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Solid lipid nanoparticles and β-lactoglobulin – a multifaceted friendship

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The increased consumer awareness of health and nutrition leads to expanding demands for new food products like dairy-products that are fat-reduced or enriched with bioactive components. Enrichment of foods with bioactive substances such as vitamins, or antioxidants can be challenging, as these substances are often sensitive to environmental influences and/ or are hydrophobic. In order to enable the application of those bioactives in food nonetheless, carrier systems were developed, that stabilize the active substances, making them soluble in water and protecting them. However, the incorporation of such particulate carrier systems in protein-rich matrices like yoghurt or cheese can modify the perception and texture. It has been shown that particles can enhance or weaken the mechanical properties of protein gels, depending on their interactions with the surrounding protein matrix. Furthermore, earlier studies demonstrated that increasing building block sizes can lead to modified food texture such as increased elasticity and syneresis in protein gels. During the production of protein rich foods such as yoghurt or ricotta, processing steps like heating or acidification are passed. This can alter incorporated carrier systems and/ or interactions between protein and the carriers. The aim of this study was to estimate and explain the change of protein matrix properties as well as carrier systems after incorporation and processing of carrier system enriched protein suspensions. Two main questions were answered within this study: (1) How were SLN modified by BLG processing and network formation? (2) How do SLN influence the protein gel structure?

Protein gels and films consisting of cross-linked protein aggregates as building blocks were selected as model matrix. The well-studied protein *β-lactoglobulin* (BLG) as major whey protein was chosen as model protein. S*olid lipid nanoparticles* (SLN) served as model carrier system and were prepared by melt emulsification and were stabilized by lecithin and sucrose palmitate. Additionally, Tween 20 or BLG were used as third emulsifiers. Based on the literature, it was assumed that Tween 20 would inhibit interactions between SLN and BLG, whereas BLG promoted would promote interactions. SLN stabilized by BLG (BS) or Tween 20 (TS) were added to BLG-solution, subjected to heat treatment, and cold-set gels were formed by lowering the pH-value. Protein adsorption on SLN before and after heat treatment was investigated by ultrafiltration and investigation of particle sizes. SLN and gels were characterized regarding free BLG, size, shape and zeta-potential or regarding syneresis, and mechanical properties, respectively.

At room temperature, a cloudy layer (soft corona) was formed around both BS and TS. As expected, BLG adsorbed on the surface of BS (hard corona), whereas TS did not achieve a hard corona. Upon heat treatment, the particle sizes of TS increased to about 3.5fold of the initial size due to coalescence, in the presence and absence of BLG. Interestingly, the heat treatment of TS in the presence of excess BLG led to the formation of an adsorption layer around TS, allowing interactions between TS and surrounding BLG. Therefore, weak interactions between adsorbed BLG and surrounding BLG could occur and prevented the weakening of the gels that is typically caused by unbound particles. Nevertheless, TS were still expelled during syneresis. In sum, TS added to BLG increased in size upon heat treatment but were still present as individual particles, that weakly interacted with the surrounding matrix. TS-filled BLG gels showed an overall fine-stranded network with few irregularities.

In contrast, BS were heat-stable, and the heat treatment of BS in the presence of excess BLG led to aggregates, in which BS were incorporated. Young's Moduli of BS filled gels increased with increasing BS contents, which is a typical matrix response to the presence of bound particles or/ and a dense network. SEM-images of BS-BLG gel networks showed a dense and fine-stranded network with small ramifications. This demonstrated the contribution of BS as part of BLG gel structures. Summarizing, BLG networks filled with BS exhibited a fine stranded gel network, in which BS were part of the network.

In sum, this thesis demonstrated that SLN can be incorporated in protein rich matrices without losing the structure neither of the BLG matrix nor of the SLN. Heat treatments and emulsifiers typically used to stabilize SLN had an influence on SLN stability and distribution within the matrix as well as on BLG structures. The findings in this thesis emphasize the importance of the choice of emulsifiers to stabilize carrier systems and the knowledge of their interactions with the surrounding ingredients. This knowledge can be used to design the properties of protein matrices in a targeted way.