ABSTRACT

SCHIANO, ANGELINA NICOLE. Consumer Perception of Dairy Foods: Sustainability and Processing Methods (Under the direction of Dr. MaryAnne Drake).

Changing consumer desires have led the growth of new dairy products and plant-based dairy alternatives to better meet these needs. The objective of this dissertation was to better understand changing consumer needs for and perception of dairy products. Four different studies were conducted. In the first study, consumer perception of the sustainability of milk and dried dairy ingredients and their respective plant-based alternatives were characterized using focus groups and two online surveys with dairy product consumers. Focus groups and survey maximum difference scaling results identified 5 key attributes for sustainability: minimal carbon footprint/greenhouse gas emissions, few/no preservatives, animal happiness and welfare, and simple/minimal ingredients. Plant-based dairy alternatives were considered more sustainable than dairy products, but package type and organic status also played a role in consumer sustainability perception. There was cognitive overlap among the terms sustainable, natural, healthy, ethical, and trustworthy as they relate to dairy products, but consumers used the terms distinctly. Consumers perceived differences in these terms between general categories of dairy as well as among products in a specific dairy category.

In the second study, an online survey with three MaxDiff exercises was conducted to determine the importance of 63 label claims to consumer definitions of the terms sustainable, natural, and healthy. Claims related to animal welfare and happiness or simple, minimal ingredients and processing were considered by consumers to be important for all three terms. Priming consumers with information did not impact consumer definitions of any of these terms. For each of these terms, there was a cluster of consumers who defined the term primarily by simple ingredients and minimal processing, and another cluster who defined the term primarily

by happy cows and conscious farming practices. The terms sustainable and healthy each had a third, unique consumer cluster. Age and to a lesser extent, gender, impacted importance placed on these three terms and also impacted definition of the term. Understanding these consumer definitions provides insight on how to formulate marketing and educational messaging to speak to each consumer segment.

In the third study, parents' implicit and explicit attitudes towards dairy milk and plant-based alternatives were assessed. An online survey including an Implicit Association Test (IAT) was conducted, followed by in-depth one-on-one qualitative interviews. Implicit bias impacted purchase likelihood for both dairy milk and plant-based alternatives. The majority of parents were biased in favor of dairy milk over plant-based alternatives, and no matter their bias, parents are more likely to purchase dairy milk than alternatives. However, the majority of parents now take a neutral stance towards encouraging their children to drink milk despite remembering encouragement from their own parents to drink milk during their childhood. These results suggest that the dairy industry should focus on developing and widely distributing marketing messaging educating parents about the benefits of dairy milk.

In the fourth study, consumer understanding of milk processing and constituents were assessed using one-to-one qualitative interviews and a follow-up online survey. Survey responses paralleled those from one-on-one interviews. The average dairy product consumer could recall key words related to dairy processing, composition, nutrients, and ingredients, but was largely unfamiliar with these subjects. For the majority of consumers, purchase intent for fluid milk and cultured dairy products was not impacted when non-conventional processing terms such as ultrafiltered or microfiltered were included in the ingredients statement. This impact was consistent for fluid milk and Cheddar cheeses but not for cottage cheese, suggesting the possibility of product specific effects. Providing respondents with a definition of filtration increased consumer understanding of, positive beliefs about, and purchase intent for fluid filtered milk and cheese made with filtered milk. Educating consumers through on-package labeling and other marketing messaging should be investigated for dairy products incorporating processes such as ultrapasteurization or filtration.

Consumer Perception of Dairy Foods: Sustainability and Processing Methods

by
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BIOGRAPHY

Angelina became interested in consumer perception while attending the College of William and Mary, where she majored in neuroscience. After graduating, she completed her Master's degree in Food Science with a focus on sensory science under the direction of Dr. MaryAnne Drake and stayed in the program to pursue her PhD. While working on her PhD, she completed a Graduate Certificate in Marketing from NC State. Away from the lab, Angelina enjoys dance, crafting, sewing, overanalyzing marketing trends, and spending time with her oversized, slightly overweight, extra-fluffy orange cat, Oliver Fluffytail.

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In my experience, there's only two types of people who read dissertation acknowledgements. Either you're here out of genuine support for me; or it's years in the future and you're desperately searching for a highly specific piece of information for your own work. If you're the second: put this down and go read the published versions of these studies. They're all in the Journal of Dairy Science (same titles). You're welcome. But if you fall into the first category, please accept my sincere gratitude and thanks from the bottom of my heart. Dr. Drake has a saying that it takes a village to raise a graduate student – this PhD has certainly driven that home. I cannot even begin to express how fortunate I feel to have been surrounded with so much support and encouragement during this process.

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CHAPTER ONE: SUSTAINABILITY: DIFFERENT PERSPECTIVES, INHERENT CONFLICT

ABSTRACT

Consumer definitions of sustainability are largely uninformed by scientific research and may not align with industry definitions. Furthermore, consumers themselves have varied perceptions, definitions, and opinions of sustainability which vary between both categories and products within the dairy category. Understanding these differences and developing marketing messaging aligned with consumer sustainability definitions offers an advantage to dairy product producers when strategically positioning their products in a changing marketplace. This review outlines the factors which may impact consumer sustainability perception to provide a basis for future marketing and scientific work to build upon. Consumer trends and desires for sustainability are explored, including how they are reflected in the rapid growth of plant-based alternatives. Factors which may influence consumer perception of dairy as sustainable are covered in detail, including packaging, labeling, animal welfare, organic status, grass-fed/pasture raised feeding systems, and local and clean label perceptions. Finally, a discussion of the challenges of marketing dairy foods with sustainability messages is addressed.

INTRODUCTION

The concept of sustainability sprung into mainstream discussion in the 1970s, when the idea that human population growth would eventually deplete all resources available began to appear in global environmental policy (Basiago, 1995; Purvis, 2019). While the term has become a political and social buzzword, its exact definition remains less clear. Alternate definitions abound, making it difficult to reach a consensus even within a specific industry such as dairy.

Conflicting definitions increase the challenges of sustainability-related communication. Understanding where sustainability definitions overlap and diverge is more than a pedantic exercise: these definitions shape public opinion and policy, and failing to consider the full ramifications of a chosen definition can have widespread consequences on industry, the environment, and human quality of life. For example, a 2018 position paper from the Society of Nutrition Education and Behavior (SNEB) published in the Journal of Nutrition Education and Behavior cited environmental sustainability concerns when calling for replacement of animal products with plant-based foods in the US dietary guidelines (Rose et al., 2019). A response to the position paper called into question the exclusive focus on environmental sustainability, instead promoting a balanced focus on four domains of sustainability (health, economics, society, and the environment) that included animal products (Miller et al., 2020). Miller et al. (2020) agreed on the need for sustainable food systems, but raised concerns that dietary guidance focused exclusively on greenhouse gas emissions and environmental factors as a measure of sustainability could have unintended consequences of disrupting local economies, making nutritionally adequate food unaffordable for vulnerable populations, disrupting cultural and religious drivers of dietary patterns, and encouraging increased consumption of already overconsumed plant-based food groups (ex: grains) as a replacement for healthy animal-based products. Counter-responses from both the authors and SNEB leadership integrated these additional dimensions of sustainability into their arguments, explaining that the role of non-environmental aspects of sustainability were initially downplayed due to the "clear and present danger presented by climate change" (Rose et al., 2020; Joseph et al., 2020). While this exchange primarily centered around livestock production for meat, it illustrates the challenges surrounding sustainability communication for the dairy industry today. Differing definitions of sustainability are inherently in conflict, and unintended consequences may abound unless the parties involved in research and policy-making carefully weigh all aspects of sustainability.

Additional complexity arises when we consider the consumer element. Consumer definitions of sustainability are largely uninformed by scientific research and may be at a mismatch with industry definitions of sustainability. Furthermore, consumers themselves have varied perceptions, definitions, and opinions of sustainability which vary by both category and product (Peano et al., 2019; Schiano et al., 2020, Verain et al., 2016; Bernués et al., 2003). Understanding these differences and developing marketing messaging aligned with consumer sustainability definitions offers an advantage to dairy product producers when strategically positioning their products in a changing marketplace. To our knowledge, no previous reviews have focused on consumer perceptions and definitions of sustainability. Rather than attempt to create a comprehensive definition of sustainability which includes consumer perceptions, the objective of this review is to highlight where differences may arise between current working definitions and consumer perception. Although research on consumer perceptions of dairy sustainability is currently limited, we will compile factors which may impact these perceptions to provide a basis for future marketing research and scientific work to build upon. We will start by outlining dimensions and definitions of sustainability utilized in industry and academic definitions to provide a counterpoint to consumer definitions. Next, we will explore consumer trends and desires for sustainability, including how they are reflected in the rapid growth of plant-based dairy alternatives. We will then cover a variety of the factors which may influence consumer perception of dairy products as sustainable, including packaging, labeling, animal welfare, organic status, grass-fed/pasture raised feeding systems, and local and clean label perceptions. Finally, a discussion of the challenges of marketing dairy foods with sustainability messages is addressed.

DIMENSIONS AND DEFINITIONS OF SUSTAINABILITY

Although a multitude of sustainability definitions are in circulation, the most common underlying conceptualization is the "three pillars of sustainability" – environmental, social, and economic. Despite widespread use, this conceptualization cannot be traced to a single source or explicit theoretical background (Purvis et al., 2019). While the general dimensions are common, the specific elements that comprise each dimension are less agreed upon. Working definitions of sustainability, each differing slightly, have been published at every level, including in legislation. Unlike related terms such as natural and healthy, sustainability does have a legal definition in the US (US Code Title 7, Section 3103): "an integrated system of plant and animal production practices having a site-specific application that will over the long-term: satisfy human food and fiber needs, enhance environmental quality and the natural resource base upon which the agriculture economy depends, make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls, sustain the economic viability of farm operations, and enhance the quality of life for farmers and society as a whole". However, as we will explore further in this review, this legal definition has little bearing on consumer definitions of sustainability. Of more use to this purpose is the United Nations (UN) definition, another of many that incorporates the three pillars model. The UN defines three strategies for sustainable development: economic (profit), social (people), and environmental (planet) (United Nations Department of Economic and Social Affairs, 2015). Ecological/environmental sustainability includes preserving the environment, maintaining species diversity, and using natural resources responsibly (United Nations Department of

Economic and Social Affairs, 2015). This dimension of sustainability is in line with dairy industry sustainability efforts focusing on environmental aspects such as water usage and greenhouse gas emissions (DFA, 2020; DMI, 2018). Consumers, on the other hand, may focus more on the social and economic dimensions. The social dimension of sustainability includes worker and animal health and wellbeing, while the economic dimension includes fair wages, affordable food prices, and supporting local economies (United Nations Department of Economic and Social Affairs, 2015).

INDUSTRY AND ACADEMIC DEFINITIONS OF DAIRY SUSTAINABILITY

Industry definitions of dairy sustainability tend to focus primarily on environmental and economic sustainability, although all three pillars of sustainability are often touched upon. As academic work often informs industry efforts, sustainability from these perspectives will be discussed together. Attempts to define sustainable agriculture in general have focused on the multifaceted nature of sustainability, such as that defined by Farshad and Zinck (1993) who described both overreaching goals of sustainable agriculture (continuity of resources, dynamic land use, stable infrastructure and economy, adequate food production over time, equilibrium between natural resources and human needs) as well as specific practices which may influence sustainability (soil fertility, crop variants, economic viability, ecological soundness, human needs, philosophical ethics). This multifaceted approach is often taken by publications from industry organizations, which reference both the three pillars model and industry-specific key indicators of sustainable practice. For example, the Dairy Farmers of America (DFA) 2020 Social Responsibility Report defines three “Sustainability Pillars” (“Our Planet”, “Our People”, and “Our Communities”), while the 2018 U.S. Sustainability Report from Dairy Management, Inc. (DMI) instead defines five priorities (“Food Safety”, “Environmental Stewardship”, “Animal Care”, “Sustainable Nutrition”, and “People and Community”) (DFA, 2020; DMI, 2018). These reports follow up with statistics on a variety of sustainability factors such as reduction in feed and water usage per cow, increase in milk production per cow, participation in voluntary sustainability auditing programs, usage of solar energy, use of nitrogen digesters, greenhouse gas emissions, crop and soil management program participation, water conservation and quality, workforce development, and community contributions (DFA, 2020; DMI, 2018). While industry reports give us insight into the most widely considered aspects of sustainability, numerous recent publications have attempted to quantify the sustainability effects of current or proposed dairy industry practices, including several invited JDS reviews such as those by von Keysterlingk et al. (2019), Martin et al., (2017), and Milani et al. (2011). Like all animal food production systems, dairy production utilizes water, land, energy, and human labor (von Keysterlingk et al., 2019). From an ecological perspective, sustainability factors include water and land usage, greenhouse gas emissions, reliance on nonrenewable resources for energy, use of manure digestion to produce renewable energy, growth of crops for animal feed, fuel required for production, by-products of production, environmental nutrient management, product packaging production and disposal, and use and safe disposal of sanitizers during production (von Keysterlingk et al., 2019; Milani et al., 2011; Martin et al., 2017). Economic sustainability factors not only the price of products and the ability of producers to remain profitable, but also factors such as the cost to the consumer of dealing with environmental pollutants, the effects of milk market globalization, the initial investment and scale required to adopt new production technologies (von Keysterlingk et al., 2019). Factors related to the social pillar of sustainability include the proportion of jobs held by undocumented workers, animal welfare, and even public pressure and consumer political support leading to policy changes which may affect other dimensions of sustainability (von Keysterlingk et al., 2019).

CONSUMER TRENDS AND DESIRES FOR SUSTAINABILILITY

Understanding the consumer element of sustainability is twofold. First, how do consumers perceive, understand, and define sustainability? Second, do consumers desire sustainable products and are they willing to pay for them? Understanding both these aspects provides insight into consumer decision making for sustainable dairy and helps communicate sustainability-related information in a way that will be understood and accepted by the average dairy product consumer. Consumer choice depends on the decision making strategies utilized, which can be grouped roughly into high-effort and low-effort processes and strategies (Hoyer et al., 2013). During high-effort decision making, consumers methodically evaluate options and tradeoffs to reach a decision, while in low-effort decision-making consumers instead rely on heuristics (subconscious decision making shortcuts) and implicit attitudes (Hoyer et al., 2013; Friese et al., 2006). For the average dairy product consumer, judgements about sustainability are often low-effort and made quickly at the point of purchase, with on-package messaging as the most common source of consumer sustainability information (Schiano et al., 2020; Schiano et al., 2021a). As such, it is important to investigate both implicit and explicit attitudes to gain a robust understanding of consumer perception of dairy sustainability.

Consumer Perception, Understanding, and Definitions of Sustainability

Unlike industry and academic definitions of dairy sustainability, consumer definitions are not well-defined and highly influenced by preconceived ideas and biases. Consumers may simultaneously define sustainability in conflicting ways or desire conflicting ideals, such as valuing both technological advances and undisturbed nature in an agricultural system (Boogard et al., 2007). Sustainability is also not a static and universal concept for consumers. Consumer perception of sustainability varies between and within product categories (Schiano et al., 2020; Bernués et al., 2003; Verain et al., 2016). In addition, segments of consumers define sustainability differently, including within the dairy category (Schiano et al., 2021a, Peano et al., 2019; Verano et al., 2012). Schiano et al. (2021) grouped U.S. dairy consumers into three clusters based on their definition of sustainability as it related to dried dairy ingredients. The largest cluster defined sustainability by terms related to reducing waste and environmental harm, but a significant percentage of consumers defined sustainable by terms related to happy cows and conscious farming or by terms related to simple ingredients and minimal processing. Peano et al. (2019) segmented Italian consumers into five clusters based on their definition of food sustainability. The clusters were: “man-nature balance” (focused on man-made environmental issues), “social welfare sensitive” (focused on sustainable economic growth, food security, and worker employment, wellbeing, and safety), “relationship with the territory” (focused on local production and personal relationships with producers), “environmental sensitive” (focused on ecology and environmental balance of ecosystems creating higher quality, and thus higher value products), and “local ecosystem preservation” (focused on local agriculture systems maintaining balance with local ecology as a method of survival for small farms). In both studies, consumer definitions of sustainability involved all three dimensions of sustainability (economic, social, and economic), often in overlapping ways. Along with cognitive overlap between the dimensions of sustainability, there is overlap between consumer perceptions of sustainability and related terms such as sustainable, natural, healthy, trustworthy, and ethical (Schiano et al., 2020; Pelletier et al., 2013; Verain et al., 2016; Aschemann-Witzel, 2015). Cognitive overlap can result in halo effects which profoundly impact perception and purchase intent – for example, a product marketed as sustainable may be seen by consumers as more healthy, or a product marketed as natural may be seen as more sustainable. Finally, characteristics of consumers themselves may impact perception of dairy sustainability (specific instances are discussed in detail in the "Dairy Foods Factors" section of this review). Consumer age has been a particular focus of sustainability-related work. While a common misconception exists that sustainability is only the focus of younger generations, food sustainability is positively viewed by all generations (Kamenidou et al., 2020; Wiernik et al., 2013). In the case of dairy sustainability, different generations may define sustainability differently, with younger generation definitions focused more on the environmental dimension of sustainability and older generations focused more on simple ingredients and minimal processing (Schiano et al., 2020).

Consumer Desire and Willingness to Pay for Sustainable Dairy

Although consumer demand for sustainability is a major topic in the dairy industry, consumer purchase habits may not reflect their stated opinions. This discrepancy between stated consumer desires for sustainability and resulting consumer choices, commonly referred to as the attitude-behavior gap, is well-documented in industries including fashion, transportation, energy, and food (Park and Lin, 2020; Haider et al., 2019; Claudy et al., 2013; Vermeir and Verbeke, 2006). When making tradeoffs, dairy consumers may prioritize other attributes over sustainability. Schiano et al. (2021) presented dairy consumers with 5 attributes (flavor, price, healthy, natural, and sustainable) and reported that for dried dairy ingredients, sustainability was the least important of the 5 attributes. The environment in which most dairy consumers make sustainability-related decisions (at point of sale) may also not be conducive to choosing sustainable products even if these products align with consumer values (Appleby et al., 2003; Schiano et al., 2020; Schiano et al., 2021a). Consumers at point of sale must balance conflicting priorities and can easily be influenced by the purchase habits of other shoppers (Appleby et al., 2003). Consumer willingness to pay (WTP) for sustainability has been investigated with global consumers and a multitude of product categories, including dairy, chocolate, coffee, wine, beer, almonds, bread, and seafood, although findings vary considerably depending on product category as well as consumer demographics and psychographics (Vecchio, 2013; de-Magistris and Gracia, 2016; Sellers-Rubio and Nicolau-Gonzalbez, 2016; Carley and Yahng, 2018; Vecchio and Annunziata, 2015; Xu et al., 2012; Echeverría et al., 2020). Several studies have focused on WTP for sustainable dairy as an effect of specific labeling or other product attributes (Canavari and Coderoni, 2020; Echeverría et al.,2014; Markova-Nenova et al., 2018; Wolf et al., 2011; Wong et al., 2010; Peira et al., 2020; Kühl et al. 2017). These studies are discussed in greater detail in the "Dairy Foods Factors" section of this review.

The Push for Plant

An increasing desire for sustainable foods is reflected in the rapid growth of plant-based dairy alternatives, many of which market themselves as more sustainable, healthier, more natural, or more humane for animals than animal-derived foods, including dairy (Mintel Group Ltd., 2019; Franklin-Wallis, 2019; Crawford, 2020). Regardless of whether they purchase plant-based alternatives or not, the average dairy product consumer is more likely to consider plant-based alternatives more sustainable than their dairy counterparts (Schiano et al., 2020; Schiano et al., 2021a; Mintel Group Ltd., 2019). A desire for sustainability and reduced environmental impact is a key driver of plant-based milk consumption (Haas et al., 2019). Animal welfare, a concept which overlaps with the consumer concept of sustainability, is also a driving force behind choosing plant-based alternatives over dairy foods (Haas et al., 2019; McCarthy et al., 2017). Currently, over half of dairy product consumers also purchase plant-based dairy alternatives, and consumers who purchase both on average place a higher importance on sustainability than those dairy consumers who do not purchase plant-based alternatives (Schiano et al., 2020).

