Agriculture, Forestry and Fisheries
2013; 2(2): 105-109
Published online April 2, 2013 (http://www.sciencepublishinggroup.com/j/aff)
doi: 10.11648/j.aff.20130202.17

Physical properties of wood in selected lessor known tree species in Botswana

Ronnie Mmolotsi, Kealeboga Kejekgabo

Department of Crop Science and Production. Botswana College of Agriculture. Private Bag 0027, Gaborone, Botswana

Email address:
rmmolots@bca.bw (R. Mmolotsi)

To cite this article:
Ronnie Mmolotsi, Kealeboga Kejekgabo. Physical Properties of Wood in Selected Lessor Known Tree Species in Botswana, *Agriculture, Forestry and Fisheries*. Vol. 2, No. 2, 2013, pp. 105-109. doi: 10.11648/j.aff.20130202.17

Abstract: A study was carried out to evaluate physical properties of wood of four indigenous tree species. Samples were obtained at random from the logs at a timber and wood processing yard. *Acacia burkea* and S. Africana possess heartwood that is distinctly different in colour from the sapwood. *Acacia burkea*showed very dark colour in the heartwood while that of Spirostachys africana was dark greyish brown in colour. *Wood of P. africanum and Terminelia serecia* displayed no distinctly different colours between the sapwood and the heartwood. Density also varied in different woods with the highest density values recorded at 0.97 g cm^3 in the *A. burkea*and the lowest was 0.70 g cm^3 in *P. africanum*. There were significant differences in densities between wood of all these species. The highest change in dimensions was recorded in the tangent side of all woods except for *A. burkea. The* highest dimensional changes were recorded at 9.02± 4.02 percentin the tangent side of *P. africanum*. The lowest dimensional changes were recorded at 0.41±0.08 percent in the longitudinal section of the *P. africanum*wood. Overall the lowest changes were recorded in the longitudinal side of wood.

Keywords: Wood, Density,Moisture, Shrinkage, Botswana

1. Introduction

Majority of timber products consumed in Botswana are imported from neighbouring South Africa and Zimbabwe with very little coming from local forests.Wood imports account for 2.7% of the total imports into the country [1]. Botswana does not harvest and export raw timber. Natural forests in Botswana make only 2% of the natural woodlands. Botswana forests are within the miombo woodlands and are managed to support local people at subsistence level. The forests also support wildlife and are managed for carbon sequestration. However round wood is utilized to a large extend within the country and used at household level to make for construction of traditional houses, fencing, furniture making, household utensils and decorative artifacts.

Wood processing in Botswana is carried out at four levels. At the highest level is the large scale timber workshops utilizing raw round timber source large of such materials from neighbouring Zambia, South Africa, Zimbabwe and Mozambique. The majority of these industries are located within the major cities. Such industries are reported to consume50, 000 m^3 per annum on average of round wood[1]. The second category is made largely of small scale and operated by Bazezuru communities and these recycle wood products in the market. Products such as pallets are recycled to make animal housing and other structures. These are sold within the local market.The third category is the local community that harvests timber and consumes within the household. Locals use simple tools and rudimentary methods to process the timber. Processed wood here is used for various purposes such as pillar and trusses in construction, fence erection and for biomass energy. Timber quantities harvested and used at household levels however have not been quantified in Botswana. The four and last category is the local workshops. Only one local wood workshop exists in Botswana and it utilizes home grown timber as a source of raw material. Local wood workshop in this case is defined as workshop owned by locals in the rural communities and using locally sourced round wood. The locally sourced round wood includesdead standing trees and trees removed from construction sites. Tree species utilized within the workshop include *Terminelia serecia, Acacia burkea*, *Spirostachays africana*, *Peltophorum africanum.* And their products are marketed and sold within the local community and within the country with the view to export in future within the African Growth and Opportunity Act (AGOA) markets[2].Pieces of the furniture products from a local workshop are shown in figure 1.Very little is known about properties of timber that is processed and used in local workshop.

Figure 1. *Chairs from a local industry made from Acacia burkea (left) and Spirostachys africanawood (right).*

Several publications in the literature report the physical characters of local wood species[3, 4]. These included species such as *Pterocarpus angolensis (mukwa)* and *Baikeaea plurijuga*(mukusi). *P. angolensis and B. plurijuga*species were previously exploited at a commercial level in most countries in southern Africa. However, lesser known timber tree species utilised at lower levels in Botswana have very little or no information known about their physical and mechanical properties. Lack of such information limits their exploitation for commercial purposes.

