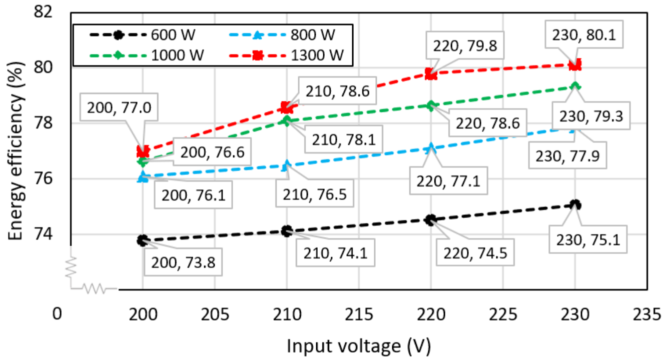

Figure 7. Comparison profile of supply voltage variation on energy efficiency of brand A induction cooker.

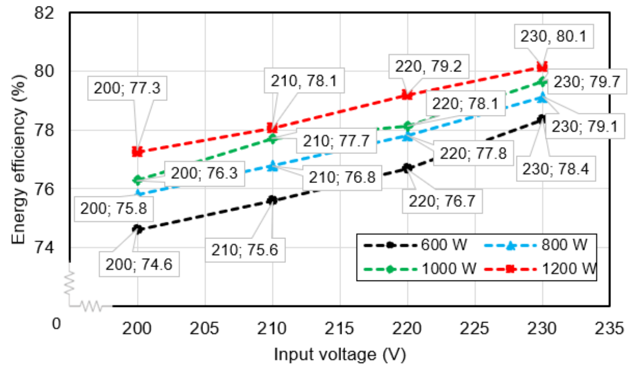

Figure 8. Comparison profile of supply voltage variation on energy efficiency of brand A induction cooker.

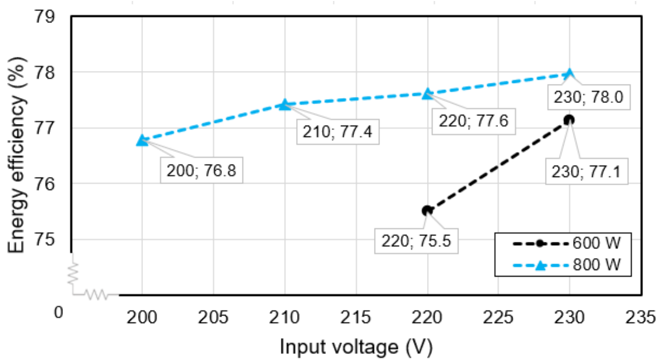

Figure 9. Comparison profile of supply voltage variation on energy efficiency of Brand D induction cooker.

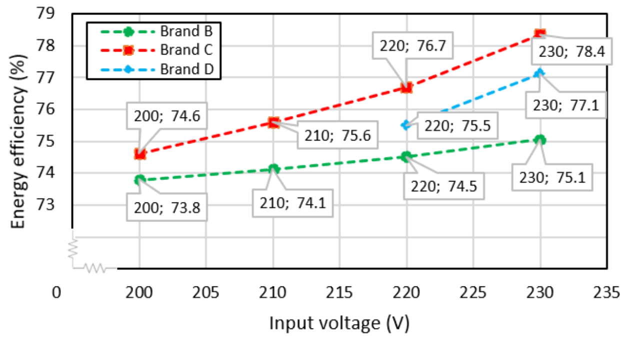

Figure 10. Comparison of supply voltage variations on energy efficiency of induction cookers between induction cockers at 600 W power.

efficiency produced. It happens because, based on the measurement results, it was found that the energy consumption data of brand A induction cookers increased along with the decrease in supply voltage. In addition, the time required for cooking also increases. Hence, with the increase in these two components, power consumption and cooking time, the energy efficiency value decreases as the supply voltage decreases.

