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Seasoning Characteristics and Potential uses of *Eucalyptus pilularis, Eucalyptus viminalis* and *Trichilia dregeana* lumber tree species

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ABSTRACT

Technical information on lumber seasoning, moisture content (MC), density, mechanical, workability and chemical characteristics would strongly determine rational utilization of each lumber species. A study was conducted on home-grown two Eucalyptus species *(Eucalyptus pilularis* and *Eucalyptus viminalis)* and one indigenous *(Trichilia dregeana) t*imbers with the main objective of determining some characteristics of lumber that will indicate quality and proper utilization. Study species were harvested from Shashemene, Asella and Arjo sites, respectively. The experimental design for seasoning and density was complete randomized design, a factorial experiment. The experiments were conducted using air and kiln seasoning methods. To determine initial moisture content oven drying method was used. The mean initial MC for the three timber species were 48.25%, 56.1% and 65.45%, respectively. The species were classified as very rapid seasoning rate during kiln seasoning. The mean shrinkage values were Tangential (6.31, 4.94 and 4.43%), radial (3.4, 4.02 and 2.10%) volumetric (9.46, 8.6 and 6.37%), when they seasoned from green to 12% MC, respectively. Seasoning defects such as cup, bow, crook, end split, surface and end-checks were observed, though the extent varies with species. The density of *E. pilulalris, E. viminalis* and *T. dregeana* at 12% MC was 780, 810 and 530 Kg/m^3, respectively. The one-way analysis of variance indicated that there was significant difference (P>0.001) in initial MC, final MC, density values at different MC and shrinkage characteristics. They revealed good lumber characteristics and qualities, comparable with many indigenous and home-grown exotic timber species in density, seasoning rate and shrinkage. The tree species have to be well managed, properly harvested and sawn. Boards have to be properly stacked and seasoned to about 12% MC, with kiln and air seasoning methods that can help to minimize seasoning time, seasoning defects, shrinkage characteristics and increase quality.

***Keywords*:** seasoning, Lumber quality, moisture content, seasoning defects, shrinkage characteristics, timber species, *Eucalyptus pilularis, Eucalyptus viminalis, Trichilia dregeana*

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1. INTRODUCTION

Human beings will be utilizing the renewable forest products and services to contribute to their comfort and ever-increasing demand. The demand of forest products to industries, construction and energy sectors in Ethiopia has been highly exceeding the supply [14]. The 2011/2012 forest products import amount in tone was 170721.3 with a value of about 3.2 billion Ethiopian Birr. Based on annual incremental yield of forests demand, and supply for the year 2020 has been projected to 132,500,000 m^3 and 28,710,856 m^3 [12]. Demand will exceed the supply by 103,789, 144 m^3 (4.6 times, > 460%). To satisfy the ever-increasing demand, large quantities of timber, panel and fiber products are being imported from different countries with hard currency [7].

In Ethiopia there are more than 300 indigenous and home-grown exotic tree species whose quality, suitability and potential as lumber are not yet investigated and realized. This was not made possible due to lack of efficient technologies for alternative use of less utilized and potential forest resources [9]. The quality and performance of wood and wood-based products have been seriously affected by the major factors, among which MC, inappropriate seasoning and density [15]. About 75% of the manufacturing problems in furniture industries are related to inappropriate moisture content of lumber [11, 18, 21]. Moisture content, density, mechanical characteristics, seasoning and shrinkage characteristics, workability, anatomy, chemical composition and technologies of utilization among the major factors that determine the quality, suitability, rational utilization and service life of wood as round and sawn lumber [11].

Increasing efficiency of utilization of forest products through product diversification, value addition and maximization of uses of wood and wood–based products, import substitution and export promotion will be possible in Ethiopia after determining the different characteristics, quality and suitability of each species. It is worth thus, to undertake integrated research on economically lesser known timber species (E. pilularis, E. viminalis and T. dregeana) that are not yet known by the development, processing and construction sectors, manufactures and end users in the lumber market of Ethiopia.