Species tested in this study included Acacia burkea (mokgwa), *Spirostachys africana* (morukuru), *Peltophorum africanum* (mosetlha) and *Terminelia serecia* (mogonono). These species, except for *P. africanum* have traditionally been used for construction of different structures within households. *P. africanum* has been considered to be inferior for any use including use for firewood in the Tswana communities. However, recently wood of this species is used in furniture making and firewood due to the decline in more valuable trees in the vicinities of cities and large villages.. The purpose of this study was therefore to evaluate physical characteristics of wood of these species. Important physical properties in wood include colour, moisture and density.

Colour is an important part of wood and influences the attractiveness of wood. Colour of wood is determined by both geneticand environmental factors resulting in variations between and within species [5, 6]. Extractives within wood influence the possible differences in colour between the heartwood and the sapwood resulting in heartwood that is generally darker in colour compared with sapwood[6]. Discolouration due to different factors in standing trees also influence colour patterns in wood. Pests, diseases and debarking animals may cause exudation of resins causing discoloration of parts of the wood.

Wood density is an important indicator of strength in wood. Heavy woods tend to be strong where the reverse is true. Wood density also affects the workability of wood [7]. Heavy woods require large quantities of energy to transport, to work in the mill and finally expensive and robust blades to cut. Very light wood on the other hand may be difficult to work resulting in split ends in planks. Wood density values for different types of wood havebeen well researched and reported in the literature [8, 6, 9, 10]. In the sub-Saharan Africa, a number of commercially exploitable species have been studied and their density values reported in the literature [3, 4, 17]. This property is affected by a number of factors which are genetic and environmental.In sub-Saharan Africa, studies on properties are scanty especially in lessor known timbers that have reached little of the local market and none of the regional markets.

Wood hygroscopicity is an important property of wood that is in use [7]. Several publications have reported the shrinkage and swelling of wood of different tree species [11, 12, 13, 14]. It is reported that change in size due moisture is highest in the tangent section, moderate in the radial section and lowest in the longitudinal direction [7]. Shrinkage values of about 15% in the tangent side of wood have been reported in literature [13]. Change in size due to moisture is important in wood that is in use such as in wood joints, doors and structural timber and have to be maintained with low changes in dimensions during use. Change in wood size due to moisture movement will affect joints, metalfasteners and general use of wood. Wood used as doors without proper coating absorbs moisture, swells and make it difficult to open and close.Minimum changes in moisture results in minimal associated defects in wood [7].

2. Methods

2.1. Sample Collection and Preparation

Wood samples of *Terminelia serecia, Acacia burkea*, *Spirostachays africana*, *Peltophorum africanum*were collected at random from different parts of the stem to assess colour and density from a local wood workshop. The timber has already been harvested and was air seasoned at the workshop site. Stems used were obtained from different farms as available. Clear wood samples measuring 20 by 20 by 300 mm were obtained from the air dried logs. Subsamples, measuring 20 by 20 by 10 mm were further obtained from these to assess air dry weight density

2.2. Density

The samples were further dried in the oven at 100 °C for 24 hours and then weighed and the dimensioned measured using a digital calliper. The mass was divided by the calculated volume to obtain the density using the formula 1 below:

$$P = \frac{m}{v} \quad (1)$$

Where, P is density (kg m^{-3}), m is mass (kg) and v is volume (m^3)

2.3. Colour Assessment

Colour was assessed in the sapwood and heartwood of each wood sample using the Munsell colour chart [14]. Wood samples were matched with different colours in the book and the colours and colour codes recorded.

2.4. Swelling of Wood

Wood swelling was assessed in wood. Wood samples of dimensions of approximately 20 by 20 by 20 mm were exposed to water in a container after measuring the longitudinal, tangent and radial dimensions at oven dry weight. Samples were measured again after exposure to moisture to evaluate the swelling.Sample sizes were measured using a digital calliper. Each side of the sample was measured at the centre. Swelling percentage was calculated for wood samples of each tree species using the formula 2 below.

$$Sw\ (\%) = 100\ \left[\frac{Wet\ dimensions - dry\ dimensions}{Dry\ dimensions}\right] \quad (2)$$

Where Sw – percent wood swelling

3. Results and Discussion

3.1. Colour

Spirostachys africana and *Acacia burkea* displayed distinctly different colours between the heartwood and the sapwood. The heartwood in *A. burkea* showed a deep dark brown colour with hue 10YR, 2/2 while the sapwood was pale to high yellow with a hue 10YR 6/3. In *S. Africana* wood dark greyish brown colour with hue 10YR, 3/2 and pale brown with a hue 10YR between 7/3 and 7/4 sapwood [14]. Variations in colour between the heartwood and the sapwood have been reported [6]. Such variations were also reported between heartwood and sapwood in *P. angolensis* (Mmolotsi *et al*, 2009). Difference in colour between the heartwood and the sapwood and this variation may be due to deposition of extractives in the heartwood of this species. Heartwoods of a number of tropical timbers were reported to be brown in colour and distinctly different from the sapwood in colour. Wood of *P. africanum* displayed weak red to red colours with a hue 10R, 4/3, 4/4, 4/5 and 4/6.*T. serecia* wood was light yellowish brown with a 2.5Y ranging between 6/3 and 6/4. There were nodistinct differences in colour between the heartwood and the sapwood in *T. serecia*. Wood of *Boscia albatrunca* and B. *foetida* are reported to lack differences in colour between sapwood and heartwood.

