Souphanouvong University Journal of Multidisciplinary Research and Development
2026, Vol. 12, No. 03, 233-239
https://doi.org/10.69692/SUJMRD1203233

Physical Properties Assessment of Chinaberry timber Melia azedarach L. / Meliaceae

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Article Info:
Submitted: July 28, 2026
Revised: August 25, 2026
Accepted: September 3, 2026

Abstract

This study examined the drying behavior, shrinkage, and density characteristics of *Melia azedarach L.* (Chinaberry) wood collected from three naturally felled trees within community coffee plantations, with diameters of 40, 50, and 60 cm. Each tree was sectioned into top, middle, and base logs (2 m in length), from which test samples (25 × 25 × 25 mm) were prepared in accordance with ASTM D143 (2013). A total of 70 samples were oven-dried at 60°C and later increased to 100°C until reaching constant weight to determine density and dimensional changes. Results showed that the moisture content (MC) decreased markedly from 89.96% to 6.91% over 48 hours, accompanied by declines in relative humidity and dew point, while temperature rose from 57°C to 103°C. Shrinkage followed an anisotropic pattern typical of hardwoods, with tangential (4.28%) and radial (2.74%) shrinkage values significantly greater than longitudinal (1.72%). The density of the samples ranged from 500 to 950 kg/m³, with most values between 600–750 kg/m³, classifying Chinaberry as a medium-density hardwood. These findings highlight the influence of drying conditions on moisture removal and dimensional stability, confirming the species' suitability for furniture and moderate structural applications.

Keywords: Chinaberry timber, Density of timber 12%, Density of timber, Shrinkage.

1 Introduction

Melia azedarach L., commonly known as Chinaberry or White Cedar, is a versatile deciduous tree recognized globally for both its aggressive ecological traits and its high economic potential. Ecologically, it is a highly resilient species characterized by high fruit output and resistance to pathogens, allowing it to colonize diverse climatic zones (Rojas-Sandoval, 2023). Structurally, the tree can reach heights of 20 m with a diameter of 60 cm, featuring complex pinnate leaves and fragrant lilac flowers (Mabberley, 1984). Melia azedarach is a deciduous tree native to the Himalayan region of Asia (McBride, 2017). This species has been widely cultivated as an ornamental and shade tree, as it is well adapted to warm climates, poor soils, and seasonally dry conditions (Punja et al., 2007). Melia azedarach is of very high value and is found over a very wide range of habitats in Australia, including semiarid areas (Atangana et al., 2013). Melia azedarach is often planted for fuel supply in the Middle East and in Assam (India), where it is grown on tea estates for fuel. Its specific gravity is about 0.66 (calorific value: 5043-5176 kcal kg-1) (National Academy Press, 1980).

The fiber saturation point (FSP) is an important parameter of wood material, related to dimensional stability and variations of mechanical performance (Almeida et al., 2020) is Investigated the FSP values of 15 tropical Brazilian wood species covering all strength classes of the Brazilian standard code. An additional goal was to estimate FSP value based on the wood's apparent density. The FSP values were determined by measuring the wood specimen dimensions during moisture content reduction from the saturated state. Wood densities at 0% and 12% moisture contents and basic density were determined according to the Brazilian standard code. The average FSP for all wood species was 21.6% moisture content. (Marasigan et al., 2025) Examined the variation in the physical properties of Bagalunga (Melia azedarach L.), teak (Tectona grandis L.f.) and mahogany (Swietenia macrophylla King.) across radial and axial positions. Physical properties were evaluated in accordance with the ASTM D1432019 standard. Five trees per species were collected in Quezon Province, Philippines. Regarding shrinkage properties, bagalunga recorded the highest tangential and radial shrinkage, which were 49.2% and

48.9% higher than those of teak, and 77.6% and 18.4% higher than those of mahogany, respectively.

