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Research Article

Comparison of Acoustic Characteristics of Date Palm Fibre and Oil Palm Fibre

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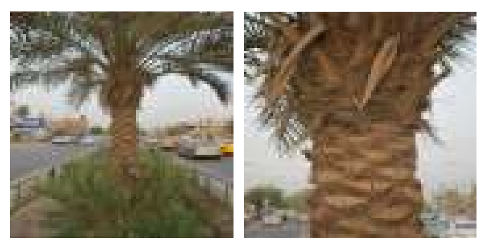
Abstract: This study investigated and compared the acoustic characteristics of two natural organic fibres: date palm fibre and oil palm fibre, these materials eligible for acoustical absorption. During the processing stage, both fibre sheets are treated with latex. The two fibres are compressed after latex treatment Circular samples (100 mm in diameter and 28 mm, based on the measurement tube requirements) are cut out of the sheets. The density of the date palm fibre sheet is 150 kg/m^3 for a 50 mm thickness and 130 kg/m^3 for a 30 mm thickness. In contrast, the density of oil palm fibre is 75 kg/m^3 for a 50 mm thickness and 65 kg/m^3 for a 30 mm thickness. An impedance tube was used to test the thicknesses of both samples based on international standards. The results show that the date palm fibre exhibits two Acoustic Absorption Coefficient (AAC) peaks: 0.93 at 1356 Hz and 0.99 at 4200-4353 Hz for the 50-mm-thick sample. In contrast, the 30-mm-thick sample has a single AAC peak of 0.83 at 2381.38-2809.38 Hz. However, the 50-mm-thick oil palm fibre has an AAC peak of 0.75 at 1946.88-2178.13 Hz and the 30-mm-thick oil palm fibre has an acoustic absorption coefficient peak 0.59 at 3225-3712.5 Hz. Thus, the date palm fibre has a higher acoustic absorption coefficient for high and low frequencies than does oil palm fibre. Both fibres are promising for use as sound absorber materials to protect against environmental noise pollution.

Keywords: Acoustic absorption coefficient, date palm fibre, density, oil palm fibre, thickness

INTRODUCTION

There is increasing interest in organic natural fibres for various uses in many applications, such as insulation materials and barriers. Iraq and Malaysia have large amounts of date palm fibre and oil palm fibre agricultural waste products, respectively. These trees are identical in nature but differ by filament fibre, as shown in Fig. 1. Date palm fibres have thin, smooth filaments, unlike oil palm fibres, which have thick, rough filaments. The advantages of these fibres are their renewability, abundance and low cost. These fibres are also more effective than industrial materials in terms of their reduced health hazards and protection during processing. Acoustic applications have widely used mineral fibres, such as rock wool, glass fibre or asbestos, especially in power plant to insulate tubes. However, this material is no longer used extensively and is associated with any health risk. Asbestos is more hazardous than other mineral fibres; thus, protection must be used during use or handling.

Agricultural wastes using barrier panels have been manufactured and have received the attention of only a small number of investigators (Davern, 1977). These fibres consist of cellulose and can very easily be made into chip particles rather than wood-based raw substances (Ingard, 1994). Furthermore, this crude fibre can be used to reduce the noise emitted from power plants, e.g., as barriers in boiler steam. The testing was conducted via impedance tubes to obtain the acoustic absorption coefficient. The tube was fabricated based on international standard ISO 10534-2 and ASTM E1050-98. This study shows that the local natural fibres in Iraq and Malaysia have good potential to compete with manufactured products.



(a) (b)

Fig. 1: Photographs of date palm tree in Iraq, (a) illustrate the frond, (b) illustrate the fibre

Many researchers have succeeded in using agricultural wastes to produce absorption materials.

