Manufacture and Perception of Portable Television Stand Prototype from Resin-Treated Kelempayan

Natrah Ahmad Fauzi[a], Siti Zalifah Mahmud[a*], Zaimatul Aqmar Abdullah[a] and Khairul Awang[b]

[a]*Faculty of Applied Sciences, Universiti Teknologi MARA Cawangan Pahang, Kampus Jengka, 26400 Bandar Tun Abdul Razak, Jengka, Pahang, Malaysia*

[b]*Wood Processing Technology Programme, Forest Products Division, Forest Research Institute Malaysia (FRIM), 52109 Kepong, Selangor Darul Ehsan, Malaysia*

Abstract

This study explores the use of resin-treated kelempayan (Neolamarckia cadamba) as a sustainable raw material for a portable television stand prototype. The use of kelempayan as an alternative material to hardwood species promotes the use of fast-growing species that can be harvested and replanted, ensuring the long-term sustainability of tropical forest resources. However, kelempayan is a light hardwood species that requires treatment to increase its durability. The aims of this study are to determine the dimensional stability properties of treated kelempayan with phenol formaldehyde resin and, to evaluate the perception of a portable television stand prototype made from resin-treated kelempayan wood on raw material, design, marketing and satisfaction. Treated specimens showed better stability, as evidenced by the significant 101% increase in weight percent gain, 86.3% in anti-swelling efficiency, 133% in resistance to water absorption, 100% in leaching and 35% bulking enhancement through PF resin infilling into the cell lumens. Thus, increasing the chemical concentration and enhancing biological resistance and dimensional stability make it a viable option for furniture manufacturers. Besides, the analysis showed significant positive correlations, with satisfaction moderately linked to raw material (r = 0.569), and strongly associated with design (r = 0.735) and marketing (r = 0.764). The findings on consumers' satisfaction indicated that the use of treated kelempayan as an alternative raw material for furniture is acceptable. Meanwhile, the portable and simple design of the product demonstrates the potential for sustainable raw materials to be used in the production of green products that meet consumers' needs and preferences. Overall, this study contributes to the knowledge of sustainable raw materials for green products and promotes the use of alternative materials that are environmentally friendly and socially responsible. The use of resin-treated kelempayan as a sustainable raw material for a portable television stand is a step towards a more sustainable and eco-friendly furniture industry.

Keywords: Sustainable furniture, Portable design, Resin treatment, Alternative materials, *Neolamarckia cadamba*

* Corresponding author. Tel.: +60-94602000; fax: +60-94602455
E-mail address: ifah@uitm.edu.my

Manuscript History:
Received 7 March 2025, Revised 11 April 2025, Accepted 14 April 2025, Published 30 April 2025

https://doi.org/10.33736/jaspe.9472.2025

e-ISSN: 2289-7771

1. Introduction

Neolamarckia cadamba, or kelempayan, is a sustainable raw material that thrives in denuded areas and self-prunes, making it valuable for tree plantations [1]. Despite being a lesser-known timber species, kelempayan is notable for its broad crown and straight trunk [2-3]. Although it is non-durable and prone to fungi and staining [4], it has been selected under the National Timber Industry Policy [5], as a promising alternative for furniture components. Kelempayan wood has favorable machining properties, a uniform white color, and a smooth surface [6], but requires treatment to improve its strength and durability for furniture use.

The research on *N. cadamba* wood dealt with the mechanical properties of juvenile wood by studying modulus of rupture (MOR) and modulus of elasticity (MOE) under different conditions of drying. In this regard, the oven-dried samples were superior in mechanical strength compared to the air-dried samples. The studies highlighted the gap in static bending strength in the lower, center, and upper parts of the wood. It was stronger at the lower portion with respect to bending, when compared to the upper one, and showed similar characteristics to that of the center. These findings suggest that juvenile *N. cadamba* wood exhibits promising strength properties, making it a valuable resource for use in various timber industry applications due to its mechanical advantages [7]. The other strength properties of kelempayan wood, such as tensile, folding, and tear resistance, are positively influenced by fiber length, which increases from the pith to the outer bark, typical of juvenile wood. Additionally, the microfibril angle (MFA) significantly impacts the wood's physical and mechanical properties, including density and stiffness. A smaller MFA value indicates greater stability, making the wood more suitable for processing and applications [8].

Kelempayan is gaining recognition as a sustainable raw material due to its ability to self-prune and thrive in overgrown or degraded areas, making it a promising species for tree plantations [1]. Its potential to supply raw materials for the furniture industry aligns with the principles of sustainable furniture, which is defined as being produced in an ecologically and socially responsible manner throughout its lifecycle. Sustainable furniture often incorporates renewable, recycled, or recovered materials and employs environmentally friendly processes such as non-toxic finishes, reduced water use, and energy-efficient production. Consumers are encouraged to seek furniture certified by organizations like the Forest Stewardship Council (FSC), ensuring the wood is sourced from well-managed forests.

Wood, as a biological material, is susceptible to degradation by various biotic and abiotic factors, such as fungi and insects. To address this, wood is often treated with biocidal preservatives, especially for outdoor use [9]. One common method to enhance the durability, moisture resistance, and dimensional stability of wood is impregnation with phenol formaldehyde (PF) resin [10-11]. It is widely used in the wood industry and is made from phenol, formaldehyde, and sodium hydroxide [12]. PF resin, primarily used in wood products and composites, offers advantages such as high heat resistance, making treated wood suitable for outdoor furniture or kitchen applications exposed to heat [13]. It is also highly resistant to water, chemicals, and moisture, making it ideal for items like bed frames and dining tables. Previous research [14] found that PF resin treatment using a vacuum-pressure technique significantly improved the properties of kelempayan wood. However, safety concerns, particularly regarding formaldehyde emissions, require careful handling and proper ventilation during manufacturing [15]. In this study, a low percentage of PF was used to ensure the safety of the final product. The study aimed to develop a portable television stand, and questionnaires were distributed to gather feedback on material performance, design, marketing, and user satisfaction.

2. Materials and methods

2.1 Materials

Kelempayan trees with a diameter at breast height (dbh) of approximately 53 cm were harvested from the fruit plot area at the Agro Technology and Plantation of Universiti Teknologi MARA (UiTM), Pahang Branch. The logs were sectioned into three billets, namely bottom, middle, and top with each measuring length of 180 cm (6 feet). These billets were then ripped into flitches and further processed into sticks. For the treatment, low molecular weight phenol formaldehyde (LMWPF) with a number molecular weight of 600 and 44% solid content was used as a treating solution. The phenolic resin was provided by Malayan Adhesives and Chemical (MAC) Sdn. Bhd., Shah Alam Selangor. This treatment process was intended to enhance the wood's durability and dimensional stability for future applications.

2.2 Product Design

Product design is a set of design tasks that follow a product from beginning to end. The process involves a series of steps, from concept development to prototype production, to creating a design solution. The design process started with creating the product concept, followed by research, designing, and making technical drawings. After that, a mock-up was built, leading to the final production of a prototype. For the television stand, the design ideation focused on concepts like portability, adjustability, simplicity, and affordability. Therefore, those elements influenced the selection of a portable-television stand as the final product concept.