The general objectives of this study were to investigate the different characteristics, generate technical information, appropriate utilization technologies, and assess potential uses of *E. pilularis*, *E. viminalis* and *T. dregeana* sawn timbers. Specific objectives were to: (i) evaluate the appropriate seasoning methods for the timbers, (ii) determine appearance, moisture content, seasoning characteristics (seasoning rate, shrinkage characteristics, seasoning defects, possible remedies, handling techniques for seasoned lumber) and density of the timbers at different MC levels (iii) observe biodeterioration attack during and after seasoning, and (iv) assess potential uses of the timbers.

2. MATERIALS AND METHODS

2. 1. Study species

The tree species for this study were *Eucalyptus pilularis* Sm. [Family: Myrtaceae] , *Eucalyptus viminalis* Labill. [Family: Myrtaceae] and *Trichilia dregeana* Sond. [Family: Meliaceae] that have fast growth, high yield, good performance, versatile timber and non-timber forest products, socio- economic and ecological benefits, good site adaptability and coppice ability

(*E. pilularis* and *E. viminalis*) in the country. *Eucalyptus pilularis* is a very large tree up to 70 m tall, with bole up to 4.1 m in diameter [4]. It has easy regeneration, quick growth ability and fire resistant. *E. viminalis* is an evergreen, large tree up to 50 m tall; bole up to 120 cm in diameter [4]. In Ethiopia it is planted on well-drained, deep soils.

Fig. 1a. *E. pilularis* stand from Shahemene/ Hamulu trial site, April 2012 (Photo by Getachew Desalegn)

Fig. 1b. *E. viminalis* Asella/ EIena CEF-FRC stand November 2012
(Photo by Getachew Desalegn)

Trichilia dregeana tree attains a height of up to 35 m, the tall main stem assuming a relatively straight trunk dividing into large branches and sometimes buttressed habit up to 1.8 m in [5].

T. dregeana is an excellent feature plant that is fast-growing and provides great shading for coffee and other crops. Vernacular names in Ethiopia: Bonga (Amaharic), Desh (Gimirigna), Luiya (Kefgna) Konu, Luya, Shego, Ambaressa (Afaan Oromo.) Common (English) names: forest mahogany, forest natal mahogany, muchichiri, white mahogany, cape mahogany, thunder tree, Christmas bells, red ash (Eng.)

Fig. 1c. *T. dregeana* from at Jimma-Arjo Dedessa river area February 2014
(Photo by Getachew Desalegn)

Figure 1. Tree with clear bole of *E. pilularis*, *E. viminalis* and *T. dregeana*, *T. dregeana* available in Wellega (Arjo-Jimma), Illubabor (Yayu, Chora), Kefa (Bonga, Bebeka) regions and Teppi areas of Ethiopia [16]. For this study Sample trees of *T. dregeana* were harvested from Arjo-Jimma Dedessa river area on the way Nekemt to Bedele.

2. 2. Experimental design

The experimental design for seasoning and density characteristics was complete randomized design (CRD), a factorial experiment with 3 tree species, 3 positions along tree height, ≥ 10 samples per species and two main factors (three timber species and two seasoning methods).

2. 3. Selection and harvesting of sample trees (Sampling techniques)

Matured trees 10 m^3 logs representative of merchantable size with good morphological quality, straight and cylindrical stem, relatively free from visible defects were selected from different sites. The selected trees were felled, cross- cut into a series of 2.5 m long logs up to top merchantable diameter of 20 cm. The sample trees of *E. pilularis, E. viminalis* and *T. dregeana* had mean height of 27, 36 and 15 m, respectively, and mean breast height diameter at 1.3 m above ground was 50, 39 and 210 cm, respectively.

2. 4. Log sawing and sample preparation

Harvested logs while green (> 30% MC) were transported to Addis Ababa Wood Technology Research Center for the preparation of testing samples. Logs were sawn to 3 cm thick using mobile circular sawmill by applying flat sawing method. This sawing method was used to obtain approximately equal proportions of sapwood and heartwood. From the sawn boards 18 defect free sample boards per tree species were selected, prepared and tested following the ISO standerds [8, 10, 11]. From the middle part of the selected sample boards control speciemen having 105 cm length cross-cut and prepared. From both ends of the control samples small sections having 1.2 cm length cross-cut and oven dried to determine initial MC of each timber species. Defect-free specimens of each timber species (2x2x3 cm) (width, thickness and length, respectively) at green state were used to determine density and shrinkage characteristics [9] using mathematical formula.

