ABSTRACT

MCCARTHY, KARA SHEA. Attributes of Fluid Milk Affecting Purchase and Preference. (Under the direction of Dr. Mary Drake).

Fluid milk has seen a steady decline in consumption while non-dairy alternatives have seen a jump in sales. Milkfat contributes flavor, color, and viscosity to fluid milk and can affect purchase habits. In addition to milkfat content, other product attributes may drive purchase of fluid milk. The objective of this thesis was to determine how much difference in milkfat content was needed to produce a noticeable difference and how milkfat affected preference in fluid milk. The second objective was to determine key attributes of dairy milk and non-dairy alternatives that drive purchase and determine the underlying reason as to why these attributes were important to consumers. Two different studies were conducted to evaluate preference in relation to milkfat content in fluid milk and to determine what other product attributes were important to consumers in driving beverage choice between fluid milk and non-dairy alternatives.

In the first study, thirteen threshold tests were conducted to determine the just noticeable difference (JND) of milkfat in skim (0.1%), 1%, 2%, and whole (3.25%) milk under two conditions: tasting-only and visual-only. Preference testing was then conducted with milk consumers to determine how varying levels of milkfat affected consumer preference. Visual-only thresholds were lower than tasting-only thresholds ($P < 0.05$). As the reference milk increased in fat content, the JND increased under both conditions. Preference testing revealed three distinct preference curves based on milk that consumers typically consumed. Skim milk drinkers preferred milkfat up to 2% milk but found whole milk too thick and creamy. Low-fat milk drinkers liked milkfat as well but felt once milk reached 6.1% milkfat, it was too creamy. Whole milk drinkers always preferred milkfat no matter the

amount. In the second study, a conjoint survey was launched to consumers of dairy milk and non-dairy alternatives. Follow-up means-end chains interviews were conducted to gain a deeper understanding as to why certain attributes drove beverage purchase. Fat content and packaging size were the most important attributes in milk and sugar content followed by plant source were the most important in non-dairy alternatives. Consumers who purchased dairy milk did so out of habit which brought them comfort. Consumers who purchased both beverage types drank dairy milk because the flavor brought happiness or because their family would consume it and they drank non-dairy alternatives because they perceived them to be lower calories or less carbs. Those who only purchased non-dairy alternatives chose so because the beverage was plant based, meaning not an animal product, personal beliefs against animal mistreatment, and the thought that plant based beverage had less of an environmental impact than milk. These findings can be utilized to optimize new dairy beverages with a fat content, flavor, nutritional content and sustainability that consumers desire to sustain or possibly increase sales of milk and milk beverages.

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Attributes of Fluid Milk Affecting Purchase and Preference

by

Kara Shea McCarthy

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APPROVED BY:

Dr. Mary Drake
Committee Chair

Dr. Edward Allen Foegeding

Dr. Timothy H. Sanders

DEDICATION

To my parents for pushing me to always give my best effort, believing in me when I did not, and always being a shoulder to cry on. To my fellow lab members for lending their hands, their ears, and their patience in my pursuit of further education. And last but certainly not least, to Dr. MaryAnne Drake, for not only serving as my graduate advisor but as a mentor and a friend.

BIOGRAPHY

Kara McCarthy was born in Upper Sandusky, OH on April 25, 1991 to Dr. F.D. McCarthy and Joy McCarthy. She grew up on a sheep farm and was an active member of 4-H. After high school she attended The Ohio State University to pursue a Bachelor's Degree in Food Science and Technology. She joined Dr. MaryAnne Drake's lab as a graduate student in June 2013 where she worked for two and a half years before completing her Master's Degree in December 2015.

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ABSTRACT

Consumption of fluid milk has been in decline since the 1970's. Sales of whole milk have decreased while reduced fat and skim milk control a larger portion of the market than ever before. Many factors may contribute to the decline in milk consumption including changing demographics and beverage competition. Many factors can affect the flavor of milk and with it, consumer acceptance. Milkfat can increase liking due to flavor but consumer education and misconceptions drive consumers away from whole milk compared to reduced fat or skim milk. Addition of solids-non-fat to milk increases consumer acceptance of milks while milk aftertaste is a driver of dislike for women who do not consume milk. Dairy cow husbandry all the way to milk marketing can affect milk liking and milk consumption.

INTRODUCTION

Fluid milk has seen a steady decline in consumption since the 1970's. Annual per capita consumption of milk has changed from 28.6 gallons in 1975 to 20.9 gallons in 2010, a 26.9% decrease (Krebs, 2013). In recent year records, in January to December 2012, total milk sales decreased every month in comparison from the previous 3 years (Agriculture Marketing Service, 2014). While total consumption has declined, there has also been a change in the type of milk purchased. Between 1966 and 1987, low-fat milk increased its share of milk sales by 30.0% while whole milk decreased by 44.8% (Gould et al., 1990). Sales of 2% reduced fat milk alone have outsold whole milk every month since January 2005 (Agriculture Marketing Service, 2014). In addition to the change in purchase of whole versus reduced fat milk, from January 2010- December 2012, all but 2 months experienced growth in total organic milk product sales despite the overall continued decline in all fluid milk purchases (Agriculture Marketing Service, 2014).

Several factors may contribute to the decline in fluid milk sales, including but not limited to; beverage competition, delayed investment in new and innovative products, and the changing demographic profile of the United States (Krebs, 2013). Statistics show that individuals in the U.S. still consume the same amount of beverages as in the past but that there has been a shift in what they are drinking. Since 2002, milk has decreased by two percent in the share of total beverages consumed while coffee, tea, and bottled water have all increased. Bottled water showed the most growth with an eleven percent increase in the last decade. Contributing to this shift, overall beverage competition has increased in the last ten years with over 8,000 new teas, 4,850 new juices, and 2,550 new energy and sports drinks compared to just 1,170 new fluid milk beverages (Krebs, 2013). With the wide selection of beverages to pick from, consumers have become less likely to drink milk at meals and on the go, reducing the overall consumption occasions. This highlights one example that while milk has always paired with cereal, breakfast on-the-go items can be paired with a variety of drinks.

Along with the wide selection of beverages to pick from, lifestyle changes are affecting what consumers pick. Half of consumers drink milk at home while only 14% choose milk away from home. By the late 2000's food purchases made away from home accounted for 48 percent of total food expenditures (Stewart et al., 2012). In the past, the milk industry has focused investment on operational efficiency and not as heavily on new product development. The dairy standards of identity create more control and standardization of existing products but prove a challenge in staying within those regulations when making new products in compared to other beverage types with more flexibility (Krebs, 2013).

In addition to increased competition and fewer new fluid milk products, the demographics of the U.S. population are changing and with it, milk consumption (Krebs, 2013). The Hispanic population is set to increase by 33 percent by 2020 but their milk consumption will grow at a slower rate than their population boom (Krebs, 2013). Overall, Hispanics are cutting back on their milk consumption. Recent data has shown 15-18 % of Hispanic teens consume milk compared to 18-24% of their non-Hispanic counterparts (Krebs, 2013). While the racial profile of the U.S. is changing, so is average household income. Household income has been on the rise and with increased household income, whole milk purchases are negatively affected (Stewart et al., 2012). A trend has also been detected that as older generations are decreasing in population and newer generations are serving as more dominant consumers in the market place, fluid milk consumption is declining in part to that change. It is hypothesized that consuming milk as a child drives purchase of milk as an adult. The younger generations of today that are now entering the workplace and starting families of their own, grew up with multiple beverage choices for every occasion. Because of this, milk may have not been consumed as much in their childhood as their parents' or their grandparents' younger years. Lack of childhood milk consumption could be another cause in the decline of fluid milk purchasing seen today (Stewart et al., 2012). Factors affecting consumer liking and fluid milk flavor will be explored in this review.

Milk Defined

The Code of Federal Regulations (CFR) defines the status of identity of milk and the Pasteurized Milk Ordinance (PMO) outlines the legal requirements for pasteurization and safe processing of fluid milk, both overseen by the U.S. Food and Drug Administration. Milk is defined by the Code of Federal Regulations Title 21, as the lacteal secretion from healthy cows that is free from colostrum. It must be pasteurized or ultrapasteurized and it must contain at least 8.25% solids-non-fat and 3.25% milkfat. Milk may be adjusted by separating the milkfat, adding cream, concentrated milk, dry whole or skim milk powder, concentrated skim milk, or fluid skim milk. Milk may be homogenized but is not required. Homogenization is the use of pressure to cause a reduction in fat globule size, which in turn increases the milk fat surface area and keeps the milk fat suspended in the continuous phase of the milk preventing the formation of a milkfat layer at the top (Cano-ruiz and Richter, 1997). Any milk that has reduced milkfat must have vitamin A (minimum of 2000 International Units (I.U.) per quart). Vitamin D fortification (minimum of 400 I.U. per quart) is optional for all fluid milk but is standard in the U.S. (U.S. Food and Drug Administration, 21CFR131.110, 2015). The recommended upper limits for fortification are 6000 I.U. per quart for Vitamin A and 800 I.U. for Vitamin D. These upper limits are based on the population that requires the lowest amount of vitamin A and D, infants under 12 months (U.S. Food and Drug Administration, M-I-92-13, 1992). Low-fat milk is defined as milk with removed milkfat to the level of 0.5-2.0% total milkfat, 8.25% solids-non-fat while skim milk must have less than 0.5% milkfat and at minimum 8.35% solids-non-fat (U.S. Food and Drug Administration, 21CFR101.62, 2015). Pasteurization is required of all milk sold and may follow one of three processes; High-Temperature-Short-Time (HTST) continuous-flow pasteurization, Ultra-pasteurization (UP), or Aseptic processing. Requirements will be defined in the heat treatment section of this paper. Federal law requires that dairies cannot transport raw milk across state lines in final packaged form to be sold to consumers however each state makes its own laws about sale of raw milk to consumers. In about half of the fifty states in the U.S., sale of raw milk directly to consumers is legal (CDC, 2013).

Milk Components Contributing to Flavor

Chemical changes in milk components can affect milk flavor due to processing or chemical reactions. Milk is typically made up of 3.2% w/w protein which includes casein, serum proteins (including whey proteins), and enzymes (Walstra et al., 2006). Denatured whey proteins play an important role in the cooked flavor of shelf stable milk products by the compounds produced during denaturation such as sulfhydryls from the breakdown of disulfide bonds. Denaturation of B-lactoglobulin is thought to be a main contributor of cooked flavor due to the high number of thiol groups (Walstra et al., 2006). Denatured whey proteins also can contribute cabbage, sulfur, or caramel flavors due to Maillard reactions or caramelization from heating (Varnam and Sutherland, 1994). A decrease in cooked sulfurous flavors has been shown in milks with high oxygen content but that leads to an increased chance of oxidation of fat leading to rancid flavors in the milk. The degradation of methionine to methional through light activated reactions can also impart off flavors in milk (Varnam and Sutherland, 1994).

Lactose constitutes 4.7% w/w of milk and is a carbohydrate composed of glucose and galactose. Lactose contributes sweet taste and sweet aromatics to milk (Walstra et al., 2006). When lactose is broken down into monosaccharides, the glucose and galactose can contribute to Maillard browning and contribute to ‘caramelized,’ ‘lacks freshness,’ and ‘processed’ flavors in lactose free milks (Adhikari et al., 2010). Minerals in milk include calcium, sodium, potassium, chloride, and various phosphates present at about 0.5% w/w which generally do not provide much flavor with the exception of salts adding salty taste (Walstra et al., 2006). Minerals such as iron or copper can induce oxidation of fats as well as UV exposure. Lipids constitute about 4.0% w/w of milk components and can contribute to the creamy or rich flavors in milk (Walstra et al., 2006). Heat processing can also affect milkfat through the formation of lactones and methyl ketones which impart typical milkfat or coconut type flavors (Varnam and Sutherland, 1994).

Dairy Cattle Feed Intake

What milking cows are fed has the potential to affect the chemical composition and the flavor of milk. A protein-free synthetic diet lowers the indole and skatole animal like flavors in milk (Urbach, 1990). Feeding a ration low in lipids produces hard milkfat, high in cheesy-flavor fatty acids while a propionate metabolism supported diet, favors the production of sweet-raspberry flavor from dietary oleic and linoleic acids (Urbach, 1990). Feeding cattle a diet high in safflower oil increased the concentration of linoleic acid in the milk and as a result, potential oxidative flavor. However, supplementing cows with α-tocopheryl acetate prevented oxidized flavor (Goering et al., 1976). Lacerda et al. (2014) evaluated preference of milks from cows fed varying amounts of oregano in their total mixed ratio diet. Fifty consumers rated the three test samples compared to a control where no oregano was fed to the cattle. A descriptive panel also evaluated the milks for aroma and flavor. No significance in preference or flavor was documented by the consumers or the descriptive panel. However, if a larger number of consumers evaluated the milks, preference might have been different and if the descriptive panel used a larger scale or more training, differences might be detected (a 5-point scale for intensity was used). In fluid milk, feed flavors in milk can reduce milk quality. Morgan and Pereira (1962) concluded that some of the compounds responsible for the production of feed flavors entered the mammary gland directly from the respiratory system of cows fed silage. Control 2% milk versus milk with pronounced feed flavor was preferred by consumers in an older study (Modler et al., 1977).

A trained descriptive analysis panel differentiated milk flavor from pasture fed cows compared to cows on a total mixed ration. Grassy flavors were documented in 1.5% milkfat milk from cows on a pasture diet. Consumers, however, were not able to differentiate the two milk sources and there was not a significant difference in liking between the milk from pasture fed cows and the milk from cows on total mixed ration (Croissant et al., 2007). Villeneuve et al. (2013) had 30 untrained panelists evaluate milk from cows fed hay, silage, or pasture in a series of triangle tests. Panelists were able to detect a difference between the milk from cows on a hay diet verses cows on pasture but not cows fed hay verses cows fed silage. Assessors (n=30) were also asked to evaluate the three treatments for overall flavor intensity, grassy flavor, and sweet flavor. The largest percentage of assessors rated pasture milk the highest in overall flavor and grassy flavors and milk from cows fed hay the highest in sweet flavors. Larsen et al. (2012) observed reduced stale aroma and creamy flavor when cows were fed an increasing amount of Lucerne silage compared to maize silage.

Coppa et al. (2011) studied the effect of volatile compounds in milk from cows on a hay based diet, a highly diverse continuous grazing pasture diet, or a less diverse rotational pasture diet. Concentrations of β-pinene and cymene-(p) and all sesquiterpenes were higher in the continuous grazing milk than the other two treatments while dimethyl-sulfone was lower in the hay based diet compared to pasture milks. The effect of increased iron levels was evaluated in a separate study to address what might happen when cows consumed water with high levels of iron at which point iron would potentially increase in concentration in the milk produced and increase the likelihood of fat autoxidation. Mann et al. (2013) purchased milk commercially and added iron in the form of ferrous sulfate at 0.3 mg/kg, 3mg/kg, and 30mg/kg. Triangle tests were conducted. Panelists were able to detect differences at all added iron levels when compared to control milk. It is thought, though, that copper naturally present in milk does not contribute to fat autoxidation, only copper added into milk (Walstra et al., 2006).

Conjugated Fatty Acids

Conjugated fatty acid has been identified as an anticarcinogen in rats (Ha et al., 1990; Ip et al., 1994). It has also been linked to decreased body fat and increased lean mass in mice (Park et al., 1999). Pasture based feeding systems increase conjugated linoleic acid (CLA) content in milk compared to total mixed rations (Dhiman et al., 1999; Jahreis et al., 1997; Kelly et al., 1998; Timmen and Patton, 1988). White et al. (2001) concluded that there was a difference in fatty acid composition between pasture based and total mixed ration fed cows along with differences between breeds. A study with different feeds showed cattle fed grass silage and maize silage had significantly more fatty acids of chain lengths C16 or less and saturated fatty acids while cattle fed a diet of mostly by-products had significantly more fatty acids of chain lengths C18 and greater along with unsaturated fatty acids (Yayota et al., 2013). Campbell et al. (2003) fortified milk with CLA triglyceride oil and found consumer acceptability was lower than the control but chocolate flavor addition to the CLA milk increased acceptability. No difference in consumer acceptability was found between high conjugated linoleic acid milk compared to the control when the CLA was adjusted by the addition of fish oil in the diet of the cows (Ramaswamy et al., 2001). Milk and cheese acceptability was tested with CLA enriched milk from pasture grazing cows and no difference was found from the control (Khanal et al., 2005). Jones et al. (2005) evaluated multiple dairy products made from high CLA milk enriched by fish oil and sunflower oil in the cows' diet. There was a significant difference by triangle test of the control verses the enriched milk however a trained panel did not detect a difference in any sensory attributes between the two samples.

Raw Milk Quality

The initial microbial quality of raw milk can affect shelf stability, safety, and flavor. The Pasteurized Milk Ordinance defines that bacteria in raw milk must not exceed 100,000 per mL from each individual milk producer and not more than 300,000 per mL in commingled raw milk before pasteurization. Somatic cell count must not exceed 750,000 per mL for individual milk producers (U.S. Food and Drug Administration, 2009). Somatic Cell Count (SCC) refers to macrophages, leukocytes, secretory cells, and squamous cells per milliliter of raw milk. When a cow has an infection in the udder such as mastitis, SCC levels increase as a side effect of fighting the infection. There is an inverse relationship between SCC and quality/shelf life of pasteurized milk (USDA APHIS, 2011). High SCC and the enzymes associated with infection will cause protein and fat degradation, producing off-flavors. High levels of psychrotrophic bacteria in raw milk can produce heat-stable proteases and lipases that survive pasteurization. If present, these enzymes will then be active in the refrigerated pasteurized milk (Barbano et al., 2006). Flavors typically associated with microbial activity include acid, malty, and fruity. Unclean, bitter and putrid flavors are often caused by psychrotrophic organisms. Just as important, refrigerated pasteurized milk shelf life is decreased.