3.2. Density

Acacia burkea displayed the highest wood density and the lowest density was determined in the wood of *P. africanum* (Table 1). There was a significant difference in basic wood density between wood of the different species (F. 17.07). There were significant differences in wood density between the heartwood and sapwood in *A. burkea* and *S. africana* species. The differences may be extractives deposited in the heartwood. During wood transformation from sapwood and heartwood, wood generally increases in density. Figures 2 and 3 showed differences in basic density between the sapwood and heartwood in *A. burkea* and *S. africana*. The change in weight is generally due to deposition of extractives such as phenols and quinines [15]. These also result in enhanced durability of wood [16]. Literature has reported such variations in basic densities in different species. Density values of different wood species are shown in Table 2.

Table 1. Descriptive data on density of wood

	T. serecia	P. africanum	A. burkea	S. africana
Mean	0.75	0.70	0.97	0.84
Standard Error	0.01	0.03	0.027	0.04
Standard Deviation	0.04	0.06	0.08	0.12
Minimum	0.67	0.65	0.87	0.64
Maximum	0.81	0.82	1.07	0.98
N	11	6	9	10

***Table 2**. Density values have been reported in literature and these show a large variation in the different species.*

Species	Density values	Author
	480.6 to 784.9 kg/m3	
Pterocarpus angolensis	511±5.82 kg m^{-3} heartwood	[17]
Pterocarpus angolensis	405±12.11 kg m^{-3} sapwood	[4]
Alnus rubra	460±0.006 kg m^{-3}	[10]
Acer pseudoplatanus	650±0.007 kg m^{-3}	[10]

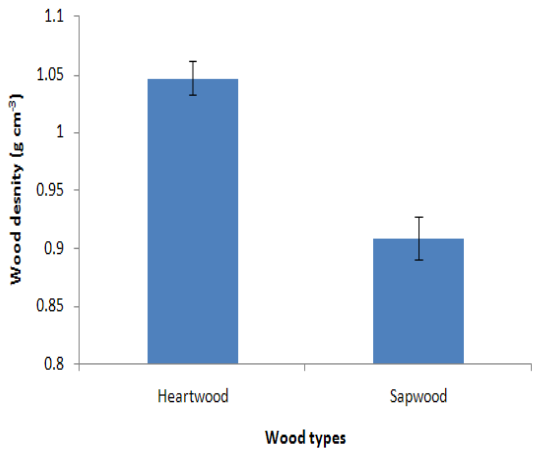

***Figure 2.** Heartwood versus sapwood in Acacia burkeadensity.*

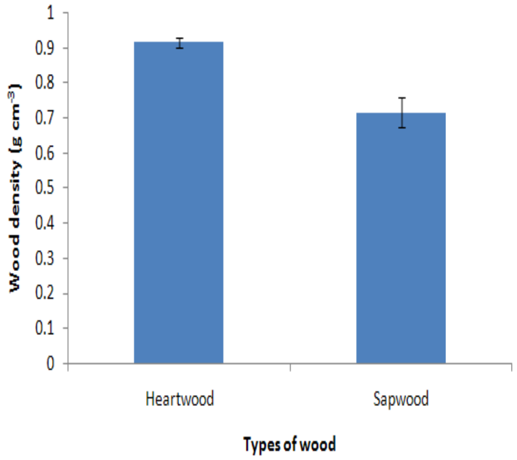

Figure 3. *Heartwood versus sapwood density in Spirostachys africana.*

3.3. Moisture Movement

Swelling was measured in different directions and results are shown in table 3.The highest swelling was calculated in the tangent side in wood of *Peltophorum africanum* and the lowest swelling was measured in the *Acacia burkea* (Table 2). Swelling has been reported in the literature with the highest values recorded the lowest swelling was determined in the longitudinal section ranging between 0.41% in wood of *P. africanum* and 0.44% in wood of *S. africana*. Moisture movement in wood is known to be highest in wood with low density and low in high density wood. This is attributed to the fact low density wood generally has high pore space that will absorb more moisture. Wood with high density possess generally possess low pore space which absorbs less moisture [7]. Different swelling rates reported in the literature. Wood of *Eucalyptus camadulensis* and *E. globulus* crosses yielded the highest densities in tangent side with the highest value of 12.7% and the lowest values in the longitudinal section at 0.2% [14].