2. 5. Stacking sawn boards

After sawing, boards were transported to the air seasoning yard (Figure 2) and compartment kiln-seasoning chamber (Figure 3). Boards of each species were stacked properly at 3 cm spacing between successive boards. To facilitate uniform air circulation, minimize warpages, avoid stain and decay occurrence during the seasoning stickers with a dimension of 2.5×2.5×180 cm (width, thickness and length, respectively) were used.

Top loading (concretes) weighing about 50 Kg/m^2 were used to minimize warping [11]. In each stack of the air and kiln seasoning, the heartwood boards, which have less moisture content, were placed in the middle while the sapwood boards were placed along the sides, top and bottom of the stacks. The ends of boards were made equal in both directions. The control sample boards were properly distributed and positioned in the pockets of the different layers of each stack.

Boards for air seasoning were stacked under shed without direct interference of moisture, rainfall or sunshine. Boards were stacked on firm foundations having 45 cm clearance above the ground and a dimension of 1.80×0.45×4 m. The boards were aligned in a north-south direction where the ends were not exposed to the direction of the wind. Boards for kiln seasoning were stacked out of the kiln on the transfer carriage having a dimension of 2.7×1.6× 0.30 m and placed in the kiln-seasoning chamber (Figure 3) and tested one species at a time.

Fig 2a. *E. pilularis* *air* seasoning stack

Fig 2b. *E. viminalis* air seasoning stack

Fig 2c. *T. dregeana* *air seasoning stack*

Figure 2. Air seasoning stacks of *E. pilularis*, *E. viminalis* and *T. dregeana* lumbers.

Figure 3. Kiln seasoning stacks of *E. pilularis*, *E. viminalis* and *T. dregeana* lumbers.

2. 6. Seasoning methods applied

2. 6. 1. Air seasoning

Natural air and artificial kiln seasoning methods were used for testing and determination of seasoning. The lumbers were stacked and dried in air from 25-30% MC prior to kiln drying in order to save energy costs. For air drying the control sample boards were initially weighed, re-placed into the stack, re-weighed and MC determined every week continuously until the average final MC of the stack reached about 12% MC [11].

2. 6. 2. Kiln seasoning

The conventional type of artificial kiln seasoning machine was used in this study. The machine is well insulated and has about 2.5 m^3 wood loading capacity chamber per kiln operation. It has controlled air circulation, temperature and humidity that can be adjusted according to each species characteristics using psychrometers (dry bulb and wet bulb thermometers). It has been equipped with fans to force air circulation, and air outlet at a temperature range of 40 -70 ºC.

The kiln seasoning schedules are steps/norms involving serious of temperature and relative humidity at different corresponding MC levels were selected based on the initial MC of timbers [22] which was adapted from England, Sweden and others. In kiln seasoning samples were weighed and the direction of the fan changed at 8 hours interval (three times in 24 hours) to allow uniform air circulation and maintain quality of the seasoned wood. Kiln seasoning boards were gone under an initial air seasoning before stacking and commencing the regular air and kiln seasoning processes. This was done to reduce kiln charge since there will be no characteristics change above and up fiber saturation point (30% MC) [11].

2. 7. Moisture content seasoning determination

MC was determined for both air and kiln seasoning stacks of the timbers. The oven-dry method of MC determination (the standard way) [1] was applied in this test. A cross section was cut from a board, then completely dried in a heated oven. To determine MC, a cross sections having 1.2 mm length Cut from a board along the grain and their initial weight were taken. After initial weights test samples were measured, they were put in an oven maintained at a temperature 103 ±2 ºC. Each of the specimens were taken from the oven every four hours and re-weighed using a sensitive balance to obtain the moisture content. This was repeated until the specimen were completely oven-dried [19, 23]. This is until the difference between two successive weights of each specimen is between 0.1-0.2 g [16]. After the samples were completely dried the MC (%) was determined by the formula adapted [11] for both seasoning methods.

