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Effect of fat content on the physical properties and consumer acceptability of vanilla ice cream

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ABSTRACT

Ice cream is a complex food matrix that contains multiple physical phases. Removal of 1 ingredient may affect not only its physical properties but also multiple sensory characteristics that may or may not be important to consumers. Fat not only contributes to texture, mouth feel, and flavor, but also serves as a structural element. We evaluated the effect of replacing fat with maltodextrin (MD) on select physical properties of ice cream and on consumer acceptability. Vanilla ice creams were formulated to contain 6, 8, 10, 12, and 14% fat, and the difference was made up with 8, 6, 4, 2, and 0% maltodextrin, respectively, to balance the mix. Physical characterization included measurements of overrun, apparent viscosity, fat particle size, fat destabilization, hardness, and melting rate. A series of sensory tests were conducted to measure liking and the intensity of various attributes. Tests were also conducted after 19 weeks of storage at −18°C to assess changes in acceptance due to prolonged storage at unfavorable temperatures. Then, discrimination tests were performed to determine which differences in fat content were detectable by consumers. Mix viscosity decreased with increasing fat content and decreasing maltodextrin content. Fat particle size and fat destabilization significantly increased with increasing fat content. However, acceptability did not differ significantly across the samples for fresh or stored ice cream. Following storage, ice creams with 6, 12, and 14% fat did not differ in acceptability compared with fresh ice cream. However, the 8% fat, 6% MD and 10% fat, 4% MD ice creams showed a significant drop in acceptance after storage relative to fresh ice cream at the same fat content. Consumers were unable to detect a difference of 2 percentage points in fat level between 6 and 12% fat. They were able to detect a difference of 4 percentage points for ice creams with 6% vs. 10%, but not for those with 8% vs. 12% fat. Removing fat and replacing it with maltodextrin caused minimal changes in physical properties in ice cream and mix and did not change consumer acceptability for either fresh or stored ice cream.

Key words: ice cream, fat reduction, maltodextrin, consumer acceptability

INTRODUCTION

Ice cream consists of fat as partially destabilized droplets, air in small bubbles, casein micelles in colloidal suspension, water in the form of ice crystals, and a concentrated unfrozen aqueous solution (Goff and Hartel, 2013). Fat plays a key role as a structural agent, aids in the stabilization of the air phase (Goff et al., 1999), and creates the characteristic sensory qualities that are expected of ice cream (Méndez-Velasco and Goff, 2012). Fat also affects the release of hydrophobic flavor molecules (McClements, 2015). In the United States, the standard of identity of ice cream requires a minimum milk fat content of 10% (21CFR§135.110; FDA, 2016).

Fat reduction is a means of eliminating calories from food, because fat provides more energy per gram than other macronutrients. Further, given the high cost of milk fat, manufacturers may be motivated to cut costs by reducing fat. However, it is widely believed that consumers tend to consider reduced-fat products to be lower in quality (Da Silva et al., 2014).

One way to reduce fat in ice cream involves simply replacing it with water (Roland et al., 1999a). This strategy results in a lower solids mix and lower viscosity (Specter and Setser, 1994; Li et al., 1997), an increase in hardness, and a faster melting rate (Guinard et al., 1997; Prindiville et al., 1999; Roland et al., 1999a). More commonly, fat is replaced with a bulking agent (McClements, 2015) to provide structural support (Roland et al., 1999a) and improve sensory properties (Conforti, 1994; Stampanoni Koeferli et al., 1996; Guinard et al., 1997). Bulking agents are usually carbohydrate or protein ingredients, used because of their lower energy content relative to fat and their water adsorption prop-

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erties (Akoh, 1998). Maltodextrins, polysaccharides produced by partial hydrolysis of starch (Sonwane and Hembade, 2014), are a common bulking ingredient in frozen desserts. The use of maltodextrin, polydextrose, and inulin in reduced-fat ice cream mix has been shown to increase viscosity (Schmidt et al., 1993; Aykan et al., 2008) and produce fast-melting frozen desserts (Ohmes et al., 1998; Roland et al., 1999b; Tiwari et al., 2015). The use of maltodextrin in 2% fat ice milk yielded a product with higher viscosity and lower whipping ability than ice creams that contained protein ingredients as bulking agents (Schmidt et al., 1993). Importantly, the use of maltodextrin in nonfat ice creams resulted in sensory ratings closer to those of a control ice cream with 10% fat (Roland et al., 1999b).

