JIMESE
Journal of Innovation Materials, Energy, and Sustainable Engineering
JIMESE 2(2): 154–163
ISSN 3048-2380

Institute for Advanced Science, Social and Sustainable Future
MORALITY BEFORE KNOWLEDGE

The potential of cassava peel as acoustic panel material: A sustainable innovation in green engineering

Sharfina Djati Pramesti[1], Silfia Mona Aryani[1,*]
[1] *Department Interior Design, Faculty Fine Arts and Design, Universitas Sebelas Maret, Surakarta, 57126, Indonesia.*
*Correspondence: silfia.aryani@uns.ac.id

Received Date: December 11, 2024 Revised Date: January 10, 2025 Accepted Date: January 31, 2025

ABSTRACT

Background: Natural waste is one of the materials that has the potential to become acoustic material because it has a porous texture and meets the requirements of suitable sound-absorbing materials. Utilizing natural waste as acoustic material can reduce cassava peel waste, especially in cassava peel processing industries, both from factories and home industries. **Methods:** This research is conducted to determine the potential of cassava peel waste as a natural material that can be utilized to create acoustic materials made from natural substances. In this study, cassava peel waste was tested as a sound-absorbing acoustic material using the impedance tube method. The sample was made by mixing finely ground cassava peel waste and PVAc (Poly-vinyl-acetate) white glue, then molding the mixture into circular molds with a diameter of 10 cm and thicknesses of 3.5 cm and 4 cm, respectively. **Findings:** The results indicate that the sample with a thickness of 3.5 cm has an absorption coefficient of 0.45 at a frequency of 500 Hz, while the 4 cm thick sample has an absorption coefficient of 0.32 at 600 Hz. Both samples show that cassava peel waste is a viable soundproofing material with absorption coefficients above 0.3, making it an effective, eco-friendly acoustic panel material. **Conclusion:** Cassava peel waste demonstrates good potential as an acoustic material, with promising sound absorption properties, making it an environmentally friendly and accessible alternative to conventional soundproofing materials. **Novelty/Originality of this Study:** This study introduces cassava peel waste as a sustainable and accessible material for acoustic applications, offering an innovative solution to both waste reduction and soundproofing. The research highlights the potential of using locally available natural waste, specifically cassava peel, in the creation of eco-friendly acoustic panels, which is a novel approach not widely explored in the acoustic material industry.

KEYWORDS: absorption coefficient value; cassava peel; impedance tube method.

1. Introduction

Cassava is one of the food ingredients that contains carbohydrates and is consumed by many people in Indonesia, which is one of the agrarian countries. According to Husen et al. (2015), Indonesia has approximately 134.58 million hectares of land designated for agricultural use. From the entire land, it is divided into several types of agricultural land according to the land ecosystem. There are 7.38 million hectares of wetland food, 7.36 million hectares of dryland food, 0.15 million hectares of highland vegetables, 1.47 million hectares of peatland horticulture, 16.35 million hectares of dryland, 0.93 million hectares of peat swamp land, and 0.93 million hectares of pastureland. Cassava is a plant that can be

Cite This Article:
Pramesti, S. D., & Aryani, S. M. (2025). The potential of cassava peel as acoustic panel material: A sustainable innovation in green engineering. *Journal of Innovation Materials, Energy, and Sustainable Engineering*, *2*(2), 154-163. https://doi.org/10.61511/jimese.v2i2.2025.1397

well-grown in both dryland and peatland (Abubakar et al., 2021), which means there is a considerable amount of land potential for cassava cultivation as one of the food commodities. The plants that can grow in this land are not many, including long beans, cassava, corn, soybeans, rice, and others.

Cassava production is one of the abundant food commodities in Indonesia. In 2019, cassava production in Indonesia reached 27 million tons (Rozi et al., 2023). Meanwhile, in 2022, Indonesia produced 23 million tons of cassava, followed by Nigeria with 57 million tons, Thailand with 30 million tons, and Brazil with 23 million tons (Ardyani et al., 2022). Meanwhile, cassava is more widely cultivated in Central Java, especially in the Gunungkidul region of Yogyakarta. Farmers tend to plant more local varieties than superior ones, which still have great potential to be processed into food products.

