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EFFECTIVENESS OF AIR DRYERS AND SOLAR KILNS FOR TIMBER WOOD DRYING

EFFICACITÉ DES SÉCHOIRS À AIR ET DES FOURS SOLAIRES POUR LE SÉCHAGE DU BOIS

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ABSTRACT

Air drying (AD) and solar kiln (SK) drying of timber are known to dependent on weather conditions; though they are reported to be more affordable compared to conventional kiln. The objective of this study was to evaluate the drying capacity of timber, using air dryers and solar kilns. *Khaya ivorensis* boards (25 mm x 300 mm x 1200 mm) were seasoned under air- and solar kiln environments for 5 weeks, and comparably assessed along with the initial moisture content (%), drying rate (%/time), moisture content gradient (%) and drying defects. From the initial moisture content of 134.65 and 137.52%, *K. ivorensis* wood attained average final moisture content of 13.07 and 26.29% at drying rate (%/time) of 3.47%/5 weeks and 3.18%/5 weeks for solar kiln-and air-dried samples, respectively. Using the equilibrium moisture content (12-15% MC) as the reference point, average moisture content gradient in solar kiln-dried board (13.07% MC) was 0.7%; while that of the air dried samples (26.29% MC) was not determined. Furthermore, defects were mild, and lower proportions of boards were affected more in solar kiln-dried samples than in the air counterpart. Selected climate variables (temperature and relative humidity) of the wood drying environments were measured on a daily basis. Average temperature (^{O}C) was higher in the solar kiln (36.27) compared to air drying (26.05) for week 1, week 2, week 3, week 4 and week 5, respectively. Relative humidity was lowest (49.33 and 81.38) and highest (56.38 and 93.52) in solar kiln and air drying, respectively. Based on the selected indices examined, it is clear from this study that the response of *K. ivorensis* wood to drying is superior in solar kilns to in air dryers.

Key Words: Drying defects, drying rate, final moisture content, initial moisture content, *Khaya ivorensis,* moisture content gradient

RÉSUMÉ

Le séchage à l'air (AD) et le séchage au four solaire (SK) du bois sont connus pour dépendre des conditions météorologiques; bien qu'ils soient rapportés comme étant plus abordables que le four conventionnel. L'objectif de cette étude était d'évaluer la capacité de séchage du bois, en utilisant des séchoirs à air et des fours solaires. Des planches de *Khaya ivorensis* (25 mm x 300 mm x 1200 mm) ont été séchées dans des environnements de four à air et de four solaire pendant 5 semaines, et évaluées de manière comparable avec la teneur en humidité initiale (%), le taux de séchage (%/temps), le gradient de teneur en humidité (%) et les défauts de séchage. À partir d'une teneur en humidité initiale de 134,65 et 137,52 %, le bois de *K. ivorensis* a atteint une teneur en humidité finale moyenne de 13,07 et 26,29 % à un taux de séchage (%/temps) de 3,47 %/5 semaines et de 3,18 %/5 semaines pour les échantillons séchés au four solaire et à l'air, respectivement. Français En utilisant la teneur en humidité à l'équilibre (12-15 % MC) comme point de référence, le gradient moyen de teneur en humidité des panneaux séchés au four solaire (13,07 % MC) était de 0,7 % ; tandis que celui des échantillons séchés à l'air (26,29 % MC) n'a pas été déterminé. De plus, les défauts étaient légers et des proportions plus faibles de panneaux étaient davantage affectées dans les échantillons séchés au four solaire que dans leurs homologues à l'air. Certaines variables climatiques (température et humidité relative) des environnements de séchage du bois ont été mesurées quotidiennement. La température moyenne (OC) était plus élevée dans le four solaire (36,27) que dans le séchage à l'air (26,05) pour les semaines 1, 2, 3, 4 et 5, respectivement. L'humidité relative était la plus faible (49,33 et 81,38) et la plus élevée (56,38 et 93,52) dans le four solaire et le séchage à l'air, respectivement. D'après les indices sélectionnés, cette étude montre clairement que la réponse du bois de *K. ivorensis* au séchage est supérieure dans les séchoirs solaires que dans les séchoirs à air.