DAIRY FOODS FACTORS

Packaging Material and Design

Material, design, and labeling all play a role in consumer perception of sustainability based on packaging. The average consumer has limited knowledge of packaging sustainability, relying on implicit beliefs rather than detailed analysis to make sustainability-related purchase decisions. These beliefs do not necessarily align with life-cycle assessments (LCAs) of packaging sustainability, leading consumers to overestimate the importance of certain aspects (such as post-consumption waste and recyclability) while underestimating the importance of other aspects (such as the energy required to produce or transport packages) (Steenis et al., 2017; Lindh et al., 2016; Nordin and Selke, 2010; Van Dam, 1996). Although the average dairy product consumer does not consider packaging sustainability in LCAs, package type does affect sustainability perceptions and purchase intent. Glass packaging in particular is considered the most sustainable by fluid milk consumers, and consumers who purchase non-conventional milks (add) are more likely to purchase milk in a glass container (Schiano et al., 2020; Getter et al., 2014). Steenis et al. (2017) found that among Dutch university students, glass jars were considered one of the most sustainable packaging options for tomato soup (second only to a biodegradable bioplastic pot), despite being the least sustainable option identified by LCA. Meanwhile, carton sachets of dry soup were considered one of the least sustainable options by these consumers despite being the most sustainable option according to LCA (Steenis et al., 2017). The low perceived sustainability of the dry carton sachets was in part due to the smaller, single use package size (Steenis et al., 2017). A similar perception of smaller packages as unsustainable was seen also for fluid milk and protein powders, although potential interactions between package size and package material were not explored (Schiano et al., 2020). More research is needed to understand how consumers perceive the sustainability of single and multi-use dairy packages produced with different materials. For fluid milk, HDPE and PET plastic jugs (what conventional milk is typically sold in) are considered the least sustainable milk packaging option, less sustainable than gabletop paperboard cartons (Schiano et al., 2020). Consumer perception of paper as more sustainable than plastic has been also shown in general studies of food packaging perception (Lindh et al., 2016)

Packaging design also likely contributes to sustainability perception of dairy products (Schiano et al., 2020), which is consistent with the heuristics applied by consumers when making low-effort judgements regarding food purchase. Package elements can be roughly split into two categories: visual (color, graphical elements, etc.) and verbal (nutrition information, claims, messaging, etc.) (Rettie and Brewer, 2000). Both visual and verbal elements can influence consumer perception and purchase intent for food products including dairy. We will discuss visual package design elements in this section, while verbal elements including labeling will be discussed in depth in the next section. Color in particular has been extensively studied in relation to sustainability perception - green signals sustainable or eco-friendly packaging (Hoogland et al., 2007; Maginer and Schoormans, 2015; Pancer et al., 2015). While other visual packaging elements have not been as widely studied as color, consumers do have expectations for the visual design of sustainable foods. Nguyen et al. (2020) found that while Vietnamese consumers would purchase “ugly” eco-friendly packaging if they understood its purchase, visually attractive packaging was expected for sustainable products. Steenis et al. (2017) found that a green leaf motif on tomato soup packages increased consumer ratings of the products as more sustainable, natural, and healthy than packages without this element. Finally, consumer responses to verbal claims and visual elements on food packages can be modulated by both other package elements and consumer existing beliefs about sustainability. Maginer and Schoormans (2015) found that among French consumers, including a verbal sustainability claim on mixed nuts packaging decreased purchase intent when the packaging appeared conventional, but increased purchase intent when the packaging design also appeared eco-friendly (mimicking currently available eco-friendly brand packaging). On the other hand, for those in Maginer and Schoorman's study (2015) with high sustainability concern purchase intent increased when either a verbal sustainability claim or an eco-friendly package design was incorporated.

Labeling

Although sustainability- or ethics-related labeling is a common practice for the dairy industry, these labels show mixed effectiveness when communicating information to consumers and affecting consumer choice. Grunert et al. (2011) outlined six barriers to sustainable consumer food choice of products with eco-labels: 1) failure to notice the label, 2) peripheral processing of a label instead of true understanding, 3) incorrect inferences from labels, 4) tradeoffs with other attributes, 5) lack of awareness and/or credibility, and 6) lack of motivation at the time of choice. Barriers four and five have already been discussed in this review in the section "Consumer Desire and Willingness to Pay for Sustainable Dairy". In order to make a purchase decision based on a sustainability label, a consumer must first notice that label. Outside of checking the price, many consumers may skip over label reading entirely for dairy products, especially those they are already familiar with (Schiano et al., 2021b, Bir et al., 2019, McKendree et al., 2012). Label reading, if it occurs at all, is a quick process – Grunert et al.

(2010) found 40% of consumers from six European countries took less than 15 seconds to read a product label before making a decision. The majority of study respondents (62.6%) looked only at the front of package, while just 7.7% looked elsewhere (Grunert et al., 2010). Label reading may be affected by consumer demographics and psychographics. For example, Bir et al. (2019) found participants with higher incomes or those with children in their household were more likely to read labels when purchasing fluid milk, which they correlated with the same groups likely to purchase organic products. Even if a consumer notices a sustainability label, understanding of sustainability- or ethics-related labels is often low (Annunziata et al., 2018; Horne, 2009; Hoogland et al., 2007). Poor understanding of sustainability-related certifications may lead consumers to both undervalue the certifications well as underestimate the effort required by producers to obtain a certification (Hoogland et al., 2007). Schiano et al. (2021) found that among US dairy consumers, certification-related claims (ex: "USDA organic") were considered less important to the sustainability of dried dairy ingredients than claims that were simpler to read and visualize (ex: "cows freely graze on green pastures and organic feed" or "organic for you and the environment"). Hoogland et al. (2007) found similar results when investigating the impact of labeling semi-skimmed milk with an organic logo or a logo with an additional panel of details among Norwegian consumers. Including the logo alone increased consumer perception of the milk as "better for nature" and "more animal friendly", adding elaborative details further increased consumer perception of the milk as having these attributes.

Despite these barriers to label use, labels do play a role in product purchase (Janßen and Langen, 2017). Labels and other extrinsic cues, such as brand, are particularly effective at influencing purchase in situations of uncertainty (ex: product quality is questioned or the product is the subject of a scandal) (Janßen and Langen, 2017). Not all consumers may respond to these labels in the same way - Janßen and Langen (2017) found three distinct clusters of consumers based on their response to a variety of labels covering all three dimensions of sustainability. In addition to an expected price-conscious cluster, two clusters prioritized sustainability labeling: one cluster was willing to pay more for any sustainability label, while a third was classified as "price-conscious label discriminators". This third cluster showed significant interactions when labels were shown together, indicating that specific combinations of sustainability labels trigger specific responses in different groups of consumers, and more is not always better when it comes to labeling. One such sustainability label that has been studied extensively is the carbon footprint (CF) label. CF labels are a more recent (and less common) sustainability label which indicate the total amount of carbon dioxide (or carbon dioxide equivalents of other greenhouse gasses) produced during the lifecycle of a product. Echeverría et al. (2014) studied Chilean consumer responses to CF labels on milk, finding that despite low familiarity (13% of consumers) with these labels, 93% of consumers who received an explanation of the labeling would prefer to see this label on foods. On average, consumers were willing to pay 29.2% of the average price of fluid milk as an additional premium for low CF milk, although WTP decreased as the percent of household budget spent on milk increased. Canavari and Coderoni (2020) investigated Italian consumer willingness to pay (WTP) for dairy with CF labels. Consumer beliefs impacted WTP for these labels – consumers who believed climate change could be combated by purchasing sustainable products were more likely to be willing to pay more for CF-labeled milk, while price-conscious consumers were less likely to be willing to pay more.

Animal Welfare

Animal welfare is one of the most important factors for sustainability for U.S. dairy consumers (Schiano et al., 2020). For dried dairy ingredients, a segment of consumers defined sustainability primarily by ideas related to animal welfare (Schiano et al., 2021). A desire to improve conditions for cows was a driving force behind consumption of plant-based milk alternatives (Haas et al., 2019; McCarthy et al., 2017). While there is US legislation that governs the animal welfare of animals in research, exhibition, and transport, these do not extend to animals raised for food or milk unless under specific conditions (USDA-NAL, 2021a). As a result, animal welfare certifications and standards are often put forth by third party organizations (USDA-NAL, 2021b). Despite their focus on animal welfare, the average consumer has little understanding of these standards or agricultural and food production systems, and forms opinions based solely on marketing cues or their own implicit biases (Bennett et al., 2012; Clark et al., 2017; Ellis et al., 2009). Consumer definitions of animal welfare may also vary, including elements such as appropriate feeding, proper handling, plenty of space, freedom to roam/free range, and environmental cleanliness (Ellis et al., 2009). Tethering/use of tie stalls is a particular area of concern for consumers, the majority of whom consider keeping cows tethered consistently an unacceptable practice (Ellis et al., 2009; Markova-Nenova et al., 2018). The majority of consumers indicate that they are willing to pay more for dairy products produced with good animal welfare (Ellis et al., 2009, Wolf and Tonsor, 2017). Consumer desire for and WTP for animal welfare may be modulated by a desire to support fair conditions for small farmers in their region (an aspect of social and economic sustainability) (Markova-Nenova et al., 2018).

Organic

Dairy is currently the second most purchased organic food category (after fruits and vegetables) (OTA, 2017). The concept of organic farming was developed in the 1940s and gained traction during natural foods-focused counterculture movements in the 1960s and 1970s, but organic milk gained prominence more recently (Du Puis, 2000; Heckman, 2005). Organic milk experienced explosive growth in the 1990s, primarily due to consumer concerns about hormones and antibiotics such as recombinant bovine growth hormone (rGBH) in dairy milk (Du Puis, 2000). For this reason, purchase of organic milk during this period primarily stemmed from a desire to avoid negative milk attributes rather than to achieve a specific positive outcome (such as increased health or sustainability) (DuPuis, 2000). In recent years, segments of consumers have shown a preference for organic products relative to other label claims in studies involving a variety of dairy products including fluid milk, chocolate milk, and protein beverages (Harwood and Drake, 2020; Kim et al., 2013; Li et al., 2014; Oltman et al., 2015). Organic products are now associated with sustainability, to the point where consumers may overestimate the sustainability of organic products. For example, Swiss consumers have been shown to underestimate the greenhouse gas emissions produced by organic meat vs. conventionally produced meat (Shi et al., 2018). Although organic foods are often investigated in studies of sustainable consumption, sustainable and organic are not interchangeable in the minds of consumers. In a study of Italian yogurt consumers, 43% of respondents considered consuming organic food a very or extremely sustainable action (a lower percentage than considered buying local or fair trade products sustainable) (Laureati et al., 2013). Schiano et al. (2020) found that when an organic claim was included on the package of a dried dairy ingredient, dairy consumers were more likely to indicate it was sustainable. However, when dairy product consumers were asked to rank the importance of 63 label claims for the sustainability of dried dairy ingredients, the claim “USDA Organic” was ranked significantly less important than claims including the term organic which were simpler to read and visualize (ie., “organic for you and the environment”, “cows freely graze on green pastures and organic feed”) (Schiano et al., 2021). This suggests claims that incorporation of other aspects of sustainability along with organic status may be most effective at increasing consumer perception of the sustainability of organic dairy products. Similarly, when studying production claims on milk and other animal products, Ellison et al. (2017) found that the production claim “organic” was ranked less important than many of the individual components of that production method, such as “no growth hormones” or “no antibiotics”. This may indicate that rather than a true desire for organic products, dairy consumers are instead looking for specific benefits they have come to associate with organic dairy.

Organic foods in general are considered by consumers to be healthier, better for the environment, more ethical for animal welfare and worker rights, and more natural, all attributes that contribute to the consumer perception of food as sustainable (Rana and Paul, 2017; Ellis et al., 2009). These perceptions go beyond the USDA standards for organic products, which do not specifically reference sustainability or ethics (USDA, 2021; USDA, 2019). USDA organic standards do require that animals have living conditions accommodating natural behaviors, consume only organic food, and are not given antibiotics or hormones, as well as prohibit use of synthetic fertilizers and pesticides or artificial colors and flavors (USDA, 2021; USDA, 2019). As a result, many consumers perceive organic milk as safer and more pure than conventional milk, which may lead consumers who define sustainability in terms of simple ingredients and minimal processing to view organic dairy as more sustainable (DePuis, 2000; Schiano et al., 2021). Organic food consumers in general are more concerned with risks related to ingestion (ex: consuming contaminated drinking water, chemicals in produce) than conventional food consumers, although they are not necessarily more risk adverse in other areas (Hammit, 1990). In addition to organic status affecting perceived sustainability of dairy foods, consumer-placed importance on sustainability can also affect perception of organic dairy foods. Laureati et al. (2013) found that "sustainable" Italian yogurt consumers had higher expectations for organic yogurts vs. conventional yogurts, "unsustainable" consumers showed the opposite response. Italian milk consumers who received information about the sustainability or animal welfare impacts of organic milk were more willing to pay for organic milk vs. conventional milk, an effect that was not seen when consumers received information about the increased production costs of organic milk or details about feed and antibiotic usage for cows on organic farms (Scozzafava et al., 2020). This further suggests consumers are not interested in the aspects of organic milk as defined by the USDA organic standards, rather, they are instead interested in sustainability- and ethics-related aspects they have come to associate with organic products.

Grass-fed/Pasture-raised.

Consumers generally prefer that cows have access to open-air areas (pastures or meadows), however, many consumers may still be unfamiliar with the implications of terms such as "grass-fed" or "pasture-raised" (Weinrich et al., 2014, Piera et al., 2020). Standards for the term "grass-fed" on meat and dairy products are defined by the USDA, and producers can get these claims certified through a voluntary program (USDA-AMS, 2007). However, definitions can become less clear in the case of cows fed mixed diets, which can lead to consumer confusion (Einstein-Curtis, 2019). Despite uncertainty surrounding it, the claim is rapidly growing in popularity for dairy marketing; in 2018, 21% of dairy milk products launched included a grass-fed term on the label (Mintel Group Ltd., 2019). Grass-fed is a universally attractive attribute for fluid milk consumers across different consumer groups (Harwood and Drake, 2018). However, this preference may be partially due to a halo effect resulting from the cognitive overlap of consumer concepts of animal welfare, sustainability, and healthiness. For example, US dairy consumers were more likely to indicate a dried dairy ingredient was sustainable, healthy, natural, trustworthy, and ethical when it was labeled with a grass-fed term (Schiano et al., 2020). Conflation between pasture-raised and organic designations may also influence consumer preference for grass fed dairy (Harwood et al., 2018; Harwood and Drake, 2020). When investigating implicit consumer bias towards fluid milks, Harwood and Drake (2020) found that milk with a USDA organic designation was more often associated with positive implicit responses than pasture-raised milk.

Several studies have investigated consumer WTP for grass-fed dairy. Wolf et al. (2011) measured U.S. milk consumer WTP for several milk production attributes including grass-fed (split into "moderate grazing" and "intensive grazing"), finding inconclusive evidence as to whether consumers were willing to pay for milk from grass-fed cows. The researchers stated that they were unsure whether this was due to a true lack of willingness to pay for this attribute, or instead due to cognitive overlap between grass-fed and other attributes used in the study, such as "milk from family farms' or "organic". Wong et al. (2010) investigated the WTP for grass-fed milks among consumers in the Southeastern US, and found that female consumers and those with higher household incomes assigned higher price premiums for these products (Wong et al., 2010). In a study of Italian milk consumers, Peira et al. (2020) found that consumers classified as concerned with sustainability or animal treatment had the highest WTP for grass-fed/pasture-raised milk, although those interested in the health benefits of milk were also interested in the claim (Peira et al., 2020). Despite the higher price premiums often placed on pasture-raised milk products, producing these milks still results in higher costs as the milk must be collected and processed separately from conventional milk products (Kühl et al., 2017). To provide a new solution, Kühl et al. (2017) investigated European consumer acceptance of two alternative label claims which would allow mixing of pasture-raised and conventional milk. One label specified the percentage of pasture-raised milk in the package while the other used a cause-related marketing approach to emphasize how purchase of the milk financially supported famers who raise their cows on pasture. While consumers preferred a label declaring the milk to be 100% pasture-raised cows (with a WTP of €0.50), the cause-related marketing label was also accepted (with a WTP of €0.38). The percentage label was the least preferred, with most consumers who rejected the label doing so due to distrust or skepticism (Kühl et al., 2017). These results suggest that alternative marketing and labeling approaches may provide conventional dairy farmers more opportunities to stay competitive in a changing marketplace. However, careful research is necessary in order to ensure these new efforts are well-received.

Local

Local itself is a poorly-defined term with a variety of definitions and use cases (Hand and Martinez, 2010; Onozaka et al., 2010). In a survey of Italian yogurt consumers, Laureati et al. (2013) found the majority of respondents indicated buying local food or zero-mile products was a very or extremely sustainable action (62% and 60%, respectively). Although local is a desirable attribute for dairy, consumers tend to ignore or underestimate the sustainability impact of energy requirements for transport of other dairy products (Steenis et al., 2017; Lindh et al., 2016; Nordin and Selke, 2010; Van Dam, 1996). When asked to rank the importance of 27 attributes to the sustainability of dairy products, “Shipped with minimal cold chain” was ranked one of the lowest, despite “Locally produced” ranking significantly higher (Schiano et al., 2020). However, some plant-based milk consumers may doubt the sustainability of plant-based dairy alternatives made from crops grown outside the country due to long transport distances (Haas et al., 2019). Coconut milk, for example, is perceived as less sustainable than nut or plant milk alternatives by both consumers who purchase exclusively dairy milk and those who purchase both dairy and plant alternative milks (Schiano et al., 2020). Consumer desire for local dairy is more closely tied to motivations to support farmers and the local economy, a motivation that is not shown for consumption of plant-based milk even when the crops used to produce it are grown locally (Haas et al., 2019; Onozaka et al., 2010). This may be due to a general desire of local food purchasers to support specific outcomes (ex: maintaining local farmland and giving farmers fair wages) vs. more complex, less clear claims (ex: reducing environmental damage) (Onozaka et al., 2010).

Clean Label

While there is no regulatory definition of “clean label”, the term is often used to refer to products which use limited processing and limited ingredients which are easy to understand and are found in nature (Asioli et al., 2017). A desire for sustainability is one factor contributing to the growth of the clean label trend (Asioli et al., 2017; Sautron et al., 2015; Maruyama et al., 2021). Schiano et al. (2021a) found a segment of dairy consumers defined sustainable dried dairy ingredients as those that contained simple ingredients and were produced with minimal processing, which may relate to the clean label trend. However, there is no clear pattern to which ingredients in dairy products consumers accept as clean label. In yogurts, perception of ingredients as natural and acceptable varies by ingredient and category of ingredient, with stabilizers and thickeners generally perceived as less natural and acceptable (Maruyama et al., 2021). Providing consumers information about the source of the ingredients improved perceived naturalness and acceptability, but providing information on the technical function of the ingredient in the product did not (Maruyama et al., 2021). Sustainability associations may also connect plant-based ingredients to the clean label movement and cause consumers to overlook processing methods or off-flavors, as Danish consumers were less likely to indicate frozen desserts and protein shakes made with protein powder had unpleasant flavor when the products were framed with sustainability information (Aschemann-Witzel, 2019).

CHALLENGES OF MARKETING SUSTAINABLE DAIRY

Avoiding Consumer Backlash

When consumers are kept unaware of dairy industry practices, the potential for miscommunications and misunderstandings surrounding sustainable dairy grows (von Keyserlingk et al., 2013). If industry efforts misalign with consumer expectations for sustainable dairy, consumers may become confused, or worse, feel mislead. “Greenwashing” (the practice of a company attempting to make their products or practices appear more sustainable than they actually are) or other misrepresentation of sustainability efforts can easily lead to consumer backlash (Lyon and Montgomery, 2013; Toptal et al., 2019). When weighed against potential publicity pitfalls, understanding consumer definitions of sustainability and related terms takes on new importance. It is not difficult to imagine a scenario in which consumers and businesses (or even different units within the same business) define sustainability differently, leading consumers to believe they have been mislead because product messaging does not align with their own perceptions. Furthermore, although product packages are a major source of sustainability information for dairy products, consumers may seek sustainability information across a wide variety of channels, including advertisements, websites, and social media both affiliated and unaffiliated with food producers (Schiano et al., 2020). Thoughtful creation of marketing messaging across all channels to educate consumers about industry practices and dairy processing may help to increase confidence in and positive perception of the industry. For example, including interactive website elements (such as hyperlinks and expandable/collapsible elements) to provide sustainability evidence without interfering with design has been shown to reduce perceived greenwashing on corporate websites (Szabo and Webster, 2020).