1.1 Potential utilization of cassava peel waste (Manihot utilissima)

Manihot utilissima, commonly known as cassava, is a tuber from the Euphorbiaceae family. Cassava can grow in areas with unpredictable climates such as in tropical countries and is resistant to dry and infertile soil conditions (Ngongo et al., 2022). Abubakar et al. (2021) explain that cassava can also grow in various types of soil, especially alluvial, latosol, podsolic, and even peatlands, where other plants besides cassava rarely thrive and produce well due to the extreme environment and unpredictable climate that affect air quality, water, and soil conditions.

Cassava has a taproot with lateral roots that develop into tubers. The tuber has three layers: the skin layer (epidermis), which is the outermost layer weighing 3% of the total weight of the tuber; the cortex layer, which is the layer inside the outer skin weighing 11-20% of the total weight of the tuber; and the flesh (parenchyma), which is the innermost part weighing 85% of the total weight of the tuber (Reihan et al., 2022). That is why cassava is able to meet food security needs with good quality, quantity, and affordability for the Indonesian people. One way to preserve it is by developing cassava products at the household level as a home industry.

Cassava peels can be processed into several food products such as cassava flour, cassava chips, boiled cassava, sautéed cassava peels, and even sweet dishes. However, in addition to that, there are also many food products that only use the inner part of the cassava (Dwirevyanti et al., 2021). The discarded cassava peels need to be processed immediately because they contain water and quickly rot due to the growth of microorganisms (Indriyati et al., 2022). Although it decomposes quickly, efforts are needed to reduce waste because it contains cyanide compounds that, when decomposed, produce hydrogen cyanide (HCN), which is harmful to nature and humans (Sari & Astili, 2018).

The abundance of cassava products in Indonesia also leads to an increase in unprocessed cassava peel waste, which over time adds to the amount of waste in the surrounding environment (Thuppahige et al., 2023). The waste has great potential to become a useful new product, such as acoustic panels (Lawanwadeekul et al., 2024). There are many types of cassava products that are consumed and utilized, but a large amount of waste is also produced. One of the most produced food wastes is cassava peels. Not many people know how to manage cassava peel waste and turn it into functional products. More people choose to just throw it away or use it as livestock feed, such as for cows, either for their own farms or to sell to cattle farmers who need it.

1.2 Potential of cassava peel waste (Manihot utilissima) as acoustic panel material

Acoustic panels are products used as sound-absorbing materials to meet the needs of a room. Acoustic panels are a factor that influences the success of sound management in a room. There are several types of materials used as acoustic panels, namely acourete fiber type made from fine polypropylene fiber weave, acourete board 230 made from polyester fiber, and acourete broadsound treatment made from MDF (Medium Density Fiberboard) polished with cloth. Acoustic panels can be processed from various raw materials that have acoustic properties. In general, acoustic panels are made from the finest quality wood, but there are some alternative materials, such as natural fibers, fabric, carpet, foam, etc.

Rock wool and glass wool are acoustic panel materials that have been used for a long time and have good sound absorption functions as acoustic panels because they have a porous texture but are expensive (Priyoko, 2011). Quoted from the Mitra Jaya Makmur Abadi (2023), rockwool is a type of insulation material made from mineral fibers characterized by its density and resistance to pressure. Meanwhile, glass wool is also an insulation material made from mineral fibers but is lighter, resulting in a lower thermal insulation value compared to rockwool. The difficulty of the materials and the complexity of the manufacturing process have prompted many acoustic observers to replace the materials used for acoustic panels with more accessible options that still maintain good acoustic quality, such as natural fibers.

Acoustic materials are divided into sound-absorbing materials, sound-dampening materials, and sound-blocking materials (Tao et al., 2021). Meanwhile, sound-dampening methods are divided into sound-absorbing materials, sound insulation materials, and vibration-dampening materials (Rosyidah & Tim Support Acourete, 2023). Sound-absorbing materials tend to have more fibers and pores that can serve as pathways to absorb and convert sound energy into heat. Sound insulation materials focus more on preventing sound from inside a room from being heard outside or vice versa. Meanwhile, vibration-damping materials are based on the characteristics of sound that can propagate to the building structure, causing vibrations, thus requiring viscoelastic damping materials (fluid but elastic).