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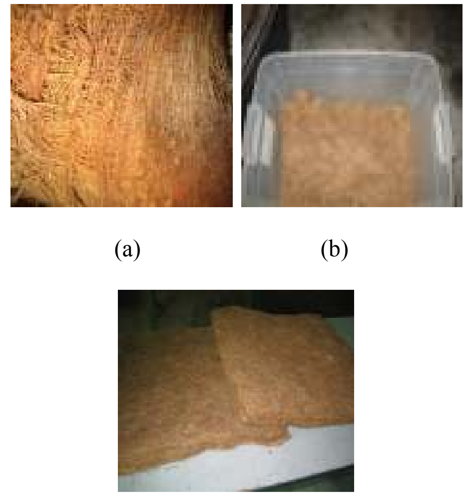
New particle boards manufactured using durian peel and coconut coir fibres have been created to achieve the lowest thermal conductivity to decrease heat transferred into space (Khedari *et al*., 2003). In terms of heat reduction, these agricultural wastes are an economical and interesting potential insulator for ceiling and walls. A year later, the same researcher discovered a particle board of low thermal conductivity manufactured using a mixture of durian peel and coconut coir (Khedari *et al*., 2004).

Zulkifh *et al*. (2008) studied the transmission loss index and acoustic absorption coefficient and compared them using natural organic fibre perforated panels with or without filler. Meanwhile, Ersoy and Küçük (2009) investigated the sound absorption of industrial tea leaf waste developed into three different layers with or without a single backing layer of woven textile cloth to test the experimental properties of sound absorption. Other researcher (Yang *et al*., 2003) studied the absorption coefficient of four fibre assemblies, cashmere, goose down and kapok, which are both natural and acrylic fibres. The natural fibres had distinctive internal structures that would influence the sound absorption coefficient.

The improvement in the acoustic characteristics and perforation plate design are used in the panel structure. The density of porous substances and the porosity of the perforated panel would significantly alter acoustical impedance and the acoustic absorption coefficient (Puglia *et al*., 2005). For porous materials, sound absorption is less a function of the material type and more a function of airflow resistivity and how well the material construction can be executed to achieve desirable properties for sound absorbers (Hong *et al*., 2007).

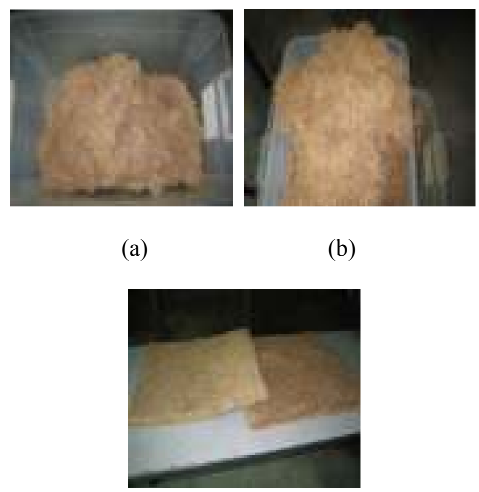
In addition, the organic fibre is used in applications to decrease noise transmission in the space interior and external transmission (Zulkifli *et al*., 2009; Ayub *et al*., 2009).

This research was conducted to understand the potential use of date palm fibre and oil palm fibre instead of industrial fibres in acoustic absorption applications. This study validated the acoustic absorption coefficient of two organic fibre samples to understand their acoustical properties. The most important parameters to determine acoustic characteristics are the acoustic absorption coefficient. To determine these parameters by using the tests conducted in the impedance tube, SCS software programme was used to determine the coefficient of absorption for two types of materials.



(a) (b) (c)

Fig. 2: (a) Crude date palm fibre, (b) chopping fibre, (c) treated date palm fibre sheet



(a) (b) (c)

Fig. 3: (a) Crude oil palm fibre, (b) chopping fibre, (c) treated oil palm fibre sheet

MATERIALS AND TEST METHODS

In this study, the two types of fibres used for the sound absorption in samples were of the same thicknesses, 50 and 30 mm, as shown in Fig. 2 and 3, respectively. Crude palm fibres are prepared for the testing of the material sound absorbing capability. The fibres were compressed to form the sample using moulds. Therefore, the sample contains almost the same ingredients (including the matrix granular part) as when it was collected. The samples were produced as a large rectangular panel and then cut into suitable circular shapes to fit into the impedance tube. For this purpose, the preliminary processing, which includes several sequential steps, such as fibre chopping, which cuts up the raw materials from natural fibres, produces a mixture of small pieces of palm fibre filaments and small pieces of wood and fibre powder that resemble powder dust. Next, the fibre extraction process is used to separate the fibre filaments, isolating them from the rest of the materials and removing impurities. The fibre compression process is performed manually to obtain fibre filaments, which are then arranged in the mould.