In the Lao PDR, Melia azedarach is prioritized as an economic timber species (Van Sam et al., 2004). In regions like Champasak, it serves dual purposes: providing essential shade for coffee plantations and supplying timber for furniture, flooring, and house construction due to its aesthetically pleasing grain patterns. Despite its utility, the commercial value of Chinaberry wood in Laos remains low compared to international markets. This disparity is largely due to a lack of localized scientific data regarding its physical and mechanical properties. Understanding wood quality is critical; for instance, research on 9-year-old trees indicates a high heartwood percentage (69.01%) but a significant fiber saturation point (36.34%) (Abdulqader, 2021). The fiber saturation point (FSP) is a critical threshold; below this level, moisture loss leads to dimensional instability, increasing the risks of splitting and deformation (Jean Gérard, 2023). Because wood shrinks differently in radial and tangential directions, understanding these ratios is vital to preventing deformation during the drying process.

Despite studies abroad, the properties of Melia azedarach in Laos' climate and altitude (such as the Volan Plateau) may be different, Currently, local operators in Laos often lack the scientific reference data needed to establish effective kiln-drying schedules, resulting in lower wood quality and suppressed market prices. Conversely, international markets utilize physical property data to optimize production, achieving higher value for the same species. Therefore, the objective of this research is to evaluate the dimensional stability and density of Melia azedarach L. timber by analyzing the relationships among drying oven temperatures, drying oven durations, shrinkage rates, and density, timber across varying oven temperatures and durations, providing a baseline for high-quality wood processing in Laos.

2 Materials and Methods

2.1 Specimen preparation

The tree is located in Luk 45 Village, Pak Song District, Champasak Province. a tree that grows in the area of people's coffee garden, it is more than 10 years old, For the wood used in this study is 5 years old. Trees standing points of is as the geocoordinate “0628092 E, 16782220 N, 1243 m of sea level”.

2.2 Methods

Starting from the natural cutting of 3 trees that occur in the area of people's coffee plantations. Front dimensions are 40, 50 and 60 centimeters. Each tree is cut into 3 parts: the top part, the middle part and the end part, 2 meters long. Saw each piece of wood on a chain saw, cut it to size with a moon saw, take a sample of wood and test it in the Oven dry for testing density and shrinkage.

Density and shrinkage test saw wood 25x25x25 mm, 70 samples (according to standard ASTM D143,2013) and weighed, measuring three dimensions of wood in thickness, thickness, length and scan sample by EPSON L222 series. Record the data and bake the wood samples at a temperature of 60 degrees Celsius. Weigh and measure every 2 hours, Dry until it reaches 12 percent density and increase the temperature to 100 degrees Celsius. Then, Dry until the weight is constant and calculate according to the formula:

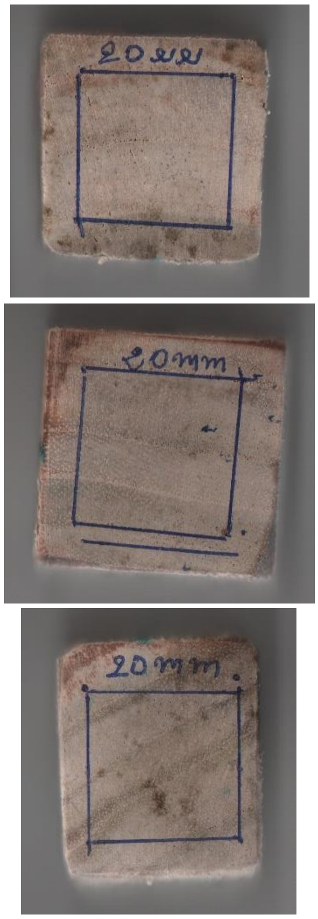

figure 1 Scan sample

Calculation of density According to the calculation method according to the 1st method.

$$\text{Density (g/cm3)} = \frac{M}{V}$$

Where, D-Density (g/cm3), M-Mass (g), V- Volume (cm3)

Calculation of shrinkage According to the calculation method according to the 2st method.

$$\text{Shrinkage (\%)} = \frac{\text{Variable wood size}}{\textit{Initial sample wood size}} \times 100\%$$

After that ONE WAY ANOVA was used to analyze the relationship between wood moisture content with density and shrinkage.