A material falls into the category of good sound absorbers if it has a coefficient value greater than or equal to 0.3 (Nurbaiti et al., 2022). Soundproofing materials can include epoxy, plastic, and glue that can stop sound through the insulating properties of these materials. On the other hand, barrier materials have denser properties Wong et al. (2021) explain that the performance of acoustic materials in sound absorption is related to the density and size of the panels. The thicker and larger the surface area of the panel, the lower the frequency of sound from the noise source that can be absorbed. It was also found that low frequencies are more effectively absorbed by thicker panels. At the same time, higher frequencies are more effective when thinner panels are used. This is because thinner panels are considered more capable of absorbing higher frequencies, while thicker panels have larger cavities, resulting in lower frequency absorption.

One common spatial issue is the problem of acoustics and noise control in that space. Therefore, the acoustic system needs to be considered when designing a building, especially buildings with activities that often produce sound, such as music studios, cinemas, and auditoriums. Music with long notes takes longer to sustain compared to music with short, slow notes. The recommended reverberation time at 500 Hz is 1.4 seconds with light music activity Ola (2023). In addition to playing musical instruments, the music studio also functions as a recording studio with a sound comfort standard of 25 to 30 decibels without activity and around 84 dB when playing music Huwaida & Nugrahaini (2022).

Besides the recording studio, the classroom also considers acoustic functionality. Artayani & Kasim (2017) revealed that noise in the classroom can reduce students' concentration levels and conversely, the lower the noise level in the classroom, the higher the students' learning concentration levels. Based on ANSI-SI2.60, the environmental noise level in classrooms should not exceed 35 dBA and 55 dBC, and the reverberation time should not exceed 0.6 seconds. Kemp et al. in 2013 studied the average frequency of classroom spaces and found that the average frequency of classroom spaces ranged between 500 Hz and 4000 Hz, with writing and drawing activities having the lowest frequency and play sessions having the highest frequency. The noisier the classroom, the more negatively the sound affects many students and teachers who are engaged in teaching and learning activities in that room. A comfortable classroom environment can also increase interest in learning and enable the production of high-quality teaching and learning.

Acoustic problems can be controlled by using acoustic panels in building design. Researchers have stated that natural fibers have very promising potential and qualify as good acoustic materials, such as corn husks, sugarcane, bamboo, cassava fibers, and tea waste (Munifatuzzahroh et al., 2021). In previous research, Kartikasari et al. (2022) studied cassava peel waste using four samples with different ratios between glue and cassava peel composition, namely 1:3, 1:4, 1:5, and 1:6. The most efficient absorption value was obtained in the sample with a 1:6 ratio. Dari & Elvaswer (2021) studied cassava pomace using the tube method with sample thicknesses of 2 mm, 4 mm, 6 mm, 8 mm, and 10 mm. The highest sound absorption coefficient value was obtained from the 10 mm thick sample. (Sari, 2009) conducted experiments on cassava pomace using the two-microphone impedance tube method with sample thicknesses of 10 mm, 20 mm, and 24 mm. The research shows that increasing the sample thickness affects the decrease in the absorption coefficient value. This research hopes to prove the potential of cassava peel waste as an acoustic panel material to absorb sound, which is related to environmental issues stemming from cassava peel waste and noise pollution problems. The aim of this study is to test the absorption coefficient of cassava peel as an acoustic panel material and the frequency range that can be absorbed from samples measuring 3.5 cm and 4 cm with a diameter of 10 cm. In addition to natural fibers, there is also research on acoustic absorption using samples of used sandals and used masks. Ingga et al. (2024) studied used sandals using the two-microphone impedance tube method, finding that samples with a thickness of 7 mm could absorb sound with an average frequency of 200 Hz to 1600 Hz. Febriyanti et al. (2024) studied used masks with the same thickness but different densities using the two-microphone impedance tube method, resulting in data that samples with lower density were able to absorb more sound.