2. 8. Shrinkage characteristics determination

The differential shrinkage characteristics caused by the differences in tangential, radial and longitudinal directions. Samples of the timbers with a dimension of 2×2×3 cm [13, 17] were prepared, measured and seasoned in the oven to a constant temperature of 103 ±2 ºC. Weights of all the shrinkage samples were measured continuously with four-hour interval. The process is continued until the difference between the two successive weights of each specimen was constant i.e. between 0-0.2 g. Then, the final weights and dimensions were taken as oven dry weight and dimensions, respectively. Shrinkage rates of each specimen at tangential, radial, longitudinal direction and volumetric were determined from green to 12% MC and from green to 0 % MC using shrinkage determination formulas [11]. Shrinkage values from green to oven dried were classified based on [6].

2. 9. Seasoning defects determination and handling of seasoned lumber

Initial and after seasoning defects of timbers including cup, bow, twist, crook, end split, end and surface checks were determined. Seasoned boards were properly piled one up on the other in the air seasoning yard, without stickers. Boards were handled and conditioned well without direct access of moisture and sunshine to avoid dimensional movement (shrinkage and swelling), seasoning defects, infestation and biodegradation attack [2]. Follow-up of seasoned boards was done for more than six months and observations were recorded.

2. 10. Density test

The density (specific gravity) values of timbers were determined, as prime indicator of wood quality, since it has strong influence on wood characteristics (physical and mechanical characteristics) and timber quality [20]. Specific gravity is unit less and is the density of wood per density of water, numerically equal to density since an equal volume of water at 4 ºC has a density of 1 g/cm^3 or 1000 Kg/m^3 [1, 10, 11].The samples (2×2×3 cm), procedures and measurements applied during shrinkage tests were used to determine the density values of each species. Basic density was determined based on green volume and oven dry weight, since the two are relatively constant conditions [8]. The dry density values have been converted to standard 12% equilibrium MC (Table 1) by applying the formula adapted [8, 9, 11] and classified based on the adapted standard classification [10].

2. 11. Data collection and Analysis

The measurements of dimension (length, width and thickness) and weight were helped to determine the following parameters: (i) moisture content (%) at green, current and final, (ii) density (gm/cm^3) at green and air dry conditions, (iii) rate of seasoning (%/day), (iv) shrinkage (%) from green to 12% MC and green to 0% MC in tangential, radial and longitudinal directions and volumetric, and (v) initial and seasoning defects (observation and measurements). The one-way analysis of variance (ANOVA) using statistical software package was applied for the analysis of the collected data [8]. Comparison was made within and between the timber species initial and final MC amounts, shrinkage characteristics, and density values.

3. RESULT / EXPERIMENTAL

3. 1. Appearance and odor

Heart wood of *E. pilularis* is yellowish brown to light brown (Figure 4a). Heart wood of *E. viminalis* is pale yellow or pink and is not clearly demarcated from sapwood (Figure 4b). The wood of *T. dregeana* was a pale pink (Figure 4c). *T. dregeana* lumber while sawing, planning and cross-cutting has very irritating odor.

