

2 Motivation and objectives

The vast amount of literature on the heat stability of milk and concentrated milk demonstrates the importance of heat stability in dairy research and industry. A brief and comprehensive summary was given in the theoretical background. It was intended to present the historical and recent approaches taken to investigate the heat stability of milk and, most relevant, concentrated milk. The lack of knowledge, especially in terms of the kinetics of heat-induced coagulation of concentrated milk, was pointed out. A quantitative description of the critical temperature-time combinations for the heat treatment of concentrated milk was therefore one of the guiding ideas.

During the studies for this thesis, the research on the kinetics of thermal inactivation of microorganisms, bacterial spores, enzymes, and degradation of nutrients in food science was taken as a role model. Fundamental understanding of the kinetics and parameter estimation enabled major advances in continuous thermal dairy processing. The systematic investigation of the inactivation and degradation processes enabled the mathematical prediction of working ranges to maximise desired effects and to minimise undesired reactions, all in all intended to keep product quality and maximise product safety.

Starting from laboratory scale, the quantitative relationship between the possible heat load in terms of heating temperature and time depending on total solids content of concentrated skim milk (CSM) was investigated. A subjective heat stability test that allows for the comparison of the lab scale experiments with continuous heat treatment of CSM on pilot scale by using kinetic dependencies was developed. The quantitative description of changes in heat stability of CSM by an increase in total solids content, by preheating of milk, and addition of milk fat was intended.

The use of continuous direct steam injection (DSI) heat treatment enabled the quantitative description of the heat stability of CSM on pilot scale. Further investigations on the mechanism of heat-induced coagulation of CSM by analysis of the different size fractions formed during coagulation of CSM by quantitative differential centrifugation were performed. The coagulation process was followed to gain mechanistic insights into the heat-induced coagulation process, the reactions preceding coagulation, and the distribution of caseins during coagulation.

Further investigation of the course of the coagulation of indirectly heat treated CSM over much longer heating times under isothermal conditions at different temperatures were performed. The quantitative data resulted in a mathematical model

capable to describe the onset of coagulation, course of coagulation, and the temperature dependency of heat-induced coagulation of CSM at different total solids content. Based on this model, a prediction of the heat stability data obtained using DSI was possible.

Further investigations on the heat stability of casein micelles in general aimed at the selective modification of the milk serum composition and the investigation of the structure of casein micelles in concentrated milk and milk systems. The reason for the decrease in the heat stability of concentrated milk should be further elucidated by using a micellar casein concentrate in simulated milk ultrafiltrate as a model milk system. The effects of pH, soluble calcium, and ionic strength on structure and the colloidal stability of casein micelles were addressed.

The results section of this thesis is structured according to publications relating to the main aspects of research on the heat stability of concentrated milk and the effect of milk serum on the structure of the casein micelle in concentrated milk systems as listed below. Investigations on

- the heat stability of CSM on lab scale,
- the heat stability of CSM on pilot scale using direct steam injection,
- the dissociation and coagulation of caseins and whey proteins in concentrated skim milk heated by direct steam injection,
- milk ultrafiltrate analysis by ion chromatography and calcium activity for the preparation of a simulated milk ultrafiltrate,
- modelling of heat stability and heat-induced aggregation of casein micelles in concentrated skim milk using a Weibullian model, and
- the implication of pH and soluble calcium on micelle size and dissociation of κ -casein in relation to heat stability of micellar casein

were conducted.

Heat Stability of Concentrated Milk Systems
Kinetics of the Dissociation and Aggregation in High
Heated Concentrated Milk Systems

Dumpler, J.

2018, XXXVI, 201 p. 67 illus., 11 illus. in color., Softcover

ISBN: 978-3-658-19695-0