
The Adaptation of Waste Date Palm Fibers for Sound Absorbing Purposes

Wafa TAKTAK

Laboratory of Mechanics, Modeling and Production (LA2MP), National School of Engineers of Sfax, University of Sfax, BP N° 1173-3038, Sfax, Tunisia,
wafa.taktak.1978@gmail.com

Dhouha TOUNSI

Laboratory of Mechanics, Modeling and Production (LA2MP), National School of Engineers of Sfax, University of Sfax, BP N° 1173-3038, Sfax, Tunisia,
dhouha.ing@gmail.com

Mohamed TAKTAK *

Laboratory of Mechanics, Modeling and Production (LA2MP), National School of Engineers of Sfax, University of Sfax, BP N° 1173-3038, Sfax, Tunisia,
mohamed.taktak@fss.usf.tn

Faten FEDHIL

Faculty of Sciences of Sfax, University of Sfax, BP N° 1171, Sfax, Tunisia
hammadifaten81@gmail.com

Chafik KARRA

Laboratory of Mechanics, Modeling and Production (LA2MP), National School of Engineers of Sfax, University of Sfax, BP N° 1173-3038, Sfax, Tunisia,
chafik.karra@ipeis.rnu.tn

Mohamed HADDAR

Laboratory of Mechanics, Modeling and Production (LA2MP), National School of Engineers of Sfax, University of Sfax, BP N° 1173-3038, Sfax, Tunisia,
mohamed.haddar@enis.rnu.tn

* Author to whom correspondence should be addressed

Abstract: - In this study, an experimental procedure is developed in order to elaborate an acoustic absorber based on date palm fibers. This kind of material has a double interest: The first is due to its great importance in environment protection by recycling wastes; the second is the fact that these materials are used in the treatment of a second environmental problem which is the noise pollution by reducing it. In this work, wastes from the date palm were used to manufacture an acoustic absorber. In fact, agriculture wastes are increasingly used in the acoustic field. In this work, wastes from date palm were used to manufacture acoustic absorbers. To achieve this goal, date palm waste is acoustically evaluated by an experimental characterization based on measuring the acoustic absorption coefficient of the studied material in the frequency band [0-4000 Hz] using the Kundt tube. The obtained results are encouraging with acoustic absorbent coefficient reaching 0.9 in some frequencies.

Keywords: Sound absorber, Palm wastes, Acoustic absorption coefficient, Experimental characterization, Insulation.

1. INTRODUCTION

Acoustic comfort in industrial and building applications is an objective which has been developed by researchers in the field of acoustics to lead a better quality of life and work in these domains since it

affects a large part of the population whether at home (architectural and building noise), in the workplace (industrial noise) or road transport noise etc.

Recently, there is a use of “natural” sources to manufacture acoustic absorbing materials to reduce noise pollution in building and industrial domains.

This kind of material is called “Eco-friendly materials”. Many researches were developed to provide a better understanding of the acoustic behavior of these eco-materials and their application domain as well as their limitations.

This type of material can be classified into the following categories as presented in Asdrubali et al [1]:

The bio-sources; these materials have natural origins obtained from plant, animal or mineral resources, they can be used in its original form or after an industrial transformation. In this category, there are acoustic absorbents based on wood [2-3], rice straw [4], Hemp [5], Tea [6], Coir [7], bamboo [8], Coccut [9], Cotton [10], Sugar Cane [11-13] and Palm fiber [14-18]. These materials showed good absorption coefficient varying between 0.3 and 1 over the studied frequency bands.

The recycled materials: In the last few years, many researchers studied the acoustic performance of recycled materials such as the tires which are developed by Swift et al. [19] and Yang et al. [20]. The obtained results indicated that tires have very good absorption properties. As well as for the carpet waste which is used at the base of the sound absorbing materials using foaming binders which have high acoustic performances [21].

The third category concerns the composite materials in which natural fibers are used as a matrix or reinforcement and resins as a binder.

The proposed work studies the acoustic behavior of a bio-source material based on the agriculture date palm waste.

