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Vacuum Kiln Drying Studies on *Cassia javanica*

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ABSTRACT: Vacuum kiln drying of *Cassia javanica was* carried out during this experiment mainly with an aim to evaluate the species drying behaviour. For *C. javanica* the moisture content came down to 12.02% from an initial value of 71.25% within 52.5 hours. The wood samples of *C. javanica* species showed little amount seasoning defects. The wood samples were slow to dry below their respective fibre saturation points. A vacuum of 220 mm Hg and a temperature profile of 50°C were applied throughout the procedure for the species. The drying of the species of *C. javanica* by this method has a very good prospect as this was dried within 52.5 hours, much quicker than that reported in conventional kiln drying of this species. No particular seasoning schedule was followed during the process as the main objective of the experiment was, to study the drying rate of the species.

Keywords: Vacuum Kiln Drying, *Cassia javanica*, Drying Rate, Seasoning Schedule, Efficient drying.

INTRODUCTION

When wood or timber comes from the mill after primary conversion, freshly cut or green wood contains tremendous quantities of water which must be removed before making any product (Simpson, 1984; Walker, 1993). Failing to this may causes various types of defects and the product will not be dimensionally stable and long lasting. The scientific process of getting this water gradually out of the wood is called seasoning (Kollmann & Côté, 1968).

The process of removing of water from wood is not an easy task. During the removal of excess water, the wood can undergo undesirable changes. Insects, stains and decay fungi can attack it, and shrinkage can cause defects such as checking and warping (Simpson, 1987). The object of any good seasoning process is to remove the water as economically as possible, energy efficient without deterioration in its physical and mechanical properties (Siau, 1984). *C. javanica* originated in Java and Sumatra, native range of this species is China, Indonesia, Malaysia, Myanmar, Mauritius, United States etc. Now it is commonly found in India and the Philippines. These trees grow in tropical, subtropical and semi temperate regions. *C. javanica*, also known as Java Cassia, Pink Shower, Apple Blossom Tree and Rainbow Shower Tree, is a species of tree in the Fabaceae family. *C. javanica* yields a lightweight to heavy hardwood with a density of 400 to 875 kg/m cubic at 15% moisture content. Heartwood pale yellow when fresh, turning red or pale orange brown with age, demarcated sharply or not sharply from the 2 to 5 cm wide white sapwood; grain interlocked; texture moderately fine. Shrinkage of the wood is low; it seasons well with little or no degrades. The wood is hard and strong. It works well and finishes well.

Yang *et al.*, (2025) studied that vacuum drying helps to release the internal stress maintain color and improve dimensional stability. Vacuum drying, conducted under pressures below atmospheric levels, accelerates moisture evaporation at lower temperatures (Sadoth *et al*., 2011; Teischinger *et al.*, 2023), reducing the accumulation of internal stress and effectively lowering the risk of cracking and deformation. Vacuum drying operates at low temperatures, which reduces damage to the wood's cell walls and helps retain its natural color (Kang *et al.*, 2004; Sandoval-Torres *et al.*, 2012). As a result, vacuum drying has emerged as a promising alternative.

Vacuum seasoning is based on the fact that the boiling point of water is substantially lowered when the pressure of the atmosphere over it is lowered; i.e. if the normal pressure of water is lowered from 101kN/m^2 to 20kN/m^2 the boiling point of water is lowered from 100°C to 60°C (Kanagawa & Yasujima, 1993). This method came into existence in the sixtieth decades of the last century (Voigt *et al*., 1940). In early use of the method the wood was placed in a cylinder like the autoclave used for preservative treatments. The vacuum by itself does not

cause drying; latent heat of evaporation is essential however (Hougen *et al.,* 1940).

Bulk flow and diffusion are two forms of water transportation inside the wood (Siau, 1984). Generally, it is recognized that free water bulk flow (FWBF) controls moisture movement at moisture content (MC) above fibre saturation point (FSP) and diffusion controls the moisture movement at MC below FSP (Zimmermann, 1983). Little is known about water vapour bulk flow (WVBF) which is driven by the total pressure difference (Moyne & Martin, 1982). It is well documented that permeability affects the vacuum drying rate (Avramidis *et al.,* 1994).