The most common organisms associated with off flavor production in fluid milk are thought to have originated in soil and plants, and proper sanitation and handling can limit their growth. Bacteria introduced from the teats of a cow's udder can include *Micrococcus* spp., coagulase-negative *Staphylococcus* spp., *Enterococcus* spp., coryneforms, *Bacillus* spp., coliforms, and other gram-negative rods. Insufficiently cleaned equipment can introduce *Lactococcus* spp., *Pseudomonas* spp., and coliforms. Bacteria that can multiply if milk is not cooled properly can include fast-growing psychrotrophic bacteria, such as *Pseudomonas fluorescens* (Holm et al., 2004). Spoilage can also occur due to *Streptococcus* spp., *Lactobacillus* spp., or *Enterobacteriaceae* spp. (Varnam and Sutherland, 1994). Spores can also be produced by bacteria like *Bacillus sporothermodurans* which is non-pathogenic but spores produced will survive UHT-treated milk and germinate causing spoilage of milk and a shorter shelf life (Aouadhi et al., 2012). Rapid cooling and holding at 4.4C or below inhibit multiplication of bacteria in raw milk (Shipe et al., 1978). Milking cows in loose boxes and milking parlours produce significant lower microbial loads than cows housed in stanchion barns and milked with a pipeline milking machine (Cempirkova, 2002). Keeping facilities and equipment clean can help to prevent introduction of new bacteria and pasteurization will kill heat sensitive bacteria already present in milk.

Milk Heat Treatment

Pasteurization is the process of heating milk to a high enough temperature and holding it there for a long enough time to kill bacteria which can cause illness in humans. It does not significantly change the nutritional benefits of milk (CDC, 2013), it can however impart flavors due to processing and effect consumer liking. Requirements for milk processing are defined by the Grade A PMO and also in the CFR. Pasteurization may occur with any of the following combinations; 63C for 30 minutes, 72C for 15 seconds, 89C for 1 second, 90C for 0.5 seconds, 94C for 0.1 seconds, 96C for 0.05 seconds, or 100C for 0.01

seconds. Ultra-pasteurization refers to dairy products that have been thermally processed at or above 138C for at least 2 seconds. After heat processing (pasteurization or ultra-pasteurization) bacteria counts must be less than 20,000 per mL and coliforms may not exceed 10 per mL (U.S. Food and Drug Administration, 2009). Adult U.S. consumer acceptability was evaluated with 2% milk using different heat treatments of 77, 79, 82, and 85C. On day zero (the day of pasteurization), consumers preferred the 79C treated milk but by day six, milk pasteurized at 79C and 82C was highly acceptable to all consumers compared to the other treatments at 77C, and 85C. The authors concluded that differences in liking scores decreased as shelf-life increased (Gandy et al., 2008). Children ages 6-11y determined preferences between ultra-pasteurized (UP) milk, high-temperature-short-time (HTST) milk, and ultra high temperature (UHT) milks. The children preferred HTST treated milk over UHT and both of those treatments over UP treated milk. How children scored the samples was correlated to how they felt about milk in general (Chapman and Boor, 2001). UHT milks were profiled by a trained panel with samples from 7 different countries at whole, 2%, and low-fat milkfat levels. Findings were not consistent between countries or fat levels, suggesting sensory properties are more dependent on the individual manufacturing practices and heat treatment levels (Oupadissakoon et al., 2009). In a study to determine drivers of liking of fluid milk among Korean women, consumers who frequently drank plain milk, preferred UHT treated whole milk. It was suggested that this result was because UHT processing is much more common in Korea than HTST processing of milk (Chung, 2009).

Milkfat

Fat contributes a variety of flavors to milk. Oxidized flavors come from autoxidation of the unsaturated fatty acids, detectable at very low concentrations (Kinsella et al., 1967). A variety of flavors from cardboard, oily, painty, fishy, grassy, oxidized, cucumber, creamy, and fruity all can originate from oxidized milkfat. Nonoxidative flavors like waxy and rancidity along with fruity or solvent-like from methyl ketones and coconut flavor from lactones are some additional flavors imparted by milkfat (Kinsella et al., 1967). Milkfat was tested compared to other fats for the role it plays in milk flavor by addition of different fat sources to skim milk. Beverages were evaluated by a panel for flavor quality and desirability. Untreated milkfat from whole milk concentrate and partially deodorized milkfat were the only fat sources that improved the flavor of skim compared to other tested fat sources of coconut oil, corn oil, and safflower oil. This result indicated that the desirable flavors in milk come from compounds probably unique to milkfat specifically (Tamsma et al., 1969). Raats and Shepherd (1992) used assessors and free choice profiling to profile products made with milk of different fat levels. “Dairy/milky” was used more frequently in products made of milks higher in fat whereas products made with skim were described by non-dairy related terms that were specific to that product. Tepper and Kuang (1996) evaluated the perception of fat content in a skim milk matrix. They concluded that it was the added cream flavor and not the content of vegetable oil that provided the sensation of higher fat content.

The amount and composition of milkfat in milk can be changed by what feed is given to the cows. Milkfat composition is changed more by the dietary fat than any other component (Palmquist and Beaulieu, 1993). Flaxseed increased fat measures by 20 percent and a mixture of sunflower seed, high oil corn, and soybean seed caused increases ranging from 8-18% (Nevens et al., 1926). Heat in the summer months causes a drop in milkfat output, more so in Jerseys and Guernseys than in Holsteins (Woodward, 1923).Composition is also affected by the stage of lactation, short chain fatty acids are low in concentration initially but increase until 8-10 weeks into lactation (Palmquist and Beaulieu, 1993).

Fat imparts flavor but what is the perception towards milkfat and do consumers prefer high milkfat products? Consumer perception of milk as a commodity was positive in a study that looked at the difference between whole milk, reduced fat milk, and soy milk (Bus and Worsley, 2003). However most misconceptions about whole milk were related to its perceived high fat, cholesterol, and calories. In the questionnaire, whole milk scored the highest in ‘feels good in the mouth’ and ‘tasty’ but reduced fat milk scored the highest in ‘necessary in my diet’ (Bus and Worsley, 2003). Chung (2009) evaluated at Korean females acceptance of milk, and liking was positively correlated with sweetness, sweet cream flavor, and smooth texture but negatively correlated with grassy and rancid flavor. Analysis of the Continuing Survey of Food Intakes by Individuals indicated that low-fat milk consumers were positively related to older age, education level, and income (Robb et al., 2007). In a study of 100 subjects, 42% drank skim, 36% drank 2% reduced fat, 27% drank 1%, and 18% drank whole milk. In a belief evaluation, skim milk had lower scores for taste and texture. Acceptance testing showed that consumers liked whole milk more than skim but milkfat content in milks were inversely correlated with average scores for “good for me” belief statements (Brewer et al., 1999). Researchers concluded that health concerns outweighed sensory attributes in purchasers of milk (Brewer et al., 1999). Palacios et al. (2009) observed two consumer segments for sensory attributes of cow’s milk, one segment that were sweet seekers and preferred reduced fat milk and fat free milk the same, and a second segment with “cream” seekers who preferred reduced fat milk. School age students (6-16 years) were surveyed in boarding schools in Mexico to determine preference in milkfat. Overall, children liked fat free milk over whole milk and low-fat milk. However what was not taken into consideration in liking was that the whole milk and low-fat milk came in the form of powder that needed to be rehydrated while the fat free milk arrived in liquid form. Trends were observed in increased liking of the same products the students usually consumed such as whole milk habitual consumers rated whole milk higher than consumers of low-fat and fat free milk (Lara-Zamudio et al., 2013).

Viscosity and Creaminess

Viscosity and color were quantified for various concentrations of milkfat from 0.06% milkfat to 2.0% (Phillips et al., 1995). Whiteness measured with a Macbeth Color-Eye spectrophotometer increased with fat content and with milkfat along with higher scores in thickness, mouth coating, and residual mouth coating by a trained panel. Under red lights, no differences were detected by the trained panel in cream aroma while there were significant differences when panelists evaluated the samples under normal lighting. Flavor and texture were also scored under red lights and trained panel texture scores of mouth coating, residual mouth coating, and thickness decreased. The trained panel was no longer able to distinguish between skim and 1%, but they were still able to distinguish between skim and 2%. There was no difference in flavor under normal lighting or red lights (Phillips et al., 1995). 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 but was affected by off-flavor, sweetness, and sour taste in products. Petty and Scriven (1991) had 60 consumers of coffee with milk evaluate three different coffee whiteners compared to whole milk in overall liking, flavor liking, appearance liking, and creaminess. Whole milk scored the highest in overall liking but not the highest in creaminess rating. It did however score the highest in appearance liking suggesting a possible relationship that appearance plays a role in overall liking. Viscosity was not scored in their study. Jervis et al. (2014) evaluated at the modality responsible for the perception of creaminess using sour cream. The parameters tested were visual only, stirring, blindfolded stirring, blindfolded tasting, blindfolded tasting with nose clips, and tasting with nose clips. Consumers were asked to evaluate their creaminess perception and overall liking of the products. The products that rated the highest in creaminess also scored high in overall liking. Flavor played the most important role in evaluating creaminess in full fat products but when the fat was removed, visual, physical stirring, and in-mouth texture became more important for creaminess perception.

Milk Aftertaste

Milk aftertaste can be any residual flavors or texture properties remaining in the mouth after consumption. Porubcan and Vickers (2005) characterized milk aftertaste and consumer acceptability within milk dislikers. Justification for the study was previous research that stated that too much aftertaste was a significant factor deterring females in consuming milk. Their focus group results supported the theory of milk aftertaste as a driver of dislike. A descriptive panel determined that sour taste, dairy sour, fatty mouth coating, and lingering dry mouthcoat were the negative aftertaste milk attributes described by the focus group participants. Milk aftertaste was a definitive component as to why these consumers did not like milk. Francis et al. (2006) determined milkfat had a critical role in the aftertastes of fresh milk. Findings showed that lower milkfat samples had higher maximum intensities and persistence of cooked flavors in the aftertaste at 15 seconds and 90 seconds. Higher milkfat samples had higher maximum intensities and persistence of sweet and sweet related attributes in the aftertaste. Chung (2009) demonstrated that overall liking scores of 10 milks (varying fat levels, heat treatments, and lactose free samples) from consumer tests with Korean females were positively correlated with the aftertaste liking scores. Milks that were liked the least had low liking scores in aftertaste.

Milk Solids-non-fat

Solids-non-fat (SNF) is calculated by subtracting the milkfat content from the total solids (U.S. Food and Drug Administration, 2015). SNF improved the flavor and consumer acceptance of milk beverages according to (Wahid-Ul-Hamid and Munus, 1960). Standardizing 2% and 3% milk from 9.2% NFS to 12-15% total solids using a combination of cream, normal skim milk, condensed or reinforced skim milk, and/or distilled water increased consumer preference above that of unfortified 4% milk. However, when SNF was added to whole milk, consumer preference was shifted back to whole milk over lower-fat milks with SNF as long as the total solids were the same or higher than the other treatments (Devero, 1973). Adding SNF was more easily detected and had a greater influence on consumer acceptance than the addition of milkfat (Devero, 1973). Janzen and Rodgers (1967) reported a significant difference in preference of milk enriched with SNF in home use test compared to the controls. This test was conducted with 3.5% and 4.0% milkfat levels in pasteurized milk. Consumer acceptance was conducted with 2,165 judgments, showing preference for the SNF enriched samples. In a separate study, addition of SNF to low-fat milk shifted the preference to the modified milk over standard milk. The most preferred combination of all milks tested was 1.5% SNF addition and 2.0% milkfat (Pangborn and Dunkley, 1964). No recent work has been done on SNF and consumer liking in recent years.

Lactose-free

Lactose-free milk is a product that a segment of consumers purchase due to lactose intolerance. Lactose intolerance stems from a lack of the enzyme lactase which breaks lactose into monosaccharides for easier digestibility. Approximately 80% of Asians and Native Americans are lactose intolerant, 75% of African Americans, 51% of Hispanic Americans, and 21% of Caucasian Americans are also lactose intolerant (UGA, 2015). According to the Total U.S. Multi-Outlet + Conv. Retail Monthly Milk Snapshot, lactose free milk increased in volume sales by 6.5% in 2014 (DMI, 2014). There are no FDA requirements for products to be labeled lactose free but it is required by law that manufacturers must not mislead consumers (FDA, 2015). Lactose-free labeling is considered a nutrient claim and according to 21 CFR 101.13, the label may be used in such a case that the food would normally contain the nutrient and through processing the food contains little to none of the nutrient in the end. Lactose-free milk can be produced by the addition of lactase to hydrolyze lactose into monosaccharides and/or ultra or nanofiltration (Jansson et al., 2014; Adhikari et al., 2010). A trained panel conducted descriptive analysis on commercially available lactose-free skim, reduced fat, and whole milk compared to their regular milk counterparts (Adhikari et al., 2010). Lactose-free skim was higher in chalky texture, lack of freshness, light oxidized, and processed flavors than the standard skim, along with fat feel, dairy fat flavor, dairy sweet, and overall sweetness. Lactose-free reduced fat milk was significantly different from regular reduced fat milk with higher intensities of color, chalkiness, viscosity, cooked flavor, and sweetness. Lactose-free whole milk was also different from regular whole milk in chalkiness, viscosity, cooked flavor, overall dairy flavor, dairy sweet, lacks freshness, processed flavor, and sweetness. In consumer acceptance testing, regular whole milk was liked best while lactose-free skim was the least accepted. Lactose-free reduced fat and lactose-free whole milks were at parity with regular skim and reduced fat milk (Adhikari et al., 2010). Chapman et al. (2001) conducted descriptive analysis on ultrapasteurized lactose-free milks and regular milks. Lactose-free milks were all different from regular milks in sweetness, caramelized flavor, and viscosity. The perceived difference in viscosity was thought to be related to the increase in sweetness of the lactose-free samples. A separate study evaluated consumer acceptance of lactose-free milk amongst 893 participants compared to soy beverages. Two percent fat lactose-free cow's milk scored the highest in liking followed by lactose-free skim which was rated higher than soy milk (Palacios et al., 2009). Palacios et al. (2010) reported that children rated lactose-free cow's milk higher than soy milk in flavor acceptance.

Milk Labeling

Factors other than flavor can affect milk consumption and what type of milk is purchased. Black women, employed women, rural area women, and women who smoked were less likely to consume milk but by location, women in the Midwest, West, and Northeast were more likely to consume milk compared to other regions of the United States (Kim and Douthitt 2004). Labeling of milk affects purchasing amongst market options. Legally, the name milk may be followed by any characterizing flavoring and on the principal display panel or panels on the label where the font is not less than half the height of the word 'milk,' manufacturers may also claim vitamin addition, the heat process used, and if the milk is homogenized (U.S. Food and Drug Administration, 21 CFR 131.110). The use of nutrition education through health professional and product packaging increased market participation of households in the South (Jensen 1995). Alviola and Capps (2010) found that single-person households, affluent households, and household heads with some college education were more likely to purchase organic milk. Their study also showed that once a decision was made to buy organic, households stayed with that choice even as size increased. By regulations of the FDA, to label a product as 100% Organic, the product must only be made from organic materials or in the case of milk, cow's fed only organic ingredients. To be labeled as Organic, the product must contain at least 95% organic material and must be certified by a third-party organization accredited by the USDA (Food Marketing Institute, 2004). The feed the milking cattle receive must be at least 95% organic material but not necessarily pasture based. Cattle must be managed organically for 12 months prior to application of certification and a producer must be inspected annually after certification is obtained (U.S. Food and Drug Administration, National Organic Program, 2013). No studies were found where flavor of organic milk versus conventional were compared. Kiesel and Villas-Boas (2007) showed that the use of the USDA organic seal increased purchase probability of organic milk.

Omega-3 fatty acids as a nutrient addition must meet the 10 percent minimum nutrient requirement to be claimed on the label. To label milk as a good source of omega-3's, manufacturers must ensure 10-19 percent of the recommended daily intake of such nutrient is present in the food according to 21 CFR 101.54. The milk may be labeled 'high' in such nutrient if 1 serving contains 20 percent or more of the recommended daily intake (RDI). Other labels such as 'grass-fed' or 'pasture based' require that 99 percent of the cow's energy source must come from grass and or forage (Agriculture Marketing Service, 2006).

Recombinant bovine growth hormone (rbGH) also known as recombinant bovine somatotropin or rbST is used by the industry to increase milk production by 10-15 percent. The FDA determined the use of rBGH as safe in milking cows due to the fact that bGH is biologically inactive if injected in humans or taken orally, and naturally occurring bGH and manufactured rbGH compounds are biologically indistinguishable (FDA, 2009). Voluntary labeling of rBGH free milk increased the demand for such products (Kiesel and Buschena, 2005). Dhar and Foltz (2005) found consumers were willing to pay significantly more for rBST-free and organic milk. Organic labeling did not affect purchase intent but did have a positive effect on consumer satisfaction for chocolate milk (Kim et al., 2013). Kanter et al. (2009), however, concluded that all milk types were stigmatized by rBST-free and organic labels. They hypothesized that the introduction of these labels could potentially reduce demand for all milk types.

Packaging Options

Packaging can affect purchasing and may have an influence on shelf life and flavor of milk. Joubert and Poalses (2012) found that brand names did affect consumer perceptions of milks in South Africa both positively and negatively. Two groups were tested; a control group that evaluated milks blind and an experimental group that evaluated the milks with the brand names. The consumers were presented with the samples and asked questions regarding overall satisfaction and intrinsic milk attributes. Overall liking was reversed when consumers tasted milk branded and unbranded. Consumers liked national brand more when they were aware it was a national brand and liked the house brand less when they were aware that it was a house brand. White (1985) interviewed 393 respondents in three different grocery stores about preference for particular milk containers. Consumers preferred white opaque jugs for their milk compared to cream, translucent, or yellow plastic jugs but said they would still buy milk in colored jugs as long as it cost the same. Simon and Hansen (2001) looked at various packages and shelf life. They showed that milk stored in standard and juice boards deteriorated in flavor faster than milk in barrier and foil boards. They concluded that the cardboard flavor migrated from the nonbarrier packaging into the milk. Mestdagh et al. (2005) showed packages with a light barrier provided protection from light oxidation while bottles with an active oxygen binding layer and bottles with a UV-absorbing additive did not. Green polyethylene terephthalate (PET) bottles and low-density polyethylene (LDPE) pouches showed better protection against lipid oxidation and vitamin A degradation than clear PET bottles (Cladman et al., 1998). Multilayer pigmented bottles showed the best protection for shelf life followed by the monolayer titanium dioxide-pigmented high-density polyethylene (HDPE) bottle of the packages tested by Moyssiadi et al. (2004).