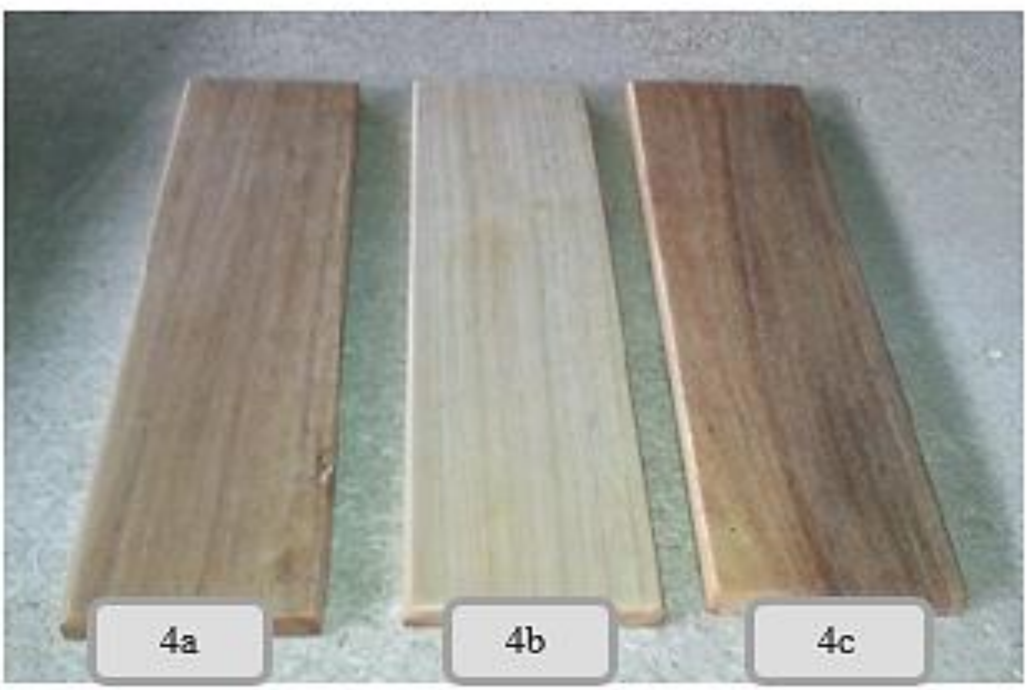

Figure 4. Lumber pictures of study tree species: **(a)** *E. pilularis* lumber, **(b)** *E. viminalis* lumber, **(c)** *T. dregeana* lumber).

3. 2. Moisture content

The results indicated that before air and kiln seasoning, the mean initial MC for the three timber species were 48.25%, 56.1% and 65.45%, while the final mean MC for both air and kiln seasoning were 11.37%, 16.39% and 11.61%, respectively (Table 1). This means that 0.12 times the weight of wood substance occupied by moisture/water, while 88% was only wood substance. The one-way analysis of variance indicated that there was significant difference (P>0.001) in initial MC, final MC, density values at different MC and shrinkage characteristics.

Initial MC along height of timbers varies slightly. In case of *E. pilularis* bottom part had 63% to 75% MC; middle part had 69.52% MC, while top part had the least MC (43%). *E. viminalis* had high initial MC (67.71%) for bottom part, 58.93% middle part and 48.56% for top part. *T. dregeana* had 62.3% initial MC for bottom part, 65.40% for middle part and 69.11% fur top part. Initial MC of *T. dregeana* lumber increased along height since its bottom part changed to heartwood having less MC.

3. 3. Rate of seasoning

Table 1. Seasoning and density characteristics of *E. pilularis, E. viminalis* and *T. dregeana* lumber species.

Timber species studied	Air seasoning stacks MC (%) and rate of seasoning(%/day)			Kiln seasoning stacks MC (%) and rate of seasoning (%/day)			Density classification at 12% MC			
	Initial MC of air seasoning stacks	Final air Seasoning MC	No. of days in air and rate seasoning	Initial MC of kiln seasoning stacks	Final kiln seasoning MC	No. of days in kiln and rate seasoning	Green /Initial	Basic density	At 12% MC	Density value (Kg/m^3)at 12% MC classification
E. pilularis	48.5	10.2	100 (0.36 %/day)	48	13	5 (7 %/day)	1000	670 (±19.27)	780 (±21.6)	Heavy
E. viminalis	59.13		50	53	16.39	4 (9.15 %/day)	990	820 (±13.02)	810 (±13.24)	*Very heavy*
T.dregeana	65.8	11.2	46 (1.19 %/day)	65.61	12	6 (8.94 %/day)	940	500 (±1.0)	530 (±10.5)	*Light*

Compared to air seasoning, kiln seasoning of *E. pilularis* lumber was 99.95 times faster (Table 1). In other words, air seasoning took extremely much time, i.e., it took more than 99.95 times greater than kiln seasoning. Air seasoning rate of *E. pilularis* was 0.36 %/day and that of *T. dregeana* lumber was 1.19 %/day. Kiln seasoning rate of *E. pilularis*, *E. viminalis* and *T. dregeana* lumber was 7 %/day, 9.15 %/day and 8.94 %/day, respectively (Table 1). Based on the adapted rate of seasoning categories [12] the three lumber species classified as rapid (77-119 days) to very rapid (< 77 days) in air seasoning methods and in kiln seasoning all classified as very rapid (< 10.5 days). *E. pilularis* took more air seasoning days (100 days) since it was long rainy season (June-August), while kiln seasoning took similar days (4-6 days) for the three timbers. According to [12] *E. pilularis* has been indicated as slow seasoning. Kiln seasoning method was better than natural air seasoning in terms of seasoning rate and quality (low shrinkage and seasoning defects) of seasoned lumber. Kiln seasoning 9 to 19 times faster than air seasoning. Controlling of environmental conditions and seasoning defects was less likely during the air seasoning process.