Many studies have been conducted on vacuum drying. Comparative evaluation of vacuum and conventional kiln drying was carried out by Harris & Taras (1984) and Taniguchi & Nishio (1991). The concept of boiling front in vacuum drying was introduced by Chen & Lamb (1995). The need for improved drying schedules in vacuum kilns was emphasized by Safin *et al.* (2007). In Indian conditions, performance of convection heating based vacuum kiln was evaluated by Upreti *et al.*, (2013).

The present study on vacuum kiln drying of *C. javanica* reveals several important research gaps. These gaps indicate the need for systematic, multi-parameter, and large-scale investigations.

MATERIALS AND METHODS

The study of Vacuum kiln drying was carried out on *C. javanica* species. For Drying of this species Vacuum kiln is used. All the research work has been carried out at the Wood Seasoning Discipline of Forest Products Division, Forest Research Institute, Dehradun.

Logs

Four logs of wood species were procured from timber depot of Range Office (Silviculture Division) Forest Research Institute, Dehradun. The dimension details are provided in the Table 1.

Table 1: Dimension details of *Cassia javanica* logs used during the study.

Species	Logs No.	Girth (cm)	Length (cm)
Cassia javanica	**1**	67.05	106.68
	2	67.05	121.92
	3	57.19	140.20
	4	64.08	121.92

Log obtained were converted into 28 planks of dimension 36”*4”*1” (L*W*T).

Kiln sample was prepared as per IS 1141:1193 Bureau of Indian Standards namely such as KSc (KSc_1, KSc_2, KSc_3, and KSc_4). Initial Moisture content of plank was calculated as per the IS 1141: 1993. Furthermore, calculated oven dry weight (COD) was also calculated for moisture calculation of daily basis.

Prong test and moisture distribution test was carried out as per IS 1141:1993 and IS 11215: 1991 respectively to ensure uniformity in operation. Under the Vacuum drying of *C. javanica*, the timber stack inside the vacuum kiln and dried through cyclic process. At the start of each cycle, the value of relative humidity (RH) and temperature was noted down. Under one cycle temperature was raised to 50^{o}C and maintained for a period of 3 hours with the help of heaters and air circulation was done with the help of fans. After sometimes when enough heating has been carried out the heaters are turned off and reached relative humidity is noted down. After three hours an absolute vacuum of 220mm of Hg was applied with the help of vacuum pump and sustained for half an hour. Two cycles were run every day of 3 hours heating and half an hour vacuum sustained of each cycle. The weight of kiln sample was measured at 5 P.M. every day and measured the amount of condensed water from the kiln was coming. The time required to reach to 220 mmHg of vacuum was 15 minutes. The Drying of *C. javanica* takes the 20 cycles span of 9 days to reach the on an average moisture content is about 12%.

Curves of hour wise Moisture content decreases, drying rate (Percentage decrease in the moisture content/hour). Drying rate of the timber was also calculated.

The drying rate can be defined as the moisture removed in unit time. It is calculated using the Initial Moisture Content (IMC) and Final Moisture Content (FMC) and drying duration:

$$\text{Drying rate} = \frac{\text{IMC}-\text{FMC}}{\text{Drying duration}}$$



Fig. 1. Vacuum kiln drying set up at Wood seasoning discipline, FRI.

RESULTS AND DISCUSSION

A. Initial moisture content

The initial moisture content of kiln sample was calculated as per IS1141: 1993. Table 1 shows the log girth dimension of *C. javanica* species. Table 2 shows the initial weight and oven dry weight of strips and moisture content of both species.

a. Initial Moisture Content of Kiln Sample of *Cassia javanica*

The Data collected of Vacuum Drying of *C. javanica* Species is mentioned in Table 3 and Table 4 shows the data of Moisture content of the *C. javanica* species. For the Vacuum drying of timber 2 cycles operated per day. It was applied 3 hours continuous heating after that applying the 220 mm Hg of vacuum and sustained for half an hour after that again applying the continuous heating and giving the vacuum and sustained for half an hour and at 5 P.M taking the weight of Kiln sample and by using the formula calculating the moisture content of sample that represent the moisture content of whole stack. The cyclic application of heating and vacuum is in line with improved vacuum kiln schedules reported by Safin *et al*. (2007).

Table 2: Initial Weight and Oven Dry Weight of Kiln Sample.

