



(MUDIMA)



Identification of the Utilization of Jember Coffee Skin Biocomposite (Coffea Canephora) as a Sound Absorber Using the Tube Method

Enos Lolang^{1*}, Israel Padang², Intan Duru' Sarungallo³, Jumiarti Andi Lolo⁴, Adewidar Marano Pata'dungan⁵

Universitas Kristen Indonesia Toraja

Corresponding Author: Enos Lolang enos@ukitoraja.ac.id, miaandilolo

ARTICLE INFO

Keywords: Sound Attenuation Coefficient, Acoustic Material, Coffee Skin

Received : 2 November

Revised : 22 November

Accepted : 22 December

©2022 Lolang, Padang,

Sarungallo, Lolo, Pata'dungan:

This is an open-access article distributed under the terms of the

[Creative Commons Atribusi 4.0](https://creativecommons.org/licenses/by/4.0/)

[Internasional.](https://creativecommons.org/licenses/by/4.0/)



ABSTRACT

The development of technology and information is in line with the era of society 5.0 which occurs in various fields, especially in terms of infrastructure which of course will lead to high mobility. One of the negative impacts that arise is noise. For that we need a material that can be used as an acoustic material that functions to absorb sound. Coffee waste is one of the agricultural wastes that can be used as an acoustic material. The purpose of this study was to determine the effect of the sound damping coefficient on sound intensity and the mixture of filler and matrix mass fractions that can be used to muffle sound. The tube method with the Sound Level meter feature from Smartphone will be used to determine the value of the sound attenuation coefficient. In this study, the sound intensity used was 60-100 dB, with a mass ratio of filler and matrix used was 80%:20%, 70%:30%, 60%:40%, 50%:50% and the thickness used is 10mm. The results of the study show that an increase in intensity for each sample will show a decreasing coefficient for each sample. This is due to the higher the intensity of the sound, the higher the sound energy will also be greater so that it is more difficult for the sample to absorb

INTRODUCTION

The development of technology and information is in line with the era of society 5.0 which occurs in various fields, especially in terms of infrastructure which of course will lead to high mobility. One of the negative impacts is noise. Noise with high intensity can potentially damage the human hearing senses where this noise is in the form of the sound of vehicle engines, the sound of industrial machinery where the noise level is in the range of 95-105 dB.

Efforts made to deal with noise are using materials that can absorb or dampen sound. However, the need for this absorbent material is increasing where the price of the material is expensive and uses synthetic materials which can have a bad effect on the environment. To deal with this, alternative materials that are environmentally friendly and inexpensive are needed, such as using natural materials that are renewable, easily degradable, not difficult to obtain, and not harmful to the environment [1].

Natural materials can be combined with several materials to form composites. Composite is a composition that uses fiber as a basis which combines two or more of its constituent materials through a non-homogeneous mixture [2]. The combination of these materials will produce a composite material whose properties and characteristics will be different from the original material [3]. If the material consists of a polymer matrix combined with natural fibers it is called a biocomposite.

Toraja as one of the coffee producers in Indonesia certainly indicates that there are many coffee plantations in Toraja. From the coffee harvest, coffee skin waste is produced which is not used and thrown away after being separated from the fruit. Coffee skin waste is produced as much as 38.1% from the processing of beans which contain 65.2% fiber [4]. Utilization of coffee waste at this time is still not optimal so that the volume of coffee waste is increasing. Even though coffee skin waste can be used in various ways such as nutrient content both dry and wet can be used, for example making

compost [5] and ruminant animal feed [6] where the coffee skin waste has around 65% and 51.4% protein for seed coat [7].