Oxidation in Milk

Light oxidation is the process of riboflavin and other photosensitive compounds producing aldehydes from energy absorbed from light sources (Walsh et al., 2015). This can occur during transportation, processing, or storage if not packaged properly. Light oxidation of milk can impart flavors of cardboard, metallic, oily, oxidized, and tallowy (Greenbank, 1948). Barnard (1972) stated children may object and refuse to drink milk with oxidized flavor, whereas for adults they may believe the flavor indicates spoilage. Some consumers may become accustomed to the flavor but the off-flavor may contribute to the decline in milk consumption (Barnard, 1972). Walsh et al. (2015) recently evaluated consumer acceptance of light protected milk, versus milk that had 8 hours, and 168 hours of light exposure. Milk was stored in high-density polyethylene (HDPE) containers with and without a light blocking foil overwrap. Consumers rated the control milk above a 7 on a 9-point hedonic scale throughout the storage time of 168 hours. Milk with light exposure went from an acceptance score of 7.2 at time zero to a score of 5.9 at 8 hours of light exposure. At 168 hours of light exposure, consumer acceptance decreased to an average of 3.5 (Walsh et al., 2015). Vitamin A degradation and light oxidation flavor development was explored by Whited et al. (2002).Whole milk, reduced fat, and skim milk samples were taken directly from the manufacturer and exposed to a fluorescent light box inside a cooler to imitate storage in grocery store shelves. Moderate oxidized flavors were detected by a trained panel in whole milk and reduced fat milk after 4 hours of light exposure while in skim, after 8 hours. Skim milk developed oxidized flavors at a slower rate than whole and reduced fat milk (Whited et al., 2002). Vickers et al. (1999) tested the relationship between liking ratings of light oxidized milk with consumption habits. Throughout several experiments, consumers rated their liking of milk with light oxidation flavor and with light oxidation flavor. That same milk was then placed in the university dining hall to test if the off flavor affected consumption. Results showed a difference in ratings by 1 point on the 9-point hedonic scale when consumers rated light oxidized flavored milk compared to defect free milk, with the control milk scoring higher. However they saw no difference in the consumption of control milk to the test milks in the cafeteria setting.

The Role Habit Plays

A larger selection of beverages exists for consumers to buy than ever before. In 1977, 70% of adults and adolescents consumed milk zero to one times a day. In 1994 that number increased to 82% and in 2007 to 86%. Americans are consuming less milk because they drink it on fewer occasions (Stewart et al., 2013). Stewart et al. (2012) suggest policymakers and checkoff program managers might focus on increasing children's consumption of milk as habits formed as a child may become long term behavior. Habits in food choices have been shown as a significant factor in consumption of sweet, salty, and fatty foods (Tuorila and Pangborn, 1988).

CONCLUSION

Many factors affect milk flavor, acceptance, and purchase among consumers. Milk fat contributes largely to milk flavor and to the appearance of milk but there are not many studies on consumer milkfat detection and what drives milk preference within appearance and flavor. Most studies are outdated and new research is needed to quantify drivers of preference in relation to milk. Qualitative research is needed to understand the current beliefs and values driving purchasing of milk and dairy alternatives. The objective of the research following this literature review was to 1) determine at what levels milkfat differences can be detected by a typical consumer 2) if the noticeable differences plays a role in preference and 3) what are the values and beliefs driving those consumers who still purchase milk and those consumers who purchase non-dairy alternatives.

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CHAPTER 2: MILKFAT THRESHOLD DETERMINATION AND THE EFFECT OF MILKFAT CONTENT ON CONSUMER PREFERENCE OF FLUID MILK

MILKFAT THRESHOLD DETERMINATION AND THE EFFECT OF MILKFAT CONTENT ON CONSUMER PREFERENCE OF FLUID MILK

K.S. McCarthy[*], K. Lopetcharat[†], and M.A. Drake[1]

[*]Department of Food, Bioprocessing & Nutrition Sciences, Southeast Dairy Foods Research Center, North Carolina State University, Raleigh 27695

[†]Nouveau Centric Co. Ltd. Bangkok 10250 Thailand

[1]Corresponding Author:

MaryAnne Drake

Box 7624, Department of Food Science

North Carolina State University Raleigh, NC 27695-7624

Phone: 919-513-4598

Fax: 919-513-0014

E-mail: maryanne_drake@ncsu.edu

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INTERPRETIVE SUMMARY

Milkfat contributes flavor, mouthfeel, and visual attributes to fluid milk and is one possible way to adjust milk composition to optimize preference. It is necessary to determine the amount of milkfat needed to produce a noticeable difference to consumers in skim, 1%, 2%, and whole milk. This study establishes the milkfat adjustment needed to produce a visible or tasting difference and then how that noticeable difference affects milk preference.

ABSTRACT

Milk consumption has been in decline since the 1960's. Milkfat plays a critical role in sensory properties of fluid milk. The first objective of this study was to determine the change in milkfat 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 milkfat 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 of 4, 8, or 15°C on tasting JND values were also investigated. The established JND values were then used to conduct 2-AFC preference tests with milks. Consumers were assigned to three 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 JNDs were lower than tasting-only JND values ($P < 0.05$). Preference testing revealed three distinct preference curves among the consumer segments. Skim milk drinkers preferred skim milk and up to 2% milkfat 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 milkfat content. Whole milk drinkers preferred whichever milk was higher in milkfat regardless of how high the fat content went; distinct from skim and low-fat milk drinkers.

The findings of this study provide insight on how the industry might adjust milkfat to increase milk preference and remain within the standards of identity of milk.

Key Words: milkfat, just noticeable difference

INTRODUCTION

Fluid milk has seen a steady decline in sales over the last several decades while 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 29.6 to 24.6 to 19.0 gallons per person (United States Department of Agriculture, 2015).While total consumption has declined, there have also been changes in the type of milk most commonly purchased. In the 21 years spanning 1966 and 1987, low-fat milk increased in sales by 30.0% while 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 while skim milk sales have remained relatively stable (Agriculture Marketing Service, 2014).

Fat contributes a variety of flavors, mouthfeel and visual attributes to milk. Previous work indicated that the desirable flavors in milk come from compounds probably unique to milkfat (Tamsma et al., 1969). This observation was supported by a later study that surveyed one hundred women about milk consumption and milk attitudes, 82% selected skim or reduced fat as the milk they most frequently consumed (Brewer et al., 1999). All consumers in the 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. The authors concluded that health beliefs played a pertinent role in decisions for milk purchase (Brewer et al., 1999). In addition to contributing to flavor, fat plays a role in the appearance of milk. Phillips et al. (1995) used a trained panel to determine that increasing levels of milkfat gave milk a whiter appearance. Increased milkfat also increased perceived thickness, mouth coating, and residual mouth coating. No significant difference in flavor was detected by the trained panel between skim and 2% milkfat milk

(Phillips et al., 1995). Another study evaluated appearance and its relationship to perceived thickness. Quinones et al. (1997) studied the influence of increased protein concentration on viscosity, color, and other sensory properties in skim and 1% milk. A high correlation was found between instrumental whiteness and trained panel thickness of milk. Instrumental whiteness increased with increased protein content concurrent with sensory thickness but that pattern was not observed with instrumental relative viscosity of the samples.

Milkfat 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, 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 powdered natural cream flavor and not the addition of vegetable oil provided the sensation of higher fat content in skim milk. 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. They also reported that samples which scored high in overall liking also were 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. (2012) determined JND values for sodium chloride in dairy products. The authors proposed that this information could be used to reduce NaCl without consumers detecting differences. Previous work has established that milkfat content of fluid milk is a critical sensory parameter for appearance, flavor, and mouthfeel but the role of specific concentrations of milkfat has not been determined. The objectives of this study were to determine the change in milkfat needed to produce a detectable difference or just noticeable difference (JND) to consumers in skim, 1%, 2%, and whole milks. The second objective was to evaluate how milkfat affected preferences for fluid milk. With this knowledge we hope that the industry will be able to optimize fluid milk within each category to a more preferred product that still falls within the standard of identity of milk under USDA regulations and or strategically position milk and identify areas for milk beverage innovation.

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 milkfat and the raw milk was then standardized to 0.1%, 3.25% or 42.0% milkfat. After the fat content of milk was standardized, it was then pasteurized at 72.8C for 25 sec. and homogenized at 10342 kPa for the first stage and 3447 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 milkfat concentrations. Mojonnier analysis was conducted in triplicate to confirm milkfat concentrations of base milks and then each test sample

(AOAC International, 1992: method number 989.05). Milk was transported and 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 milkfat needed to a produce a just noticeable difference (JND) to consumers for each reference milk (skim, 1%, 2%, and 3.25%). Milk at 0.1% milkfat, 1%, 2%, and whole milk at 3.25% milkfat served as the respective reference milk for each test. Those milkfats were chosen as they are the standard milkfat milks available in the commercial market. Milkfat concentrations for each threshold series were based on preliminary tests. All consumer testing was conducted in accordance with regulations from the North Carolina State University Institutional Review Board for the Protection of Human Subjects in Research. Milk consumers were recruited from the online database maintained by the Sensory Service Center (Raleigh, NC). A minimum of n=60 milk consumers were used to determine the just noticeable difference (JND) for milkfat of skim, 1%, 2% and whole milk as the reference milks under two conditions: tasting without visual cues and visual cues only with no tasting. Each condition was tested in a separate session. Subsequently, the impact of serving temperature on tasting JND without visual cues was also evaluated at three temperatures of 4°C, 8°C, and 15°C. Serving temperature effect was evaluated for skim milk, with each temperature tested in separate sessions. Data for all 13 sessions (4 visual JND, 6 tasting JND, and 3 temperature JND tests) were collected using Compusense Cloud (Guelph, Canada). Threshold test consumers were compensated with a food treat.

For tasting without visual cues, the JND for each reference milkfat was evaluated by a 5-series, ascending forced choice (3-AFC) threshold test. Step factors for each threshold test were determined by preliminary tests to select a range within which most consumers would detect differences. A step factor of 2.2 was used for skim milk, a step factor of 1.7 was used for 1% milk, a step factor of 1.5 was used for 2%, and a step factor of 1.4 was used for whole milk. In testing without visual cues, panelist tasted the milks under red lights and the milk was served in 177 mL, white Styrofoam cups to minimize visible differences in the milks. The reference milk was served in two of the white Styrofoam cups and the third white Styrofoam cup contained the test sample of the milk with an increased milkfat concentration. Each cup contained 59 mL of the designated sample and was labeled with a random 3-digit code. Milks were served at 4C except for the tests that evaluated serving temperature effects. For each series, consumers were presented with all 3 samples. They were asked to taste the milks in the order presented on the ballot and to select the one they thought was different. Cups within each series were presented in a randomized balanced order presentation across all panelists. A 3-minute wait was imposed between each series to prevent carryover effects. The session was limited to a 5-series to prevent fatigue.

When consumers were to only visually evaluate the milks, samples (59mL) were served in 177 mL clear plastic tumblers with random 3-digit codes under normal indoor lighting conditions. Since consumers did not taste samples, an 8-series 3-AFC was used with all other aspects of preparation and data collection remaining the same as the tasting condition without visual cues testing. Milks were served in clear plastic tumblers during the visual testing to imitate how consumers would normally consume milk. For the visual tests, a step factor of 1.5 was used for skim milk, and a step factor of 1.3 was used for 1%, 2%, and whole milk.

Preference Testing

The calculated JND values from the threshold tests for skim, 1%, and 2% milk were used to conduct preference testing to determine how the just noticeable fat difference affected consumer preferences for milks. The whole milk JND values were not used as they far exceeded any milk that would be commercially available. The milks evaluated included skim milk (0.1% milkfat), 1%, 2%, whole milk (3.25% milkfat), 4.5% (skim tasting JND), 6.1% (1% tasting-only JND), and 6.6% (2% tasting-only JND). The tasting-only JNDs were used as these covered both the visual JND and the tasting JND of each reference milk. Milks were prepared in the same manner as for the threshold tests and served (59mL) in 177 mL clear plastic tumblers with random 3-digit codes. Preference tests with all senses engaged were investigated with self-reported consumer groups of skim milk drinkers (n=59), low-fat milk drinkers (defined as those who drank 1% or 2% milk) (n=64), and whole milk drinkers (n=49). Consumers were again recruited from the online database maintained by the Sensory Service Center (Raleigh, NC). Consumers tasted all possible combinations of the 7 milks (21 pairs total) (Table 1) of the reference and test milks served at 4°C (a forced choice preference, 2-AFC) across 3 separate sessions on 3 separate days. Consumers tasted 7 pairs each day, with a 3 minute enforced rest between each pair. Consumers were presented with a random pair of the 7 samples and asked to select which sample of the pair they preferred. Data for all sessions were collected using Compusense Cloud (Guelph, Canada). Preference test participants were compensated with a gift card.

Preference Follow-up Interviews

A subset (minimum of n=10 from each group) of the consumers who completed the preference testing were asked to participate in follow-up interviews. Milks were prepared in the same manner as for the JND and preference testing. Skim milk consumers were presented with 3 pairs of milk separately and asked to identify which sample of the pair they preferred and then were asked to explain why. The 3 pairs that were given were skim versus 2% milk, 2% milk versus whole milk, and skim versus milk standardized to 6.6% milkfat. Low-fat milk drinkers were presented with 3 pairs as well, skim versus 2% milk, 2% versus whole milk, and 2% versus 6.6% milkfat milk. Whole milk drinkers were presented with 2 pairs, skim versus whole milk and whole milk versus 6.6% milkfat milk. These pairs were chosen for each consumer segment based on the preference test results and the most polarization within each group. Each interview lasted approximately 30 minutes. Panelists who completed the interview were compensated with a gift card.

Descriptive Analysis

Descriptive analysis was conducted on the same milks used in the follow-up interviews, a subset from the preference test, to document the analytical sensory properties of each milk. The descriptive panel was comprised of eight trained panelists (ages 22-45 y) and were all employed by North Carolina State University. Each panelist had a minimum of 65 hours of prior descriptive analysis training on food flavor and mouthfeel/texture attributes using the Spectrum™ method (Meilgaard et al., 2007), and at least 20 hours of prior experience with the evaluation of sensory properties of fluid milk and milk powders (Croissant et al., 2007; Drake et al., 2003). Milks were evaluated at 10°C. Milks were gently shaken and 85 mL was dispensed into coded 118 mL plastic soufflé cups with lids. Sample preparation was conducted with overhead lights off to avoid any light oxidation of the samples. At the beginning of each evaluation session, panelists were calibrated with 3 commercial warm up samples of half and half, whole milk, and skim milk that panelists had previously characterized. Panelists expectorated samples and between samples, panelists rinsed with deionized water and cleansed their palate with unsalted crackers. A 3-minute wait time between samples was enforced. The order of presentation of samples was randomized to account for presentation and carryover effects**.**

Opacity, color, and viscosity were evaluated in separate sessions from flavor to prevent interactions. For the evaluation of opacity, references of water and whole fat milk were provided to panelists. All samples were served in black 118 mL plastic soufflé cups with lids and random 3-digit codes. Color was evaluated by dispensing approximately 80 mL of each sample into 100 mm x 10 mm disposable, plastic petri dishes (Thermo Scientific, Waltham, MA, USA). The petri dishes were placed on a white paper background and Behr paint chips ('ultra pure white' PPU18-06=0.0 and 'glass of milk' P260-1u=3.5) were used as references for yellow color. Each milk was evaluated in separate sessions in triplicate by each panelist using an adapted sensory lexicon from Croissant et al. (2007) (Table 2).

Statistical Analysis

Statistical analysis was conducted using XLSTAT Version 2013.5.03 (Addinsoft, New York, NY). Thresholds were determined using the approach described by ASTM procedure E679 - 04 (ASTM, 2011). Two way analysis of variance (ANOVA) was used to determine statistical significances between JND values. A preference proximity matrix was constructed for the 2-AFC tests (ASTM, 1973). Preference curves were then plotted based on the proximity matrix for each consumer group. Qualitative data from the interviews were tallied for the most common answers among each group. Descriptive analysis data was analyzed by ANOVA with means separation.

RESULTS AND DISCUSSION

Threshold Tests

The just noticeable difference (JND) values for visual cues only were lower than the tasting-only JNDs within each reference milk ($P < 0.05$) (Table 3). The skim milk visual JND was 0.4% milkfat while the tasting-only JND was 4.4% milkfat (Table 3).This difference is consistent with results published by Phillips et al. (1995) where a trained panel was not able to distinguish differences in any flavor or aroma attribute between skim and 2% milk when evaluating the milk under red lights. When the trained panelists evaluated the milks under normal lights, differences were detected between 0.06% milk and 0.5% milk in color and opacity. Visual differences are detected at a much smaller change in milkfat than flavor and aroma attributes. It is important to note that as the base milk increased in fat, the JND for visual cues only, increased in a similar magnitude (Table 3). This result is also consistent with expected results. Just noticeable differences are proportional to the magnitude of the starting stimuli (Smeets and Brenner, 2008). The tasting JND also increased with base fat percentage but not to the same degree as the visual JNDs (Table 3). No significant difference was found in JNDs as a function of serving temperature ($P > 0.05$) and therefore only the 4°C results were presented. Previous research by Francis et al. (2005) also showed that a descriptive panel found no difference in flavor of nonfat or whole milk when served at 4°C or 15°C or in cheese flavors at 5°C, 12°C, or 21°C (Drake et al., 2005).

Preference Testing

A total of 172 self-reported milk consumers participated in the milk paired preference tests, 30.2% males and 69.8% females, 19-35y, and mostly Caucasian (65.3%). Overall, when consumers were given skim milk in a pair, the higher milkfat sample was always preferred ($P < 0.05$). Two-percent milk was preferred over whole milk but when given the option of 1% compared to 4.5% milkfat milk, 4.5% was preferred ($P < 0.05$). Consumers reverted back to preferences for a lower fat sample, 2% milk, when presented with the 6.6% milk ($P < 0.05$) (Figure 1).

More differences in milkfat preference were noted when results were separated by typical milkfat content consumed. When skim milk drinkers were presented with skim milk versus 1% milk, they preferred 1% ($P < 0.05$). They also preferred 2% over skim milk ($P < 0.05$). When given 1% or 2% versus whole milk, the reduced fat milks were preferred. Skim, 1%, and 2% were always preferred when presented with a test sample above 4.5% milkfat ($P < 0.05$) (Figure 2). Overall skim milk drinkers preferred 1% and 2% more than skim milk and whole milk. However, when fat content increased to 4.5% and above, they chose skim, 1%, and 2% ($P < 0.05$) (Figure 2). Low-fat milk drinkers preferred 1%, 2%, and whole milk over skim milk ($P < 0.05$) (Figure 3). When given 1% versus whole milk, whole milk was preferred ($P < 0.05$). When the test sample was 6.1% milkfat and above, preference was for 2% or whole but was not different when compared to 1% milk. All test samples were preferred when paired with skim milk ($P < 0.05$) (Figure 3). For low-fat milk drinkers, 2%

and whole milk were their most preferred milk types. One or both milks were preferred over skim and 1% and then again when compared to 6.1% or 6.6% milk ($P < 0.05$) (Figure 3).

