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Vegetable organogels incorporation in cream cheese products

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ABSTRACT

Edible oleogels made from rice bran wax (RBW) or ethylcellulose (EC) organogelators in combination with vegetable oils and other non-fat ingredients were used to produce oleogel cream cheese products. Four oleogel cream cheese products, two containing RBW and two with EC, were prepared and compared to control samples including full-fat and fat-free commercial cream cheese samples. Upon compositional analysis, all the oleogel cream cheese (OCC) samples showed approximately a 25% reduction in total fat content in comparison to the full-fat commercial control. More specifically by the replacement of saturated fat with healthier unsaturated fat alternatives, an improved fatty acid profile of cream cheese products was documented. Similar compositional analysis was also performed on a cream cheese sample made with non-gelled vegetable oil. Using a single penetration test and a strain sweep test, oleogel cream cheese samples prepared with RBW displayed comparable hardness, spreadability, and stickiness values to the full-fat commercial control sample. EC OCC samples also showed comparable hardness, spreadability and stickiness values but exhibited reduced adhesiveness values compared to the full-fat control. The successful microstructural incorporation of oleogels into a cream cheese, along with similarities in fat globule size, between OCC samples and commercial controls was confirmed with Confocal Laser Scanning Microscopy. The similarity in microstructure can be accounted for the similarities in textural properties between the OCC samples and the full-fat control. These results provide a thorough characterization of the use of RBW and EC in oleogels and their potential as a healthy alternative to saturated fat in cream cheese applications.

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1. Introduction

The demand for low-fat and fat-free food products has become more than just a trend ever since these products were introduced in U.S. markets. Consumers have become increasingly aware of the association between the etiology of certain chronic diseases (obesity, cardiovascular disease, and cancer) depending on the amount and type of fat consumed (Romeih, Michaelidou, Biliaderis, & Zerfiridis, 2002). Although the harmful effects of some saturated fats are in debate, numerous studies have confirmed that it is best to minimize the daily intake of saturated fats food (Mensink, Zock, Kester, & Katan, 2003). Conversely, poly and mono unsaturated fats (PUFAS and MUFAS) have been shown to increase high-density lipoprotein (HDL) ("good cholesterol") levels and decrease low-density lipoprotein (LDL) ("bad cholesterol") levels and are therefore thought to decrease the risk of contracting heart disease (Mensink et al., 2003; Roche, 2005). This association has been the driving force behind the expansion of low fat and low saturated fat dairy products.

However the removal of fat and changing fat type, remains a challenge since it adversely affects the flavor, texture, and appearance of low-fat products (He, Xue Ming, & Shi Dong, 2008). For example, reduced fat cheeses are reported to be firm and less elastic compared to their full-fat counterparts (Emmons, Kalab, & Larmond, 1980). In addition, low fat cheeses are characterized by rubbery texture, off-flavor, poor meltability, and undesirable color (Lashkari, Khosrowshahi, Madadlou, & Alizadeh, 2014).

Fat replacers, often carbohydrate-based compounds, are frequently used to replace natural fats in cheese with the objective of reducing the caloric value (Romeih et al., 2002). While using fat replacers such as pectin gels and gums can be an effective way to create a low-fat cheese product, there are problems that arise in the formulation of these products. On the other hand, direct substitution of saturated fats with liquid oils composed of MUFAS and PUFAS does not lead to food products with comparable textural attributes (Youssef & Barbut, 2009; Zetzl, Marangoni, & Barbut, 2012) because saturated fats are typically responsible for creating desirable rheological properties and mouthfeel in various foods such as dairy and meat products.

One of the most recent oil structuring techniques being explored involves the use of edible organogels in structuring liquid oils (Co & Marangoni, 2012; Zetzl et al., 2012). Organogelators such as wax esters, monoacylglycerols (MAGS), 12-hydroxystearic acid (12-HSA), are used in place of the traditional triacylglycerol crystalline fat networks, to create a 3-D gel-like substance (Marangoni & Garti, 2011; Rogers, Wright, & Marangoni, 2008; Zetzl & Marangoni, 2011).

