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Effect of processing conditions and composition on sodium caseinate emulsions stability

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Abstract

Many food products such as ice cream, yoghurt, and mayonnaise are some examples of emulsion-based food. The physicochemical properties of emulsions play an important role in food systems as they directly contribute to texture, sensory and nutritional properties of food. One of the main properties is stability which refers to the ability of an emulsion to resist physical changes over time. The aim of the present work was to analyze the effect of processing conditions and composition on sodium caseinate (NaCas) emulsions stability. The main destabilization mechanisms were identified and quantified. The relationship between them and the factors that influence them were also investigated. Emulsions stabilized with NaCas were prepared using an ultrasound liquid processor or a high pressure homogenizer. Stability of emulsions was followed by a Turbiscan (TMA 2000) which allows the optical characterization of any type of dispersion. The physical evolution of this process is followed without disturbing the original system and with good accuracy and reproducibility. To further describe systems, droplet size distribution was analyzed with light scattering equipment. The main mechanism of destabilization in a given formulation depended on different factors such as NaCas concentration, droplet size or processing conditions. The rate of destabilization was markedly lower with addition of sugar or a hydrocolloid to the aqueous phase. Xanthan (XG) and locust bean (LBG) gums produced an increase in viscosity of the continuous phase and structural changes in emulsions such as gelation. Sugars interacted with the protein decreasing particle size and increasing emulsion stability. The stability of caseinate emulsions was strongly affected not only by the oil-to-protein ratio but also by processing conditions and composition of aqueous phase. The structure of the protein and the interactions protein–sugar or the presence of a hydrocolloid played a key role in creaming and flocculation processes of these emulsions.

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Keywords: Stability; Turbiscan; droplet size; sugars; hydrocolloids

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1. Introduction

Emulsions are commonly encountered in food systems. Many traditional food products such as ice cream, low-fat spreads, yoghurt, mayonnaise, cake batters, whipped toppings, dairy creamers and cream liqueurs are some examples of emulsion-based food. The physicochemical properties of emulsions play an important role in food systems as they directly contribute to texture, sensory and nutritional properties of food. One of the main properties is stability which refers to the ability of an emulsion to resist changes in its properties over time. Physical instability results in an alteration in the spatial distribution or structural organization of the molecules. Creaming, flocculation, coalescence, partial coalescence, phase inversion, and Ostwald ripening are examples of physical instability. The development of an effective strategy to prevent undesirable changes in the properties of a particular food emulsion depends on the dominant physicochemical mechanism(s) responsible for the changes. In practice, two or more of these mechanisms may operate in concert. It is therefore important for food scientists to identify the relative importance of each mechanism, the relationship between them, and the factors that influence them, so that effective means of controlling the stability and physical chemical properties of emulsions can be established [1].

Most dispersed multiphase systems are thermodynamically unstable per se and thus require stabilization. In the food industry, actually stabilization of emulsions is obtained by the addition of proteins. NaCas is widely used as an ingredient due to its functional properties, which include emulsification, water and fat-binding, thickening and gelation [2]. The addition of this protein has a double stabilizing effect since it provokes together with other added surfactants an increase of both viscosity of the continuous phase and stability of the interface.

Emulsions have been studied by numerous techniques, such as particle sizing, microscopy, rheology, among others, to characterize their physical properties. Most of these techniques involve some form of dilution. This dilution disrupts some structures that contribute to destabilization. The ability to study the stability of food emulsions in their undiluted forms may reveal subtle nuances about their stability. A relatively recently developed technique, the Turbiscan method, allows scan the turbidity profile of an emulsion along the height of a glass tube filled with the emulsion, following the fate of the turbidity profile over time. The analysis of the turbidity profiles leads to quantitative data on the stability of the studied emulsions and allows making objective comparisons between different emulsions [3].

The aim of the present work was to analyze the effect of processing conditions and composition on sodium caseinate emulsions stability. The main destabilization mechanisms were identified and quantified. The relationship between them and the factors that influence them were also investigated.

2. Materials and Methods

Emulsions stabilized with 0.5, 2 or 5 wt.% sodium caseinate, with or without 20 or 30 wt.% sucrose or trehalose or xanthan or locust bean gum aqueous phase solution, and 10 wt.% sunflower oil as fat phase were prepared by further homogenize a coarse emulsion (ultraturrax) with an ultrasound liquid processor or with a high pressure homogenizer. The emulsion stability was analyzed using a vertical scan analyzer Turbiscan MA 2000 which was described elsewhere [4]. This equipment allows the optical characterization of any type of dispersion [5]. The samples were scanned from the bottom to the top in order to monitor the optical properties of the dispersion along the height of the sample placed in the cell. In this way, the physical evolution of this process is followed without disturbing the original system and with good accuracy and reproducibility. Thus, by repeating the scan of a sample at different time intervals, the stability or the instability of dispersions can be study in detail. The profiles allow calculation of either creaming, sedimentation, or phase separation rates, as well as flocculation, and the mechanism making the dispersion unstable can be deduced from the transmission or the backscattering data [3].