Mots Clés: Défauts de séchage, vitesse de séchage, teneur en eau finale, teneur en eau initiale, *Khaya ivorensis*, gradient de teneur en eau

INTRODUCTION

Drying of wood involves exposing timber to heat energy provided by natural or forced convection under a specified condition (Mitchell, 2019; Hajji *et al.* 2025). Sequel to wood products manufacturing, harvested logs (fresh or green timber) is seasoned (dried) as a precursor to other wood processing procedure. Timber drying is an essential aspect of wood products manufacturing, which enhances workability, dimensional stability, treatability and durability; and service life of timbers or wood products. In order to enhance wood products quality, it is imperative that timber is dried to the required moisture content, depending on the end use or application (Elustondo *et al*., 2023; Rahimi *et al*., 2023; Zhu and Yang 2025); as drying timber to proper moisture content reduces the susceptibility of wood to drying defects (Owoyemi *et al*., 2015; Amoo-Onidundu *et al*., 2016; Terziev *et al*., 2025).

Timber can be dried using artificial dryers called kiln, stack shed for air drying (exposure to ambient air), or solar chambers for solar kiln seasoning methods (Pedro *et al.,* 2015; Phonetip *et al.,* 2018; 2022; Rahimi *et al.,* 2023). Apart from the influence of inherent wood property in timber, drying outcomes depend on three basic environmental variables, referred to as wood drying factors (temperature, relative humidity and air circulation) (Amoo-Onidundu *et al*., 2016). Consequently, results on timber drying research are often based on prevailing drying factors under which timber is dried. However, related timber drying models concentrate more on temperature and relative humidity (Amoo-Onidudndu *et al*., 2020; Tagne *et al.,* 2020).

Conventional kiln drying involves drying of timber inside kilns or dryers; and is termed artificial timber drying method (Trujillo *et al.,* 2021). The process of kiln drying consists of introducing heat into a stack of sawn timber inside a chamber. A kiln could be steam-heated, fire-heated, dehumidified or vacuum-dried (Rahimi *et al.*, 2022; Elustondo *et al*., 2023). Due to its characteristic feature of possessing control units, drying procedures can be regulated as desired; hence, the drying procedure can be stipulated for drying individual timber species in accordance with the selected schedules found suitable. As reported by several researchers (Rahimi *et al.*, 2022; 2023; Elustondo *et al*., 2023), various drying schedules have been stipulated for different timber drying experiments.

A major limitation of conventional kiln drying of timber is its high cost incurred on energy generation during operations. As a result of this, there is a low level of acceptability of conventional kiln drying of timber in sub-Saharan Africa (Amoo-Onidundu *et al*., 2016).

Air drying of timber (natural method) involves exposing timber to atmospheric air; whereby the stack of lumber is arranged on joists; while alternate sawn timber are separated using stickers. The ambient heat generated from sun warms up the prevailing air and dries the stacked timber. As the temperature increases, timber moisture vaporises and moves from the wood pores to the atmosphere (Horacio and Lasserre, 2015; Mitchell, 2019). From initial moisture content (IMC), which may range from 40-269%, timber dries through critical stages: fibre saturation point- FMC (MC ranging from 25 to 30%), dry rot safety line (MC up to 20%) and equilibrium moisture content (EMC); when the moisture is at equilibrium with the surrounding air. At EMC, the wood has attained final moisture content (FMC), unless the timber is taken to a varied atmospheric condition (Amoo-Onidundu *et al*., 2020; Gerard and Groutel, 2023).

Air drying of timber has inherent limitation, including high risks of susceptibility to drying defects under unfavourable environmental conditions, low timber drying quality, inability to dry timber to lower final moisture content suitable for certain interior applications, uneven drying of stack, higher time consumption with variation depending on season of the year and geographical location of study area (Mitchell, 2019; Ogunsuyi and Owoyemi, 2022).