According to research results from Danu (2019), the productivity of coffee plants in Indonesia is quite high, the coffee agro-industry produces coffee husks of around 60% of its raw material. This study aims to determine the characteristics of three different types of coffee husks based on the people's plantations of origin in East Java, namely Jember, Banyuwangi, and Malang. Some of the characteristics analyzed were proximate content (moisture, ash, protein, fat, and carbohydrates), crude fiber content, and lignocellulosic content (lignin, cellulose, and hemicellulose). The results showed that the coffee skin has different characteristics in each region. Jember coffee husk has a moisture content of 8.59%, ash content of 6.93%, fat content of 0.88%, protein content of 6.77%, carbohydrate content of 76.83%, crude fiber content of 30.15%, lignin content of 21.95%, 11.65% hemicellulose content, and 27.26% cellulose content. Coffee husks from Banyuwangi have a moisture content of 8.83%, ash content of 11.88%, fat content of 0.93%, protein content of 7.82%, carbohydrate content of 70.54%, crude fiber content of 36.98%, lignin content 35.90%, 2.50% hemicellulose content, and 10.15% cellulose content. Malang area coffee husks had a moisture content of 8.47%, ash content of 5.60%, fat content of 1.10%, protein content of 7.99%, carbohydrate content of 76.83%, crude fiber content of 32.38%, lignin content 33.79%, hemicellulose content 6.34%, and 15.38% cellulose content.

Coffee skin contains 17% lignin, 63% cellulose, 2.3% hemicellulose, 11.5% protein, 1.8-8.56% tannins and 6.5% pectin [8]. Lignocellulose or natural fibers in coffee can be used as an acoustic material by mixing it with polymer so that the coffee skin can be used as a biocomposite. The polymer that can be used is epoxy resin. Epoxy is used in many ways because it is a chemically reactive adhesive, thermal conductive adhesive, electrically conductive adhesive, excellent corrosion resistance, tensile strength and flexural strength [9]. Biocomposites

with natural fibers have a weakness where the interfacial bond between the hydrophilic cellulose fibers and the hydrophobic resin and the matrix causes a mismatch in the bonds. Therefore, a catalyst, namely epoxy hardener, can be used to bind fiber and resin bonds.

Acoustic material properties can be measured in order to produce materials that can attenuate sound well. This is indicated by the sound attenuation coefficient. This value ranges from 0 to 1. If the value is zero then it means that no sound is absorbed. Meanwhile, if the value is 1, it means that the sound is absorbed perfectly. Energy that comes from sound can be absorbed by materials that are soft, porous and fibrous [10].

The method that will be used to measure the sound attenuation coefficient is a tube using the Sound Level Meter feature on a smartphone. In this method, the process is not difficult and the material used is relatively small. From the background above, research will be carried out regarding the initial identification of the use of Jember coffee peel biocomposite as a sound absorber using the tube method.

METHODS

In this study the method that will be used to measure the sound attenuation coefficient is a tube using the Sound Level Meter feature on a smartphone. In this method, the process is not difficult and the material used is relatively small. Following are the stages of research:

The stages in this research are as follows:

Material preparation

1. The main materials needed are collected, in this case coffee skin resulting from the separation of skin and fruit which will be dried first using direct sunlight. After the water content is 6.26%, the next step is to grind the coffee skin using mechanical milling to obtain fiber. The fiber is sieved using mesh 20. If it does not pass, it will be refined again and then sieved again.

2. Mixing of ingredients

The finely ground coffee fiber and matrix are then weighed according to a predetermined mass ratio. The catalyst used is epoxy hardener. The weighed fiber is then poured into a glass container and the weighed matrix is mixed with one drop of epoxy hardener then stirred and then poured into a container containing the fiber. The fiber and matrix are stirred evenly.

3. Biocomposite manufacture

After the fiber has been refined and mixed with the matrix and mixed thoroughly, the next step is to put the fiber mixture into the mold and press it so that it is evenly distributed. The samples were then left for about 2 days at room temperature and in the furnace for 2 hours at 160°C.

4. Testing

After drying, the sample will be removed from the mold and adjusted to the diameter of the tube. The size of the tube used is 3 inches for diameter and 30 cm and 70 cm for tube length. The purpose of determining the diameter of the tube is so that the sample matches the size of the tube diameter in the measurement of sound absorption later.