In fact, there are many papers dealing with this type of bio-sources. Thus, Taban et al. [14] which used date palm waste fibers to manufacture low-cost sound absorbing panels. Lamyaa et al. [15] who developed an experimental study in order to determine the acoustic characteristics of date palm fiber and oil palm fiber. For the same purpose Taban et al. [16] developed a high-performance green insulation material based on date palm fibers.

In another study, Raza et al. [17] focused on the influence of the different parameters (thickness, density, length) of palm fibers on sound absorption coefficient). Mohammad et al. [18] studied sound properties of date palm fibers mixed with coconut fiber. The obtained material presents a very good sound absorption coefficient.

The outline of the paper is organized as follows: In Sect.2, the different steps to obtain the samples from the date palm fibers are presented. Section.3 presents the experimental method used to measure the absorption coefficient of the manufactured samples and the obtained experimental results pointing the value of the sound absorption coefficient.

2. MATERIAL AND METHODS

In this section, the origin and all the proprieties of the used date palm are detailed. Then, all the necessary steps to obtain the desired samples are explained.

2.1. Materials made from agricultural waste: the date palm

The used material is date palm waste fibers especially their fins, which has been taken from the Kebili region (Tunisia). Palm trees cover 1.9% of the total arboreal area of Tunisia. The age of the palm tree is around 50 years. The fins used are dried for three months under natural conditions before carrying out characterization tests. The palm (called also djerid) is a leaf composed by a petiole and a rachis which is divided into thorny part and leafy part.

The only useful part of the dry palm is the leafy part, while the remaining part is discarded as agricultural waste which will be investigated in the elaboration of acoustic absorbent.

The idea is to use this renewable natural resource (date palm wastes) in the domain of acoustics to produce a bio-sourced acoustic absorbent having a positive impact on the environment and help reduce the consumption of non-renewable raw materials.

2.2. Preparation of samples

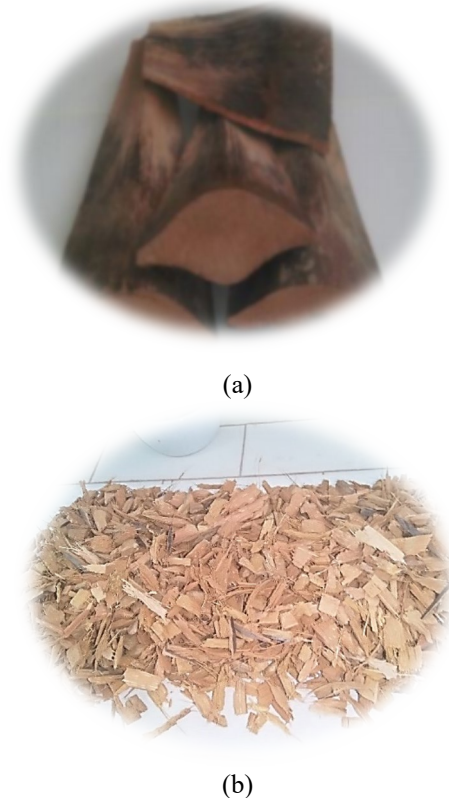


Figure 1. Date Palm wastes: (a) natural size, (b): small size

In fact, the process of preparing the date palm material goes through several steps which can be summarized as follows: drying of the palm waste which will be transformed into fibers by grinding.

The fibers are mixed with a binder and placed in a mold to take the desired shape and dimensions. These different steps are detailed in the following sections.

In the first step, the date palm waste is taken in its natural state (Figure 1) and divided into small pieces so that the shredder can destroy them because the latter is small in size, as shown in Figure 1.

The second step consists on placing the pieces obtained from date palm waste in the oven at a temperature of 80°C for 24 hours (Figure 2) to eliminate any proportion of liquid in samples.



Figure 2. Steaming of date palm waste

After that, the waste was shredded: After steaming the waste from the palm trees, it is put in the crusher in order to crush them (Figure 3).



Figure 3. Presentation of the grinding operation

After putting the raw material into the crusher, fibers are obtained as shown in the Figure 4.