Marketing Dairy Amidst the Growth of Plant-Based Alternatives

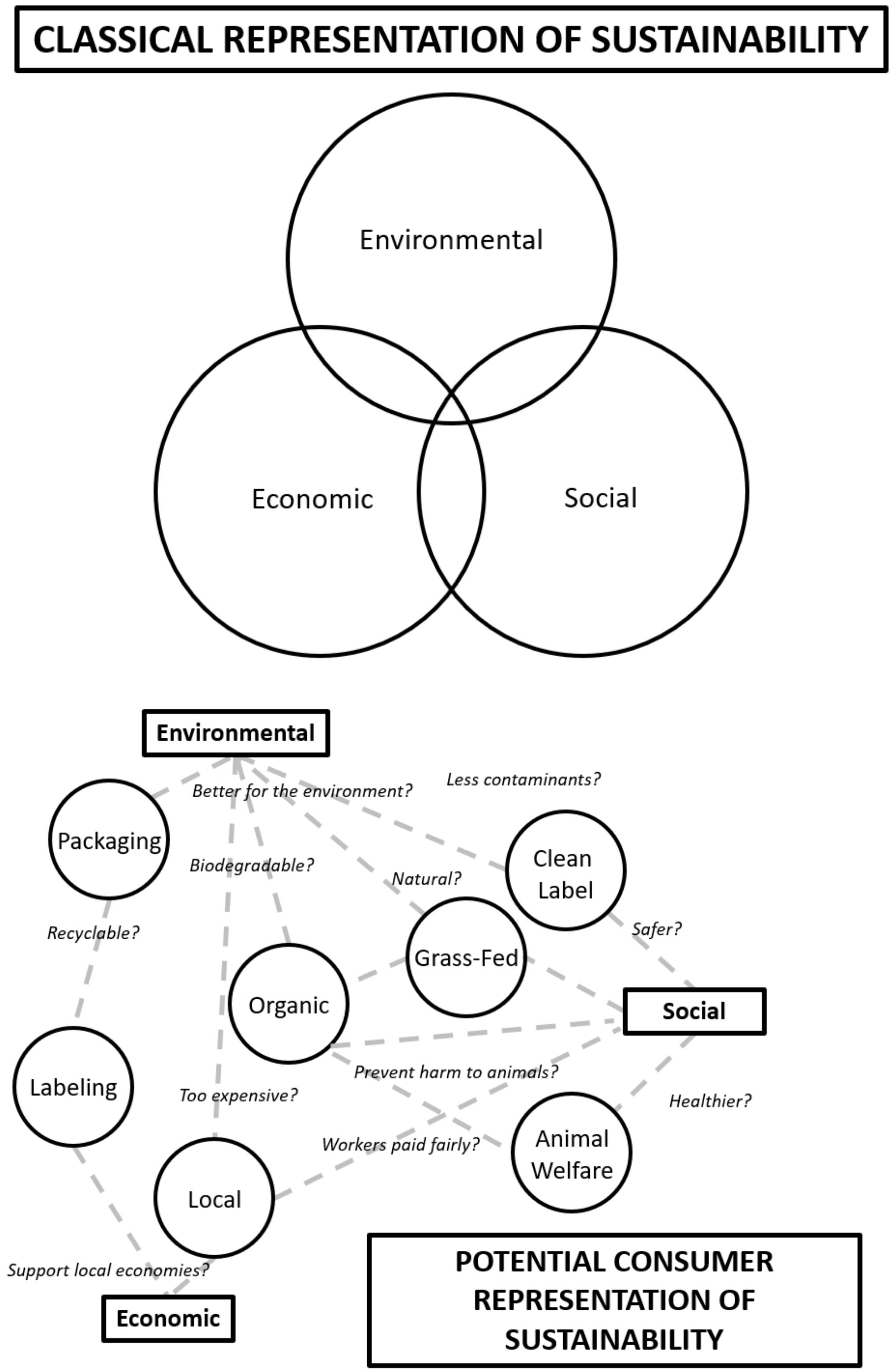
Efforts to promote sustainable dairy must consider that dairy foods have historically been marketed as a commodity, with little perceived variation between brands and offerings. As the market has expanded and non-conventional variants such as organic, grass-fed, local, and ultrafiltered have risen in prominence, there is a tendency to position these products as competitors to plant-based dairy alternatives, which consumers are more likely to consider sustainable than their dairy counterparts (Schiano et al., 2020). However, there is inherent risk that promoting these alternatives as "better" than conventional dairy will ultimately harm sales of conventional dairy and the industry overall. Analyzing Nielsen Homescan Panel data, Alviola (2010) found that organic and conventional milk were substitutes for one another, thus increased sales of organic milk decrease sales of conventional milk (although differences in price sensitivity can complicate this relationship in the case of changing prices). Kanter et al. (2009) found a similar effect for rBST-free and organic milk, concluding that the labeling resulted in a negative net economic result for producers by reducing consumer WTP for conventional milk. Attempting to compete with plant-based alternatives by positioning only non-conventional dairy as sustainable could widen the gap between conventional products and these growing alternatives. In addition, this could reinforce perceptions that only non-conventional dairy can be sustainable. Currently, consumer perceptions of conventional dairy as sustainable, particularly as a response to marketing messaging, are not well-understood. More research is needed to better understand how to strategically position and market conventional milk products.

Marketing efforts for food products typically take one of two forms – generic marketing (aiming to promote the category as a whole) and brand marketing (aiming to promote a particular branded product). In the dairy industry, examples of generic marketing campaigns include "Got Milk" and "Real California Milk," while a social media ad for a specific brand of yogurt would be an example of brand marketing. The relationship between generic marketing and fluid milk sales has been previously studied, although further research is needed to understand the nuances in these relationships with the inclusion of competitor marketing from plant-based alternatives (Hall and Folk, 1983; Schmit et al., 2002; Capps and Schmitz, 1991). Generic marketing campaigns, such as those directed by Dairy Management, Inc. (DMI), are effective at encouraging category sales (Schmit et al., 2002; Capps and Schmitz, 1991). However, brand advertising has its purpose – for example, Hall and Folk (1983) found brand advertising was twice as effective at increasing yogurt consumption than generic advertising. While these studies provide insight into the effectiveness of marketing, there is a lack of recent studies published on this topic. Updated research is needed to not only to document the current effectiveness of dairy marketing, but to understand how these strategies must be adjusted amidst the growth of plant-based alternatives. The dairy industry has established programs for generic advertising, but plant-based alternatives do not yet have the same infrastructure (for point-of-reference, the Plant Based Foods Association was founded in 2016). As a result, many plant-based alternatives rely primarily on brand marketing efforts. There is little scholarly data available to suggest whether a primarily brand-focused marketing approach will increase sales in the plant-based category more than a primarily generic-focused approach, this issue does represent a stark difference in how dairy products and plant-based alternatives are shown to consumers. Brand marketing efforts should be investigated as a potential way to increase sales of dairy products amidst this competition, however more research is needed to understand the ideal distribution of generic and brand efforts as well as consumer preferred messaging and channels for dairy marketing.

SUMMARY

Sustainability is often conceptualized using three pillars – environmental, economic, and social (Figure 1). Disconnects between consumer and industry definitions create the potential for misunderstandings and frustration on both sides. Consumer perceptions, which are often founded entirely on preexisting subconscious biases, incorporate all three dimensions of sustainability in ways dairy producers might not expect. In addition, consumers are not unified in their perceptions of sustainability. Not only do demographics and psychographics heavily affect sustainability importance and perception, but perceptions can vary between categories and between products within a single category. A growing consumer desire for sustainability is reflected in the growth of plant-based alternatives. Non-conventional dairy (such as organic, grass-fed, and local) has often been positioned in competition with these non-dairy alternatives; however, this practice may ultimately harm the industry by reducing consumer opinion and willingness to pay for conventional dairy. Taking a consumer-centric approach and using marketing efforts to educate consumers about industry practices that positively impact consumer perception in light of competitive marketing from plant-based alternatives. More research is needed to understand the best messaging and ways of communicating sustainability-related dairy information.

Figure 1-1. Conflicting representations of sustainability



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CHAPTER TWO: CONSUMER PERCEPTION OF THE SUSTAINABILITY OF DAIRY PRODUCTS AND PLANT-BASED DAIRY ALTERNATIVES

ABSTRACT

Plant-based dairy alternative (PBDA) beverage sales have increased in recent years. PBDAs often advertise on a platform of sustainability and an environmental commitment. To successfully position and market dairy products in this competitive environment, dairy companies must understand the consumer definition of and importance placed on sustainability, as well as communicate sustainability information effectively. The objective of this study was to characterize consumer perception of the sustainability of milk and dried dairy ingredients and their respective plant-based alternatives. Focus groups and two online surveys were conducted. In the first survey, maximum difference scaling was used to rank the importance of specific dairy product attributes to sustainability, along with an exercise in which respondents selected whether a fluid milk or protein powder product was sustainable. A follow up survey included two exercises in which respondents selected whether generic dairy products or dried dairy ingredients were sustainable, natural, healthy, trustworthy, or ethical. Over half of dairy product consumers reported that they looked for sustainability-related information. Consumers who purchased both PBDAs and dairy products placed a higher self-reported importance on sustainability than those who purchased dairy products only. Focus group and survey maximum difference scaling results identified 5 key attributes for sustainability: minimal carbon footprint/greenhouse gas emissions, few/no preservatives, animal happiness and welfare, and simple/minimal ingredients. PBDAs followed by fluid milk and protein powders were considered more sustainable than dairy products, but package type and organic status also played a role in consumer sustainability

perception. Product labels were the most common source of sustainability information, although consumers also sought information on websites affiliated and unaffiliated with dairy companies. There was cognitive overlap among the terms sustainable, natural, healthy, ethical, and trustworthy as they relate to dairy products, but consumers used the terms distinctly. Consumers perceived differences in these terms between general categories of dairy as well as among products in a specific dairy category. Dairy companies may be able to differentiate themselves by helping consumers make these choices by simplifying sustainability-related messaging and by maintaining open, transparent communication regarding sustainability.

INTRODUCTION

Plant-based dairy alternative beverage (PBDA) sales have increased in recent years. Currently, 7.4% of the total milk market share is made up of PBDAs – a number expected to more than double to 18.5% by 2023 (Mintel Group Ltd., 2019a). Meanwhile, sales of some traditional dairy products are declining or stagnating, such as fluid milk (15% decline since 2012) (Mintel Group Ltd., 2019a). More than half of dairy consumers also purchase PBDAs (Baertlein, 2015; Mintel Group Ltd., 2019a). In 2018, plant-based milk sales increased by 9% while cow's milk sales decreased by 6% (Plant Based Foods Association, 2018). Growth of other PBDAs was 50%, primarily driven by a 131% increase in sales of plant-based coffee creamer (Plant Based Foods Association, 2018). Additional heavy growth was documented for plant-based alternatives to yogurt (55% increase), ice cream (38% increase), and cheese (43% increase) (Plant Based Foods Association, 2018).

Messaging surrounding PBDAs often involves sustainability, commitment to the environment, elimination of "unnatural foods," or humane treatment of animals, which may give them an advantage against traditional dairy products (Franklin-Wallis, 2019; Crawford, 2020).

On-package, in-store, and digital media marketing for PBDAs emphasizes how these new products are different enough from dairy to address consumer concerns, yet similar enough to provide the experience consumers expect and serve as a direct replacement (Fuentes and Fuentes, 2017). As concerns regarding sustainability grow, dairy products are beginning to market with related claims - for example, 21% of dairy milk products in 2018 launched with a grass-fed term (Mintel Group Ltd., 2019a). An August 2018 Mintel survey found 49% of internet users ages 18+ worried about the environmental impact of dairy production, while 27% of the same consumers were willing to pay more for cheese made with milk from “free-range” cows (Mintel Group Ltd., 2019b). McCarthy et al. (2017) conducted a conjoint survey with means-end-chain interviews with both dairy and nondairy consumers. They found that a unique value ladder among nondairy consumers was that the plant-based attribute led to moral responses based on animal treatment and environmental effects. In order to successfully position and market dairy products, dairy companies must fully understand the consumer definition of and importance placed on sustainability. Furthermore, they must find a way to communicate sustainability information in a way that is understandable, believable, and authentic.

Unfortunately, there may be a mismatch between consumer and industry definitions of dairy foods sustainability. While the industry tends to consider sustainability from a farm perspective, consumers may primarily view sustainability from a food perspective. According to the United Nations, sustainable development includes three types of strategies: economic (profit), social (people), and environmental (planet) (United Nations, 2015). Ecological sustainability, typically the focus of dairy industry efforts, involves preserving the environment and using natural resources responsibly (United Nations, 2015). However, consumers may place greater emphasis on the other aspects of sustainability – the social and economic aspects of how food production benefits consumers and industry employees, and how food production impacts the wellbeing of people and animals. Peano et al. (2019) identified five clusters of consumers based on food sustainability definitions. While one cluster of respondents defined the concept of food sustainability primarily by the impact of production on the environment and ecological balance, other clusters prioritized aspects such as social welfare, access to safe and healthy food, and local sourcing of foods.

Some work has been done to understand consumer perception of sustainability, but many unknowns remain including the value and tradeoff of perceived sustainability and how or if sustainability beliefs are product-dependent. Previous research has shown that consumers place different importance on sustainability-related attributes for different product categories, yet little research has been done to understand differences within the dairy product category (Verain et al., 2016; 2014; Bernués et al., 2003). These related attributes are also sources of growing concern for consumers. An August 2019 Mintel survey of internet users ages 18+ who were purchasing less dairy milk than the previous year found 16% of respondents cited "I don't think it's healthy" and 8% of respondents cited "For animal welfare reasons" as reasons for reduced purchase (Mintel Group Ltd., 2019a). Furthermore, the relationship among consumer perception of sustainability and consumer perception of other related attributes, such as whether a product is natural, healthy, ethical, or trustworthy is critical knowledge for effective consumer messaging for dairy foods. If there is significant overlap between consumer perceptions of sustainability and terms such as healthy, natural, trustworthy, and ethical, this can be taken into consideration when marketing dairy products to more effectively communicate their benefits.

Pelletier et al. (2013) demonstrated that young adults in Twin Cities, MN who placed higher importance on sustainable food production generally had better quality dietary patterns, indicating potential overlap between concepts of sustainability and a healthy diet. Verain et al. (2016) found healthiness and sustainability were synergistically perceived by Dutch consumers across a variety of food categories, including the general dairy category. This result suggests a possible halo effect in which perception of sustainability creates a favorable impression which increases perception of healthiness, and vice versa. Furthermore, consumer concepts of sustainability, health, and naturalness have been found to overlap in the case of organic products (Aschemann-Witzel, 2015). Consumers assume organic dairy products are inherently healthier, more natural, better for the environment, and better for animal welfare then their conventional counterparts, even when there is no significant evidence to confirm this statement (Merlino et al., 2019; Ellis et al., 2009; Napolitano et al., 2010; Harwood and Drake, 2018).

Qualitative research and online surveys allow us to probe into underlying consumer perceptions of sustainability and related concepts. Focus groups and online surveys are often used to collect data regarding consumer perceptions of commercial products. Focus groups, which have been conducted extensively for dairy products, allow for a deep dive into consumer opinion and the collection of open-ended data which can direct further survey or product development (Speight et al., 2019; Thompson et al., 2007a; Thompson et al., 2007b, Jo et al., 2017). Online surveys allow for collection of both quantitative and qualitative data from a large number of consumers across many geographic areas. Specialized survey methods, such as Maximum Difference (MaxDiff) scaling, allow for direct comparison of the importance of individual attributes to overall consumer perception and has been used to study dairy products including fluid milk and cheese shreds (Harwood and Drake, 2018; Speight et al., 2019).

In order to compete with PBDAs, dairy food producers must understand how to strategically position their products in a changing marketplace. To do this, a greater understanding of how consumers value sustainability in dairy products and the key attributes that contribute to the perception of sustainability are needed. The objective of this study was to characterize consumer perception of the sustainability of milk and dried dairy ingredients and their respective plant-based alternatives. To meet this objective, we conducted focus groups and two online surveys containing MaxDiff and check-all-that-apply (CATA) exercises.

MATERIALS AND METHODS

All focus group and survey procedures were conducted in compliance with North Carolina State University Institutional Review Board regulations. A graphical outline of the study can be found in Figure 1.

Focus Groups

Three 2h focus groups with dairy consumers were conducted to establish parameters for consumer insights (n=23). Focus group consumers (10 women, 13 men; ages 25-64; primary shoppers) were recruited from a database of >11,000 US consumers managed by the Sensory Service Center (NCSU, Raleigh, NC) using an online questionnaire. Respondents were asked to rate the importance of food sustainability on a 0-100 scale, as well as their knowledge about sustainability and agreement on a 5-pt scale to statements about sustainability. K-means clustering was used to segment consumers into three clusters (high, moderate, and low sustainability importance) from which participants were selected at random.

Prior to each focus group, consumers were provided a login to Pinterest.com, an online pinboard creation website. Consumers were asked to pin images, text, or links related to sustainability (in general), sustainable foods, sustainability (dairy product specific), examples of sustainable dairy products, and examples of non-sustainable dairy products. Each consumer was given a printout of their online pinboard at the start of the focus group. Aggregated pinboards with pinned images from all consumers were used as a discussion starter during the focus group.

During the focus group, two moderators facilitated discussion through the use of a moderator guide (Table 1). As an exercise, participants were given a stack of 30 sticky notes with terms related to sustainability on them. Terms were taken from sustainability-related claims on fluid milk packages found in a survey of grocery stores around the Raleigh/Durham, NC area (Table 1). Participants were asked to categorize each sticky note by sticking it on a wall under one of the following labels: “Required for Sustainability,” “Contributes to but Not Required for Sustainability”, “Misleading”, and “I don’t understand/am not familiar with this term”. Consumers had the option to ignore and not categorize terms if they felt they were irrelevant. Term categorizations were used as a discussion starter for the remainder of the focus group. Audio and video were recorded for subsequent reference. Notes were taken by an observer remotely through a video feed in order to minimize distractions to panelists. Upon completion of the focus group, panelists were compensated with a gift card for their participation.

First Online Survey

In order to assess how consumer perception of sustainability differed for dairy products and plant-based dairy alternatives (PBDAs), focus group responses were used to develop an online survey with self-reported dairy (Dairy Only consumers) or dairy + PBDA consumers (Combination consumers). The survey was developed and launched using SSI Web^{TM} (Lighthouse Studio version 9.6.1, Sawtooth Software, Orem, UT). The survey link was sent to a database of >11,000 US consumers managed by the Sensory Service Center (NCSU, Raleigh, NC). Only participants over 18 years of age were able to enter the survey.

Consumers were asked demographic and attitude questions including importance of sustainability, knowledge of sustainability, and knowledge of the dairy industry. Sustainability importance was rated on an unstructured line scale anchored with "Not At All Important" on one end and "Extremely Important" on the other end. Knowledge of food sustainability and knowledge of the dairy industry/dairy processing questions were rated on a 5-point scale from "Not Knowledgeable" to "Extremely Knowledgeable". Consumers were asked 10 agreement questions regarding sustainable food purchase on a 5-point scale from "Disagree Strongly" to "Agree Strongly".

Next, Maximum Difference scaling (MaxDiff) was used to rank the importance of 27 specific attributes of dairy products that affect sustainability (Table 2). These attributes were selected based on focus group results, the Food and Agriculture Organization of the United Nations (FAO) publication on sustainable food systems, and label claims and marketing material from dairy products currently available in grocery stores around, Raleigh, NC (FAO, 2014). The MaxDiff exercise was designed as 15 sets of best-worst questions, with 6 randomly displayed attributes per set. Each respondent was asked to select the attributes out of each set which were "most important" and "least important" to the sustainability of dairy products. Each participant saw each attribute at least 3 times.

Finally, consumers were shown photos of dairy and plant-based fluid milk and dried ingredients and asked to classify each photo as sustainable or non-sustainable. All photos used represented products currently available on the market or realistic product prototypes. Prototypes were created using Adobe Photoshop CC 2018 version 19.0 20170929.r.165 2017/09/29: 1138933 x64 (Adobe, Inc., San Jose, CA). Product photos were categorized using the following attributes which were selected to mimic variation between products currently on the market. For fluid milks, source (animal, plant, nut, coconut, animal-free), packaging (plastic, carton, can, glass), GMO status (GMO and non-GMO), organic status (organic, conventional), and serving size (single-serve, multi-serve) were evaluated. For powders, source (animal, nut, plant), and packaging (plastic container, pouch) were evaluated. Respondents were shown 50 photos in total. For fluid milks, respondents were shown a random subset of 25 out of 63 photos. For powders, all respondents evaluated the same 24 photos. The product presented first (milks or powders) was randomized as well as the presentation of the photos within each product set.

Second Online Survey

To further evaluate consumer perception of sustainability as it pertained to dried dairy ingredients, and to determine if consumers perceived differences in sustainability among different dried dairy ingredients, an online survey with self-reported dairy consumers was designed based on responses to the first survey and focus groups. The survey was developed and launched using SSI Web™ Lighthouse Studio. The survey link was sent to a database of >11,000 US consumers managed by the Sensory Service Center (NCSU, Raleigh, NC). Only participants over 18 years of age were able to enter the survey. The second online survey was conducted 3 months after the first online survey closed. Participants from the first survey could participate in the second survey.

First, consumers were asked the same demographic and attitude questions from the first survey (including importance of sustainability, knowledge of sustainability, and knowledge of the dairy industry), using the same scales. Consumers then evaluated generic, unbranded photos of 10 common dairy products (fluid milk, yogurt, butter, sour cream, coffee creamer, whipped cream, cottage cheese, ice cream, cheese, and protein powder). Consumers were asked to check any attributes they believed to apply to the product in the photo from a list of 6 attributes in a check-all-that-apply (CATA) format (sustainable, natural, healthy, trustworthy, ethical, and none).

Finally, consumers who indicated they were familiar with at least one dried dairy ingredient repeated the categorization exercise with photos of dried dairy ingredients. Consumers who indicated they were not familiar with any dried dairy ingredients did not complete this exercise. Respondents were shown a partial presentation of 32 out of 96 product photos. All photos used represented products currently available on the market or realistic product prototypes created using Adobe Photoshop CC 2018 (Figure 2). The following attributes were investigated in a factorial design: ingredient type (skim milk powder (SMP), whey protein concentrate (WPC), whey protein isolate (WPI), casein, micellar casein concentrate (MCC), and milk protein concentrate (MPC)), package type (pouch and tub), organic status (organic and conventional), feed type (grass-fed and non-grass-fed).

Data Analysis

All statistical analyses were conducted with XLSTAT version 2019.2.1 (Addinsoft, Paris, France), with the exception of mixed model logistic regression to analyze photo categorization data (for both surveys) performed in SAS version 9.4 (SAS Institute, Cary, NC), MaxDiff score determination (for survey 1) via hierarchical Bayesian (HB) regression using Lighthouse Studio, and statistical comparison of MaxDiff scores between consumer groups which was performed in the Sawtooth MaxDiff Online Analyzer (Accessed 11.5.2019, Sawtooth Software, Sequim, WA). All analyses were performed at 95% confidence ($P < 0.05$).

Sustainability importance in the focus group screener and both subsequent surveys was considered a continuous variable, with “Not At All Important” scored as a 0 and “Extremely Important” scored as a 100. Agglomerative hierarchical clustering (AHC) on sustainability importance and agreement questions was used to determine the number of clusters, then k-means clustering was used to segment consumers into clusters for focus group participant recruitment. Note-based analysis from focus groups was used to identify key points. To reduce personal bias, consumer responses were discussed and compiled by both moderators and the observer. Key points mentioned by two-thirds or more of participants in all focus groups were used for development of questions for the subsequent online surveys.

Survey results were analyzed via univariate and multivariate statistics. Five-point scale agreement questions were analyzed with Kruskal-Wallis one-way ANOVA with Dunn's nonparametric multiple pairwise comparisons. Kruskal-Wallis one-way ANOVA with Dunn's nonparametric multiple pairwise comparisons was used to determine if ordinal demographic questions differed between groups of consumers, while Chi-square analysis was used to determine if nominal demographic questions differed between groups of consumers. Frequencies of responses to CATA questions were analyzed using chi-squared analysis. Mixed model logistic regression was performed to determine how product photo attributes related to the likelihood of a product being considered sustainable, natural, trustworthy, or ethical. Respondent number was considered a random effect in this analysis.