3. 4. Shrinkage and swelling (Dimensional changes)

When lumber of *E. pilularis, E. viminalis and T. dregeana* timbers seasoned from green (48-66%) to 12% MC, the mean shrinkage percentage values were tangential (6.31, 4.94, 4.43%), radial (3.4, 4.02, 2.10%), and volumetric (9.46, 8.6, 6.37%), respectively (Figure 5). Shrinkage percentage values of *E. pilularis, E. viminalis and T. dregeana* timbers at 12% MC respectively were classified tangential (Large, Medium, Medium), radial (Fairly large, Large, Small), and volumetric (Fairly large, fairly large, Small).The maximum longitudinal shrinkage varies from 0.1%-0.3%; maximum radial shrinkage: 2.1-7.9%; maximum Tangential shrinkage: 4.7-12.7%. Tangential shrinkage is generally 1.5 to 2 times greater than radial shrinkage.

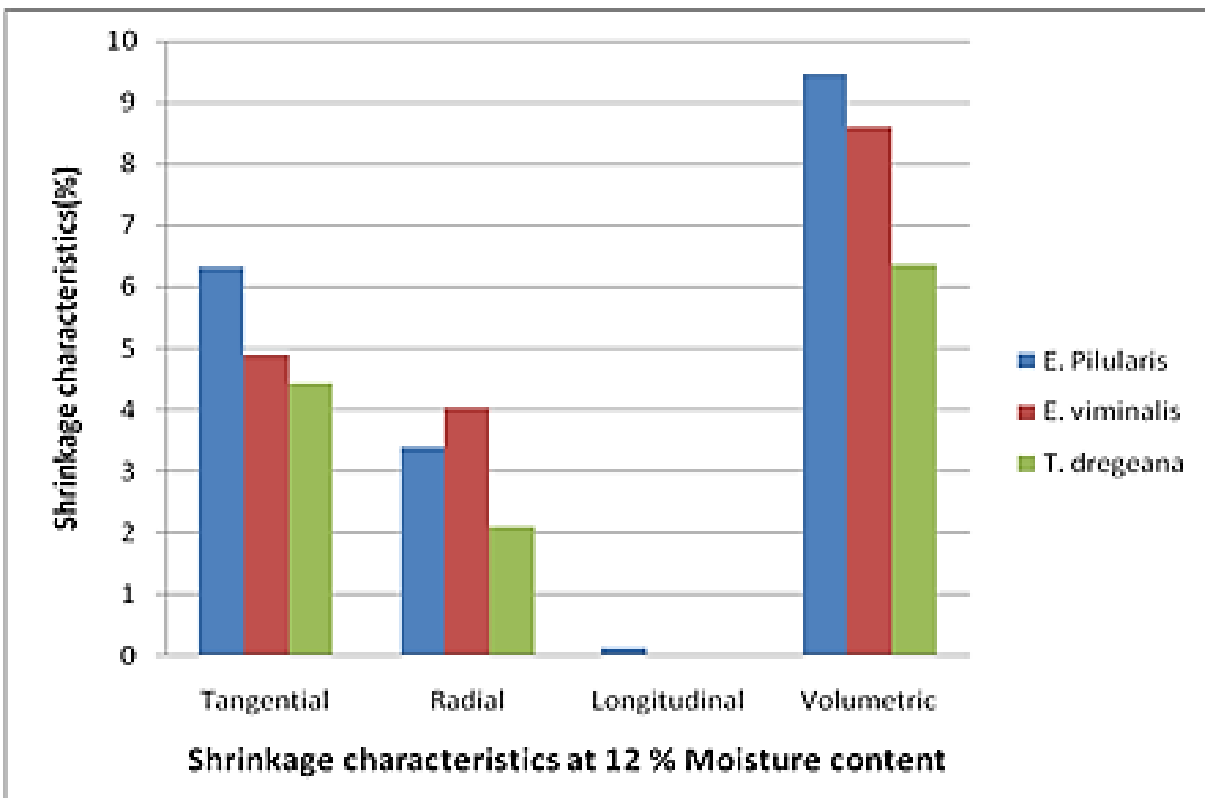

Figure 5. Mean shrinkage characteristics of *E. pilularis, E. viminalis and T. dregeana* lumber species at 12% MC.