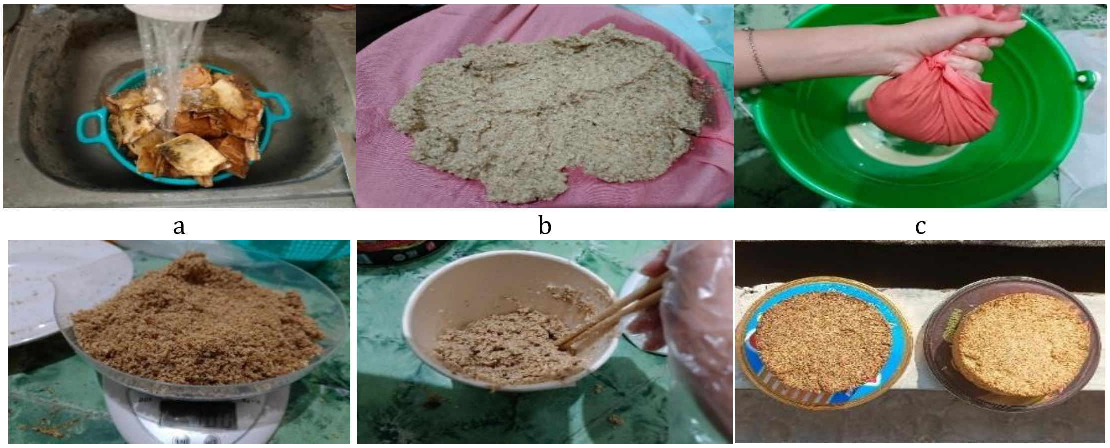
2. Methods

2.1 Samples making

This research uses the two-microphone impedance tube method and has been proven to measure the magnitude of sound frequencies that can be absorbed by the sample and can produce absorption coefficient values in graphical form. Research that uses this method includes the study by Rezita & Rasyid (2019) which tested cassava pulp as an acoustic material, Sari (2009) who also researched cassava pulp as an acoustic material, and Dari & Elvaswer (2021) who studied corn husk fibers as an acoustic material. In this research, it is divided into 2 stages.

The preparation of cassava peel samples involves several stages. We will start by preparing the tools and materials to make the sample. To make two samples, 1 kg of cassava peel, PVAc (Poly-vinyl-acetate) white glue, a grinder, a ruler, cardboard cut into circles with a diameter of 10 cm, a digital kitchen scale, a cutting board, a knife, cotton cloth, a bowl, a stirring spoon, and water are needed. First, the cassava skin is washed until it is free from dirt. The cleaned cassava peels are cut into small pieces to facilitate the grinding process. Prepare a grinding machine and enough water to submerge the cassava peels to achieve a finer texture.

The finely ground result is then squeezed with a loosely woven cloth like cotton until the moisture content decreases and it feels not too wet and looks dense. The finely squeezed cassava skin is then dried at room temperature. Dried cassava peels are then mixed with white PVAc (Poly-vinyl-acetate) glue in a 3:1 ratio. Two samples were made with different thicknesses, 3.5 cm and 4 cm. The samples to be studied were molded into circular shapes using round molds made from cardboard, which were measured into circular shapes with a diameter of 10 cm, then dried until there were no white spots from the white PVAc (Poly-vinyl-acetate) glue, and continued to be dried under morning sunlight until they were not too wet and sticky for about 6 hours. Next, the samples were further dried at room temperature until completely dry and the white PVAc (Poly-vinyl-acetate) glue appeared transparent.



a b c

d e f

Fig. 1. Preparation of cassava peel samples: a) cleaning cassava; b) crushing cassava skin; c) pressing cassava skin; d) weighing cassava skin; e) mixing cassava skin with PVac white glue; f) mixing cassava skin with PVac white glue

2.2 Sound absorption coefficient test

The samples were tested in the acoustic laboratory of the Faculty of Mathematics and Natural Sciences, Sebelas Maret University Surakarta, using a two-microphone impedance tube, producing a graph that shows the absorption coefficient values of the cassava peel samples. To test it, an impedance tube type 4206, a B&K 4187 microphone, and a laptop are needed. First, the impedance tube type 4206 is turned on and connected to the B&K 4187 microphone. To test the sample sound, the sample is placed into the impedance tube type 4206, and the B&K 4187 microphone will function as the sound source facing the sample. The impedance tube type 4206 is also connected to the laptop to transmit frequency data and absorption values in the form of graphs and tables. Data analysis in this study uses two samples of cassava peel with different thicknesses and compares the absorption coefficient values of each sample.