Solar kiln drying of timber has been identified as a cross between air and conventional kiln drying methods (Amoo-Onidundu *et al*., 2022; 2023). One peculiar feature of solar kiln drying technology is that the system depends on atmospheric condition for heat generation. Ambient temperature and relative humidity are major climatic variables which influence the internal environmental condition (temperature and relative humidity) within the kiln chamber, or prevailing weather under the air dying shed. Hence, the internal environmental condition is a microenvironment which determines the outcome of drying processes (Ugwu *et al*., 2015; 2020).

Over the years, researchers have designed several types of solar kiln for various experiments on wood drying and reported on outcomes of timber species to drying under varying locations (Ugwu *et al*., 2015; Mitchell, 2019; Amoo-Onidundu *et al*., 2023). Timber drying parameters assessed range from drying rate (Pedro *et al*., 2015), to moisture ratio (He and Wang, 2020), equilibrium moisture content (Yi *et al*., 2008), drying defects (Amoo-Onidundu *et al*., 2022) and shrinkage (Owoyemi *et al*., 2015). Reports revealed that methods of wood drying influence the timber drying outomes (Merlin Simo-Tagne *et al.,* 2020; Amoo-Onidundu *et al*., 2022). The objective of this study was to evaluate the drying capacity of timber using air dryers and solar kilns.

MATERIALS AND METHODS

Study site. The study was conducted at the Forestry Research Institute of Nigeria (FRIN) Ibadan, in Nigeria, located on latitude 7°23'15'' to 7°24'00'' N; longitude 3°51'00'' to

3°52'15''E and altitude 150 meters above sea level. The annual ambient temperature of the study area ranged from 18.07 to 34.4 °C; while the mean annual relative humidity was around 77.1%. The climate at the site was tropical, with two distinct seasons; namely rainy season (April to October) and dry season (November to March), accompanied by the harmattan in December (Ariwaodo *et al.,* 2012).

Experimental procedures. The green-house-type solar kiln used for this study (Fig. 1), was made of wooden frames and covered with transparent ultraviolet-stabilised polythene sheet (glazing material), of 200 micron thick. The inner part of the frames was lined with black polythene sheets, which served as solar collector. The air drying shed had its roof installed on wooden post (Fig. 2).

Samples used for this experiment were sawn from core-wood of *K. ivorensis,* at the base of the log obtained from the arboretum. Wood of dimension 50 mm x 300 mm x 3600 mm, was initially processed for the experiment; by laterally sawing into two boards of equal thickness. Two transverse sections (25 mm) were obtained at a distance of 300 mm away from both ends of each board. These were used for evaluating the boards' initial moisture content, using the oven-dry method, in accordance with ASTM D4442-92 (ASTM, 2003).

A total of ten planks of 25 mm x 300 mm x 1200 mm each, was selected for air- and solar-kiln drying. The moisture content of the samples was determined using the gravimetric method, represented by Equation 1 (FPRL, 1949).

$$\%IMC = \frac{W_1 - W_2}{W_2} x100 \quad .... \text{ Equation 1}$$

Figure 1. The greenhouse-type solar kiln used for drying *Khaya ivorensis* timber.

Figure 2. The air drying shed used for drying *Khaya ivorensis* timber.

Where:

W_1 = wet weight of the specimen; and W_2 = oven-dry weight of the specimen

Boards were stacked-with stickers (25 mm x 25 mm x 900 mm) separating alternate boards. During the drying process, periodic moisture content (PMC) of the boards was determined daily, using Equation 2. Subsequently, average weekly values (mean of 7 days readings) for PMC were determined. The PMC was calculated according to the formula outlined by FPRL (1949):

$$\%\text{PMC} = \frac{\text{CWB} - \text{DWB}}{\text{DWB}} \text{x}100 \quad \text{..... Equation 2}$$

Where:

The current weight of the boards (CWB) = average weight of board at week 1, 2, 3, 4 or 5 dry weight of boards (DWB) = an estimated by Equation 3:

$$\text{DWB} = \frac{\text{WWB}}{\left\{\frac{\text{IMC}}{100} + 1\right\}} \quad \text{................ Equation 3}$$

Where:

WWB = the wet weight of boards; and IMC = the average moisture content of the transverse sections (oven dry samples).

