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COMPARISON OF THERMAL CONDUCTIVITY OF SPOON MATERIALS USING CONSTANT TEMPERATURE HEATING METHOD

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Abstract (English)
Comparison of Thermal Conductivity of Spoon Materials Using Constant Temperature Heating Method A spoon is an essential kitchen tool for cooking, but its improper use in accordance with its material properties can pose a problem. This research was conducted to determine the thermal conductivity of different spoon materials, namely wood, stainless steel, plastic, and ceramic, as well as to identify the highest thermal conductivity and the most efficient one for everyday use. In this study, all types of spoon materials were placed in an electric pot filled with water. The duration of use varied, namely 1 minute, 3 minutes, and 5 minutes. The average temperature values obtained from wooden, plastic, stainless steel, and ceramic spoons were 29˚C, 29.75˚C, 32.75˚C, and 31.75˚C, respectively, with consistently increasing temperature values every minute. From these results, it was found that the highest to lowest thermal conductivity, respectively, was stainless steel, ceramic, plastic, and wood. Therefore, a wooden spoon can be a suitable choice for everyday cooking use.

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Conductivity,spoon, temperature, material

Abstrak (Indonesia)
Perbandingan Konduktivitas Termal Bahan Sendok Menggunakan Metode Pemanasan Suhu Konstan Sendok merupakan peralatan dapur yang penting untuk memasak, namun penggunaannya yang tidak tepat sesuai dengan sifat bahannya dapat menimbulkan masalah. Penelitian ini dilakukan untuk mengetahui konduktivitas termal berbagai bahan sendok, yaitu kayu, baja tahan karat, plastik, dan keramik, serta untuk mengidentifikasi konduktivitas termal tertinggi dan paling efisien untuk penggunaan sehari-hari. Pada penelitian ini, semua jenis bahan sendok ditempatkan pada panci listrik yang berisi air. Durasi penggunaan bervariasi yaitu 1 menit, 3 menit, dan 5 menit. Nilai rata-rata suhu yang diperoleh dari sendok kayu, plastik, stainless steel, dan keramik berturut-turut adalah 29˚C, 29,75˚C, 32,75˚C, dan 31,75˚C dengan nilai suhu yang terus meningkat setiap menitnya. Dari hasil tersebut diperoleh konduktivitas termal tertinggi hingga terendah berturut-turut adalah baja tahan karat, keramik, plastik, dan kayu. Oleh karena itu, sendok kayu bisa menjadi pilihan yang cocok untuk keperluan memasak sehari-hari.

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Kata Kunci
Konduktivitas, sendok, suhu, bahan

Pendahuluan

In daily life, we're always dealing with heat or thermal energy. Each material possesses different thermal properties depending on its type. Typically, metals are known for conducting heat, but non-metal materials can also conduct heat, albeit with lower conductivity values (Rifki

& Muharom, 2022). Therefore, it's important to consider the appropriate use of each material according to the desired needs.

Previous research indicates that the thermal conductivity values of materials vary. The relationship between the thermal conductivity value of a material and its heat conductivity capability is proportional (Kiniasih dkk, 2017). This means that the higher the conductivity value, the greater its ability to conduct heat (Rahmat et al., 2022). A spoon is a common kitchen tool used for cooking and stirring food. The efficiency of a spoon in conducting heat is a crucial factor in effective and efficient cooking processes (Rahmani & Thomson, 2017). Many times, spoons are used without considering their maximum potential based on their material properties. For instance, using a metal spoon for cooking without a handle made of a different material can result in heat discomfort.

Studying the thermal conductivity of various spoon materials is an intriguing topic across different fields like material science, industry, and physics. Good thermal conductivity in a spoon allows for quick and efficient heat distribution across its surface, enhancing the effectiveness of cooking (Rusli et al., 2018). Hence, this research aims to identify the conductivity of different spoon materials based on their temperature rise, determining the most efficient material for daily use, particularly in cooking.

Metode Penelitian

(1) Preparation

Figure 1. *Tools and materials used*

In this thermal conductivity study, experiments were conducted using various types of spoon materials: stainless steel, plastic, wood, and ceramic. These spoons were utilized as test specimens, while water served as the testing medium. Thermometers were prepared to measure the temperature, adjusted in quantity according to the number of spoon types. The tools and materials used are shown in **Figure 1.**

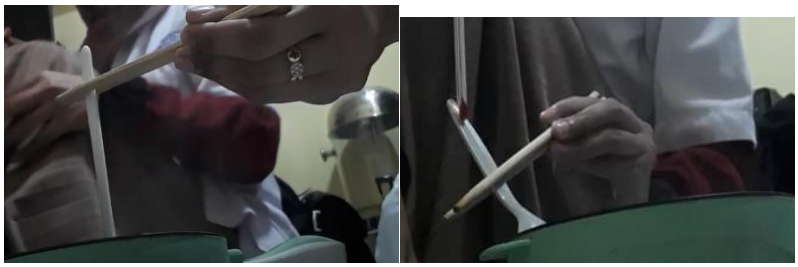
(2) Experiment

The experiment on thermal conductivity began by heating water in an electric pot, and the water was measured with a thermometer until it reached a temperature of 92˚C. The next step involved measuring the temperature on the spoons; we used four different materials for the spoons.

Before placing the spoon ends into the water, initial temperature measurements were taken for each spoon using a thermometer, ensuring that all spoons were at the same temperature before commencing the measurements. This was essential to ensure that observed differences in thermal conductivity were not due to initial temperature variations. The initial temperature of the spoons was identical to room temperature, which was 29˚C.