Fig. 2. Sample testing with the impedance tube method

3. Results and Discussion

The results of the study using a two-microphone impedance tube show that the absorption coefficient values of both samples are above 0.3. The coefficient value peaks at 0.45 at a frequency of 500 Hz for the 3.5 cm thick sample. Below that, there is an absorption coefficient value of 0.32 for the 4 cm thick sample at a frequency of 600 Hz. For the 3.5 cm thick sample, the value decreases after reaching a coefficient of 0.45 at a frequency of 1000 Hz and then rises back to a coefficient of 0.45 at a frequency of 1600 Hz. Meanwhile, for the 4 cm thick sample, the coefficient decreases to 0.25 at a frequency of 900 Hz and then rises back to 0.38 at a frequency of 1600 Hz, which means an increase of 0.06 from the previous frequency. The graph shows that thinner samples have higher absorption values and can absorb lower sound frequencies.

This suggests that bamboo panels with a thickness of 3.5 cm are more effective in dampening mid-frequency sound waves (Mohammadi et al., 2024). The greater absorption observed at 500 Hz is particularly beneficial for environments where noise control is critical, such as offices or residential interiors. The drop and subsequent rise in the absorption coefficient indicate the panel's resonance behavior across frequencies. These findings can serve as a reference for optimizing panel thickness in future acoustic product designs. Additionally, the performance across frequencies demonstrates the potential of bamboo as a sustainable material for acoustic treatment. Further refinement in panel structure could enhance its absorption performance in higher frequency ranges as well (Bravo-Moncayo et al., 2024).

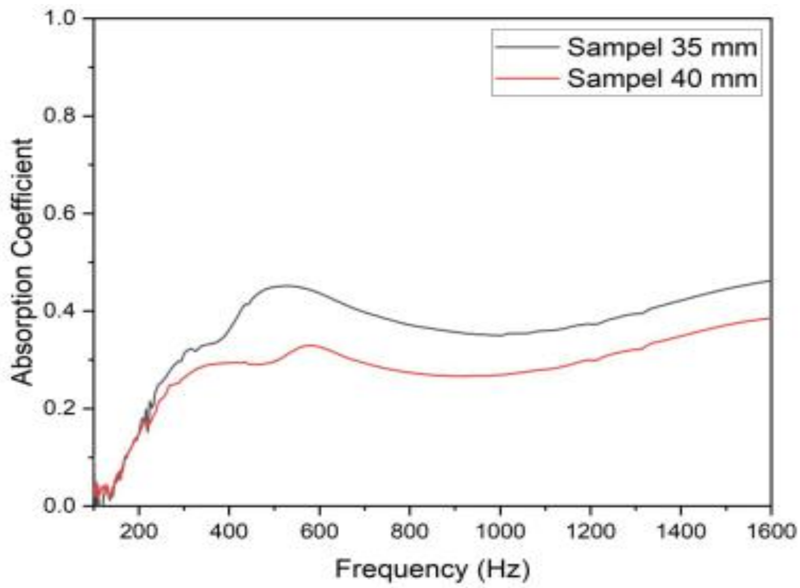


Fig. 3. Graph of absorption coefficient values and frequency magnitude

In previous research by Dari & Elvaswer (2021), which used the same research methods and sample preparation, the results from cassava pulp showed the highest coefficient value in the 1 cm thick sample with a coefficient value of 0.98 at a frequency of 1500 Hz. The samples in this study have higher coefficient values but can absorb sound that is not very low, particularly at a frequency of 1500 Hz. This is because thinner samples and samples with greater thickness can absorb sound at lower frequencies (Amares et al., 2017). From the graph, it can be concluded that cassava peels can be utilized as acoustic panel materials with absorption functions. The thickness of the sample affects the sound frequency, where the thicker the tested sample, the lower the sound frequency that can be absorbed by the sample, with a difference of 0.5 cm. The graph obtained from the acoustic test using a two-microphone impedance tube shows the absorption coefficient values of the samples to be 0.45 and 0.32 for samples with thicknesses of 3.5 cm and 4 cm at 500 Hz and 600 Hz.