Table 1: The properties of date palm fibre and oil palm fibre

Thickness (mm)	Date palm fibre density kg/m^3	Oil palm fibre density kg/m^3
30	130	65
50	150	75

Fig. 4: Impedance tube instrument and set-up for acoustic properties

(a) (b)

Fig. 5: (a) Test samples of date palm fibre, (b) test samples of oil palm fibre (50 mm and 30 mm of thickness)

Each layer is manually pressed to ensure that the fibre distribution is evenly distributed over the entire mould in terms of density.

The palm fibres formed properly when a latex treatment was used. The latex treatment involves coating all surfaces well using a spraying gun retain the same shape, known as spraying. Finally, after the latex spraying, the sample is spread over the plate of a high-precision moulding machine hot compress after the latter was sprayed with a chemical treatment (RS 33 silicone release agent). The machine was run for 30 min before operation to reach 100°C. The piece is surrounded on both sides with rods whose height corresponds to the thickness required. Next, the sample is covered with a plate. The pressing period was exactly 5 min with a pressure of 170 kg/cm². The sheets for each type of fibre are 400×400×50 mm and 400×400×30 mm in dimensions, as shown in Table 1 the properties of each type.

Therefore, to provide cohesion and arrangement between rectangular fibres, circular patterns were used for the latex testing. The latex had no effect on the acoustic absorption characteristics but did affect the physical properties. Date and oil palm fibres are not hazardous and non-degradable substances.

Test: Acoustic Absorption Coefficient (AAC): Empirical investigation using an impedance tube was performed to calculate the acoustic absorption coefficient AAC. The test was performed using the ISO 10534-2 and ASTM E1050-98. The impedance tube consists of two steel tubes, 100 mm in diameter for low frequency and 28 mm in diameter for high frequency, SCS 9020 B/K, for measuring system the calibration, two ¼” GRAS-26AK microphones, a G10 white noise generator and a 4206 SCS 9020 B/K loud speaker. The calibrator was a GRAS type 42 AB Cal 21 01 dB. For testing, the small-diameter tubes are connected and can be mounted for high-frequency measurements, which may also stand alone with its own loudspeaker case.

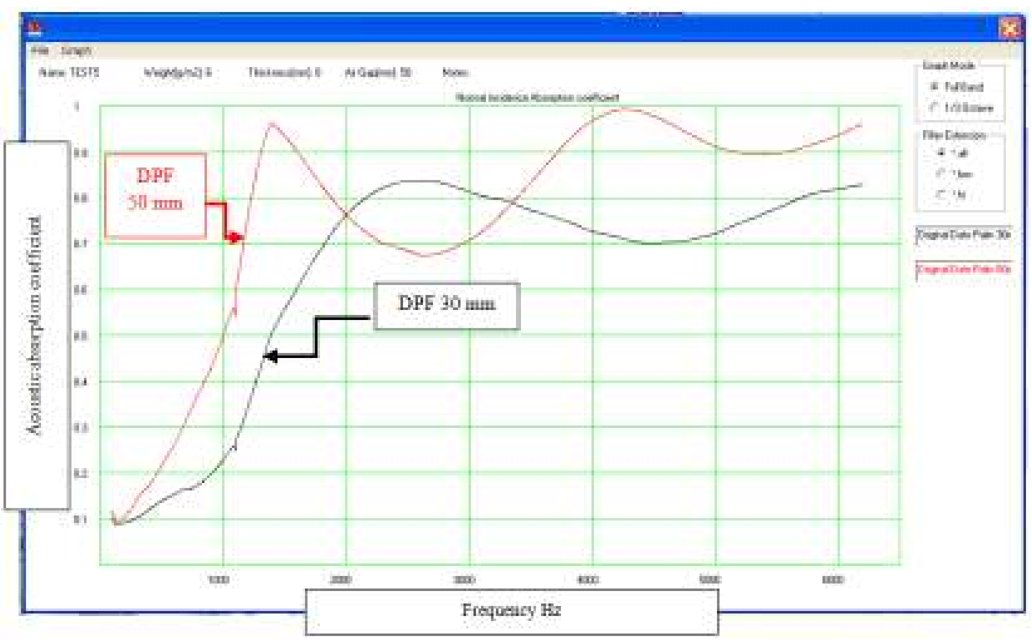


Fig. 6: Comparison between date palm fibre samples thicknesses (30 and 50 mm, respectively)

