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Comparison of emulsifying properties of milk fat globule membrane materials isolated from different dairy by-products

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ABSTRACT

Emulsifying properties of milk fat globule membrane (MFGM) materials isolated from reconstituted buttermilk (BM; i.e., BM-MFGM) and BM whey (i.e., whey-MFGM), individually or in mixtures with BM powder (BMP) were compared with those of a commercial dairy ingredient (Lacprodan PL-20; Arla Foods Ingredients Group P/S, Viby, Denmark), a material rich in milk polar lipids and proteins. The particle size distribution, viscosity, interfacial protein, and polar lipids load of oil-in-water emulsions prepared using soybean oil were examined. Pronounced droplet aggregation was observed with emulsions stabilized with whey-MFGM or with a mixture of whey-MFGM and BMP. No aggregation was observed for emulsions stabilized with BM-MFGM, Lacprodan PL-20, or a mixture of BM-MFGM and BMP. The surface protein load and polar lipids load were lowest in emulsions with BM-MFGM. The highest protein load and polar lipids load were observed for emulsions made with a mixture of whey-MFGM and BMP. The differences in composition of MFGM materials, such as in whey proteins, caseins, MFGM-specific proteins, polar lipids, minerals, and especially their possible interactions determine their emulsifying properties.
Key words: milk fat globule membrane, emulsifying property, emulsion

INTRODUCTION

Emulsifying properties of milk-derived components influence the physicochemical characteristics of dairy emulsions. Skim milk powder, sweet buttermilk (**BM**) powder, butter-derived serum phase, whey proteins, casein dispersions, phospholipids, and purified milk fat globule membrane (**MFGM**) suspensions have been successfully used to make emulsions (Tomas and Paquet, 1994; Elling et al., 1996; McCrae et al., 1999).

In recent years, interest has increased in gathering knowledge on the composition and properties of MFGM materials. Milk fat globule membrane materials are found in quite significant amounts in different dairy products, such as cream, butter, BM, BM whey, and cheese. The unique functionality of MFGM-enriched materials has led to research and development of techniques to isolate, purify, and apply the materials in different food emulsions (Singh, 2006). The serum phase as by-product from churning cream into butter is known as BM. It is rich in MFGM fragments and contains all water-soluble components from the milk, such as lactose, caseins, and whey proteins. Buttermilk whey is obtained from BM after coagulating and removing casein micelles, a process applied in production of some special cheese and in caseinate manufacturing. Buttermilk whey still contains some residual fat and consists of lipoprotein particles, MFGM fragments, and small fat globules (Rombaut and Dewettinck, 2007b). Proper utilization of these cheap by-products to isolate the functional MFGM material and subsequent application of the material in the development of new products has great economic and technological value. Besides some by-products of the dairy industry, Lacprodan PL-20 (Arla Foods Ingredients Group P/S, Viby, Denmark) is a dairy formulation enriched with polar lipids and proteins. It has potential as a market alternative to semi-synthetically head-group-exchanged soy phospholipids because it is a natural source for phosphatidylserine. Moreover, Lacprodan PL-20 can be used as an active health ingredient in functional foods, such as drinks, ice creams, and chocolate (Burling and Graverholt, 2008).

According to the results of Corredig and Dalgleish (1997), MFGM-enriched materials isolated from industrial BM were poor emulsifiers for soy oil-in-water emulsions compared with those isolated from fresh cream. The type of starting material, pretreatment, and method of separation have a significant effect on

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the composition of MFGM isolates and, consequently, on their emulsifying properties (Kanno, 1989; Kanno et al., 1991). Wong and Kitts (2003) as well as Corredig and Dalgleish (1997) found that commercial BM had inferior emulsifying and stabilizing capacity compared with nonfat dried milk. Roesch et al. (2004) studied the emulsifying properties of commercial BM powder (**BMP**) and the MFGM fragments obtained by microfiltration (**MF**) of reconstituted BM. The emulsions made with the MFGM isolate were found to have good stability against creaming; the small particle size distribution pattern increased with MFGM concentration, whereas a similar emulsion prepared with BM concentrate showed extensive flocculation. Phan et al. (2013) also found that MFGM fragments concentrated from reconstituted BM using MF had better emulsifying and stabilizing properties compared with BMP, skim milk powder, and sodium caseinate.

