Study on Chicken Feather as Acoustical Absorptive Material

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Abstract. Green materials for building insulations, specifically for noise prevention applications are on demands and attract researchers to contribute. This research seeks utilization prospects of chicken feathers (CF) as alternative of noise absorption materials through understanding of its absorption coefficient characteristics for acoustical material applications. Common absorptive material glass wool (GW) is used in measurement as counterparts. Clean and dried CF is compacted in cylindrical mesh prior to measurement for absorption coefficient using impedance tube method in anechoic room. The typical specimen made to diameter 100 mm by 25, 50 and 75 mm thicknesses, all in similar density of 48kg/m$^3$. Respond of specimen are taken within frequency range of 100 Hz - 1600 Hz for absorption coefficient measurements and averaging. Result shows that the absorption coefficients are relatively increase on all specimen thickness throughout the frequency ranges, reaching maximum value of 0.99 at frequencies 1600 Hz, 950 Hz, and 650 Hz for CF thickness 25, 50 and 75 mm, respectively. Both chicken feathers (CF) and glass wool (GW) response comparably during experiment frequency ranges, confirm the possibility of chicken feathers as acoustical absorptive material.

1. Introduction
Poultry products are always in demand and continuously increase for the protein, leaving abundant waste of feathers. This side product does not have enough utilization except for common traditional ways. There are well known utilizations of chicken feathers products. Some industries had used this waste for pillows filler, feather dusters, and handicrafts. Later, this waste took attention of many researchers for its development through science and technology. Some studies on advanced utilization of chicken feathers were reported[1]–[4]. These researches ranged from keratin extraction, bio gas source to its potential for bio-based composite materials [5]–[10]. Specific to acoustical material, its applications has not enough records. Hence, it is a necessity to understand the acoustical characteristics of chicken feathers, whether it is appropriate or not for acoustical material.

Comfort ability issue in building architecture consist of three main fields, i.e. lighting, thermal and acoustic. In field of noise prevention on architectural building and interior, there are some reports for alternative acoustic materials and structures possibilities instead of the common glass wool noise insulation [11]–[14]. The first identification on acoustic material feasibility for noise insulation purpose is by measurement of its absorption coefficient through some known techniques using set of acoustical devices [15]–[17]. Here, standard industrial glass wool always referred as comparison
counterpart, due to its wide application on noise insulation purposes in building acoustic interiors.

Still many factors to consider before chicken feathers resolves as alternative of acoustic insulation material, including production cost, operational lifetime, humidity and climate effects, sustainability and others. However, main considerations to be analysed are the characteristic of its absorption coefficient and stock availability. This study would provide new reference in the field of architectural acoustics material, giving new information about feasible solution for noise prevention by environmental friendly and abundant materials. The application of recycled chicken feathers as noise insulation material, should give additional option to have more acoustically comfortable buildings.

2. Experimental Set Up
A comparison methods experiment is performed in this study by estimation of experiment results deviation to the reference counterpart. Here, chicken feather (CF) variations are treated as specimen and glass wool (GW) with identical dimensions to the specimen were measured as references. Measurements were analysed through standard method which commonly applied in acoustical measurement fields, especially on absorption coefficient characteristics. The systematic deviations on the basis of the differences observed between the measurements, determines the level of specimen performance and feasibility for acoustical material insulation. In addition, for more clarity on results, comparisons of measurements were presented in simplified graphics of appropriate statistical calculations

Thirty pieces of samples were made of chicken feathers (CF), compacted inside cylindrical mesh with diameter 100 mm by density 48 kg/m³. The samples was varied in three thicknesses, i.e. 25, 50, and 75 millimetres as shown in Figure 2. Only the clean, soft and healthy feathers are selected to be used, from any part of chicken but wings and tail. Before application, preparation of CF including thoroughly wash by liquid soap, rinsing, a whole night soak in bleach and disinfectant solutions, then dried under direct sunlight for about two days to make it completely dry. The second stage is aimed to reduce the number of pathogenic microorganism, bacteria, fungi and virus [18] while completely dried feathers will ensure its durability and effective lifetime as can be seen in Figure 1.

Measurements of acoustical performance identified by level of absorption coefficients were conducted in Acoustic Workshop, Building Science and Technology Laboratory, Faculty of Engineering, Hasanuddin University, performed in an anechoic room to maintain quiet environment while measurement is in progress. There are ten samples for each variation of sample thickness, all compacted in a same density. Measurements applied to analyse the sound absorption coefficient based on material thickness. The data collection based on sound waves recorded inside impedance tube in

Figure 1. Cleaning process: (a) Chicken feather separation process (b) Washing and soaking with soap and disinfectant solution (c) dried under direct sunlight
form of absorption coefficients values. There are 801 selected frequencies within frequency range of 100 Hz-1.6 kHz was taken for analysis and comparisons.

Determination of absorption coefficients by using two microphones attached on the impedance tube code B&K 4206. This tube is designated to measure acoustic parameters of small sample by measuring the reflected sounds inside tube. Measurement configuration works by placement of sample at one end of the tube, and sound source at the other end, where two microphones are placed between both tube ends (inline or face-to-face configuration). Played from an audio player, the sound then be amplified then be forwarded into the impedance tubes. The sound reflections are then captured by two microphones subsequently recorded and processed using PULSE Labshop software version 16.1.