RESULTS

For clarity, consumers who reported that they purchased only dairy products are referred to as Dairy Only consumers while those who reported that they purchased both dairy products and PBDAs are referred to as Combination consumers.

Focus Groups

Consumers perceived differences in sustainability between product categories (ex: milk vs. yogurt) and made judgments about sustainability largely from looking at product packaging before purchase. Key attributes for sustainability from focus groups were packaging, environmental impacts, animal welfare, and simple ingredient lists.

Most consumers agreed that the food industry (including the dairy industry) should exercise more transparency when providing sustainability information to consumers. Many sustainability terms, such as resource cycling and ecological balance were not well understood by consumers, who expressed that they were more likely to ignore or distrust sustainability claims that they do not understand. Most consumers (approximately 60%) struggled to define common terms such as organic, non-GMO, and animal welfare, expressing that while they frequently heard these terms, they did not understand their implications fully. Although consumers desired greater transparency from companies, they did not always trust or understand information currently provided by companies. These results demonstrate a need for genuine, easily understandable sustainability messaging from industry to consumers, including on product packaging.

First Online Survey

Survey Demographics

A total of 608 consumers (280 Dairy Only consumers and 328 Combination consumers) participated in the survey. Of the 608 respondents, 23.7% were male and 76.3% were female. The majority of participants identified as Caucasian (75.8%), followed by Black/African American (10.2%), South Asian or Indian (5.1%), Latino or Hispanic (4.4%), and East Asian (4.6%). An even distribution of ages was reported: 15.1% of the participants were 18-24 y, 24.5% were 25-34 y, 18.9% were 35-44 y, 17.9% were 45-54 y, 13.5% were 55-64 y, and 10.0% were 64 y or older. A range of total annual household incomes was also self-reported (<$19,999 to >$100,000).

Purchase Habit and Agreement Questions

The average self-reported importance of sustainability was 68.6 (out of 100). The average sustainability importance score for Dairy Only consumers was 64.8 (SD=22.9), while the average score for Combination consumers was significantly higher 71.9 (SD=20.0) ($P<0.05$). Gender and income did not differ between Dairy Only and Combination consumers ($P > 0.05$). However, the age of the Combination consumers was lower than that of the Dairy Only consumers ($P<0.05$). Fifty one percent of consumers indicated that they looked for information about the sustainability of foods. Among those consumers who did look for information, the most frequently cited information source was product labels (82.3%) (consistent with focus groups), followed by websites not affiliated with food companies (49.2%), company websites (48.9%), word-of-mouth (45.3%), newspapers or magazines (43.7%), government websites (36.7%), blogs (28.3%), friends on social media (28.8%), social media profiles from organizations not affiliated with food companies (24.1%), company social media profiles (19.90%), and email newsletters (18.6%).

Seventy seven percent of respondents agreed that they believed food sustainability should be promoted for the greater good, rather than personal benefit. Fifty five percent were willing to pay more for sustainable foods, 34.49% agreed they always considered sustainability when purchasing foods and beverages, and 26.0% avoided purchase of foods or beverages which were not sustainable. The most frequently agreed with reason for purchase of sustainable foods among all consumers was “for the greater good” (77.5%), followed by for the wellbeing of the planet (61.2%), the economic wellbeing of others (53.0%), because they are better/safer (48.0%), and because they offer a better experience than non-sustainable products (37.2%). A lower percentage of Dairy Only consumers agreed they purchased sustainable products for each reason than Combination consumers (P<0.05) (Figure 3). Approximately half of consumers considered themselves moderately or somewhat knowledgeable about both sustainability of foods and the dairy industry (57.6% and 45.2%, respectively). Self-reported knowledge of sustainability and knowledge of the dairy industry were higher for Combination consumers than Dairy Only consumers (P<0.05).

MaxDiff Scaling

The MaxDiff scaling results are shown in Table 2. Healthiness was the most important attribute for sustainability (P < 0.05). The next most important attributes were minimal carbon footprint/greenhouse gas emissions, few/no preservatives, animal happiness and welfare, and simple/minimal ingredients. These five most important attributes aligned with focus group results. The least important attributes were parent companies are disclosed, produced by a small company, lactose free, shipped with minimal cold chain, and packaging which can be returned to the manufacturer. The low importance placed by consumers on minimal cold chain (along with a relatively high importance placed on “Locally Produced”) indicates differences in how consumers and industry perceive sustainability, and perhaps a lack of knowledge regarding production and shipping methods. MaxDiff scaling results were similar between Dairy Only consumers and Combination consumers, suggesting these consumers share similar definitions of sustainable dairy products.

Check-All-That-Apply Exercise

Source (plant, nut, coconut, animal-free, or animal), package (glass, carton, can, or plastic), organic status (organic or conventional), and package size (single-serve or multi-serve) (P<0.05), but not GMO status (GMO or non-GMO) affected consumer perceived sustainability of fluid milks and milk alternatives (P>0.05). Plant-based, animal-free, nut-based, and coconut-based fluid milk alternatives were more likely to be marked as sustainable than fluid cow's milk ($P<0.05$). Plant-based alternatives were also more likely to be considered sustainable than nut-based and coconut-based alternatives ($P<0.05$). Animal-free cow's milk alternatives (products produced by genetically engineered microorganisms) were at parity with the plant-based, nut-based, and coconut-based alternatives for sustainability. However, as these products are uncommon in the market at the time of this study, only two animal-free products were included in this CATA exercise, and these results should be interpreted with caution.

Milks and milk alternatives packaged in glass were considered the most sustainable, followed by those packaged in cartons ($P<0.05$). Products packaged in plastic were the least likely to be marked as sustainable ($P<0.05$), while those packaged in cans scored at parity with both those packaged in cartons and those packaged in plastic. Organic products were more likely to be considered sustainable than conventional products ($P<0.05$) and multi-serve products were more likely to be considered sustainable than single-serve products ($P<0.05$). There was no difference in the likelihood of being considered sustainable between GMO and non-GMO products ($p>0.05$). For protein powders, source (plant, nut, or animal) and package (plastic tub or pouch) affected consumer perceived sustainability ($P<0.05$). Plant-based powders were considered the most sustainable, followed by nut-based powders and then animal (dairy-based whey, milk powder, or micellar casein concentrate) powders, which were considered the least sustainable ($P<0.05$). Powders packaged in pouches were more likely to be marked as sustainable than those packaged in plastic tubs ($P<0.05$).

Second Online Survey

As for previous results, for clarity, consumers who reported they only purchased dairy products are referred to as Dairy Only consumers while those who reported they purchased dairy products in addition to plant-based dairy alternatives are referred to as combination consumers. A total of 777 consumers (369 Dairy Only consumers and 408 Combination consumers) participated in the survey. Of these consumers, n=689 (310 Dairy Only consumers and 379 Combination consumers) indicated they were familiar with at least one dried dairy ingredient. Consumers who did not indicate they were familiar with at least one dried dairy ingredient were not included in the dried dairy ingredient categorization exercise.

Survey Demographics

Of the respondents, 34.0% were male and 66.0% were female. The majority of participants identified as Caucasian (77.6%), followed by Black/African American (8.5%), South Asian or Indian (7.5%), Latino or Hispanic (4.8%), and East Asian (4.6%). An even distribution of ages was reported: 25.4% of the participants were 18-24 y, 28.8% were 25-34 y, 19.0% were 35-44 y, 13.0% were 45-54 y, 10.3% were 55-64 y, and 3.5% were 64 y or older. An even distribution of total annual household incomes was also self-reported (<$19,999 to >$100,000).

Purchase Habits and Agreement Questions

About 88% of respondents indicated they were familiar with at least one dried dairy ingredient. The majority of consumers were familiar with whey protein concentrate (56.8%) and skim milk powder (56.5%) (Table 3). Consumers were least familiar with micellar casein concentrate (7.9%) (Table 3). Of the consumers who indicated that they purchased protein powders or dried dairy ingredients regularly (n=254 overall, 189 Combination consumers and 65 Dairy Only consumers), the most commonly purchased dried dairy ingredients were whey protein concentrate (60.2%), whey protein isolate (52.8%), and protein powder blends (50.0%) (Table 4). The least commonly purchased ingredient was micellar casein concentrate (10.6%).

Gender, age, and income did not differ between Dairy Only and Combination consumers ($P > 0.05$). Unlike for the first survey, we did not find differences in age between the two groups ($P > 0.05$). Agreement question results were similar to those from the first survey ($p>0.05$). Combination consumers were more likely to report they looked for information about the sustainability of foods than Dairy Only consumers (67.4% vs. 38.8%) ($P<0.05$). The three most commonly cited sources of information regarding sustainability for all consumers were product labels (78.0%), websites not affiliated with food companies or the government (54.1%), and word of mouth (50.2%). These results are similar to those of the first survey. The average self-reported importance of sustainability was 69.2 (out of 100). The average sustainability importance score for Dairy Only consumers was 64.1 (SD=22.3), while the average score for Combination consumers was higher 73.8 (SD=20.2) ($p<0.05$), consistent with survey 1. Age, but not gender or income, affected sustainability importance, with average self-reported sustainability importance decreasing as age increased ($P=0.025$).

Generic Dairy Product CATA Exercise

Consumers perceived differences in the sustainability, naturalness, healthfulness, ethicalness, and trustworthiness of different dairy products ($P<0.05$). The percentage of consumers who selected a descriptor for each product ranged from 6 - 84% (± 19%) (Fig. 4). Combination consumers were more likely to check any product as sustainable, natural, healthy, trustworthy, and ethical than Dairy Only consumers ($P<0.05$). Healthy was the attribute with the greatest difference between the products for which the highest and lowest percentages of consumers checked the attribute (7% for whipped cream vs. 84% for yogurt) (Fig. 4). Conversely, the ethical attribute had the least difference between the products for which the highest and lowest percentages of consumers checked the attribute (12% for coffee creamer vs.

23% for milk) (Fig. 4). Milk was considered the most natural product ($P<0.05$) and was among the products checked most frequently for sustainable, ethical, and trustworthy. However, yogurt was considered more healthy than milk ($P<0.05$) (Fig. 4). Healthy, sustainable, ethical, natural, and trustworthy loaded similarly (along the same factor in the same direction) on a principal component analysis (PCA) biplot of the frequencies of term selection from this generic dairy CATA (Fig. 5). This result further indicates there is significant overlap in consumer use of these terms.

Consumers tended to use the attributes healthy, natural, and sustainable with higher frequency than the terms ethical and trustworthy. While this result could indicate they do not view dairy products as ethical or trustworthy, it is also possible that consumers are simply less accustomed to using these terms to describe food products. Our survey did not ask consumers to decide whether each product was ethical/trustworthy vs. unethical/untrustworthy, instead, it asked them to select which of the 5 attributes they believed applied to the product. This allowed us to determine which attributes come to mind more easily when it comes to dairy products, however, a follow-up survey in which consumers are asked to choose between the positive and negative form of each attribute may provide additional insights as to whether consumers truly believe dairy products are not trustworthy or ethical. A biplot of frequencies of term selection displayed two groupings of products (Fig. 5). Protein powder, dairy creamer, whipped cream, and ice cream were characterized by a high frequency of selection of the term “none,” with low frequency of selection of all other terms. By contrast, cottage cheese, yogurt, milk, cheese, and butter were characterized by low frequency of selection of the “none” term. Sour cream fell in between these groups on the biplot. This further reinforces the halo effect of term selection as these generic dairy products were rarely characterized by a single attribute. Respondents either used multiple terms to describe a product or none at all. One exception to this was protein powder. More than 50% of respondents indicated it was healthy, but few indicated it was sustainable, natural, trustworthy, or ethical. This discrepancy could be due to consumer association between protein powders and health/fitness in combination with consumer unfamiliarity with how protein powders are processed and produced.

Dried Ingredient CATA Exercise

Combination consumers were more likely to mark a dried dairy ingredient product as sustainable, natural, trustworthy, healthy, and ethical than Dairy Only consumers ($P<0.05$). Dried ingredients labeled as organic and grass-fed were more likely to be marked as sustainable, natural, healthy, ethical, and trustworthy than conventional and non-grass-fed products ($P<0.05$). Dried ingredients packaged in a pouch were more likely to be marked as sustainable, natural, healthy, ethical, and trustworthy than dried ingredients packaged in a tub ($P<0.05$).

Ingredient type significantly affected likelihood of a product being checked as all 5 attributes ($P<0.05$) (Figure 6). Consumers used the terms sustainable, natural, and healthy with greater frequency than the terms ethical and trustworthy, suggesting once again that consumers may not fully understand these terms or be comfortable using them in relation to dairy products. WPC and SMP were the most likely ingredients to be marked sustainable while MCC was the least likely to be marked sustainable ($P<0.05$). WPI scored at parity with both SMP/WPC and casein ($P>0.05$), which was less likely to be marked sustainable than SMP/WPC ($P<0.05$). MPC, which scored at parity with casein, was less likely to be marked sustainable than WPI but more likely to be marked sustainable than MCC ($P<0.05$). Casein scored at parity with both MPC and SMP/WPI ($p>0.05$). WPC was the most likely to be marked healthy, followed by WPI ($P<0.05$). MCC was the least likely to be marked healthy ($P<0.05$). Casein and SMP (which scored at parity, $P>0.05$) were more likely to be marked healthy than MCC but less likely than WPI ($P<0.05$). MPC scored at parity with both WPI and casein/SMP ($P>0.05$). WPC was the most likely ingredient to be marked natural, followed by WPI, SMP, and casein (which scored at parity), then MPC, then MCC, which was the least likely to be marked as natural ($P<0.05$). WPC was the most likely ingredient to be marked trustworthy, along with MPC and WPI, which scored at parity with each other and WPC, as well as with SMP which was less likely to be marked trustworthy than WPC ($P<0.05$). Casein was less likely than all other attributes to be marked as trustworthy with the exception of MCC, which was the least likely ($P<0.05$).

As respondents in this exercise were asked to check whether an attribute applied to a product (rather than choose between a binary positive and negative option, ex: sustainable/not sustainable), it is possible that differences in frequencies of attribute selection could be due to lack of familiarity with certain protein products. For example MCC, which was among the least likely to be marked as all attributes, was familiar to just 7.9% of respondents. MCC is a relatively new dried dairy protein ingredient and as such, is not as widely commercially available. By contrast, WPC, which was among the most likely to be marked as all attributes, was familiar to 56.8% of respondents. It is possible that educating consumers about the production of dried dairy ingredients would increase consumer perception of these products as sustainable, natural, healthy, trustworthy, and ethical. One limitation of this study is that we cannot fully determine if consumers who did not check a product as sustainable truly felt the product was unsustainable, versus having a neutral opinion or being too uninformed/unfamiliar with the product to answer the question. Knowing this, we selected this design as we aimed to improve data quality and reduce nonresponse bias from respondent drop out. In consumer surveys, item nonresponse (the behavior of respondents who complete the entire survey but do not answer particular questions) increases when questions are too complex or difficult for the respondent to answer easily (Rässler and Riphahn, 2006). If consumers are asked a large number of forced answer questions they are unable to answer, their chances of abandoning the survey increase greatly (Décieux et al., 2015). As such, we believe the percentages of term selection for each product realistically represent the estimated percentage of the population who are both familiar enough with the product to form an opinion and who believe the term applies to the product.

DISCUSSION

Consumers reported a moderately high level of importance placed on the sustainability of dairy foods, but our results also indicate that consumers have difficulty fully understanding the concept and may thus have difficulty choosing sustainable products even if they are motivated to make sustainable choices. This is consistent with previous studies (Grunert et al., 2014; Sautron et al., 2015; Verain et al., 2012). Focus group and first survey MaxDiff results identified 5 key attributes for sustainability: minimal carbon footprint/greenhouse gas emissions, few/no preservatives, animal happiness and welfare, and simple/minimal ingredients. These attributes reference all three types of sustainable development strategies outlined by the United Nations (economic/profit, social/people, and environmental/planet), however, focus group results indicated it is unlikely that the average dairy consumer has a clearly-defined perception of sustainability (United Nations, 2015). Factors we found important for sustainability were also found important for the purchase of organic milk by Harwood and Drake (2018), which were enhanced nutrition/well-being, environmental sustainability, ethical animal treatment, and local farm support. These similarities further suggest that dairy consumers' concept of sustainability and other altruistic purchase motivations are deeply intertwined with their concepts of other related terms. Consumers in focus groups indicated that they made sustainability judgements about dairy products largely by reading product labels at point of purchase, although many also indicated they did not fully understand sustainability- and ethics-related packaging claims. These consumers may be driven by the "feeling" they perceive after seeing sustainability messaging on dairy packaging rather than by forming opinions through prior research. These results are consistent with previous findings on organic milk by Harwood and Drake (2018), who found extrinsic milk features that imply passive participation in altruistic movements (such as sustainability, animal welfare, etc.) were drivers of value for some dairy consumers who viewed organic milk purchase as a "passively benevolent" act.

Our first survey CATA results suggested that consumers perceived dairy products as less sustainable than PBDAs, as dairy-based fluid milks and protein powders were less likely to be sustainable than plant or nut alternatives even when controlling for package type or organic status. Accordingly, consumers who purchased both PBDAs and dairy products (the Combination consumers), placed a higher self-reported importance on sustainability than those who purchased dairy products only (Dairy Only consumers). Combination consumers were significantly more involved with sustainability than Dairy Only consumers, and were both more likely to look for information about the sustainability of foods and to agree that they purchased sustainable foods for every reason we provided than Dairy Only consumers. Despite regular self-reported purchase of PBDAs, these Combination consumers were also more likely to purchase and be familiar with all dried dairy ingredients than the Dairy Only consumers. These results suggest that Combination consumers are more informed about food/food labeling than Dairy Only consumers, and sustainability-related marketing efforts should take this observation into account. Further research is needed to understand the differing needs and expectations of dairy foods between Combination and Dairy Only consumers. McCarthy et al. (2017) observed a unique value ladder for nondairy plant based beverage and Combination consumers in means-end-chain (MEC) interviews in which the plant-based attribute of nondairy beverages led to peace of mind and relief of stress regarding animal mistreatment and environmental impacts. Consumers of exclusively dairy milk in this previous study did not demonstrate any value ladders related to sustainability, perhaps indicating that they are less involved with sustainability relative to Combination/exclusively nondairy milk consumers.

Food choice inherently involves trade-offs between varying motives, which for the purpose of investigating sustainable food consumption can be grouped into “pro-self” and “altruistic” motives (Aschemann-Witzel, 2015; van Dam and van Trijp, 2011). High price is often considered a trade-off of sustainable products, but flavor or product quality trade-offs have also been suggested as a deterrent for consumer purchase of sustainable foods (Aschemann-Witzel, 2015; Grunert et al., 2014). Our results suggest that consumers are more likely to agree that they purchased sustainable products for reasons focused on others (the greater good, the wellness of people and animals, and the wellness of the planet) rather than reasons focused on themselves (a better experience or better/safer products). At the same time, few consumers disagreed that sustainable products offered a better experience – with >40% of consumers in both surveys responding they neither agreed nor disagreed with this statement. However, previous work on organic milk consumers suggested an opposite effect. While organic status of a product is not the same as its sustainability, organic status is another example of an ethical/altruistic product attribute (one that may overlap with consumer perception of sustainability). Previous study results indicated that not only do these consumers not see an unavoidable trade-off between organic status and milk quality, they believed organic milk was of higher quality and had better flavor than conventional milk (Harwood and Drake, 2018). Similarly, consumer perceived liking and liking following tasting of both meat and cheese has been shown to increase for Italian consumers when consumers were told the product was organic or promoted animal welfare (Napolitano et al., 2010). Further research is needed to fully understand perception of the trade-off between sustainability/ethics and product quality in sustainable dairy foods and PBDAs, if a significant one does exist for consumers.

The results from both our online surveys indicated that more than half of dairy product consumers are actively looking for sustainability-related information. While product labels are by far the most common source of sustainability information, many consumers are also turning to both company websites and websites not affiliated with companies and/or the government. Word of mouth is also a commonly cited sustainability information source for consumers. Social media profiles, both those associated and not associated with dairy foods companies, were among the least commonly cited sources of sustainability-related information. While a company story that promotes sustainability was not considered important in the MaxDiff analysis, it is likely that consumers are looking for consistency in sustainability messaging between product labels and company websites, especially in the face of consumer backlash against "Greenwashing" and misrepresentation of sustainability efforts by companies on social media (Topal et al., 2019; Lyon and Montgomery, 2013). As packaging is the primary source of sustainability-related information, dairy producers seeking to emphasize the sustainability of their products should carefully consider how to present sustainability-related information in a clear, engaging, accessible manner on product packaging. We noticed significant packaging effects in the CATA exercises in both our first and second surveys, as both fluid milks and dried ingredients packaged in glass or paper-based packaging were more likely to be considered sustainable than those packaged in plastic, and dried ingredients packaged in pouches were more likely to be considered sustainable than those packaged in tubs. Further research is needed to understand how consumers perceive different sustainability-related claims that may appear on packaging, as choosing the correct claim could mean the difference between a sustainability conscious consumer purchasing a product, ignoring it completely, or writing off sustainability-related marketing as insincere.

