Coalescence of droplets stabilized by potato protease inhibitor: Microfluidic investigation on the effect of temperature and adsorption time on protein functionality

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The main product extracted from potatoes is starch. However, the leftover liquid has a high protein content, and is a potential source for alternative proteins. Particularly protease inhibitors show strong potential as natural emulsifiers for food applications. Their functionality, however, is highly sensitive to processing conditions during food production such as thermal treatment, and the process used to obtain these ingredients. Besides, the functionality of proteins is generally not known under the conditions at which they are applied. That is why we have used a microfluidic technique to investigate droplet stability under relevant conditions.

In this study, we focus on the protease inhibitor fraction of the potato protein Solanic 300 and its ability to stabilize oil-water interfaces under varying thermal conditions. We employ a custom-designed microfluidic chip (Figure 1) to investigate protein-stabilized emulsion droplet coalescence at millisecond timescales. The system enables precise control over droplet formation at a T-junction (highlighted in light blue), followed by real-time observation of droplet interactions within a coalescence chamber (medium to dark blue). This setup allows us to mimic and monitor the behavior of emulsions during food processing with unprecedented temporal and spatial resolution.

In this study, we examined the impact of heating (55, 65, and 75 °C) on the interfacial behavior of protease inhibitor fractions in both spray-dried (S300) and liquid (S300L) forms. Droplet stability was assessed at millisecond timescales. The effect of concentration and adsorption time (varied through the length of the adsorption channel as shown in figure 1, right side) were investigated. The results revealed that for the spray dried protein at lower concentrations, droplet stability decreased upon heating at 55 and 65 °C compared to non-heated samples, but improved markedly at 75 °C. In contrast, the liquid protein exhibited enhanced droplet stability at 55 °C and 65 °C relative to the control, with further improvement at 75 °C. Adsorption studies indicated that droplet stability generally increased with adsorption time for both samples; however, the spray-dried protein heated at 75 °C showed no change with time, an observation that appears unprecedented. We were able to connect this to differences in protein structure and conformation, caused by the isolation process as well as the heating temperature, as evidenced by surface hydrophobicity and circular dichroism spectroscopy measurements of the proteins. This shows that the process used to obtain the proteins has considerable influence on their operational functionality, and that the process used to make the emulsions can be tuned to facilitate droplet stability. Both aspects that are quantified in this work allow food designers to make informed choices on the use of this specific alternative protein. The approach can obviously be used in a much wider perspective, e.g., as a screening tool for new protein sources, as well as existing ones.

Keywords:
Potato proteins, Emulsion stability, Food emulsions, Protein processing

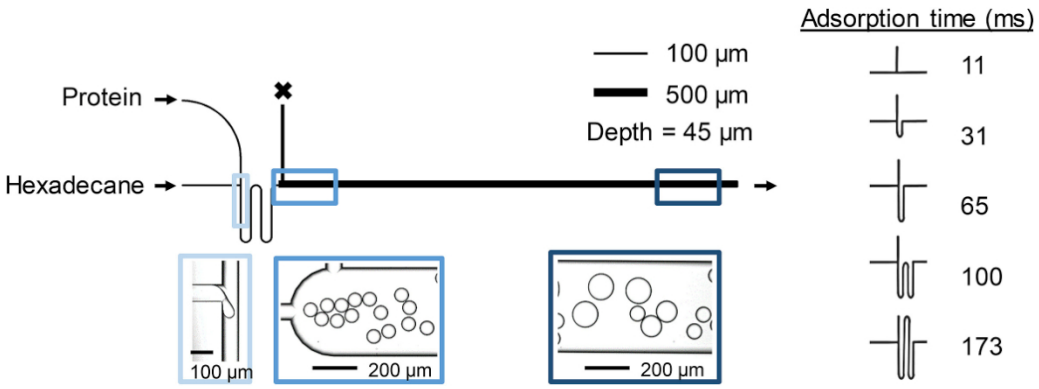

Figure 1: Schematic representation of microfluidic chip

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