3 Results and Discussion

3.1 Results

This study found that the concentration of the study sample was reduced with the time spent drying, the humidity of the initial sample was equal to 89.96 percent, followed by a further 5 hours equal to 62.53 percent, 7 hours equal to 49.67 percent, 24 hours equal to 33.19 percent, 26 hours equal to 18.22 percent, 28 hours equal to 29 hours equal to 16.84 percent and 48 hours equal to 6.91 percent (respectively).

Picture2 is analyze the correlations between time and various parameters including temperature (Temp), relative humidity (RH), dew point (DewPt), and moisture content (MC) in materials over a period of 48 hours.

- Material Moisture Content (MC) decreased significantly from 89.96% at 0 hours to 6.91% at 48 hours, indicating a strong impact from the reduction of ambient humidity.
- Relative Humidity (RH) dropped from 54.27% to 19.25% by hour 26, then slightly increased to around 24.11% at hour 29.
- Dew Point decreased from 49.54°C to 0°C by hour 48, reflecting the decline in air moisture.
- Temperature remained relatively stable around 57–62°C initially, then sharply rose to 103°C at 48 hours.
- Moisture content in materials (MC) is closely related to RH and Dew Point. As RH and Dew Point decrease, the moisture content in materials also drops significantly.
- Increased temperature appears to enhance drying, although the correlation may not be consistent throughout all time points.

The decrease in material moisture content is clearly correlated with reductions in relative humidity and dew point. High temperature plays an important role in promoting evaporation from the material. These findings can be applied to optimize drying processes or preserve material quality more efficiently.

Figure 3 shows the variation in shrinkage percentage of Chinaberry (*Melia azedarach L.*) timber over different drying times (0–48 hours) in tangential (T), radial (b), and longitudinal (L) directions. The results indicate that tangential shrinkage (Shr T) remains consistently higher than radial (Shr b) and longitudinal (Shr L) shrinkage throughout the drying process. At the beginning (0–28 h), shrinkage values remained relatively stable, with slight increases over time. However, after 29 hours of drying, a sharp increase was observed, reaching maximum values at 48 hours—4.28% (tangential), 2.74% (radial), and 1.72% (longitudinal). This trend aligns with the general behavior of wood, where dimensional change is greatest tangentially and least along the grain. The noticeable increase in shrinkage at sample 8 indicates a response to higher moisture loss or variation in wood structure. Overall, these results suggest anisotropic behavior in wood drying, with tangential shrinkage approximately twice the radial and significantly greater than longitudinal shrinkage**.**

Figure 4 illustrates the density distribution of Chinaberry (*Melia azedarach L.*) wood across 70 measured samples. The recorded densities range from approximately 500 kg/m³ to 950 kg/m³, with most samples clustering between 600–750 kg/m³, indicating a medium-density hardwood. The fluctuations observed among the samples suggest natural variability in the wood's anatomical structure, moisture distribution, and growth conditions. Peaks in density, such as those near samples 25, 40, and 52, may correspond to areas with higher latewood content or reduced porosity, whereas lower values may be linked to increased earlywood proportion or internal voids. Overall, the average density aligns with previously reported values for Chinaberry (540–690 kg/m³), confirming its suitability for furniture, joinery, and moderate structural applications where medium strength and workability are desired.

3.2 Discussion

The results of this study indicate that Melia azedarach exhibits a notably high Fiber Saturation Point (FSP) of 36.34%, which significantly exceeds the average FSP of 21.6% found in various tropical species Brazilian study (Almeida et al., 2020) and the general scientific benchmark of 25-30% for most timbers. This deviation suggests unique anatomical and chemical characteristics of Chinaberry wood grown in the Lao context. Several factors may contribute to this elevated FSP: Environmental and Growth Factors: The rapid growth rate of Melia azedarach in the tropical climate of Southern Laos (Champasak) may result in a more porous cell wall structure, allowing for a higher volume of bound water before the free water is completely removed from the cell lumina. Anatomical Structure and Juvenile Wood: The high percentage of heartwood (69.01%) in relatively young (9-year-old) trees often implies a significant presence of juvenile wood.

