Phase transitions during storage of infant milk formula powders produced under varying wet-mix processing conditions

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Infant milk formulas (IMFs) are commonly presented in spray-dried form due to their long shelf life and reduced transport and storage costs. IMFs have high lactose content and are susceptible to glass transition during drying and storage. Powders with low glass transition temperatures (Tg) are prone to stickiness, caking, and crystallization, negatively impacting the quality and stability of the product. Effects of composition and spray drying conditions on Tg have been reported, but less attention has been paid to the effects of pre-spray drying wet-mix processing conditions. The aim of this work was to evaluate the impacts of pasteurization temperature and total solids (TS) of the wet-mix on the phase transitions of IMF powders during storage. Four IMF powders (50%-75°C, 50%-100°C, 60%-75°C, 60%-100°C) were produced at pilot scale by dispersion of the ingredients (lactose, whey protein isolate, skimmed milk powder, sunflower oil, galacto- and fructo-oligosaccharides) in deionized water (T=65°C, pH=6.8), to obtain wet-mixes with 50 or 60% TS. The wet mixes were subsequently pasteurized at 75 or 100°C×18s, homogenized (P1st stage=13MPa, P2nd stage= 3MPa) and spray dried (Tinlet air=180°C, Toutlet air=85°C). Each formula was stored under “open package” (HR=58%, T=25°C) and “closed package” (multilayer sealed bag, T=25°C) conditions, for 4 and 12 weeks, respectively. IMFs stored in “closed package” were amorphous for 12 weeks, as indicated by DSC and XRD. In formulas stored under “open package” conditions, lactose fully crystallized between weeks 1 and 2. IMFs produced from wet-mixes with 60% TS presented broken particles, as shown by SEM, which accelerated the water sorption. As aw increased faster in 60%-75°C and 60%-100°C than in 50% samples, glass transition and crystallization occurred earlier. In conclusion, TS of the wet-mix affected the stability of the IMFs powders. Formulas stored under “closed package” conditions were stable for 12 weeks, as Tg was above the storage temperature (Ts=25°C). Under “open package” storage conditions, the water adsorption induced Tg reduction and lactose crystallization by week 2. Phase transitions occurred earlier in IMFs produced from wet-mixes with 60% TS, due to the morphology of the powder particles which accelerated the water sorption, reducing Tg below Ts.