To commence the measurement, the four spoons were simultaneously placed in the water, which had reached 92˚C. Care was taken to ensure that the handle and ends of the spoons were not influenced by anything other than the water. To address this, we used wooden chopsticks to hold the spoons, preventing their contact with the pot's edge.

a)



b)

Fi 2. *(a) Testing the spoon in water and (b) measuring the temperature on the spoon*

Next, leave the four spoons in the water while the electric pot remains on to prevent their temperature from decreasing. They are left for durations of 1 minute, 3 minutes, and 5 minutes. Once the designated timespan is reached, the subsequent step involves measuring the spoons using a thermometer. Place the thermometer at the same point on each spoon; we chose the handle as it determines the material quality of the spoon. Record the temperature readings at one-minute intervals for later comparison with the initial temperatures of these spoons. This experimental procedure can be illustrated in the chart in **Figure 3**.

Figure 3. *Experimental procedures*

Hasil dan Pembahasan

This experiment aims to compare the thermal conductivity of various types of spoons, namely wooden spoon, plastic spoon, stainless steel spoon, and ceramic spoon.

Table 1. *Results of thermal conductivity measurements of spoon materials*

Type of Material	Temperature Rise (˚C)			
	0 s	60 s	180 s	300 s
Wood	29	29	29	29
Plastic	29	30	30	30
Stainlees steel	29	33	34	35
ceramic	29	32	33	33

Based on the experiment results and the data presented in **Table 1**, the wooden spoon exhibits good thermal insulation. This is evident from the consistent temperature of the wooden spoon at 29˚C throughout the experiment, at 0 s, 60 s, and 300 s. This aligns with the statement by Lukma and Budairi (2018) indicating that wood has low thermal conductivity, making it a good thermal insulator.

Plastic spoons, similar to wooden spoons, exhibit low thermal conductivity. This is evident from the experimental results, where the temperature of the plastic spoon remains at 29˚C for 60 s, followed by a temperature increase of 1˚C to 30˚C between 60 and 300 s. This minor temperature increase indicates that the plastic spoon is not efficient in conducting heat from hot water to the handle end of the spoon. This aligns with the statement by Lukma and Budairi (2018) that plastic has lower thermal conductivity compared to metals like stainless steel, which has high conductivity, as mentioned by Astuti (2015).

Ceramic spoons have lower thermal conductivity compared to stainless steel spoons but higher than wooden and plastic spoons. This is observed in the experimental results, where the temperature of the ceramic spoon increases by 3˚C over 300 s. It starts from an initial temperature of 29˚C, reaching 32˚C at 60 s, then 33˚C at 180 s, and remains constant until 300 s. This is supported by the slightly warmer sensation at the spoon's end when touched. Consistent with the nature of ceramic materials, which tend to be good thermal insulators due to a dense microscopic structure and the presence of small pores hindering heat movement, as stated by Lukma and Budairi (2018).

Based on the experimental results, the order of thermal conductivity from best to least suitable for cooking or eating purposes can be seen in the graph in **Figure 4** below:

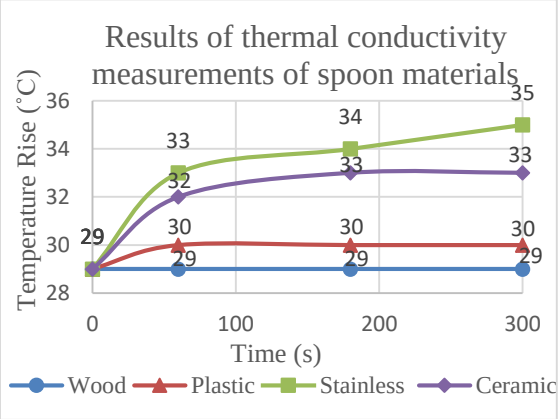


Figure 4. *Results of measuring the thermal conductivity of spoon materials*

From the graph in **Figure 4**, the four spoon materials align with the order of thermal conductivity values for various materials from the literature in **Table 2**. It is noted that the larger the thermal conductivity value, the faster the material heats up (Rahmat et al., 2022).

Table 2. *Thermal conductivity values of various ladle materials (Suhada, 2021)*

Material	W/m.^{o}K
Stainless steel	14-20
Wood	0,17-0,3
Plastic	0,1-0,3
Ceramic	1-2

Even though it had been heated for 5 minutes, the four spoons did not experience a significant increase in temperature. This could be due to the use of wooden chopsticks to hold each spoon material, where the wooden chopstick material is an insulator so it can absorb heat from the statement of Prihartono and Irhamsyah (2022), so that the heat of the spoon material will be absorbed slightly by the wooden chopsticks.

Kesimpulan

Berdasarkan hasil eksperimen pengujian berbagai material sendok untuk membuktikan konduktivitas termal dari waktu perpindahan panasnya diperoleh data bahwa berturut-turut kenaikan suhunya selama 5 menit dari material kayu, plastik, stainless steel, dan keramik ialah sebesar 0˚C, 1˚C, 6˚C, dan 4˚C. Dari hasil tersebut, sendok kayu memiliki konduktivitas termal yang paling rendah dengan kenaikan suhunya yang paling lama di antara semua material yang diujikan, kebalikan dari material stainless steel. Oleh karena itu sendok dengan material stainless steel efektif untuk memasak, dengan syarat disertai dengan gagang sendok yang terbuat dari material kayu agar menghambat perpindahan panas yang akan terjadi.

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