Comparison with Equilibrium moisture content curves for wood or Keyword diagram (Jean Gérard, 2023) presents the relationship between the measured moisture content (MC) of *Melia azedarach* samples and the theoretical equilibrium moisture content (EMC) estimated from the Keyword diagram. The initial MC of the green sample was 89.96 %, which decreased rapidly during the first 24 hours of drying, reaching 33.19 %. This initial sharp decline corresponds to the removal of free water from the wood cell lumina, where moisture loss occurs primarily through evaporation. Between 24 and 28 hours, the rate of moisture reduction slowed as the process transitioned to the bound water diffusion stage, with MC decreasing from 33.19 % to 16.84 %. After approximately 48 hours of drying, the wood reached a final moisture content of 6.91 %, which closely matches the theoretical equilibrium moisture content (≈ 6 %) predicted by the Keyword diagram for air conditions around 70 °C and 50 % relative humidity. This agreement indicates that the samples had reached a stable equilibrium with the surrounding drying environment. Overall, the comparison between experimental and theoretical data confirms that the drying process followed the typical two-phase pattern observed in hardwoods: (1) a rapid loss of free water followed by (2) a slower removal of bound water until equilibrium was achieved. The close match between the final measured MC and the theoretical EMC demonstrates the efficiency and adequacy of the applied drying conditions for *Melia azedarach* timber.

The density values obtained in this investigation for Melia azedarach show a wide variation, with many values clustering in the ~600–750 kg/m³ range and extremes approaching ~900 kg/m³. When compared with published studies, the variations are broadly similar but appear to extend to higher values in the present dataset. These results can be compared with (Van Duong & Matsumura, 2018)reported a mean density of about 510 kg/m³ for 17-19-year-old trees in northern Vietnam, while other reports indicate specific gravities of 0.55-0.65 (≈550-650 kg/m³) for this species. The fact that the lower end of our results aligns with literature supports the validity of our measurements, A study in Mexico (Venson et al., 2008) reported densities of 560–760 kg/m³ for 11-year-old trees, which lies comfortably within the mid-range of the current results. A study in Indonesia (Saefudin et al., 2024) found densities of 460–580 kg/m³ in younger trees (5-13 years), which corresponds to the lower end of our range. Another study in Tanzania reported densities around 436 kg/m³, which is lower than most of our values, suggesting site and age effects may strongly influence density. The commonly cited commercial range for M. azedarach is 500–650 kg/m³. The fact that many of our samples exceed this common range and approach ~900 kg/m³ indicates significant within-species variation, likely driven by factors such as tree age, growing site (soil fertility, spacing, climate), anatomical variation (heartwood/ sapwood ratio, latewood content) and sample position in the tree. This wide density span has practical implications: in processing, strength grading, drying behaviors, and end-use selection of the timber from plantation or natural stands of M. azedarach.