Whole milk drinkers preferred 2% and whole milk over skim or 1% milk ($P < 0.05$) (Figure 4). They always preferred the higher fat sample over 1% milk. There was no difference in their preference between whole milk and 4.5%, 6.1%, or 6.6% milk. However, 6.1% and 6.6% milk were preferred over skim, 1% and 2% milk ($P < 0.05$) (Figure 4). Whole milk drinkers preferred any fat sample over skim milk but as the test sample increased in fat content, they preferred the higher fat sample ($P < 0.05$) (Figure 4). Palacios et al. (2009) observed two consumer segments for sensory attributes of cow's milk, one segment being "cream" seekers who preferred strong milk aroma, creaminess, and smoothness. People who consume whole milk normally can be categorized in that more milkfat is always preferred.

These results show preferences for each consumer group for higher fat content milk than what they drink regularly and for skim milk drinkers and low-fat milk drinkers, a higher fat content that was not an extreme amount beyond what they usually consume. Consumers preference was influenced my milkfat content and which milkfat percentage they were accustom to in their daily life. Tuorilla (1987) reported similar results in that skim milk drinkers scored whole milk the lowest in a hedonic liking test, low-fat drinkers scored low-fat and whole milk higher than skim milk, and whole milk drinkers rated whole milk highest in the hedonic test.

Previous research has showed that consumers preferred whole milk in a milk acceptance test (Brewer et al., 1999) and Saba et al. (1998) showed in survey results that consumers preferred milk that they usually consume. However, Brewer et al. (1999) did not evaluate liking scores segmented by milk type consumed and Saba et al. (1998) grouped those who drank skim milk up to 2% in one segment. No previous research has separated skim, low-fat, and whole milk drinkers and tested paired preferences for blinded samples with the only variable of milkfat. This research bridges that gap where skim milk drinkers are separated from low-fat consumers or all milk consumers and establishes that skim milk drinkers prefer some milkfat but have a different milkfat preference level than that of consumers who typically drink low-fat milk or whole milk.

Preference Follow-up Interviews

Qualitative interview results provided further clarification of consumer segment preferences. When skim milk drinkers were presented with skim and 2% milk samples, 2% milk was selected and consumers stated that the reason for preference as “like the thickness,” “stronger flavor,” “better aftertaste,” “less watery,” “fuller flavor,” and “better color.” They were then given 2% milk and whole milk. The 2% milk was preferred and consumers stated that the whole milk was “too creamy,” “had too much aftertaste,” and “had more of a filmy residue.” When skim milk drinkers were then presented with skim milk and 6.6% milkfat milk, preference went back to skim milk. Skim milk consumers stated that the 6.6% milk was “too thick,” “too heavy,” “flavor and texture like cream,” “too fatty,” and “looks like half and half.” Skim milk drinkers preferred some milkfat in their milk but then disliked milk when it continued to increase in milkfat and they felt it was too creamy, too thick, and too heavy.

Low-fat milk drinkers were asked to first evaluate skim milk and 2% milk. 2% milk was selected with reasoning being the skim milk was “too watery” and the 2% was “richer,” “creamier,” “tasted more like milk,” and “had a better aftertaste.” When they were given 2%

and whole milk, whole milk was preferred because they "preferred the color/whiteness," thought it was "creamier," and because it tasted "richer." The third pair presented was 2% milk and 6.6% milk. The 2% milk was preferred because it was "less thick," had no "residue" left on the sides of the cup, and because the 6.6% milk was "too rich." Low-fat milk drinkers followed a similar trend as skim milk drinkers. They preferred slightly more milkfat in their milk than they normally consumed but disliked milk when they felt it too rich and too thick.

Skim milk and low-fat milk drinkers both stated aftertaste as a deciding factor in preferences for milk. Porubcan and Vickers (2005) characterized milk aftertaste and consumer acceptability within milk dislikers. Focus group results suggested that milk aftertaste was a driver of dislike. A trained panel determined sour taste, dairy sour, fatty mouth coating, and lingering dry mouthcoat were the milk aftertaste attributes described by focus group participants. Consumers stated milk aftertaste was a definitive component as to why they did not like dairy milk. Francis et al. (2005) determined that milkfat had a critical role in the aftertastes of fresh milk. Results showed that lower milkfat samples had higher maximum intensities and persistence of cooked flavors in the aftertaste at 15 sec. and 90 sec. Higher milkfat samples had higher maximum intensities and persistence of sweet and sweet related attributes in the aftertaste. In the current study, the aftertaste of skim milk was not preferred or liked by skim milk or low-fat milk consumers.

Whole milk drinkers again, showed their preference towards milkfat and the attributes it contributes to fluid milk. Whole milk drinkers were presented with skim and whole milk and selected whole milk because they liked the "thickness," "color," and thought the whole milk had "more flavor." They then evaluated whole milk and 6.6% milk. They preferred the

6.6% milk, stating it was “creamier,” had a “fuller flavor,” “tasted richer,” and that it had “more body/mouthfeel.”

These qualitative results give insights as to why each consumer segment had distinct preferences for milks. Skim milk drinkers preferred up to 2% milk but did not like the aftertaste of skim or the flavor and texture of the 6.6% milk, milkfat content far above what they normally consume. Low-fat milk drinkers disliked skim milk for its appearance, aftertaste, and perceived watery flavor but also did not like the 6.6% milk because they felt it was too rich in flavor and did not like the texture. Whole milk drinkers preferred whole milk over skim due to flavor, texture and appearance and then preferred 6.6% milk over whole due to a richer flavor and texture. Collectively these results confirm that milkfat provides appearance, flavor, mouthfeel, and aftertaste attributes to fluid milk that are desired by consumers at varying intensities. All consumers preferred some level of milkfat over skim and preference was not solely due to the appearance of skim. It should be noted that this study was conducted in a very controlled environment to ensure milkfat was the only factor affecting the fluid milk. Other factors may also affect consumer liking such as the flavor heat treatment imparts, possible undesirable flavors from vitamin fortification, or light oxidation. In addition, previous literature concluded consumers drink certain milks due to sensory properties but also beliefs and health concerns (Brewer et al., 1999).

Descriptive Analysis

Significant differences were noted among all samples in milkfat/lactone flavor, viscosity, and yellow color ($P < 0.05$) (Table 4). Milkfat/lactone flavor, viscosity, and yellow color increased as fat content increased in the milks. Opacity increased while astringency decreased with fat content ($P < 0.05$). Sweet taste and sweet aromatic flavor followed the same trend however cooked flavor was not different between the milks and aroma intensity was only lower in the skim milk ($P < 0.05$) (Table 3). These results align with previous literature on the effect of milkfat and milk appearance, flavor, and texture of milk (Phillips et al., 1995; Francis et al., 2005) and they quantify the differences the consumers were describing in appearance, flavor, and texture of each pair they evaluated. Consumers frequently stated that skim milk was more watery, this result is reflected in the trained panel opacity and viscosity scores. Consumers also stated that milk flavor/milkfat was a reason they preferred or did not preferred the higher fat sample. The trained panel was able to distinguish that the higher fat milks did have high milkfat flavor and viscosity. Thickness was also an attribute that drove preference of high fat milks for whole milk drinkers and lower fat milks for skim and low-fat drinkers.

CONCLUSIONS

Skim milk drinkers preferred 1% and 2% milks and stated they preferred 2% milk over skim in interviews due to appearance, flavor, and thickness. From previous research we know that both sensory and instrumental whiteness increases with fat content and with it perceived creaminess, a desired attribute in dairy products. Our JND results show that skim milk at 0.5% milkfat was visually different than skim milk at 0.1% milkfat. Therefore skim milk at 0.5% milkfat remains within the legal definition of skim milk but may be more appealing to skim milk consumers because of the visible difference and potentially a perceived creamier taste due to appearance.

Low-fat milk drinkers preferred 2% and whole milk in the paired preference tests. In the interviews, they preferred whole milk over 2% because of the appearance, richness in flavor, and perceived creaminess. Because of the legal restriction of milkfat in 1% or 2% milk, the addition of skim milk powder might enhance appearance and perceived creaminess to consumers. The U.S. Food and Drug Administration under the Code of Federal Regulations Title 21, defines that milk may be adjusted by separating the milkfat, adding cream, concentrated milk, dry whole or skim milk powder, concentrated skim milk, or fluid skim milk (U.S. Food and Drug Administration, 2015). Addition of skim milk powder would allow the final product to remain defined as milk.

In the preference tests and interviews, whole milk drinkers preferred whichever milk had higher fat content as they are milkfat seekers. Milkfat is preferred by all consumer segments to varying levels. After drinking a certain fat percentage of milk for an extended amount of time, consumers prefer milk with similar sensory properties creating different preference groups. Milk as a commodity was seen as positive in a study that looked at the difference between whole milk, reduced fat milk, and soy milk (Bus and Worsley, 2003), however, most misconceptions about whole milk were related to its perceived high fat, cholesterol, and calories. Data published by the USDA showed 1% and 2% are milks that have increased in sales in the past years. The dairy industry should take advantage of this trend, as 1% and 2% milks meet in the middle between all consumers providing the positive sensory attributes of milkfat and the perceived health benefits that consumers value.

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TABLES

Table 1. Sample pairs used for 2-AFC preference tests. Percentages refer to milkfat content

	Sample 1	Sample 2
Pair 1	Skim (0.1%)	1%
Pair 2	Skim (0.1%)	2%
Pair 3	Skim (0.1%)	Whole milk (3.25%)
Pair 4	Skim (0.1%)	4.5%
Pair 5	Skim (0.1%)	6.1%
Pair 6	Skim (0.1%)	6.6%
Pair 7	1%	2%
Pair 8	1%	Whole milk (3.25%)
Pair 9	1%	4.5%
Pair 10	1%	6.1%
Pair 11	1%	6.6%
Pair 12	2%	Whole milk (3.25%)
Pair 13	2%	4.5%
Pair 14	2%	6.1%
Pair 15	2%	6.6%
Pair 16	Whole milk (3.25%)	4.5%
Pair 17	Whole milk (3.25%)	6.1%
Pair 18	Whole milk (3.25%)	6.6%
Pair 19	4.5%	6.1%
Pair 20	4.5%	6.6%
Pair 21	6.1%	6.6%

Pairs and samples within pairs were served in a random presentation

Table 2. Trained panel sensory attributes for fluid milk

Term	**Definition**	**Reference**
Aroma Intensity	The overall orthonasal impact of the sample	
Sweet aromatic[1]	Aromatics associated with materials having a sweet taste	Molasses, vanilla, caramelized sugar
Cooked[1]	Aromatics associated with cooked milk	Skim milk heated to 85°C for 30 min
Milkfat/lactone[1]	Aromatics characteristic of milk fat, lactones, and coconut	Fresh coconut meat, heavy cream, δ-dodecalactone (40 mg/kg)
Sweet taste[1]	Fundamental taste sensation elicited by sugars	Sucrose (5% in water)
Astringency[1]	Chemical feeling factor on the tongue or oral cavity described as puckering or dry	Alum (1% in water)
Viscosity	Amount of force required to slurp 1 tsp liquid from a spoon over the lips	Water= 1.0, heavy cream= 3.2
Opacity	Visual term denoting the degree of opacity	Water= 0.0, whole fat milk= 12
Yellow Color	Degree of yellow color visible to the human eye	Behr paint chips: ultra pure white (PPU18-06)=0.0, glass of milk (P260-1u)=3.5

[1]Terms adapted from Croissant et al. (2007)

Table 3. The amount of milkfat increase needed to produce the just noticeable difference (JND) in each reference milk for each test condition

Reference Milks	**Visual cues only**	**Tasting without visual at 4C**
Skim milk (0.1%)	0.4bD	4.4aC
1% milk	1.5bC	5.1aB
2% milk	3.0bB	4.6aB
Whole milk (3.25%)	4.3bA	6.0aA

Data represents at minimum n=60 consumers for each JND value
Difference in milkfat is presented and was calculated by the group JND fat %-reference fat %= difference in %
Capital lettering shows significant differences within each column ($P < 0.05$); lower case letters designate differences within rows ($P < 0.05$)
Log-transformation of individual thresholds were used to determine statistical lettering

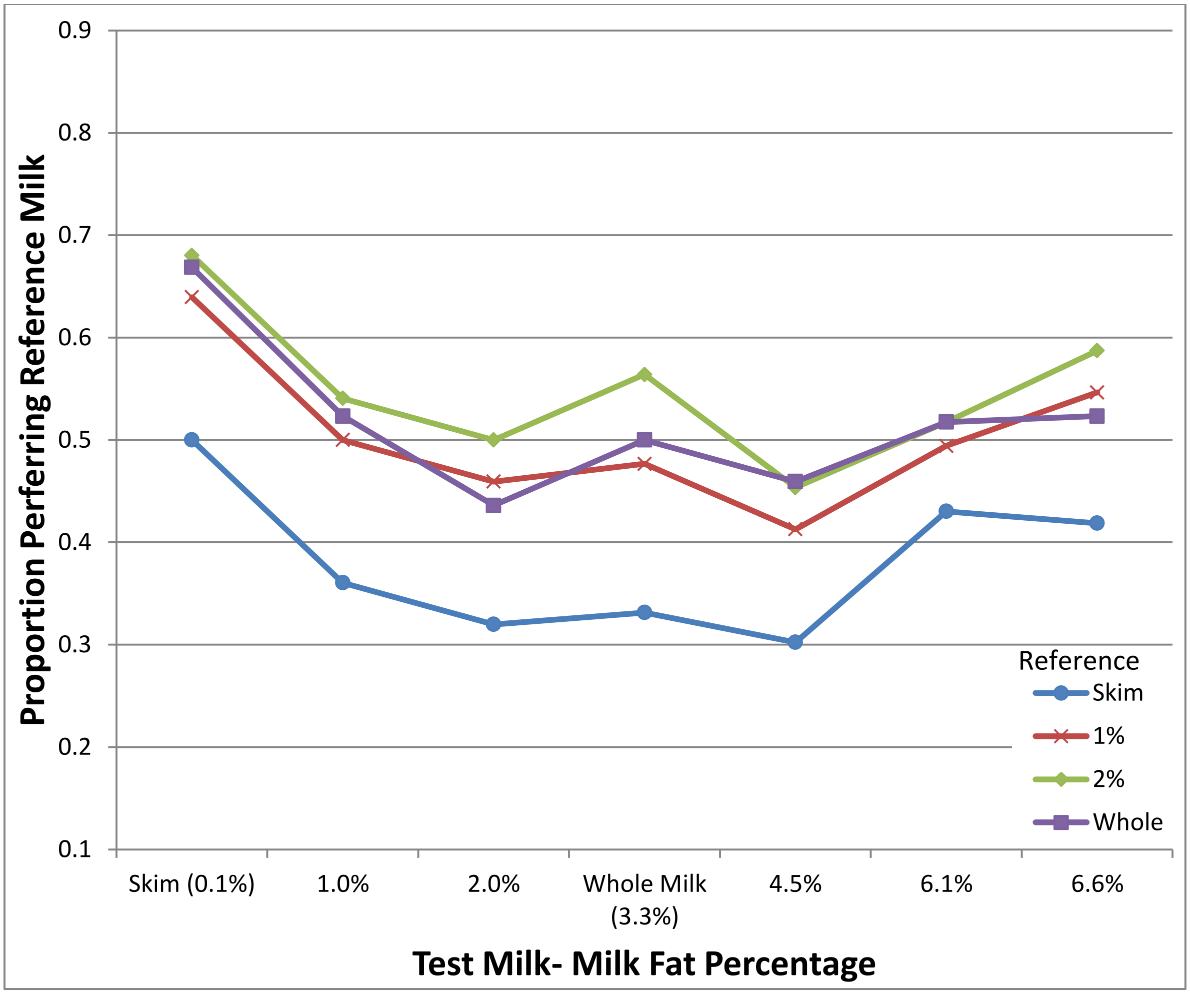

Figure 1. Preference curves for milks with different fat contents for "all consumers (n=172)". Each line represents the designated reference milk in the pair. The x-axis represents the test milk in the forced-choice preference (2-AFC) pair. Identical pairs were not tested to eliminate extra tasting sessions, points are placed at 50% at those pairs on the graphs to aid in visualizing relationships.

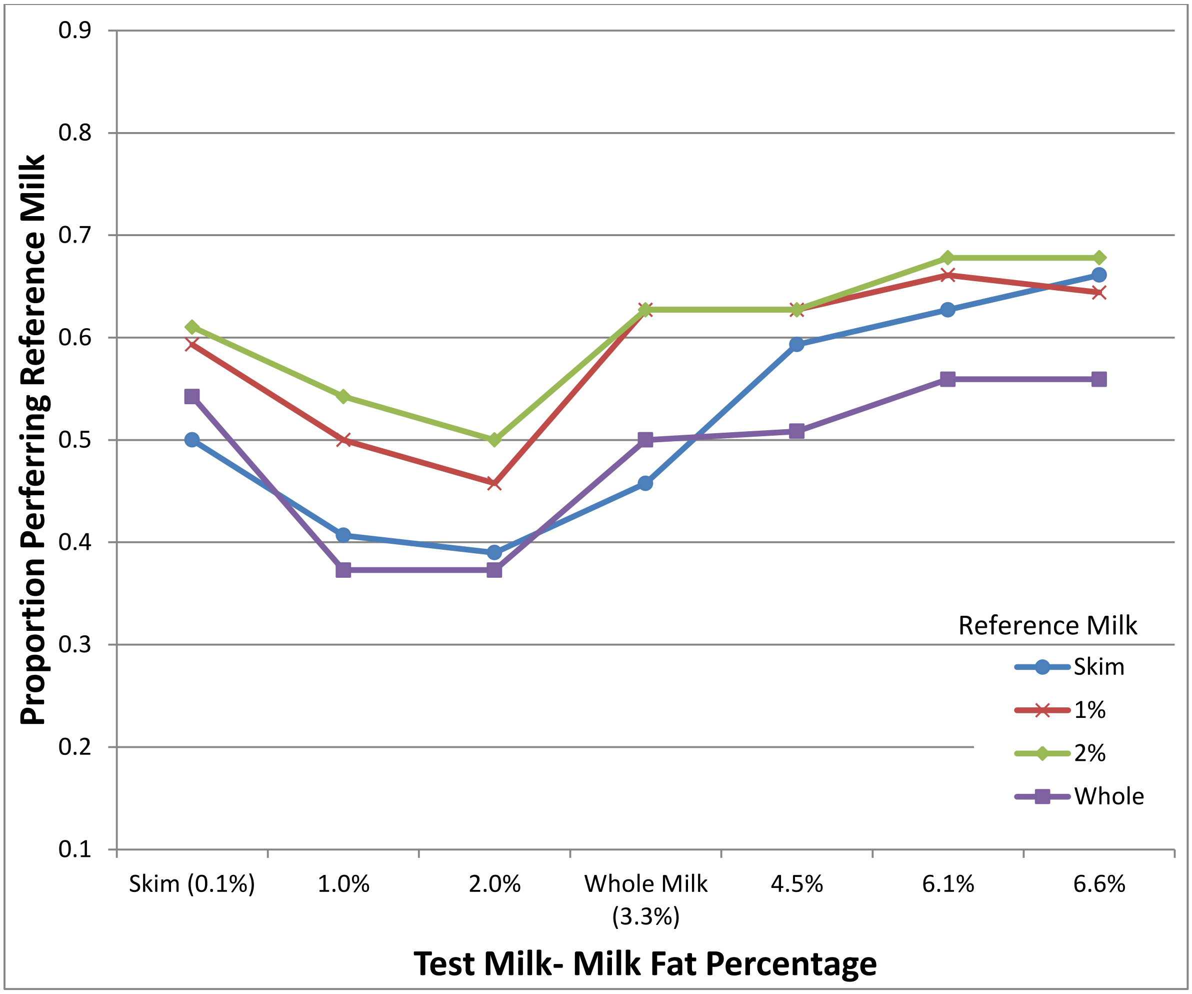

Figure 2. Preference curves for milks with different fat contents for self-reported "skim milk drinkers (n=59)". Each line represents the designated reference milk in the pair. The x-axis represents the test milk in the forced-choice preference (2-AFC) pair. Identical pairs were not tested to eliminate extra tasting sessions, points are placed at 50% at those pairs on the graphs to aid in visualizing relationships.