Species	Moisture Strip Number	Green Weight (gm.)	Oven dry weight (gm)					Average Moisture Content (%)
			After 24 hrs	After 26 hrs	After 28 hrs	Moisture Content= Mg = Wg – Wo/ Wo (%)		
Cassia javanica	**A1**	33.3	20.6	20.5	20.5	62.43		64.38
	A2	36	22	21.9	21.9	64.38		
	B1	3 9.4	21.9	21.7	21.7	81.5		81.56
	B2	44.5	24.7	24.6	24.5	81.63		
	C1	39.2	23.6	23.5	23.5	66.80		69.74
	C2	43.1	24.3	24.1	24.1	78.83		
	D1	37.5	22.6	22.4	22.4	67.41		66.25
	D2	38.8	23.6	23.5	23.5	65.10	Average =	70.48

b. Drying Parameters of Vacuum Drying of *Cassia javanica* Species

Table 3: Seasoning parameters collected during the Vacuum Kiln Drying of *Cassia javanica* Species wooden samples.

Day	Cycle No.	Temperature in O C at the Start of Cycle	RH % in at the Start of cycle	Applied Temperature in O C	Heaters were on for Minutes	Reached RH %	Absolute Vacuum applied in mm	Vacuum Pump Was on for Minutes	Reached RH % when Pump was switched off	Duration in minutes for which vacuum Sustained	Water Collected in litre
1	1	26	81	50	75	108	220	15	96	30	2.5
1	2	43.5	118	50	70	129	220	15	100	30	2
2	3	27.8	121	50	85	138	220	15	116	30	1.9
2	4	47.8	134	50	20	148	220	15	121	30	1.7
3	5	28.9	125	50	60	142	220	15	117	30	2
3	6	48.5	123	50	15	132	220	15	108	30	2
4	7	24.9	126	50	75	157	220	15	148	30	1.8
4	8	47.4	147	50	10	147	220	15	148	30	2
5	9	26	139	50	60	157	220	15	138	30	4
5	10	48.7	149	50	10	153	220	15	146	30	3
6	11	26	118	50	60	147	220	15	108	30	3
6	12	48.7	149	50	5	149	220	15	118	30	3
7	13	26	118	50	60	134	220	15	108	30	4
7	14	48.5	149	50	10	156	220	15	118	30	2.5
8	15	27.6	96	50	50	134	220	15	108	30	2.3
8	16	47.5	136	50	10	156	220	15	134	30	2
9	17	28	101	50	46	134	220	15	117	30	1.8
9	18	45.8	138	50	10	146	220	15	121	30	2

c. Moisture Content of *Cassia javanica* Species during Vacuum Drying

Table 4: Moisture content of the seasoning samples of *C. javanica.*

Day	SAMPLE A	Green Weight (Kg)	Calculated Oven Dry Weight (Kg)	Moisture Content (%)	SAMPLE B	Green Weight (Kg)	Calculated Oven Dry Weight (Kg)	Moisture Content (%)
-		1.813	-	64.38		2.054	-	81.56
1		1.645	1.158	42.05		1.828	1.192	61.62
2		1.579	1.158	36.35		1.724	1.192	52.43
3		1.515	1.158	30.82		1.64	1.192	45.00
4		1.45	1.158	25.21		1.559	1.192	37.84
5		1.393	1.158	20.29		1.493	1.192	32.00
6		1.341	1.158	15.80		1.432	1.192	26.61
	Moisture Content of Moisture Distribution Test of Kiln Sample							
-		1.099	-	16.17		1.134	-	23.81
7		1.09	0.946	15.22		1.118	0.9159	22.06
8		1.07	0.946	13.10		1.087	0.9159	18.68
9		1.057	0.946	11.73		1.062	0.9159	15.95
Moisture content of *Cassia javanica* decreasing Day wise of Kiln Sample C and D								
Day	**Sample C**	**Green Weight (Kg)**	**Calculated Oven Dry Weight (Kg)**	**Moisture Content (%)**	**Sample D**	**Green Weight (Kg)**	**Calculated Oven Dry Weight (Kg)**	**Moisture Content (%)**
-		2.031	-	72.81		2.034	-	66.25
1		1.791	1.183	51.39		1.798	1.314	47.01
2		1.689	1.183	42.77		1.691	1.314	38.26
3		1.597	1.183	34.99		1.597	1.314	30.58
4		1.506	1.183	27.30		1.507	1.314	23.22
5		1.432	1.183	21.92		1.432	1.314	17.08
6		1.365	1.183	17.92		1.362	1.314	13.81
	Moisture Content after Moisture Distribution Test of Kiln Sample							
-		1.123	-	16.93		1.069	-	14.62
7		1.09	0.946	15.22		1.054	0.8733	13.09
8		1.07	0.946	13.10		1.028	0.8733	10.30
9		1.067	0.946	12.79		1.003	0.8733	7.61