2.3 Evaluation of dimensional stability specimens

The treated samples were immersed in distilled water at 500 mm Hg for 90 minutes, then resumed at atmospheric pressure for 24 hours at room temperature. Then, the dimensions of the water-absorbed samples were measured and oven-dried at 105 °C for 24 hours. The dimensions and weight once again were measured to determine weight percent gain (WPG), the resistance of water absorption (RWA), anti-swelling efficiency (ASE), bulking (B) and leaching (L) which accordance to the formula established by Shi et al. [16]. Scanning electron microscopy (SEM) was used to examine the microscopic structure of selected kelempayan wood specimens, which were cut into 5 mm x 5 mm sections in transverse orientations with a magnification of 50 times.

Weight percent gain (WPG) was calculated using the equation below;

$$WPG = \frac{G_2 - G_1}{G_1} \times 100 \quad (1)$$

G_1 represents the weight of the oven-dried wood samples before treatment (in grams), while G_2 represents the weight of the oven-dried wood samples after treatment (in grams).

The resistance of water absorption **(**RWA**)** was measured using the following equation;

$$RWA = \frac{\Delta G_0 - \Delta G}{\Delta G_0} \times 100 \quad (2)$$

G_0 is the weight of the oven-dried untreated wood sample (g),

$\Delta G_0 = \frac{G_p - G_0}{G_0} \times 100,$

$\Delta G = \frac{G_3 - G_2}{G_2} \times 100,$

G_3 is the weight of the treated wood samples subsequently water saturation (g),

G_p the weight of the untreated wood samples subsequently water saturation (g)

Anti-swelling efficiency (ASE) was calculated by the following equation;

$$ASE = \frac{\Delta V_0 - \Delta V_1}{\Delta V_0} \times 100 \quad (3)$$

ΔV_0 is the volumetric swelling coefficient of untreated wood samples (%),
$\Delta V_0 = \frac{V_p - V_0}{V_0} \times 100$,
ΔV the volumetric swelling coefficient of treated wood samples (%),
$\Delta V = \frac{V_3 - V_2}{V_2} \times 100$,
V_2 is the volume of the oven-dried treated wood samples (mm^3),
V_3 the volume of treated wood samples subsequently water saturation (mm^3),
V_0 the volume of the oven-dried untreated wood samples (mm^3),
V_p is the volume of untreated wood samples subsequently under water saturation (mm^3).

The bulking coefficient **(**B**)** was measured using the following equation;

$$B = \frac{V_2 - V_1}{V_1} \times 100 \quad (4)$$

V_1 refers to the volume of the oven-dried wood that has been treated, typically measured in cubic millimeters (mm^3).

The leaching efficiency (L) was calculated using the below equation;

$$L = \frac{G_2 - G_4}{G_2 - G_1} \times 100 \quad (5)$$

G_4 represents the weight of the oven-dried treated wood after the leaching process (in grams). This formula calculates the percentage of material that has leached out of the treated wood, indicating the effectiveness of the treatment process.

2.4 Wood treatment preparation

The treatment of kelempayan wood was conducted at the Forest Research Institute Malaysia (FRIM). The timbers were first soaked in a phenol-formaldehyde (PF) solution, consisting of a 70% resin ratio and 30% water, designed to enhance the wood's durability and resistance. After soaking, the timbers were placed in an impregnation chamber (Figure 1), where they underwent a vacuum process for 90 minutes to ensure deep penetration of the PF resin. They were then left in the solution at atmospheric conditions for 24 hours to allow for complete permeation. Following this, the timbers were transferred to an oven and pre-cured at 60°C for 24 hours to stabilize the wood. Finally, they were cured in the oven for an additional 20 hours at 90 °C to ensure that the resin was fully cured, resulting in improved structural integrity and performance (Figure 2).

Figure 1. Impregnation chamber

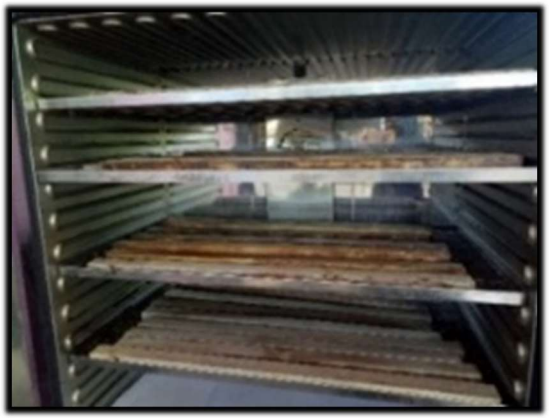


Figure 2. Oven curing process

2.5 Prototype manufacturing

The prototype was created at the Wood Industry Workshop at UiTM Jengka Campus. Processes of prototype manufacturing are shown in Figure 3. The planks underwent various machining processes, including cutting, planing, thicknessing, ripping, and routing to build the television stand. For the shelves, the timbers were clamped together. The planks were cut into pieces measuring 5 inches by 2 inches, then glued using white adhesive and secured with sash clamps for 24 hours at room temperature. All components were sanded to eliminate splinters and ensure smooth surfaces. Most pieces were assembled using wood glue, nail pins, and screws. Once all the wood parts were put together, casters were attached with a hand drill, secured with hexagon screws and washers. Finally, the product was finished with a walnut-colored wood stain, polyurethane sealer, and a clear polyurethane lacquer applied using a conventional sprayer.

Figure 3. The process of prototype manufacturing

2.6 Production cost

The production cost, based on the cost of solid wood and hardware, totalled RM 313.50, including RM 40.50 for timber with a total volume was 0.0382301 m^3 and RM 273.00 for hardware and coating. The price of treated kelempayan referred to as the mixed hardwood price is based on the Grading Malaysian Standard (GMS), which was RM 1,059/m^3 [17]. After a 30 % markup, the final production cost was approximately RM 410.00.

2.7 Data collection and analysis

In this study, a survey was conducted to gather participant data regarding the prototype, focusing on demographics such as gender, age, profession, and income, along with factors like raw materials, design, marketing, and satisfaction. Responses were collected using a five-point Likert scale through Google Forms and were analyzed for reliability and descriptive statistics using Statistical Package for the Social Sciences (SPSS) software. In total, 143 respondents were selected to answer the questionnaire. Most of the respondents were from around Bandar Tun Abdul Razak Jengka. Table 1 indicates that the reliability analysis instrument used is good and reliable enough to be used in the field study since the Cronbach's alpha value for each variable (raw material = 0.752, design = 0.853, marketing = 0.892, satisfaction = 0.927) exceeded the minimum requirement of at least 0.7 for well-developed standardized achievement tests [18].

