Termite Resistance of Thermally-Modified *Dendrocalamus asper* (Schultes f.) Backer ex Heyne

by

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Abstract

The effects of thermal modification on the resistance of *Dendrocalamus asper* against *Microcerotermes losbañosensis* were investigated after exposure to virgin coconut oil at 140 to 200 °C for 30 to 120 min. The results showed that heat treatment significantly improved the resistance of bamboo against termites using weight loss and visual observations. The enhancement is greatest at the 200ºC. Prolonging the treatment duration has a positive effect on the resistance at lower temperature levels only.

Keywords: *Dendrocalamus*, *v*irgin coconut oil, oil heat treatment, *Microcerotermes*

Introduction

Worldwide interest on bamboo has intensified resulting in its emergence as one of the most important non-timber forest products. From its traditional use for food, construction, handicrafts and furniture, bamboo is now being utilized for pulp and paper, floors, roofs, charcoal, panel boards and reconstituted panel products. The growth can be attributed to advances in processing technology and increased market demand. However, the supply of bamboo is fast depleting due to increasing utilization since it is being used as substitute for timber. In addition, bamboo is susceptible to attack to decay fungi and boring insects. Proper utilization and protection are, therefore, necessary to maximize the benefits we derive from this versatile material.

A number of treatment methods have been developed to prolong the life of bamboo using chemical preservatives (INBAR and ICFRE 1994, Garcia *et al.* 1997, Acda 2007). However, stricter environmental rules are now being enforced, thus other treatment methods have been explored. One method that has been studied recently is thermal modification using different types of vegetable oils (Leithoff & Peek 2001, Razak *et al.* 2004, 2005, Manalo and Acda 2009). The oil facilitates fast and uniform heat transfer and provides limited oxygen in the heating vessel (Rapp & Sailer 2001, Militz 2002). Studies on oil heat treatment of bamboo are limited only on the physical and mechanical properties. Very few articles were done on the durability, which is confided only on decay fungi (Leithoff & Peek 2001, Razak *et al.* 2004, 2005). This paper reports the effects of oil heat treatment on the resistance of *Dendrocalamus asper* against subterranean termites *Microcerotermes losbañosensis.*

Materials and methods

Sample Preparation

Three, three-year old healthy poles of *Dendrocalamus asper* were collected from the Bambusetum located at the Los Baños Experimental Station of the Ecosystem Research and Development Bureau (ERDB), Los Baños, Laguna, Philippines. The poles were cut into transportable lengths of approximately 8 feet and brought to laboratory of the Department of Forest Products and Paper Science, College of Forestry and Natural Resources for sample preparation.

The nodes of the bamboo culms were removed. Culms with any sign of defect, visible mould infection or discoloration were rejected. For this study only the 10th to 15th internodes were used. The samples were split into 25.4 x 300 mm slats. Average culm thickness was 11.50 mm. All samples were conditioned at 20±2°C and 65% RH to obtain 12% MC.

Thermal Modification

The samples were immersed in hot oil using a fabricated electric oil curing apparatus. The apparatus consisted of stainless steel cylindrical vat (300 mm diameter and 450 mm height) heated by electric plates (6800 watts) connected to a thermocouple and digital temperature controller. Virgin coconut oil (VCO Grade B, specific gravity 0.92, viscosity 1.5 cps, pH 5.9, smoke point 212°C) obtained from the National Institute of Molecular Biology and Biotechnology, University of the Philippines Los Baños (UPLB). The coconut oil was first heated to 60 °C. Bamboo samples were completely submerged in the heated oil. Oil temperature was raised to 140, 160, 180 or 200 °C for 30, 60 or 120 min. Treatment time started when the oil bath reached the target temperature. Treated samples were then blotted using paper and allowed to cool for 24 hours.

Resistance Against Subterranean Termites (FPRDI Laboratory Method)

Bamboo samples measuring 2 cm x 6 cm x culm thickness were cut 50.8 mm from the ends of the treated and untreated slats. The samples were conditioned for 4 weeks following the conditions described above. A total of five replicates per treatment (including the control) were prepared. A secondary nests of subterranean termites *Microcerotermes losbañosensis* Oshima (Isoptera : Termitidae) was collected from the grounds of UPLB. It was placed in a halved plastic drum (200 L) with soil. The nest was conditioned for two weeks by allowing the termites population to feed on the wood slats placed around the nest. After the specified time, when several termites' tunnels were already formed on the feeder wood slats, the thermally treated and untreated/control bamboo samples were laid out randomly around the secondary nest with the rind facing up.

The experimental set-up was inspected every other day for the first 2 weeks of exposure taking note of the termites' tunneling activities. Subsequent observations were done once a week. The experiment was continued up to 16 weeks and was then evaluated. The degree of damage caused by the termites on the bamboo samples was assessed based on visual observations. The value range of 0 to 100, with increasing failure was used.

Aside from the visual assessment of the damage caused by the termites on each sample, sample weight loss based on the ovendry weight of the samples was also obtained.

Results and discussion

The results of the test (Table 1 and Figure 1) show that thermal modification using oil can improve the resistance of *D. asper* against subterranean termites, *M. losbañosensis*. The average weight losses were 79.73, 56.74, 50.47, 43.88, and 34.09% for the untreated, 140, 160, 180, and 200ºC, respectively. The improvement varies with different treatment temperature and soaking duration combinations ($p<0.001$). Exposure of the sample at the highest temperature greatly enhanced the resistance of bamboo. In addition, prolonging heat treatment has a positive effect on the resistance specifically at lower temperature levels (140 to 160ºC). The advantage, however, is lost at higher temperature levels (180 to 200ºC).

