# EFFECT OF WOOD-DEGRADING FUNGI ON MECHANICAL PROPERTIES OF *Boscia angustifolia* (A. RICH) WOOD

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## ABSTRACT
*Lesser-used wood species are gradually becoming commercially important due to an economic loss resulting from wood degrading fungi and thus reducing quality of grade of timber. This study therefore investigated the influence of wood-degrading fungi on mechanical properties of lesser-used wood of Boscia angustifolia. The weight loss and mechanical properties of the B. angustifolia wood after exposure to brown and white rot fungi (Sclerotium rolfsil and Pleurotus ostreatus) respectively for 16 weeks were measured. Data collected were subjected to analysis of variance at $_{0.05}$. The results revealed that B. anguistifolia could be classified as non-durable wood since its average weight loss was 16.47% and 14.16 % for brown and white fungus respectively. The pooled mean for the initial MOE and MOR of the wood samples were 6291.33 Nmm$^2$ and 46.44 Nmm$^2$ respectively while the MOE after exposure to Sclerotium rolfsil and Pleurotus ostreatus was 617.08 and 627.78 Nmm$^2$ and MOR of 24.47 and 19.54 Nmm$^2$ respectively. The results indicated that the bending strength properties of B. anguistifolia wood reduced significantly ($P<0.05$) due to activities of the fungi when compared with initial MOE and MOR of the wood before inoculation. Consequently, there is a need to preserve B. anguistifolia wood using suitable preservatives against wood-decaying fungi.*

***Keywords:*** *Boscia anguistifolia, Sclerotium rolfsil, Pleurotus ostreatus, modulus of rupture, modulus of elasticity, weight loss*

## INTRODUCTION
Wood is a heterogeneous material and its composition and structure differs depending on the species, individual, and location in the tree (Young and Rowell, 1986). The wood used as a raw material in structural work originates usually from either softwood or hardwood trees. the diversity of wood structure is high, it always consists mainly of cellulose, hemicelluloses and lignin together with extractives. The hemicelluloses and lignin which form the main strength of wood. The lignin component is associated with compressive strength of wood and it plays the role of binding other components together while cellulose is linked with the tensile and bending strength of wood acting like a building block acts like sand and rubble (Gabrelli, 2000; Bon and Ferrara, 2007). According to Barnett and Jeronimidis (2003), any change that affects lignin and cellulose contents affect both chemical and mechanical properties of wood. Reduction of wood strength occurred when degradation of hemicelluloses component such as arabinose and galactose occurred (Winandy and Morrell, 1993; Curling, *et al.*, 2002a).

Wood-degrading fungi often belong to the *Basidiomycetes* class and they destroy cell wall components; including cellulose, hemicellulose, and lignin, that make up the woody portion of a tree (Malakani, *et al.*, 2014). Depending on the organism, decay fungi can destroy the living (sapwood) or the central core (heartwood) part of the tree. White rots fungi break down lignin and cellulose, and commonly cause rotted wood to feel moist, soft, spongy, or stringy and appear white or yellow. The brown rots fungi primarily decay the cellulose and hemicellulose (carbohydrates) in wood, leaving behind the brownish lignin (Downer and Perry, 2019). Scholars such as Malakani, *et al.* (2014); Bari, *et al.(*2015) reported effect of different fungi on the mechanical properties including compression strength parallel to the grain, Brinell hardness perpendicular to tangential and radial surfaces among others.

Consequently, many lesser-used wood species are becoming commercially important due to an economic loss resulting from wood decay which actually brings about reduction in the quality of grade of timber.

*Boscia angustifolia* is a small evergreen tree of 10 –15m tall that is found in Nigeria and in deciduous wood bush land in West Africa countries like southern Mauritania, Senegal and Gambia eastward to Somalia and southward to northern South Africa. It usually grows in sites such as hills, laterite outcrops and cliffs and sometimes dry riverbeds (Hassan *et al*., 2007). The wood is hard and used for charcoal production for gun powder. Also, it is used in carpentry and for making vessels for water storage (Orwa *et al*., 2009). Being a lesser used wood, there is shortage of information on the durability of the wood against wood decaying fungi. It is therefore important to investigate the durability of *Boscia angustifolia* against fungi before choosing it as a replacement for other known wood species for structural applications.