The shrinkage characteristics of *E. pilularis*, *E. viminalis* and *T. dregeana* along height (bottom, middle and top parts) were not much significant when boards seasoned from green condition (47%-62% MC) to 12% MC. Tangential shrinkage of *E. pilularis, E. viminalis* and *T. dregeana* were 1.86, 1.21 and 2.11 times greater than radial shrinkage, respectively. The shrinkage values of the lumbers up to oven dry (0%) MC compared at 12% MC was increased by about 1.66-1.68 times. Tangential (4.94%) and radial (4%) shrinkage values of *E. viminalis* compared with similar study of tangential (9.7-31%) and radial shrinkage (5.2-13%) was very low. *T. dregeana* had the least while *E. pilularis* the highest shrinkage characteristics. The lower the shrinkage value, the higher the quality of lumber for application. The respective mean tangential, radial, and volumetric swelling characteristics of *E. pilularis* (7.10, 3.63, 11.32%), *E. viminalis* (5.34, 4.34, 10.06%) and *T. dregeana* (4.48, 2.21, 4.86%) lumbers at 12% MC. The rate of tangential shrinkage/radial shrinkage were 2, 1.6 and 2.03 for *E. pilularis*, *E. viminalis and T. dregeana* respectively. The higher this index from the value of one, the higher will be the propensity of the wood to present warping, cracking and splitting during seasoning. According to this result care sould be taken for *E. pilularis* and *T. dregeana* timber species during seasoning.

3. 5. Seasoning defects and possible remedies

Seasoning defects such as cup, bow, twist, end split and checks were observed, though the extent varies with species (Table 2).

Table 2. Seasoning defects.

Timber species	Bow	Cup	Crook/spring	End split	Surface check	End check	Knot
E. pilularis	x	x	x	x	x	x	
E. viminalis	x	x	x	x	x	x	x
T.dregeana	x	x			x	x	x dead knot

Preventions or remedies for seasoning defects indicated below:

Bow and spring: Avoid seasoning low grade material with irregular grain, juvenile wood or reaction wood. **Cup:** Weights or adjustable strapping can minimize this defect. **Distortion**: Pile carefully with correct sticker size and spacing can minimize this defect. Careful control on the uniformity of the thickness of the boards being cut can reduce distortion. **End splitting**: Use end sealants or plastic end cleats. Stickers have to be placed up to the ends of the boards. Use timber shades if strong sunlight or warm winds are likely. **Surface checks**: Modify stacks to retard air circulation that can help to minimize checking. **Internal checking**: Use same measures as for end splits and surface checks. **Twist**: Avoid lumber with spiral, interlocked or irregular grain. In brief, preventions or remedies for seasoning defects: Proper stacking using standard and well-seasoned stickers, end sealants or plastic end cleats, top loading/ adjustable strapping. Boards were piled, handled and conditioned well without direct access of moisture and sunshine to avoid dimensional movement, additional defects, infestation and biodegradation attack***s.*** Seasoned boards were inspected for more than six months and no infestation and biodegradation attack observed.

3. 6. Density characteristics

Mean green, basic and dry density of *E. pilularis*, *E. viminalis and T. dregeana* lumber species at 12% MC were 780, 810 and 530 Kg/m^3, respectively (Table 1). The three lumber species in density at 12% MC categorized light to very heavy. The density of *E. pilulalris* (780 kg/m^3) classified as heavy, *E. viminalis* (810 kg/m^3) classified as very heavy and the density of *T. dregeana* (530 kg/m^3) at 12% MC, classified as light density lumber species. The density of *E. pilulalris* was 740–960 kg/m³ at 12% MC [3] while that of *E.viminalis* was 670–940 Kg/m³ [4]. Comparable lumber species in density values at 12% MC with accuracy of ± 5% were selected with those same method and laboratory [13]. *E. pilularis* was comparable with *Celtis africana, Diospyros abyssinica, Eucalyptus globulus, Eucalyptus nitens, Syzygium guineense* and *Warburgia ugandensis.* Lumber species *Acacia decurrens, Eucalyptus paniculata, Olea welwitschii* were comparable with E. viminalis while lumber species *Albizia schimperiana, Eucalyptus delegatensis, Grevillea robusta* and *Podocarpus falcatus* are comparable with T. *dregeana.*

