Global Scientific JOURNALS

Age Effect on the Mechanical Properties of acid treated Yushania Alpine Bamboo Species.

Dawit Tessema Ebissa, awwce2005@gmail.com

Ethiopian Institute of Textile and Fashion technology Institute, Bahir Dar University, Ethiopia.

Bamboo has received increasing attention over the last two decades for its economic and environmental values. In Africa, Asia and Latin America, it is closely associated with indigenous culture and knowledge and is widely used for housing, forestry, agroforestry, agricultural activities and utensils. In countries undergoing economic development, traditional bamboo culture gradually disappears. However, industrial development of bamboo is offering a new opportunity to younger generations to retain and continue developing cultural traditions related to the cultivation, harvesting and use of bamboo.

Ethiopia is one of the few countries in the world endowed with a vast bamboo resource base. The country has an estimated one million hectares of natural bamboo forest, 7% of the world total and 67% of the African total. There is large amount of bamboo distributed in both highland and lowland areas including areas not suitable for other plants. And also there is a new species 'jiant bamboo' that is cultivated under amhara agricultural research center. Currently these different bamboo species uses in the country as construction material, for making furniture, and as livestock fodder whereas, their mechanical properties are not characterized yet. Therefore in addition to these bamboo applications for advanced industrial development textile and other energy production all properties have to be characterized for researcher and users. To characterize, first the fiber is extracted with different extraction method.

In this study, Yushania alpine species bamboo fiber at different age is extracted chemically(acid HCl tratment) in different concentration and then test their mechanical properties based on ASTM D3822-07 international fiber testing standard by using FAVIMAT FIBER TEST and finally Analysis the age effect on the mechanical properties of the bamboo fiber.

Key Words: - Bamboo Plant, Yushania alpine species, Mechanical properties, age effect, acid treatment.

1. Introduction

Developing countries those are suited for growing bamboo and aspiring for better welfare and faster rate of development need to produce and utilize such commodities. Ethiopia is known for its large amount of bamboo distributed in both highland and lowland areas including areas not suitable for other plants. And also there is a new species 'jiant bamboo' that is cultivated under amhara agricultural research center. However, unlike other countries, the economic return obtained from these species is very low. Given the role played by bamboo in the global economy, the country has not used it even to its minimal potential[1].in different region of the country the population practices local bamboo for food, charcoal, construction (house, fence) and furniture[2]. Whereas, the extraction and characterization of bamboo fiber is the main duties in the bamboo utilization process for industrial development and energy production as well as for local purpose. Fiber characterization is conducting a series of tests in order to assess its general quality and its specific ability to support a particular application or applications.

2 Bamboo plant

Fig.1 Bamboo plant [3]

Bamboo is a term used to describe a group of large woody grasses (including 1250 species) that normally grow in warm and humid condition. Bamboos are distributed mostly in the tropic, but they can naturally live in subtropical and temperate regions except for Europe. Bamboo has been planted and used by human for thousands of year for many purposes. Bamboo have strong, light and flexible woody stem. Bamboo fibers are used to make paper, textiles and board. In many Asian countries, bamboo shoots of some species as a source of food. In recent years and in the

urge of finding alternative energy source to replace fossil fuel, which is running out of stock, a new way of utilizing bamboo has been added to the list. It is the exploitation of bamboo biomass as a source to produce different type of energy, for instance, electricity and biofuels[3].

3. Ethiopia bamboo species

Ethiopia has the greatest bamboo resources in Africa representing a significant proportion of Africa's total bamboo resources. Ethiopia has more than 1 million hectares of bamboo which is 67% of African bamboo resources and more than 7% of the world total area covered by bamboo is found in Ethiopia. Ethiopia has two bamboo species namely, Yushania alpine (highland bamboo) and Oxytenantheriaabyssinica (lowland bamboo)[4].