From the reports cited above, it appears that processing conditions in dairy processing influence differently the nature of MFGM materials in the derived by-products and that their MFGM isolates differ in composition (of polar lipids and proteins) and in their technological functionalities. Milk fat globule membrane-specific proteins are amphiphilic molecules that can act as surface-active compounds (Singh, 2011). Polar lipids are also known to be good emulsifiers (Kanno, 1989; Dewettinck et al., 2008). Many investigators have been successful in isolating MFGM fragments, which contain high concentrations of polar lipids and specific membrane proteins, from by-products of dairy industrial processing. However, whether proteins or polar lipids are responsible for the emulsifying activity is unclear. The competitive adsorption between the proteins and polar lipids at the interface during emulsification has not been studied. It is also unclear how the emulsifying properties are modified by possible interactions between MFGM materials and other components (e.g., whey proteins, caseins, and minerals). To get a better understanding of the role of MFGM components, in the current study, the properties of emulsions made with different MFGM materials and mixtures of MFGM and the initial material (BMP) were investigated.

MATERIALS AND METHODS

Materials

Buttermilk powder was obtained from FrieslandCampina (Lummen, Belgium). Buttermilk whey was obtained from a local dairy company (Büllinger Butterei NV, Büllinger, Belgium). Lacprodan PL-20 (a spray-dried powder, rich in milk phospholipids and proteins) was kindly provided by Arla Foods Ingredients Group P/S. Soybean oil was purchased from a local supermarket.

Isolation of the MFGM Materials

Reconstituted BM was prepared according to Le et al. (2011b). Trisodium citrate (1%, wt/wt) was added to dissociate casein micelles into casein components that were small enough to permeate the membrane during the filtration process (Corredig et al., 2003; Rombaut et al., 2006). For BM whey, the pH was adjusted to 7.5 by adding 1 *N* KOH before MF (Rombaut et al., 2007a). Cross-flow MF was performed in combination with continuous diafiltration (the rate of water addition was equal to the permeate rate) to separate the MFGM fragments from the 2 materials (reconstituted BM and BM whey; Phan et al., 2013). The materials obtained from reconstituted BM and BM whey after MF were designated BM-MFGM and whey-MFGM, respectively. The BM-MFGM and whey-MFGM were freeze-dried (VaCo 5-D; Zirbus Technology GmbH, Bad Grund, Germany) to obtain a water-free MFGM-enriched powder. For further analysis and emulsion preparation, the MFGM-enriched powder was stored below −20°C.

Compositional Analysis

The DM content of the experimental materials was determined by gravimetric difference after heating at 105°C (IDF, 2004). The total protein content of the samples was determined by the Kjeldahl method (IDF, 1993) using 6.38 as a conversion factor. The Röse-Gottlieb method (gravimetric determination) was used to determine the total fat content (IDF, 1986). Total ash content of the samples was determined according to the procedure of the Association of Official Analytical Chemists (AOAC, 1984). The polar lipids were extracted and analyzed according to the method of Le et al. (2011a), using a Shimadzu HPLC system (Shimadzu Corp., Tokyo, Japan) with an evaporative light-scattering detector (Alltech-3300; Alltech Associates Inc., Lokeren, Belgium). The method and the calculations used to determine protein using SDS-PAGE have been described by Le et al. (2009) and Phan et al. (2013).

Emulsion Preparation

To compare the emulsifying properties of MFGM material and the interaction between MFGM material and other components (caseins and whey proteins) the following materials were used to stabilize oil-in-water emulsions [35% (wt/wt) soybean oil]: BM-MFGM, whey-MFGM, Lacprodan PL-20, or mixtures composed of the MFGM material and BMP. For emulsions pre-