Table 1. Cronbach's alpha value of reliability analysis

Cronbach's Alpha Based on Standardized	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Raw Material	0.752	0.759	4
Design	0.853	0.854	3
Marketing	0.892	0.892	4
Satisfaction	0.927	0.928	4

3. Results and discussion

3.1 Dimensional stability properties

Table 2. Dimensional stability properties

Portion	WPG	ASE	RWA	Bulking	Leaching
Top					
Untreated	-0.31	9.20	-27.87	4.25	0.00
Treated	59.58	76.03	86.40	5.91	9.62
Middle					
Untreated	-0.80	10.34	-29.70	4.39	0.00
Treated	58.94	78.28	86.05	6.87	10.81
Bottom					
Untreated	-0.44	13.48	-29.36	5.12	0.00
Treated	60.69	86.97	92.17	8.37	10.77

The dimensional stability of kelempayan wood was evaluated through weight percentage gain (WPG), anti-swelling efficiency (ASE), resistance to water absorption (RWA), bulking coefficient (B), and leaching (L) efficiency. Table 2 shows that treated specimens had higher stability than untreated ones, with the bottom trunk section showing the best results. Figure 4 highlights a 101% improvement in WPG, 86.3% increase in ASE, 133% in RWA, bulking improved by 35%, and leaching increased by 100%.

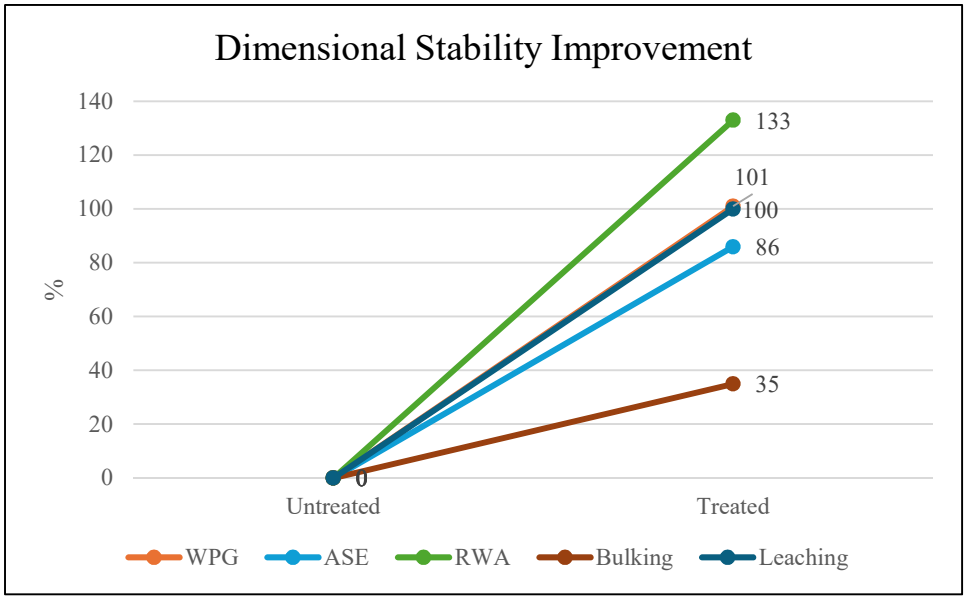


Figure 4. Dimensional stability improvement of resin-treated kelempayan

Weight percent gain (WPG) is the weight increase of wood after treatment, as a percentage of its initial weight [19]. This parameter is most important for the evaluation of the level of impregnation or modification achieved by the treatment process. Treated wood has a greater wood percent gain because PF resin infiltrates the structure and solidifies during curing, thereby adding weight [20]. Untreated wood loses weight as moisture is evaporated in the drying process, and without chemical infusion or substance infiltration, hence, it does not have the extra weight that treated wood obtained.

The anti-swelling efficiency (ASE) measures the effectiveness of wood treatments in reducing swelling due to moisture absorption. Higher ASE values represent greater dimensional stability. Results show that treated samples exhibit significantly lower swelling. The PF resin increases hydrophobicity after polymerization in the cell walls, thus reducing swelling, while untreated wood has a higher coefficient of swelling due to its hydrophilic cell walls can absorb water more, hence showing more dimensional expansion [20].

The resistance of wood to absorption, RWA is its ability to resist water uptake, which is influenced by factors such as wood species, treatment type, and chemical composition It measures how much moisture can be absorbed under certain conditions. High RWA values indicate greater water uptake. For instance, resin impregnation fills cell walls, and enhances the hydrophobicity, thus reducing water uptake in treated samples [21].

Wood bulking is the process of increasing the volume or size of wood by impregnating it with a substance to fill the voids within the cell structure, such as PF resin, to modify the physical properties of wood to make it more suitable for specific applications, including in environments with high moisture exposure. The bulking process reduces the porosity of wood; afterwards, polymerization can improve wood properties [21]. Untreated wood has a low bulking percentage due to the cell wall spaces remaining unaltered, limiting the wood's density and strength. The absence of bulking agents allows the wood to maintain its original porosity, which results in lower resistance to swelling and less structural modification [22].

Leaching in wood involves the extraction of water-soluble compounds, like unreacted phenol or formaldehyde, from the resin into the environment. This process is influenced by factors such as moisture exposure, prolonged water contact, curing conditions, and the wood species' permeability. Leaching is also used in treatments to remove excess preservatives or reduce toxicity, altering the wood's properties [23]. The data shows that wood treated with PF resin exhibits minimal leaching of PF under normal environmental conditions. For instance, studies on the process of impregnating wood with PF

resin have demonstrated that the resin penetrated significantly within the wood's cellular structure, including the cell walls, which implies a strong bond that significantly hinders leaching [24]. Meanwhile, untreated wood has zero leaching, indicating that the wood has not released any of its water-soluble compounds, due to non presence of any wood treatment.

Initially, the impregnation process started in the wood through the wood tracheids, later spreading through pits in both axial and transverse directions. During the process, the chemicals react with the outer surface layer. This enhancement is attributed to the PF resin filling the wood cell lumens [25], increasing chemical concentration and improving biological resistance and dimensional stability [26].

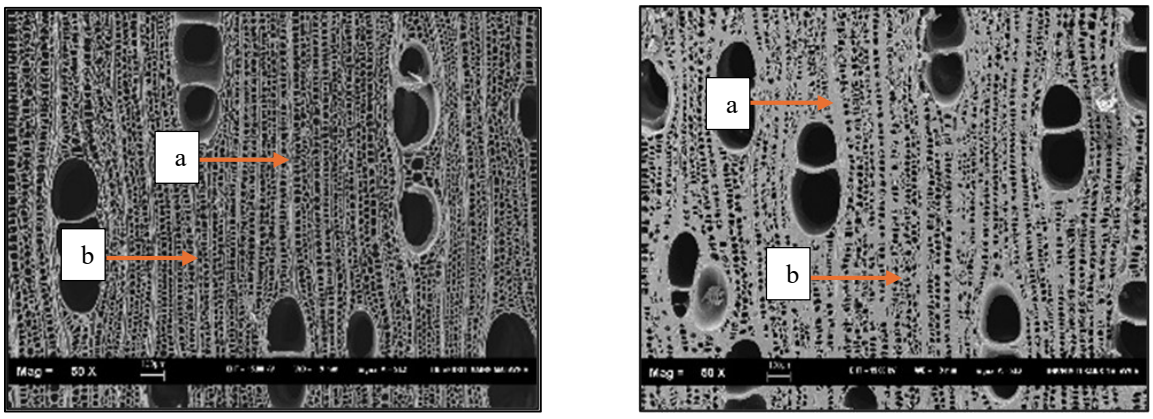
Table 3. Dimensional stability improvements

