

The physical properties of treated oil palm veneer used as face layer for laminated veneer lumber

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Abstract. The depletion of our tropical timber supply has encouraged the Malaysian wood-based industry to seek alternative resources such as fast-growing plantation trees and crops for wood-based products. Oil palm tree (*Elaeis guineensis*) has been identified as one of the potential alternative raw materials for the production of value-added products such as plywood, laminated veneer lumber (LVL) and even solid oil palm lumber. As we know, the properties of oil palm lumber or veneer is inferior to those of wood. Modification and treatment to the oil palm are needed to enhance the quality and dimensional stability. The main objective of this study is to determine the physical properties of LVLs made from oil palm veneers (OPVs) treated with low molecular weight phenol formaldehyde (LMWPF) resin with different resin solid content and different initial moisture content (MC) of veneer. OPVs were soaked into LMWPF and re-dried to semi gel condition before being hot-pressed. There was no additional resin was added to bond the veneers together into LVL. The physical properties such as density, moisture content, thickness swelling, water absorption and weight percent gain were determined in this study. The results showed that the LVLs made by treated OPVs exhibited better physical properties compared to LVLs made from untreated OPVs but still inferior with rubberwood LVL. It can be concluded that treating OPVs prior to their usage for LVL-making is essential and effective to produce LVLs with convincing physical properties.

1. Introduction

Oil palm veneer (OPV) is rapidly used for plywood manufacturing in Malaysia since years back and being used as core veneers for plywood production. This is due to the finding that oil palm trunk (OPT) can be transformed into veneer and can be used to produce high performance as engineered board such as plywood and laminated veneer lumber (LVL). The intention was to reduce usage of tropical hardwood wood veneer in the production. Recently, wood veneers were used only for the outer part while OPV were used as core of the board. Although, OPV can be used as material to produce high quality boards, it was found that the LVLs produced from OPVs exhibited inferior physical performance in comparison with those made of rubberwood [1]. Impregnating resins into the veneer was found great way to enhance its dimensional stability and strength. It had been confirmed by many researchers before [2]. According to [3], pre-treatment of veneer with phenolic or equivalent



resin polymer can enhance the quality of OPV as well as final product such as plywood or LVL. The price of the final product can be reduced as the OPV is cheaper than normal hardwood veneer. This technology will also reduce amount of hardwood veneer used in the product because OPV has greater thickness than hardwood veneer.

Based on the research by [1], it was discovered that impregnating resins into veneers was a good way to enhance the LVL dimensional stability and their strength. Thus, this project was carried out to determine the effectiveness of low molecular weight phenol formaldehyde (LMWPF) resin in increasing the strength and dimensional stability of LVL boards made of OPV. Quality improvement studies on solid oil palm lumber revealed that initial moisture content of the material and the solid content of the resin used were significantly affected by the physical and mechanical properties [4], [5], durability [5], and machining properties of the treated oil palm lumber [6]. The veneers, with different initial MCs were dipped into LMWPF with different rate of solid content, to allow the resin penetration into the veneers before the veneers were hot-pressed to produce LVL boards. This research can help to promote the usage of OPT as an alternative material for the production of LVL. Consequently, it will reduce the usage of tropical hardwood and help to achieve more sustainable forest management.

2. Materials and methods

In this study, OPVs were used as main raw material. The OPVs with a size of 127 cm (width) x 127 cm (length) were obtained from Kang Sem Enterprise, Johor. The average thickness of the OPVs was 4.5 mm (wet veneer after peeling) and only the outer/superior part of the OPVs was chosen for this study. Superior part was chosen to diversify this research as inferior part has been used in many previous researches. Four different target moisture content (MC) were used i.e. 100, 70, 30 and 15%. The veneers were trimmed to size 40 cm x 40 cm each before they were dried in a conventional oven separately to the four different targeted moisture content (MCs). All veneers were weighed by using digital balance before and after they were dried. The MC of the veneers was calculated by using reverse MC formula. The monitoring of the MC commenced until the targeted MC was recorded.