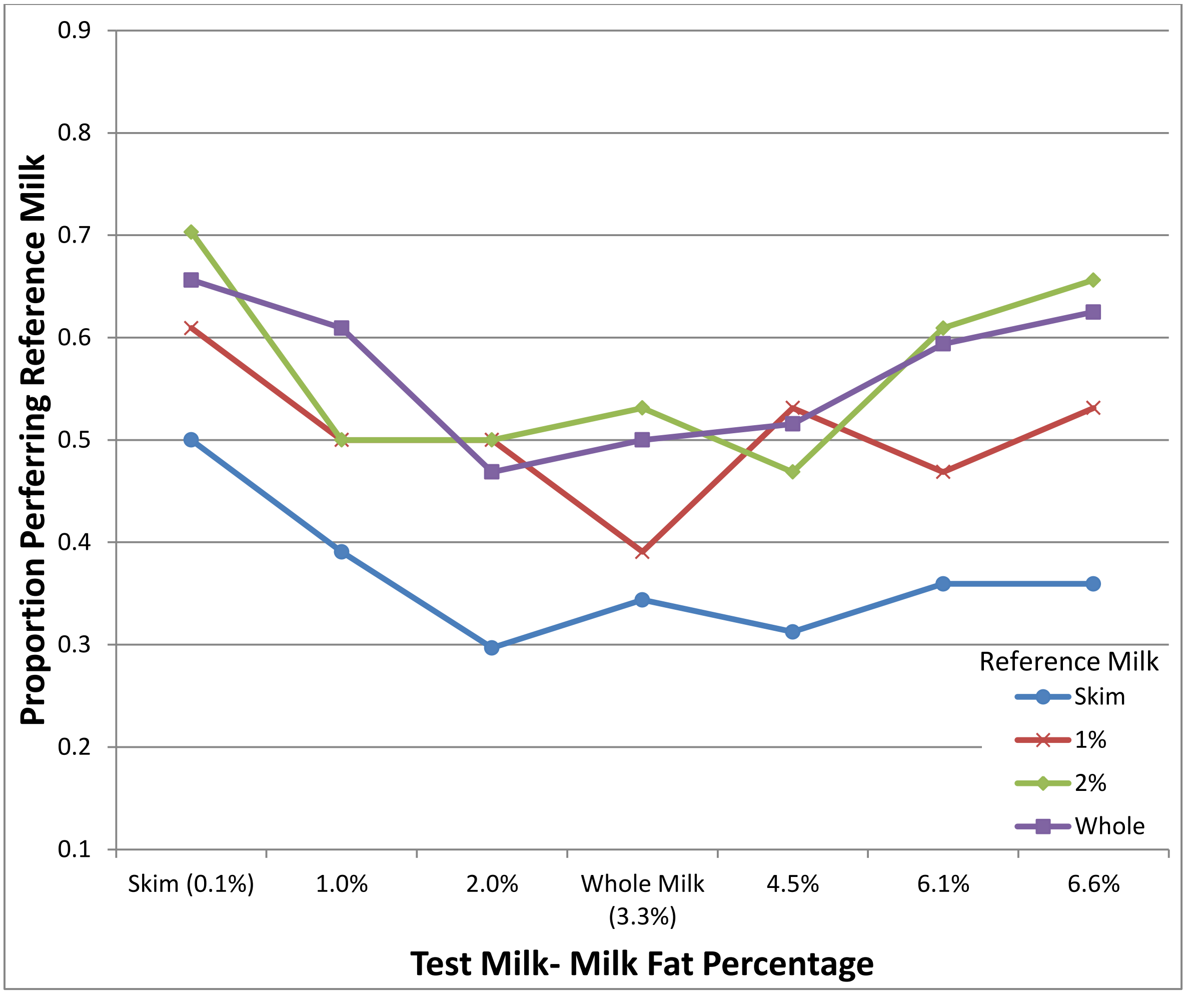

Figure 3. Preference curves for milks with different fat contents for self-reported "low-fat milk drinkers (n=64)". Each line represents the designated reference milk in the pair. The x-axis represents the test milk in the forced-choice preference (2-AFC) pair. Identical pairs were not tested to eliminate extra tasting sessions, points are placed at 50% at those pairs on the graphs to aid in visualizing relationships.

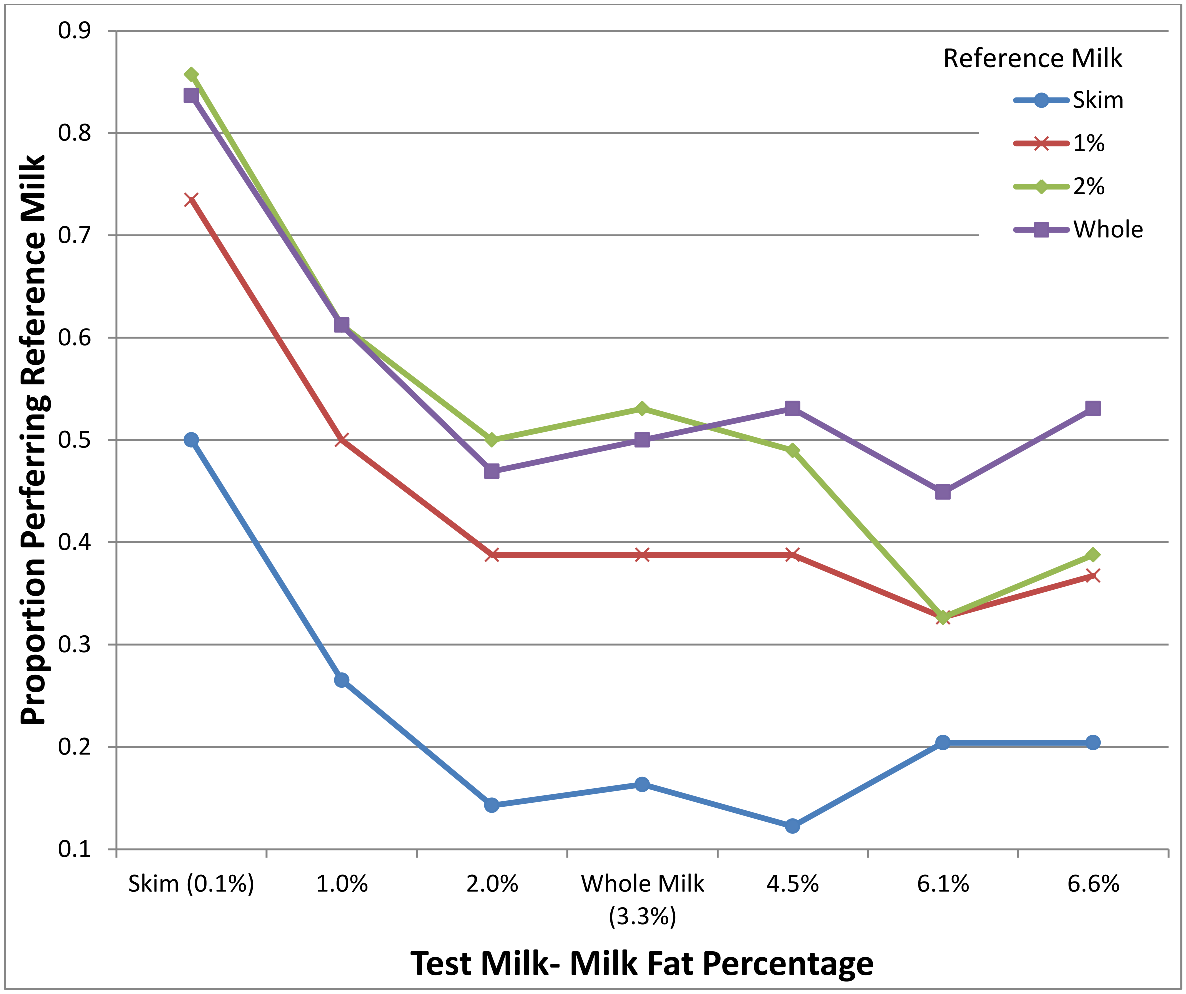

Figure 4. Preference curves for milks with different fat contents for self-reported "whole milk drinkers (n=49)". Each line represents the designated reference milk in the pair. The x-axis represents the test milk in the forced-choice preference (2-AFC) pair. Identical pairs were not tested to eliminate extra tasting sessions, points are placed at 50% at those pairs on the graphs to aid in visualizing relationships.

Table 4. Descriptive analysis of milks used in follow-up interviews, a subset from the milks used in the preference testing

	Skim milk (0.1%)	**2% milk**	**Whole milk (3.25%)**	**6.6% milk**
Aroma Intensity	2.0b	2.2a	2.3a	2.3a
Sweet Aromatic	1.6c	1.9b	2.0ab	2.1a
Cooked	2.9a	2.9a	2.9a	2.8a
Milkfat/lactone	ND	1.6c	2.9b	3.7a
Sweet Taste	1.8b	1.9ab	2.0a	2.0a
Astringency	1.8a	1.5b	1.4b	1.1c
Viscosity	1.3d	1.6c	1.8b	2.4a
Opacity	8.1c	11.0b	12.1a	12.6a
Yellow Color	0.7d	2.0c	2.5b	3.7a

Attribute intensities were scored on a 0 to 15 point universal intensity scale (Meilgaard et al., 2007). Letters in rows following means signify significant differences ($P < 0.05$).

CHAPTER 3: DRIVERS OF CHOICE FOR FLUID MILK VERSUS NON-DAIRY ALERNATIVES: WHAT ARE CONSUMER PERCEPTIONS OF FLUID MILK?

DRIVERS OF CHOICE FOR FLUID MILK VERSUS NON-DAIRY ALERNATIVES: WHAT ARE CONSUMER PERCEPTIONS OF FLUID MILK?

K.S. McCarthy[1], A. Ameerally[1], M. Parker[1], S.L. Drake and M.A. Drake[1*]

[1]Department of Food, Bioprocessing & Nutrition Sciences, Southeast Dairy Foods Research Center, North Carolina State University, Raleigh 27695

[*]Corresponding Author:

MaryAnne Drake

Box 7624, Department of Food Science

North Carolina State University Raleigh, NC 27695-7624

Phone: 919-513-4598

Fax: 919-513-0014

E-mail: maryanne_drake@ncsu.edu

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INTERPRETIVE SUMMARY

Milk consumption has declined while non-dairy alternatives have seen growth in sales. It is necessary to gain a better understanding in what drives purchase and what product features are most appealing to consumers for fluid milk. This study establishes what attributes are most attractive and what values drive purchase in dairy milk and non-dairy alternatives to consumers who only buy dairy milk, those who only buy non-dairy alternatives and those who purchase both beverages.

ABSTRACT

Dairy milk consumption has been declining for decades while consumption of non-dairy alternatives has seen an increase. A better understanding into why consumers purchase dairy milk or non-dairy alternatives is needed in order to increase sales of milk or maintain sales without further decline. The objective of this study was to determine the product attributes that drive purchase within each product category. The second objective was to determine the personal values behind purchasing each beverage type to give further understanding behind why particular attributes were important. An online conjoint survey was launched with 702 dairy consumers, 172 non-dairy consumers, and 125 consumers of both beverages. Individual means-end chain interviews were conducted with dairy milk consumers (D) (n=75), non-dairy alternative consumers (ND) (n=68), and consumers of both beverages (B) (n=78). Fat content ($p<0.05$) was the most important attribute for dairy milk followed by package size and label claims. Consumers of D preferred 1% or 2% fat content, gallon or half gallon packaging, conventional pasteurized store brand milk ($p<0.05$). Sugar level ($p<0.05$) was the most important attribute for non-dairy beverages, followed by plant source, and package size. Almond milk was the most desirable plant source and half gallon packaging was the most preferred packaging. MEC results suggested that maintaining a balanced diet and healthy lifestyle was important to all consumer groups. Lactose-free was important for non-dairy alternatives consumption to ND and B consumers. A distinguishing attribute of those who only drank non-dairy alternatives was the beverages being plant based which included a goal to consume less animal products, beliefs about animal mistreatment, and less environmental impact than dairy milk. Unique to only D consumers, was the attribute of staple food item for dairy milk. Results from MEC analysis suggest that the dairy

industry should focus on their strength of nutrition available in milk and educating people about misconceptions regarding dairy milk. Future beverage innovation should include the development of lactose free milk that is also appealing to consumers in flavor.

Keywords: fluid milk, non-dairy alternatives, means-end chain analysis, conjoint analysis, drivers of consumer purchasing

INTRODUCTION

Overall U.S. fluid milk sales have been steadily declining since January 2011, with retail sales down an estimated 3.8% in 2014 (DMI, 2014; Kennedy, 2015). As fluid milk sales have declined, non-dairy alternative beverage sales have concurrently seen a strong increase in the past few years; up a projected 30.0% from 2010-year end 2015, with a growth of 13.7% in 2014 alone (DMI, 2014; IFT, 2015). Almond milk and coconut milk led the 2014 increases, with the ever-expanding non-dairy alternative varieties also including options such as soy, rice, and quinoa milks (DMI, 2014; IFT, 2015). This expansion and sales increase appears to be driven by increased consumer interest in non-dairy alternative products due to health trends, allergen concerns, and health claims made on these products (IFT, 2015). Dairy milk comprises 68.0% of dairy/non-dairy beverage sales, but per capita consumption of dairy milk has decreased steadily since 1975 by a rate of 830 mL/yr (Geuss, 2013). More than half of dairy consumers also purchase non-dairy beverages and U.S. retail sales of non-dairy beverages are projected to increase two-fold by 2019 at the expense of dairy milk purchases (Baertlein, 2015; Mintel, 2015a).

With the decline in dairy milk purchase and consumption, gaining an understanding of how consumers make choices in their beverages has become of particular interest and would be useful to shift consumer choices to dairy milk products from non-dairy options. One way to gain this insight is by conjoint analysis. Conjoint analysis is a survey technique used to evaluate consumer preferences for a product or product category with varying product attributes (Green and Srinivasan, 1978). The goal is to understand the attributes within a product category that drive purchase (Ewald and Moskowitz, 2007). Consumers are presented with combinations of product attributes and must choose which attributes are most appealing. Several types of conjoint analysis exist: full-profile conjoint analysis, adaptive conjoint analysis (ACA), choice-based conjoint (CBC), menu-based conjoint (MBC), and adaptive choice based conjoint (ACBC) analysis (Jervis et al., 2012a; Rao, 2014). Menu-based conjoint analysis is an advanced tool similar to choice based conjoint but with prices presented with each level of the attribute (Rao, 2014). Adaptive choice analysis (ACA) conjoint asks consumers to rank or rate attributes then assign importance scores to each while CBC analysis presents questions that represent real world decision making for the consumers (Jervis et al., 2012a). Adaptive choice based conjoint (ACBC) analysis combines the techniques of both ACA and CBC conjoint analysis (Jervis et al., 2012a). Jervis et al. (2012a) evaluated ACBC versus CBC conjoint analysis with a limited sample size. The authors concluded ACBC and CBC yielded similar results. Chapman et al. (2009) determined that results from ACBC were more consistent to observed market data than CBC results.

A second means of understanding consumer purchasing within a product category is to use means-end-chain (MEC) analysis. MEC is a marketing research technique based on the psychology behind human behavior and decision making, in which consumers are interviewed to elicit responses that can be categorized as attributes (A), consequences (C), or values (V) (Gutman, 1982). These responses are then linked using a laddering technique to show how they relate in a hierarchal relationship (Gutman, 1982; Reynolds and Gutman, 1988). A hierarchical values map (HVM) is then constructed to illustrate the overall qualities that influence decisions for that category of consumers (Reynolds and Gutman, 1988). The objective of MEC interviews is to determine how a product or service enables the consumer to reach their desired end state (Gutman, 1982). As such, this qualitative technique can be applied alone or in conjunction with a quantitative research tool.