Average weekly drying rate (DR) of boards was calculated from PMC values. The DR is change in percentage moisture content per given time (“%MC/time) or percentage moisture content loss or difference between two consecutive readings (Equation 4):

$$\text{DR (weekly)} = \frac{\text{PMC}_{\text{pst}} - \text{PMC}_{\text{prs}}}{\text{time}}$$
.... Equation 4

Where:

DR = drying rate (%/time); PMC_{pst} = periodic moisture content for past reading (%); and PMC_{prs} = periodic moisture content for present reading (%).

Weekly drying rate was calculated by dividing the difference between two consecutive PMC values by 1 week of drying; while overall DR (throughout the drying period) was computed by dividing the difference between Initial moisture content (IMC) and Final moisture content (FMC) by 5 weeks of drying (Equation):

$$\text{DR (overall)} = \frac{\text{IMC} - \text{FMC}}{\text{5 Weeks}} \quad \text{....... Equation 5}$$

At the end of drying period, moisture content gradient (%MCG) of the boards was evaluated. The procedure included sawing (obtaining) a transverse section of 25 mm, as a representative sample from the boards. Subsequently, the samples were sawn into surface and core (outer and inner) portions. The portions were separately weighed on weighing. Thereafter, samples were oven-dried at 103±2 ^{O}C until the weight of samples remained constant. After oven drying, weight of samples were taken; while the MC was calculated gravimetrically. The difference between the MC of core and surface portions of the wood was calculated as MCG using Equation 6 (Welling *et al.,* 1999):

MCG = MC(core) - MC(surface) ....Equation 6

Where:

MCG = moisture content gradient; MC(core) = moisture content at core portion of wood; while MC(surface) = moisture content at surface portion of wood.

For warp and checks measurement, 10 samples were selected from the experiment under each drying method. Each board was positioned on a flat table, to examine the type of defects. The extent of warp was measured using a calibrated inclined plane wedge of 10 mm height and 100 mm length; while checks were measured with a ruler.

A digital thermo-hygrometers was placed on the stack of boards inside the solar dryer and under the air dryer to measure the environmental conditions-temperature (T) and relative humidity (RH). Data on T and RH were collected three times a day; at the hours of 10:00, 13:00 and 16:00 to represent morning, peak period and evening, respectively. This followed a climatic data capturing system for meteorological information (WMO, 1974).

On a daily basis, periodic moisture content (PMC) was calculated using Equation 2. Consequently, correlation between mean weekly drying factors and weekly drying rate was obtained. The initial moisture (IMC) and final moisture content (FMC) in were evaluated. At the end of the drying experiment, selected wood defects were assessed to determine (with reference to Rasaily 1993).

RESULTS AND DISCUSSION

Moisture content of timber. Data for moisture content (MC%) of dried wood from 1 to 5 weeks of drying are presented in Table 1. Moisture content differed significantly ($P<0.05$) between the two drying environments. In SK drying, wood dried from initial MC of 134.65 to 38.40% in week 1; and attained final moisture content (FMC) of 13.07% in week 5. On the other hand, AD wood attained 50.23% dryness in week 1 and 26.29% in week 5. The final moisture content (SK: 13.07 and AD: 26.29%) implied that SK-dried samples attained lower MC values than its AD counterparts; which is an indication of differences in response to drying conditions. Since SK boards dried to 13.07%, the boards already attained equilibrium MS, EMC (12-15%MC) in accordance with TRADA (2011) and Esen and Türüdü (2020). Consequently, they were categorised as suitable for a wider range of interior and exterior applications (TRADA, 2011; Kherais *et al*., 2024).

