

**ECO-FRIENDLY PRESERVATIVE FORMULATIONS FOR
BAMBOO TREATMENT UNDER STORAGE**

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CENTER FOR RURAL DEVELOPMENT AND TECHNOLOGY

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**ECO-FRIENDLY PRESERVATIVE FORMULATIONS FOR
BAMBOO TREATMENT UNDER STORAGE**

by

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Center for Rural Development and Technology

Submitted

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DOCTOR OF PHILOSOPHY

to the



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DEDICATED
TO
MY FAMILY

CERTIFICATE

This is to certify that the thesis entitled, “**Eco-friendly preservative formulations for bamboo treatment under storage** ” being submitted by **Ms. Perminder Jit Kaur** to the **Indian Institute of Technology Delhi** for the award of ‘**Doctor of Philosophy**’ is a record of bonafide research work carried out by her. She has worked under our guidance and supervision, and has fulfilled the requirements for the submission of this thesis. To the best of our knowledge the results contained in this thesis have not been submitted, in part or full, to any other university or institute for the award of any degree or diploma.

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ABSTRACT

Continuous increase in human population coupled with modern life style has generated huge demand for wood and wood based products in service sector causing severe deforestation, world-over. Hence to find suitable substitute of wood, metal, plastic etc. in construction industry, researchers have focused attention on renewable materials like bamboo – a unique creation of Nature. Field survey and literature review reveals that one of the biggest constraints in the utilization of bamboo is short life span (1-3 years) of bamboo culm due to infestation by organisms under storage conditions. Environmental and human health hazards of commercial chemical preservatives (CCA, CCB, PCP etc.) are now well known. In this background, present study focuses on two main aspects: (i) Physico- chemical characterization of commercially important bamboo species for identification of suitable species for diverse applications (ii) Development of eco-friendly preservatives and laboratory to field level evaluation for bamboo treatment. In addition, scientific validation of traditional technology system in this context is also attempted.

Physico-chemical characterization and decay resistance against white rot fungi (*P.versicolor*) of 7 commercially important bamboo species procured from different agro-climatic regions was carried out. Various parameters viz. moisture, ash, water solubles, alkali solubility, ethanol-toluene solubility, lignin, lingo-cellulose and starch content were found to vary significantly with species and geographical location. Data reveals significant difference in some properties of *D.strictus* species from two states in India. *D.strictus* (Haryana) with lowest ash content (2.6%) requiring simple tools/ machine for processing and maximum lignin content (27%) leading to higher load bearing capacity was used for entire experimental work.

In order to develop eco-friendly preservatives for bamboo treatment, to begin with, details on traditional technological system used by bamboo artisans were collected. Out of these, two widely used methods- Water leaching and Smoke treatment were selected for scientific investigation. Experimental setups were installed in field laboratory (Micro-model complex, IIT Delhi). It was amazing to note that decay resistance of bamboo treated by Water leaching method (weight loss: 9.76%) was found at par with chemical treatment (weight loss: 7.3%), whereas this value was lower (weight loss: 12.2%) in case of bamboo conditioned with smoke treatment (8 hrs exposure). In these methods, leaching/ reduction of starch content in treated bamboo and formation of black sooty layer on surface of treated culm may resist the attack of fungus/ insect-pest on stored bamboo. In field investigations Smoke treated and Water leached bamboo samples were found to be completely sound for first 3 months and 6 months of installation respectively.

Plant kingdom is well known to possess antifungal, insecticidal and termicidal properties. Based on literature information, leafy biomass of *Jatropha* (*J. curcus*) and *Lantana* (*L.camara*), *J.curcus* de-oiled seed cake, Cedar wood oil and Neem oil were selected for study. Different concentration (5 – 20 %) of aqueous extract of leafy biomass/seedcake as preservative solution were prepared and tested. Dipping process as well as pressure application (to enhance absorption of preservatives in bamboo culm) was used for bamboo treatment. In laboratory experiments,

15% concentration of aqueous extract of leafy biomass of *J.curcus* and *L.camara* and *J.curcus* seed cake under dip treatment exhibited maximum decay resistance in terms of weight loss being 12.11% , 13.62% and 19.55% respectively. Pressure treatment (2 bar in Boucherie equipment) significantly enhanced their bio-efficacy i.e weight loss being 9.29%, 9.36% and 9.81% respectively. In dip treatment, out of two oils studied Cedar wood oil was found superior (weight loss : 11.09%) than Neem oil (weight loss : 25.12%). Field investigation reveals efficacy of leafy extract of *J.curcus* and *L.camara* at par (sound till 3 months of installation) and lower than *J.curcus* seed cake extract (sound till 6 months of installation in field). Thus, above preservatives enjoys 'A' and 'B' classes of preservatives. Interestingly, pressure treatment is able to upgrade their class from 'B' to 'A' making the treatment process more economical.

Search and efforts continued to develop more reliable and efficient eco-friendly preservative for long term outdoor applications of bamboo. Therefore, detailed investigation was focused on chelation of metal ions with easily available Neem oil. Decay resistance analysis of bamboo culms treated with varying concentrations of different copper salts reveals that 0.3% copper naphthenate may give best results. Thus, a new preservative called Copperised Neem Oil (0.3% cu-naphthenate, 25% Neem oil in kerosene) was prepared. Decay resistance of newly developed preservative under lab conditions against white rot fungi (*P.versicolor*) gave amazing results on dip treatment (weight loss: 6.02%) and pressure treatment (weight loss: 3.27%). Further, field testing of this new preservative for 3 consecutive years (2011-2014) exhibited excellent decay resistance (weight loss: 5.26%). Visual observations also confirmed this and 'Ranking Model' clearly established this fact.

The effect of the above mentioned best preservative (Copperised Neem Oil) on physico-chemical properties and compressive strength of bamboo samples was studied. Preservative treatment resulted in no significant change in starch, lignin, ligno-cellulosic content of treated samples. FTIR and SEM analysis shows no major change in functional groups of bamboo culms on above treatment. In order to see the effect of above preservative on structural properties of treated bamboo, compressive strength analysis using HEICO testing machine was performed. No significant change in behavior of treated culms on application of pressure was observed at constant rate of loading 0.02 mm/sec. The specimen seems to be fairly linear up to 51 KN and decreases progressively. The average of seven replicates for treated culms shows compressive strength of treated samples same as Control samples.

Overall, the research findings would help in preparing guidelines based on physico-chemical characterization of commercially important bamboo species for selection of suitable species for various applications. Results of scientific validation of Water leaching and Smoke treatment methods for bamboo treatment would help in strengthening the confidence of scientific community in Traditional Knowledge System of rural people. For enhancing the service life of bamboo, application of Copperised Neem Oil at 2 bar pressure can be considered an excellent eco-friendly alternative to harmful chemical preservatives. It has great potential for entrepreneurship in rural housing and artisan sector.

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Abbreviation list

PCP	Penta Chloro pphenol
CCA	Copper Chrome Arsenic
CCB	Copper Chrome Boron
TBTO	Tributyl Tin Oxide
NaPCP	Sodium Penta Chloro Phenol
Cu-HDO	Bis-(N-Cyclohexyl-diazeniumdioxide)-copper
IPBC	Iodo-2-propynyl butylcarbamate
ASTM	Ameriacn Standard for testing materials
IS	Indian Standards
HESCO	Himalayan Environment Studies and Conservation
FTIR	Fourier Transform Infrared Spectroscopy
SEM	Scanning Electron Microscopy
IVC	Integrated Vector Control
RH	Relative Humidity