
35	36	4.25a	4.75a

Note: means having the same letter are not significantly different at $P < 0.05$, n- number of observation

Table 4 shows as 35 year-old trees had high mean values of saw mark ripping defects (4.25 mm) while the 30 year-old trees had lowest saw mark ripping defects (4.1 mm). However, 30 year-old trees had high mean values on the woolly grain defects (4.92 mm) while the 35 year-old had lowest mean values of woolly grain ripping defects (4.75). Generally, the mean value of the three age groups of the saw mark and woolly grain ripping defects are varying with age variation. This is might be due to the maturity difference between the three age groups.

Planing Defects

The summary of ANOVA on planing defects is presented in (Table 5).

Table 5: Summary of ANOVA on Planing defects of *Cupressus lusitanica*

Source of variation	DF	Mean square and statistical significances					
		Torn grain (1mm Depth) (mm)	Torn grain (2mm Depth) (mm)	Torn grain (3mm Depth) (mm)	Chip-mark (1mm Depth) (mm)	Chip-mark (2mm Depth) (mm)	Chip-mark (3mm Depth) (mm)
Age	2	1.03ns	1.75ns	1.19ns	0.36ns	1.86*	1.19*
Tree diameter	1	5.44**	7.11**	4.00*	0.44ns	0.11ns	0.03ns
Age x Tree diameter	4	1.36ns	0.03ns	0.58ns	0.36ns	0.86ns	0.53ns

Note: ns- not significant at $P < 0.05$, * significant at $P < 0.05$, ** highly significant at $P < 0.01$

As indicted in (Table 5) age variation shows significant effects ($P < 0.05$) on chip mark 2mm and 3mm depths of blade cut. However, age had insignificant ($P > 0.05$) effects on torn grain defects all depths of blade cut. On the other hand, variation of tree diameter showed high significant effects ($P < 0.01$) on torn grain with 1mm, 2mm while it had significant effects on torn grain with 3mm depth of blade cut. However, tree diameter variation had insignificant ($P > 0.05$) effect on chip mark defects.

Table 6: Average values of planing defects of *Cupressus lusitanica*

Mean value of planing machining defects of *C. lusitanica* in (mm)							
Age	n	Torn grain (1mm depth)	Torn grain (2mm Depth)	Torn grain (3mm Depth)	Chip-mark (1mm Depth)	Chip-mark (2mm Depth)	Chip-mark (3mm Depth)
25	36	4.17a	4.01a	3.42a	4.66a	4.33a	3.92a
30	36	3.58a	3.33a	2.83a	4.75a	3.58b	3.83a
35	36	3.92a	3.58b	2.91a	4.41a	3.75b	3.33b

Note: means having the same letter are not significantly different at $P < 0.05$, n- number of observation

The interaction of age and tree diameter variation showed that insignificant ($P > 0.05$) effects on all depth of torn grains and chip marks of the three age groups and two tree diameters. From this result it is understood that how the planing machining defects had significant effects on the lumber quality of *Cupressus lusitanica* tree.