Table 4 represents the day wise reduction in moisture content (MC) of kiln dried *C. javanica* samples. The initial MC of the kiln charge was calculated from moisture strips, while the MC of kiln samples was calculated using their calculated oven dry (COD) weights. The average MC decreased progressively from an initial value of 70.48% to approximately 18% after 6 days of drying. Such progressive reduction in MC under vacuum conditions has also been reported by Lin, *et al.*, (2007). At this stage, a moisture distribution test was conducted, which showed average core shell MC values of 16.17%, 23.81%, 16.93%, and 14.62% for samples A, B, C, and D, respectively. Due to variations between kiln samples and moisture strips, the COD weights were modified to 1.099, 1.134, 1.123, and 1.069 kg for samples A, B, C, and D, respectively. The existence of core to shell moisture gradients during vacuum drying supports the boiling front mechanism described by Chen and Lamb (1995). Subsequent MC calculations based on the modified COD weights indicated an average MC of 12.02% on the 9th day, after which drying was stopped and the charge was removed from the vacuum kiln.

Drying Curve of *C. javanica* Species:

The Drying curve of *Cassia javanica* species is shown in the Fig. 1 and 2 that is showing the decreasing moisture content of kiln samples. The initial moisture content of sample A is 64.38%, sample B is 81.56%, sample C is 72.81% and sample D is 66.25% (Table 5). The moisture content of samples is decrease as the drying hours increase day wise. It took total 52.5 hours to bring down the average moisture content of samples to 12.02%. Similar drying behavior under vacuum conditions has been observed in modeling studies by Jun *et al.* (2008).

d. Decreasing of Moisture Content of Kiln Sample with the Drying Duration

Table 5: Showing the Moisture content of Kiln Samples of species decreasing on the Hourly basis.

Drying Duration (in hrs)	*Cassia javanica*			
	Moisture Content (%) of Kiln samples			
	A	B	C	D
0	64.38	81.56	72.81	66.25
5.5	42.05	61.62	51.39	47.01
11.5	36.35	52.43	42.77	38.26
17.5	30.82	45.00	34.99	30.58
23.5	25.21	37.84	27.30	23.22
29.5	20.29	32.00	21.92	17.08
35.5	15.80	26.61	17.92	13.81
41.0	15.22	22.06	15.22	13.09
47.0	13.10	18.68	13.10	10.30
52.5	11.73	15.95	12.79	7.61

e. Drying Rate of *Cassia javanica* Species with the Moisture Content

Table 6: Drying Rate of *Cassia javanica* species with Moisture content.

Drying Duration in hrs	Moisture Content of Sample A (%)	Drying Rate (MC/Hr)	Moisture Content of Sample B(%)	Drying Rate (MC/Hr)	Moisture Content of Sample C(%)	Drying Rate (MC/Hr)	Moisture Content of Sample D(%)	Drying Rate (MC/Hr)
0	64.38	-	81.56	-	72.81	-	66.25	-
5.5	42.05	4.06	61.62	3.62	51.39	3.89	47.01	3.49
11.5	36.35	0.49	52.43	0.799	42.77	0.74	38.26	0.76
17.5	30.82	0.316	45	0.42	34.99	0.44	30.58	0.43
23.5	25.31	0.23	37.84	0.3	27.3	0.32	23.22	0.31
29.5	20.29	0.17	32	0.19	21.92	0.18	17.08	0.2
35.5	15.8	0.12	26.61	0.15	17.92	0.11	13.81	0.09
41.0	15.22	0.0146	22.06	0.11	15.22	0.065	13.09	0.017
47.0	13.1	0.045	18.68	0.07	13.1	0.045	10.3	0.059
52.5	11.73	0.026	15.95	0.052	12.79	0.005	7.61	0.051

f. **Drying Rate of Kiln Sample of *Cassia javanica* Species with Drying Duration Hours**

Table 7: Drying Rate of *Cassia javanica* species with Drying Duration (Hours).