C. ENERGY EFFICIENCY ANALYSIS OF BRAND B INDUCTION COOKER

Figure 7 shows the effect of supply voltage variation on the energy efficiency produced by brand B induction cookers. This brand B induction cooker has four levels of operating power, namely 1300 W, 1000 W, 800 W, and 600 W. At the 1300 W operating power level, the efficiency for voltages of 230 V, 220 V, 210 V, and 200 V were 80.1%, 79.8%, 78.6%, and 77.0%, respectively. The difference in efficiency between the 230 V and 200 V supply voltages reached 3.1%. At 1300 W operating power, the rate of occurring efficiency changes follows the equation:

$$\eta(\%) = (0.1059 \times \text{ supply voltage}) + 56.116.$$

At an operating power of 1000 W, the efficiency for voltages of 230 V, 220 V, 210 V, and 200 V were 79,3%, 78,6%, 78,1%, and 76,6%, respectively. The difference in efficiency between the 230 V and 200 V supply voltages at this power level reached 2,7%. At an operating power of 1000 W, the rate of the occurring efficiency change follows the equation:

$$\eta(\%) = (0.0862 \times supply\ voltage) + 59.632.$$

At an operating power of 800 W, the efficiency for voltages of 230 V, 220 V, 210 V, and 200 V were 77.9%, 77.1%, 76.5%, and 76.1%, respectively. The difference in efficiency between the 230 V and 200 V supply voltages at this power level reached 1.8%. At this operating power of 800 W, the rate of the occurring efficiency change follows the equation:

$$\eta(\%) = (0.0594 \times \text{supply voltage}) + 64.108.$$

At an operating power of 600 W, the efficiency for voltages of 230 V, 220 V, 210 V, and 200 V were 75.1%, 74.5%, 74.1%, and 73.8%, respectively. The difference in efficiency between the 230 V and 200 V supply voltages at this power level is 1.3%. At this operating power of 600 W, the rate of the occurring efficiency change follows the equation:

$$\eta(\%) = (0.0422 \times supply\ voltage) + 65.301.$$

Similar to the induction cooker of brand A, in brand B, it was found that an increase in the supply voltage of the cooker results in an increase in the energy efficiency value. In addition, it can be seen in the measurement results that the power consumption value of brand B became larger with an increase in supply voltage. Despite this phenomenon, the time required to heat the water became much shorter as the voltage increases. Thus, the increase in voltage has an impact on increasing the efficiency value of this brand B induction cooker.

D. ANALYSIS OF BRAND C INDUCTION COOKER

Figure 8 shows the effect of supply voltage variations on the energy efficiency produced by the brand C induction cooker. This brand C induction cooker has four levels of operating power, namely 1200 W, 1000 W, 800 W, and 600 W. At an operating power level of 1200 W, the efficiency for voltages of 230 V, 220 V, 210 V, and 200 V were 80.1%, 79.2%, 78.1%, and 77.3%, respectively. The difference in efficiency between the 230 V and 200 V supply voltages reached 2.9%. At this operating power of 1200 W, the rate of the occurring efficiency change follows the equation:

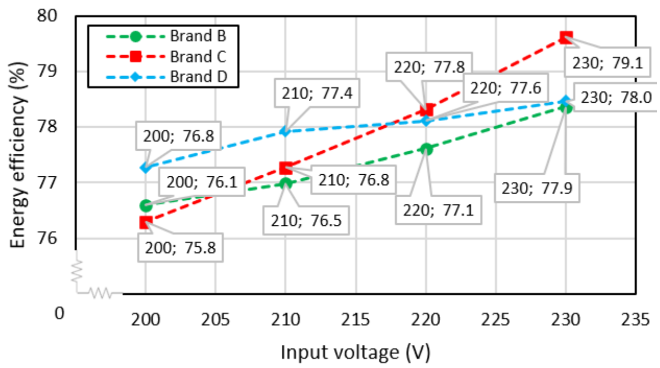

Figure 11. Comparison of supply voltage variation on energy efficiency of induction cooker between induction cooker brands at 800 W power.