## MATERIALS AND METHODS

### Materials source and preparation of test samples

Two trees of *Boscia angustifolia* were harvested from Onigambari Forest Reserve, Oyo state, Nigeria. Taking into account stem straightness and absence of obvious decay, they were selected based on defect-free, clear, and normally grown (without zone lines, reaction wood, decay and insect damage, or fungal infection).

The method for the preparation of test samples followed the work of Ogunsanwo and Onilude (2002) as described by Adebawo, *et al.* (2019). The trees were felled and converted to three bolts from 50cm in length from the base. The three bolts were collected from the top (90%), middle (50%) and base (10%) of the merchantable lengths of the trees. The bolts were partitioned into three equal zones, namely inner wood, middle wood and outer wood along the radial planes. The test samples were converted to standard sizes of 20 mm X 20 mm X 300 mm and 20 mm X 20 mm X 60 mm in the wood workshop of Department of Wood and Paper Technology, Federal College of Forestry, Ibadan according to the British Standard BS373 (1989).

### Accelerated Decay Test (BS EN 350)

The white rot fungi (*Pleurotus ostreatus*) and brown rot (*Sclerotium rolfsil*) were obtained from Pathology Department, Forestry Research Institute of Nigeria, Ibadan Oyo State Nigeria. The fungi were cultured using Potato Dextrose Agar as the culturing medium. 40ml of PDA was poured into McCartney bottles and sterilized by autoclaving at 0.1N/mm$^2$ (120 °C) for a period of 20 minutes. The medium was inoculated with the test fungi within 6 days after preparation of the bottles (Sarker, *et.al.*, 2006).

The wood specimen was infected by placing them in the bottles in which there were actively growing cultures of the test fungi and then incubated at room temperature (27±2$^0$C) in the laboratory for 16 weeks. At the end of incubation period, the blocks were removed from the culture bottles, cleaned and oven dried at 103±2$^0$C to constant weight (Sarker, *et. al,* 2006).

Percentage weight loss of each sample was calculated using equation 1.

$$\%\ \text{Weight Loss} = \frac{T_3 - T_4}{T_3} \times 100 \quad \%\text{Weight loss} = \ldots\ldots\ldots\ldots \qquad (1)$$

$T_3$ =weight of test block after treatment.

$T_4$ = weight of test block after exposure to fungi attack.

According to Findlay, (1985) as described by Olfat, *et al.* (2007) and Malakani, *et al.* (2014), the classification was used for natural durability. This was considered in order to classify and determine the durability of wood. However, the natural durability of wood species was grouped according to the weight loss (Table 1).

**Table 1:** Typical service life criteria for the evaluation of durability on wood species and mass loss criteria of laboratory durability test (wood blocks)

| Natural durability or decay resistance class | Laboratory tests mass loss (%) |
|---|---|
| 1. Very durable | 0, or negligible |
| 2. Durable | <5 |
| 3. Moderately durable | 6-10 |
| 4. Non-durable | 11-30 |
| 5. Perishable | >30 |

**Source:** Findlay (1985)

### Mechanical Test

The mechanical properties (static bending) of *Boscia angustifolia* wood after exposure to fungi decay were carried out at Forest Products Development and Utilization (FPD&U), Forestry Research institute of Nigeria (FRIN). The tests were performed on the wood samples at 12 % MC using universal testing machine - manufactured by Jinan Hensgrand Instrument Co., Ltd. Jinan, China with model number WDW-50. The measurement accuracy was ±0.01 mm for position, ±0.1 % for speed and ±0.5 % for loading. The properties measured were Modulus of rupture (MOR) and Modulus of Elasticity (MOE).