Previous studies have used conjoint analysis to evaluate key consumer choice attributes for soy products, dairy products, and dairy related products (Jervis et al., 2014a; Jervis et al., 2014b; Jones et al., 2008). Kim et al. (2013) applied conjoint analysis to evaluate packaging information on chocolate and Li et al. (2014) evaluated parents' key attributes for chocolate milk purchase for their children. Gutman (1984) used MEC analysis to determine consumer choices related to beverages. Attributes such as natural/sugar free led consumers to achieve a higher self-esteem through healthy food choices in all beverage consumption. Milk was consumed due to calcium content which led to being healthy which in turn, achieved the value of happiness for consumers (Gutman, 1984). Other studies have explored consumer attitudes towards conventional milk (Horwath et al., 1995; Mobley et al., 2014) and acceptability of soy beverages compared to lactose-free dairy milks (Palacios et al., 2009). Mobely et al. (2014) evaluated attitudes and beliefs using focus groups of older, lower income women in the U.S. Primary reasons for dairy milk consumption included that it was "good for bones/osteoporosis," "good for health," and "what the doctor recommended." Horwath et al. (1995) studied reasons for low milk consumption in young and elderly women in New Zealand. For young women, the health concerns were weight loss or lower fat intake with milk being negatively associated with these needs. Lactose intolerance was mentioned by both young and elderly women. Palacios et al. (2009) showed that lactose-free dairy milks at 2% milkfat, 1% milkfat, and skim (0.1% milkfat) were rated higher in overall liking than soy beverages regardless of if the consumers were lactose intolerant. Based on these previous studies, a more targeted evaluation and understanding of why consumers purchase milk, both dairy milk and non-dairy or only non-dairy alternatives is needed if the dairy industry hopes to maintain or gain market shares of beverage sales again.

Several research studies have been performed using MEC theory and conjoint analysis, including several applicable to the food and beverage industry. However, there has not yet been a study to directly relate key attributes to values held by consumers and how that influences dairy milk versus non-dairy alternative beverages purchase. This study aimed to determine and compare drivers of choice for dairy and non-dairy beverage consumers and to subsequently uncover the underlying values behind non-dairy alternatives or dairy milk purchase in these different consumer segments. By identifying what consumers value when making decisions regarding milk or non-dairy alternative purchase, it may be possible to influence consumers to switch from one category to another; i.e. from non-dairy alternatives to milk consumers, and/or maintain current milk consumers.

MATERIALS AND METHODS

Experimental Overview

Online surveys were uploaded to an internet server and completed by consumers from the Raleigh, NC area from a database of over 8000 NC individuals maintained by the North Carolina State University Sensory Service Center. Qualified consumers were primary shoppers (25-70 y) who purchased cow's milk and/or non-dairy alternatives at least 2-3 times per month. After demographic questions and based on product usage, participants were designated as dairy only consumers (D), non-dairy only consumers (ND), or consumers of both beverages (B). Participants completed a series of usage questions, emotion questions and Kano-related questions (described in the Kano analysis section of this paper) before the conjoint survey. Consumers of D completed a dairy milk conjoint section followed by a dairy Kano analysis section and consumers of ND completed a non-dairy alternatives conjoint section followed by a non-dairy Kano analysis section. Consumers of B completed the dairy and non-dairy beverage conjoint analyses in succession followed by the dairy and non-dairy Kano sections in succession. Upon completion of the entire survey, participants were entered into a drawing for one $100 gift card and five $20 gift cards. Qualitative interviews with MEC analysis were subsequently conducted with a subset of consumers from each group to further understand the values behind the conjoint results. All consumer research was conducted in accordance with regulations from the North Carolina State University Institutional Review Board for the Protection of Human Subjects in Research.

Conjoint Analysis

An Adaptive Choice Based Conjoint analysis (ACBC) survey was conducted for dairy and non-dairy beverages using SSI Web (Sawtooth Software version 8.3, Orem, UT). The dairy milk survey addressed fluid milk related attributes (fat content, packaging, label claims, shelf life, protein content, pasteurization and brand) with 3-7 levels per attribute (Table 1). The non-dairy beverage survey addressed seven plant beverage related attributes (sugar level, milk source, package size, fat content, protein content, label claims and brand) with 3-7 levels per attribute (Table 2). Each ACBC survey was designed with 1 build-your-own (BYO) task followed by 10 screening tasks. Each task screening task contained 4 product concepts and possible responses of “it won’t work for me” or “a possibility” for each product concept. For each product concept, a random presentation was generated for each attribute showing random level with every attribute presented in all ten choice tasks. Six unacceptable questions and four must-have questions were built in to the survey. After the screening task, panelists completed a ten question choice task tournament section with a maximum of 18 product concepts and 3 concepts per choice task.

Emotions Questions. Consumers were asked to complete a choose all that apply (CATA) section regarding their emotions when purchasing non-dairy beverages and/or dairy milks for their household as described by Li et al. (2014). This section was completed by panelists after conjoint analysis and before Kano analysis. Emotions selected by over 20.0% of respondents were reported. Consumers of both types of beverages completed separate emotion questionnaires for each type of milk.

Kano Analysis. After the emotions section, participants completed a Kano questionnaire for dairy milk and/or non-dairy beverages to determine how consumer satisfaction was affected by product attributes. In Kano analysis, attributes are classified into one of five quality based **attributes** (Kano et al., 1984). These categories include: **Attractive**: unexpected by the consumer; consumers are satisfied if this attribute is present, **Indifferent**: attributes that the consumer does not care about, **Must have**: expected by the consumer; if unavailable, consumers are dissatisfied, **One dimensional**: as the attribute increases, so does consumer liking and **Reverse**: leads to dissatisfaction. All questions were first asked in positive format such as “Milk that is creamy” before being asked in negative format such as “Milk that is NOT creamy.” For each statement, participants selected one of five responses from: “I will like it,” “I must have it,” “I do not care,” “I can live with it,” and “I will dislike it.” Consumers of both types of beverages completed separate Kano questionnaires for each type of beverage. Responses for consumers of both beverages were placed into respective categories for analysis.

Means-end Chain Analysis

Consumers were recruited from the online database maintained by the Sensory Service Center (Raleigh, NC) from the pool of consumers that had completed the conjoint analysis survey. Consumers were asked to identify if they purchased and consumed only dairy milk, only non-dairy alternative beverages, or if they purchased and consumed both. They were asked how they normally consumed the beverages as the objective was to interview those who consumed the beverages as a drink and not just an ingredient. Consumers who were interviewed were 65.3% females, 34.7% males, 19-45y, and were mostly Caucasian (66.8%).

Interviews were conducted in a 1-on-1 setting, each interview lasting approximately 30-45 min. Consumers were first asked to identify if they consumed only dairy milk (D) (n=75), only non-dairy alternatives (ND) (n=68), or if they purchased and consumed both (B) (n=78). They were then asked how they typically consumed each beverage type to ensure that self-classification aligned with classification for this study. Consumers were then asked why they consumed their particular beverage. In the cases where consumers drank both, laddering questions were conducted with both beverage types. After the first reason of purchase and consumption was established, the interviewer proceeded with "Why?" questions (Reynolds and Gutman, 1988). This series of questioning was allowed to proceed beyond the focus of the beverage type as the goal was to determine how the product fit into the consumer's personal life and ultimately, what they were trying to achieve and or gain by this decision of buying dairy, non-dairy alternatives, or both beverages (Reynolds and Gutman, 1988).

Statistical Analysis

The online survey data analysis was performed using XLSTAT version 2012.6.04 (Addinsoft, New York, N.Y.). For conjoint analyses, individual utility scores were extracted by hierarchical Bayesian estimation and rescaled using a zero-centered difference method to standardize utility scores (Jervis et al., 2012a; Li et al., 2014). A one way analysis of variance with Fisher's least significant difference was used for analysis of utility scores and clusters; cluster analysis was performed using XLSTAT to categorize similar responses into groups. Emotion questions were analyzed for frequency of choice using a chi-square significance test and Kano questions were evaluated according to the model proposed by Kano et al. (1984).

Data for the means-end chain interviews were analyzed as described by previous studies (Reynolds and Gutman, 1988; Santosa and Guinard, 2011). The ladders were first analyzed for content; any similar elements were combined into a single code at each level of attributes, consequences, and values. Nutrition and health factors were categorized separately in the coding process to distinguish between positive attributes (nutrients available in the products), compared to negative attributes or what consumers didn't want the product to contain (fat, carbs, calories). A summary matrix was constructed to display connections within the ladders. Connections were categorized into two types, direct (elements that lead directly to another within a ladder) and indirect (for example, an attribute to a value). A minimum cut-off point of n=5 for each connection was selected to construct the hierarchical value map (HVM) to ensure the HVM represented the majority of respondents (Reynolds and Gutman, 1988).

RESULTS AND DISCUSSION

Online Survey

A total of 999 consumers participated in the survey (702 dairy consumers, 172 non-dairy consumers, 125 dairy/non-dairy consumers). Seventy-eight percent of participants were female and 22.0% were male. Participants were mostly Caucasian (69.6%) followed by African American (19.2%). Eighty-seven percent of participants completed 2+ years of college, there was an even spread of income ($25,000 to >$100,000) and ninety-eight percent of participants were between 34-64 y. The majority of consumers (87.8%) did not claim to follow any specific diet plan or claim to be lactose intolerant (83.4%). All participants had purchased dairy and/or plant based beverages in the past month. Twenty-seven percent of consumers purchased one of both beverages more than once a week, 47.0% purchased one of both beverages once a week and 25.0% purchased one of both beverages 2-3 times per month. No significant differences in purchase frequency or demographics were detected between the three user groups of D, ND, and B ($p<0.05$). Based on no differences in demographics or responses to the conjoint results ($p>0.05$), results from users of both products were pooled into D and ND results respectively (827 dairy consumers, 293 non-dairy consumers).

Conjoint Analysis. Conjoint importance scores indicate which attributes are most important and conjoint utility scores indicate which levels within an attribute are most desirable to the consumer. Fat content ($p<0.05$) was the most important attribute for dairy milk followed by package size and label claims. Pasteurization type (heat treatment) and milk brand were the least important attributes (Table 3). Dairy milk consumers preferred 2% or

1% fat content and gallon or half gallon packaging ($p<0.05$). They also preferred conventional pasteurized milk and store brand milk (Table 4). Dairy conjoint results were consistent with data from previous studies (DMI, 2014; Goff and Griffiths, 2006; Kim et al., 2013). Nearly 70.0% of 2014 dairy milk sales were reduced or fat free milk with gallon or half gallon jugs followed by gabletop liter cartons as the most popular packaging (DMI, 2014; Goff and Griffiths, 2006). Over 90.0% of milk sold in 2014 was conventionally pasteurized and pasteurization temperature was not listed among the 11 value added food trends for milk (DMI, 2014). Ultrapasteurization is appealing to the dairy industry to increase shelf life and to facilitate the consumer supply chain. The heat pasteurization treatments presented in the current study were defined to consumers in terms of shelf life (Table 1). However, our results suggest that increased shelf life is not a key value to consumers. Similarly very little advertising has been devoted to branding fluid milk and consumers are not generally brand aware for this product.

Sugar level ($p<0.05$) was the most important attribute for non-dairy beverages, followed by plant source and package size (Table 5). Label claims and brand were the least important attributes for non-dairy beverages (Table 5). Non-dairy consumers preferred plant beverages that were naturally sweetened or had no added sugar ($p<0.05$) (Table 6). Mintel (2015b) reported consumers are demanding more natural sweeteners and more information the differences between each sweetener type. Confusion exists about which sweeteners are truly all natural which may be a contributing factor as to why consumers are looking towards beverages that are unsweetened. Almond milk was the most desirable plant source and half gallon packaging was the most preferred packaging (Table 6). Over 65.0% of non-dairy beverages sold in 2014 were almond milk (DMI, 2014). For both dairy and non-dairy beverages, utility scores were higher for higher levels of protein content. Protein utility scores were consistent with 2014 marketing results, where more than half of U.S. consumers expressed a desire to consume more protein and also claimed non-meat sources as the best source for this increased protein (NPD, 2014).

Three consumer clusters were identified for dairy milk and three consumer clusters were identified for non-dairy alternatives based on utility scores (Figure 1 and Figure 2). Dairy consumers as a whole were associated with conventional pasteurization and half gallon packaging and not associated with 3.25% fat (whole milk), lactose free, and shelf stable milk (Figure 1). Dairy cluster one (n=351) was characterized by preference for 2% milk, that was locally farmed, and conventionally pasteurized milk (Figure 1). Cluster one gave 2% milk a high utility score with whole milk coming in second, this group may be considered the fat seekers (data not shown). Dairy cluster two (n=275) was characterized by preference for skim and 1% milk, store brand, half gallon packaging, and again conventionally pasteurized milk (Figure 1). Cluster two can be considered the fat free seekers. Dairy cluster three (n=201) was split between the previous two clusters and loaded most closely towards 1% milk and half gallon packaging but also preferred conventionally pasteurized milk (Figure 1). This cluster gave 1% and 2% milkfat equal utility scores and can be considered the low-fat seekers (data not shown). Protein utility scores for 5g, 8g, and 8g all had similar loadings on Factor 1 while 1g and 2g of protein loaded negatively on factor 1 and away from all clusters (Figure 1). This suggests that consumers are attracted by higher protein but do not associate milk as a source of protein or are unaware of the specific amount of protein per serving.

All non-dairy consumers were associated with the utility scores that loaded positively on principal component 1: national brand, vitamin and calcium fortified, no sugar added, naturally sweetened (Figure 2). Upon clustering, more specific consumer groups were defined. Non-dairy cluster one (n=112) was differentiated by soy, fat-free or 1% fat and naturally sweetened (Figure 2). Non-dairy cluster two (n=107) was characterized by preferences for almond milks with 1% fat, GMO free, and no added sweetener while non-dairy cluster three (n=74) was characterized by organic, GMO free, naturally sweetened almond milk (Figure 2).

Non-dairy and dairy conjoint results were consistent with previous studies from Villegas et al. (2009), Saba et al. (1998), Jones et al. (2008), Li et al. (2014), Kim et al. (2013) and Palacios et al. (2009). Villegas et al. (2009) suggested that different factors impacted consumer acceptance of milk versus soymilk beverages. Li et al (2014) and Kim et al (2013) reported that fat content and sugar content were important attributes to consumers when purchasing chocolate milks and that dairy milk consumers preferred store and regional brand milks. Saba et al. (1998) established fat content as a differentiating feature among fluid milk consumers. Palacios et al. (2009) established sweetness as a key driver of liking for lactose free dairy milk and plant based beverages. This study also found that sweet driven consumers preferred fat free and reduced fat non-dairy alternatives (Palacios et al., 2009). Conjoint results from this study support previous work but further understanding into why these attributes are important are revealed through the means-end chain interview results.

Kano Analysis. Attractive features for dairy milk included milk that was all natural, organic, reduced fat, and vitamin fortified (Table 4). Milk that was healthy and milk that tastes good were considered must have attributes. Cluster one consumers (n=351) were characterized by liking of milk that their family/spouse/partner also likes, cluster two consumers (n=275) were characterized by liking of milk that helped with weight control and milk that was fat free, and cluster three consumers (n=201) were characterized by preferences for milk that helped with weight control, milk that was RGBH/growth hormone free, reduced fat/fat free, contained DHA and contained probiotic/digestive benefits. Similar clusters driven by household liking and fat content were identified from Kano results regarding consumer liking of chocolate milk and parents' purchase of chocolate milk (Li et al., 2014). Consumers were also differentiated by preferences for milk that was reduced fat and milk that was all natural (Li et al., 2014; Kim et al., 2013). Parental purchase of chocolate milk was influenced by their children's liking of the milk and consumer clusters were differentiated by traditional consumers, organic consumers and all natural consumers (Li et al., 2014). Kim et al. (2013) identified organic as an overall attractive attribute for all consumers for chocolate milk, but found that it did not affect purchase decisions.

For non-dairy consumers, beverages that tasted good and were healthy were must haves. Non-dairy alternatives that helped with weight control, did not contain growth hormones, had digestive benefits, were all natural, organic, vitamin fortified, and contained as much protein and calcium as skim milk were attractive. Full fat non-dairy alternatives and those that had extra added protein were reverse features (Table 8). Cluster one of non-dairy alternatives was categorized by fat-free as an attractive attribute. Cluster two categorized non-dairy alternatives that their family would drink as a must have and found creamy, reduced fat, fat free, and no extra protein attributes attractive (Table 8). Cluster three found reduced fat and non-dairy alternatives their family would consume, attractive.

Consumers of both beverages had some distinctions from sole user groups in Kano results (Tables 7 and Table 8). For consumers of both beverages, dairy milk that tastes good was a one dimensional performer, and milk that helps with weight control and milk with extra added protein were considered must have attributes. Growth hormone free and milk with probiotic benefits were attractive attributes for B consumers and milk that was fat free was considered a reverse attribute. This is different than when all consumers were pooled together, suggesting consumer who drink both dairy and non-dairy beverages are looking for beverages that fit into a healthy lifestyle or that they may pay more attention to the nutrition label. A non-dairy beverage that tastes good was a one dimensional performer for B consumers, while non-dairy beverages with added sweetener were reverse attributes. This suggests that, consumers who drink both types of beverages are potentially more health conscious of what beverages do not have (i.e. no added sweetener, less calories, lower carbs). This is supported in the results of the MEC interviews with this consumer segment.

Emotional Results. All consumers had positive emotions towards purchasing their respective milks. Both dairy and non-dairy consumers reported the feelings happy, positive and good (results not shown). No significant differences were noted between the user groups ($p>0.05$).

Means-end Chain Analysis

Overall, consuming a beverage for a balanced diet and healthy lifestyle was a consequence that all consumer groups (D, ND, and B) had in common which led to the value of living a long healthy life. Previous literature has shown consumers of both beverages believe in nutritional benefits for their respective category, dairy milk (Mobely et al., 2014) and plant based foods (Lea et al., 2006). The exception of this ladder, was for dairy milk consumers where a balanced diet also led to their value of family, whether it was to practice good parenting through proper nutrition of their children or to live long because they wanted to be around for their family (Figure 3). Comfort was a value D and B consumers had in common in their hierarchical value maps of dairy milk, both stemming from flavor as the attribute and habit as the consequence (Figure 3 and Figure 4). Habit has been stated as an important factor policymakers and checkoff program managers might focus on, as increasing children's consumption of milk may form behavior as a child that might continue through adulthood (Stewart et al., 2012). School lunch milk represents one possible key to lifelong milk consumption if the milk is of high quality and liked. Removal of flavored milk decreases school milk consumption and possibly lifelong milk consumption. Unpleasant experiences with school lunch milk (i.e. cardboard carton flavors, fat free milk, and spoilage) may also have long term negative impacts on milk consumption. Tuorila and Pangborn (1988) also concluded that habit was an important factor in consumption of sweet, salty, and fatty foods. D consumers also reached comfort through the attribute of staple food item and from flavor to the attribute convenient (Figure 3). Consumers in the B group reached comfort through the attribute of nutrition. They drank milk as a habit due to their knowledge of the nutritional benefits of milk (Figure 4). Consumers in the B group saw dairy milk flavor as a treat which led to their happiness and they also connected the flavor of dairy milk to no waste due to the fact they knew their family would drink it (Figure 4). Flavor led to no waste for D consumers also but the value differed in leading to peace of mind (Figure 3).