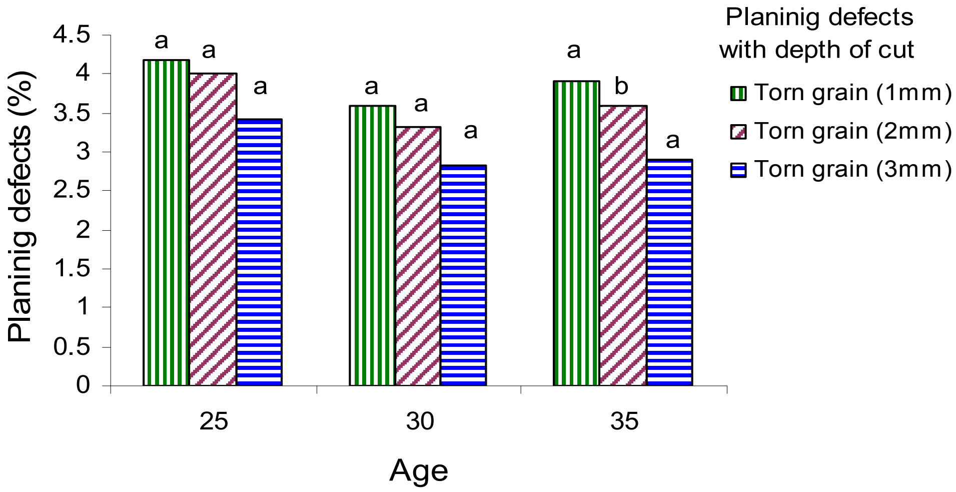

Figure 1: Average torn grain planing defects on 1mm, 2mm and 3mmdepth of blade cut planing machines of *C. lusitanica* of the three age groups.

As indicated in (Figure 1) all age groups (25, 30 and 35 year-old trees) had 4.17, 3.58, 3.92mm mean value of torn grain at 1mm depth of blade cut respectively. As depicted in (Figure 1) the mean value of torn grain defects on 2mm depth of blade cut for 25, 30 and 35 year-old trees are 4.01, 3.33 and 3.58mm correspondingly. In the figure above the mean values of torn grain at 3mm depth of blade cut also illustrated.

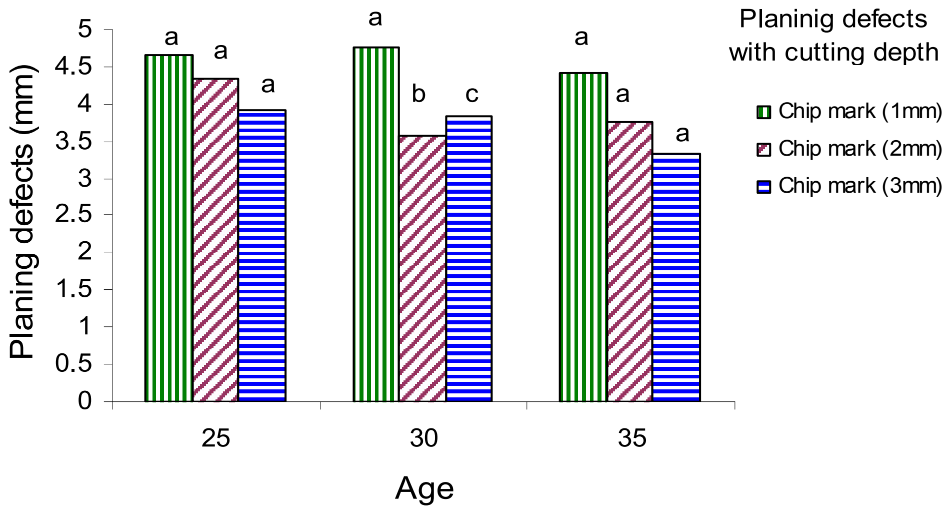

Figure 2: Average chip mark defects on 1mm, 2mm and 3mmdepth of blade cut planing machines of *C. lusitanica* of the three age groups

As depicted on the (Figure 2) the mean values of chip mark defects showed variation at all depth blade cut in all age groups of *C. lusitanica* (Figure 2).

Chip mark is a broadly visible surface irregularity caused when particles are chipped or broken off below the line of cut (Williston, 1988). From the obtained result for planing defects in this experiment the 25 year-old of *C. lusitanica* had showed high mean values chip mark planing defects more than that of 30 and 35 year-old of this tree on 2mm depth of cut. This is might be due to juvenility of the 25 year-old of *C. lusitanica* trees relatively from 30 and 35 year-old trees.

Table 7: Average planing machining defects of *C. lusitanica* of the two sections

Mean value of planing machining defects of *C. lusitanica* of the two sections in (mm)							
Section	n	Torn grain (1mm depth)	Torn grain (2mm Depth)	Torn grain (3mm Depth)	Chip-mark (1mm Depth)	Chip-mark (2mm Depth)	Chip-mark (3mm Depth)
Sapwood	18	4.27a	4.11a	3.38a	4.72a	3.83a	3.66a
Heartwood	18	3.5b	3.22b	2.72b	4.5a	3.94a	3.72a

Note: means having the same letter are not significantly different at *P < 0.05*, n- number of observation

These planing machining defects were tested with three different depth of blade cut (1mm, 2mm and 3mm depth of blade cut). The (Table 7) shows that the average planing machining defects of *C. lusitanica* of the three age groups. This table also shows that how all planing machining defects less appear on the 30 year-old trees relatively with 25 and 35 year-old of *C. lusitanica.* Therefore, it shows that how the 30 year-old of *C. lusitanica* is recommendable for harvesting age.