Figure 2. Samples preparation process: (a) Plastic mesh (b) Sewing machine (c) Compacted chicken feather (CF) by density 48 kg/m$^3$ in a shape of cylindrical mesh with 100mm in diameter. (d) Cleaned chicken feather (e). The chicken feather (CF) samples was varied in three thicknesses i.e. 25, 50, and 75m (f) Glass wool (GW)

Figure 3. Absorption coefficients measurement with impedance tube.
3. Results and Discussions

3.1 Absorption Coefficients of Chicken Feathers (CF)

The absorption coefficients of three thicknesses of CF samples with similar densities were measured by using impedance tube. This method works with two pressure microphones attached on the wall of impedance tube, resulting absorption coefficients characteristics within frequency range of 100 Hz - 1600 Hz. The measurement results of CF, can be seen in Figure 4. As comparison the well-known acoustical material of glass wool (GW) with similar thickness were also measured as seen in Figure 5. This material is commonly used as a reference in the measurement of sound absorption materials due to its availability in market and applied as reference in many studies [15]–[17].

In 10 samples measurement of 25 mm thick, 48 kg/m³ density CF (next will be written as CF25), several samples with absorption coefficients with maximum deviation value of 0.07 at frequency of 800 Hz were omitted, hence for CF25, only five samples considered for data processing of measurement. The obtained averaging value of absorption coefficients for these five samples, then represent the absorption coefficient characteristics of CF25. It was continuously increase

![Figure 4. Absorption coefficients of CF25, CF50, and CF75](image)

![Figure 5. Absorption coefficients of GW25, GW50, and GW75](image)
from low to high frequency ranges, reaching the maximum absorption coefficient of 0.99 at frequency of 1600 Hz.

Next, 10 CF samples measurements of 50 mm thickness (CF50) resulted in some values with deviation 0.07 at frequency 450 Hz, then result of remaining 6 samples are considered for data processing of averaging values. Absorption coefficients of CF50 give the highest values reached at intermediate frequencies of 946 Hz with value of 0.99. From this point, by higher frequencies (> 1000 Hz), the absorption coefficient declined to 0.89 at frequency 1600 Hz.

Lastly, measurement of ten samples CF with 75 mm thickness (CF75) shows the results contained one sample by deviation of 0.07 at frequency 1,400 Hz, which is then excluded from averaging process. As shown in Figure 2, the average calculation on the remaining nine samples, resulted in the highest absorption coefficient reached within intermediate frequencies (500 Hz - 1000 Hz), i.e. at frequency 638 Hz, with a value of 0.99. The absorption coefficients then start to decreased and reached the lowest value of 0.88 in the high frequency range (> 1000 Hz) at frequency 1,342 Hz, then back to 0.91 at a frequency 1600 Hz.

3.2 Sample Comparisons of Chicken Feathers (CF) and Glass Wool (GW)

Figure 6 shows comparison of absorption coefficient for GW25 and CF25. It can be seen that significant differences of absorption coefficient occurred at high frequencies, where the maximum sound absorption coefficient of CF25 was higher by 0.08 compare to its counterpart.

From the comparison of absorption coefficient shown in Figure 7, CF50 and GW50 are comparable at low frequency ranges, and then the absorption coefficient of CF50 was slightly higher compare the GW50 in the frequency range of 556 Hz - 1186 Hz. At frequency 1,236 Hz both material had similar absorption coefficient of 0.96. In the next frequency ranges, absorption coefficient of GW50 remains stable while CF50 starts to decline.

Figure 8 shows comparison of absorption coefficient for GW75 and CF75. The absorption coefficients shows similar trend to absorption coefficients of CF50 and GW50, but the domination of CF75 came earlier at frequency range 400 Hz – 950 Hz. However, after reaching its maximum value of 0.99, absorption coefficient of CF75 start to decline and surpassed by GW75 at frequency 950 Hz. This trend continues until frequency 1300 Hz where the absorption coefficient of CF75 start to increase approaching the absorption coefficient of GW75.

In general, characteristics of absorption coefficient of GW and absorption coefficient of CF are comparable at the beginning of lower frequencies (below 500 Hz) depends on thickness, while for intermediate frequencies (500 Hz-1000 Hz) the absorption coefficient of CF are relatively higher than GW. During high frequencies (above 1000 Hz) absorption coefficient characteristics of both materials started to behave differently depending on sample thickness. For thickness 25 mm, absorption coefficient of CF are continue to perform higher compare to GW, but for thickness 50 mm and 75 mm, GW start to performed slightly better compare to its counterpart.
Figure 6. Comparison of absorption coefficients between CF25 and GW25.

Figure 7. Comparison of absorption coefficients between CF50 and GW50.
4. Conclusions

Measurement of absorption coefficient for CF material within frequency range of 100 Hz-1600 Hz resulted in maximum value of 0.99 at frequency 1,600 Hz, 946 Hz and 638 Hz for sample CF25, CF50 and CF75, respectively. The thickness of sample affects the absorption coefficient level where the increasing thickness of material resulted in higher absorption coefficient at lower frequencies. Regardless of other factors, study shows the absorption coefficients of CF were comparable to absorption coefficient of GW, and performed better in certain frequencies. The measurement results indicate prospect of chicken feathers as alternative for acoustical material application.

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