HUNGARIAN UNIVERSITY OF AGRICULTURE AND LIFE SCIENCES

Institute of Food Science and Technology

Bachelor's degree in Food Engineering

Studies on Hydrodynamics and Process heat transfer of Bioreactors

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Abstract

Dairy-based food formulations, both non-fermented and fermented, have attracted considerable interest across different demographics. Over time, the dairy industry has continually advanced the quality of these formulations to meet consumer expectations. One promising approach to reduce milk protein allergens is enzymatic hydrolysis, which targets allergenic epitopes in protein sequences. Additionally, enzymatic modifications can enhance the functional properties of milk proteins. Typically, enzymatic hydrolysis of milk proteins is conducted in a stirred-tank bioreactor, where understanding key operating conditions, such as temperature and stirrer speed is essential for optimizing enzyme-catalyzed reactions and scale-up the bioprocess.

In this study, the focus is on the mechanical design of a lab-scale bioreactor and optimization of process parameters specific to milk protein hydrolysis. Key factors, such as impeller geometry and the bioreactor's overall heat transfer coefficient have been given special attention. The effects of impeller rotational speed, along with the inlet and outlet water temperatures in the bioreactor's jacket, on heat transfer were closely examined, particularly regarding the overall heat transfer coefficient. Various dimensionless numbers, including the Reynolds number, Prandtl number and Nusselt number were analyzed. The inlet and outlet water temperatures in the bioreactor jacket were studied to evaluate the change in milk temperature from 25 °C to 50 °C within 30 minutes (preheating for enzyme-catalyzed reaction), and from 50 °C to 70 °C within 20 minutes. Additionally, startup power requirements were calculated for impeller speeds of 25 rpm and 50 rpm, assuming a motor efficiency of 75%. Key findings regarding operating conditions for enzymatic hydrolysis of milk proteins in a stirred-tank bioreactor are as follows:

1. To increase the temperature of milk from 25 °C to 50 °C with an impeller speed of 25 rpm, the water inlet and outlet temperatures should be 69 °C and 60.1 °C, respectively.
2. To increase the temperature of milk from 25 °C to 50 °C with an impeller speed of 50 rpm, the water inlet and outlet temperatures should be 65 °C and 55 °C, respectively.
3. To increase the temperature of milk from 50 °C to 70 °C with an impeller speed of 25 rpm, the water inlet and outlet temperatures should be 85 °C and 82 °C, respectively.
4. Finally, for heating milk from 25 °C to 50 °C with an impeller speed of 50 rpm, the water inlet and outlet temperatures should be 80 °C and 77 °C, respectively.

The selection of water inlet and outlet temperatures in the bioreactor jacket proved suitable, as the error in overall heat transfer coefficient measurements was within 5%.