Original article

Effect of oil content and processing conditions on the thermal behaviour and physicochemical stability of oil-in-water emulsions

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Summary
The destabilisation mechanism of oil-in-water (o/w) emulsions was studied as a function of oil content (20% and 40% o/w), homogenisation conditions and crystallisation temperatures (10, 5, 0, −5 and −10 °C). A mixture of anhydrous milk fat and soya bean oil was used as the lipid phase and whey protein isolate (2 wt%) as emulsifier. Crystallisation and melting behaviours were analysed using differential scanning calorimetry. Physicochemical stability was measured with a vertical scan macroscopic analyser. Emulsions with 20% oil were found to be less stable than those with 40% oil. For 20% o/w emulsions, the crystallisation was delayed and inhibited in emulsions with smaller droplets and promoted in emulsions with larger droplets when compared with 40% o/w emulsions. Depending on the droplet sizes in the emulsion, the formation of lipid crystals (in combination with the emulsifier) either stabilises (small droplets) or destabilises (big droplets) the emulsion.

Keywords Anhydrous milk fat, destabilisation mechanism, oil content, oil-in-water emulsions, soya bean oil.

Introduction
Consumer demand for trans-fat-free products has increased over the years. Since January 2006, the United States requires trans-fat information to be included on nutrition labels. This requirement was a consequence of the association between trans-fatty acids, coronary heart disease (CHD) and the increase of undesirable LDL (Aro et al., 1997; Hu et al., 2001; Tarrago-Trani et al., 2006). As a result of the harmful effects of trans-fatty acids, healthy lipid alternatives are being sought. For items such as salad dressings, mayonnaise and baked goods (where trans-fat is prominent), an appropriate fat emulsion substitute is desirable. A possible substitute would be anhydrous milk fat (AMF), which is already known as a butter replacement and can easily be used in an oil blend (Bylund, 2003). AMF is known to be high in stearic acid, which has been shown to have a neutral effect on CHD, unlike other saturated fats which contribute to CHD and increased levels of LDL (Aro et al., 1997; Tarrago-Trani et al., 2006). Besides fat composition, AMF has good sensory attributes such as flavour and mouthfeel (Kaylegian et al. (1993)). Blending AMF with vegetable oils [i.e. soya bean oil (SBO)] can decrease the amount of saturated fats while maintaining functional and sensory attributes.

Emulsions are thermodynamically unstable systems. Emulsifiers are used to avoid or delay phase separation and to increase emulsion stability. Whey protein has been found to be an effective stabilising agent (Thanasukarn et al., 2006; Kiokias et al., 2007). The combination of AMF, SBO and whey protein creates a blend of nutritive components to substitute for trans-fat in foods. By replacing one ingredient (i.e. trans-fat) with another, the quality of the product is at risk. Therefore, it is crucial to understand the substitute’s attributes and how they change, given the various processing conditions. Understanding the different aspects of emulsion destabilisation leads to creating innovative new products and updating the ones that are not meeting consumer demands. Studies have been performed on the effect of crystal formation in oil-in-water (o/w) emulsions (Coupland, 2002). However, to the best of our knowledge, very few studies provide a systematic approach to address the specific effects of processing conditions, such as crystallisation temperature, oil content and homogenisation on the stability mechanisms and destabilisation kinetics of the emulsion (Marquez et al. (2004)).

The aim of this research is to study the effect of oil content and processing conditions (homogenisation and crystallisation temperature) on the physicochemical stability of o/w emulsions.