In AD drying, samples dried to FMC of 26.29%; which, according to Mitchell (2019), falls within the fibre saturation point (FSP), which is a MC that ranges from 25-30%. Hence, it implied that AD-dried samples did not attain the required equilibrium moisture content (12 to 15%) at which timber becomes more stable and adequately suitable for interior and exterior applications, in relation to environmental condition (TRADA, 2011; Gerard and Groutel, 2023).

More so, since the FMC (26.29%) of AD-dried samples was above the dry rot safety line of 20% (Shupe *et al.,* 2008), the samples will be highly prone to biodeterioration (Adebawo *et al*., 2021; Azeh *et al*., 2023).

TABLE 1. Wood moisture content in the timber dryers during the five weeks of drying

Week of drying	Solar kiln (SK)	Air drying shed (AD)
Week 1	38.40(±0.02)	50.23(±0.03)
Week 2	29.33(±0.01)	45.45(±0.02)
Week 3	25.70(±0.01)	38.94(±0.01)
Week 4	21.11(±0.02)	36.67(±0.01)
Week 5	13.07(±0.01)	26.29(±0.01)

Values are mean of 10 replicates; Values in parenthesis are standard deviation; and Average Initial Moisture Content for SK samples =134.65(±0.00). Average Initial Moisture Content for AD samples = 137.52(±0.00)

More so, the air-dried samples will be limited to external applications (TRADA, 2011; Gerard and Groutel, 2023).

Data for analysis of variance (ANOVA) for wood moisture content are presented in Table 2. It is clear, the effect of treatment (drying methods) on MC was significant ($P<0.05$); implying that there was a significant difference between SK and AD, for FMC for *K. ivorensis* wood dried in this study. This conforms to the findings of Amoo-Onidundu *et al.* (2023); who reported significant differences in the FMC of SK- and AD-dried *Gmelina arborea* samples. The statistical difference in the MC could be attributed to the difference in environmental conditions of the solar dryer and air-drying media.

Wood drying rate. Results revealed a significant difference in timber drying rate between SK- and AD-dried boards over time (Table 3). The DR ranged from 3.63 to 13.75; and from 2.28 to 12.47 for solar kiln and air drying method, respectively. The highest drying rates (13.75: SK and 12.47: AD) were recorded during the initial drying stage (week 1) of drying. This could be attributed to the high rate of movement of excess moisture from the cell lumen to the outer surface (Pedro *et al.,* 2015; Ogunsuyi and Owoyemi, 2022). However, there were inconsistent trends in the DR from week 2 to week 5. This could be due to fluctuations in environmental variables within solar dryer and air-drying medium (Trujillo *et al*., 2021; Rahimi *et al*., 2023).

Results on overall drying rate revealed that SK-samples dried at 3.47%/ 5 weeks; while AD-samples dried at 3.18%/ 5 weeks. This implied that within 5 weeks of drying, SK-boards dried from IMC (134.65%) at a faster rate (3.47%/ 5 weeks) and attained FMC of 13.07%; whereas AD-boards dried from IMC (137.52%) at a slower rate (3.18%/ 5 weeks) and attained FMC of 26.29%. This agreed with the findigs of Amoo-Onidudndu *et al*. (2022) that timber dries at a faster rate in SK compared to AD.

Analysis of variance for weekly drying rates of *K. ivorensis* wood, showed no significant ($P>0.05$) for drying method differences (Table 4). The DR was a function of differences between wood IMC and FMC, divided by 5 weeks, the total period of drying wood samples. As presented earlier (Table 1), the FMC of SK-dried samples was 13.07% (at equilibrium moisture content); whereas the MC of AD-dried samples was 26.29% (at fibre saturation point). This uncommon factor probably resulted from the effect of drying method not being significant on DR between SK and AD (Table 4).