Drying Duration in hrs	Drying Rate Of Kiln Sample A (MC/Hr)	Drying Rate Of Kiln Sample B (MC/Hr)	Drying Rate Of Kiln Sample C (MC/Hr)	Drying Rate Of Kiln Sample D (MC/Hr)
0	-	-	-	-
5.5	4.06	3.62	3.89	3.49
11.5	0.49	0.799	0.74	0.76
17.5	0.316	0.42	0.44	0.43
23.5	0.23	0.3	0.32	0.31
29.5	0.17	0.19	0.2	0.2
35.5	0.12	0.15	0.15	0.09
41.0	0.0146	0.11	0.026	0.017
47.0	0.045	0.07	0.045	0.059
52.5	0.026	0.052	0.005	0.051

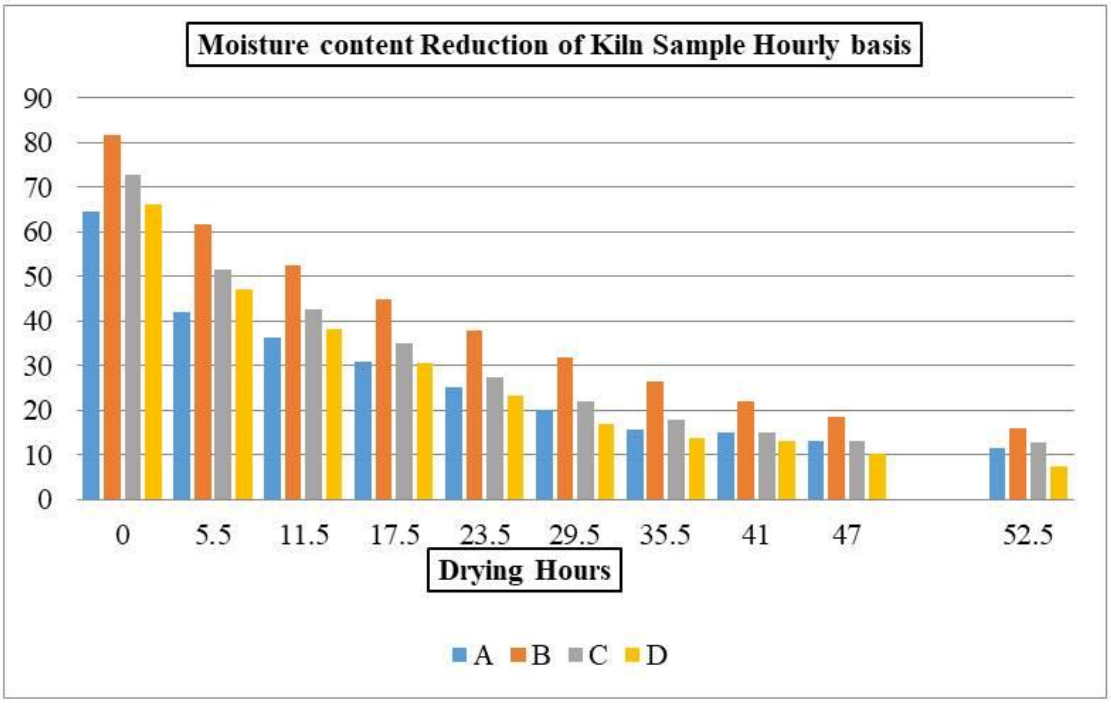


Fig. 1. Moisture content reduction of Kiln Sample with drying hours.