4. POTENTIAL USES OF STUDY TIMBER SPECIES

E. pilularis, *E. viminalis* and *T. dregeana* timber species have versatile lumber and wood-based products, non-timber forest products and live tree uses/ **cultural aspects.** Based on the results on seasoning, moisture content and density characteristics and references each timber species recommended for the different potential applications/uses accordingly. *E. pilularis* is one of the main hardwoods of Australia, a significant commercial species. It is well regarded by foresters for the high quality of timber, easy regeneration and quick growth. The wood is moderately heavy, with a density of 740–960 kg/m³ at 12% MC, strong, tough and moderately hard, not particularly difficult to work. It can be used as poles, posts, railway sleepers, flooring, panelling, construction, building framework, cladding, joinery, lining boards, furniture, veneer wood chipping and decking. It makes good charcoal and fuel wood.

The *E. viminalis* wood can be used for poles, tool handles, shingles, indoor construction, flooring, boards, paneling, interior trim, joinery, ship and boat building, vehicle bodies, furniture, ladders, sporting goods, veneer, plywood, boxes, crates, particle board and fuel wood [4]. *E. viminalis* as potential source of pulp for paper making compared to pulps from *E. globulus* and *E. grandis*, which are currently the main sources of pulpwood. Pulp from *E. viminalis* had a high strength, high opacity and low porosity. It especially suited for wood free printing, writing papers and specialty papers [4]. The wood contained 44% cellulose, 22% glucuronoxylan and 29% lignin [4, 6, 8]. As non-timber forest products *E. viminalis* is bee forage. Branchlets have been used for weaving. A decoction of the leafy twigs is used in baths against rheumatism in the legs. In Ethiopia, leaves yield 0.8% essential oil, with main components 1, 8-cineole (50.9%), α-pinene (28.2%), globulol (5.1%) and limonene (4.3%). The essential oil content is highest in the summer season, when temperature and humidity are high. The species is planted as an ornamental, shade tree and wind breaks. The trees coppices well and resistant to fire [4]. It is considered as good alternative of *Eucalyptus glubulus* at higher altitudes. It has also good prospects for paper making and as source of cineole –rich essential oil [12].

Trichilia dregeana wood easily worked and very suitable for carving. It is used for furniture and household implements, plywood and veneers, furniture, mortars, joinery, cabinetworks and interior decoration, construction and firewood [5]. As a non-timber forest product, its seeds are edible after removing seed coat and the seed arils are cooked as a vegetable or crushed to yield a milky juice taken as a drink or with side dishes. The seeds are also rich in fat. This fat is being used for soaps, as body ointment and hair oil as well as for cooking [5].

Its seeds, oil, leaves, roots and bark are being used for medicinal purpose. Owing to its attractive nature it makes an effective shade tree. In Ethiopia its commonly used as shade tree in coffee farm. *T. dregeana* is highly ornamental species with considerable cultural and ecological values. Flowers October to December and fruiting between January to May. Tree provides suitable nesting sites for a number of birds.

5. CONCLUSIONS

The Timber species were revealed good lumber characteristics and qualities. They were comparable with many indigenous and home-grown exotic timbers in density, seasoning rate and shrinkage. They have multipurpose lumber and wood-based products, and live trees have ecological uses. These lumber tree species have to be well grown and managed, timber properly sawn, stacked and seasoned to about 12% MC. preferably with kiln seasoning method that can help to minimize seasoning time, defects and shrinkages thereby increase quality. Seasoned lumbers of all study species have to be properly handled and rationally utilized at specified MC and density for intended construction and furniture purposes. Lumber species namely *E. pilularis, E. viminalis* and *T. dregeana*, to a certain extent can substitute accordingly comparable and endangered timber species in Ethiopia.

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