Lowland bamboo in Ethiopia grows only in the western part along major river valleys and in the lowlands bordering Sudan and The coverage of lowland bamboo is estimated to be 1,000,000 hectares [4]. The lowland bamboo has enormous importance for the rural society. Because of the shortage of proper woody plants for construction in the lowlands, the lowland bamboo is commonly used as an alternative for timber in house construction, fences and also as fodder for cattle, human food and as energy supply.The highland bamboo on the other hand grows naturally in the south, south-west, central and north-west highlands of Ethiopia and the coverage of the highland bamboo is estimated to be 300,000 hectares[4]. And also there is a new bamboo plant species ‘‘jiant bamboo’’ which is cultivated by amhara agricultural research center.

4. Mechanical properties of bamboo fiber

The mechanical analysis is the study of a material's behavior when subjected to loads. The mechanical properties mainly provided by the cellulose content, which is influenced by many factors such as age, species type and the extraction methods[5].

Table.1 Mechanical properties of India species bamboo fiber at different extraction methods[6].

Sodium Carbonate Concentration (g/L)	Tenacity at maximum (g/den)		
	Natural retting	Acid retting	Alkali retting
0	1.808	2.5479	2.174
5	1.446	2.0266	1.6335
10	1.464	1.8019	1.2602
15	1.4063	1.4962	1.2571
20	1.6005	1.9941	1.8989
30	1.7955	1.978	1.9700

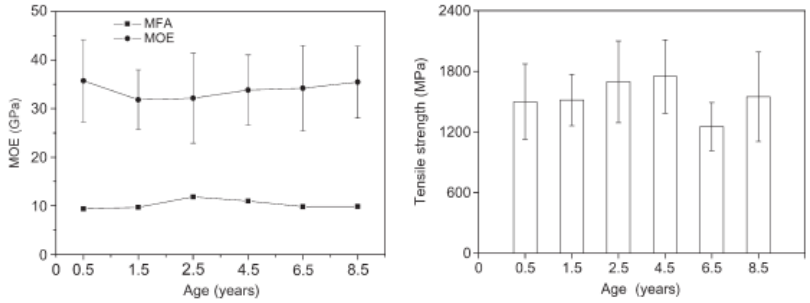

Fig.2 variation of bamboo fiber modulus of elasticity (MOE) and tensile strength with age (Moso bamboo which china bamboo species)[7].

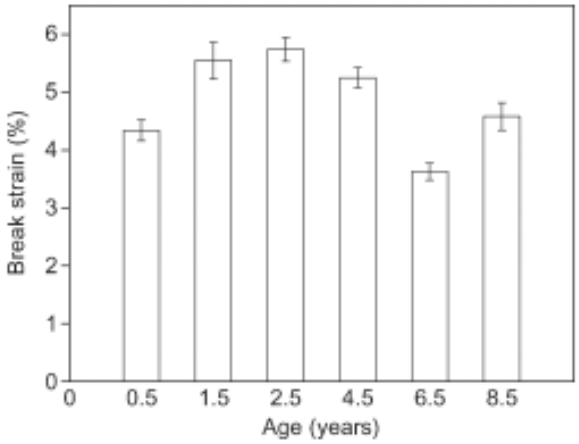

Fig. 3 Variation of bamboo fiber strain with age (Moso bamboo which china bamboo species)[7]

Table.2 Compressive strength and moisture content of Malaysia different bamboo species[8].

Species	Part	Average Compressive Strength (1st Month) (N/mm^2)	Average Moisture Content (%)	Average Compressive Strength (5th Month) (N/mm^2)	Average Moisture Content (%)
Dendrocalamus Asper	Top	68.05	20.83	73.65	15.85
	Middle	61.34	20.57	59.84	17.91
	Bottom	60.23	18.32	53.08	18.44
Bambusa Vulgaris	Top	76.52	15.29	78.74	14.01
	Middle	66.09	17.17	78.67	15.10
	Bottom	60.26	21.43	66.43	19.20
Gigantochloa Scortechinii	Top	69.02	16.09	68.62	15.60
	Middle	57.16	20.29	67.11	16.95
	Bottom	48.26	22.38	59.4	18.09
Schizostachyum Grande	Top	30.42	23.36	40.03	16.87
	Middle	28.32	19.67	31.70	17.98
	Bottom	27.05	20.44	25.77	19.63