The sample with a thickness of 3.5 cm has an absorption coefficient value of 0.45 at a frequency of 500 Hz, making it suitable for application in classrooms with a minimum frequency of 500 Hz and music studio rooms with an average frequency of 500 Hz. The wider the surface of the acoustic panel, the higher the likelihood of sound absorption.

In the sample testing, there were cracks, a reduction in thickness and surface area of the sample by 0.5 cm, and cavities in the sample that hardened, which could affect the test results. In the sample preparation process, the grinding stage using a grinding machine is carried out in several parts, and the different grinding durations also allow the resulting cassava peel to be uneven in size and density.

4. Conclusions

Cassava peels can be said to absorb sound and are considered suitable soundproofing materials because they have an absorption coefficient value above 0.3. The absorption value of cassava peels is influenced by the thickness, surface width, and density of the cassava peels, as well as the mixing materials used to create the sample. These physical characteristics determine how effectively the material can trap and dissipate sound energy. A more porous structure with irregular surfaces tends to improve absorption, especially at mid to high frequencies. When combined with other natural fibers or binding agents, the acoustic properties of cassava peel composites can be further enhanced. In experimental settings, increasing the thickness of the panel often results in higher absorption values at lower frequencies. This makes cassava peel-based panels promising for applications in sustainable architecture and interior acoustic treatments. Their biodegradability and local availability also contribute to their appeal as eco-friendly building materials.

Acknowledgement

The authors would like to extend heartfelt thanks to the reviewers for their constructive feedback and thoughtful suggestions, which significantly enhanced the quality of this manuscript. Appreciation is also given to all those who provided support and encouragement throughout the development of this work.

Author Contribution

This study was collaboratively conducted by P.S.D and A.S.M. P.S.D was responsible for the research design, data collection, and drafting of the manuscript, while A.S.M contributed to data analysis, interpretation of results, and manuscript revision.

Funding

This research received no external funding.

Ethical Review Board Statement

Not available.

Informed Consent Statement

Not available.

Data Availability Statement

Not available.

Conflicts of Interest

The authors declare no conflict of interest.

References

Abubakar, Y., Anhar, A., Hamid, A. H., Nasution, A., Faizin, R., Muslimah, Y., Baihaqi, A., Bagio, Zulkarnain, Bahri, T. S., & Putra, I. (2021). Peningkatan Produksi Bahan Pangan Singkong Dengan Memanfaatkan Lahan Gambut Di Gampong Kuala Baro, Kecamatan Kuala Pesisir Kabupaten Nagan Raya. *Community Development Journal*, *2*, 829–834. https://doi.org/10.31004/cdj.v2i3.2620

Amares, S., Sujatmika, E., Hong, T. W., Durairaj, R., & Hamid, H. S. H. B. (2017). A review: Characteristics of noise absorption material. *IOP Conference Series: Journal of Physics: Conference Series, 908*(1), 012005. https://doi.org/10.1088/1742-6596/908/1/012005

Ardyani, N. P., Gunawan, B., & Harahap, J. (2022). Ekologi Politik Budidaya Singkong di Kecamatan Arjasari Kabupaten Bandung Provinsi Jawa Barat. *Aceh Anthropological Journal*, *6*(2), 137. https://doi.org/10.29103/aaj.v6i2.8040

Artayani, M., & Kasim, N. N. (2017). Analisis desain akustik ruang kelas unifa dalam meningkatkan kualitas belajar mengajar. *LOSARI: Jurnal Arsitektur Kota dan Pemukiman*, 1-6. http://dx.doi.org/10.33096/losari.v2i1.51

Bravo-Moncayo, L., Puyana-Romero, V., Argotti-Gómez, M., & Ciaburro, G. (2024). Enhanced environmental sustainability for the acoustic absorption properties of Cabuya fiber in building construction using machine learning predictive model. *Sustainability, 16*(14), 6204. https://doi.org/10.3390/su16146204