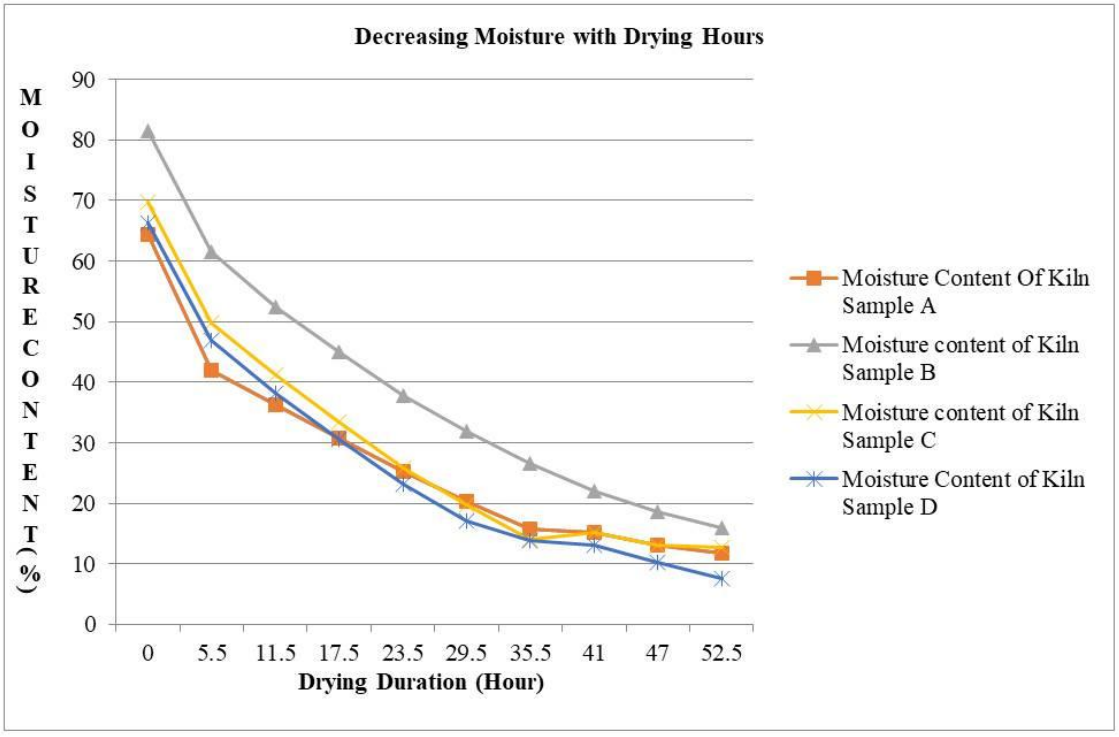


Fig. 2. Drying rate curve with moisture content of *Cassia javanica* seasoning samples.

In this species the drying curves are steeper when the free water is being removed and afterwards the curves are becoming flatter when the bound water is coming out of wood. This two-stage drying pattern is consistent with the mechanisms reported by Feng *et al.*, (2008), where rapid removal of free water is followed by slower diffusion-controlled bound water movement.

The drying rate of *C. javanica* species were studied on 4 kiln samples. The drying rates have been calculated in Table 7. It is seen that from Fig. 3 and 4 at the initial stage the drying rate was faster and became slower gradually with increase of drying time. This trend agrees with the critical dimension and drying rate observations under vacuum drying reported by Lin *et al.*, (2007). This is because initially the free water was coming out hence the drying rate in all the four kiln samples was high, which is also supported by the drying mechanism explained by Chen and Lamb (1995).

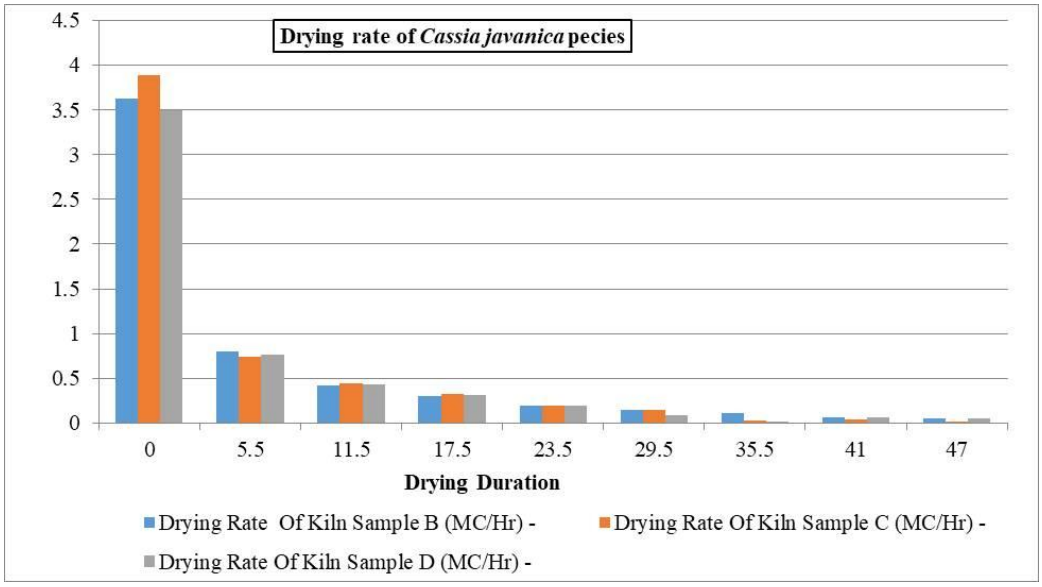


Fig. 3. Drying rate curve with drying duration of *Cassia javanica* samples.

