Lactose in Dairy Powders - from Crystal Size to Powder Functionality

QI X. (1), MALMOS K. (2), VAN DER BERG F. (1), GRUMSEN F. (3), BAKALIS S. (1)
1 Department of Food Science, University of Copenhagen, Frederiksberg, Denmark
2 Arla Foods, Viby, Denmark
3 Department of Civil and Mechanical Engineering, Technical University of Denmark, Kgs.Lyngby, Denmark

Dairy powders are an excellent source of high-quality protein, essential in the nutritional intake of children in the developing world. Challenging environmental conditions can result in detrimental quality losses. Lactose should be in the glassy state to ensure good functional properties. However, transportation and storage conditions can exceed critical relative humidity (RH) and temperature (T), resulting in the glassy amorphous lactose transforming into a rubbery amorphous and eventually crystalline state with detrimental effects on quality. There is currently a knowledge gap in understanding the nature of crystalline lactose formation - e.g. phase, size, and crystallization-kinetics – for (complex) dairy systems.
We exposed a fat filled milk powder at five RHs, from 22.5% to 75.3%, and two Ts (25°C and 40°C) for 4 months. The functionality, i.e. reconstitution and colloidal stability, was investigated. Surface morphology, chemistry and lactose crystallization were characterized using SEM, FTIR, XRD and DSC.
Powders stored at RH 22.5% reconstituted into stable colloidal systems, irrespective of the storage temperature. XRD indicated that lactose remained amorphous under these storage conditions. For the other samples, powder wettability and colloidal stability were reduced. When increasing RH and T, crystallinity of lactose increased, leveling to approximately 50%. The anhydrous phase mixture of ?-lactose and ?-lactose dominated in powders stored between 40.0% to 57.7% RH. Only ?-lactose monohydrate was observed at 75.0% RH. The crystal size increased from nanometers to micrometers by increasing RH and T, in an opposite fashion to wettability and colloidal stability. Our study demonstrated that the transition of amorphous to crystalline lactose in complex dairy powders is not necessarily harming reconstitution-performance for the stored powders or colloidal stability. The results indicate that for dairy powders, phase and size of lactose, rather than total crystallinity, are key in controlling functionality.