## STATISTICAL ANALYSIS

The statistically significant differences that exist in the mean weight loss values of *B. anguistifolia* wood against brown and white-rot fungus and mechanical (static bending – MOR and MOE) were tested using the analysis of variance. All comparisons were made using Duncan Multiple Range Test (DMRT) at statistical levels of $\alpha_{0.05}$

## RESULTS AND DISCUSSION

The weight loss of *Boscia anguistifolia* wood after exposure to *Sclerotium rolfsil* and *Pleurotus ostreatus* for 16 weeks is presented in Table 2. The percentage weight loss of *B. anguistifolia* ranged from 11.68 % - 17.92 % and 11.37 – 16.07% for *S. rolfsil* and *P. ostreatus* fungi respectively along the axial position with a decreasing pattern observed from top(16.47±1.67) and (14.16±0.35) to base (14.74±1.59) and (13.33±0.82) and for *S. rolfsil* and *P. ostreatus* respectively along the bole of the tree as presented in Table 2. The top of the sampling height of the *B. anguistifolia* wood species has the highest weight loss with pooled mean of 16.47 and 14.16 % for *S. rolfsil* and *P. ostreatus* fungi respectively. The base portion of the wood has the lowest weight loss values 13.32 % and 12.52 % for *B. anguistifolia* as caused by brown and white fungi. All portion of the wood (top-middle, inner-wood, middle-wood and outer-wood) also had a weight loss. Meanwhile, the results of the analysis of variance indicated that the *S. rolfsil* and *P. ostreatus* fungi had a significant effect on the weight loss of the *B. anguistifolia* wood (P< 0.05) as presented in Table 2.
However, since the pooled mean weight loss of decayed *B. anguistifolia* wood caused *S. rolfsil* and *P. ostreatus* was 14.74 % and 13.33 % respectively as presented in Table 2, *B. anguistifolia* wood is placed into non-durable wood class as indicated in Table 1 (Messner *et al.,* 2003). Although, Adebawo *et al*., (2019) reported that *B. angusitifolia* is moderately durable by other deteriorating agents such ad termite during graveyard test. The proportion of heartwood to sapwood of *B. anguistifolia* wood might made it more resistance to decay. In that the toxic extractives in the heartwood of *B. anguistifolia* have a slight effect on natural durability against the brown and white fungus. Olfat *et al.* (2007) reported that the weight loss of *Fagus orientalis* wood samples was of 42.20 % after incubation with *Coriolus versicolor* fungus for 16 weeks. Malakani *et al.,* 2014, reported that highest weight loss of 36.08% was observed for sapwood samples of *Fagus orientalis* and the heartwood samples *Fagus orientalis* had the lowest value of 32.98% when exposed to white rot fungus.

**Table 2: Weight loss of *B. anguistifolia* wood due to fungi attack**

| Sampling Height | Radial Position | Basidiomycete fungi | |
|---|---|---|---|
| | | ***Sclerotium rolfsil*** **(%)** | ***Pleurotus ostreatus*** **(%)** |
| Top | Core | 17.89±0.36[c] | 14.06±0.92[b] |
| | Middle | 16.88±0.56[b] | 14.55±2.18[b] |
| | Outer | 14.63±2.39[a] | 13.88±4.42[ab] |
| | **Mean** | **16.47±1.67** | **14.16±0.35** |
| Middle | Core | 11.68±0.86[a] | 11.37±0.81[a] |
| | Middle | 17.92±9.61[c] | 16.07±1.51[c] |
| | Outer | 13.48±0.14[b] | 12.53±1.05[ab] |
| | **Mean** | **14.33±3.23** | **13.32±2.45** |
| Base | Core | 12.09±2.15[a] | 12.05±0.45[b] |
| | Middle | 13.74±1.15[ab] | 11.85±0.93[a] |
| | Outer | 14.12±4.65[bc] | 13.65±0.01[bc] |
| | **Mean** | **13.32±1.08** | **12.52±0.99** |
| **Pooled Mean** | | **14.74±1.59** | **13.33±0.82** |

*Mean Value ± Standard Error; Number carry different letter in column are significantly different from each other (P≤0.05)*