LMWPF resin was used as a treatment chemical and also as a binder. The resin impregnated into the veneers was left to semi gel/cure condition before being hot-pressed to form LVL boards. Two different resin solid contents of 30 and 45% solution were prepared. The solid content of the resin was reduced by diluting the resin with distilled water. The dried veneers, then, were soaked into the LMWPF for ten (10) minutes before they were pre-pressed to remove excessive resin. The soaked veneers were then dried by using conventional oven and were stacked with wood sticker to make sure each veneer was dried evenly until targeted MC (10%) was reached. The LMWPF resin in veneers was left to semi cured condition. Then, the veneers were arranged in parallel grain direction before they were being hot pressed with standard temperature and pressure to produce LVL boards. Five layers of OPV were used for the LVL fabrication process. The LVLs were trimmed and cut according to standard sizes before they were utilized for physical tests such as density and MC, thickness swelling (TS), water absorption (WA) and weight percent gain (WPG). Moisture content was determined in accordance with standard method for direct moisture content measurement of wood and wood-based materials, D4442 [7], water absorption and thickness swelling was conducted based on European Standard EN 317:1993 [8]. The WPG was conducted using a method described by [9] and [10].

3. Results and discussion

3.1 Weight Percent Gain (WPG)

Weight percent gain is to determine the amount of resin uptake by the OPVs after they were immersed into LMWPF resin. Table 1 shows highly significant difference of results between veneers at 15% MC (WPG value was 34.48% resin before re-dry) as compared veneer at 70% MC, where the WPG value was 11.97%. It shows that, the drier the samples, the more efficient they would be able to absorb the resin. It is because in dried samples, water in cell already removed and resin can easily filled up the empty space in cell. This is important to facilitate the resin to penetrate deeper and improve the physical and mechanical properties of the samples. From the table, it showed that both LMWPF SC gave similar result patterns. The lower OPV MC, the higher WPG value uptake was recorded. In addition, a comparison has been made using different LMWPF SC and the results showed that there was no significant difference of results between samples treated using 30 and 45% LMWPF SC. This finding was similar to [11], they was found that OPV treated with 41% SC of LMWPF was 32.5% WPG and a similar finding was reported by [12] using Japanese cedar (*Cryptomeria japonica*). These achievement of the highest level of WPG was attribute to the short chain of LMWPF resin, so that the resin could easily penetrate the parenchyma cells.

Table 1. Cross tabulation between LMWPF SC and initial OPV MC.

Properties	LMWPF SC (%)	Initial OPV MC (%)			
		100	70	30	15
Weight Percent Gain, WPG (%)	45	7.89 ^c (3.10)	11.97 ^c (9.55)	21.40 ^b (4.44)	34.48 ^a (5.08)
	30	11.51 ^c (7.51)	16.52 ^c (8.41)	24.70 ^b (3.97)	34.25 ^a (4.69)

Notes:

Values in parentheses are standard deviation

Means in the same row followed by the same letter are not significantly different at $p \leq 0.05$

3.2 Density and Moisture Content (MC)

MC determination of raw/fresh OPV is important to make sure the veneers were dried sufficiently and met the targeted MC. It is also important to calculate the oven dry weight of veneer using reversible MC formula. The study showed that the MC of the outer OPVs were in the range of 181.6 to 262.2% and the results were in line with [13], [14] and [15] who stated that the MC for oil palm was in the range of 76.5% up to more than 500%. Table 2 shows density and MC of OPVs treated using 30 and 45% of LMWPF SC at 100, 70, 30 and 15% initial veneer MC. From the result, it shows that there was no significant difference for density and MC for each LVL board using different initial MC of OPV for 45% LMWPF SC. But, significant difference ($p \leq 0.05$) was noted for density that using 30% LMWPF SC at 100 and 70% initial MC of OPV LVL. No significant difference was observed when 30 and 15% initial MC of OPV were used.

Table 2. Cross tabulation between LMWPF SC and initial OPV MC.

