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Effects of Phyto-Chemicals on Wood Modification and Dimensions Stability of *Pinus roxburghii* Wood

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***Abstract*:** The study was carried out to examine the effects of *Acorus calamus* and *Parthenium hysterophorus* plants chemical constitute on dimension stability of *Pinus roxburghii* wood. Results of the study clearly shows the positive effects on the dimension stability of wood. However, *A. calamus* found more efficient as compare to the *P. hysterophorus*, due to the higher content of oil. In case of solvents used for extraction, petroleum ether found more effective compare to the methanol extract. Present investigation helpful for the further investigation to develop natural chemicals for wood modification which is free from the hazardous effect on environment health as well as human health.

***Keywords*:** Dimensions stability, Shrinkage, Swelling, Plant extract, *Acorus calamus, Parthenium hysterophorus, Pinus roxburghii,* Wood modification

Wood is a renewable material and hygroscopic in nature due to the OH group. It is naturally consist with cellulose, hemicellulose, lignin, and other extractives like gum, resin and oils etc. It is described as secondary xylem, formed during the secondary growth Sharma et al (2020). Wood has been mainly utilized in furniture making, timber, fuel and shelter. In the past time wood has been utilized without any modification Rowell (2014, 2016). However, in the modern time chemical modification is involved for the increase the dimensions stability and life of wood Rowell (2016). Now a days, Humans are well aware about the utilization of wood and realized that the dimensions of wood are affected by moisture content. Wood can be damaged by different wood degrading fungi, decay and other wood degrading agencies and the ultraviolet energy is also one of the factors for wood damage. With the increase in the awareness regarding utilization of wood, effects of environmental factors on dimensions properties of wood and needs of wood durability, the new techniques have been innovated to improve the durability of wood without the using poisonous chemicals (Hill 2006, Rowell et al 2009, Rowell 2012, Gerardin 2016). Issue of chemicals with the human and environment health, ultimately put great pressure on primary timber species like; teak, sheesham, sal, deodar etc. to fulfil the demand of wood, however due to higher demand their cost is very high Meena et al (2017). In this context the utilization of secondary species is of vital importance. The main disadvantage with these lesser known timber species is less durability Gupta et al (2016). To utilize the secondary species with wood modification with environment friendly chemicals search new technologies to increase the durability and dimensions stability during the utilization of wood Rowell (2016). In addition to the progress of regulations, some wood based industries are using bio chemical products, biocide products for wood modification and to protect the wood from the biodegrading agencies Gerardin (2016). It results in an increasing use of different plants oils, extracts, thermal modification and impregnation modification for dimension stability (Hill 2006, Rowell 2012). Low durable wood can be upgraded with new modified wood properties through chemical modification with bio chemicals without any harmful effects on environment conditions and ecological biodiversity (Rowell 2014, Hill 2006). In the present study, the dimension stabilization of secondary wood species *Pinus roxburghii* has been done with environment friendly phytochemicals.

MATERIAL AND METHODS

Preparation of wood samples: Wood samples procured from the local carpenter were cut in to the dimensions of 5 ×2.5 × 2.5 cm, longitudinal, radial, and tangential respectively (±0.25, ±0.15, ±0.15 cm longitudinal, radial, and tangential respectively). Wood samples prepared from the heart wood of the selected tree species.

Collection of plant materials: *Acorus calamus* L. and *Parthenium hysterophorus* L. were selected for the study as both the plants possess antifungal property. The rhizomes of *Acorus calamus* L. were collected from Nauni and Khaltu Village, whereas the aerial parts of *Parthenium* *hysterophorus* L. were collected from the college and university campus area. The collected samples were initially dried separately in open conditions under shade condition for the 20 days. The dried material was converted into powdered in wood grinder machine and again dried in oven for 24 hours at 50±1ºC temperature and it finely powdered.