The difference in DR of *K. ivorensis* wood on weekly basis, was statistically significant (Table 4). This could have been as a result of weather variation or response of wood to drying at various stages of drying; conforming

TABLE 2. Analysis of variance (ANOVA) for wood moisture content (MC) for drying period versus drying method of timber

Source of variation	SS	df	MSS	F	Sig.
Drying method (DM)	4896.79	1	4896.79	148.53	0.000*
Week of drying (WD)	6815.79	4	1703.95	51.68	0.000*
DM*WD	63.84	4	15.96	0.48	0.75Ns
Error	2967.160	90	32.968		
Total	14743.583	99			

Asterisk (*) means that the value is significant; Ns means that the value is not significant at $P<0.05$

TABLE 3. Drying rate (DR%/time) of *K. ivorensis* wood

Week of drying	Solar kiln IMC= 134.65(±0.00)%FMC=13.07(±0.01) %		Air drying shedIMC= 137.52(±0.00)%FMC=26.29(±0.01)%	
	Average weekly DR	Overall DR	Average weekly DR	Overall DR
Week 1	13.75(±0.02)	$\frac{IMC-FMC}{5\ Weeks}$ DR=3.47%/5Weeks	12.47(±0.03)	DR= DR=3.18%/5Weeks
Week 2	9.07(±0.01)		4.78(±0.02)	
Week 3	3.63(±0.01)		6.50(±0.01)	
Week 4	4.58(±0.02)		2.28(±0.01)	
Week 5	8.05(±0.01)		10.38(±0.01)	

Values are means of 10 replicates; Values in parenthesis are standard deviation; IMC = Initial Moisture Content; FMC = Final moisture content, and DR = Drying rate

to the conclusion made by several other studies (Amoo-Onidundu *et al*., 2023).

Wood moisture gradient. Data for assessment of MC gradient in wood are presented in Table 5. There were significant differences in wood surface MC and Core MC. For solar kiln-dried samples, MCG ranged from 0.5 to 0.8; with an average MCG of 0.7. For air-dried samples, core and surface of boards still contained excess moisture-above fibre saturation point. Hence, there was no perceived differences between core and surface moisture for computation on MCG. Mild MCG is an indication that dried timber is less susceptible to developing drying defects such as checks (Muñoz and Moya, 2008).

Types and sizes of defects. Data for drying defects on *K. ivorensis* boards after drying, are presented in Table 6. For SK-drying, results revealed that out of a total of 10 boards, 1 board each developed warp (mild bow and moderate cup), respectively.

In contrast, one out of 10 boards (10%) developed a mild end check, for SK or AD methods. For air-dried samples, no board developed warp at the end of the drying experiment (Table 6). This implies that shrinkage, which causes board distortion due to wood anisotropy, did not develop; yet AD boards still contained moisture above FSP (26.29%) (Table 2). According to several researchers, shrinkage; which tends to develop drying stress in wood, occurs when wood MC is at or below FSP (Dong *et al*., 2025).

It was observed that about 30% of AD the boards developed end check, irrespective of drying method. This may be due to excessive drying of the boards' ends; leading to fissuring of fibres that developed end checks. According to Dong *et al*. (2025), the extent of distortion and checks in wood greatly affects the appearance and mechanical properties of sawn timber.

Drying factors (temperature and relative humidity) *vs* MC in drying wood. Results of

TABLE 4. Analysis of variance for drying rate in AD and SK drying of *K. ivorensis* wood

Source of variation	SS	df	MSS	F	Sig.
Drying method (DM)	7.111	1	7.111	0.138	0.711Ns
Week of drying (WD)	1143.878	4	285.970	5.540	0.000*
DM*WD	187.956	4	46.989	0.910	0.462Ns
Error	4645.521	90	51.617		
Total	5984.466	99			

Asterisk (*) means value is significant; while Ns means value is not significant at $P<0.05$

