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Freeze–thaw stability of edible oil-in-water emulsions stabilized by sucrose esters and Tweens

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ABSTRACT

This work aimed to investigate freeze thaw stability of 20 wt% coconut oil (*CtO*) and corn oil (*CnO*)-in-water emulsions stabilized by 1 wt% of various types of sucrose esters and Tweens. Sucrose esters composed mainly of sucrose monostearate (*S1670*), sucrose monopalmitate (*P1670*), sucrose monolaurate (*L1695*), Tween 20 (*TW20*), Tween 60 (*TW60*), and Tween 80 (*TW80*) were used. After all emulsions were frozen at $\sim -20 \pm 2$ °C and thawed to room temperature, their stability was analyzed from visual appearance, optical micrographs, amounts of destabilized oil, and average particle sizes. The *CtO* emulsions stabilized by *S1670* and *P1670* were very stable, the *CtO* emulsions stabilized by *L1695* partly destabilized, and the *CtO* emulsions stabilized by *TW20*, *TW60*, and *TW80* mostly destabilized into oil layers separated on top. The excellent stability of *CtO* emulsions stabilized by *S1670* and *P1670* was also confirmed from similar thermograms obtained from differential scanning calorimeter after three cooling–heating cycles (40 °C to −40 °C to 40 °C at 5 °C/min). It was proposed here that *S1670* and *P1670* affected the interfacial fat crystallization and their interfacial layers protected *CtO* emulsions against partial coalescence. Differently for the case of *CnO* emulsions, the *CnO* droplets remained liquid during freezing. All *CnO* emulsions stabilized by any emulsifiers destabilized by coalescence since these small surfactants could not provide enough interfacial barriers.

1. Introduction

Many types of foods are in the form of oil-in-water emulsions e.g. milks, creams, dressing, desserts, and sauces, and sometimes, the frozen storage is required to increase the shelf life of products. Because of thermodynamic instability of emulsion systems, they easily destabilize after thawing. During a freeze–thaw cycle, liquid–solid–liquid phase transition of both lipid and water in emulsion creates interfacial stress, the membranes coated around oil droplets may rupture. Consequently, oil droplets can merge or coalesce in the thawed emulsion, and eventually break down into oil layers separated on top. For decades, the mechanisms and factors that govern freeze thaw stability of emulsions have been investigated (Ghosh and Coupland, 2008).

Several studies investigated freeze thaw stability of emulsions prepared from different types of oils; for example, a series of n-alkane (Cramp et al., 2004); n-hexadecane and confectionary coating fat (Vanapalli et al., 2002); sunflower oil, high oleic sunflower oil, corn oil, soy oil, rapeseed oil, and medium chain triglyceride oil (Magnusson et al., 2011); and hydrogenated palm kernel oil and sunflower oil (Cornacchia and Roos, 2011). The freeze thaw stability of emulsions was found to depend on the chain length of oil, the amounts of saturated and unsaturated fatty acids, the solid fat content, the size and structure of fat crystals, and the sequence of crystallization events between oil and water. The presence of solidified fat crystals in oil droplets induced partial coalescence, increasing tendency of emulsions to coalesce and destabilize (Coupland, 2002; Fredrick et al., 2010; McClements, 2012).

Effects of emulsifier types on freeze thaw stability of emulsions were widely investigated (Cramp et al., 2004; Palanuwech and Coupland, 2003; Palazolo et al., 2011; Thanasukarn et al., 2004). Generally, small molecular surfactants could not provide enough emulsion stability toward freeze–thaw process, while proteins provided thicker interfacial membranes and created emulsions with a better stability. For example, Thanasukarn et al. (2004) found that, when only fat crystallization occurred, the hydrogenated palm oil emulsions containing Tween 20 destabilized, but the emulsions stabilized by casein and whey protein isolate were stable. Similarly, Palanuwech and Coupland (2003) found that the confectionery coating fat emulsions stabilized by sodium dodecylsulfate,

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