Testing with the tube method aims to determine the sound attenuation ability of the material from the coffee shell to absorb sound. The components of the device are installed and connected first, such as a Bluetooth loudspeaker, a smartphone equipped with a sound level application.

5. Data retrieval

Data collection was carried out to obtain the value of the sound attenuation coefficient using the tube method.

6. Data processing

The data obtained from the measurement results is then used to determine the sound attenuation coefficient and acoustic impedance of the coffee fiber.

RESULTS AND DISCUSSION

The provision that a material or material can be used as a good sound absorber is indicated by the value α , which is the sound absorption coefficient. The sound damping coefficient is a number without units that shows the ratio between the sound energy that is not reflected (absorbed) by the barrier material to the total sound energy that hits the barrier material. The value of α ranges from 0-1. If the value of α is greater, the better the material is used as a sound absorber. If α is 0, it means that no sound is absorbed. Meanwhile, if α is 1, it means that the material absorbs sound perfectly. The sound suppression coefficient complies with ISO 11654 standards.

In this study using the tube method which uses a Bluetooth speaker as a sound source, a smartphone equipped with a sound level meter feature, a tube with a length of 30 cm and 70 cm, a smartphone connected to a Bluetooth. The circuit image is as shown in the following figure.

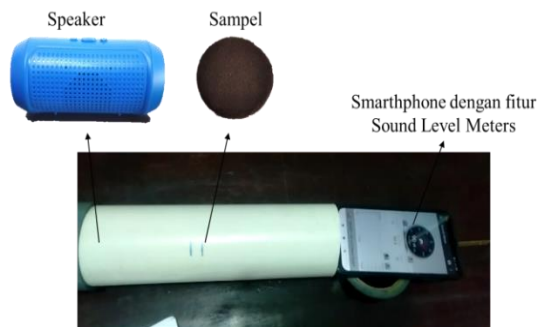
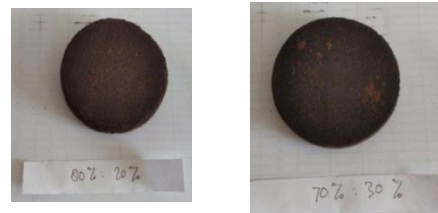


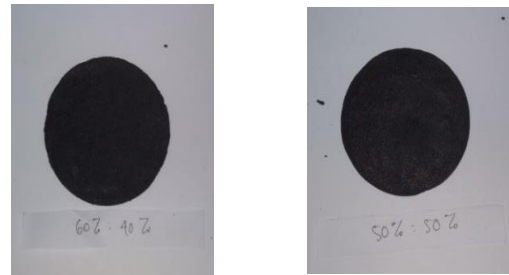
Figure 1. Tube Method

The research sample was made with a fiber and matrix ratio of 80%:20% (sample A), 70%:30% (sample B), 60%:20% (sample C), and 50%:50% (sample D)



Sample A

Sample B



Sample C

Sample D

Figure 2. Research Sample

The figure above shows the sound absorption coefficient at different sound intensities and different fiber and matrix mass fractions at a tube length of 30 cm. Figure 3 shows that the higher the sound intensity, the smaller the absorption coefficient. Sample A shows a smaller absorption coefficient as the sound intensity is given to the sample. This indicates that sample A in the range of up to 91 dB can be used as a sound absorber because it complies with the ISO 11654 standard, which is a minimum value of 0.15. However, at high intensity it cannot be used as a sound absorber because the coefficient value is less than 0.15.

In sample B, the absorption coefficient is getting smaller as the sound intensity increases. At high intensity, sample B has the highest coefficient, namely 0.3 at an intensity of 102 dB. At an intensity of 80 dB, the sample has the highest coefficient, namely 0.51. Sample B could potentially be used in accordance with ISO 11654 standards at intensities in the 60-90 dB range. This is indicated by the coefficient value which does not decrease significantly in the low and high intensity ranges.