Preparation of extract for wood treatment: Prepared extract (2 % stock solution) was used to prepare 0.25, 0.50, 1.00, 1.50, and 2.0 per cent different concentrations for dip treatment and control wood samples were dipped in 5% methanol solution with distilled water. After dip treatment, the wood samples were first dried at room temperature in open condition and then dried at 105±2°C up to constant weights.

Volumetric swelling coefficient (S): The volumetric swelling coefficient (S) was calculated by using formula as given by Islam et al. (2012).

$S = (V_2 - V_1) / V_1 \times 100$

Where, S = Volumetric swelling coefficient, V_1= Wood volume of oven-dried sample before treatment, V_2 =Wood volume after treatment.

Anti-swelling efficiency (%): The anti-swelling efficiency (ASE), was calculated by using formula as given by Rowell (2005) - $ASE = (S_1 - S_2) / S_1 \times 100$

Where, S_1= Volumetric swelling coefficient of untreated wood samples, S_2=Volumetric swelling coefficient of treated wood samples

Volumetric shrinkage coefficient (S): The volumetric shrinkage coefficient (S) was calculated according to ASTM-1037 (1999) - $S = (V_2 - V_1) / V_1 \times 100$

Where, S= Volumetric shrinkage coefficient, V_1= Wood volume of oven-dried sample after treatment, V_2 = Wood volume after treatment.

Anti-shrink efficiency (%): The anti-shrink efficiency (ASE), which is the reduction in swelling resulting from a treatment, was calculated by using the methods as given by Rowell (2005) - $ASE = (S_1 - S_2) / S_1 \times 100$

Where, S_1 = Volumetric shrinkage coefficient of untreated wood samples, S_2=Volumetric shrinkage coefficient of treated wood samples

Statistical analysis: CRD One way analysis of variance (ANOVA) was used to analyze all the data with op stat CCS HAU, Hisar.

RESULTS AND DISCUSSION

Volumetric swelling coefficient (S): The results of present investigation on volumetric swelling coefficient (S) of treated and untreated wood samples are presented in Table 1. The analysed data presented in the table shows the significant variation at 1 per cent level of significance. Presented data was clearly shown the effects of plant extracts on wood modification. Volumetric swelling coefficient of untreated wood sample was recorded higher and minimum was found for treated wood samples with 2% concentrated plant extract. Volumetric swelling coefficient was increased with decreasing concentration of extract. Both of selected botanicals show the efficiency and fix the dimension properties of wood. The dimensions properties of wood were affected due to the moisture absorption. The volumetric swelling coefficients for all the treatments have shown decrease with the application of plant extracts. The volumetric swelling coefficient of wood is an important parameter to examine the dimensional stability of wood in all directions. Rowell and Ellis (1978) have reported that raise the volume of wood with the rising in added chemical. Islam et al (2012) while studying the dimensional stability of chemically modified wood noticed that there is high swelling coefficient for all the control wood samples as compared to treated wood samples. Wu et al (2012) has also reported similar results, where the eucalypt woods treated with chemicals have shown significant reduction in volumetric swelling as compared to control wood samples. Oduor et al (2013) studied the dimensional stability of *Pinus radiata* D.

Table 1. Effect of plants extracts treatment on volumetric swelling (volumetric shrinkage) coefficient on treated and untreated wood samples of *Pinus roxburghii*

Treatments	*Acorus calamus*		*Parthenium hysterophorus*	
	Methanol	Petroleum ether	Methanol	Petroleum ether
0.25	9.54 (6.85)	12.02 (10.86)	11.67 (12.33)	10.43 (10.76)
0.50	7.16 (6.79)	10.50 (10.76)	11.51 (11.66)	9.17 (9.22)
1.00	8.33 (6.77)	11.44 (11.07)	10.66 (10.23)	8.24 (8.51)
1.50	9.00 (6.71)	11.10 (11.15)	10.53 (9.53)	7.96 (8.75)
2.0	8.32 (5.15)	8.43 (8.06)	9.72 (7.55)	7.03 (6.56)
Control	11.19 (7.04)	12.14 (11.97)	15.85 (13.34)	10.72 (11.72)
CD (1%)	1.70 (1.0)	1.81 (1.42)	1.89 (0.83)	0.15 (1.74)
SE (m)	0.39 (0.23)	0.42 (0.33)	0.44 (0.19)	0.64 (0.40)