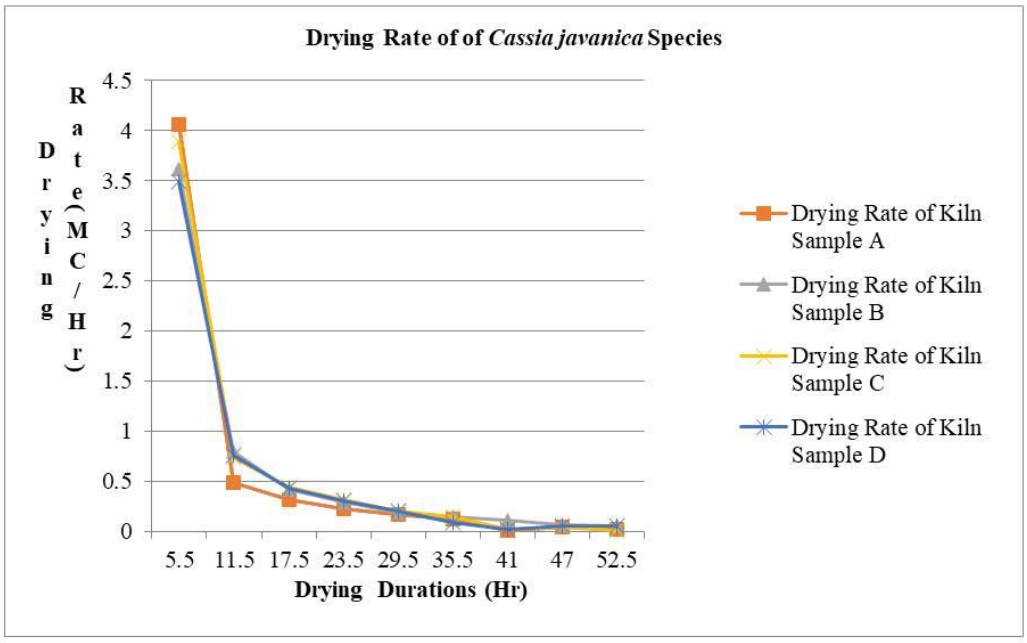


Fig. 4. Drying rate curve with drying duration of *Cassia javanica* seasoning samples.

CONCLUSION

The vacuum drying of *C. javanica*was studied the research work. In this experiment, planks of the species were vacuum dried by applying an absolute vacuum of 220 mm of Hg. In steam heated kiln *Cassia javanica* species is seasoned by using kiln schedule VII and it takes 1" (inch) thick plank 24 to 30 days to dry to 12 % moisture content. During Vacuum drying study it was observed that the *C. javanica* species took only 52.5 hours to dry to final moisture content of 12.02 %. The vaccum drying demonstrated significantly higher efficiency reducing seasoning time from 24 to 30 days to just 52 hours. From this experiment it is clearly inferred that the Vacuum drying of this species is much faster in comparison to traditional steam heated kiln drying. Throughout the study period a vacuum of 220mm Hg was maintained and subsequently was found suitable to bring the moisture content of both the species down to a desired level of 12%. The aim of the experiment was to generate vacuum drying data on *C. javanica* which helped in the better understanding of drying behaviour of species under vacuum. With such studies it would become easier to understand the drying behaviour of various other wood species. Further investigations may be undertaken to optimize vacuum pressure levels, temperature combinations, and plank thickness to enhance drying efficiency and energy utilization.

FUTURE SCOPE OF THE STUDY

The study on drying kinetics, especially below the fibre saturation point where the wood exhibited slower drying,

are necessary to understand moisture diffusion behavior and internal stress development. Experimental trials using different vacuum pressures and higher temperature profiles may also help to reduce drying time further while maintaining quality.

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Conflict of Interest: None

REFERENCES

Avramidis, S., Liu, M., & Neilson, B. J. (1994). Radio-frequency/vacuum drying of softwoods: Drying of thick western red cedar with constant electrode voltage. *Forest Products Journal*, *44*(1), 41–47.

Chen, Z., & Lamb, F. M. (1995). The concept of boiling front in vacuum drying. *Drying Technology*, *13*(5–7), 110–116.

Feng, Q., Wang, G., & Wang, F. (2008). Methods and mechanism for drying scraps mulberry. *Transactions of the Chinese Society of Agricultural Engineering*, *24*(7), 264–268.