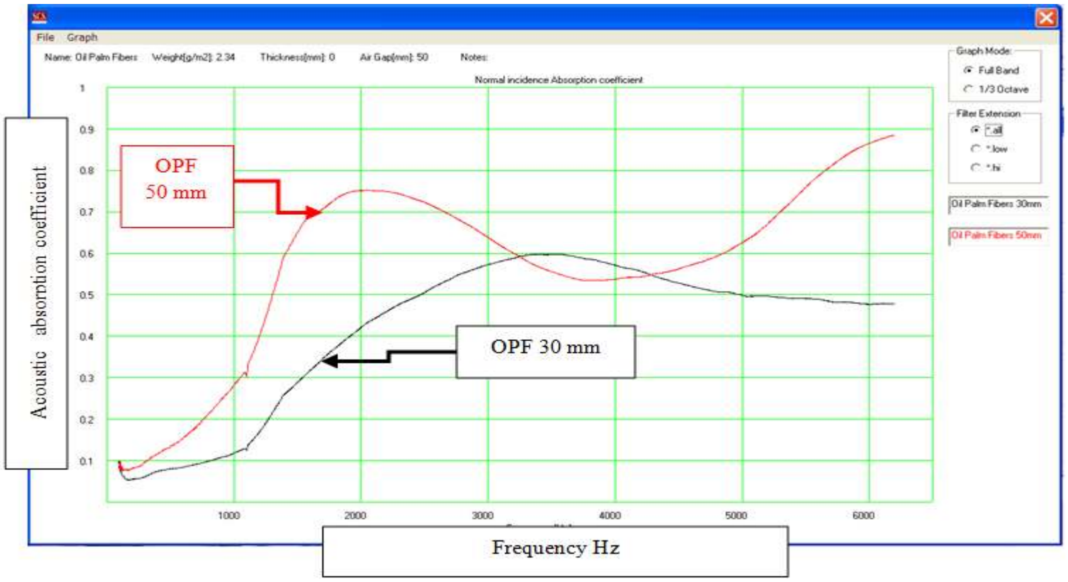


Fig. 7: Comparison between oil palm fibre samples thicknesses (30 and 50 mm, respectively)

