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Spray Dried Milk-Protein Stabilized Emulsions with High Oil Content

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Abstract

This study explores the behaviour of oil droplets in milk protein-stabilized emulsions during spray drying. The impact of preheat treatment on the stability of oil droplets during drying in milk protein-stabilized emulsions in maltodextrin was also observed, using a variety of techniques such as particle size analysis, various microscopy techniques and sodium dodecyl sulphate polyacrylamide gel electrophoresis. In the last section of the study, the stability of the powdered emulsions was investigated against oxidative deterioration when soybean oil was replaced with fish oil in the emulsion formulation.

The results showed that spray drying and redispersion of the powdered emulsions in water (at similar total solids content) caused a shift in the droplet size distribution to larger values for all emulsions made using low concentration of whey protein isolate or sodium caseinate (0.5–2.0%, w/w w.b.), in comparison with their respective parent emulsions. However, the droplet size distribution was affected only very slightly by spray drying when the protein concentration was above 2.0% (w/w). This minimum concentration of protein that was required to produce emulsions that were stable during the spray drying process was 3.0% (w/w) for the emulsions prepared using aggregated milk protein products as compared with 2.0% (w/w) for the NaCas- and WPI-containing emulsions.

It was suggested that the amount of unadsorbed protein in the bulk phase of the parent emulsions play a crucial role in stabilizing the oil droplets during spray drying. When the surface of the oil droplet is saturated with protein molecules and the bulk phase of the emulsion has sufficient unadsorbed protein, the oil droplet is

stable during drying. However, for emulsions with a low concentration of unadsorbed protein in the bulk phase ($\leq 1.0\%$ for WPI or NaCas emulsions), protein molecules could potentially migrate from the surface of the oil droplet to the air–water interface, causing “gaps” in the oil droplet interface and leading to coalescence and/or bridging flocculation.

Emulsions containing low levels of maltodextrin showed marked coalescence during spray drying and redispersion even at a WPI concentration of 10.0% (w/w). Above a critical concentration (12.0%, w/w), maltodextrin appeared to stabilize proteins at the interface and provide adequate rigidity to the matrix perhaps by forming a glass, under the drying conditions.

In whey protein-stabilized emulsions made with preheat treated protein solution (above 70°C), a shift was observed in average droplet diameter towards the larger size range, because of droplet coalescence as a result of spray drying. This was thought to probably be a result of protein aggregation in emulsions, which adversely affected the ability of proteins to stabilize the emulsion droplets during spray drying and further emphasized the crucial role of monomeric whey proteins. A reduction in the non-adsorbed monomeric whey proteins as a result of preheat treatment led to oil droplet coalescence during drying. The stability of the emulsion made with pre-heat treated whey proteins was noticeably improved when NaCas was added to the emulsion either before or after the homogenization step. This improved stability was believed to be a result of the steric effect of caseins that prevented large-scale aggregation of whey proteins.

The stability of emulsions during drying as shown by the change in the average droplet diameter before and after drying showed a negative correlation with

oxidative stability of these emulsion where soybean oil was replaced with fish oil. The protein content and preheat treatment also showed a positive impact on the oxidative stability of spray-dried emulsions.

Overall, the finding from this systematic study has advanced the understanding of the mechanisms of the stability of oil droplet during drying as well as the impact of emulsions components and processing conditions. This may help to design emulsion formulations and processes and extend the applications of milk-protein stabilized powdered emulsions with high oil content.

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Taneja, A., & Singh, H. (2012). Challenges for the delivery of long-chain n-3 fatty acids in functional foods. *Annual review of food science and technology*, 3, 105-123.

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