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Type of milk typically consumed, and stated preference, but not health consciousness affect revealed preferences for fat in milk

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ABSTRACT

Fat is an important source of both pleasure and calories in the diet. Dairy products are a major source of fat in the diet, and understanding preferences for fat in fluid milk can potentially inform efforts to change fat consumption patterns or optimize consumer products. Here, patterns of preference for fat in milk were determined in the laboratory among 104 free living adults using rejection thresholds. Participants also answered questions relating to their health concerns, the type of fluid milk typically consumed, and their declared preference for type of milk (in terms of fat level). When revealed preferences in blind tasting were stratified by these measures, we observed striking differences in the preferred level of fat in milk. These data indicate a non-trivial number of consumers who prefer low-fat milk to full fat milk, a pattern that would have been overshadowed by the use of a group mean. While it is widely assumed and claimed that increasing fat content in fluid milk universally increases palatability, present data demonstrate this is not true for a segment of the population. These results underscore the need to look beyond group means to understand individual differences in food preferences.

1. Introduction

Fat is responsible for many sensory attributes in foods, affecting appearance, texture, flavor, and palatability (Mela, 1990; Richardson-Harman et al., 2000). Previously, many researchers have examined the sensory properties of milk with varying fat content, and it is clear that milk fat plays a role in appearance and texture attributes in fluid milk (Drewnowski & Greenwood, 1983; Mela, 1988; Pangborn, Bos, & Stern, 1985; Pangborn & Dunkley, 1964; Pangborn & Giovanni, 1984). Beyond appearance and texture, dairy fats are somewhat unique in that they also make a direct contribution to sensory aroma and flavor perception (Badings & Neeter, 1980; Kinsella, Patton, & Dimick, 1967; Tamsma, Kurtz, Bright, & Pallansch, 1969). A half century ago, Pangborn and Dunkley showed that panelists could detect less than 0.5% milk fat added to skim milk. As visual differences were masked in their study, one can presume that flavor, aromatic, and textural cues were primarily used to discern these differences (Drewnowski & Greenwood, 1983; Mela, 1988; Pangborn & Dunkley, 1964; Pangborn & Giovanni, 1984; Pangborn et al., 1985). Using descriptive analysis with 15 trained panelists, Tuorila investigated sensory differences between 0%, 1.9%, and 3.9% fat milk in Finland; the panelists identified significant differences in blue color, transparency, visual thickness, and greasy mouthfeel. Conversely, the panel did not note any significant differences in taste, flavor, or aroma attributes (Tuorila, 1987). More recently, trained panelists performing descriptive analysis were able to discern flavor differences, with increasing fat content significantly increasing creamy flavor and sweet taste and significantly decreasing boiled milk flavor (Frøst, Dijksterhuis, & Martens, 2001). Other research suggest naïve consumers are also able to accurately judge fat content differences in fluid dairy products (Mela, 1988). This discrimination is far from perfect, however. Chapman and Lawless estimated only 30% discriminators among the subjects completing a triangle test comparing skim and 2% fat milk (Chapman & Lawless, 2005). Even in a dual standards test, where subjects were presented with references for both skim milk and 2% milk and asked to match samples to those reference samples, discrimination was estimated at 76% (chance corrected) (Chapman & Lawless, 2005).

A handful of studies have investigated the effects of milk fat content on product liking and consumption. Tuorila measured milk liking of 236 subjects who regularly used nonfat (0.5% fat), low-fat (1.9% fat), or regular fat milk (3.9%) and found that subjects

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generally best liked the type of milk that they regularly consumed (Tuorila, 1987). In contrast, Chapman and Lawless examined preferences between 2% milk and non-fat milk among both non-fat and 2% fat milk consumers and found a preference for 2% milk in both groups (Chapman & Lawless, 2005). In a female Korean population, participants also showed generally higher liking for higher fat milks (4.0% fat) compared to lower fat milks (1.0% fat) (Chung, 2009). In another Korean study relating descriptive sensory attributes to consumer overall liking ratings, Lee and colleagues found cooked, creamy, and sweet attributes associated with increased ratings of overall liking (Lee, Lee, & Shin, 2003). Richardson-Harman and colleagues examined consumer creaminess perception, consumer overall liking, and trained panel descriptive profiles in New Zealand, using thickened and unthickened fresh and reconstituted fluid dairy beverages ranging from 0.1% fat to 40% fat. They found that consumers generally defined creaminess in a similar manner. Consumer ratings of creaminess were correlated with trained panel ratings of cream aroma and flavor, butter aroma and flavor, vanilla flavor, and oily/greasy, mouthcoating, slippery, and viscous textures. Consumer segments for overall liking were found with one segment preferring full fat beverages and another preferring low fat beverages (Richardson-Harman et al., 2000). Individual differences in liking of dairy products varying by fat content have been seen to vary due to PROP phenotype (Hayes & Duffy, 2008; Keller, Steinmann, Nurse, & Tepper, 2002), weight status (Pangborn et al., 1985), health status (Rapp et al., 2009), and level of fat consumption (Mattes, 1993; Pangborn & Giovanni, 1984), but the levels of fat investigated vary considerably between studies, often including levels of fat that would not typically found in beverages. Other research has shown that health attitudes can influence consumers' perception and acceptance of milks of varying fat content (Roininen, Lähteenmäki, & Tuorila, 1999; Shepherd, Sparks, Bellier, & Raats, 1991/2).