Properties	LMWPF SC (%)	Initial OPV MC (%)			
		100	70	30	15
Density (Kg/m ³)	45	532.01 ^a (12.76)	550.48 ^a (40.20)	517.44 ^a (37.71)	536.82 ^a (57.23)

30	Moisture Content (%)	7.89 ^a (0.28)	7.97 ^a (0.75)	8.01 ^a (0.89)	8.28 ^a (0.30)
	Density (Kg/m ³)	473.11 ^c (19.09)	532.22 ^b (18.36)	571.83 ^a (46.38)	599.42 ^a (39.36)
	Moisture Content (%)	7.92 ^a (0.48)	8.12 ^a (0.34)	8.08 ^a (0.34)	8.27 ^a (0.98)

Notes:

Values in parentheses are standard deviation

Means in the same row followed by the same letter are not significantly different at $p \leq 0.05$

Meanwhile, there was significant difference between 30 and 45% LMWPF SC when treated at 100, 30 and 15% of initial MC veneer before treatment as shown in Figure 1 and 2. But, when treated at 70% of initial MC of OPV, there was no significant difference observed when using either 30 or 45% LMWPF SC. Although, there was significant difference for 100, 30 and 15% initial MC by using 30 and 45 LMWPF SC, the mean density was still acceptable because the result almost similar to that of [16], [1] and [17]. On the other hand, the MC for all boards presented no significant difference because it was set at 10% before hot press.

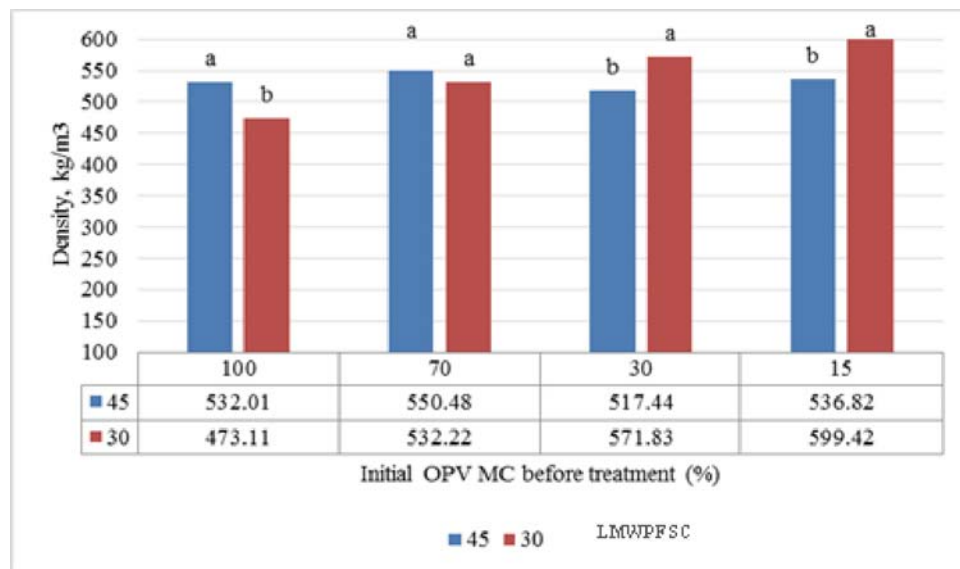
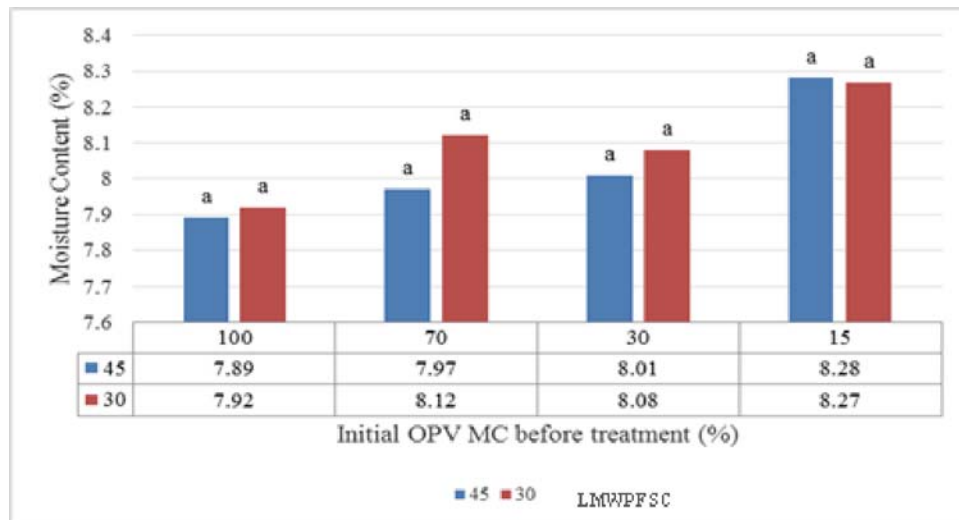
**Note:** Means in the same letter are not significantly different at $p \leq 0.05$

Figure 1. Bar chart of effect initial OPV MC before treatment with LMWPF SC for density.



