HUNGARIAN UNIVERSITY OF AGRICULTURE AND LIFE SCIENCES

INSTITUTE OF FOOD SCIENCE AND TECHNOLOGY

DEPARTMENT OF FOOD PROCESS ENGINEERING

ECONOMIC ANALYSIS OF A BIOPROCESS FOR PRODUCING DAIRY FORMULA HAVING LOWER ALLERGENIC ACTIVITY

SUPERVISORS

Dr. Attila Csighy

Dr. Arijit Nath

Dr. Emőke Szerdahelyi

Rachel Agyepong

2025

Cow’s milk protein allergy (CMPA) is one of the most prevalent food allergies in early childhood, affecting approximately 2-3% of infants. The primary allergens-casein, β-lactoglobulin, and α-lactalbumin-can trigger a wide spectrum of immune responses, ranging from mild gastrointestinal symptoms to severe anaphylactic reactions. This presents a significant challenge, especially given dairy’s vital role in human nutrition. Dairy foods are recognized as functional foods rich in high-quality proteins, essential amino acids, and bioactive compounds. However, their allergenic potential can limit consumption among sensitive populations, particularly infants and young children.

The allergenicity of dairy proteins is largely influenced not only by their primary structure but also by processing conditions and the variability of individual IgE responses. To mitigate this, various bioprocessing techniques such as enzymatic hydrolysis, microbial fermentation, thermal processing, and high-pressure treatment have been explored. Among these, enzymatic hydrolysis is a promising strategy due to its capacity to reduce allergenicity while preserving nutritional value. Nonetheless, extensive hydrolysis often leads to undesirable sensory properties and high production costs, limiting its wide application in hypoallergenic formulations.

This study investigates the economic and technological feasibility of a novel, sequential bioprocessing scheme involving tryptic and microbial hydrolysis for reducing the allergenic activity of dairy proteins. Previous experimental data demonstrated the efficacy of this dual-treatment strategy in altering the structure of allergenic epitopes, thus reducing their immunogenic potential. However, there was a gap in understanding the process's economic viability. The objective of this research is to perform a techno-economic analysis using SuperPro Designer software (v.12, Intelligen Inc., USA) to model the proposed bioprocess and compare it with other conventional techniques including microwave heating, high hydrostatic pressure, and single-step enzymatic or microbial treatments.

Profitability indicators such as gross profit, net profit, payback time, return on investment (ROI), and net present value (NPV) were evaluated. Results suggest that the proposed dual hydrolysis scheme could be a commercially attractive approach for the dairy industry, offering a balance between reduced allergenicity and nutritional adequacy. The developed formula not only retained high concentrations of essential, glucogenic, ketogenic, and branched-chain amino acids but also exhibited potential as a functional ingredient for consumers seeking hypoallergenic and protein-rich dairy alternatives.

Moreover, by potentially expanding the consumer base to include those with milk sensitivities, this approach supports innovation in the functional food sector and aligns with the growing

demand for personalized nutrition and sustainable protein sources. This research not only highlights the technological promise of sequential enzymatic and microbial hydrolysis but also reinforces its economic and health value in modern dairy product development.