The fibers have been classified according to their sizes into several categories using sieves of different mesh sizes.

The mesh diameters of the sieves used are respectively 0.315 mm, 0.5 mm, 0.8 mm and 2 mm.



Figure 4. The obtained date palm fibers

Yet the obtained date palm fibers are classified into 3 sizes (Figure 5):

- Coarse fibers: the diameters of the fibers vary from 0.8 mm to 2 mm
- Medium fibers: the diameters of the fibers vary from 0.5 mm to 0.8 mm
- Fine fibers: the diameters of the fibers vary from 0.35 mm to 0.5 mm

To have more porosity on the manufactured bio-source material, only the coarse fibers with a diameter of 0.8 mm is used as demonstrated in a previous work [10].

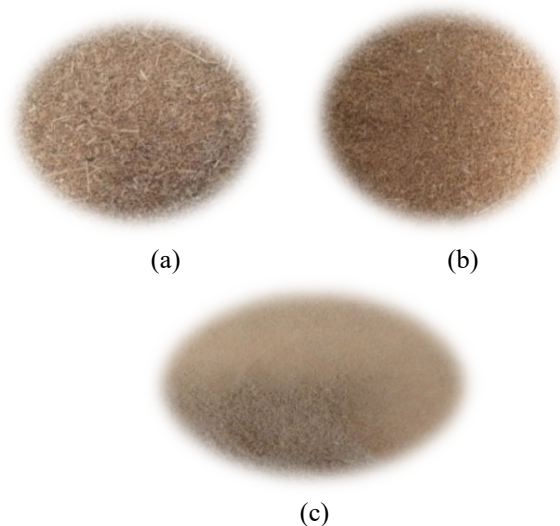


Figure 5. Presentation of the date palm fibers obtained: (a) coarse fibers, (b) medium fibers and (c) fine fibers

After obtaining the desired dimension of date palm fibers, the next step consists on the preparation of the material which requires a binder to bind the fibers together into a solid mass.

Materials based on plant fibers generally use Organic resins. In our case, isophthalic resin is used which will be added to the date palm fibers.

The content of each element of the mixture is carried out by weighing using an electronic balance. To obtain the desired sample, the fibers are mixed with isophthalic resin. For each sample, the resin concentration ratio was 60% of the total composite mass. So, the resin/hardener ratio was 60:40. then the mixture of fibers is placed in a mold of 96 mm diameter (Figure 6) and it is left for 24 hours in the mold.

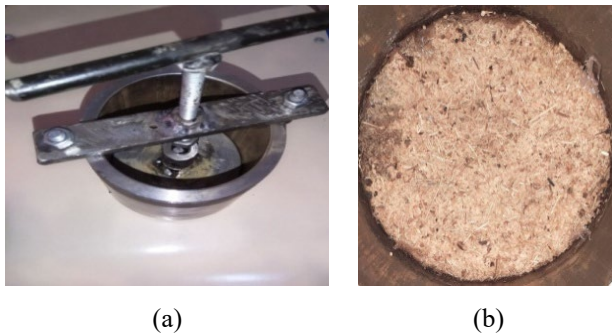


Figure 6. (a)The mold, (b) the obtained sample

3. EXPERIMENTAL MEASUREMENTS

The objective of this part is devoted to the presentation of the experimental measurement of the absorption coefficients of the absorbent material already prepared by the waste of the date palm. This measurement is performed using the Kundt tube. Finally, the results of the measurements will be presented and analyzed. The experience parameters can be resumed in Table 1.

Table 1. Experience paramters

Diameter and length of the instrument tube	96 mm / 1000 mm
Location of the sample in the tube	At the end
Frequency range under use	0 – 4000 Hz
Time in (sec) required acquiring the absorber's spectrum by the instrument	15 x 30 s
Resolution in (Hz)	250
Calibration process	Pistophone

The Kundt tube (see figure above) consists of a cylindrical tube filled with air with rigid walls constructed of a dense material in order to reduce acoustic losses.

A loudspeaker for generating sound waves is attached to one end of the acoustically rigid tube.