Figure 3: Average torn grain defects on the1mm, 2mm and 3mm depth of cut of planing machines of *C. lusitanica* of the two tree diameter

As depicted in (Figure 3) the mean values of torn grain at all depth of blade cut showed variation across the diameter (sapwood and heartwood) of *C. lusitanica*. From this result it is possible to conclude that lumber quality produced from sapwood and heartwood section of this tree can be used for various applications.

The mean value tree diameter had showed that torn grain planing machining defects of 2mm depth of blade cut higher on sapwood section than on the heart wood tree diameter. This is might be due to the sapwood tree diameter has high amount of initial moisture content than the heartwood tree diameter since the high amount of initial moisture content highly affect the planing properties of wood (Nakada *et al.* 1998, and Ryogo, 2006).

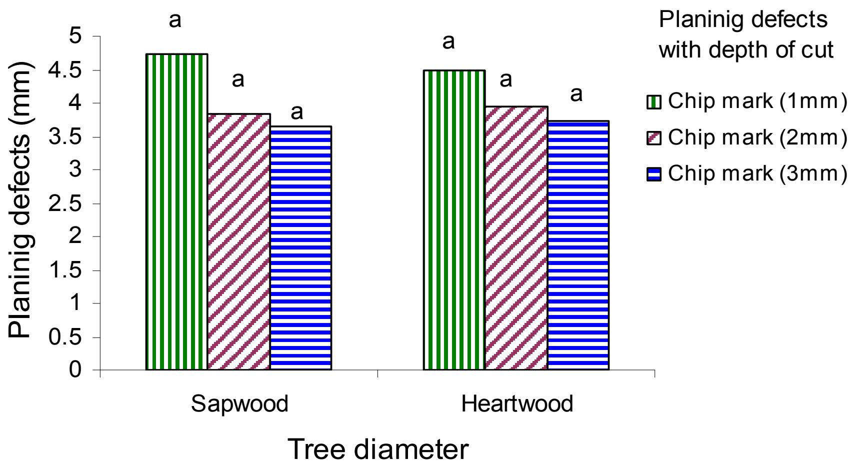

Figure 4: Average chip mark defects on the1mm, 2mm and 3mm depth of cut of planing machines of *C. lusitanica* of the two tree diameter

As depicted in the (Figure 4) all the chip mark on 1mm depth of cut had high mean values on both sapwood (4.72 mm) and heartwood (4.5 mm) and had the lowest mean values on the chip mark of 3mm depth of blade cut for both sapwood (3.66 mm) and heartwood (3.77 mm) tree diameter.

As these average planing machining defects shows that the 25 year-old trees had high defects than the 30 and 35 year-old trees of *C. lusitanica.* This is might be due to the juvenility of this tree relatively to the 30 and 35 year-old trees (Gatchell, 1990; Wengert, 1990). The 25 year-old also had high mean value of chip mark planing defects on 3mm depth of blade cut than the 30 and 35 year-old. This is indicated that how this age group is not recommendable for harvesting age due to its juvenility and since it had high amount of planing defects and those defects lead the lumber of this age group to reduce in its quality and as well as its price.

This result also indicated that how the heart tree diameter of this wood has a good planing machining property than the sapwood tree diameter. Generally, the mean value sapwood tree diameter of *C. lusitanica* of the three age groups shows that how the sapwood tree diameter is highly affected by planing defects than the heartwood tree diameter, this generally shows that how the heart wood tree diameter of this tree has good planing machining properties and high quality timber than the sapwood tree of *C. lusitanica*.