Don, impregnated with various resins. Solid wood stakes were impregnated with either an isocyanate and phenol formaldehyde resin than exposed in different three type's soil beds or two moisture contents. The treatments resulted in no effect on solid wood. Meena et al (2017) also reported significant effect on dimensional stability of *Pinus roxburghii* wood. Nampelly et al (2022) also reported that variation in swelling coefficient variation in different five wood species.

Anti-swelling coefficient (ASC): The result of dimension stability of wood in term of anti swelling coefficient of treated and untreated wood samples are presented in Table 2. Presented results was showing significant variation and data was found highly significant at 1 per cent level of significance, data related to wood samples treated with methanol extract of *A. calamus* was found non significant. Maximum ASC of treated wood was noticed at 2% concentrated treated wood samples. ASC was reduced with decreasing concentration of extract. Selected plants for the wood modification *A. Calamus* and *P. hysterophorus* was efficient to control dimension stability of wood. In case of *A. calamus* extract petroleum ether treated wood samples was shown more efficiency as compare to the methanol treated extracted treated wood samples. Similar wood samples treated with *P. hysterophorus* extract whereas methanol extracts treated wood samples was shown more efficient as compare to petroleum ether treated wood samples. Anti-swelling efficiency is a basic way to examine the dimensional stability of wood. The sample treated with plant extracts significantly improved ASE than controlled wood samples, due to restriction in movement of water molecules into the cell wall of wood Baysal et al (2004). The anti-swelling efficiency decreased with different concentrations of plant extracts. The results are similar to the study carried out by Islam et al (2012) where effects of chemical modification on different five types of tropical light hardwoods species namely, *Alstonia pneumatophora, Endospermum diadenum, Paraserianthes moluccana, Dyera costulata, Hevea brasiliensis* and and concluded that dimensional stability of wood improved by chemical modification. Sonowal and Gogoi (2010) reported that the treated wood samples showed higher dimensional stability in terms of anti-shrink efficiency (ASE), bulk co-efficient (BC) and weight percent gain (WPG). Baysal et al (2004) reported that the treated samples significantly improved ASE as compared to untreated wood samples which can be due to restriction in movement of water molecules inside the wood cell wall. Reduction in shrinking results in better dimensional stability of wood and is expressed as anti-shrink efficiency (ASE). It is considered as important measure of the dimensional stability of wood and is used to describe the degree of dimensional stability given to the wood by various treatments. Babinski (2007) investigated shrinkage of wood a little degraded, freeze dried archaeological oak-wood. Wood samples treated before drying with 10, 20, and 30% water solutions of PEG 300, PEG 4000, and sucrose and concluded that shrinkage of untreated wood samples and treated freeze dried oak-wood samples was significantly less, as compare to the wood samples was dried naturally.

Volumetric shrinkage coefficient (S): Volumetric shrinkage coefficient of wood samples treated and untreated was measured and data related to finding was presented at Table 1. Presented data showed significant variation at 1 per cent level of significance. Lowest volumetric shrinkage coefficient was noticed at treated wood samples and higher was noticed in untreated wood sample. Wood samples treated with *A. calamus* extract had high efficiency as compare to the *P. hysterophorus* treated wood samples. Due to the presence of higher oil content in *A. calamus* extract it was found more effective to fix the dimensional properties of wood and reduce the volumetric shrinkage coefficient of treated wood samples. Similar investigations were carried out by Wu et al (2012) where eucalypt wood treated with chemicals, it has been noticed that there is shrinkage of wood significantly less as compare to the untreated wood. Bazyar (2012) also reported