Sample C has the highest coefficient value at an intensity of 80 dB which is 0.61 and at a high intensity of 102 dB it has a coefficient of 0.26. Sample C has the potential to be used as soundproofing at low and high intensity ranges. This is shown in Figure 8 which shows a decrease in the coefficient that does not too significant in the range of low and high intensity.

Sample D has the highest coefficient of 0.66 in the intensity range of 81 but the coefficient decreases at high intensities. This is because the sample is unable to absorb sound energy with high sound intensity. In all fiber and matrix fractions, the intensity decreased at 90 dB because the sample was unable to absorb the incoming sound. Sample D also has a lot of matrix so that the density is high which causes the sound energy to be reflected by the sample a lot because it cannot be absorbed by the sample.

The highest coefficient is at intensity 70 and 81, namely 0.66 in sample D. Meanwhile, the lowest coefficient value is in sample A, which is 0.12. This is because the fiber fraction is too much so that the sample is less porous which causes the waves not to be absorbed but to be transmitted.

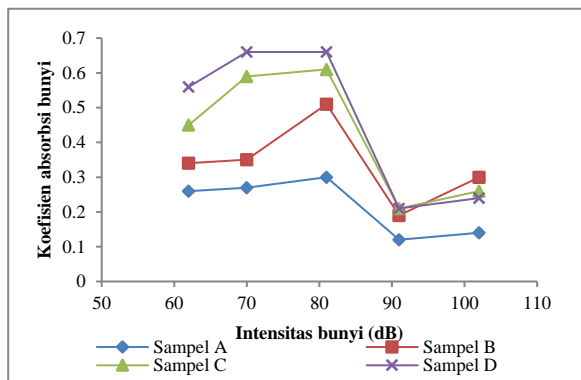


Figure 3. The Relationship between the Sound Damping Coefficient and the Sound Intensity With the Mixed Fraction as Shown in Table 1 where the Length of the Tube is 30 Cm

Figure 2 shows the sound absorption coefficient with the mass and fiber mixture fraction according to table 1 with a tube length of 70 cm. Figure 10 above shows that the higher the sound intensity is given, the absorption coefficient will be smaller.

Sample A has a coefficient that decreases with increasing sound intensity. At an intensity of 64 dB it has the highest coefficient of 0.3 so it has the potential to be used at that intensity. According to the ISO 11654 standard, sample A can only be used at an intensity of 64 dB and 102 dB.

In sample B, it has the highest coefficient value in the range of 64 dB, namely 0.33. However, at low and high intensities the coefficients do not significantly decrease where the coefficient values are in the range of 0.21-0.33 so that the sample has the potential to be used as a sound absorbing material. The sample fraction B shows a good fraction used in soundproofing.

Sample C shows a good absorption coefficient. This is indicated by a high absorption coefficient of 0.5 at an intensity of 64. Sample C has the potential to be used as a sound absorbing material at low and high intensities. This is indicated by the high coefficient value of 0.33 at an intensity of 102 dB. Where in this case it is known that sample C is able to absorb wave energy with high intensity. The absorbed energy will be converted into heat energy. Sample C also shows the optimum fraction which has the potential to be used as a sound absorbing material.

The coefficient value in sample D is highest at intensity 73 which is equal to 0.56 but decreases at high intensity. This is because at high intensity the sample is unable to absorb sound because the matrix fraction is large so that the material reflects a lot of sound so that only a small amount is absorbed.

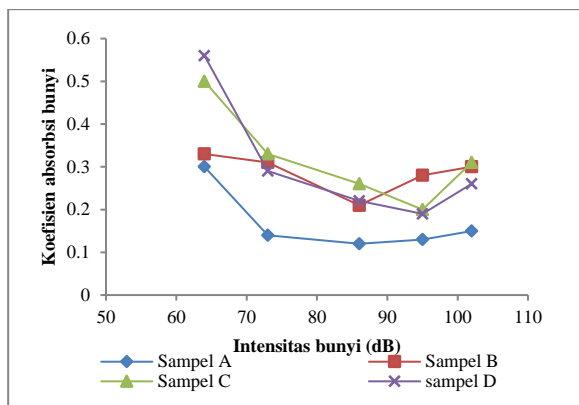


Figure 4. The Relationship between the Sound Damping Coefficient and Sound Intensity with Mixed Fractions as Shown in Table 1 with a Tube Length of 70 Cm

Increasing intensity in each sample will show a decreasing coefficient in each sample. This can be shown on the graph with a cylinder length of 30 cm da 70 cm. This is because the higher the sound intensity, the higher the sound energy, the greater it will be, making it more difficult for the sample to absorb.