The shrinkage behavior of Melia azedarach observed in this study reflects its unique physical characteristics when compared to other commercial timbers. At a 12% moisture content, Melia azedarach exhibited shrinkage rates of 4.28% (tangential), 2.74% (radial), and 1.72% (longitudinal). When compared with (Marasigan et al., 2025), the tangential and radial shrinkage of Melia azedarach is significantly lower than that of Bagalunga (6.58% and 4.50%) and remains relatively comparable to Teak (3.98% and 2.73%). This suggests that Melia azedarach possesses a moderate level of dimensional stability in its cross-section, similar to high-value hardwoods like Teak. The higher shrinkage in Bagalunga may be attributed to a higher density of cell wall material or a different hemicellulose-to-cellulose ratio, which increases the wood's hygroscopicity. A critical finding in this research is the high longitudinal shrinkage (1.72%) of Melia azedarach, which is substantially greater than that of Bagalunga (0.25%), Teak (0.25%), and Mahogany (0.46%). Typically, longitudinal shrinkage in mature wood is negligible (less than 0.5%). The elevated rate observed here is a strong indicator of the presence of juvenile wood, which explains the rapid increase in shrinkage observed after 29 hours of drying. The shrinkage radial of Melia azedarach in this study is approximately 1.56, which is slightly higher than Teak (1.45) but still within a range that suggests manageable stability. However, the combination of a high Fiber Saturation Point (36.34%) and high longitudinal shrinkage poses a dual risk. The wood begins to lose dimensional integrity at a much higher moisture level, and the significant length-wise contraction increases the likelihood of bowing, warping, and internal stresses during the kiln-drying process.

4. Conclusion

The drying behavior and physical properties of *Melia azedarach L.* (Chinaberry) wood were investigated to understand moisture loss, dimensional stability, and density variation over time. The results show that moisture content (MC) decreased sharply from 89.96% at the initial stage to 6.91% after 48 hours, indicating a strong influence of drying time and temperature on water removal. Relative humidity (RH) and dew point (DewPt) both declined substantially during this period, while temperature gradually increased from 57–62°C to 103°C, promoting the evaporation process. The close relationship between MC, RH, and DewPt confirms that controlled temperature and humidity are key parameters in efficient drying.

In terms of dimensional stability, shrinkage behavior followed the typical anisotropic pattern of hardwoods: tangential shrinkage (4.28%) was approximately twice that of radial shrinkage (2.74%), and both exceeded longitudinal shrinkage (1.72%). This anisotropy became more pronounced after 29 hours of drying Moisture content 12%, corresponding with accelerated moisture loss and potential internal stress development within the wood matrix.

The density analysis across 70 samples revealed a range from 500 to 950 kg/m³, with the majority concentrated between 600 and 750 kg/m³, classifying Chinaberry as a medium-density hardwood.

5. Conflict

I, as a scientific researcher, hereby certify that all the information contained in this article has no conflict of interest with any part and does not favor any other part, in case of any form of violation, I am happy to take sole responsibility.

6. Acknowledgments

This study was completed because of the attention to support in terms of raw materials, equipment, and finance from many sectors. The research team would like to thank the Faculty of Forestry Science for giving the opportunity to use the Wood Science and Wood Products Research Center of the Department of Forestry Economics

and Wood Processing Technology to participate in experimental research.