Few studies have focused on the effect of fat removal on consumer acceptability. Guinard et al. (1996) observed a small increase due to changes in fat content when no replacement strategy was involved. However, consumer acceptability of chocolate ice creams did not vary when fat content ranged from 0.5 to 10% fat and when polydextrose or whey protein were used as bulking agents (Prindiville et al., 1999). On the other hand, Li et al. (1997) reported a decrease in liking when fat was reduced and replaced with polydextrose.

Many previous studies have used descriptive analyses to quantify the sensory attributes thought to be critical to ice cream liking in the context of fat reduction, but very few have compared the acceptability of reduced-fat frozen desserts to consumers. Thus, it remains unknown whether sensory changes detected by trained panelists correspond to meaningful differences in acceptability by naïve consumers. Specifically, the extent to which fat can be replaced without affecting liking has not been adequately explored. The objectives of this study were to: (1) investigate the effect of fat reduction using maltodextrin as a bulking agent on select physical properties of ice cream mix and finished ice cream; (2) assess the consumer acceptability of fresh and stored ice creams; and (3) determine whether consumers could discriminate between vanilla ice creams based on their fat content.

MATERIALS AND METHODS

Formulation and Manufacture of Ice Cream

Pasteurized whole milk, pasteurized cream, sucrose, 36 DE (dextrose equivalent) corn syrup solids, and nonfat dried milk were provided by the Berkey Creamery (University Park, PA). Maltodextrin (10 DE) was kindly provided by Tate & Lyle (Star-dri 100; London, UK). A commercially available stabilizer-emulsifier blend (Grindsted IcePro 2005 SH; DuPont, Wilmington, DE) was used; this blend is composed of propylene glycol mono-esters, mono- and diglycerides, cellulose gum, guar gum, and carrageenan with silicon dioxide added as an anticaking agent.

Vanilla ice creams were formulated with milk fat content ranging from 6 to 14% in increments of 2 percentage points, and maltodextrin was added to compensate for the loss of fat. The level of milk solids nonfat, sugar, corn syrup solids, and stabilizer-emulsifier blend was kept constant throughout the treatments (Table 1). All mixes were formulated using TechWizard version 4 (Owl Software, Columbia, MO) for a 35 kg batch per treatment.

Wet (milk and cream) and dry (sucrose, nonfat dried milk, corn syrup solids, maltodextrin, and the stabilizer-emulsifier blend) ingredients were weighed separately and blended under low-speed agitation for 20 min at room temperature to allow for complete dispersion of the solids. The mixes were pasteurized (HTST) in an APV Junior Pasteurizer (APV Invensys, Woodstock, GA) at 80°C for 25 s and homogenized (Gaulin, Lake Mills, WI) in a 2-stage process applying pressure of 10.3 and 3.5 MPa. Following pasteurization, the cooled mix (7°C) was collected into milk cans and stored at refrigeration temperature (<7°C) for 48 h. After aging, samples were collected for physical and microbiological analysis. Before freezing, all mixes were flavored (4.45 mL/kg mix) with 2-fold vanilla extract (David Michael & Co., Philadelphia, PA). A continuous freezer (Gram IF 600; Gram Equipment Inc., Northvale, NJ) was used to freeze the mixes into ice cream, with overrun set at

Table 1. Vanilla ice cream formulations with decreasing fat content and replacement with maltodextrin (MD)

	Treatment				
Component (%)	6% fat, 8% MD	8% fat, 6% MD	10% fat, 4% MD	12% fat, 2% MD	14% fat, 0% MD
Milk fat	6.00	8.00	10.00	12.00	14.00
Milk SNF	10.50	10.50	10.50	10.50	10.50
Sucrose	12.96	12.96	12.96	12.96	12.96
Stabilizer/emulsifier	0.50	0.50	0.50	0.50	0.50
Corn syrup solids	3.70	3.70	3.70	3.70	3.70
Maltodextrin	8.00	6.00	4.00	2.00	0.0
Total solids	41.66	41.66	41.66	41.66	41.66