CASEIN DRYING

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TO TITA,

Without whose support, care and love this research work would have been far less exciting and enjoyable.

ABSTRACT

Fundamental aspects of casein drying have been investigated to provide relevant information for design, operation and control of industrial casein driers.

Casein desorption isotherms were sigmoid in shape and of type II according to the BET classification. A modified Henderson equation could describe the equilibrium moisture content (EMC) of casein as a function of water activity (equilibrium relative humidity) and temperature. Under similar drying conditions, the EMC of casein decreased in the order mineral acid > rennet > lactic. Studies on mineral acid casein indicated that the EMC was not affected by wet processing conditions but more severe drying conditions caused a significant decrease.

Drying mechanisms were studied in a laboratory tunnel drier and a fluidized bed drier. The batch drying curve in the tunnel drier consisted of a short constant rate period (CRP) and two linear falling rate periods (FRP). The critical moisture content was about 1.5 kg water/kg dry solids. In contrast the batch drying curve in the fluidized bed drier had a long constant rate period down to a critical moisture content of around 0.5 kg water/kg dry solids, followed by a single linear falling rate period.

The effects of drying conditions and casein manufacturing conditions were studied in the fluidized bed drier. The CRP drying rate was directly proportional to the air temperature driving force. The FRP drying rate also increased with an increase in air temperature. An increase in air velocity caused an increase in the CRP drying rate but did not affect the drying rate in the FRP. A rise in casein precipitation pH from 4.3 to 4.8 caused a significant reduction in the CRP drying rate but had only a small effect on the FRP drying rate. The precipitation and hot wash temperatures of casein curd had no significant effect on the drying rates. Curd plasticization did not affect the drying rate in the CRP but increased the FRP drying rate. In the CRP, larger particles (> 2.00 mm) tended to dry more slowly than smaller particles because of reduced fluidization efficiency, but particle sizes ranging from 0.50 to 3.35 mm did not appear to affect drying rates in the FRP. In general the CRP was affected by factors which altered the gas phase heat and mass transfer whereas the FRP tended to be influenced by factors affecting the solid phase heat and mass transfer.

Measurements in a commercial plant indicated that bigger casein particles leaving the drier had significantly higher moisture contents than the smaller particles. Moisture equilibration between the big and small particles was reached in about 3 hours.

Studies on drying of single casein particles indicated that lactic casein particles had higher air contents than rennet casein and mineral acid casein particles when drying from a mean initial MC of 1.2 kg water/kg dry solids to a final MC of 0.02 kg water/kg dry solids. This caused particle shrinkage of about 40% for all three types of casein which was brought about by both evaporation of moisture and contraction of the casein matrix. Below about 0.40 kg water/kg solids, the casein matrix no longer contracted significantly and the voids left by the evaporating moisture became air pores.

A pulsed NMR technique was used to obtain the self diffusion coefficient (D) and transverse relaxation time (T_2) of water in mineral acid, lactic and rennet casein particles, as well as the moisture distribution images within mineral acid casein particles. The self diffusion coefficient and transverse relaxation time for all casein types decreased with decreasing moisture content. But at the same moisture content the T_2 values for acid caseins were much higher than for rennet casein. This may be attributed to the extra mineral content of rennet casein. The maximum self diffusion coefficient of water within a casein particle was about 25% that of pure water. The T_2 of pure water was about 200 times that for acid caseins and 750 times for rennet casein. Moisture equilibration between particles took about 3 hours to reach an equilibrium D value which compares well with the value above. The proton density image within a wet casein particle showed regions of high moisture content and some regions of very low moisture content which may be air gaps.

The effects of temperature and time on casein colour and casein solubility in alkali were studied for a range of moisture contents. In general low moisture samples were more soluble than high moisture samples. However for holding temperatures up to $100^{o}C$ and holding time up to 2 hours, the maximum insolubility of casein occurred at a moisture content of around 0.43 kg water/kg dry solids. Casein colour was not affected by holding temperatures of up to $100^{o}C$ at holding times of up to one hour. However a 2 hour holding time at $100^{o}C$ caused severe discoloration of casein.

The implications of these results for commercial casein drying are discussed and a new design concept for casein dry processing is proposed.

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