TABLE 5. Assessment of moisture content gradient in dried *K. ivorensis* wood

Board	Solar drying			Air drying		
	Surface moisture content (%SMC)	Core moisture content (%CMC)	Difference between SMC and CMC (%MCG)	Surface moisture content (%SMC)	Core moisture content (%CMC)	Difference between SMC and CMC (%MCG)
Sample 1	12	12.7	0.7	Above 12-15%	Above 12-15%	ND
Sample 2	14.2	15	0.8	Above 12-15%	Above 12-15%	ND
Sample 3	9.5	10.2	0.7	Above 12-15%	Above 12-15%	ND
Sample 4	12.8	13.6	0.8	Above 12-15%	Aabove 12-15%	ND
Sample 5	15.1	15.8	0.7	Above 12-15%	Above 12-15%	ND
Sample 6	12	12.7	0.7	Above 12-15%	Above 12-15%	ND
Sample 7	14.2	14.9	0.7	Above 12-15%	Above 12-15%	ND
Sample 8	9.5	10	0.5	Above 12-15%	Above 12-15%	ND
Sample 9	12.8	13.5	0.7	Above 12-15%	Above 12-15%	ND
Sample 10	15.1	15.8	0.7	Above 12-15%	Above 12-15%	ND
Average	12.72	13.42	0.7	Above 12-15%	Above 12-15%	ND

MCG = moisture content gradient; ND = not determined; MCG for AD-dried samples was denoted as ND since moisture content of core and surface portion was above 12-15% MC

the effect of temperature and relative humidity on MC of *K. ivorensis* wood in under different drying methods are presented in Figure 3. It was revealed that, throughout the wood drying period, temperature in the solar kiln was higher compared to air drying for weeks 1 to 5.

The overall average temperature was 36.27 ^{O}C in the SK; and 26.05 in the AD (Table 3). Relative humidity in SK, was consistently lower, ranging from 48.14 to 56.38%; than the AD counterpart, which ranged from 81.38 to 94.86%. Trujillo *et al*. (2021) conducted comparative studies on solar-and air dying of wood, and found out that higher temperature and lower relative humidity in SK, contributed to higher wood drying rate and lower final

TABLE 6. Drying defects (warps and checks) on *K. ivorensis* boards after drying using different drying methods

Drying method	Defect type	Category	No. of boards without defect	Severity of defect			No. of defected boards	% of defected boards
				Mild	Moderate	Severe		
Solar kiln	Warp	Bow	9	1		-	1	-
		Cup	9		1	-	1	10
		Twist	10	-	-	-	-	0
	Check	End	9	1			1	10
		Surface	9		1		1	10
Air drying	Warp	Bow	10	-	-	-	-	-
		Cup	10		-	-	-	-
		Twist	10	-	-	-	-	-
	Check	End	7	-	-	3	-	30
		Surface	10	-	-	-	-	-