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A limited number of studies have structured vegetable oils (composed of PUFAS and MUFAS) with different edible organogels and incorporated these gels into food systems (Patel et al., 2014; Stortz & Marangoni, 2013; Zetzl et al., 2012; Zulim Botega, Marangoni, Smith, & Goff, 2013). These works have evaluated the rheological characteristics of edible oleogels matrices under a variety of conditions and found them to be a potential replacement for saturated fatty acids in food systems (Co & Marangoni, 2012). Zulim Botega et al. (2013) reported that RBW oleogel was effectively emulsified into low saturated fat ice cream mix and led to the formation of small fat droplets and gelled droplets. The level of fat destabilization between the RBW oleogel ice creams and milk fat controls were comparable (Zulim Botega et al., 2013). In another study, when EC was used in the formulation of canola oil organogel to replace saturated fat in frankfurters, the organogel produced a product that was not statistically different in either hardness or chewiness when compared to the hot dogs made with beef fat (Zetzl et al., 2012).

An investigation was conducted into the use of shellac oleogels as a replacer for oil binder in chocolate paste as well as a structurant alternative to shortening in cake formulation (Patel et al., 2014). Chocolate paste made with shellac oleogel was stored at 30 °C and showed no signs of "oiling out" even after 4 weeks, suggesting that the replacement the oil binder with the oleogel did not have any effect on the physical stability of the paste (Patel et al., 2014). Cakes also prepared with shellac oleogel had comparable firmness and cohesiveness values to cakes made with margarine (Patel et al., 2014).

The recent developments of oleogel food products encouraged us to further investigate their usage in other food products such as cream cheese. The objective of this study was to incorporate an oleogel, initially combined with skim milk, into a cream cheese product using edible oleogels, made from rice bran wax (RBW) or ethylcellulose (EC) and liquid vegetable oils. Rheological and textural properties of the oleogel cheese product were evaluated and compared to different commercial cream cheese products.

2. Materials and methods

2.1. Materials

Skim milk, soybean oil, salt, and non-fat dry milk (NFDM) were purchased from a retail food market. High-oleic soybean oil (HOSO) was acquired from Bunge (St. Louis, MO). Ethylcellulose (EC) and rice bran wax (RBW) were provided by Dow Chemical Company (Hebron, OH) and Koster Keunen (Watertown, CT), respectively. Whey protein isolates (WPI) and starter cultures containing rennet were obtained from Hilmar Cheese Company (Hilmar, CA) and Cultures for Health (Sioux Falls, SD), respectively. All gums were kindly provided by TIC gums (White Marsh, MD). Fast green FCF and Nile red were acquired from Fisher Scientific (Waltham, MA, BP123-10), and Sigma- Aldrich (St. Louis, MO), respectively. Two commercial cream cheese spread samples, original (full-fat) and fat free cream cheese, were purchased from local grocery stores.