The pores of each sample were determined from the mass ratio of filler and matrix. If the matrix composition is small, it will absorb sound waves better than matrix samples that have many matrices. This is because the incoming sound waves will be absorbed by porous materials or high porosity where more waves are absorbed than reflected back. This is shown by samples B and sample C which have good coefficients at high and medium intensities.

In this study it was found that the coefficient value increased at high intensities, which means that there is a large wave absorption when the sound wave passes through the sample. This is because at certain frequencies the acoustic material tends to be recessive which decreases the value of the sound absorption coefficient at certain frequencies [11].

The sound attenuation coefficient for each acoustic material sample has a fluctuating value at a certain intensity. This is clearly seen in Figures 9 and 10 at an intensity of 102 dB there is an increase in sound absorption. This is due to the deviation (anomaly) that there is a cavity in the sample when it is inserted into the tube, so that the sound absorption that occurs is also large [12].

The sound absorption coefficient on the acoustic material of coffee husk fiber and epoxy resin in all samples increased at low and high intensities. This is due to the change from sound energy to heat energy. When a sound wave enters the material, it causes the air molecules in the pores to vibrate. This vibration causes friction, so that there will be a change of energy into heat energy which causes a loss of energy from the sound wave, the loss of sound wave energy causes the amplitude of the reflected wave to weaken, the weakening of the amplitude of the reflected wave results in an increase in the value of the sound absorption coefficient.

When compared to the egg crust, the coffee shell sample has a better coefficient at a high coefficient. But the difference is not too far with the egg crust.

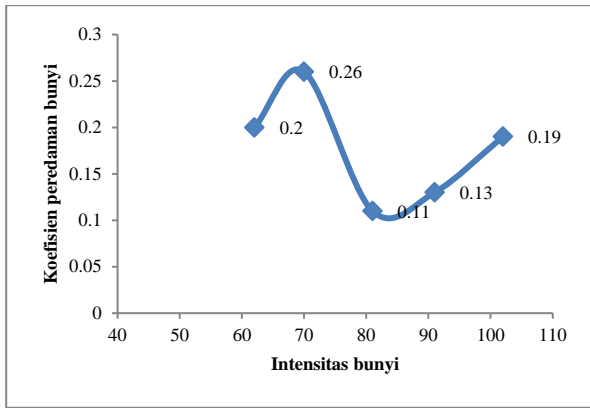


Figure 5. The Relationship between the Sound Damping Coefficient and Sound Intensity with a Tube Length of 30 Cm in Egg Crust

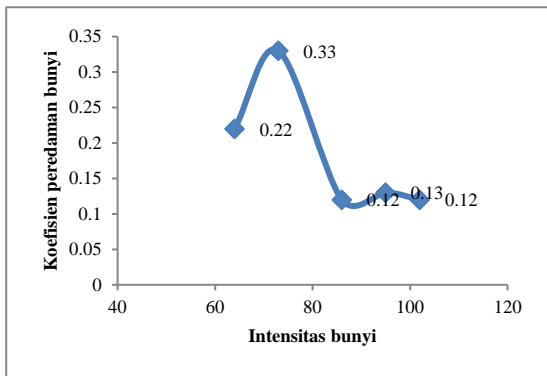


Figure 6. The Relationship between the Sound Damping Coefficient and Sound Intensity with a Tube Length of 70 Cm in Egg Crust

From the research results that have been obtained, namely coffee fiber and epoxy resin, it appears that a smartphone equipped with a sound level meter application has great potential to be used as a device for measuring the sound absorption coefficient. Although the accuracy of the smartphone from this study still needs to be improved to make it more optimal. However, the application of a smartphone provides the potential to be used in the process of measuring the sound attenuation coefficient

CONCLUSION

1. The greater the sound attenuation coefficient, the smaller the sound intensity that reaches the Sound Level Meter (I_0).
2. The higher the percentage of the matrix fraction, the smaller the value of the sound attenuation coefficient.