Table 3. *Wood swelling in the different sides of wood*

Wood species	Tangent	Radial	Longitudinal
P. africanum	9.02±4.02	1.95±0.2	0.41±0.08
A.burkea	1.95±0.15	1.93±0.13	0.42±0.06
S. africana	2.12±0.63	2.09±0.24	0.44±0.21
T. serecia	2.02±0.4	1.5±0.13	0.42±0.04

4. Conclusion

The four different woods species tested showed good physical characteristics. Wood of *A. burkea* was very heavy. Use of this wood may result in household furniture that is heavy making it difficult to move. This may also result in reduced workability. The other species displayed high to average densities. *S. africana* and *A. burkea* had varied colour between the heartwood and sapwood. *P. africanum* and T. *serecia* did not have distinct colour variations between the heartwood and the heartwood. Swelling and moisture loss in wood was found to be within a range below 10%. Overall, the four species may be used to make furniture, with *A. burkea* used in a limited amount to reduce the total weight of individual furniture pieces.

References

[1] Stats Bots (2013). Botswana international merchandise trade statisticsmonthly digest - December 2012. www.cso.bw. Accessed 04/03/2013

[2] Kejekgabo, K. (2012). Personal communication

[3] Ali, A. C., Uetimane, Jr, E., Lhate, I. A. and Terziev, N. (2008). Anatomical characteristics, properties and use of traditionally used and lessor known wood species from Mozambique: a literature review. *Wood Sci. Tech*, 42: 453 – 472

[4] Mmolotsi, R., Lumbile, A., Kwerepe, B. C., Kopong, I., Rampart, M., Segwagwe, A., Sebolai, B., Lekorwe, L. and Maphane, T. (2011). Effect of sap deposition on properties of sapwood in *Pterocarpus angolensis* (Mukwa) following bark stripping by elephants in Chobe forest reserves in northern Botswana. *Bots. J. of Agric. and Appl. Scie.*, 7(1), 107 - 111

[5] Climent, J., Gil, L. and Pardos, J. (1993). Heartwood development and its relationship to growth and environment in *Pinus canariensis* Chr. Sm ex DC. *For. Ecol. Man*, 59, 163 - 174

[6] Knapic, S., Tavares, F. and Pereira, H. (2006). Heartwood and sapwood variation in Acacia melanoxylon R. Br. Trees in Portugal. *For.*, 79(4), 371 – 380.

[7] Desch, H. E. and Dinwoodie, J. M. (1996). Timber: Structure, Properties, Conversion and Use. 7th edition. Macmillan Press, London

[8] Barbosa, R. I and Fearside, P. M. (2004). Wood density of trees in open savannahs of the Brazilian Amazon. *For. Ecol an.d Man*, 199, 115 – 123.

[9] Mmolotsi, R. (2004). Potential Uses of *Alnus rubra* in Silvopastoral Systems. PhD Thesis, University of Wales

[10] Mmolotsi, R. M. and Teklehaimanot, Z. (2006). The effectof initial tree-plant density on timber and wood-fuel properties of red alder and sycamore. *Canadian J. For. Res.*, 36, 1475 – 1483

[11] Chafe, S. C. (1994). Relationship between shrinkage and specific gravity in the wood of eucalyptus. Aust. For., 57, 59 – 61.

[12] Chowdhury, Md, Q., Manzoor Rashid, A. Z. M., Newaz, Md S. and Alam, A. (2007). Effect of height on physical properties of wood of jhau (*Casuarina equisetifolia*). Aust. For., 70(1), 33 – 36.

[13] Innes, T. C. (2005). Processing and material properties of Tasmanian yellow gum, Eucalyptus johnstonii. Aust. For., 68(2), 121-125

[14] McComb, J. A., Meddlings, R. A., Siemon, G. and Davis, S. (2004). Wood density and shrinkage of five-year old *Euca-*

lyptus camadulensis x *E. globulus* hybrids: a preliminary assessment. *Aust. For.*, 67 (4), 236-239.

[15] Kokutse, A. D., Bailleres, H., Stokes, A. and Kokou, K. (2004). Proportion and quality of heartwood of Togolese teak (*Tectona grandis* LF). For. Ecol. Man., 189: 37 – 48.

[16] Searle, S. D. and Owen, J. V., (2005). Variation in basic wood density and percentage heartwood in temperate Australian *Acacia* species. Aust. For., 68(2): 126 – 136.