Consumers perceived sustainability differences between dairy products and PBDAs, between different generic dairy products, and between different specific dairy dried ingredients. Our second survey CATA exercise suggested that while the terms sustainable, natural, healthy, ethical, and trustworthy were used independently in relation to dairy foods, there was significant cognitive overlap between the terms, consistent with previous work (Sautron et al., 2015; Schuldt et al., 2012; Harwood and Drake, 2018). MaxDiff results from our first online survey further reinforced this overlap, as healthy was considered the most important attribute for a sustainable dairy food, and two of the top 5 attributes from the MaxDiff were related to ethical treatment of animals ("animal happiness and welfare" and "doesn't harm wildlife"). Consumers used the terms natural and healthy more frequently in relation to all the dairy foods presented than sustainable, trustworthy, and ethical. Because there is considerable cognitive overlap between the terms sustainable, natural, and healthy, dairy producers should consider emphasizing perception of their products as natural and healthy, thus increasing sustainability perception as a halo effect. An example of this halo effect can be seen for the grass-fed products included in our second online survey CATA exercise. While "USDA Organic" scored of very low importance to sustainability in our MaxDiff exercise, organic dried ingredients in the CATA were significantly more likely to be considered sustainable, natural, healthy, trustworthy, and ethical than conventional dried ingredients (P<0.05). Dried ingredients labeled grass-fed (the 10^{th} most important attribute for sustainability from our MaxDiff) were significantly more likely to be considered sustainable, natural, healthy, trustworthy, and ethical than those not labeled grass-fed (P<0.05). As grass-fed and the idea of cows grazing freely is associated with animal welfare (and thus ethical treatment of animals), the inclusion of grass-fed as a label claim could increase consumer perception of multiple positive attributes (Ellis et al., 2009; Napolitano et al., 2010). This is consistent with previous research with German consumers that demonstrated a pasture-raised attribute increased the consumers' willingness to pay for milk due to greater positive perception of animal welfare (Markova-Nenova and Wätzold, 2018).

Familiarity and consumer knowledge also appear to contribute to sustainability perception. Whey protein concentrate, which was among the most likely dried dairy ingredients to be considered sustainable, natural, healthy, trustworthy, and ethical, was the dried dairy ingredient that the most consumers indicated they were familiar with (56.8%). By contrast, micellar casein concentrate, which was the dried dairy ingredient that the least number of consumers indicated they were familiar with, was among the least likely to be considered sustainable, natural, healthy, trustworthy, and ethical. This result suggests that educating consumers about dried dairy ingredient processing may increase the likelihood they perceive these products as sustainable, natural, healthy, trustworthy, or ethical.

CONCLUSIONS

Although dairy product and PBDA consumers self-report relatively high levels of personal importance of sustainability, there is much confusion as to what the sustainability of dairy products actually involves. The top 5 most important attributes to dairy sustainability identified by this study were minimal carbon footprint/greenhouse gas emissions, few/no preservatives, animal happiness and welfare, and simple/minimal ingredients. These attributes are different than the purely environmentally-focused concept of sustainability typically adopted by industry, and suggest that consumer sustainability perception is muddled and overlapping with their perception of related terms. There is cognitive overlap among the terms sustainable, natural, healthy, ethical, and trustworthy as they relate to dairy products, but consumers do use the terms distinctly. Our results suggest a misalignment between consumer and industry definitions of sustainability, which if addressed could lead to development of marketing messaging which better appeals to consumers. Furthermore, we found consumer perception of sustainability differed widely among dairy products. Within the scope of this study, plant-based alternatives to fluid milk and protein powders were considered more sustainable than dairy products, but package type and organic status also played a significant role in consumer sustainability perception. Consumers perceived sustainability differences between the general categories of dairy products investigated in our study as well as among products in a specific dairy category (as demonstrated in this study with dried dairy ingredients). As consumer concern with sustainability grows, understanding these differences will offer an advantage to dairy product producers who must understand how to strategically position their products in a changing marketplace. As our results suggest consumers may be biased towards believing PBDAs are more sustainable than their dairy counterparts, providing consumers with the necessary knowledge to make an alternative judgement is key. Dairy companies may be able to differentiate themselves by helping consumers make these choices by simplifying sustainability-related messaging as well as maintaining open, transparent communication regarding sustainability. While more research is needed, educating consumers through multiple approaches – for example, optimizing product packaging, including information on product websites, and working with third party websites to disseminate information – could be crucial to get sustainability messaging to stick when consumers make snap judgements at the point of purchase.

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TABLES AND FIGURES

Table 2-1. Focus group moderator guide

Sustainability Focus Group Moderator Guide

Respondent introductions: introduce yourself and share your online pinboard

Focus Area 1: Involvement with Sustainability

1) What dairy products and non-dairy alternative products do you buy?
2) How important is sustainability to you as a consumer? What aspects of your life does your desire for sustainability influence?
3) How knowledgeable would you say you are on the topic of sustainability?
4) What does sustainability mean to you?
5) What are your main suitability concerns?

Focus Area 2: Corporate Branding

1) How does a company show a commitment to sustainability?
2) To you trust companies when they claim to care about sustainability?
3) What sources of information do you look to when deciding whether to trust a company?
    a. Ex: packaging, website, social media, bloggers, company advertisements, company annual report, in-store information, recommendations, non-profit consumer advocates and special interest organizations
4) Is it more important for a product to be sustainable, or for a company to show a commitment to sustainability?
5) Opinions of large companies with sustainable product lines vs. small companies selling only sustainable products

Term Categorization Exercise

Give consumers stacks of sticky notes with the following terms. Ask them to categorize each term into one of these categories by sticking it on the board under the chosen label: "Required for Sustainability," "Contributes to but Not Required for Sustainability", "Misleading", and "I don't understand/am not familiar with this term".

Terms: eco-friendly packaging, animal happiness, locally produced, animal wellness, animal feed (grass, grain, etc.), fair trade, resource cycling, certifications (Fair Trade, Rainforest Alliance, Validus, etc.), ethically sourced, ecological balance, good for/doesn't harm wildlife, brand narrative, minimal cold chain, reasonably priced, employees paid fairly, all products from company are sustainable, water conservation, simple/minimal ingredients, minimal carbon footprint, heathy, pesticide-free, ownership transparency, recyclable packaging, non-GMO, charitable donations, plant-based, shelf-stable, biodegradable packaging, all-natural, produced by large company.

Elaborating on Categorization Exercise

1. Why did you categorize each term as you did?
2. How does the presence or absence of these attributes influence your purchase of dairy products?
3. Are there any terms on here that you see on dairy product packages that you find misleading or questionable? Why do you feel this way?
4. Are there any terms on this list that you do not understand but frequently see on dairy product packages? Why do you think these terms are included?

Wrap up: inquire as to any final thoughts

Figure 2-1. Graphical outline of study design

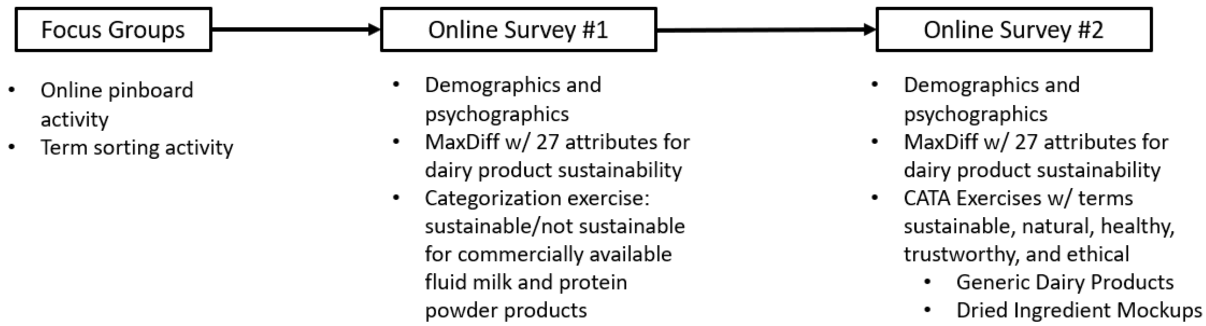
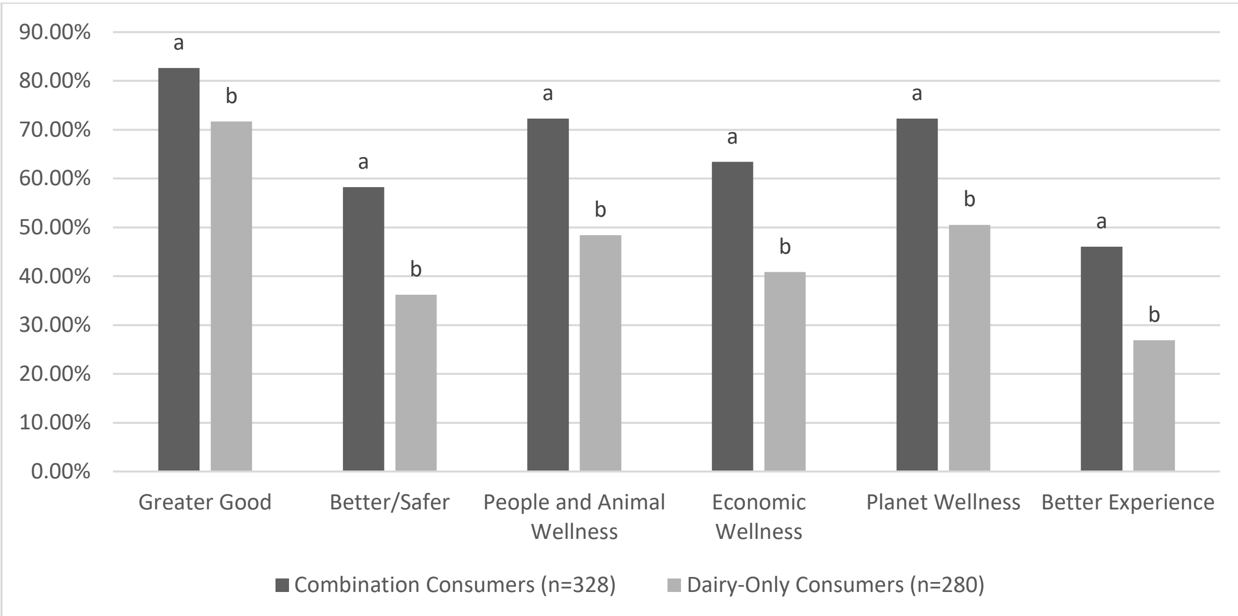


Figure 2-2. Examples of market-realistic product photos used in second online survey

Figure 2-3. Percentage of consumers who agreed that they purchased sustainable foods for each reason (First Survey)



N=608 dairy product consumers[1]

[a-d]*Different letters within attributes indicates significant differences between consumer segments (P<0.05)*

[1]*Dairy product consumers are segmented into combination consumers (those who purchased both dairy products and plant-based dairy alternatives) and dairy-only consumers (those who purchased dairy products but not plant-based dairy alternatives.*

Table 2-2. Mean maximum difference (MaxDiff) scaling scores for sustainability of dairy products (First Survey)[2].

N=608 dairy product consumers[1]
A higher score indicates the attribute was perceived as more important to dairy product sustainability than an attribute with a lower score.
Items within a column which do not share a letter are statistically different (P < 0.05)
*Items followed by a * indicate the averages for Dairy Only and Combination consumers are statistically different (P<0.05)*
[1]Dairy product consumers are segmented into combination consumers (those who purchased both dairy products and plant-based dairy alternatives) and dairy-only consumers (those who purchased dairy products but not plant-based dairy alternatives.)
[2]Sum of values in each column is 100 total points, and the results are interpreted as ratio-scaled values.
3GMO = genetically modified organism

	Average (All Consumers, n=608)	Average (Dairy Only Consumers, n=280)	Average (Combination Consumers, n=328)
All-natural	4.74ef	4.59de	4.87defgh
Animal feed (ex: grass, hay, grain, etc.)	4.11g	4.15e	4.08h
Animal happiness and welfare	5.89ab	5.83abc	5.94abc
Biodegradable packaging	4.19fg	4.16e	4.21fgh
Company story promotes sustainability	1.25i	1.13g	1.36k
Doesn't harm wildlife	6.05a	6.04ab	6.06ab
Employees are paid fairly	5.03cde	5.19cd	4.89defg
Fair Trade Certified	2.53h	2.55f	2.51ij
Few/No Preservatives	5.38bcd	5.23cd	5.51bcd
Grass fed	2.54h	2.39f	2.67ij
Healthy	6.28a	6.27a	6.28a
Lactose-free	0.57j	0.4h	0.71lm
Locally produced	4.31fg	4.48de	4.16gh
Long shelf life*	2.39h	2.87f	1.98j
Minimal carbon footprint/greenhouse gas emissions	5.41bc	5.17cd	5.61abcd
Minimal food waste	5.11cde	5.3bcd	4.94defg
Minimally processed	5.27cde	5.25cd	5.28cde
Non-GMO[3]	2.83h	2.48f	3.12i
Packaging which can be returned to the manufacturer	1.07i	1.21g	0.95kl
Parent companies are disclosed	0.28k	0.28h	0.28n
Produced by a small company	0.42jk	0.39h	0.46m
Promotes ecological balance	5.14cde	5.1cd	5.18de
Recyclable packaging	5.07cde	5.2cd	4.96def
Shipped with minimal cold chain	0.95i	1.1g	0.81klm
Simple/minimal ingredients	5.47bc	5.59abc	5.36cde
USDA Organic	2.93h	2.73f	3.1i
Water conservation	4.82df	4.93de	4.74efgh

Table 2-3. Consumer familiarity with dried dairy ingredients (Second Survey)

Product	All	Combination (n=369)	Dairy Only (n=408)
Skim Milk Powder (SMP)	56.5%	62.3%a	50.1%b
Whey Protein Isolate (WPI)	43.6%	52.9%a	33.3%b
Whey Protein Concentrate (WPC)	56.8%	65.7%a	46.9%b
Casein	29.0%	36.3%a	20.9%b
Milk Protein Concentrate (MPC)	26.3%	37.0%a	14.4%b
Micellar Casein Concentrate (MCC)	7.9%	11.5%a	3.8%b
Blends	44.5%	54.4%a	33.6%b
Other	1.8%	1.0%b	2.7%a

N=777 dairy product consumers[1].

Percentages shown are the percentage of consumers who indicated they were familiar with each ingredient. Consumers were asked which products they were familiar with in a check-all-that-apply format. Different letters in rows indicates a significant difference between Combination and Dairy Only consumers (P<0.05).

[1]Dairy product consumers are segmented into combination consumers (those who purchased both dairy products and plant-based dairy alternatives) and dairy-only consumers (those who purchased dairy products but not plant-based dairy alternatives.)

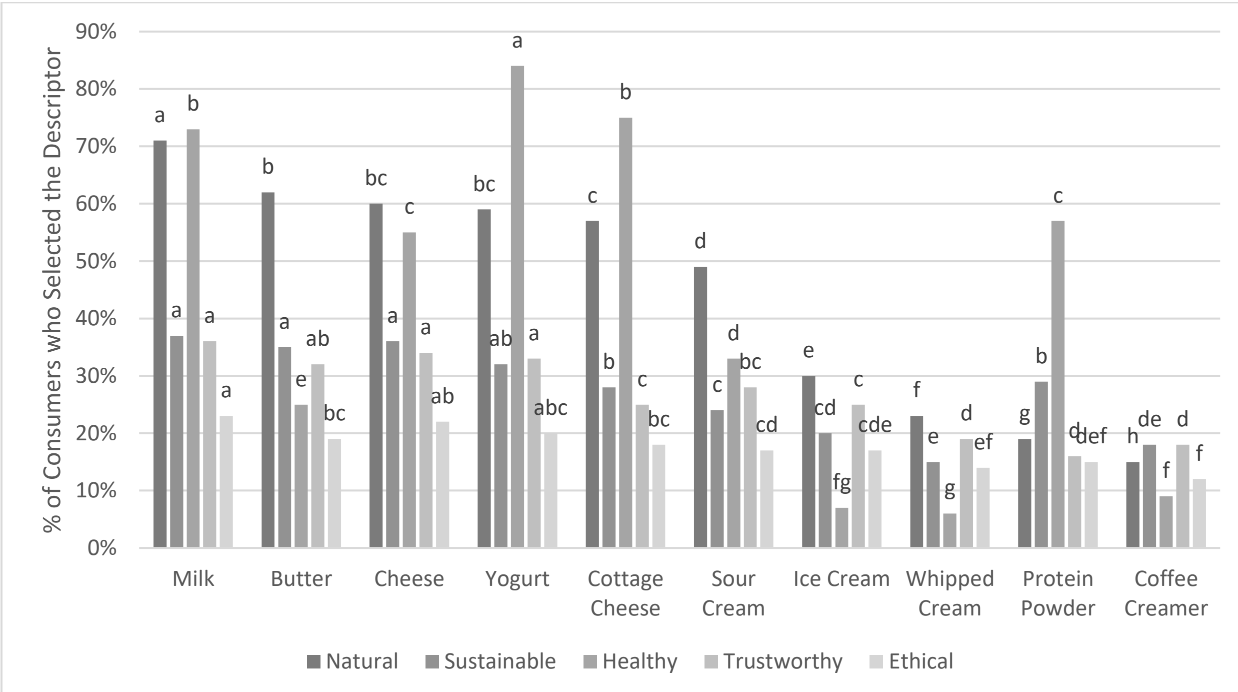
Table 2-4. Consumer purchase habits for dried dairy ingredients (Second Survey)

Product	All
Whey Protein Concentrate (WPC)	60.2%
Whey Protein Isolate (WPI)	52.8%
Blends	50.0%
Skim Milk Powder (SMP)	26.8%
Milk Protein Concentrate (MPC)	24.8%
Casein	17.7%
Micellar Casein Concentrate (MCC)	10.6%
Other	2.0%

N=254 dried dairy ingredient consumers

Percentages shown are the percentage of consumers who self-reported they regularly purchased each ingredient. Consumers were asked which products they purchased regularly in a check-all-that-apply format. Dried dairy ingredient purchase habits question was only asked of consumers who indicated they purchased protein powders or dried dairy ingredients regularly in a previous CATA with general products (n=254).

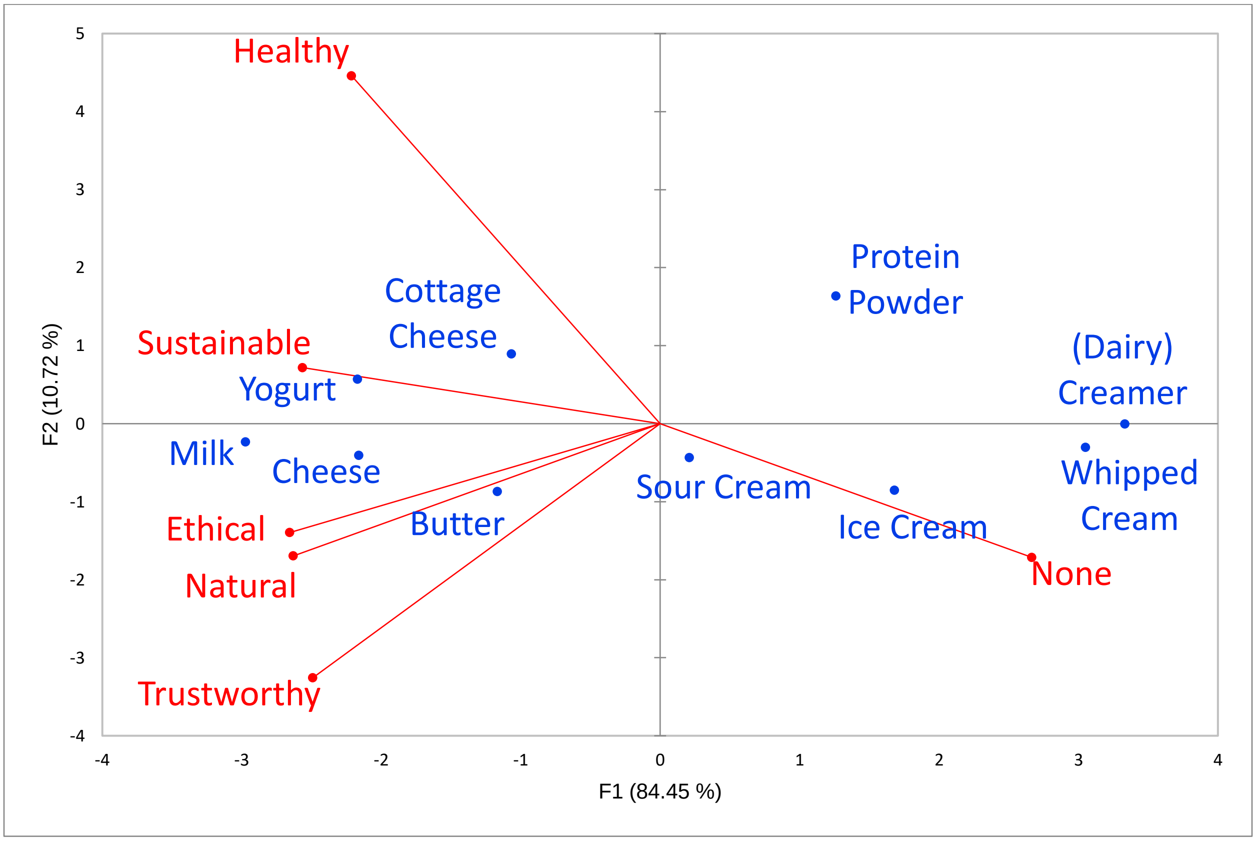
Figure 2-4. Generic dairy product check-all-that-apply results by product for the attributes sustainable, natural, healthy, trustworthy, and ethical (Second Survey)



N=777 dairy product consumers.

