University of Modena and Reggio Emilia

Models and Methods for Material and Environmental Sciences

PhD Course - XL cycle – academic year 2024/2025

Development of optical systems based on the integration of spectroscopy and chemometrics for dairy products and processes monitoring

Abstract:

In the Italian dairy PDO production, there are several traditional cheeses with artisanal production processes where not standardized raw milk is used and milk renneting occur in small vats. In these processes, the success of milk coagulation phase is closely tied to cheesemakers' skills, that based on their personal expertise, determines the coagulation time and the curd cutting time by visual and manual curd firmness evaluation. The absence of standardization can be problematic, particularly regarding the management of curd cutting and syneresis that can affect both cheese yield and final product quality.

The aim of the project is to use an optical system based on NIR spectroscopy, integrated with trilinear chemometric methods and MCR, to perform milk coagulation monitoring. The system will be composed by a commercial spectrometer mounted on a food-grade probe, that will be placed in vat, in contact with coagulating milk, detecting a NIR optical signal in diffuse reflectance during the coagulation process. This system will be able to perform real-time monitoring, supporting cheesemakers in managing the milk coagulation process, moreover, it could be used to record data for ex post analysis to compare different coagulation batches.

The high cost of this system could be limiting for some dairies, therefore, to enable coagulation monitoring also in small and medium-sized productions, the second aim of the project is the development of a low-cost prototype optical probe, that will operate in the same manner as the commercial probe, quantitatively detecting a NIR signal in diffuse reflectance, but including a reduced number of wavelengths.

The expected outcome of this project is that the use of optical systems will enable the prediction of curd-firmness during milk coagulation, allowing cheesemakers to enhance the management of curd cutting and syneresis, leading to a reduction in yield losses, defects, and non-conformities, and an optimization of the process respecting the natural variability of the product due to the use of not standardized raw milk and natural starters.

The process of milk coagulation is a transformation that co-involves chemical (hydrolysis of K-casein) and physical phenomena of casein micelles aggregation, with the formation of a gel: from a spectroscopic point of view, monitoring this process involves both scattering and matrix absorbance changes and can be considered an ideal case study of many processes in the food industry in which state changes are observed.

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