For ND and B consumption of non-dairy beverages, the attribute of lactose free led to physical consequences such as easier on digestive tract, increased productivity, and to feel better physically, laddering up to the value of living a long and healthy life. Both groups also saw the flavor as a self-reward which led to their happiness (Figure 5 and Figure 6). This suggests that innovation and new dairy beverages that were flavored or provided a variety of options for consumers might appealing to some consumers in these segments, especially those who consumer both beverage types. Key differences in the two groups were that ND consumers had nutrition, meaning perceived calcium and protein, and plant based as attributes in their hierarchal value map (Figure 5) while B had health factors such as lower calories or useful calories, lower carbs, and milk substitute as an attribute (Figure 4). In previous research, misconceptions of dairy milk include whole milk's perceived high fat, high cholesterol, and high calories (Bus and Worsley, 2003). Looking at the results of consumers in group B, these misconceptions may be held about all milkfat levels of fluid milk. Another unique ladder ND consumers elicited was flavor leading to no waste which led to the value of relief of stress (Figure 5). The plant based attribute led to ease of mind which included choosing non-dairy alternatives because they are not animal products, morals based on animal mistreatment, and the environmental impact it took to produce dairy milk compared to non-dairy alternatives which led to the value of feeling achievement or accomplished (Figure 5). This ladder is support by research by Izmirli and Phillips (2011) who reported that students from 11 countries in Europe avoided meat products, due to environmental and health reasons. Milk produced sustainably, green, and with low environmental impact could be appealing to the consumers that purchase plant based milk due to it leaving less of a carbon footprint.

An interesting observation is that consumers in the B group had lactose free as an attribute in their non-dairy alternative map (Figure 6). They then had flavor as a self-reward in their dairy map (Figure 4). Palacios et al. (2009) determined that lactose intolerant consumers still rated lactose-free dairy milk higher than soy milk in overall liking. During the MEC interviews, some B consumers stated they consumed dairy milk due to preference in flavor at the cost of willing to feel uncomfortable due to their lactose intolerance.

Differentiating consumers of B from ND and D was the attribute of health factors meaning their desire for a product with less calories, less fat, and lower carbs (Figure 6). This suggests beverage innovation such as a lactose free or reduced carbohydrate, more protein and more calcium milk beverage option could be very successful in bringing consumers of both beverages back to solely consuming dairy milk.

Comparing D consumers to ND consumers, D consumers were differentiated by staple food item as an attribute of dairy milk and the consequences of convenience and habit (Figure 3). Unique to ND consumers compared to D was lactose free and the plant based attributes of non-dairy alternatives (Figure 5). Consumers who only drank non-dairy alternatives were not necessarily vegetarians or vegan but sought out plant based beverages for various reasons including their desire to limit animal based foods due to health concerns, their beliefs about animal mistreatment, and that plant based beverages were more environmentally friendly than dairy milk. On the contrary, some vegetarians (whether in the group of D or B) did consume dairy milk because they believed in the nutritional value of fluid milk (Figure 3 and Figure 4).

CONCLUSIONS

Results of this study give insight for the dairy industry as to which product attributes are most important or appealing to consumers and why they are important as it relates to their personal life. Results showed key dairy purchase drivers included fat content followed by package size. Dairy consumers found 1% and 2% fat content and gallon sized packaging to be attractive features. Key non-dairy purchase intent drivers include sugar level followed by plant source. Non-dairy consumers found naturally sweetened products and almond milk to be attractive features. Organic, vitamin fortified, reduced fat, and natural were attractive beverage attributes to all consumers. Consumers of both types of beverages differed in their expectations for dairy and non-dairy beverages than consumers who consumed dairy milk only or non-dairy beverages only.

A balanced diet and healthy lifestyle were ladders for all consumer groups. Unique to consumers of both beverages, health factors such as lower fat and lower carbs was an attribute that drove purchase of non-dairy alternatives. This suggests that misconceptions exist about milk as a healthy food within this consumer group. The dairy industry should focus on their strength of nutrition and educating people about misconceptions held for dairy milk. A beverage that tastes good was a must have for both dairy milk and non-dairy alternatives. For dairy milk consumers, great taste was associated with comfort and for non-dairy consumers it led to happiness. The dairy industry should focus on starting children to drink milk at an early age to create a lifelong habit. Lactose free was an attribute in the non-dairy map and flavor was an attribute in the dairy map of consumers of both types of milk. Beverage innovation with lactose free milk would appeal to these consumers and may eliminate their need to purchase non-dairy alternatives all together. These results suggest that consumers who drink dairy milk do so out of habit or because they like the flavor. Consumers who still purchase dairy milk but reach for non-dairy alternatives as well, might not have a need to consume non-dairy beverages if new dairy products are developed that are appealing in flavor but are also lactose free. To those who only drink non-dairy alternatives, grass-fed milk that has a lower carbon footprint may be appealing as long as flavor is appealing. Flavor is a strong driver of choice but the industry must remember other milk attributes that can be applied to create an even more desired product. Taking into consideration what attributes are important in these products and how it fits into the consumer’s life can be used by manufacturers and marketing to create desirable products that are strategically marketed.

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TABLES

Table 1. Attributes and levels used for dairy conjoint analysis

ATTRIBUTES	LEVELS
Fat Content per 8 oz serving	0 (skim/fat free) 1 (2.5 g fat) 2 (4.8 g fat) 3.25 (8 g fat) (whole milk)
Package Size	Gallon Half gallon Liter Pint (16 oz)
Label Claims	Locally farmed Extra Calcium Extra Protein Reduced Calorie Omega-3 fortified Recombinant Bovine Somatotropin (rBST)- free Lactose Free
Shelf life	Conventional pasteurized (shelf life of 18-21 days) Ultrapasteurized (shelf life of 30-65 days) Shelf stable (does not have to be refrigerated until opened)
Milk Type	Conventional Organic Pasture Based
Protein Content per 8 oz serving	1g 2g 5g 8g 9g
Brand	Store brand (e.g. Archer Farms, Great Value) Regional Brand (e.g. PET, Hunter farms) Organic Brand (e.g. Horizon, Organic Valley) National Brand (e.g. Dean's)

Table 2. Attributes and levels used for non-dairy conjoint analysis

ATTRIBUTES	LEVELS
Fat Content per 8 oz serving	1 (fat free) 2 (2.5 g fat) 3 (4.8 g fat) 4 (8 g fat)
Package Size	Gallon Half gallon Liter Pint (16 oz)
Label Claims	Fortified (Vitamin A/D, calcium) Organic GMO free Extra Protein Omega-3 fortified Reduced calorie Conventional (no claim)
Sugar Level	Naturally sweetened No added sweetener Non-nutritive (no calorie) natural sweetener (e.g. stevia, monkfruit) Non-nutritive (no calorie) artificial sweetener (e.g. acesulfame K, aspartame)
Plant Source	Almond Soy Coconut Rice
Protein Content per 8 oz serving	1g 2g 5g 8g 9g
Brand	Store brand (e.g. Archer Farms, Great Value, etc.) Regional Brand (e.g. Westsoy, Zensoy, etc.) Organic Brand (Eden Soy, Organics, Pacific) National Brand (e.g. Silk, Blue Diamond, 8th Continent, So Delicious, etc.)

Table 3. Dairy beverage conjoint importance scores

ATTRIBUTES	**IMPORTANCE SCORES**
% Fat Content	26.9a
Package Size	18.6b
Label Claims	16.7c
Shelf life	15.2d
Protein Content	9.1e
Milk Type	7.1f
Brand	6.4f

Attribute importance scores for the total population of dairy consumers. Letters (a-f) denote significant differences ($p<0.05$).

Table 4. Dairy beverage conjoint utility scores

ATTRIBUTES	LEVELS	UTILITY SCORES
Fat Content per 8 oz serving	2 (4.8 g fat)	31.9a
	1 (2.5 g fat)	29.6b
	0 (skim/fat free)	-18.3c
	3.25 (8 g fat) (whole milk)	-43.2c
Package Size	Gallon	30.3a
	Half gallon	26.3b
	Liter	-11.4c
	Pint (16 oz)	-45.2c
Label Claims	Locally farmed	19.8a
	Extra Calcium	14.4b
	Extra Protein	4.2b
	Reduced Calorie	4.0b
	Omega-3 fortified	3.0b
	Recombinant Bovine Somatotropin (rBST)- free	1.9c
	Lactose Free	-47.3d
Shelf life	Conventional pasteurized (shelf life in refrigeration of 18-21 days)	43.8a
	Ultrapasteurized (shelf life in refrigeration of 30-68 days)	-1.9b
	Shelf stable (no need for refrigeration until open)	-41.9c
Milk Type	Conventional	8.1a
	Organic (shelf life in refrigeration of 30-68 days)	0.4b
	Pasture Based	-8.5c
Protein Content per 8 oz serving	5g	14.6a
	8g	12.5b
	9g	11.9c
	2g	-13cd
	1g	-26d
Brand	Store brand (e.g. Archer Farms, Great Value)	16.2a
	Regional Brand (e.g. PET, Hunter farms)	-1.1b
	Organic Brand (e.g. Horizon, Organic Valley)	-2.1b
	National Brand (e.g. Dean's)	-13c

Zero centered utility values for levels within dairy attributes. Letters (a-d) denote significant differences within each attribute ($p<0.05$).

Table 5. Non-dairy beverage conjoint importance scores

ATTRIBUTES	IMPORTANCE SCORES
Sugar Level	26.9a
Plant Source	18.6b
Package Size	16.7b
% Fat content	15.2c
Protein content (per 8oz serving of non-dairy alternatives)	9.1d
Label Claims	7.1d
Brand	6.4e

Attribute importance scores for the total population of non-dairy consumers. Letters (a-f) denote significant differences ($p<0.05$).

Table 6. Non-dairy beverage conjoint utility scores

ATTRIBUTES	LEVELS	UTILITY SCORES
Fat Content per 8 oz serving	2 (2.5 g fat)	16.6a
	1 (fat free)	5.6b
	3 (4.8 g fat)	3.8b
	4 (8 g fat)	-26.1c
Package Size	Half gallon	39.7a
	Liter	6.1b
	Gallon	-17.3c
	Pint (16 oz)	-28.5d
Label Claims	Fortified (Vitamin A/D, calcium)	13.6a
	Organic	7.4ab
	GMO free	4.4bc
	Extra Protein	-0.7cd
	Omega-3 fortified	-4.5de
	Reduced calorie	-8.6e
	Conventional (no claim)	-11.6f
Sugar Level	Naturally sweetened	52.1a
	No added sweetener	49.9b
	Non-nutritive (no calorie) natural sweetener (e.g. stevia, monkfruit)	-22c
	Non-nutritive (no calorie) sweetener (e.g. acesulfame K, aspartame)	-80c
Plant Source	Almond	57.7a
	Soy	-6.3b
	Coconut	-6.3b
	Rice	-45.1c
Protein Content per 8 oz serving	8g	16.5a
	9g	14.4b
	5g	12c
	2g	-16.1cd
	1g	-26.8d
Brand	National Brand (e.g. Silk, Blue Diamond, 8th Continent, So Delicious, etc.)	14.2a
	Store brand (e.g. Archer Farms, Great Value, etc.)	1.9b
	Organic Brand (Eden Soy, Organics, Pacific)	-3.1c
	Regional Brand (e.g. Westsoy, Zensoy, etc.)	-13d

Zero centered utility values for levels within non-dairy attributes. Letters (a-e) denote significant differences within each attribute($p<0.05$).

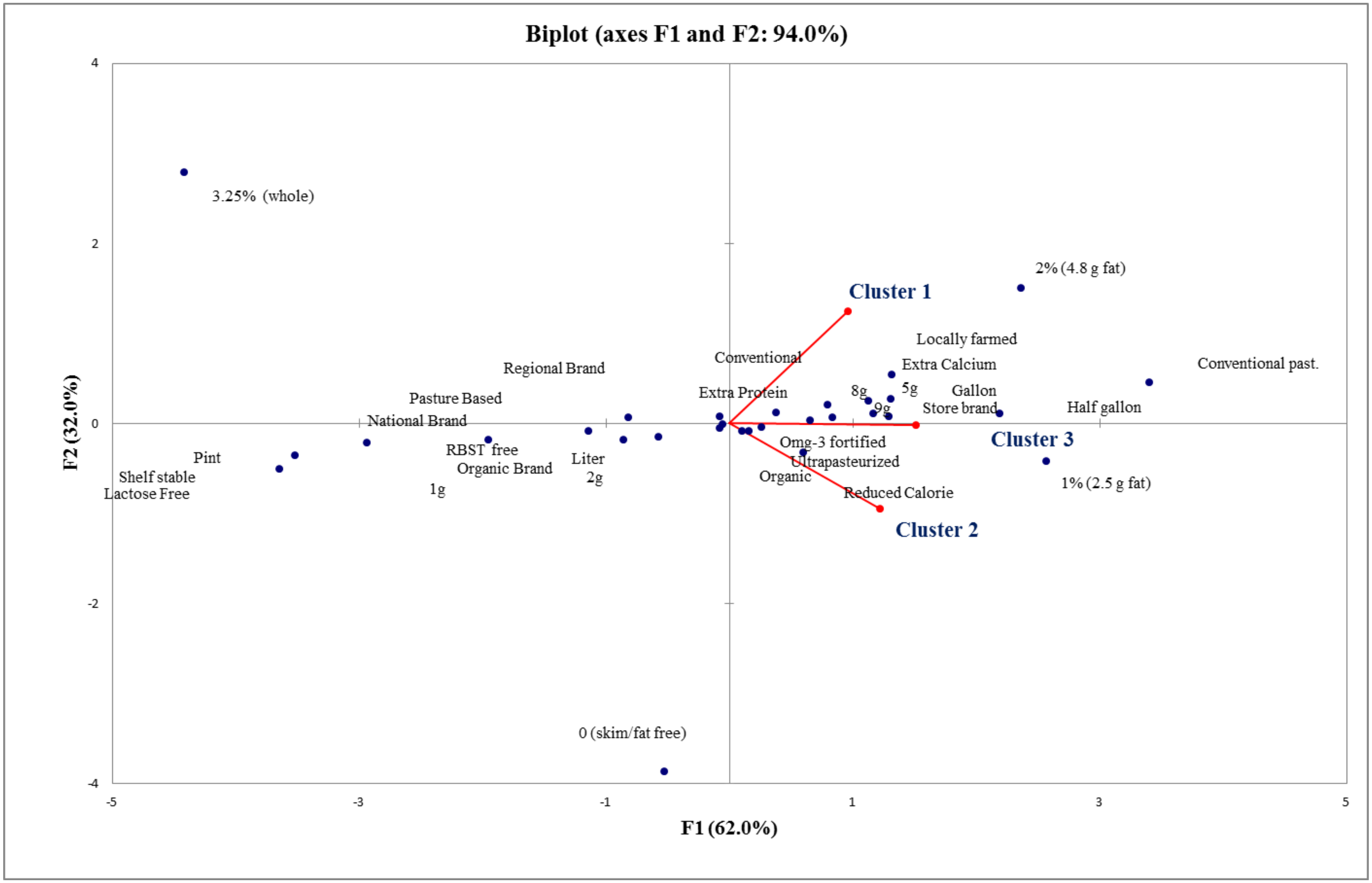

Figure 1. Principal component biplot of dairy consumer clusters with respect to utility scores

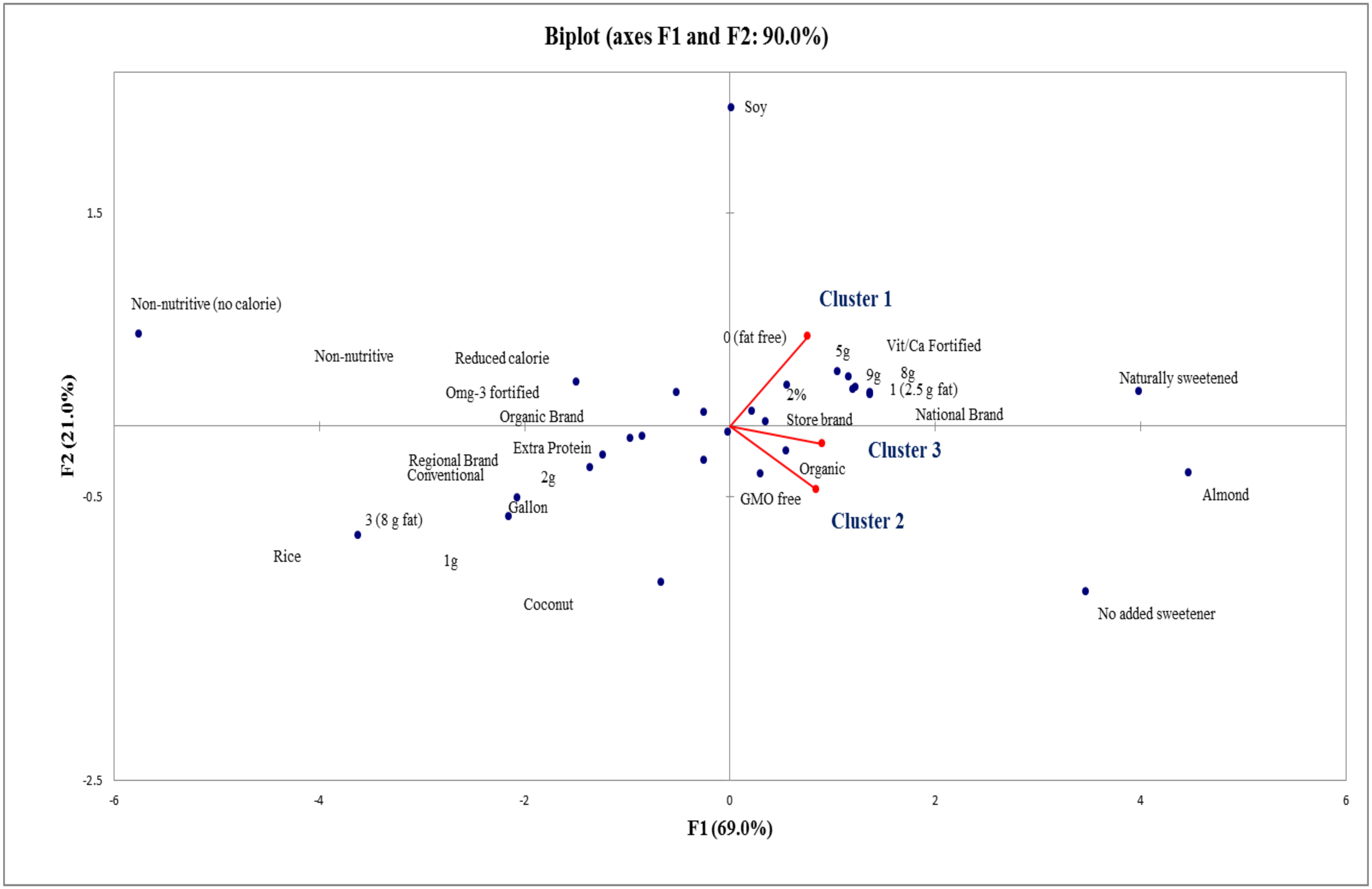

Figure 2. Principal component biplot of non-dairy consumer clusters with respect to utility scores