Table 2. Effect of plants extracts treatment on anti-swelling (anti shrinkage) coefficient of *Pinus roxburghii* wood samples

Treatments	*Acorus calamus*		*Parthenium hysterophorus*	
	Methanol	Petroleum ether	Methanol	Petroleum ether
0.25	14.28 (2.54)	0.85 (9.16)	26.25 (7.55)	2.66 (7.96)
0.50	35.48 (3.49)	13.47 (10.05)	27.35 (12.52)	14.40 (21.13)
1.00	25.12 (3.72)	5.62 (7.57)	32.64 (23.29)	23.16 (27.31)
1.50	19.18 (4.75)	8.65 (6.73)	33.52 (28.52)	25.75 (25.46)
2.0	25.54 (26.77)	30.51 (32.53)	38.78 (43.40)	34.36 (43.66)
CD (1%)	NS (13.54*)	12.81 (10.04)	NS (5.77)	5.66 (13.86)
SE (m)	5.29 (4.24)	4.01 (3.14)	2.81 (1.80)	1.77 (4.34)

*CD value at 5%

that wood samples treated with linseed oil minimum volumetric shrinkage as compared to control. Similar results treated wood samples have low volumetric shrinkage coefficient have been reported by (Salim et al 2010, Sailer et al 2000, Wang and Cooper 2005) where the oil heat treated wood samples has resulted in decline of volumetric shrinkage. Okon (2014) has reported variations in shrinkage behaviour along and across bole of 25 years old *Gmelina arborea.* Sharma et al (2020) reported that heat treatment of volumetric shrinkage coefficient of wood decrease with increasing time and temperature in case of *Toona ciliata*.

Anti-shrinkage coefficient (ASC): Result of anti-shrinkage coefficient of wood presented in Table 2. Data was showing significant variation and found significant at 1 per cent level of significance, data related to wood samples treated with methanol extract of *A. calamus* was found significant at 5 per cent level of significance. Wood samples treated with various concentrations; out of all concentration wood samples treated with 2% concentration was found highest anti shrinkage coefficient. The anti shrinkage coefficient of wood was decrease with reducing the concentration of plant extract for wood samples treated with methanol and petroleum ether extract from *A. calamus* and *P. hysterophorus* plants. Decrease in shrinking results in better dimensional stability of wood and is expressed as Anti-shrink Efficiency (ASE). It is considered as an important measure of the dimensional stability of wood and is used to describe the degree of dimensional stability given to the wood by various treatments. The plant extracts treated wood samples have shown an increase in the anti-shrink efficiency over control. ASE observed in these investigations decrease with the increasing the plant extract concentrations. Similar results have been reported by Deka et al. (2000) have shown an increase in the anti-shrink efficiency of treated wood samples over control. Yan and Morell (2014) have also reported a more pronounced increase in anti-shrink efficiency of treated wood samples over control with the increase in temperature. Wang and copper (2005) studied the effect of palm oil-, soy oil- and slack wax for different processing times and temperatures on moisture properties of treated wood and concluded that wood samples treated with wax at 100°C or 160°C improved anti-shrink efficiencies (ASE). Chloroform extracted samples treated with palm oil and soy oil treated at high temperature shown similar hygroscopicity and ASE properties than unextracted samples. The ASE values are consistent with the findings of Pavlic et al (2007). Sailer et al (2000) showed an improvement in the ASE of treated specimens at 220°C of about 40 per cent.

CONCLUSION

There was improvement in the dimensional stability of treated wood samples with respect to volumetric shrinkage coefficient, anti shrinkage efficiency, volumetric swelling coefficient and anti-swelling-efficiency. Also, the plant extracts influenced the dimension stability of wood. Improvement in the dimension stability of wood sample was more with petroleum ether as compared to methanol extract. The plant extract of *Acorus calamus* efficiently fixed the dimension stability of wood.

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