Dimensional stability	WPG	ASE	RWA	Bulking	Leaching
Untreated	-0.50	11.00	-29.00	4.60	0.00
Treated	59.70	80.40	88.20	7.10	10.40
Improvements	100.90	86.30	132.90	35.00	100.00

3.2 Microstructure analysis

Scanning electron microscopy (SEM) was utilized to examine the microscopic structure of both untreated and treated kelempayan wood, specifically focusing on the bottom portion of the trunk. It reveals notable differences between the two conditions, as shown in Figure 5 (a) the multiseriate rays of the treated specimen have diminished in size, and (b) the interfacial bonding between the wood fibers has been strengthened. It is evident that in the untreated wood, the walls and lumen of the cells are free of any hardened resin fillers, highlighting their natural state. In contrast, the SEM image of the resin-treated wood shows that the resin penetrated deeply into the thin cells of the rays, parenchyma, and fibers, effectively enhancing the material's properties [25].

Physically, the resin treatment reduces the wood's porosity by filling voids in the cell walls and lumen, which lowers water absorption and enhances moisture resistance. The resin also creates a hydrophobic barrier, further preventing swelling and shrinkage due to moisture exposure [21]. However, it is noteworthy that no resin was deposited within the vessels, indicating selective permeation that contributes to the overall structural integrity of the treated wood. This analysis emphasizes the effectiveness of the resin treatment in modifying the wood's microscopic structure, which may lead to improved performance characteristics.



(a) Untreated (b) Treated

Figure 5. Microscopy strcuture of (a) untreated and (b) treated kelempayan sample

3.3 Descriptive analysis

Table 4. Descriptive analysis

Descriptive	Mean (M)	Standard Deviation (SD)
Raw Material	**4.39**	**0.70**
Kelempayan is suitable as a raw material for making simple and portable television stand components	4.34	0.69
Resin treated kelempayan stronger and durable as compared to untreated kelempayan	4.50	0.67
Resin treated kelempayan can increase dimensional stability properties	4.50	0.66
Resin treated kelempayan is safe to use and does not harmful to human health	4.20	0.79
Design	**4.33**	**0.64**
The design of portable tv stand is suitable and align to the trend	4.27	0.66
Combination of the portable and minimalist concept is suitable to be applied	4.37	0.61
Television stand is much more simplified and minimal furniture pieces which can hold the television	4.34	0.65
Marketing	**4.16**	**0.74**
The price range for this portable tv stand is within RM400 to RM450	4.14	0.72
The price range stated above is reasonable	4.15	0.78
It fulfills the target market for furniture	4.10	0.77
This product is suitable to be commercialized in the market	4.25	0.7
Satisfaction	**4.16**	**0.76**
I feel the design is simple and attractive	4.29	0.71
I feel confident to use the stylish portable tv stand	4.10	0.76
I will recommend this stylish portable tv stand to others	4.23	0.72
I will buy this portable stylish tv stand	4.00	0.83

Descriptive analysis provides a method to summarize data meaningfully and identify trends or patterns that align with specific research objectives [27]. Also, these are methods used to organize and summarize research data in a clear and meaningful way. They provide straightforward summaries of the data and its measurements, serving as the foundation for most quantitative analyses [28].

In this study, descriptive analysis (Table 4) was applied to four key factors raw material, design, marketing, and customer satisfaction. Based on the description analysis, respondents gave a high score of M = 4.50 on the strength and durability of treated kelempayan as a raw material, in addition to increasing dimensional stability properties. Regarding design, respondents strongly agreed by giving a score of M = 4.37 that the combination of portable and minimalist is very suitable to be paired besides making the product appear simpler and more modern. Meanwhile, feedback for marketing indicated that

respondents believed that this product has commercial value with the highest score of M = 4.25. Finally, satisfaction presented that respondents were very satisfied with the simple and attractive design by giving a score of M = 4.29.

As shown in Figure 6, the raw material of kelempayan received the highest mean score of 4.39, highlighting its perceived quality and durability as furniture products. Design as a portable television stand followed closely with a mean of 4.33, indicating a positive response from respondents regarding both the aesthetic and functional aspects of the product. Marketing with an affordable range price and customer satisfaction on the product's design has an average mean of 4.16, suggesting that while the product was generally well-received, there was slightly less enthusiasm in terms of promotion and overall satisfaction compared to the raw material and design aspects.

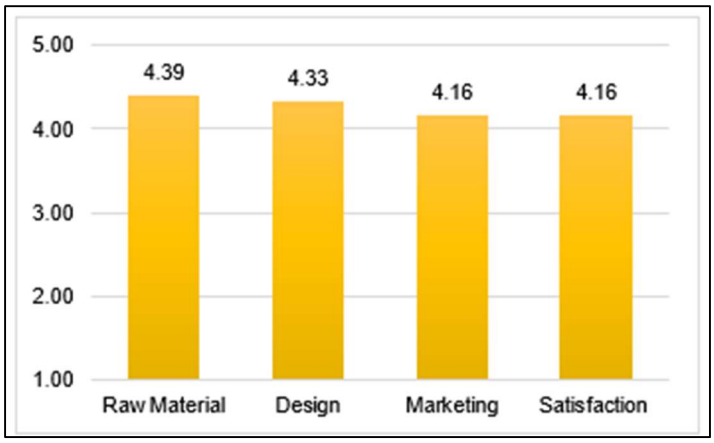


Figure 6. Overall descriptive of the study

3.4 Comparative analysis

Comparative research or analysis is an extensive concept that encompasses both quantitative and qualitative comparisons of social entities. The underlying goal of comparative analysis is to search for similarity and variance [29]. It intends to compare two or more subjects with the aim of finding similarities, differences, and insights into their nature. This approach aims at enhancing understanding through weighing different aspects of the data under comparison. This approach allows researchers to understand not only how subjects are alike but also how they differ, hence providing in-depth insight into their characteristics, behaviors, or processes. Ragin [30] emphasized the fact that comparative research is a great way to develop theoretical insights by comparing cases across different settings. Accordingly, this study analyzes the comparison between demographics (gender, age, profession and income) and factors that influence a portable television stand prototype that has been produced, such as raw material, design, marketing and satisfaction.

3.4.1 Gender

Figure 7 shows a comparative analysis based on gender. The score trend shows that male respondents gave higher scores than female respondents for all factors. Yoon et al. [31] demonstrated significant differences in results between males and females in their priority considerations, style preferences for furniture, and the number of possibilities they try before making final choices. Accordingly, consumer characteristics and furniture choices among genders for residential furniture have significant financial and symbolic meaning. Based on the results, both genders equally agreed on using kelempayan wood as a new alternative material for making furniture as compared to the established rubberwood. Regarding the design factor, males showed slightly more interest, possibly

because they preferred simpler designs. In terms of marketing, both genders agreed on the price and marketability of the product. Finally, male respondents expressed higher satisfaction with the product, likely due to a greater interest in portable and minimalist designs, which require less cleaning and maintenance.