The food environment and attitudes toward food and nutrition have both changed considerably since much of the research in this area was conducted. Over the past 25 years, milk consumption has decreased, and many more consumers have shifted from consuming whole milk to reduced-fat and skim milks (Briefel & Johnson, 2004). This is in part due to changes in dietary recommendations beginning in the 1980s, which were based on research linking fat consumption to cardiovascular disease and obesity. Adoption of a low-fat diet "became an overarching ideology, promoted by physicians, the federal government, the food industry, and the popular health media" (La Berge, 2008). More recent investigations into the role of dairy fat into the development of cardiovascular disease and obesity have called into question this association (German et al., 2009; Kratz, Baars, & Guyenet, 2013). Health concerns and consciousness (founded or not) can influence food choices (Hearty, McCarthy, Kearney, & Gibney, 2007; Sun, 2008), leading consumers to sometimes choose foods on the basis of health or weight consciousness rather than taste preferences per se (Visschers & Siegris, 2010). Given that food choices are influenced by such non-hedonic factors, grouping people based on their typical habits in addition to hedonics may give additional insights into the food choices and preferences for these individuals.

In 2005, Prescott, Norris, Kunst, and Kim (2005) introduced the concept of a rejection threshold, which is defined as the concentration at which a substance becomes objectionable, rather than the concentration at which it is perceived (the detection threshold). Several other authors have used the method to study rejection of objectionable compounds in foods (Nikolantonaki & Darriet, 2011; Saliba, Bullock, & Hardie, 2009; Weekes, Walsh, Ferguson, & Ross, 2010; Yoo, Saliba, Prenzler, & Ryan, 2012). Harwood and colleagues showed the method could be extended by segmenting consumers by self-reported *a priori* preferences, demonstrating that compared to solid milk chocolate consumers, solid dark chocolate consumers tolerated a higher level of a bitterant in fluid chocolate milk (Harwood, Ziegler, & Hayes, 2012). However, use of this method is not limited to off flavors and taints. Blackman and coworkers examined sweetness tolerance in wine and found evidence for segmentation among novice wine consumers, experienced wine consumers, and wine experts. They also found that added sweetness was preferred at lower levels and became less tolerated at higher levels, applying this method to a situation where the added ingredient was not strictly objectionable (Blackman, Saliba, & Schmidtke, 2010).

Here, we use the rejection threshold method to further understand individual differences in preferences for fat in fluid milk within a convenience sample of adults in North America. We stratified our participants in terms of (1) self reported type of milk typically consumed, (2) stated preference for type of milk based on its taste, and (3) health consciousness. *A priori*, we hypothesized that patterns of milk preference determined in a blind taste test (i.e., revealed preferences) will better align with stated (declared) preferences than with the type of milk typically consumed. That is, those who report a preference for skim milk would prefer lower fat levels than whole or 2% milk preferrers, but those who report drinking skim milk would not necessarily prefer lower fat levels. We also expected that health consciousness scores would be related to type of milk typically consumed but not necessarily related to stated milk preference.

2. Methods

2.1. Ethics statement

Testing was performed in a single session in the Sensory Evaluation Center in the Department of Food Science at The Pennsylvania State University. Procedures were exempted from Institutional Review Board review by professional staff in the Penn State University Office of Research Protections under the wholesome foods/approved food additives exemption in 45 CFR 46.101(b) (6). Participants provided informed, implied consent and were paid for their time.

2.2. Participants

One hundred and four non-smoking adults (32 men) who regularly consumed dairy milk were recruited from the Pennsylvania State University campus and surrounding community (State College, PA). Forty-five participants reported typically drinking skim milk, 40 participants reported typically drinking 2% milk, 15 participants reported typically drinking whole milk, and 4 reported 'other'. Twenty-two participants reported preferring the taste of skim milk, 45 participants reported preferring the taste of 2% milk, 31 participants reported preferring the taste of whole milk, and 6 reported 'other'.

2.3. Stimuli

Samples were prepared one day prior to the experiment using freshly processed whole and skim milks from the Berkey Creamery (University Park, PA). Samples were standardized to 0.1%, 0.5%, 1%, 2%, and 3.5% milk fat using the Pearson square method (Olson, 1924). Fat content was verified with NMR analysis in a SMART Trac II system (CEM Corporation, Matthews, NC). These concentrations were selected to represent commercially available milk fat levels in the United States: 0.1% and 0.5% milk fat correspond to skim milk and 3.5% milk fat corresponds to whole milk, as legally defined by United States Food and Drug Administration (see Table 1).