Visual observations supplement the results of the weight losses. On the average, the ratings were 100, 92.33, 83.67, 80.00, and 58.00% for the untreated, 140, 160, 180, and 200ºC, respectively. It is important to note that termites start to feed on the edges towards of center of the bamboo samples. They leave behind only the fiber near the periphery and the rind portion after the 16-week exposure.

The results of this study deviates somewhat with the results of Smith et al. (2003). In their study, on Scots Pine and Norway Spruce wood, they found out that oil heat treatment alone can not enhance the resistance against subterranean termites and that impregnation with vegetable oil after oil heat treatment should be done. It is possible that wood and bamboo samples have different response to oil heat treatment due to anatomical differences. The oil, in this study may have penetrated the bamboo samples, though no test was performed to verify the amount of retention. Also, the type of oil may have different effects (Wang & Cooper 2005). In addition, the improved resistance can also be attributed to the changes in the chemical composition of bamboo during the thermal modification. These may include the degradation of the chemical components and/or the formation of toxic degradation products.

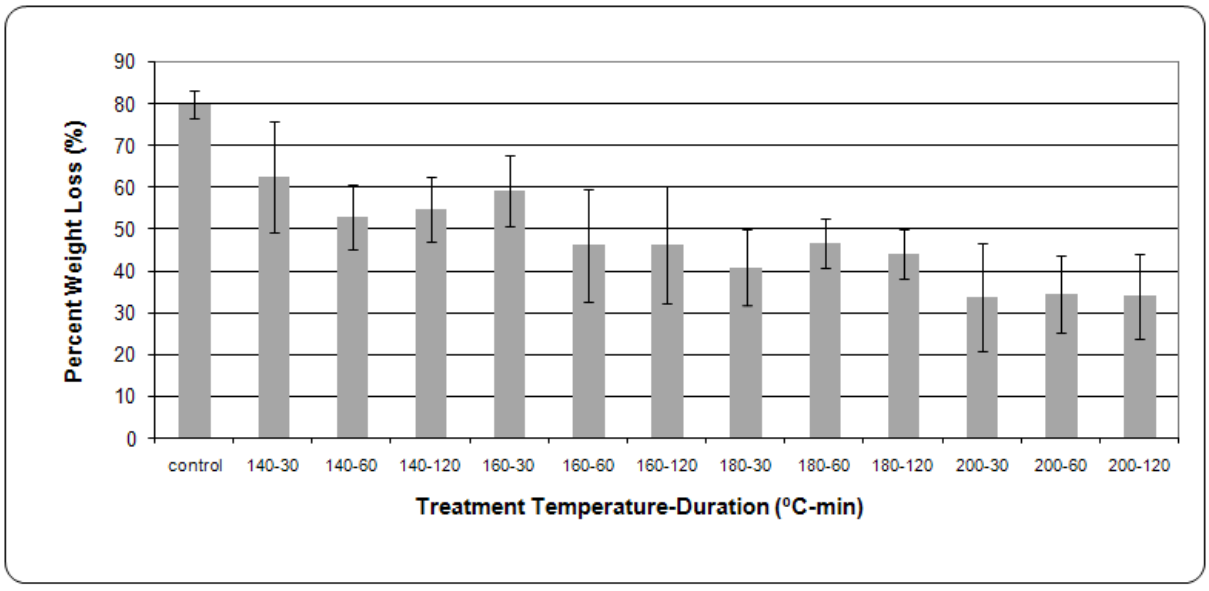

Fig. 1. Means of weight losses of thermally modified *D. asper* due to *M. losbañosensis.* as affected different treatment temperature-duration combinations after 16-week exposure. Lines on top of bars represent standard deviation of the means.

Table 1. Summary of results for exposure of *D. asper to M. losbañosensis* after 16- week exposure.

TREATMENT TEMPERATURE-DURATION (°C-min)	WEIGHT LOSS* (%) Mean ± SD	RATING (%) Mean ± SD
control	79.73 ± 3.32[a]	100 ± 0.00
140-30	62.42 ±13.33[ab]	99 ± 2.24
140-60	53.02 ± 7.77[bc]	95 ± 6.12
140-120	54.76 ± 7.91[bc]	83 ± 13.96
160-30	59.04 ± 8.47[ab]	94 ± 5.48
160-60	46.11 ± 13.30[bc]	75 ± 27.39
160-120	46.25 ± 14.05[bc]	82 ± 12.04
180-30	40.95 ± 9.04[bc]	79 ± 12.94
180-60	46.61 ± 5.76[bc]	79 ± 12.94
180-120	44.07 ± 6.05[bc]	82 ± 18.91
200-30	33.70 ± 12.89[c]	57 ± 35.64
200-60	34.51 ± 9.22[c]	59 ± 27.70
200-120	34.06 ± 10.12[c]	58 ± 34.93

*Means followed by the same letter are not significantly different with each other using Tukey's HSD at α=0.05.

Conclusions

The 16-week laboratory exposure test was done to determine the effects of oil heat treatment using virgin coconut oil. Improvement in the resistance against subterranean termites varied with different temperature levels and duration. The exact cause of the improved resistance of thermally-modified bamboo necessitates further investigations.

Acknowledgement

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