**Mechanical Test**

The initial static bending - Modulus of elasticity (MOE) and Modulus of rupture (MOR) of the *B. anguistifolia* wood before inoculation were presented in Table 3 and 4, respectively, to compare the level of degradation that occurred. The pooled mean MOE and MOR was estimated to be 617.08 $Nmm^2$ and 627.78 $Nmm^2$ and 24.47 $Nmm^2$ and 23.55 $Nmm^2$ for *S. rolfsil* and *P. ostreatus* fungi respectively as presented in Table 3 compared with initial MOE and MOR estimated to be 6291.33 $Nmm^2$ and 46.44 $Nmm^2$ respectively as presented in Table 4. However, it was also found that the rates of deterioration by fungus are inconsistent in radial positioning (core wood, middlewood and outerwood) whereas at the top of sampling height experienced an increase from top to base and also a decrease from top to base for *Boscia* wood before and after inoculation respectively. The highest MOE and MOR of degraded *B. anguistifolia* were 673.13$Nmm^2$ and 729.84$Nmm^2$; 33.07$Nmm^2$ and 25.94 $Nmm^2$ as caused by *S. rolfsil* and *P. ostreatus* fungi respectively while the base of the sampling height had the lowest MOE and MOR 588.65 $Nmm^2$ and 551.32$Nmm^2$; 14.45$Nmm^2$ and 12.09 $Nmm^2$ (Table 3 and 4). There were significance differences between initial MOE and MOR of *B. anguistifolia* when compared with the degraded *Boscia* wood as caused by the fungi likewise also at the sampling height and radial. This implies that the activities of fungi differ in term of deterioration. The exposure of *B. anguistifolia* wood samples to *S. rolfsil* and *P. ostreatus* fungi caused weight loss and reduction in strength properties of the wood after 16 weeks. Fungal degradation alters the microstructure (Bader *et al.,* 2012) and, thus, causes changes in the mechanical properties (Wilcox, 1978; Curling, *et al*., 2001 Curling *et al.,* 2002b; Clausen and Kartal, 2003).

According to Winandy and Rowell, (2005) that changes in temperature, pressure, humidity, pH, chemical adsorption from the environment, UV radiation, fire, and biological degradation (fungi) can have significant effects on the strength of wood. Similarly, Hashemi *et al.,* (2010) reported a decrease in the mechanical properties of poplar wood samples. In the same vein, Malakani *et al.,* (2014) and Bari *et al.,* (2015) also reported deteriorating effects on the mechanical properties and chemical composition as that caused by *Coriolus versicolor* and *Trametes versicolor* respectively.

**Table 3: Modulus of Elasticity (MOE) of *B. anguistifolia* wood exposed to fungi attack**

| | | MOE ($Nmm^2$) | | |
|---|---|---|---|---|
| **Sampling Height** | **Radial Position** | **Initial MOE (Before Inoculation)** | ***Sclerotium rolfsil*** | ***Pleurotus ostreatus*** |
| Top | Core | 4204.91±807.00$^c$ | 476.31±197.60$^a$ | 607.91±178.79$^b$ |
| | Middle | 5939.64±3489.04$^c$ | 707.68±512.77$^{ab}$ | 708.84±230.82$^b$ |
| | Outer | 3502.45±678.48$^c$ | 835.40±198.99$^a$ | 872.78±125.91$^b$ |
| **Mean** | | **4549.00±1254.50** | **673.13±148.61** | **729.84±109.15** |
| Middle | Core | 6102.03±2543.14$^c$ | 539.80±215.32$^c$ | 674.69±57.33$^b$ |
| | Middle | 5027.66±0.00$^c$ | 453.32±30.80$^b$ | 355.33±101.42$^c$ |
| | Outer | 5070.513±097.67$^b$ | 775.29±179.67$^a$ | 775.29±179.66$^a$ |
| **Mean** | | **5400.07±608.30** | **589.47±141.93** | **601.77±112.80** |
| Base | Core | 9867.84±1667.19$^c$ | 730.11±311.48$^b$ | 502.51±116.48$^a$ |
| | Middle | 8889.29±200.96$^c$ | 465.96±50.66$^a$ | 494.20±91.86$^b$ |
| | Outer | 8019.05±4965.19$^c$ | 569.89±254.64$^a$ | 657.22±76.13$^b$ |
| **Mean** | | **8925.39±2277.78** | **588.65±205.59** | **551.31±74.97** |
| **Pooled Mean** | | **6291.33±1380.19** | **617.08±148.61** | **627.78±109.15** |

*Mean Value ± Standard Error; Number carry different letter in row are significantly different from each other ($P \leq 0.05$)*