The planing operation can lead to several types of machining defects, which is differentiated by the depth of defect. The depth of defect is a measurement of the surface roughness of the machined planed wood surface, expressed in microns. Previous research have found that the most common types of machining defects in the machine planing operation of wood are fuzziness, tear-out, torn grain and chip-mark (Ratnasingam, 2008). The planing defects observed in this study were two or namely torn grain and chip-mark planing defects. The frequency and distribution of these defects on the machine plane surface is however a function of the interaction between the stock removal rate and density of the wooden material (Ratnasingam, 2008). Nevertheless, previous study on tropical hardwoods have found that the machining defects can reduce the processing yield by almost 27%, hence reflecting the importance of controlling machining defects during the machine planing operation (Davis, 1962; Koch, 1964; Wengert *et al*.,194; Hoff *et al*., 1997; Ratnasingam, 2008).

Identifying the major machining defects after drying and investigating the machining properties of *C. lusitanica* tree species has the prominent implications on the capacity of quality timber produced in Ethiopia and since the machining process of wood is an integral value-added process of wood products manufacturing industry, generally contributing almost 23% of the total production cost of such products and the machining defects can reduce the value of the lumber (Hoff *et al*., 1997; Ratnasingam, 2008).

Conclusion

From the above investigation results the following conclusions can be made:

The major machining defects observed in this study was saw-mark, chip-mark, torn grain and woolly grain machining defects.

The age variation had high significant effects on the basic density, saw mark and woolly grain cross cutting defects. Age variations also had significant effects on the radial sapwood section 2mm and 3mm depth of blade cut chip-mark planing defects. The variation of age had insignificant effects on the 1mm, 2mm and 3mm depth of cut torn grain planing defects and 1mm depth of cut chip mark defects of planing defects of C. lusitanica of the three age groups.

The effects of machining defects on the quality of this tree species was very high and it need pre-mechanism for machining process to minimize those defects even though it is difficult to avoided completely.

References:

Anonymous.1988. National Atlas of Ethiopia. Ethiopian Mapping Authority, Addis Ababa.

Anonymous, 1990. Munessa Shashemane State Forest Project Management plan. Forest Management division. Ministry of Agriculture, Addis Ababa, Ethiopia.

Anonymous. 1994. TAPPI Testing Procedure. Technical Association of Pulp and Paper Industry, Atlanta, USA.

Anonymous. 1999. Wood handbook; Wood as an engineering material. General Technical Report. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. p463.

Anonymous. 2000. Wood Handbook: Wood as Engineering Material. University press of the pacific Honolulu, Hawaii. p240.

Anonymous. 2007. Common defects in wood. Available at: (http://www.coateshomecentre.com.au/tips_tricks/tip_wood_defect.htm) (Viewed on Feb10, 2010).

Anonymous. 2008.Common Wood Defects. Available at: (http://woodzone.com/Merchant2/articles/common.htm) (Viewed on Feb 07, 2010).

Bendtsen, B.A., 1978. Properties of wood from improved and intensively managed trees. *Forest Products Journal*. 28: 61–72.

Buchanan A. 2007. Information sheet-Structural Materials; Sawn Timber Manufacture, Timber Industry Federation, New Zealand.

Chaffey, D.R. 1979. South-West Ethiopia Forest Inventory Project. A reconnaissance inventory of forest in south-west Ethiopia. Project report 31. Land Resource Development Center, England.

Chen, P.Y., and C.E. Helton. 1989. Design and evaluation of a low-cost solar kiln. *Forest Products Journal* 39:19-22.

Chudnoff, M. 1980. Tropical Timbers of the World. Forest Products Laboratory, Forest Services, USDA, Madison, Wisconsin.

Dan B. 2000.Lumber Drying. An Overview of Current Processes. University of Vermont Extension and School of Natural Resources. USA.

Davis, C., C. Carrington, Z. Sun. 2002. The influence of compression wood on the drying curves of *Pinus radiata* dried in dehumidifier conditions. *Drying Technology* 20: 2005-2026.