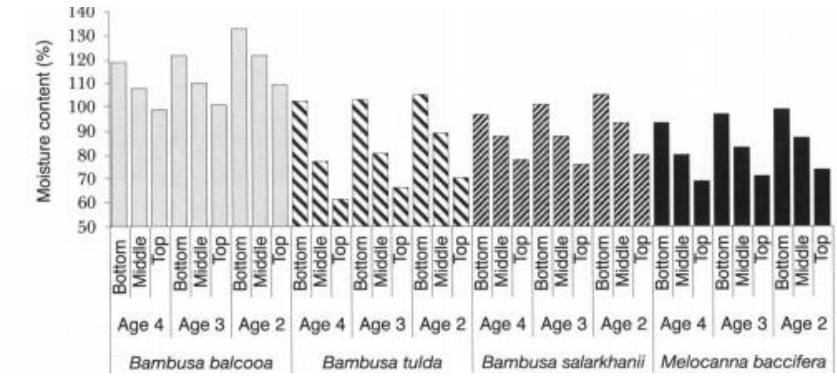

Fig.4 Moisture content of Bangladesh four bamboo species at different height positions and ages[9].

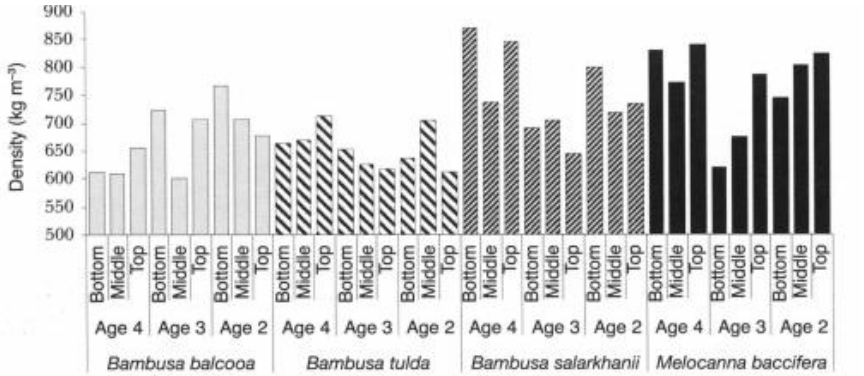

Fig.5 density of Bangladesh four bamboo species at different height positions and ages[9].

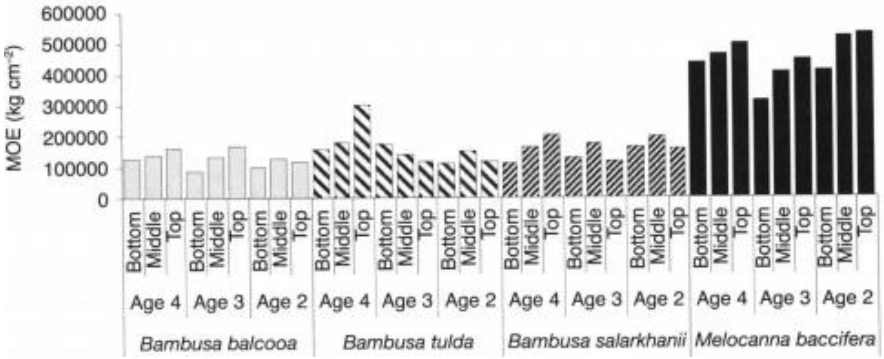

Fig.6 modulus of elasticity of Bangladesh four bamboo species at different height positions and ages [9].

5. Methodology

- ✓ At three different ages (9month, 21month and 33month), at the middle stem around 25 -30 cm length bamboos will prepare and cleave with slicer to remove residual parts.

Fig.7. High land bamboo at different age

- ✓ Cutting the sampling in to strip.

Fig.8. High land bamboo strip

- ✓ Soaking the sample bamboos in acid retting in different concentration

Fig.9. Acid treatment at different concentration

- ✓ From each extraction methods, single bamboo fiber will extract and then characterize their mechanical properties (tensile strength, modules of elasticity, strain and maximum breaking applied force) based on the standard of ASTM D3822-07 by using FAVIMAT FIBER TEST Lab Equipment.