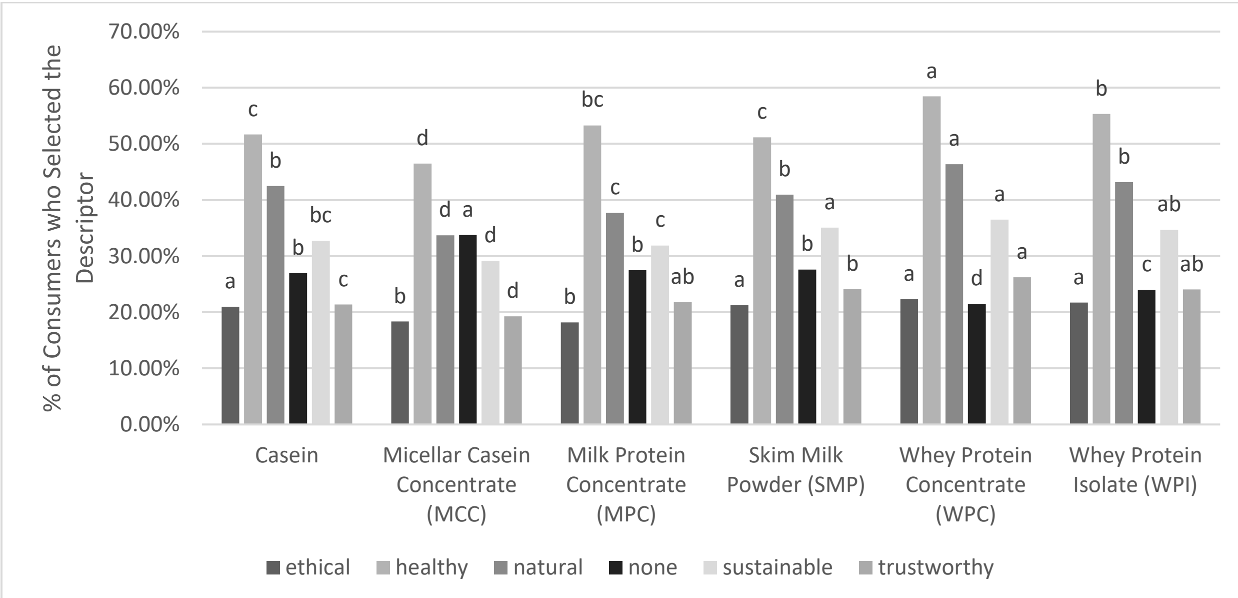
[a-f]*Different letters within products indicate significant differences between products among attributes.*

Figure 2-5. PCA biplot of frequencies of term selection from generic dairy CATA exercise for the attributes sustainable, natural, healthy, ethical, and trustworthy (Second Survey).



N=777 dairy product consumers

Figure 2-6. Dried ingredients check-all-that-apply – results by product for the attributes sustainable, natural, healthy, trustworthy, and ethical (Second Survey).



N=689 consumers familiar with at least one dried dairy ingredient.

[a-d]Different letters within attributes indicate significant differences among products within specific attributes.

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CHAPTER THREE: DRIED DAIRY INGREDIENTS: HEALTHY, NATURAL AND/OR SUSTAINABLE?

ABSTRACT

Conscious consumerism is growing, along with consumer demand for socially conscious dairy products or dairy alternatives. To successfully position dairy products (especially conventional dairy) in this changing marketplace, dairy producers/processors must understand how to strategically use both on- and off-package messaging aligned with consumer perceptions. However, consumer perception of attributes such as sustainable, natural, and healthy is complex, and varies between product categories as well as among products within a category. The objective of this study was to characterize consumer definitions of the terms sustainable, natural, and healthy as they pertain to dried dairy ingredients. To meet this objective, we conducted an online survey with three MaxDiff exercises to determine the importance of 63 label claims to consumer definitions of the terms sustainable, natural, and healthy. The role of priming with dried ingredient processing information on consumer perception of these terms was also explored. Within the dried dairy ingredients category, there is extensive cognitive overlap between the terms sustainable, natural, and healthy. Priming did not impact consumer definitions of any of these terms ($P>0.05$). Certification-related claims were considered among the least important claims for consumer definitions of sustainable, natural, and healthy, while claims that were simple to read and visualize were considered among the most important. Claims related to animal welfare and happiness or simple, minimal ingredients and processing were considered by consumers to be important for all three terms. For each of these terms, there was a cluster of consumers who defined the term primarily by simple ingredients and minimal processing, and

another cluster who defined the term primarily by happy cows and conscious farming practices. The terms sustainable and healthy each had a third, unique consumer cluster. For sustainable, this third definition cluster defined sustainability primarily by environmental impacts, while for healthy, this cluster defined healthy primarily in fitness and nutrition terms. Age and to a lesser extent, gender, impacted importance placed on these three terms and also impacted definition of the term. Understanding these consumer definitions provides insight on how to formulate marketing and educational messaging to speak to each consumer segment.

INTRODUCTION

Conscious consumerism is a growing force in every sector, and the dairy industry is no exception. Consumer demand for socially conscious products is reflected in the growth of plant-based dairy alternatives (PBDAs), many of which claim to be dairy alternatives that are more sustainable, healthier, more natural, or more humane for animals (Mintel Group Ltd., 2019; Franklin-Wallis, 2019; Crawford, 2020). Dairy products face increasing stiff competition from their plant-based counterparts. In 2018, as sales of cows' milk decreased by 6%, sales of plant-based milk increased by 9% (Plant Based Foods Association, 2018). More than half of dairy product consumers now purchase PBDAs as well, indicating a growing threat for dairy producers (Schiano et al., 2020; Baertlein, 2015; Mintel Group Ltd., 2019). The average dairy product consumer believes that PBDAs are more sustainable than their dairy counterparts, putting dairy at a disadvantage when competing for socially conscious consumers (Schiano et al., 2020). Organic, locally-farmed, or grass-fed dairy products may offset this bias towards plant products. Sales of organic milk have increased steadily despite decreases in conventional milk sales, and groups of consumers have shown a preference for and willingness to pay for organic dairy (OTA, 2017; Harwood and Drake, 2018; McCarthy et al., 2017; Smith et al., 2009; Schott and

Bernard, 2015). Local or grass-fed designations may also increase consumer desirability (Wolf et al., 2011; Harwood and Drake, 2020; McCarthy et al., 2017). Dairy products with these designations may be better equipped to compete against PBDAs, but they offer little guidance for conventional product producers.

In order to successfully position dairy products – especially conventional dairy products – in a changing marketplace, dairy producers/processors must understand how to strategically use both on- and off-package messaging aligned with consumer perceptions. Unfortunately, consumer perception of attributes such as sustainable, natural, and healthy is complex, and varies between product categories as well as between products within a category (Schiano et al., 2020; Bernués et al., 2003; Verain et al., 2016). Due to extensive cognitive overlap between the terms sustainable, natural, and healthy, consumer perception of what product attributes contribute to a sustainable, natural, or healthy dairy product may deviate sharply from industry expectations (Pelletier et al., 2013; Verain et al., 2016; Aschemann Witzel, 2015; Ellis et al., 2009; Napolitano et al., 2010; Schiano et al., 2020). For example, essential consumer attributes for sustainability of dairy products included healthiness, minimal carbon footprint/greenhouse gas emissions, few/no preservatives, animal happiness and welfare, and simple/minimal ingredients (Schiano et al, 2020). Only one of these (minimal carbon footprint/greenhouse gas emissions) aligns with the ecological sustainability focus typically prioritized by the dairy industry. Furthermore, consumer perceptions of these concepts are not universal (Verain et al,; 2012; Peano et al., 2019). Peano et al. (2019) identified 5 clusters of consumers based on food sustainability definitions. One cluster of respondents defined the concept of food sustainability primarily by the effect of production on the environment and ecological balance, other consumer clusters prioritized aspects such as social welfare, access to safe and healthy food, and local sourcing of foods. In order for targeted socially conscious messaging to be successful, we must understand how groups of consumers differ in their definitions of and importance placed on terms such as sustainable, natural, and healthy.

We have many unanswered questions about consumer perception of sustainable, natural, and healthy dairy products, but consumer perception of attributes as they relate to dried dairy ingredients is even less understood. The majority of dairy product consumers (>50%) considered protein powders healthy, however few dairy product consumers considered them sustainable or natural (<30% and <20%, respectively) (Schiano et al., 2020). Understanding the perceptions that contribute to this discrepancy is critical for positioning and development of messaging aligned with consumer beliefs. The average dairy product consumer is also less familiar with dairy protein ingredients than more common products such as milk, ice cream, and butter, which may contribute to reduced perception of these products as sustainable, natural, or healthy (Schiano et al., 2020). Because consumers are less familiar with dried dairy ingredients, we assume they will have to make a "best guess" evaluation of whether they are sustainable, natural, or healthy. Informal consumer explanations used to interpret situations where gaps in product knowledge exist are often referred to as "naive theories" (named so because experts or those with full information do not share these biases) (Deval et al., 2013). Although education can change whether consumers are susceptible to naïve theories, priming consumers with naïve theories can affect how they interpret facts (for example, consumers primed with information about how "good art takes effort" were more likely to rate a piece of art as good when told it took a longer time to produce, whereas those primed with "good art takes talent" showed the inverse tendency) (Cho and Schwarz, 2008). Since many consumers are still unfamiliar with dried dairy ingredients, it is likely they are using naïve theories to form their perceptions of these products when encountering or purchasing them. As a result, dairy producers seeking to emphasize the sustainability, naturalness, or healthiness have the unique challenge of needing to develop marketing messaging that aligns with these naïve consumer perceptions, which may be irrational or at odds with scientific evidence and industry standard definitions.

Online surveys allow for collection of qualitative and quantitative data from a large number of consumers with a range of demographic traits and geographical locations. In particular, Maximum Difference (MaxDiff) scaling with realistic label claims allows us to assess the naïve theories of dairy product consumers about dried dairy ingredient sustainability, naturalness, or healthiness. MaxDiff is a specialized survey method which allows for the direct comparison of attribute importance while removing biases associated with rating scale use. The structure of a MaxDiff exercise forces respondents to make choices within each set of attributes presented (in our case, to decide which of a presented set of label claims is most important for whether a dried dairy ingredient is sustainable, natural, or healthy). In addition, including a fact-based priming statement before a MaxDiff exercises allows us to investigate the impact of information on consumer processing knowledge naïve theories and definitions of sustainable, natural, and healthy as they relate to dried dairy ingredients. MaxDiff has been used to study a variety of dairy products such as cheese shreds and fluid milk, including consumer perception of milk sustainability and organic milk purchase motivations (Harwood and Drake, 2018; Schiano et al., 2020; Speight et al., 2019). The objective of this study was to characterize consumer definitions of the terms sustainable, natural, and healthy as they pertain to dried dairy ingredients. To meet this objective, we conducted an online survey with three MaxDiff exercises to determine the importance of 63 label claims to consumer definitions of these three terms. The role of priming with dried ingredient processing information on consumer perception of these terms was also explored.

MATERIALS AND METHODS

Experimental overview and survey

All focus group and survey procedures were conducted in compliance with North Carolina State University Institutional Review Board regulations. An online survey with self-reported dairy consumers that were familiar with at least one dried dairy ingredient (n=900) was conducted. The survey was developed and launched using SSI Web™ (Lighthouse Studio version 9.6.1, Sawtooth Software, Orem, UT). The survey link was sent to a database of >11,000 US consumers managed by the Sensory Service Center (NCSU, Raleigh, NC). Only participants over 18 years of age were able to enter the survey. As an incentive for completing the survey, respondents were entered into a drawing to win one of several Target gift cards. Demographic and psychographic questions were included. To understand how information impacted consumer perception of the terms sustainable, natural, and healthy, half of the respondents were primed with a statement explaining dried dairy ingredient production. The remaining half were shown a placeholder statement. Following priming, consumer participants used maximum difference scaling (MaxDiff) to rank the importance of 63 attributes to the sustainability, naturalness, or healthiness of dairy products.

Priming Statement Development

Prior to survey launch, one 30-min focus group with dairy consumers (n=8) was conducted to confirm the priming statement presented in the survey was comprehensible and believable. Focus group consumers (6 women, 2 men; ages 22-64 y) were recruited from a database of >11,000 US consumers managed by the Sensory Service Center (NCSU, Raleigh, NC) using an online screening questionnaire. During the screening questionnaire, respondents were asked to rate their familiarity with different dairy and plant-based dried ingredients on a 5-pt scale. K-means clustering was used to segment consumers who responded to the screening questionnaire into three clusters (high, moderate, and low familiarity with ingredients) from which 3 participants were selected at random (final focus group attendance was 8 participants due to a no-show). During the focus group, participants were presented with a priming statement about how dried dairy ingredients are produced. They were asked to rate their agreement with statements about the comprehensibility and believability of the information on a 5-point scale. Following this exercise, participants highlighted and discussed anything on the priming statement that they found confusing. A final priming statement, modified based on participant comments, was discussed and approved as comprehensible and believable by the participants. The final priming statement and placeholder statement are included in **Figure 1.** Survey Design

The full survey flow is shown in **Figure 2.** Attention check questions were included throughout the survey to filter out "click through" responses and respondents who were not thoroughly reading the questions. Consumers were asked demographic and psychographic questions including familiarity with and purchase of dried dairy ingredients and plant-based proteins. Familiarity of 8 dairy protein powders (whey protein isolate, whey protein concentrate/whey protein, skim milk powder, milk protein concentrate, native whey protein concentrate/isolate, casein, micellar casein, and dairy protein blends) and 8 plant protein powders (almond, coconut, oat, soy, hemp, pea, peanut, and plant protein blends) was evaluated on a 4 point scale where 1= "I have never heard of this product before", 2 = "I have heard of this product but never purchased it", 3 = "I have purchased this product on occasion", and 4 = "I purchase this product regularly or have purchased it regularly in the past". Participants were disqualified if they were under 18 years of age, did less than 25% of the household shopping or did not purchase one of: dairy products, plant-based dairy alternatives, or protein powders (either dairy or plant-based). In order to ensure focused results, participants who were not familiar with (defined as rating at least one of the options a 2 or higher on the previously mentioned scale) at least one dried dairy ingredient were also disqualified. However, no participants were disqualified due to this criteria. Participants then completed two types of importance questions, one using unstructured line scales and another using a constant sum exercise. Three unstructured line scale importance questions were asked, and responses to each of the three questions were independently assessed. The importance of “sustainability of food,” “healthiness of food,” and “whether food is natural” were rated on unstructured line scales anchored with “Not At All Important” on one end and “Extremely Important” on the other end. These questions were followed by a constant sum/chip allotment exercise in which respondents were asked to distribute 100 points among 5 terms (sustainable, natural, healthy, flavor, and price) to indicate how important each term was to a dairy protein powder product (such as a ready-to-mix protein shake or as a protein powder sold on its own). Consumers were instructed to only consider those 5 attributes and that the total points allocated must equal 100. Due to the nature of a constant sum exercise, these importance scores were not independent and represent tradeoffs consumers are typically forced to make when purchasing protein products.

Next, respondents were randomly assigned to a primed condition (in which they were shown the priming statement describing dried dairy ingredient manufacture) or an unprimed condition (in which they were shown a placeholder statement) (**Fig. 1)**. Following the priming or placeholder statement, Maximum Difference scaling (MaxDiff) was used by consumers to rank the importance of 63 specific attributes to the sustainability, naturalness, and healthiness of dried dairy ingredients (**Table 1**). Each respondent was shown three sets of MaxDiff exercises (for sustainability, naturalness, and healthiness) presented in a randomized order. Each MaxDiff exercise was designed as 27 sets of best-worst questions, with 7 randomly displayed attributes per set. Each respondent was asked to select the attributes out of each set which were “most important” and “least important” to the sustainability, naturalness, or healthiness of dried dairy proteins. The attributes for the MaxDiff exercises were selected based on previous work (Schiano et al., 2020) as well as label claims and marketing materials from dried dairy proteins and protein products currently available in the US online and in grocery stores around Raleigh, NC.

Data Analysis

Statistical analyses were conducted with XLSTAT version 2019.2.1 (Addinsoft, Paris, France) unless otherwise indicated. All analyses were performed at a significance level of 0.05.

Survey Demographics, Purchase Habits, and Psychographics

Protein powder familiarity on a 1-4 scale was analyzed using ANOVA in SAS version 9.4 (SAS Institute, Cary, NC). A familiarity question was asked for each of 16 protein types (WPC, NFDM, Dairy Protein Blends, Soy, WPI, Almond, Plant Protein Blends, Peanut, MPC, Casein, Native Whey, Pea, Coconut, Oat, Hemp, and Micellar Casein). Familiarity responses were pooled for the ANOVA analysis (protein types were used as levels of the independent variable) and respondent was included as a random effect. Frequencies of “select one” questions (demographics, protein powder usage) are shown. Open-ended comment data from follow-up question regarding protein powder usage was coded according to common themes and presented as categorical data. Only themes in comment data shared by at least n=2 respondents are reported.

Consumer Definitions of Sustainable, Natural, and Healthy

MaxDiff score determination (importance score) was performed via hierarchical Bayesian (HB) regression using Lighthouse Studio (Lighthouse Studio version 9.8.1, Sawtooth Software, Sequim, WA). The impact of priming on MaxDiff scores was determined using multivariate analysis of variance (MANOVA) in SAS version 9.4 (SAS Institute, Cary, NC). Statistical testing between MaxDiff utility scores was conducted via one-way analysis of variance (ANOVA) with means separation via the Bonferroni method (XLSTAT). Clustering of consumers by term definitions was performed using latent class analysis of individual MaxDiff responses (Chrzan and Orme, 2019; Sawtooth Software, Inc., 2012).

Impact of Specific Claims on Perception of Sustainable, Natural, and Healthy

Principal component analysis (PCA) was used to project label claim utility scores (from HB regression) to the definition of sustainable, natural, and healthy onto a two-dimensional biplot. Consumer clusters for sustainability, natural, and healthy were used as supplementary categorical variables in the analysis.

Importance of Sustainable, Natural, and Healthy

When assessed on a sliding scale, sustainability, healthiness, and naturalness importance was considered a continuous variable, with “Not At All Important” scored as a 0 and “Extremely Important” scored as a 100. ANOVA with Fisher’s least significant difference for means separation was also used to determine if constant sum importance scores (for sustainable, natural, healthy, price, and flavor) differed between clusters of consumers.

RESULTS AND DISCUSSION

Priming Statement Focus Group

Focus group responses confirmed the priming statement was appropriate for use in an online survey. On a 5-point scale where 1=disagree strongly and 5=agree strongly, the average response for the initial statement was “The information presented here makes sense and is easy for me to comprehend.” was 3.5 and the average response for “The information presented here is believable.” was 3.6. Out of 8 participants, 3 expressed confusion about the term “spray dried”, 1 expressed confusion about the term “filtration,” and 2 expressed confusion over the wording of a sentence explaining milk protein is comprised of casein and whey proteins. The statement was then edited to clarify these sentences.

Survey Demographics

Survey data presented represents n=900 consumers familiar with at least one dried dairy ingredient. Once outliers were removed, the average survey completion time was 36 minutes across 21 hours, indicating respondents did take breaks during the survey. Of the respondents, 24.8% were male and 74.8% were female. The majority of participants identified as Caucasian (73.1%), followed by Black/African American (13.8%), South Asian or Indian (5.1%), Latino or Hispanic (4.8%), and East Asian (4.0%). A range of ages was reported: 22.9% of the participants were 18-24 y, 28.1% were 25-34 y, 20.1% were 35-44 y, 12.7% were 45-54 y, 10.9% were 55-64 y, and 5.3% were 64 y or older. For ease of analysis, we grouped age ranges into three categories by generation: Millennials (ages 18-34, n=459), Gen X (ages 35-54, n=295), and Baby Boomers and the Silent Generation (ages 55+, n=146). An even distribution of total annual household incomes was also self-reported (<$19,999 to >$100,000).

Purchase Habits and Psychographics

Dried ingredient familiarity is shown in **Table 2**. Over half (56.3%) of respondents indicated they did not regularly consume protein powders (all were familiar with at least one dried dairy ingredient). Of the protein powder consumers, 44.8% consumed both dairy and plant-based protein powders, 26.5% consumed dairy protein powders and had never consumed plant protein, 18.3% consumed plant protein after switching from dairy protein powders, 6.5% consumed plant protein after switching from dairy protein powders, and 4.1% consumed plant protein powders and had never consumed dairy protein powders (**Fig. 3).** Respondents were then asked their reasons for their protein powder usage in an open-ended follow up question. Themes in comments from respondents who consumed both plant based and dairy protein powders regularly (n=176) included variety/novelty (29), flavor (25), wanting balance in diet or consumption (24), price (22), health concerns (21), liking both (19), availability (18), intolerance (15), a desire to avoid or minimize dairy products (13), uncertainty as to the difference between dairy and plant-based proteins (6), and sustainability (2). Respondents who consumed only dairy protein powders and had never consumed plant protein powders (n=104) indicated they did so due to satisfaction with their current product/no strong reason to change (n=17), an advantage for working out or building muscle (n=13), recommendations from friends/family/trainers/nutrition professionals (n=13), flavor (n=10), availability (n=9), uncertainty about alternatives (n=9), lower cost (n=8), nutritional advantages (n=5), advertising/marketing/branding (n=4), or because dairy proteins are a "better protein" (n=4). Respondents who consumed only plant proteins and never dairy proteins (n=27) indicated they did so because plant proteins were healthier (n=5), due to a vegan or vegetarian diet (n=3), they had a lactose or dairy sensitivity (n=2), plant proteins had better digestibility/to avoid stomach upset (n=2), or due to recommendations (n=2).