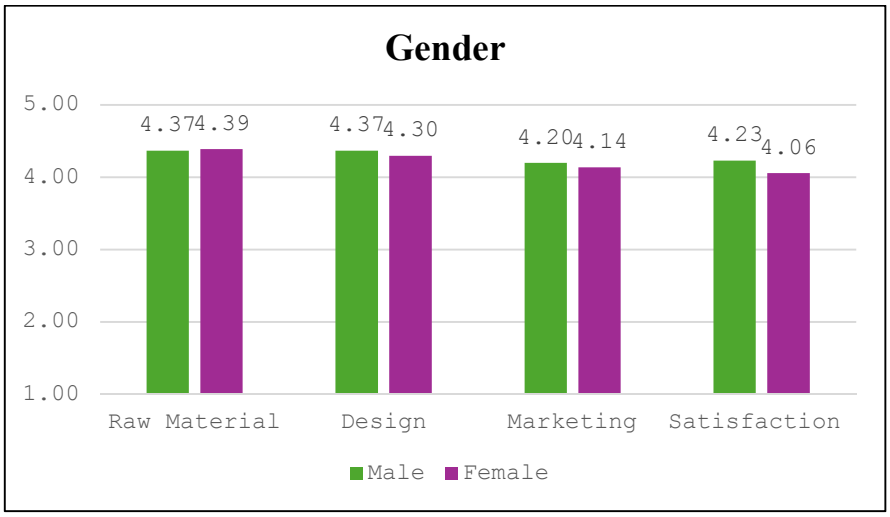


Figure 7. Comparative analysis chart based on respondent's gender

3.4.2 Age

Figure 8 provides a comparative analysis of scores by age, highlighting important differences in preferences. Respondents aged between 18 to 25 years gave a slightly lower mean score than respondents aged between 26 to 45 years for all factors, except for the raw materials factor (M = 4.43). This is because many respondents are students whose knowledge regarding new materials is more advanced as compared to those older than them. Respondents in the age group 26 to 45 years scored highest for design (M = 4.43) and marketing (M = 4.20) aspects but lower scores for raw material and satisfaction aspects. This might indicate that they appreciate treated kelempayan wood due to its portability and minimalist design, which is in line with modern trends. This is consistent with Mao and Hao (2024), who found that young consumers prioritize functionality and prefer modern-style furniture focused on functionality. In contrast, respondents aged 46 to 60 years gave the highest mean score (M = 4.26) in terms of satisfaction. This demographic likely exhibits a more critical view of furniture products, as older individuals often have distinct preferences based on their evolving lifestyle needs. According to Jonsson [32], older adults tend to seek furniture that offers comfort, pleasure, and emotional significance, such as pieces that provide relaxation and aesthetic value. These preferences suggest that older adults may favor natural materials like wood, which not only evoke a sense of tradition and stability but also contribute to well-being by reducing stress and enhancing the interior environment.

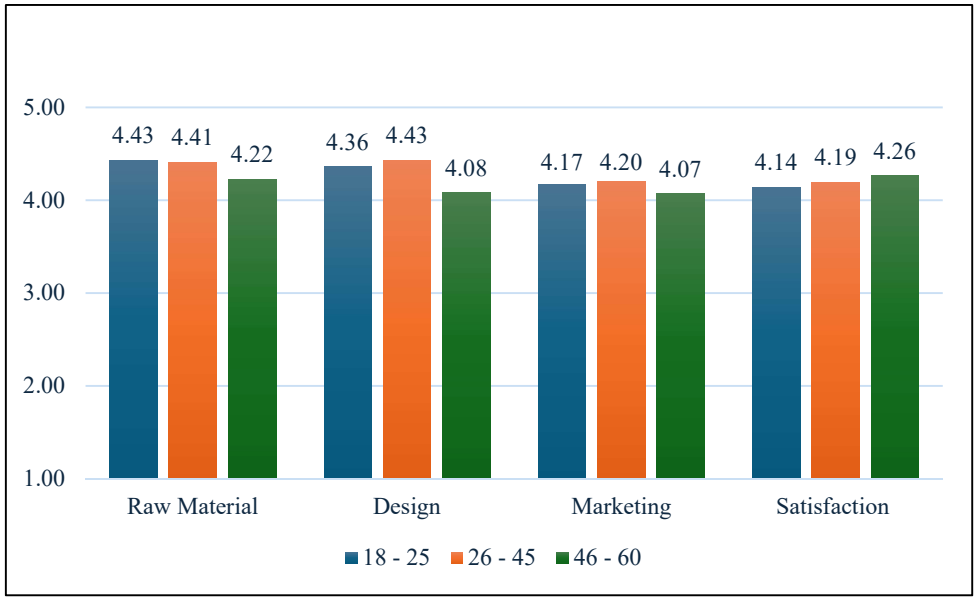


Figure 8. Comparative analysis chart based on respondent's age

3.4.3 Profession

Figure 9 shows the comparative analysis of different professions. The self-employed respondents gave a higher mean score (M = 4.44) for the raw material aspect than the other aspects. This shows that they have fewer constraints on their decision-making freedom and on how to organize their work, so they are more likely to give a logical and correct view on a matter. In addition, the results show that the mean score for the private profession is higher than government profession for all aspects except satisfaction. According to [33], in the private sector, individuals tend to have a consistent preferred cognitive style and perceive less risk in the choice, except in a public setting where risk perception remains unaffected. Therefore, private-sector employees are more courageous in making decisions than public-sector employees.

Based on the graph**,** it is evident that students had the highest mean score across all factors compared to other professions. This suggests that students are more familiar with and knowledgeable about kelempayan wood as a raw material, which likely contributes to their higher ratings. Additionally, students are more receptive to the portable and minimalist designs reflected in the products, aligning with modern trends that prioritize functionality and space-saving qualities. The preference for certain products is often shaped by the profession and lifestyle of the consumers, as different professions create distinct needs and desires for products and services that cater to specific circumstances [33].

Karaman [34] highlights that as individuals' education levels increase, so do their needs and demands for more sophisticated and versatile products. This is particularly true for consumers who are well-informed and can recognize the practical and aesthetic value of products, such as furniture. Students, who often live in smaller spaces and prioritize functional, space-saving furniture, tend to favor designs that are portable and minimalist, reflecting broader trends in youth culture that value flexibility and convenience.

Moreover, the level of education and exposure to various design concepts plays a significant role in shaping consumer preferences. As consumers gain knowledge about the types of furniture and the features of various materials, they are better equipped to make informed choices based on their lifestyle needs. For example, students, being part of a younger, more educated demographic, are likely to have a greater awareness of the benefits of materials like kelempayan and how they fit into contemporary design trends. This knowledge empowers them to choose furniture that not only meets practical needs but also aligns with their values, such as sustainability and modern aesthetics.