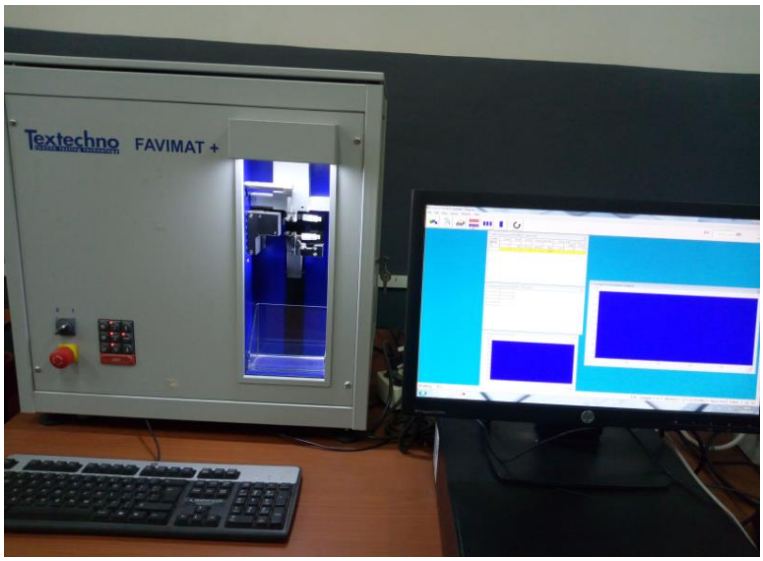

Fig.10. FAVIMAT Fiber Test Lab Equipment.

- ✓ The interaction effect of age and acid concentration on the mechanical properties of the fiber was analyzed.

6. Experimental Procedure

The high land bamboo (Yushania alpine) was harvested from a local plantation in enjibara, awi zone, west gojam, Amhara region, Ethiopia. At different age (9 month, 21month and 33 month)

Fig 11. High land bamboo plants.

The internodes of raw bamboo were cut and residual part was cleaved in longitudinal direction to thin slabs with 25 - 30 cm in length and 2.0 – 2.5mm in thickness by the slicer. Finally, they were converted manually into fibre bundles. For acid treatment the bamboo fibre bundles were soaked in 1%, 2%, 3% HCl solution at room temperature for 1 hour. Finally, they were washed with fresh water and dried under shadow.

And then the fiber bundles cleaned and hammer using plastic mallet to separate the fibres strands from the lignin.

Finally based on the ASTM D3822 international standard test methods, by using FAVIMAT lab equipment measured the tenacity, modulus of elasticity, strain and breaking force of the fibers at different age for each fiber at gauge length of 20mm.

7. Result and Discussion

The extraction of fiber from bamboo plant mean that the removal of lignin from the fiber.

The fibre strands of each test were tested and their maximum stress, Young's modulus and maximum breaking force of test samples were measured. The samples consist of acid treated fibres at different age.

Fig.12 shows that the stress strain diagrams of HCl treated different age bamboo fiber with different concentration the result show that the linearity and yielding point of the stress. And also for 1% concentration of the fiber have lower yielding point and 3 % concentration fiber have higher yielding stress.