**Table 4: Modulus of Rupture (MOR) of *B. anguistifolia* wood exposed to fungi attack**

| Sampling Height | Radial Position | MOR (Nmm$^2$) | | |
|---|---|---|---|---|
| | | Initial MOR (Before Inoculation) | *Sclerotium rolfsil* | *Pleurotus ostreatus* |
| Top | Core | 50.351±1.52$^c$ | 27.79±2.34$^b$ | 20.79±1.74$^a$ |
| | Middle | 54.09±3.60$^c$ | 30.98±4.56$^b$ | 23.89±2.54$^a$ |
| | Outer | 65.23±0.00$^c$ | 40.45±5.10$^b$ | 33.14±3.56$^a$ |
| **Mean** | | **56.56±1.71** | **33.07±3.24** | **25.94±6.42** |
| 6Middle | Core | 49.76±0.00$^c$ | 27.29±2.34$^b$ | 21.30±2.85$^a$ |
| | Middle | 45.84±0.00$^c$ | 23.96±2.16$^b$ | 17.05±1.56$^a$ |
| | Outer | 48.75±6.73$^c$ | 26.43±2.67$^{ab}$ | 23.46±2.37$^a$ |
| **Mean** | | **48.12±2.03** | **25.89±1.73** | **20.60±1.23** |
| Base | Core | 35.34±5.64$^c$ | 15.04±1.20$^{ab}$ | 12.33±0.97$^a$ |
| | Middle | 32.26±0.00$^c$ | 12.42±1.05$^{ab}$ | 10.77±1.68$^a$ |
| | Outer | 36.34±0.00$^c$ | 15.89±1.65$^{ab}$ | 13.16±1.67$^a$ |
| **Mean** | | **34.65±2.13** | **14.45±1.80** | **12.09±1.76** |
| **Pooled Mean** | | **46.44±1.96** | **24.47±2.25** | **19.54±3.16** |

*Mean Value ± Standard Error; Number carry different letter in row are significantly different from each other (P≤0.05)*

## CONCLUSION

This study evaluated the effect of wood-degrading fungi on *B. anguistifolia*, a lesser used wood species using weight loss and their selected mechanical properties. It is evident that from the study that *S. rolfsil* and *P. ostreatus* fungi had a significant effect on the weight loss of the *B. anguistifolia***,** the wood species is placed into non-durable wood class based on mass loss criteria of laboratory durability test. The selected mechanical properties of *B. anguistifolia* wood using MOE and MOR also reduced significantly after exposure to brown and white fungi when compared with initial values of MOE and MOR of the wood. Thus, confirming the degradation effect of the fungi on the wood species.

## REFERENCES


Adebawo, F. Ajala, O. Aderemi, T. (2019). Variation of Physical and Mechanical Properties of *Boscia angustifolia* (A. Rich.) Wood along Radial and Axial Stem Portion. *Proligno*15(1): 32-42.

Bader, T.K., De Borst, K., Alfredsen, G. and Bollmus, S. (2012). Changes in Microstructure and Stiffness of Scots Pine (Pinus Sylvestris L) Sapwood Degraded by *Gloeophyllum Trabeum* and *Trametes Versicolor* - Part I: Changes in Chemical Composition, Density, and Equilibrium Moisture Content. *Holzforschung* 66(2):191-198.

Bari, E., Taghiyari, H.R., Mohebby, B., Clausen, C.A., Schmidt, O., TajickGhanbary, M. A. and Vaseghi, M. J. (2015). Machanical properties and chemical composition of beech wood exposed for 30 and 120 days to white-rot fungi" *Holzforschung*, 69(5): 587-593.

Barnett, J.R. and Jeronimidis, G. (2003). "Wood Quality and its Biological Basis", Oxford Blackwell CRC Press, pg. 226.

British Standard 373 (1989). Methods of testing small clear specimens of timber. British Standards Institution, London, UK.

Clausen, C.A., Kartal, S.N., (2003) Accelerated deterioration of brown-rot decay: Comparison of soil block test, chemical analysis, mechanical properties, and immunodetection. Forest Products Journal 53(11/12: 90-94.