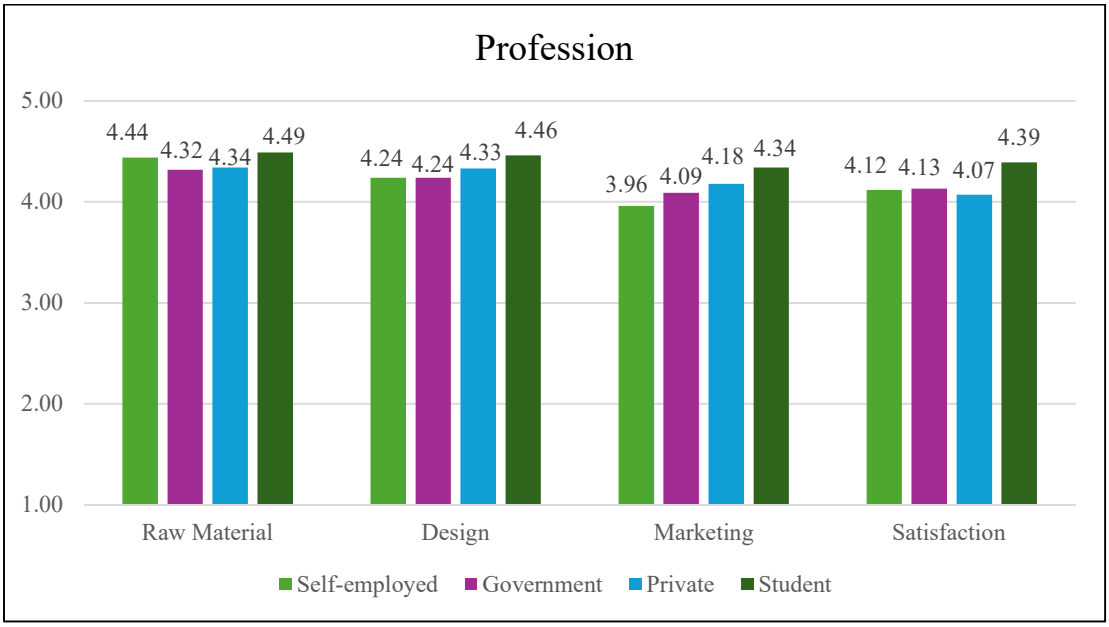


Figure 9. Comparative analysis chart based on respondent's profession

3.4.4 Income

Figure 10 shows how preferences vary based on income, revealing some interesting patterns among different income groups. People with a monthly income between RM 1500 to RM 3000 gave the highest scores for both raw material (M = 4.42) and design (M = 4.34). This suggests that individuals in this income range are particularly attentive to the quality of the material and the design of the furniture. They may be seeking a balance between value and affordability, preferring materials like kelempayan that are both durable and reasonably priced while also offering a stylish design that fits their needs. Respondents earning RM 3001- RM 5000 gave a variety of mean score trends, where they gave the lowest mean score for the design and satisfaction aspects and gave comparable mean scores for raw material and marketing aspects respectively with the group earning RM 1500 - RM 3000 and over RM 5001. This suggests that the decision-making of this group was based more on material quality and economical price compared to aesthetic value. On the other hand, those earning over RM 5001 tended to rate the marketability (M = 4.24) and satisfaction (M = 4.19) of the product higher, indicating that they find it a worthwhile investment. With more disposable income, this group is likely to view the product's price as affordable and aligned with the value it offers, making them more confident in their purchasing decision.

Income level has a significant impact on consumer preferences, especially when it comes to how much people are willing to spend. As many consumers today look for ways to save money, more affordable furniture options are becoming increasingly popular. This aligns with a broader trend where consumers seek out products that strike a balance between price and quality. Akyüz et al. [35] found that, as both income and education levels rise, people tend to make purchasing decisions together with others, often considering factors like marketability and satisfaction more thoroughly.

Moreover, a person's economic status greatly influences their purchasing behavior. Lower-income consumers tend to prioritize affordability, focusing on products that meet basic needs [36], while higher-income consumers are more likely to consider aesthetic appeal and brand reputation, as they are less limited by budget constraints. This means that furniture brands should adjust their strategies to cater to the different priorities of each income group, offering practical, affordable options for those with lower incomes, while appealing to the taste for quality and style that higher-income consumers seek.

Income plays a big role in shaping what consumers want from their furniture, with different income groups valuing different aspects of the products, such as design, material, and overall marketability. By understanding these differences, businesses can better target their marketing efforts to meet the specific needs of each group.

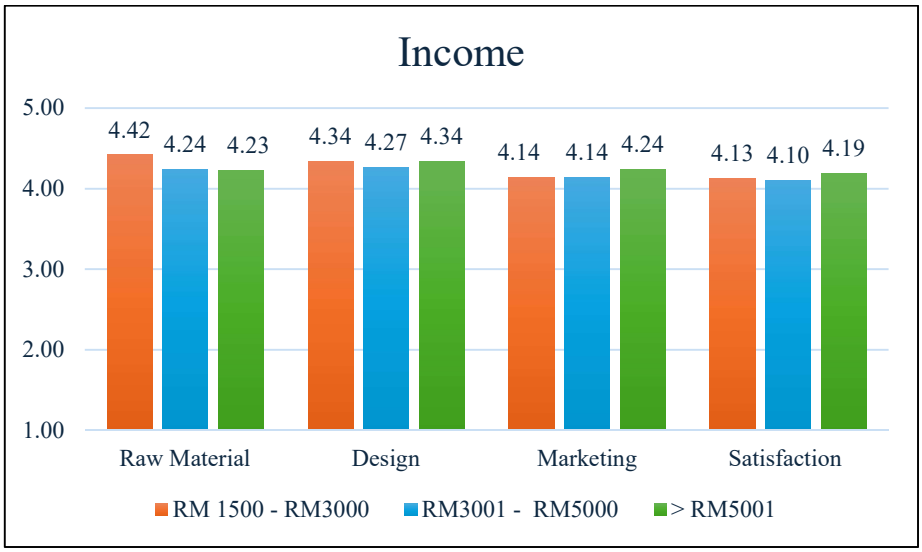


Figure 10. Comparative analysis chart based on respondent's income

3.5 Correlation analysis

Table 5 shows the Pearson correlation analysis of satisfaction preference. A Pearson correlation coefficient of 0.569 between satisfaction and raw material shows a moderate positive relationship. This means that when customers are more satisfied with the raw material used in a product, their overall satisfaction with the product tends to rise as well. Research backs this up, highlighting that product quality, including the quality of the raw materials, plays a big role in customer satisfaction**.** For example, a study on consumer products found that quality and durability are the most important factors influencing satisfaction, followed by things like reliability, features, and aesthetic appeal [37]. This suggests that companies should make the quality of raw materials a priority, as it has a major impact on how customers perceive the overall product and, in turn, their satisfaction with it [38].

A correlation value of 0.735 between satisfaction and design indicates a moderate to strong positive relationship between these two variables. Academic research highlights the appeal and effectiveness of minimalist furniture design, with Poon [39] demonstrating how minimalist aesthetics influence consumer preferences by emphasizing the growing demand for furniture that embodies simplicity and functionality. Similarly, Tahir et al., [40] emphasize that minimalist furniture not only enhances the efficient use of living spaces but also adds a modern and stylish touch to interiors. Designed for portability, the stand offers the flexibility to move it easily around the home and rearrange it in any space or room. Overall, this design not only looks great but also meets the practical needs of modern living, making it a design that truly enhances space and lifestyle.