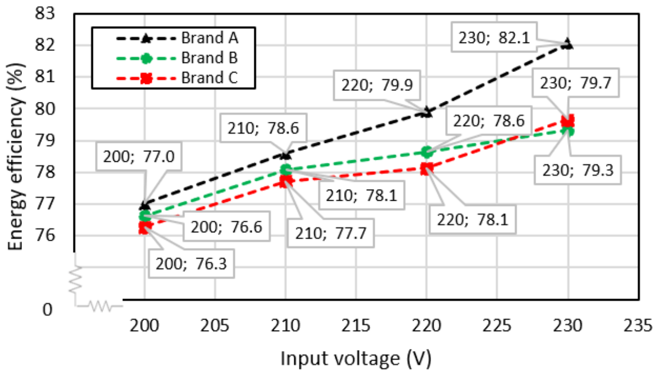

Figure 12. Comparison of supply voltage variation on energy efficiency of induction cooker between induction cooker brands at 1000 W power.

$$\eta(\%) = (0.0979 \times \text{supply voltage}) + 57.614.$$

At an operating power of 1000 W, the efficiency for voltages of 230 V, 220 V, 210 V, and 200 V were 79,7%, 78,1%, 77,7%, and 76,3%, respectively. The difference in efficiency between the 230 V and 200 V supply voltages at this power level reached 3,4%. At an operating power of 1000 W, the rate of the occurring efficiency change follows the equation:

$$\eta(\%) = (0.1054 \times \mathit{supply\ voltage}) + 55.28.$$

At an operating power of 800 W, the efficiency for voltages of 230 V, 220 V, 210 V, and 200 V were 79,1%, 77,8%, 76,8%, and 75,8%, respectively. The difference in efficiency between the 230 V and 200 V supply voltages at this power level reached 3,3%. At this operating power of 800 W, the rate of the occurring efficiency change follows the equation.

$$\eta(\%) = (0.1099 \times \mathit{supply\ voltage}) + 53.745.$$

At an operating power of 600 W, the efficiency for voltages of 230 V, 220 V, 210 V, and 200 V were 78.4%, 76.7%, 75.6%, and 74.6%, respectively. The difference in efficiency between the 230 V and 200 V supply voltages at this power level was 3.7%. At this operating power of 600 W, the rate of the occurring efficiency change follows the equation:

$$\eta(\%) = (0.123 \times \mathit{supply\ voltage}) + 49.862.$$

It can be observed that as the supply voltage of the induction cooker decreases, the energy efficiency decreases. As can be observed in Table III and Figure 8, there is a phenomenon of decreasing power consumption with decreasing supply voltage. In contrast, the cooking time was increased significantly with a decrease in voltage, resulting in an increase in the total energy required for cooking. It results in a decrease in efficiency.

E. ENERGY EFFICIENCY ANALYSIS OF BRAND D INDUCTION COOKER

Figure 9 shows the effect of supply voltage variation on the energy efficiency generated by brand D induction cookers. This brand D induction cooker has only two operating power levels, namely 800 W and 600 W. At the operating power level of 800 W, the efficiency for voltages of 230 V, 220 V, 210 V, and 200 V were 78.0%, 77.6%, 77.4%, and 76.8%, respectively. The difference in efficiency between the 230 V and 200 V supply voltages reached 1.2%. At this operating power of 800 W, the rate of the occurring efficiency change follows the equation.

$$\eta(\%) = (0.0376 \times \text{supply voltage}) + 69.36.$$

Whereas, at an operating power of 600 W, the efficiency for 230 V and 220 V voltages was 77.1% and 75.5%, respectively. At this 600 W operating power level, the supply voltage variations of 210 V and 200 V cannot activate the induction cooker. Therefore, no measurement data was obtained at these two voltage levels. Meanwhile, the difference in efficiency between the 230 V and 220 V supply voltages at this power level reached 1.6% or 0.4% greater than at 800 W. At an operating power of 600 W, the rate of the occurring efficiency change follows the equation:

$$\eta(\%) = (0.1622 \times \text{supply voltage}) + 39.81.$$

Furthermore, as can be observed in Table III and Figure 9, there is a phenomenon that the more the supply voltage decreases on the induction cooker, the more energy efficiency decreases. This condition is similar to brand B and brand C induction cookers, where there is a phenomenon of decreasing power consumption with a decrease in supply voltage. In contrast, the cooking time is increased significantly with a decrease in voltage, resulting in an increase in the total energy required for cooking. It results in a decrease in the efficiency of the brand D induction cooker.