Dari, T. W., & Elvaswer, E. (2021). Koefisien Absorspi Bunyi dan Impedansi Akustik dari Panel Serat Kulit Jagung dengan Menggunakan Metode Tabung. *Jurnal Fisika Unand*, *10*(4), 473–478. https://doi.org/10.25077/jfu.10.4.473-478.2021

Dwirevyanti, A., Nurani, A. S., & Mahmudatussa'adah, A. (2021). Substitution of cassava peel flour in making siomay skin. *Media Pendidikan, Gizi, dan Kuliner*, *10*(2). https://doi.org/10.17509/boga.v10i2.40777

Febriyanti, D., Arifa, S. L., Aryani, S. M., & Priliana, S. C. P. (2024). The density effect on disposable mask waste as an acoustic absorber material. *IOP Conference Series: Earth and Environmental Science*, *1404*(1), 012017. https://doi.org/10.1088/1755-1315/1404/1/012017

Husen, E., Agus, F., & Nursyamsi, D. (2015). *Sumber Daya Lahan Pertanian Indonesia*. IAARD Press.

Huwaida, A. P., & Nugrahaini, F. (2022, August). Identifikasi Aspek Akustik Ruang pada Desain Ruang Studio Musik Studi Kasus Lokananta dan Oemah Pink Music Studio. In *Prosiding (SIAR) Seminar Ilmiah Arsitektur* (pp. 657-666). https://proceedings.ums.ac.id/siar/article/view/1047/1023

Indriyati, O., Nurrahmania, V., & Wibowo, T. (2022). Pengolahan limbah kulit singkong sebagai upaya mengurangi pencemaran lingkungan. *Jurnal Pengolahan Pangan*, *7*(1), 33-37. https://doi.org/10.31970/pangan.v7i1.64

Ingga, A., Nurhaliza, D., Brenda, B., Aryani, S. M., & Priliana, S. C. P. (2024, October). The potential of flip-flops waste as an environmentally friendly sound-absorbing material. In *IOP Conference Series: Earth and Environmental Science*, *140*(1). IOP Publishing. https://doi.org/10.1088/1755-1315/1404/1/012020

Kartikasari, F. Y., Erlangga, M. F., Widiyanti, N. E., Nuryadin, A., Subagiyo, L., & Santoso, H. (2022). Potensi Limbah Kulit Singkong sebagai Alternatif Material Akustik Ramah Lingkungan. *Jurnal Literasi Pendidikan Fisika (JLPF)*, *3*(2), 130-137. https://doi.org/10.30872/jlpf.v3i2.1125

Lawanwadeekul, S., Jun-On, N., Kongthavorn, P., Sangkas, T., & Daothong, S. (2024). Chemical-free thermal-acoustic panels from agricultural waste for sustainable building materials. *Cleaner Materials, 12*, 100245. https://doi.org/10.1016/j.clema.2024.100245

Mitra Jaya Makmur Abadi. (2023). *Perbedaan Glasswool dan Rockwool*. Mitra Jaya Makmur Abadi.

Mohammadi, M., Taban, E., Tan, W. H., Che Din, N. B., Putra, A., & Berardi, U. (2024). Recent progress in natural fiber reinforced composite as sound absorber material. *Journal of Building Engineering, 84*, 108514. https://doi.org/10.1016/j.jobe.2024.108514

Munifatuzzahroh, U. M., Yulianti, I., & Fianti, F. (2021). Potensi Limbah Ampas Teh sebagai Alternatif Material Akustik Ramah Lingkungan. *Physics Education Research Journal*, *3*(2), 113–120. https://doi.org/10.21580/perj.2021.3.2.8390

Ngongo, Y., Basuki, T., deRosari, B., Mau, Y. S., Noerwijati, K., daSilva, H., Sitorus, A., Kotta, N. R. E., Utomo, W. H., & Wisnubroto, E. I. (2022). The roles of cassava in marginal semi-arid farming in East Nusa Tenggara—Indonesia. *Sustainability, 14*(9), 5439. https://doi.org/10.3390/su14095439

