Functionality of spray-dried whey protein powders - Surface composition, particle morphology and rehydration

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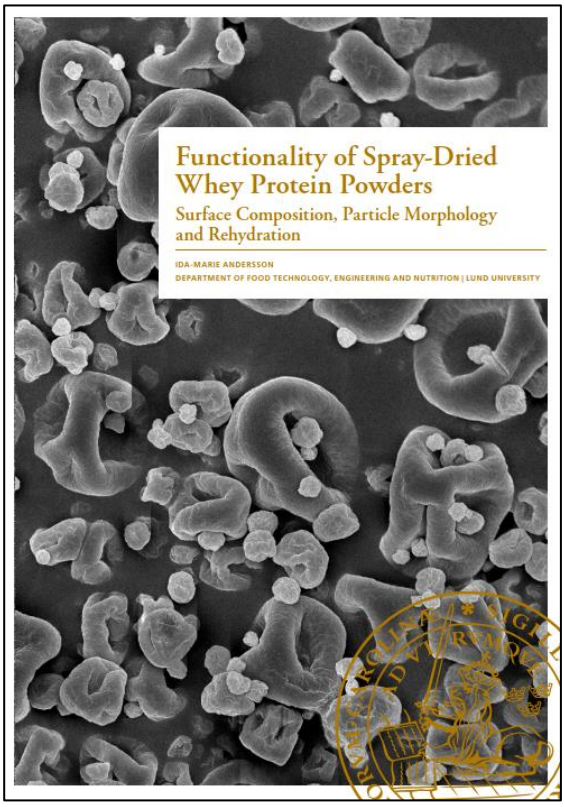

Abstract
Whey protein powder functionality is expected to be closely linked to both structure and properties of the proteins. It is essential that whey protein powders are easily dispersed and dissolved in order to fulfil the specified nutrient content and the functionality in the final product. Poor rehydration can cause challenges on an industrial level as well as for the consumers. In this thesis, several studies were carried out, examining the effects of varying the composition in the feed on surface properties, particle morphology and functional properties of spray-dried powders. A membrane filtered product, serum protein concentrate (SPC), with a high fraction of native proteins, was studied with varying lactose content using different techniques.

For SPC/lactose (% w/w) systems, the stiffness of the interface of the feed droplet had an impact on the particle morphology. Feed droplets with a high modulus of elasticity and, thus, a stiff interface resulted in particles with thick ridges and deep dents. Systems with a low modulus of elasticity resulted in particles that were either smooth or covered with a high frequency of dents and thin ridges. The time needed to obtain wettability of these powders showed a positive relationship with the protein surface coverage, which was estimated by X-ray photoelectron spectroscopy (XPS). Microstructural investigations of the internal structures of the particles with confocal Raman microscopy revealed that the protein-rich domain in the vicinity of the powder particle tended to become thinner as the bulk protein concentration increased in the powders. This suggests that the protein surface coverage has a more important role for the wettability than the thickness of the protein layer.

Scanned electron microscopy images revealed a similar particle morphology as the fraction of native proteins decreased from 100 to 45% as a result of heat treatment of the feed. However, the interior of the particle showed large differences where protein aggregates could be distinguished. The

results imply that the surface composition was rather similar. In addition, the rehydration properties of these powders were not affected to a large extent by the protein denaturation. However, in serum protein/lactose 40/60 (% w/w) powders with a large fraction of aggregated proteins (95%), it was observed that an addition of native proteins improved the wettability. Further, the results from the XPS indicated that the powders with <15% native protein had approximately 10-15% of denatured/aggregated proteins at the particle surface which could explain the poorer wettability of these powders.

Lactosylation of the native protein fraction had no effect on the rehydration properties of serum protein/lactose (% w/w) 1/99 and 60/40 powders even though the degree of lactosylation increased from 10 to 35% in some of the powders after storage (30°C, aw 0.23 for 25 days). On the other hand, it was observed that lactosylation was more pronounced in powders with a high fraction of proteins and not in the powders with a high fraction of lactose. It is suggested that the rate of lactosylation is higher in protein-rich domains with dissolved lactose than in lactose-rich domains with dissolved proteins.

Even though the feed was subjected to severe heat treatment and a large fraction of the protein aggregated, the rehydration properties and the particle morphology of the spray-dried powder was not affected to a large extent. Thus, as long as there are native proteins present in the system, they tend to dominate the particle surface and thereby protect the denatured and aggregated proteins, which are mainly found in the interior of the powder particles. This insight has relevance for formulation of whey powders with improved rehydration properties.