Curling, S.F., Clausen, C.A., and Winandy, J.E. (2002b). Relationship between mechanical properties, weight loss, and chemical composition of wood during incipient brown-rot decay. *Forest Products Journal*, 52(7): 34-39.

Curling, S.F., Clausen, C.A., and Winandy, J.E., (2001). The effect of hemicellulose degradation on the mechanical properties of wood during brown rot decay. Document of The International Research Group on Wood Preservation (Stockholm Sweden). Document No. IRG/WP 01-20219, 11 pg.

Curling, S.F.; Clausen, C.A.; Winandy, J.E. (2002a). Experimental method to quantify progressive stages of decay of wood by basidiomycete fungi. *International Biodeterioration & Biodegradation* 49: 13-19.

Downer, A.J. and Perry, E.J. (2019). UCIPM *Pest Notes: Wood Decay Fungi in Landscape Trees.* UC ANR Publication 74109. Oakland, CA.

Findlay, T.P.K. (1985). "Preservation of Timber in the Tropics", Martinus Nijhoff/ Dr Junk Publishers, pg 292.

Hashemi, S. K. H., Latibari, A. J., Eslam, H. K., and Alamuti, R. F. (2010). "Effect of Boric acid treatment on decay resistance and mechanical properties of poplar wood," *BioResources* 5(2): 690-698.

Hassan, S.W., Lawal, M., Muhammad, B.Y., Umar, R.A., Bilbis, L.S., Ebbo, A.A. & Dabai, Y.U. (2007). Isolation and identification of bioactive antibacterial components in root extracts of Boscia angustifolia (Capparidaceae). Journal of Pharmacology and Toxicology 2(4): 366–372.

Malakani, M., Khademieslam, H., Hosseinihashemi, S. And Zeinaly, F. (2014). Influence of Fungal Decay on Chemi-Mechanical Properties of Beech Wood (*Fagus orientalis*). *Cellulose Chem*. *Technol*., 48(1-2): 97-103.

Messner, K., Fackler, K., Lamaipis, P., Gindl, W., Srebotnik, E. (2003). "Wood Deterioration and Preservation", edited by B. Goodell, D. D. Nicholas and T. P. Schultz, American Chemical Society, pg 73-96.

Ogunsanwo O. Y., Onilude M. A. (2000). Specific gravity and shrinkage variations in plantation grown obeche *Triplochiton scleroxylon* K. Schum. *Journal of Tropical Forest Resources* 16:39-44.

Olfat, A.M., Karimi, A.N. and Parsapajouh, D. (2007). Biological Method to Quantify Progressive Stages of Decay in Five Commercial Wood by *Coriolus versicolor*. *Pakistan Journal of Biological Sciences*, 10(6): 1073-1077.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R. and Simons, A. 2009: Agroforest tree Database: a tree reference and selection guide version 4.0, http://www.worldagroforestry.org/af/treedb/

Wilcox, W.W. (1978). Review of literature on the effects of early stages of decay on wood strength, *Wood and Fiber*, 9(4): 252-257

Winandy, J.E., and Morrell, J.J. (1993). Relationship between incipient decay, strength, and chemical composition of Douglas-fir heartwood. Wood and Fiber Science 25(3): 278-288.

Winandy, J. F. and Rowell R. M. (2005). Chemistry of Wood Strength In: Handbook of Wood Chemistry and Wood Composite, Print ISBN: 9781439853801, eBook ISBN: 9781439853818, 10.1201/b12487-15.

Bon, E. P. S. and Ferrara M. A. (2007). Bioethanol production via enzymatic hydrolysis of cellulosic biomass on "The role of agricultural biotechnologies for production of bioenergy in developing countries", FAO seminar, Rome.

Gabrelli, I., Gatenholm, P.G., Glasser, W. G, Jain, R.K, Kenne, L. (2000). Separation, characterization and hydrogel-formation of hemicellulose from Aspen wood. Carbohydrate polymers 43: 367-374.

Young, R. and Rowell, R. (1986). Cellulose: Structure, Modification and Hydrolysis, In: Young, R.; Rowell, R. (Ed.), In: Wiley Interscience, 3-50, ISBN 0471827614, New York