Nurbaiti, Y., Yulianto, A., & Nurbaiti, U. (2022). The Natural Composite of Sawdust Teak as a Sound Absorption Materials Using The Resonator Space Method. *Physics Education Research Journal*, *4*(1), 29–34. https://doi.org/10.21580/perj.2022.4.1.8601

Ola, F. B. (2023). Desain Tata Bunyi Ruang Ibadah Gereja Melalui Kegiatan Pengabdian Masyarakat. *E-Dimas: Jurnal Pengabdian kepada Masyarakat, 14*(2), 274-282. https://doi.org/10.26877/e-dimas.v14i2.11851

Priyoko, B. B. (2011). *Pembuatan Panel Akustik Material Komposit Serat Alami Ampas Tebu (Saccharum Officinarum) dan Ijuk*. Universitas Islam Indonesia.

Reihan, N. D., Daima, A. S., Lukviana, D. L., & Ridha, M. R. (2022). *Buku Panduan Pengembangan Produk Olahan Pangan Singkong*. Penerbit K-Media.

Rezita, Y., Elvaswer, E., & Rasyid, R. (2019). Koefisien Absorbsi Bunyi dan Impedansi Akustik dari Ampas Singkong (Manihot esculenta) dengan Menggunakan Metode Tabung. *Jurnal Fisika Unand*, *8*(2), 146-150. https://doi.org/10.25077/jfu.8.2.146-150.2019

Rosyidah, N., & Tim Support Acourete. (2023). *Teori & Aplikasi Akustika Bangunan*. Tim Support Acourete.

Rozi, F., Santoso, A. B., Mahendri, I. G. A. P., Hutapea, R. T. P., Wamaer, D., Siagian, V., Elisabeth, D. A. A., Sugiono, S., Handoko, H., Subagio, H., & Syam, A. (2023). Indonesian market demand patterns for food commodity sources of carbohydrates in facing the global food crisis. *Heliyon, 9*(6), e16809. https://doi.org/10.1016/j.heliyon.2023.e16809

Sari, F. D. N., & Astili, R. (2018). Kandungan asam sianida dendeng dari limbah kulit singkong. *Jurnal Dunia Gizi*, *1*(1), 20. https://doi.org/10.33085/jdg.v1i1.2899

Sari, N. P. (2009). Pengukuran Karakteristik Akustik Ampas Singkong Sebagai Bahan Penyerap Bunyi Dengan Metode Tabung Impedansi Dua Mikrofon. *Undergraduate Thesis.* Universitas Sebelas Maret.

Tao, Y., Ren, M., Zhang, H., & Peijs, T. (2021). Recent progress in acoustic materials and noise control strategies–A review. *Applied Materials Today, 24*, 101141. https://doi.org/10.1016/j.apmt.2021.101141

Thuppahige, V. T. W., Moghaddam, L., Welsh, Z. G., Wang, T., & Karim, A. (2023). Investigation of critical properties of Cassava (*Manihot esculenta*) peel and bagasse as starch-rich fibrous agro-industrial wastes for biodegradable food packaging. *Food Chemistry, 422*, 136200. https://doi.org/10.1016/j.foodchem.2023.136200

Wong, Y.-S., Sekar, V., Eh Noum, S. Y., & Sivanesan, S. (2021). Effect of Thickness and Perforation Size on the Acoustic Absorption Performance of a Micro-Perforated Panel. *MATEC Web of Conferences*, *335*, 03016. https://doi.org/10.1051/matecconf/202133503016

Biographies of Authors

Sharfina Djati Pramesti, Department Interior Design, Faculty Fine Arts and Design, Universitas Sebelas Maret, Surakarta, 57126, Indonesia.

- Email: sharfina.djati@student.uns.ac.id
- ORCID: N/A
- Web of Science ResearcherID: N/A
- Scopus Author ID: N/A
- Homepage: N/A

Silfia Mona Aryani, Department Interior Design, Faculty Fine Arts and Design, Universitas Sebelas Maret, Surakarta, 57126, Indonesia.

- Email: silfia.aryani@uns.ac.id
- ORCID: 0000-0001-6542-1293
- Web of Science ResearcherID: N/A
- Scopus Author ID: 57200078427
- Homepage: http://dosen.fsrd.uns.ac.id/data/index.php?prodi=&id=1979022601