J. Dairy Sci. 100:1–10
https://doi.org/10.3168/jds.2016-11417

Milk fat threshold determination and the effect of milk fat content on consumer preference for fluid milk

K. S. McCarthy,* K. Lopetcharat,† and M. A. Drake*[1]
*Department of Food, Bioprocessing and Nutrition Sciences, Southeast Dairy Foods Research Center, North Carolina State University, Raleigh 27695
†Nouveau Centric Co. Ltd., Bangkok 10250, Thailand

ABSTRACT

Milk consumption in the United States has been in decline since the 1960s. Milk fat plays a critical role in sensory properties of fluid milk. The first objective of this study was to determine the change in percent milk fat needed to produce a detectable or just noticeable difference (JND) to consumers in skim, 1%, 2%, and whole milks. The second objective was to evaluate how milk fat affected consumer preferences for fluid milk. Threshold tests were conducted to determine the JND for each reference milk (skim, 1%, 2%, and whole milk), with a minimum of 60 consumers for each JND. The JND was determined for milks by visual appearance without tasting and tasting without visual cues. Serving temperature effect (4, 8, or 15°C) on tasting JND values were also investigated. The established JND values were then used to conduct ascending forced-choice preference tests with milks. Consumers were assigned to 3 groups based on self-reported milk consumption: skim milk drinkers (n = 59), low-fat milk drinkers (consumed 1% or 2% milk, n = 64), and whole milk drinkers (n = 49). Follow-up interviews were conducted where consumers were asked to taste and explain their preference between milks that showed the most polarization within each consumer segment. Descriptive sensory analysis was performed on the milks used in the follow-up interviews to quantify sensory differences. Visual-only JND were lower than tasting-only JND values. Preference testing revealed 3 distinct preference curves among the consumer segments. Skim milk drinkers preferred skim milk and up to 2% milk fat, but disliked milk higher in fat due to it being "too thick," "too heavy," "flavor and texture like cream," "too fatty," and "looks like half and half." Low-fat milk drinkers preferred 2% milk up to 3.25% (whole milk), but then disliked higher milk fat content. Whole milk drinkers preferred whichever milk was higher in milk fat regardless of how high the fat content was, distinct from skim and low-fat milk drinkers. The findings of this study provide insights on sensory characteristics of milk fat in fluid milk and consumer sensory perception of these properties. These results also provide insights on how the industry might adjust milk fat references for adjusting milk sensory properties to increase milk preference and remain within the standards of identity of milk.
Key words: milk fat, just noticeable difference, milk

INTRODUCTION

Fluid milk has seen a steady decline in sales over the last several decades whereas other dairy products, such as yogurt and cheese, have increased in per capita consumption in the United States. From 1975 to 1995 to 2014, milk consumption decreased from 112.05 to 93.12 to 71.92 L (29.6 to 24.6 to 19.0 gallons) per person (Economic Research Service, 2015). Whereas total consumption has declined, changes in the type of milk most commonly purchased have also been observed. In the 21 yr spanning 1966 and 1987, low-fat milk increased in sales by 30.0% whereas whole milk sales decreased by 44.8% (Gould et al., 1990). Sales of 2% reduced-fat milk alone have outsold whole milk every month since January 2005, whereas skim milk sales have remained relatively stable (Economic Research Service, 2014). Fat contributes a variety of flavors, mouthfeel, and visual attributes to milk. Previous work has confirmed that the desirable flavors in milk come from compounds probably unique to milk fat (Tamsma et al., 1969).

Brewer et al. (1999) surveyed 100 women about milk consumption and milk attitudes, and 82% selected skim or reduced fat as the milk they most frequently consumed. All consumers in their study were asked questions pertaining to their attitudes and beliefs of various milks. The women, as a whole, including the 82% who purchased skim or reduced fat milk, actually preferred whole milk, confirming that many desirable sensory aspects of milk were contributed by milk fat. Those au-

Received May 7, 2016.
Accepted November 3, 2016.
[1]Corresponding author: maryanne_drake@ncsu.edu

thors concluded that health beliefs played a pertinent role in decisions for milk purchase (Brewer et al., 1999). More recently, Bakke et al. (2016) also reported that health consciousness had no effect on preferred milk fat levels in blinded tastings of fluid milk.