Those who switched from dairy protein powders to plant proteins (n=72) commented the following reasons: plant proteins were easier on their body or stomach (n=13), trying to avoid dairy specifically (n=12), health (n=12), a vegan or vegetarian diet (n=10), increased availability of plant proteins (n=7), environmental sustainability concerns (n=7), recommendations from friends/family/trainers/doctors/nutrition professionals (n=7), dairy or lactose sensitivity (n=4), trying to consume less animal products (n=3), plant proteins are “better for you” (n=3), ethical concerns (n=3), a desire to try new things (n=2), reducing acne caused by dairy (n=2), flavor (n=2), nutritional advantages (n=2), and social media (n=2). Fewer respondents switched from plant powders to dairy protein powders (n=18), citing better taste (n=3), recommendation from a friend/family member/medical or nutrition professional (n=3), or not having as many digestion concerns or ill effects after consuming dairy powders as expected (n=2).

Concerns about ethics and sustainability were not the primary reason consumers chose plant-based protein powders, but these reasons did play a role. As consumers are biased towards thinking plant-based dairy alternatives are more sustainable than dairy products (Schiano et al., 2020), dairy producers should consider how to strategically use messaging in response to these concerns. Familiarity and habit are strong motivators for dairy consumers, with many dairy product consumers continuing to choose dairy because they grew up consuming it (McCarthy et al., 2017; Stewart et al., 2012). Some consumers who had never tried plant-based protein powders did so because they had no reason to switch from their current dairy products. Despite familiarity creating loyalty within the dairy category, novelty and variety were key reasons for use of plant-based protein powders. Food purchase may involve low-effort decision making, in which consumers rely on heuristics (subconscious decision making shortcuts) and biases to make choices instead of methodical decision-making processes (Hoyer et al., 2013). In low-effort situations, a common consumer choice tactic is variety seeking, or choosing a new option for the sake of change rather than continuing to choose a habitually purchased product (Hoyer et al., 2013). Variety-seeking is more common in categories where purchases are mainly low-effort and driven by hedonic desires (such as food categories), and is likely to occur when consumers become satiated with a product's sensory characteristics (Hoyer et al., 2013). Variety-seeking behaviors have been documented within the dairy category. McCarthy et al. (2017) also noted that many fluid milk consumers also purchased fluid PBDAs out of a desire for variety. Some respondents in our study who had switched from dairy to plant indicated the increased availability of plant proteins or becoming aware of perceived benefits of these new products. As more plant-based alternatives enter the market, gain market share, and become more accessible, variety-seeking dairy consumers may choose novel plant-based options despite continued satisfaction with their current dairy options. Rather than rely on established consumer habits, dairy producers must educate their consumers on the benefits of their products as well as develop new options to meet variety seeker's needs.

Consumer Definitions of Sustainable, Natural, and Healthy

MaxDiff results are shown in **Table 1**. The priming statement had no overall effect on MaxDiff scores for sustainable, natural, or healthy ($P > 0.05$). In other words, priming with processing-related information did not affect how consumers defined sustainable, natural, and healthy as they related to dried dairy ingredients. Although some previous studies have suggested including factual-only information about products affected consumer perception of safety, altering consumer perception of socially conscious or health-related attributes typically requires more targeted messaging (Shim et al., 2011; Dixon et al., 2017; van Kleef et al., 2005). Furthermore, many dairy consumers use packaging cues as their primary indication of whether a dairy product is sustainable or socially conscious, with package graphics playing a clearly but largely undefined role in this perception (Schiano et al., 2020). When consumers are exposed to processing information without accompanying graphics or emotional triggers, they may be less likely to use the information to form new opinions about whether a dairy protein is sustainable, natural, or healthy. The lack of effect from our priming statement suggests that a single exposure to fact-based messaging is not enough to alter existing consumer perceptions about dairy products and socially conscious attributes. It is also possible that U.S. consumers are so unfamiliar with the dairy industry and food processing in general that they are unable to formulate opinions on the downstream implications of processing when these implications are not clearly stated.

Latent class analysis of MaxDiff scores resulted in clusters of consumers based on their definition of each term. In other words, consumers who tended to indicate the same label claims were most important for a term were clustered together, as their MaxDiff results indicated that they shared a similar definition of that term. The terms sustainable and healthy each had three clusters of consumers, while natural had two. Cluster sizes and most important label claims are shown in **Table 3**. For ease of discussion, these clusters will from here on be referred to by the following abbreviations: “Happy Cows, Conscious Farming” = “Cows Cluster”, “Simple Ingredients, Minimal Processing” = “Simple/Minimal Cluster”, “Reduce Waste and Environmental Harm” = “Environmental Cluster”, “Fitness and Nutrition First” = “Fitness Cluster”. Consumer definitions were similar for all three terms, suggesting high cognitive overlap among them. All three terms had a Cows cluster which primarily defined each term by claims relating to animal welfare, “green” farming practices, or organic farming. In addition, all three terms had a Simple/Minimal cluster which primarily defined each term by claims related to real dairy, lack of preservatives or complex ingredients and lack of processing. The terms sustainable and healthy each had an additional unique cluster. For sustainable, the Environmental cluster defined sustainable primarily by claims regarding emissions, water and energy use, environmentally-friendly packaging, and minimal waste or byproducts. For healthy, the Fitness cluster defined healthy primarily by claims related to amino acid composition, digestibility or absorption, supporting aspects of physical health, and purity. These results align with previous work which indicated the most important attributes for dairy product sustainability included few/no preservatives, animal happiness and welfare, and simple/minimal ingredients (Schiano et al., 2020). Although naturalness is not well-defined by consumers, previous work has suggested that the amount of processing a product has undergone is strongly related to consumer perception of naturalness, with less processing indicating a more natural food (Rozin, 2006).

Consumers tended to define multiple terms in the same way. Of the consumers in the Cows cluster for sustainable, 57% also fell in the Cows cluster for healthy and 70% fell in the Cows cluster for natural. Of the consumers in the Simple/Minimal cluster for sustainable, over half fell in the same cluster for healthy and natural (54% and 57%, respectively). Consumer demographics also varied by cluster. Protein powder purchase habits did not impact definitions of sustainable, natural, or healthy ($P > 0.05$). Gender did not impact consumer definitions of sustainability ($P>0.05$), however female participants were more likely to define natural or healthy by simple/minimal ingredients, whereas male participants were more likely to define natural and healthy by happy cows and fitness-related claims, respectively ($P < 0.05$). Age significantly impacted definition of all terms (**Table 4)**. Baby Boomers and Silent Generation members (ages 55+) were the most likely age group to define sustainable by simple ingredients and minimal processing claims, while Millennials (ages 18-34) were the most likely to define sustainable in environmental terms ($P < 0.05$). Boomers/Silent Generation members were more likely than Millennials to define natural by simple ingredients and minimal processing, while Millennials were more likely to define natural by claims related to happy cows and conscious farming ($P < 0.05$). Gen X members were equally likely as the other age groups to define natural in either way ($P > 0.05$). There was no difference in the likelihood of the age groups to define whether a dried dairy ingredient was healthy by claims related to fitness/nutrition or happy cows/conscious farming ($P > 0.05$), but Millennials were less likely than the other groups to define healthy by simple ingredients/minimal processing ($P < 0.05$). Previous work has suggested that older consumers are more concerned with food safety risk than younger consumers, and this increased concern about safe foods may explain the increased likelihood of the Baby Boomers/Silent Generation age group in this study to define sustainable, natural, and healthy by simple ingredients and minimal processing (De Jonge et al., 2007).

Impact of specific claims on perception of sustainable, natural, and healthy

To better understand how specific on-package claims contribute to perception of dried dairy ingredients as sustainable, natural, or healthy, we used principal component analysis to project the importance of each claim to each term onto a biplot, along with the consumer definition clusters for each term (**Fig. 4).** All 8 of the consumer definition clusters load similarly on the biplot, suggesting a high degree of cognitive overlap among the terms. In other words, overall, if a label claim was important to the consumer definition of one term, it tended to be important for consumer definition of the other two terms. Among the claims least important for consumer definitions of all three terms were certification-related claims, such as “Fair trade certified”, “B corporation certified”, “Forest Stewardship Council (FSC) certified”, “Rainforest alliance certified packaging”, and “Informed Sport Certified”. By contrast, the claims ranked most important for all three terms tended to be those that were simple to read and visualize, such as “all-natural”, “contains no preservatives”, “milk sourced 100% from sustainable US farms”, “minimally processed milk sourced from grass-fed, pasture-raised cows”, “no artificial sweeteners, flavors, or colors”, or “real dairy”. This trend is reflected in the rankings of claims incorporating organic. The claim “USDA organic” was overall the 34th most important claim for sustainability, however when organic was used as part of a longer, more descriptive claim the importance was increased. “Cows freely graze on green pastures and organic feed” (17th), “organic for you and the environment” (16th), and “commitment to the highest organic standards and animal care practices” (4th) are examples of this issue. The claims shown here to be important to consumer definitions of sustainable, natural, and healthy are in sharp contrast to the certification labeling often prioritized by dairy producers. Consumer understanding of sustainability and ethics-related labels is typically low, leading consumers to overlook or underestimate the importance of these labels (Annunziata et al., 2018; Horne, 2009). Although strategic labeling can increase sales, adding sustainability labels to products is often a cost and labor-intensive process. Dairy companies looking to differentiate through the use of certifications should consider testing alternative (and more cost-effective) messaging that aligns with consumer definitions of sustainability and related terms.

Furthermore, consumer responses in this study also suggests that when consumers state a preference for organic products, they may not be looking specifically for the attribute organic, but instead for other benefits that they have come to associate implicitly with organic (ex: animal welfare, environmental sustainability, healthiness). Harwood and Drake (2018) reported that the top motivating concepts for organic milk users were “healthier for me”, “encourages ethical treatment of animals”, and “supports local farmers and farms”. Although the average consumer has a poor understanding of organic practices, organic products are often perceived as healthier (Hill and Lynchehaun, 2002). Consumer perception of organic and locally farmed milk also has been shown to overlap (Haas et al., 2013, Harwood and Drake, 2020). Conventional dairy producers may be able to position their products successfully against organic competitors through carefully constructed messaging emphasizing conventional dairy products share the same benefits perceived to be offered by organic ones. It is critical to note that the consumer importance of each label claim to their definition of the terms sustainable, natural, or healthy was evaluated here in order to better understand consumer definitions of these terms. We did not investigate willingness to pay for these claims, which may deviate from consumer perceived definition importance. For example, although a consumer may consider the claim “real dairy” to strongly indicate a product is natural, they may not be willing to pay for this claim or be willing to pay more for natural products in general. Further work is needed to understand how marketing messaging which incorporates these claims and concepts relates to consumer purchase intent and willingness to pay for dairy products.

Importance of Sustainable, Natural, and Healthy

Average importance for terms as reported from sliding scale and constant sum questions are shown in **Figure 5-6**. Sliding scale importance: Respondents were asked to indicate the importance of 3 attributes (sustainable, natural, and healthy) for a dried dairy ingredient on separate sliding scales where the response on one scale did not impact the responses on other scales. The attribute with the highest average self-reported sliding scale importance for a dried dairy ingredient was healthy, followed by sustainable, with natural scoring the lowest of the three ($P < 0.05$). Constant sum importances: respondents were asked to indicate the importance of 5 attributes (flavor, price, sustainable, natural, and healthy) for a dried dairy ingredient. In a constant sum exercise, respondents allot points to each attribute in proportion to the importance placed on that attribute, thus, tradeoffs must be made between the attributes presented. Constant sum results displayed a similar pattern as sliding scale importance results, with flavor, health, and price more important than natural and sustainable. To understand how consumer definition related to self-reported importance of each term, we analyzed constant sum importance scores by cluster. Clusters (determined from latent class analysis of MaxDiff scores) grouped consumers based on their definitions of sustainable, natural, and healthy and are shown in **Table 3**. Constant sum importance was selected instead of sliding scale importance as this constant sum incorporates trade-offs between attributes, better representing the choices consumers face when making daily purchases. For natural, there was no difference in importance between the three clusters ($P > 0.05$). In other words, how consumers defined the term natural did not affect the importance they placed on whether a dried dairy ingredient is natural. The lack of differences in importance between clusters as well as the lack of a unique cluster for natural may be due to poor consumer understanding of this term (Chambers et al., 2019; Chambers et al., 2018). Unlike for natural, clusters for sustainable and healthy showed significant differences in importance placed on each term. For sustainable, the Environmental cluster placed the highest importance on sustainability, while the Cows cluster placed the least importance ($P < 0.05$). Sustainability importance for the Simple/Minimal cluster was at parity with both other clusters ($P > 0.05$). Healthy showed the biggest differences in importance between clusters. The Simple/Minimal cluster placed the most importance on whether a dried ingredient was healthy, above the Fitness and Cows clusters ($P < 0.05$). The higher importance placed on health by consumers in the Simple/Minimal cluster may relate to the trend of “clean label” products. Although there is no regulatory definition of “clean label,” it is often interpreted as products which use easy to understand ingredients found in nature and limited processing (Asioli et al., 2017). The concept of health is a key motive for choosing clean label foods (Asioli et al., 2017). Understanding how consumer definitions relate to importance placed on each term offers valuable insight for personalized marketing messaging. Consumers who define sustainability primarily as relating to environmental factors (such as greenhouse gas emissions, water usage, waste, etc.) may be most willing to pay for sustainable products, while consumers who define healthy primarily by simple ingredients and minimal processing (such as clean-label products, no added sweeteners or colors, preservative-free, etc.) may be most willing to pay for healthy products.

CONCLUSIONS

Within the dried dairy ingredients category, there is extensive cognitive overlap between the terms sustainable, natural, and healthy. Label claims which were considered by consumers to be important for one term also tended to be considered important for the other two. In general, certification-related claims were considered among the least important claims for consumer definitions of sustainable, natural, and healthy, while claims that were simple to read and visualize were considered among the most important. Claims related to animal welfare and happiness or simple, minimal ingredients and processing were considered by consumers to be important for all three terms. Including these concepts in on-package marketing messaging may increase consumer perception of a dried dairy ingredient as sustainable, natural, or healthy. For each of these terms, there was a cluster of consumers who defined the term primarily by simple ingredients and minimal processing, and another cluster who defined the term primarily by happy cows and conscious farming practices. Sustainable and healthy each had a third, unique consumer cluster. For sustainable, this third definition cluster defined sustainability primarily by environmental impacts, while for healthy this cluster defined healthy primarily in fitness and nutrition terms. Members of the Baby Boomer and Silent generations were more likely to define all three terms by simple ingredients and minimal processing. Millennials, on the other hand, were more likely to define sustainability by environmental impacts and natural by claims related to happy cows or conscious farming. Female consumers were more likely to define natural and healthy by simple ingredients and minimal processing, whereas male participants were more likely to define the terms by happy cows/conscious farming and fitness/nutrition, respectively. Understanding these consumer definitions provides insight on how to formulate marketing and or educational messaging to speak to each consumer segment.

ACKNOWLEDGMENTS

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TABLES AND FIGURES

Figure 3-1. Priming and placeholder statements

Priming Statement

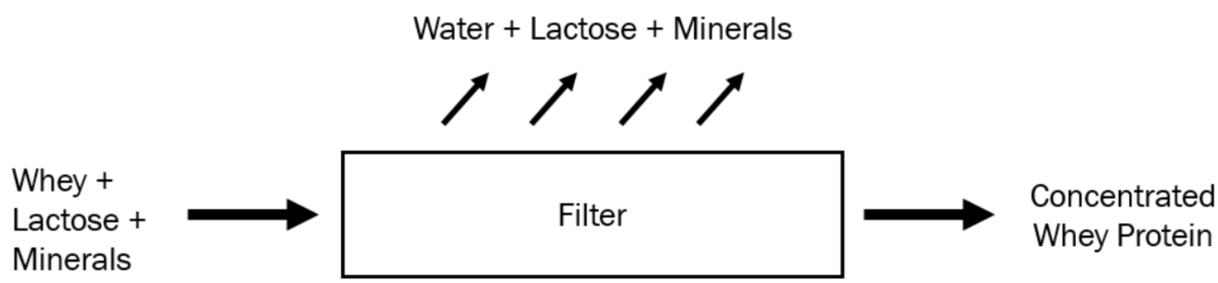
Fluid cow's milk contains two main types of protein: whey protein and casein protein.

Cheesemaking causes casein proteins to coagulate (stick together) resulting in curds. Wisconsin fried cheese curds, fresh cheese curds, and the lumps in cottage cheese are both examples of coagulated casein protein. To make blocks of cheese, the curds are pressed together to squeeze the moisture out.

The moisture squeezed out is called whey and contains whey proteins. Fluid whey is mostly water but also contains lactose (milk sugar), minerals, and some fat. In previous years, whey was considered a waste product.

Rather than throw out this mixture, which can harm the environment if dumped in large quantities, it is used to make food ingredients.

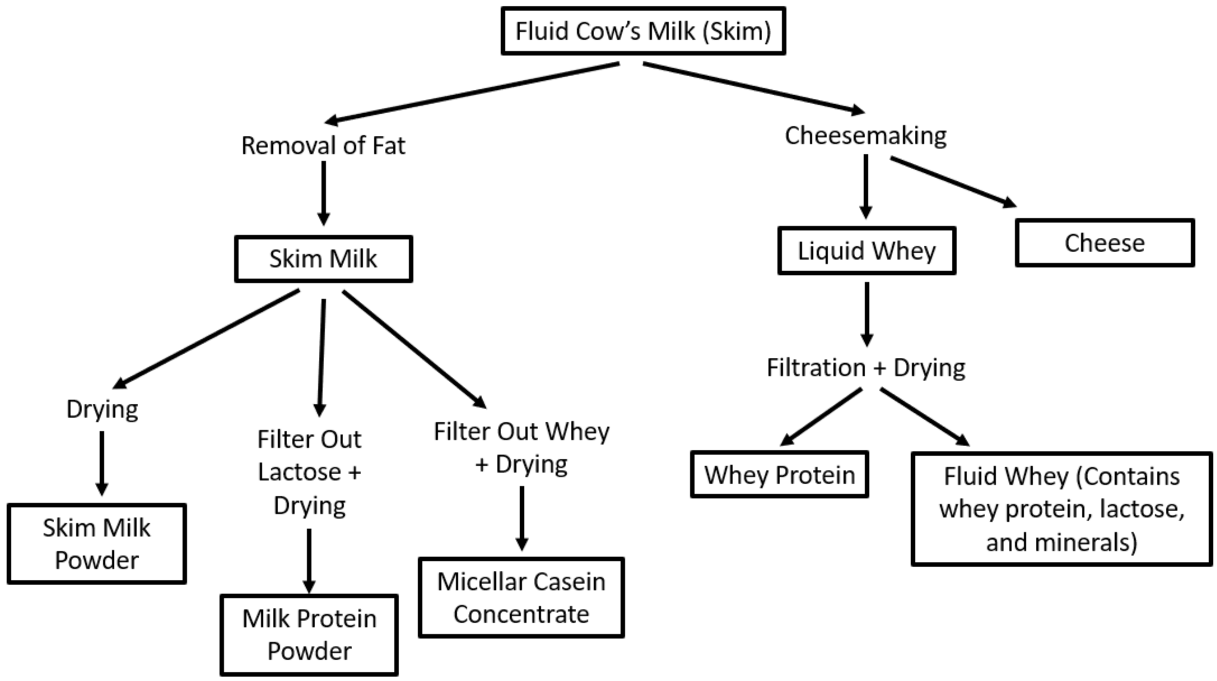
To make whey protein, fluid whey passes through a very fine filter. Whey proteins are too large to pass through the filter and are trapped. Lactose and minerals are smaller and can pass through the filter. Concentrated whey protein (with small amounts of lactose and minerals) cannot pass through the filter.



This concentrated protein is then dried to a powder to make whey protein powders.

Protein powders can also be produced directly from milk that has not been used for cheesemaking.

To make skim milk powder, skim milk is evaporated and dried. To make milk protein powders, skim milk is filtered to remove some of the lactose and to concentrate the milk protein before the product is dried. The resulting milk protein powder contains both casein and whey proteins. Micellar casein concentrate is another protein powder made from skim milk, but has whey protein removed so that the protein powder contains only casein.



Placeholder Statement

Protein powders (such as whey powder, skim milk powder/nonfat dry milk powder, milk protein concentrate, and micellar casein concentrate) are made from fluid cow's milk.

