Comparison of Ohmic and Electric Heating of Milk

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Introduction

Ohmic heating (OH) technology is considered as a major advance in the processing of food products. OH is direct resistance heating by the flow of an electrical current through foods, so that heating is by internal heat generation. In this study, milk was heated using static Ohmic reactor and results were compared with heating using an electric cooker. Cow milk (1 litre) was heated from 20 to 90 °C. Comparison was made with respect to temperature profile, heating rate (°C/min), heating time, temperature gradient and power consumption. It was found that the average time required for OH was significantly lower (3.41 min) compared to electric heating (10.3 min). The power consumption in OH was 0.066 kWh which was almost half required for electric heating (0.143 kWh). Temperature gradient was almost similar in both the systems. The results show that OH technology is better than electric heating. This system can be up-scaled and can be used for processing milk at small scale.

Objective

Heating is an important step in food processing. Heat treatment for complex food fluids is considerably improved when newer systems such as microwave heating, inductive or Ohmic heating are used. These volumetric heating methods generate heat inside the food and depend less on thermal conduction and convection and so cause fewer temperature gradients (Singh and Heldman, 2001). The main factor which attracts towards the study Ohmic heating is the Rapid and uniform heating of the food and high energy efficiency. In this study, comparison was made between Ohmic and electric heating of milk. Development of Ohmic heater will be helpful for small and medium entrepreneur for small scale milk processing.

Methodology

Static Ohmic reactor (1litre capacity) designed and developed at NDRI was used for this study. It was operated at electrical field strength of 20 V/cm. For electric heating, milk was heated using electric cooker (Panasonic, SR-WA22H, 750 W). For the trials, cow milk (4.5% Fat, 8.5 % SNF) was used and was heated from 20 to 90 °C. Data logger interfaced pt 100 sensors (4 Nos.) were used to measure temperature distribution in the Ohmic reactor and Electric cooker. Data-logger sampling frequency was set at 5 s. To determine uniformity of heating, four temperature probes were placed at equal distance in static Ohmic heater and electric cooker. Electrical parameters were measured using digital power analyzer (Meco, Powerguard PG07). Comparison was made with respect to temperature profile, heating rate (°C/min), heating time, temperature distribution and power consumption.

Result and Discussion

Temperature profile

It was observed that temperature profile in Ohmic heating followed sigmoid trend Amount of generated heat during Ohmic heating is directly related to the electrical conductivity. Steep increase of milk temperature was due to increase in electric conductivity of milk at higher temperatures. In case of electric heating, temperature rise was linear with respect to time

Heating rate

The voltage gradient has significant effect on the heating rate of milk. At higher voltage, the current passing through the sample is higher and results in rapid heat generation. At 20 V/cm, Ohmic heating rate was very fast (19.48 °C/min) compared to electrical heating (7.65 °C/min). Lower values of heating rate in electric cooker were observed due to natural convective heating. Whereas high heating rate in Ohmic heating was due to volumetric heating.

Average temperature gradient

Temperature mapping during batch Ohmic heating is a challenging but critically important task. It is essential to be able to monitor temperature changes at various, selected locations within a food product (Zell et al., 2009). The uniformity of milk heating is very important. Average temperature gradient in Ohmic and electric heating was 2.56 °C and 2.60 °C respectively. Thus average temperature gradient was similar in both of the heating methods and lower experimental value indicates uniform heating of milk.

Heating Time

As the heating rate was very high in Ohmic heating, the total time taken for heating was less (3.4 min). While electric cooker took 10.5 min for heating milk from 20 to 90 °C. The results shows that the milk can be heated rapidly in Ohmic heater. Compared with conventional heating method, Ohmic heating has obvious advantages in shorting the heating time (Chen et al., 2010).

Power consumption

In static Ohmic reactor the average power consumption was 0.066 kWh which was significantly lower than the electric cooker (0.1433 kWh). De Halleux et al. (2005) also reported that Ohmic heating provided 82–97% of energy saving while reducing the heating times by 90–95% compared to conventional heating. And that it could be possible to obtain efficiency greater than 90% in an industrial process.

Conclusion

It was found that the heating rate was exceptionally high in static Ohmic heater compare to electric heating. Also the total time for heating the milk in the Ohmic heater was much lower. But average temperature gradient was similar in both the heating methods which implies uniform heating. The power consumption in electric heating was significantly higher than Ohmic heating. Overall results establish that Ohmic heating is better than the electric heating.

References

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