REFERENCES

- Danu, I. W. (2019). (Peer Review+ Similarity+ Document) Karakteristik Kulit Kopi Robusta Hasil Samping Pengolahan Metode Kering Dari Perkebunan Kopi Rakyat Di Jawa Timur. *Jurnal Agritop*, 17(2), 214-223.
- Dong, C., Davies, I. J., Fornari Junior, C. C. M., & Scaffaro, R. (2017). Mechanical properties of Macadamia nutshell powder and PLA bio-composites. *Australian Journal of Mechanical Engineering*, 15(3), 150-156.
- Sagitta, J. N., Sugita, I. K. G., & Kencanawati, C. I. P. K. (2017). Variasi ketebalan panel green komposit terhadap koefisien serap bunyi komposit serabut kelapa (cocos nucifera) dengan perekat getah pinus (pinus merkusii). *Teknik Desain Mekanika*, 6(4), 318-322.
- Safitra, E. R., & Herlina, I. (2020). Pembuatan film plastik biodegradable dari limbah kulit kopi dengan penambahan kitosan/glisierol. *Journal of Science and Applicative Technology*, 4(1), 38-42.
- Firman, F., Hasbi, M., & Aksar, P. (2018). Studi Eksperimen Kekuatan Mekanik Daun Nanas Hutan Dengan Metode Pengujian Tarik. *Enthalpy*, 3(1).
- Novita, E., Fathurrohman, A., & Pradana, H. A. (2018). Pemanfaatan kompos blok limbah kulit kopi sebagai media tanam. *AGROTEK: Jurnal Ilmiah Ilmu Pertanian*, 2(2), 61-72.
- Daning, D. R. A., & Karunia, A. D. (2018). Teknologi Fermentasi Menggunakan Kapang *Trichoderma sp* untuk Meningkatkan Kualitas Nutrisi Kulit Kopi sebagai Pakan Ternak Ruminansia. *Agriekstensi: Jurnal Penelitian Terapan Bidang Pertanian*, 17(1), 70-76.
- Azwar A.B. 2012. Intensifikasi kopi jadi program unggulan baru. *Media Perkebunan*, 99, 16-17.
- Corro, G., Panigua, L., Pal, U., Banuelos, F., Rosas, M., 2013, "Generation of Biogas from Coffee Pulp and CowDung Co-Digestion: Infrared studies of postcombustion emission", *Energy Conversion and Management*.
- Pamungkas, A. (2011). Studi Sifat Mekanik dengan Pengujian Tarik dan Ketangguhan Retak pada Komposit Epoxy-Kaolin. *MeTriK Polban*, 5(01), 1-1.
- Pawestri, A. K. R., Hasanah, W., & Murphy, A. (2018). Studi Karakteristik Komposit Sabut Kelapa Dan Serat Daun Nanas Sebagai Peredam Bunyi. *Jurnal Teknologi Bahan Alam*, 2(2), 112-117.
- Yuliantika, S. dan Elvaswer., Penentuan Koefisien Absorpsi dan Impedansi Material Akustik Resonator Panel Kayu Lapis (Plywood) Berlubang dengan Menggunakan Metode Tabung, *Jurnal Ilmu Fisika*, 7(2), hal 56-62 (2015).

Nabila, N., & Mahyudin, A. (2020). Pengaruh Ketebalan Pelepah Pisang terhadap Koefisien Absorpsi Material Akustik. *Jurnal Fisika Unand*, 9(2),244-249.