Modeling Lactose Crystallization and Deterioration Mechanisms Using Raman Spectroscopy in Dairy Powders

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Dairy powders are a diverse, widely applied food ingredient with high export potential, both from a financial and health benefit perspective. However, shipping products from a more tempered northern climate to markets in Asia or Africa can lead to product deterioration. Especially the long shipping times (30+ days) combined with high temperatures and relative humidities experienced during transportation might have an adverse effect on important product parameters such as flowability and dissolution times. These issues are mostly associated with the undesirable transition from amorphous to crystalline lactose [1], next to other processes such as product browning. Traditional remedies to avoid deterioration, custom in the food industry such as protective packaging and/or refrigerated sea containers, are cost prohibitive for large-volume-low-cost products such as milk powder. Adjustments in production technologies (e.g. spray drying conditions) are a more desirable (and more sustainable in the long run) alternative towards "robust powders", but they require a much better understand of the physical and chemical mechanisms taking place. In the AMUSE research project we investigate the multi-scale pathways to better understand (and counteract) powder deterioration.

In this investigation we apply Raman spectroscopy and multivariate curve resolution to quantify lactose crystallization. We illustrate the idea that concepts originating in PAT/Industry 4.0 - i.e. vibrational spectroscopy combined with statistics, large scale experimentation, automation, etc. – are not only suitable for "real time" control and optimization but can also be central in "one-off investigations" during research projects [2]. Raman spectroscopy specifically, with its non-invasive nature ("looking through the container" [3]), combined with its low-labor/high-frequency sampling potential, can compete with traditional extractive analytical chemistry in the study of dynamic systems.