A sample of the studied material is placed at the other end. A pure frequency is applied to the loudspeaker. The sound pressure wave propagates in the tube, is reflected on the sample of acoustic material and propagates in the opposite direction: a standing wave phenomenon is established.

A microphone fixed on a mobile rod can be moved inside the tube, longitudinally, to measure the acoustic pressures at various points of the tube.

The signal coming out of the microphone is sent to a voltmeter that provides access to the effective value of the signal.

In addition, a graduated ruler makes it possible to identify the position of the microphone in the tube.

The tube being rigid, the proportion of the energy that it absorbs is negligible compared to the energy absorbed by the sample.

By measuring the characteristics of the generated standing waves, the acoustic properties of the material are determined: by measuring the ratio between the maximum and the minimum pressure in the tube, one can calculate the acoustic absorption coefficient, α , which gives the proportion of incident energy absorbed by the material

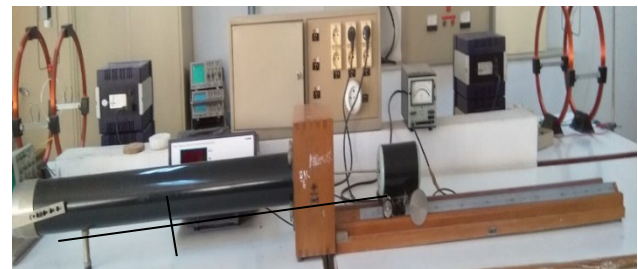


Figure 7. Kundt tube

The Kundt tube was used to determine the absorption coefficient of the sample, following the measurement protocol indicated in the previous paragraph. The result found is presented in Figure 8.

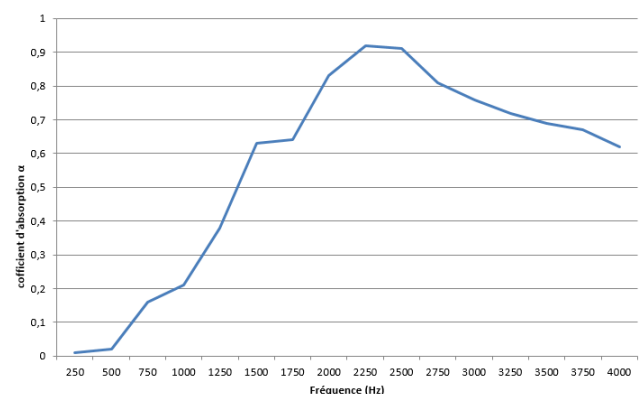


Figure 8..Direct measurement of sound absorption for the sample as a function of frequency

From the fig 8 it is noticed that for the interval from [0 to 2250] Hz, there is an increase in the absorption coefficient, then over the interval [2250 to 2500] Hz the curve stabilizes to obtain a maximum absorption which is close to the maximum value 1, $\alpha = 0.92$ and then on the last interval of [2500 to 4000] Hz the coefficient decreases and reaches the value of 0.6. It is observed that the obtained material has a typical behavior of porous materials.

The obtained results demonstrate the efficiency of the developed material with acceptable values of the acoustic absorption coefficient. This is encouraging to more develop this solution to manufacture absorbent from these wastes.

4. CONCLUSIONS

This paper is interested in the characterization of a new acoustic wave absorbing material based on agricultural waste.

In fact, the results obtained clearly show that this material made from date palm waste and which has an absorption coefficient which can reach the value of $\alpha = 0.92$ for a frequency range from 2250 to 2500Hz, has good sound absorption. So, this new absorber can be used for industrial noise treatment for medium and high frequencies.

So, it can be a very effective way to protect the nature from palm waste on the one hand and on the other hand to benefit from this waste in order to manufacture sound absorbers.

ACKNOWLEDGMENTS

The authors thank Professor Nader HADDAR from the national School of Engineers of Sfax for the help in manufacturing the experimental samples and the Faculty of Sciences of Sfax for its support by providing the experimental set up to measure the acoustic absorption coefficient.

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