Desch, H.E. and J.M. Dinwoodie. 1996. Timber: Structure and Properties. Macmillan Press Ltd., London. p306.

Donaldson, L.; and J. Turner. 2001. The influence of compression wood and microfbril angle on the occurrence of distortion in window frames made from radiata pine. *Holz als Roh-und Werkstoff* 59:163.168.

Eugene, M., and M. Dan. 1993. Causes and Cures for Warp in Drying. University of Wisconsin School of Natural Resources, Department of Forestry

FAO (Food and Agriculture Organization of United State). 2003. Management of Wood Properties in Planted Forests a Paradigm for Global Forest Production. Planted Forests and Trees Working Papers. University of Maine Department of Forest Ecosystem Science, Orono, Maine (USA).

FAO (Food and Agriculture Organization of United State). 2006. Management of Wood Properties in Planted Forests. A Paradigm for Global Forest Production, by Richard Jagels. Planted Forests and Trees Working Papers, Forest Resources Development Service, Forest Resources Division. FAO, Rome

Farjon, A. 1993. Nomenclature of the Mexican cypress or "cedar of Goa", *Cupressus lusitanica* Mill. *(Cupressaceae). Taxon* 42: 81-84.

Farjon, A. 2005. A monograph of Cupressaceae and Sciadopitys. Royal Botanic Gardens, Kew. p648.

Gene, W. 1998. Rx for Wood Machining Defects: the causes for defects in solid lumber caused by machining, Department of Forestry, University of Wisconsin-Madison.

Gatchell, C. 1990. The effect of crook on yields when processing narrow lumber with a fixed arbor gang ripsaw. *Forest Products Journal* 45: 45-50.

Hallock, H. 1968. Observation on form of Juvenile Core in Loblollypine. MadisionWI. USDA.Forest Service Resource Note. *Forest product Laboratory*. 188: 2-6.

Hoff, K.; N. Fisher, S. Miller, and Webb A. 1997. Source of Competitiveness for Secondary Wood Products Firms: A Review of Literature and Research Issues. *Forest Products Journal*: 47: 31-37.

Ilker U. 2003. Comparative Study of Wood Density by Specific Amount of Void Volume (Porosity). *Turkish Journal of Agriculture and Forestry* 27:1-6.

Innes, T. 1996. Improving Seasoned Hardwood Timber Quality with Particular Reference to Collapse. PhD Thesis. University of Tasmania, Australia. p172.

ISO 3130-1975(E). 1975. Wood –Determination of moisture content for physical and mechanical test.

ISO 3131-1975(E). 1975. Wood Determination of Density for Physical and Mechanical tests.

James E. 1997. Drying wood; University of Kentucky College of Agriculture, Lexington, and Kentucky State University, Frankfort. p93.

John, B. 2005. Builders guide to safe aircraft materials; Properties of wood. Available: (http://www.redlettuce.com.au/) (Viewed on Feb 16, 2010).

Kebede Seifu,. 1998. Estimating land use/land cover change in Munessa area using remote sensing techniques. M.Sc Thesis. Awassa University Wondo Genet College of Forestry and Natural Resource. p12.

Kedir Nino. 2009. Isolation and Identification of Fungi associated with Needle blight and Death of *Pinus patula* trees in Forest Plantations of Arsi Forest Enterprise, Ethiopia. MSc Thesis. Hawassa University Wondo Genet College of Forestry and Natural Resource. p8.

Khiari, S. and S. Iddi . 1989. Basic Density of Wood of *Pinus Caribaea* Grown in Zanzibar, United Republic of Tanzania. *Tropical Forest Science Journal* 4: 113- 118 pp.

Kilic, M., S.Hiziroglu, E. Burdurlu. 2005. Effect of Machining on Surface Roughness of Wood. *Building and Environment Journal*: 41: 1074-1078.

Koch, P. 1966. Straight studs from southern pine veneer cores. USDA Forest Service Research paper. SO-25. *Southern Forest Experiment*. New Orleans, Louisiana. 9:28-35.

Leekokonn 2007. Studies of convective drying using numerical analysis on local hardwood; Universiti Sains Malaysia. p39.