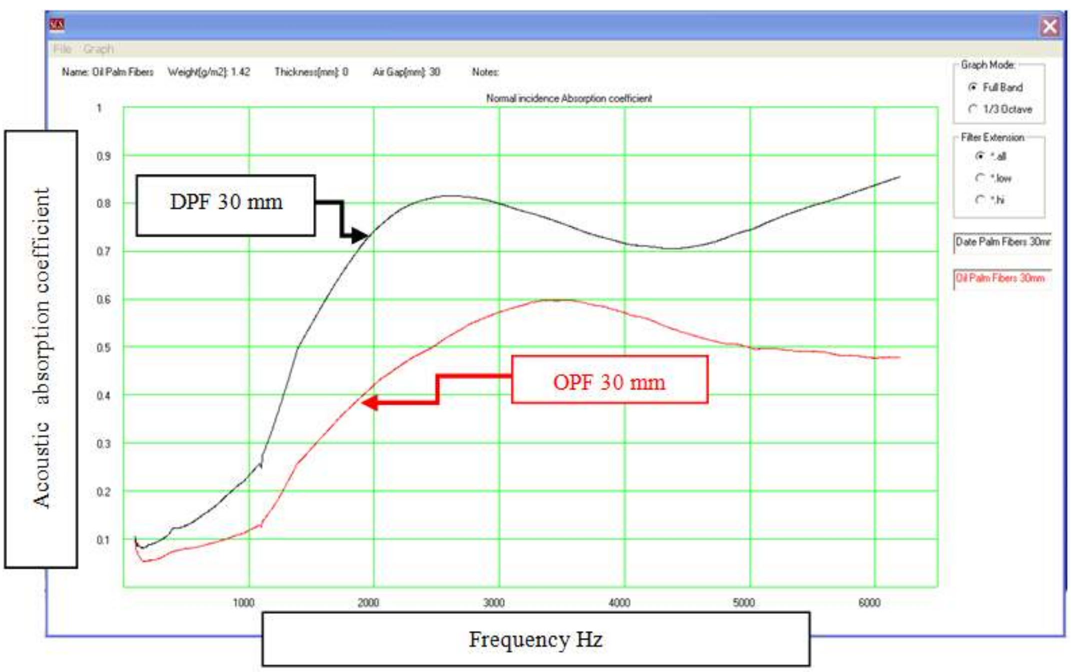


Fig. 8: Comparison between date palm fibre and oil palm fibre of thickness 30 mm

The microphones are connected to the PC, which also includes a random noise generator. The other instruments used include a loudspeaker case and audio amplifier, microphones and power supply sets. Alternatively, the larger-diameter tube can be mounted for low-frequency measurements. For translating sound waves to digital signals, SCS 8100 software was used to save the output signal data.

Figure 4 shows the impedance tube setup, and Fig. 5 shows photograph of two types of materials with circular shape diameters of 100 and 28 mm. Figure 6 compares the two thicknesses (30 and 50 mm, respectively) of date palm fibre, whereas Fig. 7 shows the same but for oil pump fibre. Figure 8 and 9 compare the two types of fibres with 30 and 50 mm thicknesses.

RESULTS

The comparison between the two sample thicknesses (30 and 50 mm, respectively) of date palm fibre and oil palm fibre are shown in Fig. 6 and 7, respectively. The maximum values of the acoustic

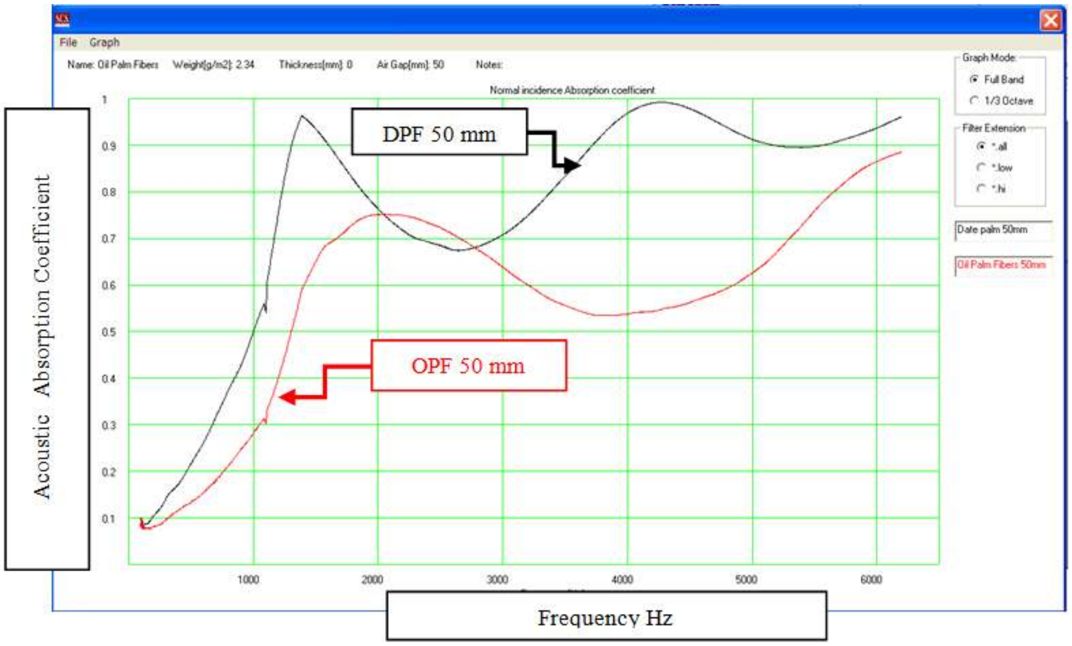


Fig. 9: Comparison between date palm fibre and oil palm fibre of thickness 50 mm

Table 2: Illustrate the maximum value of acoustic absorption coefficient AAC for each sample thicknesses at the range of frequencies

Type of fibre	Thickness mm	Density kg/m^3	Maximum value of AAC	Frequency Hz
DPF	30	130	0.83	2381.38-2809.38
DPF	50	150	0.93	1365
	-	-	0.99	4200-4353
OPF	30	65	0.59	3225-3712.50
OPF	50	75	0.75	1946.88-2178.13

absorption coefficient AAC are illustrated in Table 2. We can see that the date palm fibre gives a higher acoustic absorption coefficient value than the oil palm fibre.