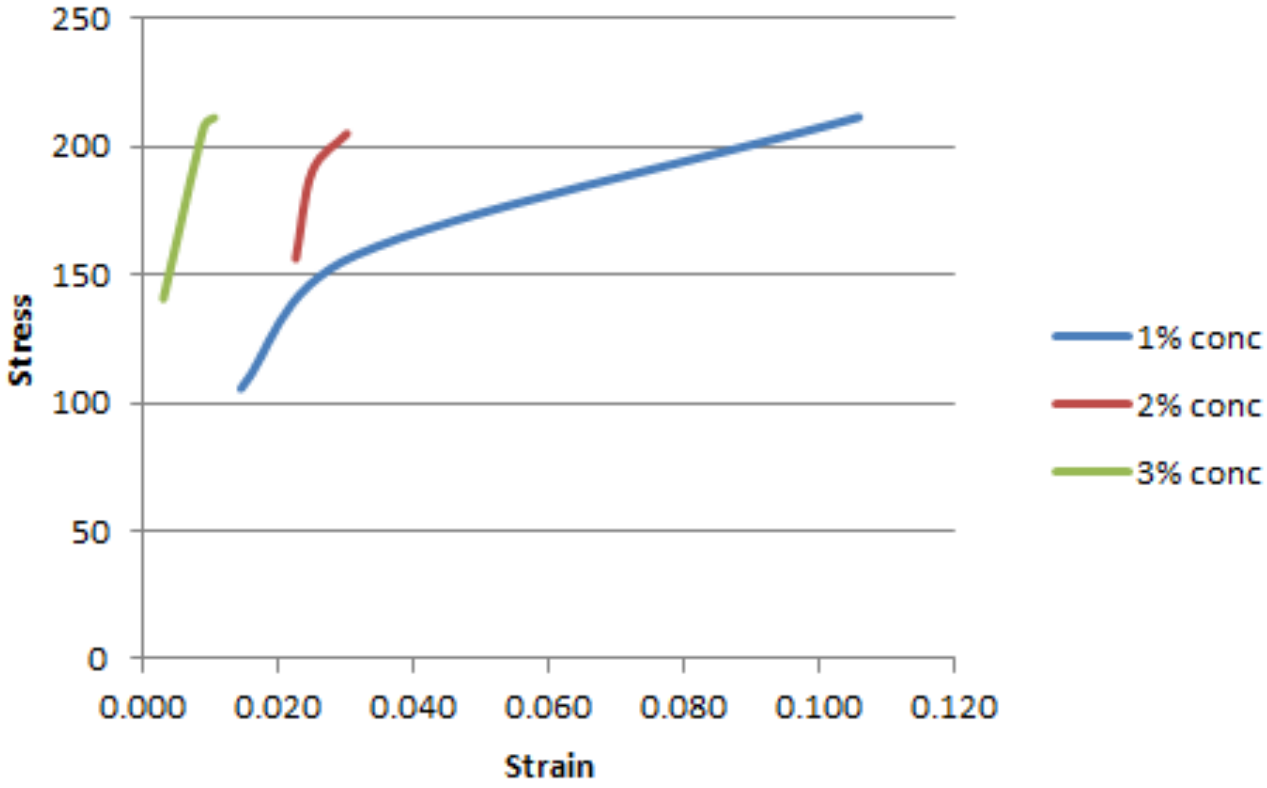

Fig12. Stress strain diagram of HCl treated fiber at different concentration

Table 3 by taking the significant level $\alpha = 0.05$ (the confidence intervals are 95%) the significant of bamboo fiber age $0.004 < 0.05$, for HCl concentration $0.026 < 0.05$ and their interaction $0.001 < 0.05$ therefore the result show that age change, concentration change and their interaction is significant for the response (tenacity). And also the adjusted R squared value is 0.817 which means there is an error but the error have no that much impact on the observed tenacity values.

Table.3. significance checking of age, concentration and their interaction (extracted with HCL treatment)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	23989.385[a]	8	2998.673	10.484	.001
Intercept	498088.497	1	498088.497	1741.464	.000
Age	6046.806	2	3023.403	10.571	.004
Conc	3234.357	2	1617.179	5.654	.026
Age * Conc	14708.222	4	3677.055	12.856	.001
Error	2574.154	9	286.017		
Total	524652.036	18			
Corrected Total	26563.539	17			

a. R Squared = .903 (Adjusted R Squared = .817)

Fig 13, interaction graph of age and HCl concentration show that the better fiber strength is yield at 1% concentration and 33 month age of bamboo plant.