Note: Means in the same letter are not significantly different at $p \leq 0.05$

Figure 2. Bar chart of effect initial OPV MC before treatment with LMWPF SC for moisture content.

3.3 Thickness Swelling

The thickness swelling and water absorption were greatly influenced by the value of board density [1]. The higher the density, the lower the percentage of thickness swelling and water absorption. From Table 3, it shows that there was no significant difference when using 45% LMWPF SC at 70 and 30% initial OPV MC. Significant difference was noted at 15% MC compared to others. It showed that OPV MC at 15% has lowest thickness swelling results (0.76%). On the other hand, when 30% LMWPF SC was used, different results were obtained which there was no significant difference when treated at 70, 30 and 15% initial MC of OPV. These results were better than LVLs made from untreated OPV which is 2.99% as stated by [1]. In the other hand, the results of thickness swelling when treated using 30 and 45% LMWPF SC at 70, 30 and 15% initial OPV MC shows that there was no significant difference between 30 and 45% LMWPF SC when treated at 30 and 15% initial MC of OPV as shown in Figure 3. Although, there was no significant difference, samples treated with 45% LMWPF SC at 15% initial MC gave lesser thickness swelling value than the other samples. It was also observed that there was significant difference when the samples were treated at 70% initial MC of OPV.

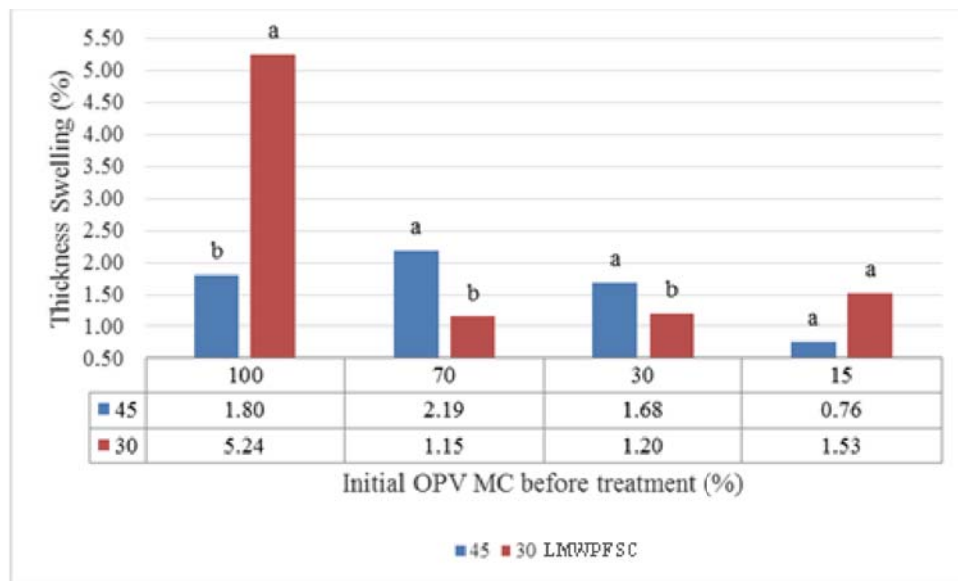
Table 3. Cross tabulation between LMWPF SC and initial OPV MC.

Properties	LMWPF SC (%)	Initial OPV MC (%)			
		100	70	30	15
Thickness Swelling (%)	45	1.80 ^a (0.82)	2.19 ^a (1.01)	1.68 ^a (0.68)	0.76 ^b (0.59)
	30	5.24 ^a (1.72)	1.15 ^b (0.80)	1.20 ^b (0.72)	1.53 ^b (1.02)

Notes:

Values in parentheses are standard deviation

Means in the same row followed by the same letter are not significantly different at $p \leq 0.05$



Note: Means in the same letter are not significantly different at $p \leq 0.05$

Figure 3. Bar chart of effect initial OPV MC before treatment with LMWPF SC for thickness swelling.