DISCUSSION

Effect of fibre thickness: In Fig. 6 and 7 show the acoustic absorption coefficient of date palm fibre and oil palm fibre for different thicknesses. Increasing the fibre layer thickness increases the absorption and moves absorption peak towards lower frequencies for both cases. Increasing the fibre thickness enhanced the acoustic absorption in lower frequencies, as shown in Table 2. This finding indicates that the absorption increases because the impinged wave must travel a long distance through the fibre and losses its energy. According to the absorption phenomena inside the porous material, long dissipative processes for the viscosity and thermal conditions in the fluid inside the material due to the increased thickness increase absorption (Kino and Ueno, 2007).

Effect of bulk density: In Fig. 8 and 9 compare the two sample types for each thickness. The absorption coefficient for the 30 mm thickness with various densities is shown in Fig. 8 to illustrate its effect on the acoustic absorption of two panels. This figure shows that the increasing density of the porous material enhances the absorption of fibre and moves the peaks toward lower frequencies, as shown in Table 2, so that the density of date palm fibre is 130 kg/m^3 and that of oil palms fibre is 65 kg/m^3. Absorption enhancement occurs due to the greater flow resistivity with increasing bulk density of date palm fibre, which is greater than that of oil palm fibre (Nor *et al*., 2004). Similarly, the 50-mm-thick sample is shown in Fig. 9. This results illustrate a considerably variability in the AAC due to the enormous difference between the density of each type; thus, increasing the density enhances the absorption considerably due to increased flow resistivity.

Therefore, the effect is greater considering its porosity due to the similar fibre layer thickness. Figure 9 also shows a significant decline in high frequency absorption with increased density, but this value is at slightly less high frequencies in Fig. 8 and the additional bulk density increases the absorption. Thus, increasing the bulk density to increase the absorption coefficient is considered. As long as there is no additional layer (perforated plate or air space) with an existing layer, no additional change occurs in the absorption value. The outcomes indicate that the absorber ability with a small density has a small effect on the absorber with high density, which may enhance absorption, but according to boundaries of the sound wave that distributes the material (Li *et al*., 2007).

On the other hand, a sound wave might be reflected by the surface area of this material, rather than being absorbed by this material. Both materials are porous, although the flow resistivity of date palm fibre is greater than that of oil palm fibre due to the flow resistivity of the porous material being inversely proportional to the fibre filament diameter for a given porosity (Hosseini *et al*., 2010).

CONCLUSION

This research was conducted to investigate acoustic absorption characteristics of two fibres materials as an agricultural waste material in Iraq and Malaysia. This study indicates that the use of an impedance tube to determine the acoustic absorption coefficient AAC between date palm fibre and oil palm fibre has been successful. The results illustrate that date palm fibre has an acoustic absorption coefficient, which is higher than that of oil palm fibre due to the differences between the thicknesses and densities.

Experimental testing, using thicknesses of 30 and 50 mm for each panel, revealed different densities for each thickness and different densities for fibre type.

The effect of physical elements, such as density and thickness, are described, illustrating the variations in the acoustic behavior of two fibres with changes in these parameters. The date palm fibre has good performance ability and is a promising industrial product in acoustic absorption applications to absorb various ranges of frequencies. The two types of fibres are eco-friendly, are plentiful in agricultural waste and have the advantages of renewability, abundance and low-cost. Therefore, these organic materials are alternatives to industrial products used in barriers and muffler. Finally, the properties of two types of fibres suggest that they are more likely to be used than synthetic materials are to protect the environment from noise pollution. However, the use of green technology for absorption sound via organic materials is the best current approach.

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