Lundgren, B. 1971. Soil Studies in Amontane Forest in Ethiopia. Department of Forest Ecology and Forest Soils, Royal College Forestry Research Notes No. 11, Stockholm, Sweden.

Mcmillen. J. 1958. Stresses in wood during drying. Forest Products Laboratory. United State, Department of Agriculture. USA.

Michael, S., W. Peter, C.Graham, R. Murray, S. Robyn, L. Roger, Parfitt and D. John. 2008. Modelling the influence of environment and stand characteristics on basic density and modulus of elasticity for young *Pinus radiata* and *Cupressus lusitanica; Forest Ecology and Management Journal:* 12*:* 1023-1033.

Michel, D.; B. Daniel, P. Christian, G. Raffaello, R. Paolo, R. Alain, S. Jaime, and T. Bernard, 1999. Cypress a Practical Handbook. Studio Leonardo, Florence, Italy. p6.

Nakada, R., Y. Fujisawa, Y. Hirakawa and K. Yamashita. 1998. Longitudinal change of the green moisture content in the stem of *Cryptomeria japonica* D. Don. *Wood Science Journal* 44: 395–402.

Negash, Mamo, Berehane Habte, Dawit Beyan. 1995. Growth and Form Factor of Some Indiginous and Exotic Tree Species in Ethiopia. Forestry research Center, Addis Ababa, p42.

Negash, M. and Hubert, S. 2006. Site index function for *Cupressus lusitanica* at Munesa Shashemane, Ethiopia. *Forest Ecology and Mangement Journal* 237: 429-435.

Niklas K. 1992. Plant biomechanics. University of Chicago Press, Chicago. pp76-83.

Panshin, A. and C de Zeeuw. 1980. Text of wood Technology: Structure, Identification, Properties, and Uses of the Commercial Woods of the United states and Canada. McGraw-Hill, New York. p705.

Pang, S. 2007. Mathematical modeling of kiln drying of softwood timber: Model development, validation, and practical application. Taylor & Francis, Philadelphia, PA, ETATS-UNIS, *Drying technology Journal,* 25: 421-431.

Pearson, R. and R. Gilmore. 1971. Characterization of the strength of juvenile wood of loblolly pine. *Forest Product Journal* 21:23-30.

Pukkala, T. and V. Pohjonen. 1993. Yield of *C. lusitanica* in Ethiopia. *East African Agriculturul Forest Journal* 59: 51-73.

Ratnasingam, J. 2008. Machining Technology; the Implications of Machining Defects in Wood Planing Operations (Part 1); Faculty of Forestry, University Putra Malaysia, Malaysia. pp10-12.

Reuss, M.; S. Benkert, A. Aeberhand, P. Martina, G. Raush, B. Rentzell, and N. Sogar, 1997. Modelling and experimental investigation of a pilot plant for solar wood drying. *Solar Energy Journal* 59: 259-270.

Rice, R. 1988. Mass transfer, creep and stress development during the drying of red oak, Ph.D Dissertation, Virginia Poly technique Institute and State University, Blacksburg, Virginia. p153.

Rozenberg, P. and C. Cahalan. 1997. Spruce and wood quality: genetic aspects (A review), Silvae Genet. 46: 270–279.

Ryogo, R. 2006. Within-stem Water Distribution in Living Trees of Some Conifers. Forest Tree Breeding Centre, Tohoku Regional Breeding; *IAWA Journal* 27: 313–327.

Salim, H. 1972. Dimensional Changes in Wood. Oklahoma Cooperative Extension Service, USA. NREM-5009-4.

Seyoum, K. M. Paridah, E .Wong and S. Raim. 2008. The Effects of Selected Anatomical Characteristics of Ethiopian Highland Bamboo Arundinaria Alipina K. Schum. (Poaceae).*Ethiopian Journal of Biological Science* 7: 69-84.

Samson Waktole. 2004. Effects of Thinning Age on Some Wood Properties of *Cupressus lusitanica* Mill. Wondo Genet College of Forestry, MSc Thesis. p46.

