Coconut Husks as Thermal Insulators

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Introduction

This idea started upon observing the vast amount of waste produced just from one coconut, as a whole coconut consists of 50% husk, 15% shell, 25% meat, and 10% water. Based on Global Leading Producers of Coconuts, Indonesia is the world's leading coconut producer in 2020, with about 16.82 million metric tons.

Coincidentally, heat transfer was being studied at school, of which it was mentioned that low-density objects are better heat insulators, supported by the research of Guo and Feng (2011). Thus it was decided to implement the physics theory to coconut husks as a thermal insulator.

Research Methodology

This scientific research uses quantitative methods by experimental research by testing the independent variable(s) to determine whether it influences a dependent variable(s) (Creswell, 2012). During the study, two variables were engaged, which compromised as independent variable – the presence of coconut husk and the dependent variable – change of temperature in different containers. This quantitative analysis research was carried out in three stages as follows:

a. The Preparation of tools and materials
b. Preparation of coconut
c. Comparing and measuring the temperature in different containers

Result and Analysis

1. The average change in temperature for 400 minutes with 85°C as the initial temperature in four different conditions, which are:
   - inside the coconut husk
   - placed at room temperature (29.5 ± 0.1°C)
   - in food thermos
   - food insulation bag

   can be seen in the chart shown below.

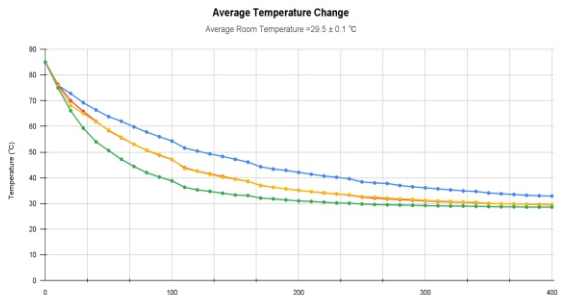

Figure 1 - Temperature Changes in The Bowl Placed in Coconut Insulator, Food Thermos, Bag Insulation, and Room Temperature

2. Thermal energy is a form of energy which is stored in molecules as molecular vibration. A material that has more amount of molecules (higher density) usually vibrates faster thus conducts greater amount of thermal energy. Whereas, materials with less amount of molecules (lower density); such as coconut husks which stores a lot of air, with a vast intermolecular distance, is a good thermal insulator (Guo and Feng, 2011).

3. There are three ways that thermal energy moves in, which are conduction, convection, and radiation (Craven and Robbin, 2011). Based on the experiment that has been conducted, these three methods of energy lost take place.
   - Conduction occurs through a medium which has contact with each other like the hot water conducts the energy to the ceramic pot before reaching the coconut husk.
   - Convection occurs when heat moves freely in fluids.
   - Radiation is the transfer of thermal energy in the form of invisible waves called infrared radiation which can travel through matter or even in a vacuum. The coconut insulator also emmits thermal energy to the surrounding.

4. The energy lost calculation is done by using the formula below.

$$Q = m\,c\,(\Delta T)$$

Q = Thermal energy required (J)
m = mass (kg)
c = heat capacity (J/kg°C) - 4,184 J/kg°C
ΔT = change in temperature (°C)

The heat lost amount in percentage can be seen in the chart below.

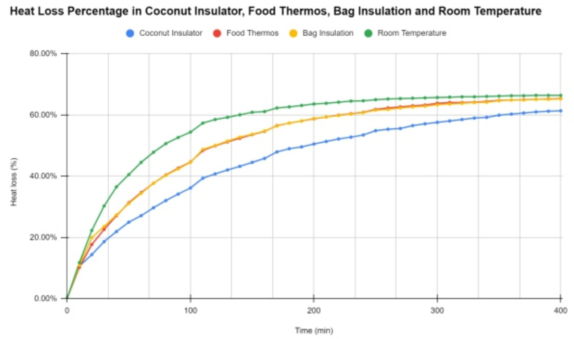

Figure 2 - Heat loss percentages in The Bowl Placed in Coconut Insulator, Food Thermos, Bag Insulation, and Room Temperature

5. The thermal conductivity of coconut insulator is calculated by using the formula below.

$$k = \frac{Q\,d}{\Delta t\ A\ \Delta T}$$

k = thermal conductivity (W/mK)
Q = Thermal energy required (J)
d = thickness (m)
Δt = change in time (s)
A = Area (m²)
ΔT = change in temperature (°C)

As the result of calculation done for the 400 minutes, it can be obtained that coconut husk has an average of 0.0065 W/mK for it's thermal conductivity.

Conclusion

Based on the research analysis, it can be concluded that coconut husk has low average thermal conductivity which is 0.0065 W/mK. Thus, being able to keep food or drinks warm for a more extended time compared to the other three conditions.

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