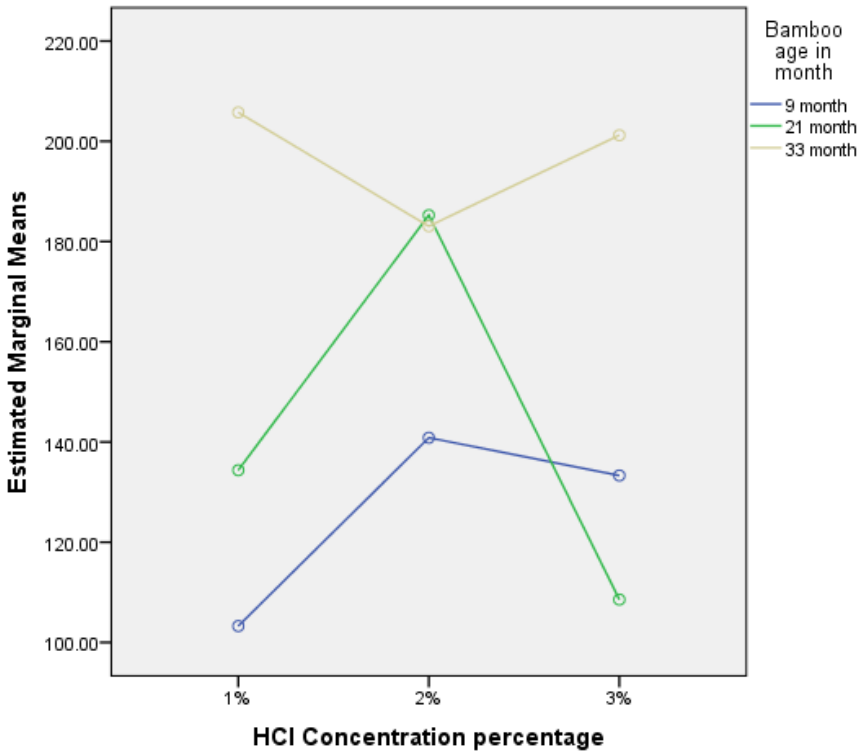

Fig.13. Estimated Marginal Means of Tenacity of bamboo Fiber (extracted with HCL treatment)

8. Conclusion

Various methods have been used to extract fibers based on their application in different fields of study and industries. In this study only acid treatment extraction method is done. Different factors have there on impact on the mechanical properties of the bamboo fiber. In this study the effect of age and concentration on the mechanical properties of the fiber is carried out. from the study the better fiber strength is yield at 1% concentration and 33 month age of bamboo plant.

The study is carried out on only the high land bamboo plant species and only on the acid treatment method therefore in the future on the other Ethiopian bamboo species and with other extraction and treatment methods these mechanical properties and other properties have to be characterized for better fiber data information and to use for different application mean that for textile industries and energy production.

7. Reference

[1] YIGARDU MULATU and MENGISTIE KINDU, "Status of bamboo resource development , utilization , and research in Ethiopia : A review," *Ethiop. J. Nat. Resour.*, 2010.

[2] E. Kelbessa, T. Bekele, A. Gebrehiwot, and G. Hadera, "A Socio-Economic Case Study of the Bamboo Sector in Ethiopia: An Analysis of the Production-to-Consumption System," no. March, 2000.

[3] T. A. Ha and L. T. M. Anh, "Overview of bamboo biomass for energy production," 2014.

[4] I. Journal, A. S. Culture, T. Vol, E. Centre, and D. Uk, "REVIEW OF BAMBOO VALUE CHAIN IN ETHIOPIA Teshome Kassahun (Teshe Dawuro) Agricultural Department of Dawuro zone, P.O. Box 17, Dawuro, Southern Ethiopia," vol. 2, no. 3, pp. 52–67, 2015.

[5] K. Rassiah and M. M. H. M. Ahmad, "A Review On Mechanical Properties Of Bamboo Fiber Reinforced Polymer Composite.pdf," vol. 7, no. 8, pp. 247–253, 2013.

[6] V. Kaur, D. P. Chattopadhyay, and S. Kaur, "Study on Extraction of Bamboo Fibres from Raw Bamboo Fibres Bundles Using Different Retting Techniques," *Text. Light Ind. Sci. Technol.*, 2013.

[7] H. Yan-hui, F. Ben-hua, Y. Yan, and Z. Rong-jun, "Plant Age Effect on Mechanical Properties of Moso Bamboo (Phyllostachys Heterocycla Var. Pubescens) Single Fibers," *Wood Fiber Sci.*, vol. 44, no. 2, pp. 196–201, 2012.

[8] D. Awalluddin *et al.*, "Mechanical properties of different bamboo species," *MATEC Web Conf.*, vol. 138, p. 01024, 2017.

[9] M. Kamruzzaman, S. K. Saha, A. K. Bose, and M. N. Islam, "Effects of age and height on physical and mechanical properties of bamboo," *J. Trop. For. Sci.*, 2008.