Shmulsky, R. and D. Butler. 2005. Shrinkage and grade retention in restraint-dried thick dimension loblolly pine. *Forest Products Journal*. 55: 34-36.

Siau, J. 1984. Transport Processes in Wood. Springer-Verlag, NewYork. p245.

Stamm, A. 1964. Wood and Cellulose Science. Ronald Press, New York. p509.

Stewart, C. 1967. Moisture content of living trees. *Nature Journal* 214: 138–140.

Tesfaye Teshome. 1996. A growth and yield model for *C. lustanica* in Munessa Shashemane State Forest Project, Ethiopia. PhD Thesis. University of Aberdeen, Scotland, UK.

Tiruneh Kide. 2002. Effects of stand density on specific gravity and selected mechanical properties of Cypressus lusitanica mill. MSc Thesis. Wondo Genet College of Forestry. p29.

Timell, T. 1986. Compression wood in gymnosperms. Springer-Verlag, Berlin. *Journal of Wood Science and Technology* 26: 107-121.

Tsegaye Bekele. 1994. Kiln drying of sawn boards of young *Eucalptus globulus Labill.* and *Eucalyputs camaldulensis* Dehnh. Grow on the Ethiopia Highlands. *Holz als Roh-und Werkstoff* : 52: 377-382.

Tsegaye Bekele. 1995. Degradation boards of *Eucalptus globulus Labill.* and *Eucalyputs camaldulensis* Dehnh. during air drying. *Holz als Roh-und Werkstoff*: 53: 407-412pp.

Tsegaye Bekele. 1996. Utilization of Sawn Boards from Young Eucalyptus Plantation Timber in Ethiopia, PhD Thesis. SLU Uppsala, Sweden. p411.

Thomas, R. 1984. The characteristics of juvenile wood. In: Proceedings on utilization of the changing wood resource in the Southern United States; School of Forest Resource. Raleigh, NC: *North Carolina State University Journal*: 12: 40–52.

Valentino,G., L. Leija, E. Riera, E. Rodríguez, J. Gallego. 2005. Wood drying by using high power ultrasound and infrared radiation, Avenida Instituto Politécnico Nacional, Mexico. p6.

Vidakovic M. 1991.Conifers: morphology and variation. Translated from Croatian by Maja Soljan. Croatia: Graficki Zavod Hrvatske.

Walker J. 1993. Primary Wood Processing; principles and practice. Chapman and Hall, London.603p.

Walker, J., B. Butterfield, T. Langrish, J. Harris and J. Uprichard. 1993. Primary Wood Processing. Chapman and Hall, London. p595.

Web, D., P. Wood J. Smith, G. Henman. 1984. A guide to species selection for tropical and sub tropical plantations. Tropical Forestry Papers, No. 15, second revised ed. Unit of Tropical Silvicultural, Commonwealth Forestry Institute, University of Oxford, p256.

Wengert, E. 1990. Drying oak lumber. Madison, WI: University of Wisconsin, Department of Forestry. p167.

Willcocks, A. and W. Bell. 1994. Effect of stand density on the growth and timing of harvest and establishment costs of coniferous stands. OMNR, *Northeast Science & Technology Journal* 7: 1-12.

William T. 1978. Properties of Wood Related to Drying; Research Forest Products Laboratory, U. S. Department of Agriculture, USA. p41.

Williston, E. 1988. Lumber Manufacturing: The Design and Operation of Sawmills and planer Mills. Miller Freeman, USA.p 486.

Zobel, B. C. Webb, F. Henson, 1959. Core or juvenile wood of loblolly and slash pine trees. *Tappi Journal*. 42:345-355.

Zobel, B. & van Buijtenen, J. 1989. Wood variation. Its causes and control. Springer Verlag. p363.

Zobel, B. and R. Blair. 1976. Wood and pulp properties of juvenile wood and top wood of the southern pines. *Applied Polymers Journal* 28: 421–433.

Zobel, B. and D.G. Kirk. 1972. Wood property of young Loblolly and slash Pine on the effect of growth acceleration on properties of wood. Madision Wisconsin. p258.