3.4 Water Absorption

Understanding water absorption in a great detail will help us to improve the dimensional stability of a wood-based product. It was expected that good dimensional stability contribute to good mechanical results. The higher the water absorption value, the weaker the wood-based product could be. From the Table 4, it showed, there was no significant difference when using 45% LMWPF SC treated at all initial OPV MC, but when using 15% initial MC, the water absorption value was lower than others. Samples treated with 30% LMWPF SC, also showed no significant difference at 70 and 15% initial MC but significant difference was recorded when the treatment was done at the MCs of 30% and (70, 15%). By looking at the results, it can be concluded that samples treated using 30% LMWPF SC at 30% initial MC gave the best results because the water absorption value was 17.60% which was the lowest in comparison with the others. According to [1], water absorption in LVL from untreated OPV is 63.03%, which was higher than treated OPV with LMWPF in this study. Figure 4 shows the results of water absorption for the samples treated using 30 and 45% LMWPF SC at 70, 30 and 15% MC before treatment are show that significant difference of results were recorded from the samples treated using 30% LMWPF SC and treated at 30% initial OPV MC. The treatment using that parameter was found effective to reduce water absorption compared to the other parameters. The reduction of water absorption was believed caused by the density of the samples.

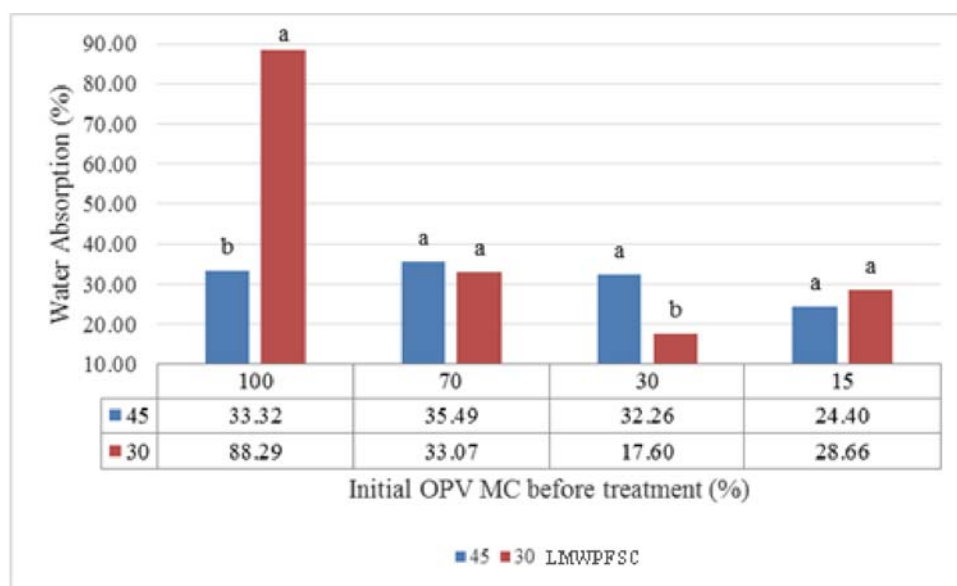
Table 4. Cross tabulation between LMWPF SC and initial OPV MC.

Properties	LMWPF SC (%)	Initial OPV MC (%)			
		100	70	30	15
Water Absorption (%)	45	33.32 ^a (8.74)	35.49 ^a (15.87)	32.26 ^a (12.90)	24.40 ^a (9.54)
	30	88.29 ^a (13.85)	33.07 ^b (6.39)	17.60 ^c (13.26)	28.66 ^b (8.90)

Notes:

Values in parentheses are standard deviation

Means in the same column followed by the same letter are not significantly different at $p \leq 0.05$



Note: Means in the same letter are not significantly different at $p \leq 0.05$

Figure 4. Bar chart of effect initial OPV MC before treatment with LMWPF SC for water absorption.

4. Conclusion

From this study, the density of oil palm LVL was almost similar to the untreated LVL. Although the density almost equal (LVL using outer veneer), the physical properties of LVLs using treated veneer with LMWPF shows better results than untreated LVL veneer. To get better properties of LVL board from OPV, the veneer need to do treatment especially using 45% LMWPF SC at 15% MC of OPV and re-dried to semi gel condition at 10% MC before the commencement of hot-pressing process. As proven in this study, physical properties of oil palm LVLs was better than untreated oil palm LVLs.

5. References

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