Total of 10 planks each was examined for solar kiln and air drying

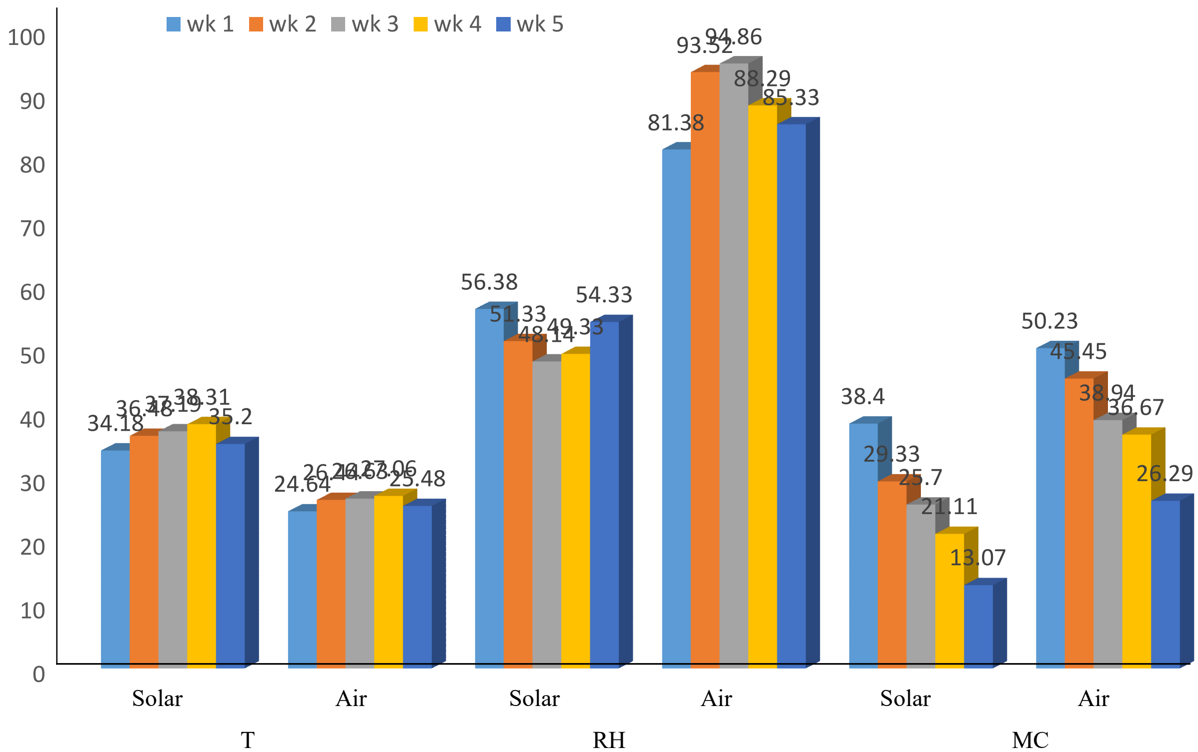

Figure 3. Effect of temperature and relative humidity on moisture conten of wood dried in a solar kiln and air drying. solar = solar kiln, air = air dryer, T = temperature, RH = Relative humidty, MC = Moisture content

moisture content. This implied that solar SK drying is potentially a more efficacious method for drying wood than air drying.

According to several other researchers (Phonetip *et al.,* 2018; 2022), higher temperatures and lower relative humidity increase the rate of wood drying; thereby increasing the vapour pressure difference between the wood and its surrounding air. In Figure 3, results on drying factors (temperature and relative humidity) *vs* MC in drying wood revealed that higher temperature and lower relative humidity in SK could be attributed to the lower moisture content attained (38.40, 29.33, 25.70, 21.11 and 13.07%) compared to AD (50.23, 45.45, 38.94, 36.67 and 26.29) for week 1, week 2, week 3, week 4 and week 5, respectively.

The air in the AD contained a greater amount of moisture compared to what it could hold at a given temperature; contrasting with the solar kiln. Hence, the prevailing air in AD was damper; consequently, the AD offers a potentially less favourable environment for wood drying than its solar kiln. In this study, it was observed that throughout the weeks of drying (week 1 to week 5) higher temperature and lower relative humidity in the solar kiln dryer (compared to air dryer), resulted into a more effective drying of *Khaya ivorensis* which was associated with lower moisture content in SK-dried samples.

CONCLUSION

The study has demonstrated that solar kilns are remakably superior in drying timber of *K. ivorensis,* to conventional air drying. This is attributed to the former generating higher temperatures and diminished relative humidity; factors that are most determinants in the drying process. Solar kiln dried timber samples most effectively within five week of drying; attaining a moisture content of 13.07±0.01%; whereas air-dried (AD-dried) samples attained MC of 26.29±0.01%, over the same period. Air-dried samples (with MC of 26.29%) did not attain EMC; the boards contained moisture within fibre saturation point (25-30%); implying that the samples were more susceptible to dimensional instability (shrinkage/swelling), distortion and biodeterioration in service.

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