Table 7. Kano results for dairy milk with all dairy consumers and consumers who drink both dairy and non-dairy alternatives (B)

Feature	All consumers (n=827)	Cluster 1 (n=351)	Cluster 2 (n=275)	Cluster 3 (n=201)	B (n=112)
Milk that tastes good	**Must Have**	Indifferent	Indifferent	Indifferent	**One dimensional**
Milk that helps me with weight control	Indifferent	Indifferent	**Attractive**	**Attractive**	**Must Have**
Milk that is growth hormone free	Indifferent	Indifferent	Indifferent	**Attractive**	**Attractive**
Milk with probiotic benefits	Indifferent	Indifferent	Indifferent	**Attractive**	**Attractive**
Milk that is healthy	**Must Have**	Indifferent	Indifferent	Indifferent	Indifferent
Milk that is all natural	**Attractive**	Indifferent	Indifferent	Indifferent	**Attractive**
Milk that is organic	**Attractive**	Indifferent	Indifferent	Indifferent	**Attractive**
Milk that is reduced fat	**Attractive**	Indifferent	Indifferent	Indifferent	Indifferent
Milk that is fat free	Indifferent	Indifferent	**Attractive**	**Attractive**	**Reverse**
Milk that my family likes	Indifferent	**Must Have**	**One-dimensional**	Indifferent	Indifferent
Milk that is vitamin fortified	**Attractive**	Indifferent	Indifferent	Indifferent	Indifferent
Milk plus added DHA Omega-3	Indifferent	Indifferent	Indifferent	**Attractive**	Indifferent
Milk with extra added protein	**Attractive**	Indifferent	Indifferent	Indifferent	**Must Have**

Kano calculation was calculated as described by Kano et al. (1984). Questions were presented in positive and negative format for each feature to create the contingency table. Bolded attributes represent features that produced a response other than ‘indifferent’ for consumers.

Table 8. Kano results for non-dairy alternatives with all non-dairy consumers and consumers who drink both dairy and non-dairy alternatives (B)

Feature	All consumers	Cluster 1 (n=112)	Cluster 2 (n=107)	Cluster 3 (n=74)	B (n=112)
Non-dairy alternative that tastes good	**Must Have**	Indifferent	Indifferent	Indifferent	**One dimensional**
Non-dairy alternative that helps me with weight control	**Attractive**	Indifferent	Indifferent	Indifferent	Indifferent
Non-dairy alternative that is growth hormone free	**Attractive**	Indifferent	Indifferent	Indifferent	**Attractive**
Non-dairy alternative that has digestive benefits	**Attractive**	Indifferent	Indifferent	Indifferent	**Attractive**
Non-dairy alternative that is healthy	**Must Have**	Indifferent	Indifferent	Indifferent	Indifferent
Non-dairy alternative that is all natural	**Attractive**	Indifferent	Indifferent	Indifferent	Indifferent
Non-dairy alternative that is organic	**Attractive**	Indifferent	Indifferent	Indifferent	**Attractive**
Non-dairy alternative that is full fat	**Reverse**	Indifferent	Indifferent	Indifferent	**Reverse**
Non-dairy alternative that is creamy	Indifferent	Indifferent	**Attractive**	Indifferent	Indifferent
Non-dairy alternative that is reduced fat	Indifferent	Indifferent	**Attractive**	**Attractive**	Indifferent
Non-dairy alternative that is fat free	Indifferent	**Attractive**	**Attractive**	Indifferent	Indifferent
Non-dairy alternative that my family likes	Indifferent	Indifferent	**Must Have**	**Attractive**	Indifferent
Non-dairy alternative that does have a long shelf life	Indifferent	Indifferent	Indifferent	Indifferent	Indifferent
Non-dairy alternative that is vitamin fortified	**Attractive**	Indifferent	Indifferent	Indifferent	**Attractive**
Non-dairy alternative that does have added sweetener	Indifferent	Indifferent	Indifferent	Indifferent	**Reverse**
Non-dairy alternative with Ca equal to 8 oz SM	**Attractive**	Indifferent	Indifferent	Indifferent	**Attractive**
Non-dairy alternative with protein equal to 8 oz SM	**Attractive**	Indifferent	Indifferent	Indifferent	**Attractive**
Non-dairy alternative that has extra added protein	**Reverse**	Indifferent	**Attractive**	Indifferent	Indifferent

Kano calculation was calculated as described by Kano et al. (1984). Questions were presented in positive and negative format for each feature to create the contingency table. Bolded attributes represent features that produced a response other than 'indifferent' for consumers.

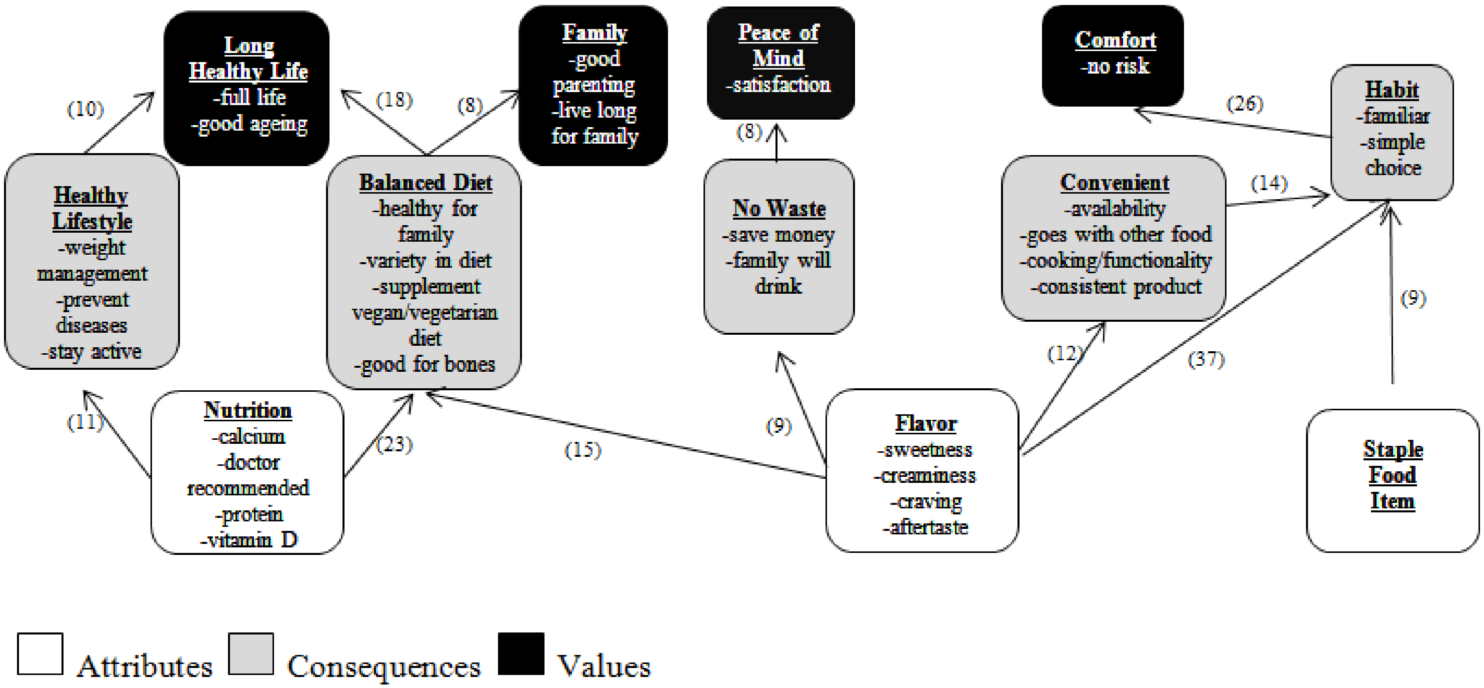

Figure 3. Hierarchical value map for consumers of dairy milk (n=75). Numbers in brackets are the number of times the link was evoked both directly and indirectly.

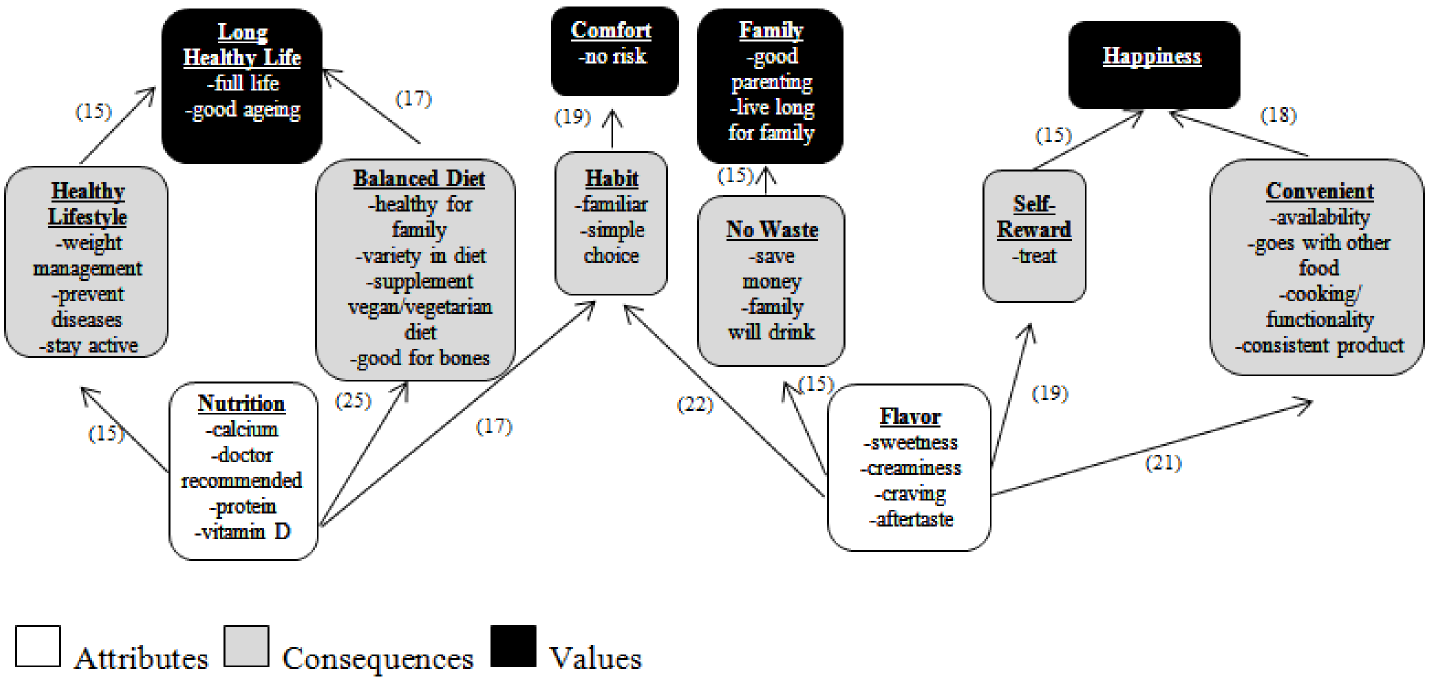

Figure 4. Dairy milk hierarchical value map for consumers of both types of beverages (n=78). Numbers in brackets are the number of times the link was evoked both directly and indirectly.

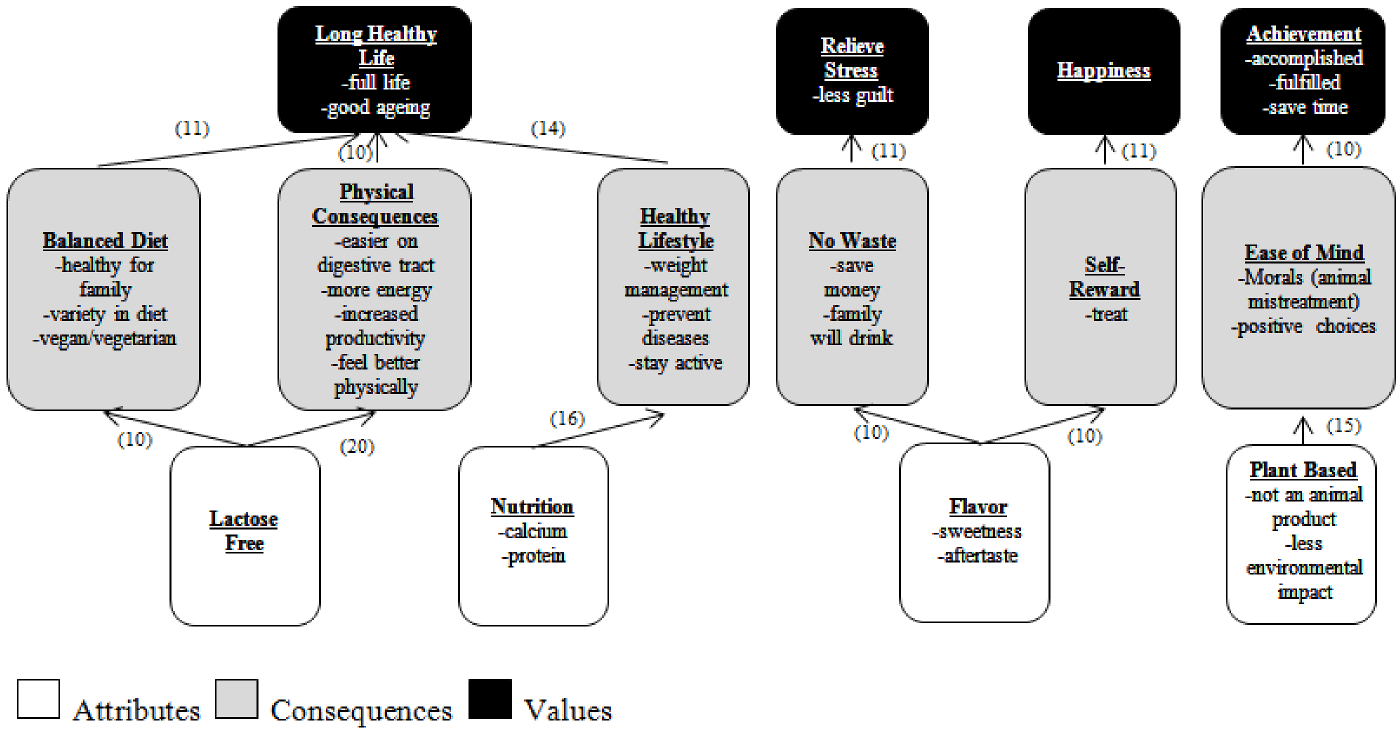

Figure 5. Hierarchical value map for consumers of non-dairy alternative beverages (n=68). Numbers in brackets are the number of times the link was evoked both directly and indirectly.

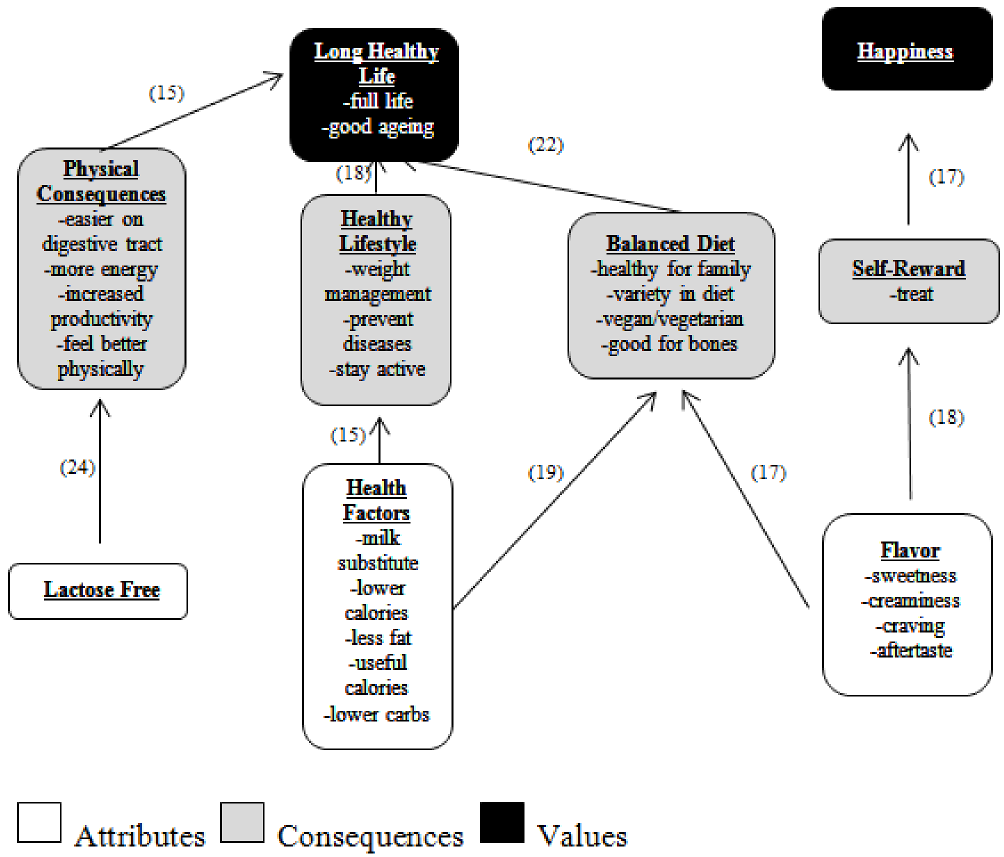

Figure 6. Non-dairy alternative beverage hierarchical value map for consumers of both types of beverages (n=78). Numbers in brackets are the number of times the link was evoked both directly and indirectly.