In all types of induction cooker brands, all measurement results have the same phenomenon, i.e., the efficiency level increases with increasing supply voltage. It is illustrated in Figure 10, Figure 11, and Figure 12 for power supply conditions of 600 W, 800 W, and 1000 W for comparison on all induction cookers. Referring to the three figures, the increase in voltage leads to higher average power consumption but with shorter cooking times for all brands. This results in the total energy consumption for cooking being smaller and the level of energy efficiency being better. As an illustration, the phenomenon in brand A induction cookers, for the operating power options of 1000 W, 1400 W, and 1800 W has a total energy efficiency change rate against the supply voltage variation of 0.164; 0.183; and 0.193 $\Delta\eta$/V, respectively.

V. CONCLUSIONS

Based on the research that has been carried out, referring to all test results, it is known that the energy efficiency of the induction cooker is affected by changes in supply voltage with a large value of change approaching linear. The higher the supply voltage, the higher the energy efficiency.

This condition occurs in all brands of induction cookers used in this study, even though the four cooker brands used have different operating power options. At the operating power of the 1800 W induction cooker, namely cooker A, the difference in supply voltage from 230 V to 200 V causes a 5.5% decrease in the efficiency of the induction cooker. The change in supply voltage from 230 V to 200 V also caused a decrease in the efficiency of brand A induction cookers for 1400 W and 1000 W operating power by 5.5% and 5.0%, respectively. A decrease in efficiency also occurred for operating powers of 800 W and 600 W for all induction cookers used in this study. In general, the change in supply voltage from 230 V to 200 V causes a decrease in efficiency for the entire operating power of the induction cooker between 1.2% and 5.5%, depending on the cooker brand and the employed operating power. The test results indicate that energy efficiency is affected not only by the supply voltage but also by the selection of the operating power of the induction cooker. The higher the operating power of the stove, the higher the efficiency is obtained. The highest efficiency is obtained for 1800 W operating power with a supply voltage of 230 V, which is 85.8% on brand A stoves, while the lowest efficiency is obtained at 600 W stove operating power with a supply voltage of 200 V, which is 74.1% on brand B cooker. With the condition that the efficiency of the induction cooker is affected by the magnitude of the supply voltage, it is hoped that the supply voltage can be kept at a higher limit so as to increase the energy efficiency of the induction cooker, especially in the future the induction cooker is predicted to be one of the cooking utensils that can replace the currently popular gas stove because of the advantages of energy efficiency and energy security.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest in the research and preparation of this paper.

AUTHOR CONTRIBUTION

Conceptualization, Budi Sudiarto and Justinus Dipo Nugroho; methodology, Justinus Dipo Nugroho; software, Budi Sudiarto, and Justinus Dipo Nugroho; validation, Budi Sudiarto, Justinus Dipo Nugroho, and Faiz Husnayain; formal analysis, Budi Sudiarto, Justinus Dipo Nugroho, and Agus R Utomo; investigation, Budi Sudiarto, Justinus Dipo Nugroho and I Made Ardita; resources, Budi Sudiarto, Justinus Dipo Nugroho, Agus R Utomo and I Made Ardita ; data curation, Budi Sudiarto, Justinus Dipo Nugroho, and Faiz Husnayain; writing-original drafting, Justinus Dipo Nugroho; writing-reviewing and editing, Budi Sudiarto and Faiz Husnayain; visualization, Budi Sudiarto, Justinus Dipo Nugroho, and Faiz Husnayain; supervision, Budi Sudiarto, Agus R Utomo and I Made Ardita; project administration, Budi Sudiarto; funding acquisition, Budi Sudiarto.

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