Harris, R. A., & Taras, M. A. (1984). Comparison of moisture content distribution, stress distribution and shrinkage of red oak lumber dried by a radio frequency/vacuum drying process and a conventional kiln. *Forest Products Journal*, *34*(1), 44–54.

Hougen, O. A., McCauley, H. J., & Marshall, W. R. (1940). Limitations of diffusion equations in drying. *AIChE Journal*, *36*(2), 183–206.

IS 11215. (1991). *Moisture content of timber and timber products — Methods for determination*. New Delhi: Bureau of Indian Standards.

IS 1141. (1993). *Code of practice for seasoning of timber*. New Delhi: Bureau of Indian Standards.

Jun, L. X., Guang, Z. B., Jun, L. W., & Dong, Z. Y. (2008). Mathematical modeling of wood microwave–vacuum drying. *Journal of Beijing Forestry University*, *30*(2), 124–128.

Kanagawa, Y., & Yasujima, M. (1993). *Vacuum drying of wood*. Tokyo: Forestry and Forest Products Research Institute. 292 pp.

Kang, W., Lee, N. H., and Choi, J. H., (2004). A radial distribution of moistures and tangential strains within a larch log cross section during radio-frequency/vacuum drying. *HolzalsRoh- und Werkstoff*, *62*(1), 59–63.

Kollmann, F. F. P., & Côté, W. A. (1968). *Principles of Wood Science and Technology: Solid Wood*. New York: Springer-Verlag. 592 pp.

Lin, Y. S., Guang, Z. B., Rong, L. Y., & Shu, W. (2007). Preliminary research on critical dimension of wood under vacuum drying. *Chinese Forestry Science and Technology*, *6*(3), 51–54.

Moyne, C., & Martin, M. (1982). Influence of a total pressure gradient in gaseous phase on drying with particular reference to wood. *International Journal of Heat and Mass Transfer*, *25*(7), 1839–1845.

Sandoval Torres, S., Jomaa, W., Puiggali, J. R., & Avramidis, S. (2011). Multiphysics modeling of vacuum drying of wood. *Applied Mathematical Modelling*, *35*(10), 5006-5016.

Safin, R. R., Mustafin, Z. R., & Chernyshev, A. N. (2007). Improving the drying schedules for lumber in vacuum conduction kilns. *Derevoobratyvayushchaya Promyshlennost*, *5*(2), 6–7.

Sandoval-Torres, S., et al., 2012. Colour alteration and chemistry changes in Oak Wood (*Quercus pedunculata* Ehrh) during plain vacuum drying. *Wood Science and Technology*, *46(*1–3), 177–191.

Siau, J. F. (1984). *Transport Processes in Wood*. New York: Springer-Verlag. 218 pp.

Simpson, W. T. (1984). Drying wood: A review. *Drying Technology*, *2*(3), 353–368.

Simpson, W. T. (1987). Vacuum drying of northern red oak. *Forest Products Journal*, *37*(1), 35–39.

Taniguchi, Y., & Nishio, S. (1991). High frequency power vacuum drying of wood IV: Comparison of physical and mechanical properties of lumber dried by several drying methods. *Journal of the Japan Wood Research Society*, *37*(5), 405–414.

Teischinger, A., Avramidis, S., Hansmann, C., & Mayrhofer, A. (2023). Sawn timber steaming and drying. In *Springer handbook of wood science and technology* (pp. 1167-1210). Cham: Springer International Publishing.

Upreti, N. K., Kukreti, M. C., Kandpal, R. P., & Swaroop, C. (2013). Convection heating based vacuum kiln for timber drying and its performance. *Indian Forester*, *139*(1), 43–48.

Voigt, H., Krischer, O. U., &Schauss, H. (1940). Special technique for wood drying. *HolzalsRoh- und Werkstoff*, *5*(3), 364–375.

Walker, J. C. F. (1993). *Primary Wood Processing*. New York: Chapman & Hall. 955 pp.

Yang, L., Liu, X., Li, T., & Li, J. (2025). Influence of temperature and vacuum level on the drying rate, moisture content distribution, wood color and drying stress of rubberwood in vacuum drying. Wood Material Science & Engineering, 1–7.

Zimmermann, M. H. (1983). *Xylem Structure and the Ascent of Sap*. Berlin: Springer-Verlag. 143 pp.

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