The strong correlation of 0.764 between satisfaction and marketing indicates that effective marketing strategies can significantly enhance customer satisfaction. For this portable television stand, the price range is set to be affordable, falling within RM400 to RM450**,** which aligns well with the target market for furniture. By offering this product at an accessible price, it meets the needs of consumers seeking functionality and style without exceeding their budget. As a result, many people have agreed that this product is ready to be commercialized, indicating strong interest and confidence in its success in the market. Based on research of marketing in the Jordanian furniture industry, it shows that having

the right product and pricing strategies helps companies stay innovative and competitive. This highlights how important strong marketing is for both satisfying customers and giving businesses an edge in the market [41].

Table 5. Pearson correlation analysis

Relationship	Correlation (r-value)
Satisfaction versus Raw Material	0.569**
Satisfaction versus Design	0.735**
Satisfaction versus Marketing	0.764**

**Correlation is significant at the 0.01 level (2-tailed)

4. Conclusion

In conclusion, the portable television stand prototype made from phenol formaldehyde (PF) treated kelempayan wood, was successfully developed and well-received. The PF resin treatment significantly enhanced the wood's properties by increasing its density, improving dimensional stability, enhancing water resistance, and reinforcing its microstructure. Due to kelempayan wood's natural porosity and moderate vessel size, the vacuum-pressure method allowed the resin to penetrate deeply, filling gaps in the cell walls and lumens. This not only strengthened the wood's internal structure but also made it more durable, proving its potential as a sustainable, high-quality material for furniture. The descriptive analysis stated that raw materials gain the highest mean, stressing the furniture's apparent durability and quality. Besides, gender analysis revealed both genders saw potential in the material, with men favoring simpler designs and reporting higher satisfaction, while women focused more on aesthetics. Age was another factor, where younger users (18-25) prioritized material quality, middle-aged respondents (26-45) cared more about design and marketability, and older users (46-60) valued comfort and natural materials, reflecting changing lifestyle needs. Profession and income also influenced preferences. Students, often younger and more eco-conscious, favored modern, space-saving designs like this portable television stand. Meanwhile, income levels shaped the priorities of lower-income buyers looked for affordability and durability, while higher-income consumers placed more weight on aesthetics and brand appeal. The strong correlation between satisfaction and marketing shows that effective marketing with the television stand's affordable price will boost customer approval and market readiness. With good marketing and competitive pricing, the product stood out in the market, proving that a well-positioned, affordable design can drive consumer interest. Overall, the television stand was praised for its durability, portability, and unique design, with its affordability giving it a strong edge in the market. These findings highlight kelempayan wood's potential as a sustainable, high-performance material for future furniture designs.

Acknowledgement

The authors would like to acknowledge Universiti Teknologi MARA (UiTM) Cawangan Pahang and Forest Research Institute Malaysia (FRIM) for contributing the materials and laboratory equipment. Additionally, this research would not have been possible without the generous financial support from the Geran Penyelidikan Dana Lestari Khas 2020 UiTM Cawangan Pahang.

Conflict of interest

We declare no conflict regarding the publication of the study.

References

[1] Rasat, M. S. M., Wahab, R., Shafie, A., AG, A. M. Y., Yusoff, M., Ramle, S. F. M., & AK, Z. (2013). Effect of wood-fiber geometry size on mechanical properties of wood-fiber from neolamarckia cadamba species reinforced polypropylene composites. *Journal of Tropical Resources and Sustainable Science (JTRSS), 1*(1), 42-50. https://doi.org/10.47253/jtrss.v1i1.669

[2] Ismail, J., Jusoh, M. Z., & Sahri, M. H. (1995). Anatomical Variation in Planted Kelempayan (Neolamarckia Cadamba, Rubiaceae). *IAWA Journal*, *16*(3), 227-287. https://doi.org/10.1163/22941932-90001411

[3] Lim, S. C., Can, K. S., & Thi, B. K. (2005). Identification and utilization of lesser-known commercial timbers in Peninsular Malaysia. 4. kelempayan, melembu, membuloh and mempari. *Timber Technology Bulletin 32*, 139, 258.

[4] Abd Latib, N., Mohamed Tamat, N. S., & Kasim, J. (2014). The effects of tree portion on extractive content of kelempayan (*Neomalarckia cadamba* sp.) wood. *Konferensi Akademik.*

[5] Zaini, I. A. R. (2010). Forest plantation programme in Malaysia-The way forward. *In Proceedings of the Seminar and Workshop on Improved utilization of Tropical Plantation Timbers*, 23-29.

[6] Choo, K. T., Gan, S., & Lim, S. C. (1999). Timber notes-light hardwoods vi (dedali, kedondong, kelempayan, kelumpang, kembang semangkok). *Timber Technology Bulletin*, *16*, 139-258.

[7] Mahmud, S. Z., Hashim, R., Saleh, A. H., Sulaiman, O., Saharudin, N. I., Ngah, M. L., Masseat, K., & Husain, H. (2017). Physical and mechanical properties of juvenile wood from *Neolamarckia cadamba* planted in west Malaysia. *Maderas. Ciencia Y Tecnología, 19*(2), 230. http://dx.doi.org/10.4067/S0718-221X2017005000020

[8] Anna, N., Siregar, I. Z., Supriyanto, S., Sudrajat, D. J., & Karlinasari, L. (2023). Physical, mechanical, and anatomical properties of 12 jabon (Neolamarckia cadamba) provenances wood in Indonesia. *Biodiversitas Journal of Biological Diversity*, *24*(11).https://doi.org/10.13057/biodiv/d241107

[9] Hill, C. A. (2007). Wood modification: chemical, thermal and other processes. *John Wiley & Sons*.https://doi.org/10.1002/047002174

[10] Sandberg, D., Kutnar, A., & Mantanis, G. (2017). Wood modification technologies-a review. *Iforest-Biogeosciences and forestry*, *10*(6), 895.https://doi.org/ 10.3832/ifor2380-010

[11] Stamm, A. J., & Seborg, R. M. (1939). Resin-treated plywood. *Industrial & engineering chemistry*, *31*(7), 897-902. https://pubs.acs.org/doi/pdf/10.1021/ie50355a023

[12] Huang, Y., Fei, B., Yu, Y., & Zhao, R. (2012). Effect of modification with phenol formaldehyde resin on the mechanical properties of wood from Chinese fir. *BioResources, 8*(1), 272-282.

[13] Sarika, P. R., Nancarrow, P., Khansaheb, A., & Ibrahim, T. (2020). Bio-based alternatives to phenol and formaldehyde for the production of resins. *Polymers*, *12*(10), 2237. https://doi.org/10.3390/polym12102237

[14] Mahmud, S.Z. (2020). *Effect of urea and phenol formaldehyde resin ımpregnation on properties of 7-Year-old kelempayan (Neolamarckia cadamba) wood*. PhD thesis, Universiti Sains Malaysia.