2.2. Processing techniques for preparation of oleogel cream cheese products

Four oleogel cream cheese (OCC) samples labeled as EC1, EC2, RBW1, and RBW2 were prepared and analyzed in this study. Ethylcellulose (EC. 45 cP) was used as the structuring agent for high-oleic soybean oil and regular soybean oil to prepare samples EC1 and EC2, respectively. Following the method described by Zetzl and Marangoni (2011), a 10:90 w/w mixture of ethylcellulose and vegetable oil was made and heated (25 °C/min) above the glass transition temperature (130 °C for EC). The samples were cooled from 130 °C to 75 °C at 10 °C/min. Once the gel had formed upon cooling to 75 °C, the heated skim milk, whey protein isolate (0.5 and 2% w/w), and non-fat dry milk (8 and 10% w/w) were added. The mixture was blended using a two-speed Waring Laboratory Blender (Waring Pro Products, Odessa, FL) on the "high" setting. Samples were cooled to 30 °C and about 1.5% (w/w) *Lactococcus lactis* subsp. *Lactis*, *L. lactis* subsp. *Cremoris* culture and rennet were added. Samples were then allowed to coagulate for approximately 14–16 h, followed by a 12 hour-long whey drain. Both coagulation and whey drain occurred at 22 °C. Samples were then refrigerated at 4 °C for 12 h and salt (0.2 and 0.5% w/w), gums (0.5% w/w) (xanthan and guar), were then added to the products. All the oleogel cream cheese samples were prepared in triplicate and were transferred for further analysis. Using rice bran wax as the oil structuring agent instead of ethylcellulose, samples RBW1 & RBW2 were prepared in a similar manner, with a few minor differences. Rice bran wax was combined with vegetable oil and heated above the melting point of rice bran wax (85 °C) with moderate mixing at 300 RPM. The main differences between samples RBW1 and RBW2 is that RBW1 contains 10% (w/w) NFDM while RBW2 contains only 8% (w/w) NFDM. The remainder of the procedure for samples EC1 and EC2 is identical to that illustrated above.

Two commercial cream cheese spreads including a full-fat and a fat-free cream cheese spread (labeled as P1 and P2, respectively) were utilized as control samples. Moreover, a third control sample (named as P3) was also prepared using non-gelled vegetable oil in place of oleogelled oils. For the non-gelled control 10% of high-oleic soybean oil was combined with 79% (w/w) skim milk and heated to 85 °C at a rate of 25 °C/min with moderate shearing (300 RPM). Once the sample was heated, 1% (w/w) of whey protein isolates and 10% (w/w) of non-fat dry milk were added to the solution and blended on "high" setting. The remainder of the processing for the non-gelled sample was similar to the procedure described in oleogel cheese samples.

2.3. Analysis of cream cheese samples composition

Analysis of cream cheese samples' composition, including moisture, total non-fat solids, and fat, were conducted with a CEM Smart Trac II machine (CEM Corporation, Matthews, NC). The samples were analyzed in triplicate as described by the Association of Analytical Communities (AOAC) method for dairy products (Cartwright, McManus, Leffler, & Moser, 2005). This method involves placing a CEM sample pad on the balance component within the "CEM Smart System." 2.2–2.5 g of samples were spread and covered between two sample pads. "CEM Smart System" was used to dry the sample (Cartwright et al., 2005). The dried sample was folded and rolled into a CEM "trac tube," placed in the "Smart Trac" system. The "Smart Trac" system used Low-Resolution Time Domain Nuclear Magnetic Resonance (LR-NMR) to evaluate the "transverse relaxation" of the lipid protons, thus yielding the sample fat content (Cartwright et al., 2005).

To determine if syneresis had occurred, the moisture content of RBW1 and RBW2 samples were measured over Days 1, 2, 3, 7 and 10 using the method described above.

2.3.1. pH measurements of the cream cheese samples.

Using an Accumet pH meter 25 (Fisher Scientific, Waltham, MA) all the samples pH values were measured.

2.4. Confocal laser scanning microscopy

Olympus FV 1000 Spectral Confocal microscope system (Olympus Corporation, Tokyo, Japan) was utilized with a 40× oil-immersion objective to image the microstructure of the samples. Nile Red (prepared as a 0.02 g/L solution in acetone) and Fast Green FCF (prepared as a 0.1 g/L solution in distilled water) was used to dye the lipid components and the protein content of the samples, respectively (Gallier, Gragson, Jiménez-Flores, & Everett, 2010). 10 μL of each dye solution was mixed with 25 mg of the cheese products and stored at 4 °C for 24 h. The mixture was then spread evenly on a superfrost, pre-cleaned slide and covered with a cover glass (22 × 22) (Fisher Scientific, Pittsburgh, PA). Two