In addition to contributing to flavor, fat plays a role in the visual attributes of milk. Phillips et al. (1995) used a trained panel to demonstrate that increasing levels of milk fat gave milk a whiter appearance. Increased milk fat also increased perceived thickness, mouth coating, and residual mouth coating by the trained panel (Phillips et al., 1995). Another study evaluated milk appearance and its relationship to perceived thickness by trained panelists (Quiñones et al., 1997). A high correlation was found between instrumental whiteness and trained panel thickness of milk.

Milk fat is also associated with the desirable consumer attribute of creaminess. Richardson-Harman et al. (2000) showed that creaminess was defined by high-fat dairy products that exhibited dairy flavors such as cream aroma, butter aroma, and vanilla flavor, and texture characteristics of mouth coating, slipperiness, and higher viscosity. Creaminess was positively related to product liking. Tepper and Kuang (1996) evaluated the perception of fat content in skim milk using a select group of milk consumers. Results showed that powdered natural cream flavor and not the addition of vegetable oil provided the sensation of higher fat content in skim milk, suggesting that specific aromatics rather than viscosity were key contributors from milk fat. Jervis et al. (2014) evaluated the effect of different modalities on perceived creaminess and how creaminess affected overall liking in sour cream. In full-fat sour cream, flavor played the biggest role when assessing creaminess. As fat was removed, other modalities of visual appearance, physical stirring, and in-mouth texture played a more important role in fat perception. Those authors also reported that samples scoring high in overall liking were also rated highly in creaminess. These studies collectively demonstrate that both appearance and flavor contribute to creamy perception in dairy products and that creaminess is a desired attribute in dairy products.

Threshold tests are used to determine the lowest concentration for detection of sensory changes. A just noticeable difference (**JND**) threshold is the minimum change in a stimulus to elicit a detectable difference (Allen, 1981). Drake et al. (2011) determined JND values for sodium chloride in dairy products and proposed that this information could be used to reduce NaCl without consumers detecting differences. Previous work has established that milk fat content of fluid milk is a critical sensory parameter for appearance, flavor, and mouthfeel, but the role of specific concentrations of milk fat has not been determined. Appearance has been purported to play the primary role in consumer differentiation and selection of fluid milk. Our hypothesis was that sensory factors other than appearance influence consumer perception of milk fat and consumer selection of fluid milk. The objectives of our study were to determine the change in milk fat needed to produce a JND to consumers in skim, 1%, 2%, and whole milks. The second objective was to evaluate how milk fat affected consumer preferences for fluid milk.

MATERIALS AND METHODS

Sample Preparation

Raw milk was obtained from the North Carolina State University Dairy Enterprise System. A cold bowl separator was used to skim the milk fat and the raw milk was then standardized to 0.1, 3.25, or 42.0% milk fat. After the fat content of milk was standardized, it was then pasteurized at 72.8°C for 25 s and homogenized at 10,342 kPa for the first stage and 3,447 kPa for the second stage to produce the base milks. Milks were stored in sterile bag and box containers at 4°C in the dark. The skim milk, whole milk, and heavy cream were then mixed to desired milk fat concentrations. Mojonnier analysis was conducted in triplicate to confirm milk fat concentrations of base milks and then each test sample (AOAC International, 1992: method number 989.05). Milk was stored with black plastic coverings and was mixed and prepared for sensory testing with overhead lights off to prevent light oxidation.

Threshold Tests

Threshold testing was conducted to determine the amount of milk fat needed to a produce a JND to consumers for each reference milk (skim, 1%, 2%, and 3.25%). Milk at 0.1, 1, 2, and 3.25% (whole milk) milk fat served as the respective reference milk for each test. Those milk fats were chosen as they are the standard milks available in the commercial market. Milk fat concentrations for each threshold series were based on preliminary tests. The JND for milk fat of skim, 1%, 2%, and whole milk as the reference milks under 2 conditions was determined: tasting without visual cues and visual cues only with no tasting. Threshold tests within each condition were tested in separate sessions a minimum of 7 d apart. The 4 tasting without visual cues JND tests were conducted first across an 8-wk period. Four weeks later, the visuals cues only tests were conducted. Within each of these conditions, the reference fat content evaluated was in a randomized or-