[15] Adamović, D., Čepić, Z., Adamović, S., Stošić, M., Obrovski, B., Morača, S., & Vojinović Miloradov, M. (2021). Occupational exposure to formaldehyde and cancer risk assessment in an anatomy laboratory. *International journal of environmental research and public health*, *18*(21), 11198. https://doi.org/10.3390/ijerph182111198

[16] Shi, J., Li, J., Zhou, W. & Zhang, D. (2007) Improvement of wood properties by urea formaldehyde resin and nano-SiO2. Frontiers of Forestry in China. *2*(1):104-109.

[17] Lembaga Perindustrian Kayu Malaysia. (2022). *Harga kayu.*

[18] Kennedy, I. (2022). Sample size determination in test-retest and Cronbach alpha reliability estimates. *British Journal of Contemporary Education*, *2(1),* 17-29. https://doi.org/10.52589/BJCE-FY266HK9

[19] Rahayu, I. S., Zaini, L. H., Nandika, D., Darmawan, W., Prihatini, E., & Agustian, R. (2020). Physical properties of impregnated sengon wood by monoethylen glycol and nano silica from betung bamboo sticks. *IOP Conference Series: Materials Science and Engineering, 935*(1), 012057. https://doi.org/10.1088/1757-899x/935/1/012057

[20] Furuno, T., Imamura, Y., & Kajita, H. (2004). The modification of wood by treatment with low molecular weight phenol-formaldehyde resin: a properties enhancement with neutralized phenolic-resin and resin penetration into wood cell walls. *Wood Science and Technology, 37*(5), 349-361. https://doi.org/10.1007/s00226-003-0176-6

[21] Augustina, S., Dwianto, W., Wahyudi, I., Syafii, W., Gérardin, P., & Marbun, S. D. (2023). Wood impregnation in relation to its mechanisms and properties enhancement, *BioResources*, *18*(2), 4332-4372. https://doi.org/10.15376/biores.18.2.Augustina

[22] Mingming, H., Dandan , X., Changgui, L., Yuzhen, M., Xiaohan, D., Xiya, P., Jilong , F., Zaixin , H., Shihan, G., Xiaoying, D., & Yongfeng, L. (2020). Cell Wall Bulking by Maleic Anhydride for Wood Durability Improvement. *Forests, 11*(4), 367. http://dx.doi.org/10.3390/f11040367

[23] He , G., & Yan, N. (2005). Effect of wood on the curing behavior of commercial phenolic resin systems. *Journal of Applied Polymer Science, 95*(2), 185–192. https://doi.org/10.1002/app.21115

[24] Wang, X., Chen, X., Xie, X., Cai, S., Yuan, Z., & Li, Y. (2019). Multi-scale evaluation of the effect of phenol formaldehyde resin ımpregnation on the dimensional stability and mechanical properties of Pinus massoniana Lamb. *Forests, 10*(8), 646. https://doi.org/10.3390/f10080646

[25] Wang, X., Chen, X., Xie, X., Yuan, Z., Cai, S., & Li, Y. (2019). Effect of Phenol Formaldehyde Resin Penetration on the Quasi-Static and Dynamic Mechanics of Wood Cell Walls Using Nanoindentation. *Nanomaterials*, *9*(10), 1409. https://doi.org/10.3390/nano9101409

[26] He, G., & Riedl, B. (2004). Curing kinetics of phenol formaldehyde resin and wood-resin interactions in the presence of wood substrates. *Wood Science and Technology*, *38*, 69-81. https://doi.org/10.1007/s00226-003-0221-5

[27] Arifin, M. Z., & Wicaksono, A. (2020). The probability prediction model of motorcyclist accident against IRSMS and AIS from the police department, East Java (a case study in Kediri Regency and Surabaya City). *In 2nd International Symposium on Transportation Studies in Developing Countries (ISTSDC 2019),* 136-138. https://doi.org/10.2991/aer.k.200220.028

[28] Vetter T. R. (2017). Descriptive Statistics: Reporting the Answers to the 5 Basic Questions of Who, What, Why, When, Where, and a Sixth, So What?. *Anesthesia and analgesia, 125*(5), 1797–1802. https://doi.org/10.1213/ANE.0000000000002471

[29] Mills, M. C., Van De Bunt , G. G., & De Brujin, J. G. M. (2006). Comparative research: Persistent problems and promising solution. *International sociology, 21*(5), 619-631. https://doi.org/10.1177/0268580906067833

[30] Ragin, C. C. (2014). The comparative method: Moving beyond qualitative and quantitative strategies. *Univ of California Press.*

[31] Yoon, S. Y., Oh, H., & Cho, J. Y. (2010). Understanding furniture design choices using a 3D virtual showroom. *Journal of Interior Design*, *35*(3), 33-50. https://doi.org/10.1111/j.1939-1668.2010.01041.x

[32] Jonsson, O. (2013). Furniture for later life: Design based on older people's experiences of furniture in three housing forms. *Doctoral Thesis (compilation), Industrial Design. Department of Design Sciences, Faculty of Engineering, Lund University.*

[33] Nutt, P. C. (2006). Comparing public and private sector decision-making practices. *Journal of Public Administration Research and Theory, 16*(2), 289-318. https://doi.org/10.1093/jopart/mui041

[34] Karaman, A. (2023). Factors affectıng furnıture preference: Usak Unıversıty academıc staff example. *Archıtecture, Plannıng and Desıgn*, 27.

[35] Akyüz, I., Ersen, N., Akyüz, K. C., & Bayram, B. Ç. (2019). A research on the effects of demographic and socio-economic status factors on consumer preferences in furniture purchase (case of Black Sea region). *Wood Industry and Engineering, 1*(2), 63-76.

[36] Roy, G., Shrivastava, A., Debnath, & Mitra, P. (2021). Analytical study of low-income consumers' purchase behaviour for developing marketing strategy . *International Journal of System Assurance Engineering and Management, 12*(5), 895-909. https://doi.org/10.1007/s13198-021-01143-6

[37] Lone, R. A., & Bhat, M. A. (2023). Impact of product quality on customer satisfaction: Evidence from selected consumer durables. *International Journal for Research Trends and Innovation*, *8*(4), 1014-1024.

[38] Söderlund, M. (2002). Customer familiarity and its effects on satisfaction and behavioral intentions. *Psychology & Marketing, 19*(10), 861-879. https://doi.org/10.1002/mar.10041

[39] Poon, S. (2017). The role of minimalist aesthetics in ınfluencing consumer preferences for furniture design. *New Design Ideas , 1*(1), 50-58.

[40] Tahir, H. M., & Qaradaghi, A. M. A. (2020). The Influence of Using Minimalist Furniture on the Efficiency of the Living Space-Residential Apartments in Sulaimani City as Case Study. *Diyala Journal of Engineering Sciences*, *13*(2), 78-86. https://doi.org/10.24237/djes.2020.132010

[41] Joudeh, J. M., Allan, M., Zamil, A. M., Alfityani, A., Dandis, A. O., Nusairat, N. M., & Al-Gasawneh, J. A. (2022). The impact of marketing strategy on the marketing innovation and the marketing competitive advantage in the jordanian furniture industry. *Journal of Southwest Jiaotong University, 57*(6), 395-412. https://doi.org/10.35741/issn.0258-2724.57.6.38