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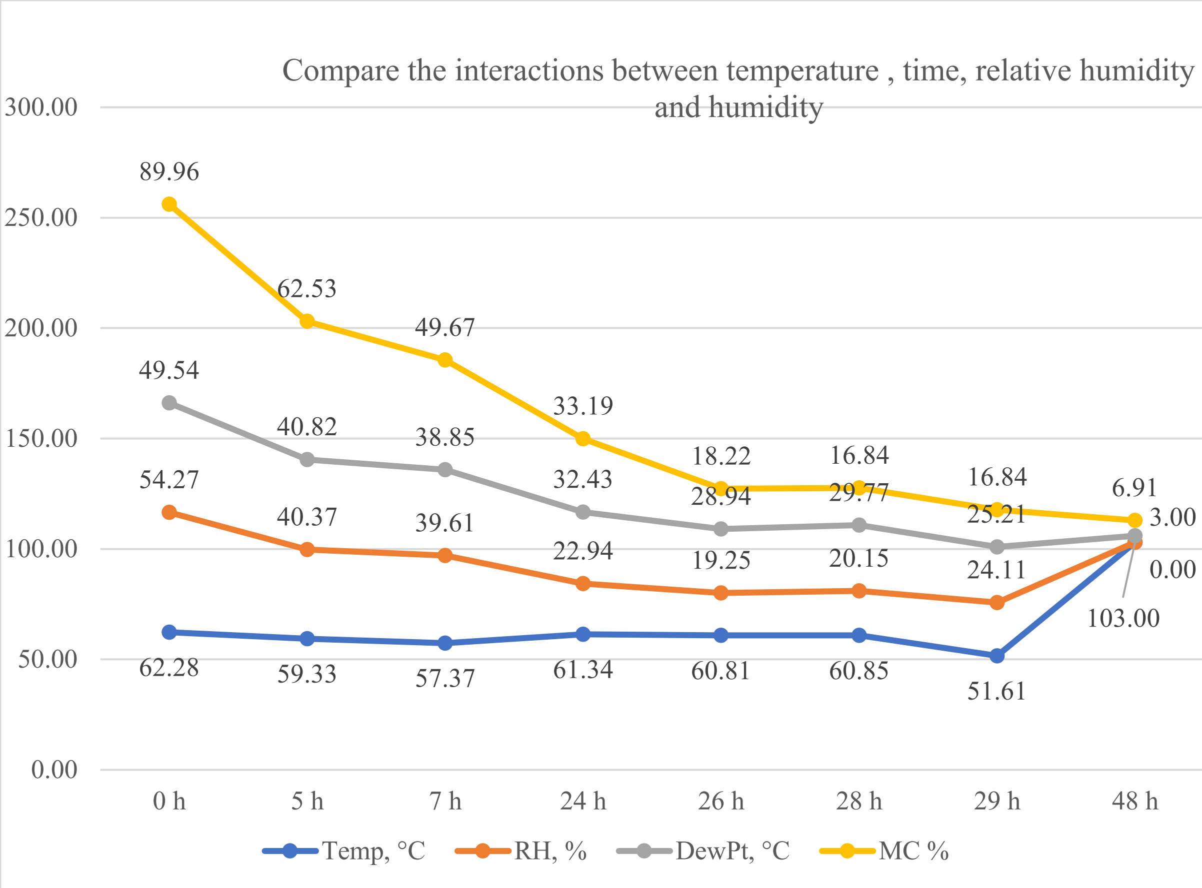
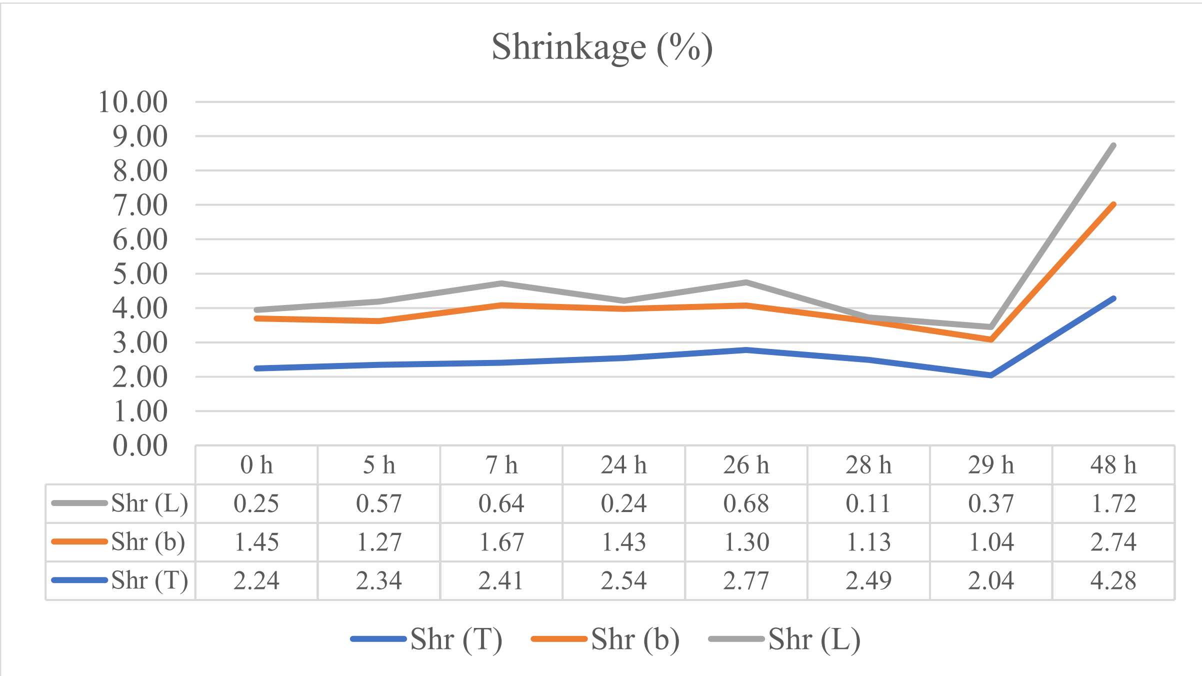
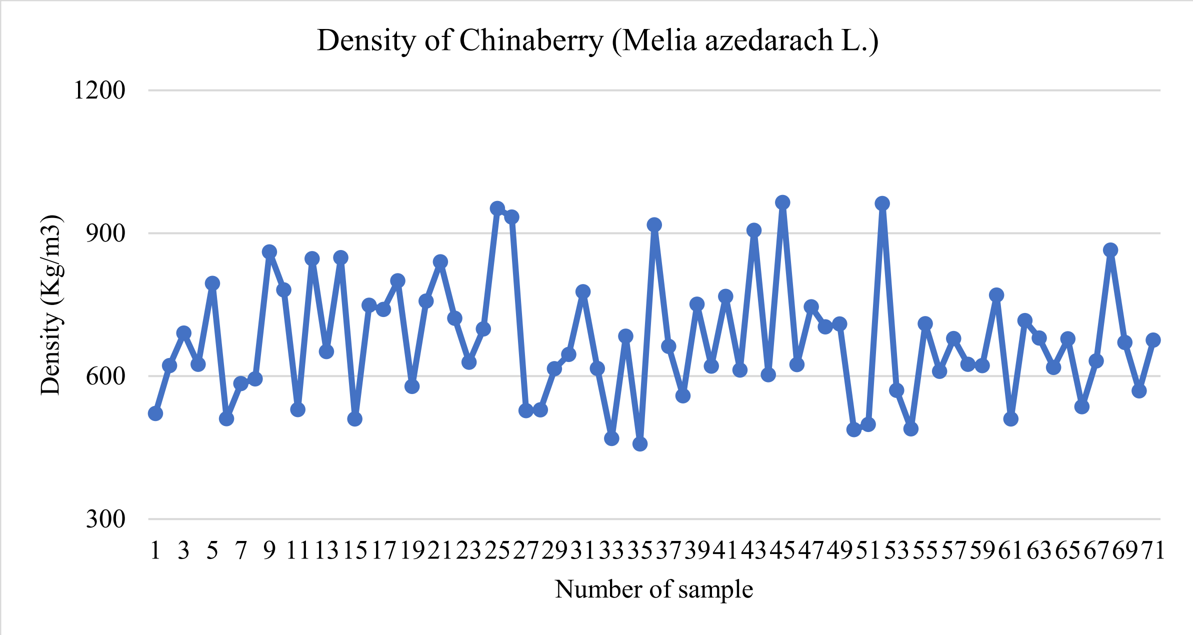


Picture2 The correlation between temperature, time, relative humidity and humidity



	0 h	5 h	7 h	24 h	26 h	28 h	29 h	48 h
Shr (L)	0.25	0.57	0.64	0.24	0.68	0.11	0.37	1.72
Shr (b)	1.45	1.27	1.67	1.43	1.30	1.13	1.04	2.74
Shr (T)	2.24	2.34	2.41	2.54	2.77	2.49	2.04	4.28

Picture3 The percentage of shrinkage in Tangential (T), Radial (b), and Longitudinal (L)



Picture 4 The density 12% of Chinaberry (*Melia azedarach L.*)