Figure 3-2. Survey flow

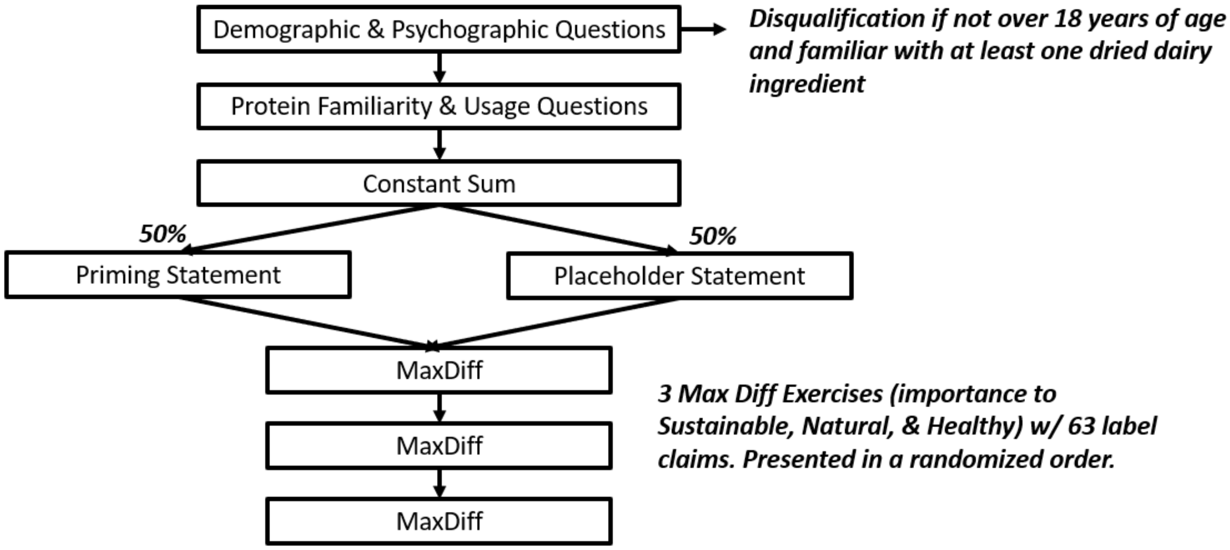
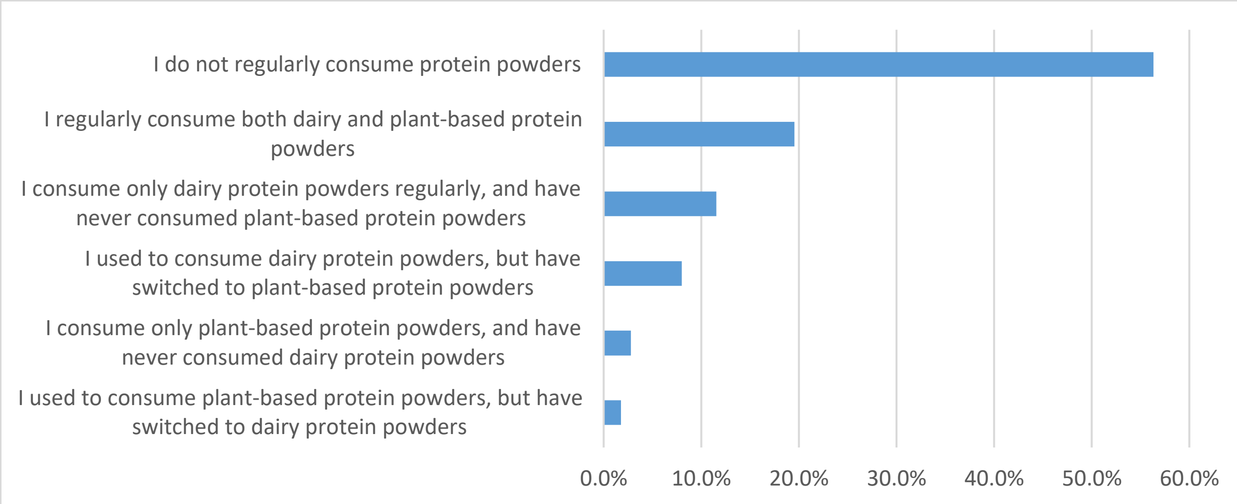
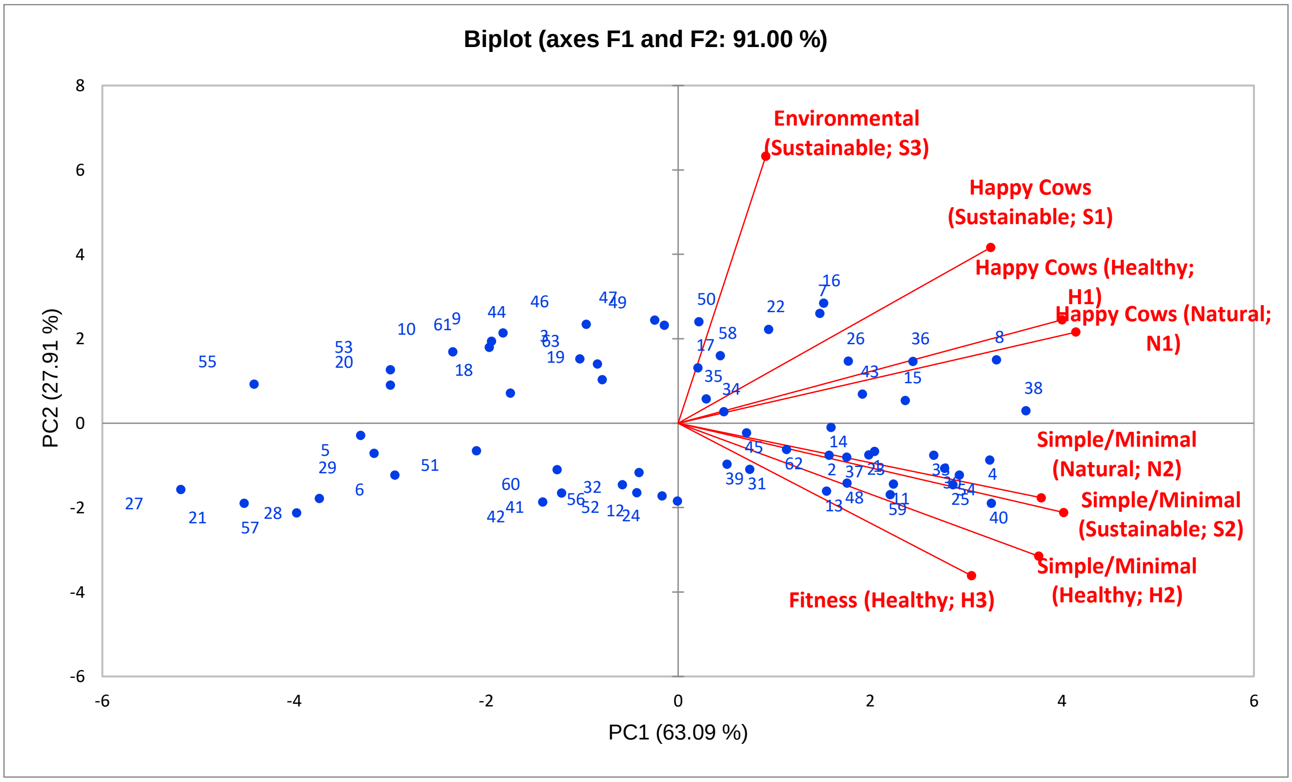


Figure 3-3. Consumer protein powder usage



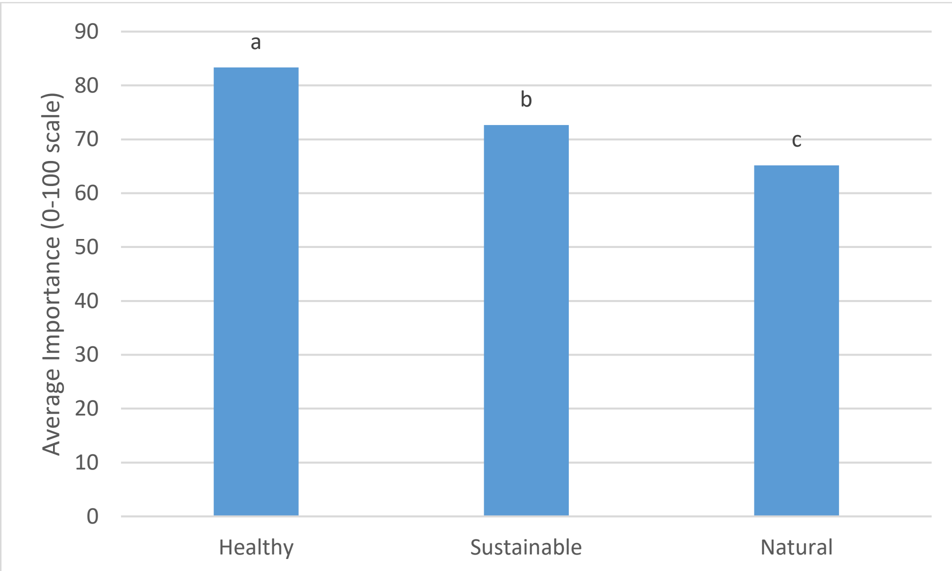
Data represents n=900 consumers familiar with at least one dried dairy ingredient.

Figure 3-4. Principal component analysis of MaxDiff scores for label claim importance to whether a dried ingredient is sustainable, natural, and healthy. Consumer MaxDiff scores were clustered by Latent Class analysis into clusters



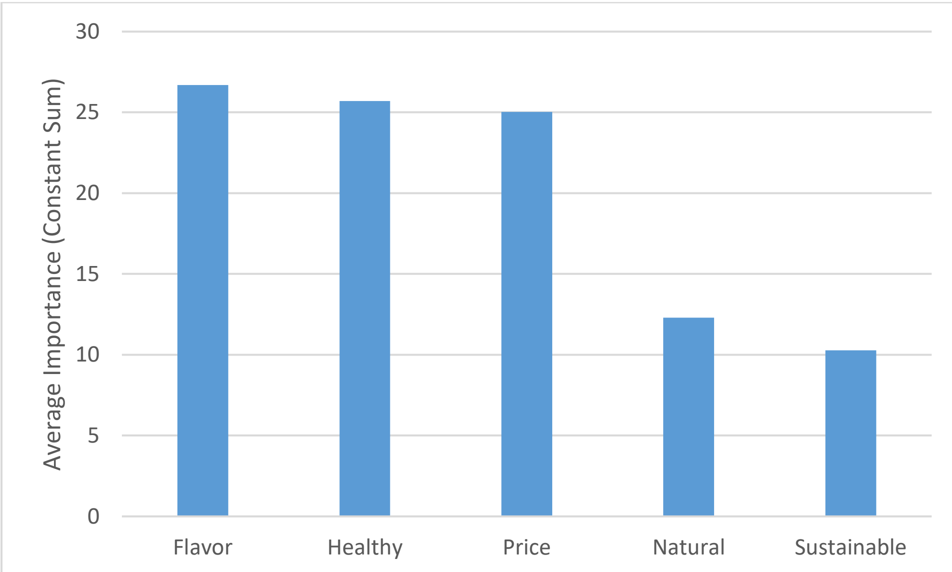
Data represents n=900 consumers familiar with at least one dried dairy ingredient. Percentages show the percent of variability in the data explained by each principal component. Positive loading with principal component PC1 indicates generally higher importance of the claim to the terms sustainable, natural, and healthy. Numbers correspond to claim numbers from ***Table 4****. Clusters shown here are described in* ***Table 2.*** *Sustainability clusters: S1 = "Happy Cows, Conscious Farming", S2 = "Simple Ingredients, Minimal Processing", S3 = "Reduce Waste and Environmental Harm". Natural clusters: N1 = ""Happy Cows, Conscious Farming", N2 = "Simple Ingredients, Minimal Processing". Healthy clusters: H1 = "Happy Cows, Conscious Farming", H2 = "Simple Ingredients, Minimal Processing", H3= "Fitness and Nutrition First".*

Figure 3-5. Importance of three attributes to consumers for purchase of dried dairy ingredients as determined by sliding scale importance questions



Data represents n=900 consumers familiar with at least one dried dairy ingredient. Importance was evaluated on a sliding scale where 0=not at all important and 100=extremely important. Attributes which do not share a letter are statistically different (P < 0.05).

Figure 3-6. Importance of 5 attributes to consumers for purchase of dried dairy ingredients as determined by constant sum allocation exercise



Data represents n=900 consumers familiar with at least one dried dairy ingredient. Each respondents' scores must sum to 100 in a constant sum question. Data is ratio scaled (for example, a score of 2x another score indicates that the higher scoring attribute is twice as important as the other).

Table 3-1. Maximum difference scaling (MaxDiff) importance of 63 label claims to sustainable, natural, and healthy as they pertain to dried dairy ingredients (n=900)

A higher score indicates the claim was perceived as more important to whether a dried dairy ingredient is sustainable, natural, or healthy than a claim with a lower score. Sum of values in each column is 100 total points, and the results are interpreted as ratio-scaled values.

The top 10 most important claims for each term are highlighted in gray. Statistical lettering has been provided for the top 10 most important claims. Bolded claims within a column that do not share a term are statistically different ($P < 0.05$).

GMO = genetically modified organism

Item Number	Label Claim	Sustainable	Healthy	Natural
1	100% transparent label that fully discloses the dose of each active ingredient	1.499	2.752	0.408
2	Acid and bleach-free processing	2.422	2.482	0.556
3	All employees paid a fair, living wage	2.425	0.853	0.549
4	All-natural	1.236	3.061 bcd	0.323 `ab
5	B Corporation certified	2.261	0.320	0.571
6	Cold processed	2.097	0.361	0.49
7	Commitment to sustainable agriculture	1.399 ijklm	1.154	0.812
8	Commitment to the highest organic standards and animal care practices	2.068 ef	2.639 efgh	1.942
9	Completely biodegradable packaging	3.214	0.432	3.13
10	Compostable packaging	1.178	0.380	2.103
11	Contains no preservatives	1.339	3.037 bcd	2.188 klm
12	Contains only easily digestible A2 milk proteins	2.103	2.097	3.17
13	Contains probiotics – supports digestive health	3.073	3.090	1.057 uvwx
14	Cows fed a balanced grain-based diet	3.201	2.129	1.084
15	Cows freely graze on green pastures and organic feed	3.622	2.360 ijk	1.621
16	Environmentally sustainable practices	3.802 a	1.111	1.681
17	Ethically sourced	3.024	0.898	1.603
18	Fair trade certified	1.274	0.455	0.402
19	Farms certified by Validus, a leading independent animal welfare auditor	0.261	0.710	0.414
20	Forest Stewardship Council (FSC) certified	0.31	0.303	0.380
21	Gluten-free	1.318	0.366	2.393
22	Good for wildlife and the environment	0.227 w	1.192	0.308
23	Heavy metal free	0.756	2.812	1.725
24	Helps reduce post-workout muscle breakdown and protect gains in strength and lean muscle mass	0.710	2.416	0.933
25	High-quality, complete protein with all 9 essential amino acids in every serving	0.841	3.703	0.731 [\]^_
26	Humane treatment of cows	1.390	1.578	2.031
27	Informed Sport certified	0.693	0.268	0.694

Table 3-1. (continued).

28	Lactose-free	0.954	0.503	0.941
29	Long shelf life	0.942	0.511	0.971
30	Made from a few, simple ingredients	0.968	3.262 b	1.279 stu
31	Made from pasteurized milk	2.24	1.908	2.777
32	Made from ultrapasteurized milk	1.336	1.407	2.597
33	Made with milk from cows not treated with rBGH or rBST	0.880	3.098 b	1.509 qrs
34	Made with milk from family farms	0.627	1.206	1.068
35	Manufactured in a cGMP (current good manufacturing process) certified facility	1.202	1.289	2.253
36	Milk 100% sourced from sustainable US farms	1.522 hijk	1.979	3.559
37	Minimally processed		2.562	3.847
38	Minimally processed milk sourced from grass-fed, pasture-raised cows	1.559 hij	3.532 a	3.249 cd
39	More bioavailable and easily absorbed than other proteins	1.249	2.164	2.284
40	No artificial sweeteners, flavors, or colors	1.197	3.727 a	3.469 bc
41	Non-GMO[4]	1.564	1.499	3.506
42	Only ingredients you can pronounce	1.361	1.595	3.923
43	Organic for you and the environment	0.630	2.315	1.802
44	Package made from 100% recyclable material	1.197	0.445	3.456
45	Pasture-raised	0.299	1.548	0.411
46	Produced in a zero-waste facility	3.104 b	0.561	1.007
47	Produced using green/renewable energy	2.988 bc	0.765	0.783
48	Produced with Grade A milk	1.350	2.689	2.927
49	Produced with minimal carbon footprint	2.451 d	0.804	0.711
50	Produced with responsible water usage and conservation in mind	1.239 lmn	0.872	2.528
51	Proudly made in the USA	1.929	0.675	1.146
52	Provides a slow and sustained release of amino acids	0.430	1.927	0.997
53	Rainforest Alliance certified packaging	1.419	0.322	1.474
54	Real dairy	2.277	3.031 bcd	1.344 rst
55	Return the packaging at your local grocery store for a discount	1.194	0.244	0.579
56	Slow rate of absorption – keeps you satisfied longer	3.549	1.714	2.477
57	Soy-free	2.029	0.549	1.271
58	Supports small farms. Being a good neighbor is good business.	1.624	1.064	0.856
59	The only ingredient is real milk	0.530	2.831 cde	0.354 `ab
60	Third party tested for purity	0.839	1.263	0.415
61	Upgraded reusable packaging which is picked up, hygienically cleaned, and refilled	0.176	0.486	0.178
62	USDA organic	0.909	2.152	0.742
63	Utilized byproducts to minimize food waste	1.700 gh	0.540 xyz[\	4.002

Table 3-2. Consumer familiarity with protein products (n=900)

		Percentage of Respondents For Each Level of Familiarity			
	Average Familiarity (0-4 Scale)	"I have never heard of this product before"	"I have heard of this product but never purchased it"	"I have purchased this product on occasion"	"I purchase this product regularly or have purchased it regularly in the past"
WPC	2.50a	11.1%	43.1%	30.3%	15.4%
NFDM	2.35b	7.7%	54.7%	32.3%	5.3%
Soy	2.30bc	12.0%	52.8%	28.4%	6.8%
Dairy Protein Blends	2.28c	19.7%	42.6%	27.3%	10.4%
WPI	2.14d	30.4%	37.4%	20.1%	12.0%
Almond	2.10d	25.7%	45.9%	20.8%	7.7%
Plant Protein Blends	2.09d	28.7%	41.6%	22.1%	7.7%
Peanut	2.00e	28.8%	47.0%	19.4%	4.8%
MPC	1.87f	36.1%	45.3%	13.9%	4.7%
Oat	1.84gf	36.3%	46.6%	14.2%	2.9%
Pea	1.81gh	41.7%	39.6%	14.7%	4.1%
Coconut	1.79gh	40.9%	42.9%	12.8%	3.4%
Casein	1.78gh	38.9%	47.7%	9.7%	3.8%
Native Whey	1.77hi	44.2%	38.4%	13.0%	4.3%
Hemp	1.73i	41.3%	47.2%	8.7%	2.8%
Micellar Casein	1.46j	64.0%	27.8%	6.8%	1.4%

For average familiarity, products that do not share a letter are statistically different ($P < 0.05$). Familiarity was evaluated on a 4 point scale where 1= "I have never heard of this product before", 2 = "I have heard of this product but never purchased it", 3 = "I have purchased this product on occasion", and 4 = "I purchase this product regularly or have purchased it regularly in the past". In order to ensure relevant results, only data from consumers familiar with (scoring a 2 or higher) at least one dried dairy ingredient was kept.

Table 3-3. Consumer clusters by their definition of sustainable, natural, and healthy as it pertains to dried dairy ingredients. Determined via latent class clustering of MaxDiff scores. (n=900)

The top 10 most important label claims (out of 63 total) for each cluster's definition of each term are shown in order of importance.

Sustainable Clusters			
Cluster Name	**Cluster Abbreviation**	**Size**	**Top 10 Label Claims**
Happy Cows, Conscious Farming (Cluster S1)	Cows Cluster	277	Environmentally sustainable practices
			Commitment to the highest organic standards and animal care practices
			Commitment to sustainable agriculture
			Humane treatment of cows
			Minimally processed milk sourced from grass-fed, pasture-raised cows
			Milk 100% sourced from sustainable US farms
			Good for wildlife and the environment
			Produced with responsible water usage and conservation in mind
			Organic for you and the environment
			Produced using green/renewable energy
			High-quality, complete protein with all 9 essential amino acids in every serving
			Produced with minimal carbon footprint
			Cows freely graze on green pastures and organic feed
			Made with milk from cows not treated with rBGH or rBST
Simple Ingredients, Minimal Processing (Cluster S2)	Simple/Minimal Cluster	191	Real dairy
			All-natural
			No artificial sweeteners, flavors, or colors
			The only ingredient is real milk
			Produced with Grade A milk
			Made from a few, simple ingredients
			High-quality, complete protein with all 9 essential amino acids in every serving
			Milk 100% sourced from sustainable US farms
			Minimally processed milk sourced from grass-fed, pasture-raised cows
			Contains no preservatives
			Made with milk from cows not treated with rBGH or rBST
			Commitment to the highest organic standards and animal care practices
			Contains probiotics – supports digestive health
			Minimally processed

Table 3-3. (continued).

Reduce Waste and Environmental Harm (Cluster S3)	Environmental Cluster	432	Environmentally sustainable practices
			Commitment to sustainable agriculture
			Produced in a zero-waste facility
			Produced with responsible water usage and conservation in mind
			Produced using green/renewable energy
			Produced with minimal carbon footprint
			Milk 100% sourced from sustainable US farms
			Good for wildlife and the environment
			Completely biodegradable packaging
			Utilized byproducts to minimize food waste
			Package made from 100% recyclable material
			Upgraded reusable packaging which is picked up, hygienically cleaned, and refilled
			Commitment to the highest organic standards and animal care practices
			Compostable packaging

Table 3-3. (continued).

Natural Clusters			
Cluster Name	**Cluster Abbreviation**	**Size**	**Top 10 Label Claims**
Happy Cows, Conscious Farming (Cluster N1)	Cows Cluster	418	Commitment to the highest organic standards and animal care practices
			Minimally processed milk sourced from grass-fed, pasture-raised cows
			Humane treatment of cows
			All-natural
			Cows freely graze on green pastures and organic feed
			Milk 100% sourced from sustainable US farms
			Environmentally sustainable practices
			Real dairy
			High-quality, complete protein with all 9 essential amino acids in every serving
			Commitment to sustainable agriculture
			No artificial sweeteners, flavors, or colors
			Good for wildlife and the environment
			Organic for you and the environment
			Made from a few, simple ingredients
Simple Ingredients, Minimal Processing (Cluster N2)	Simple/Minimal Cluster	482	All-natural
			No artificial sweeteners, flavors, or colors
			The only ingredient is real milk
			Minimally processed milk sourced from grass-fed, pasture-raised cows
			Contains no preservatives
			Made from a few, simple ingredients
			Real dairy
			Made with milk from cows not treated with rBGH or rBST
			Minimally processed
			Cows freely graze on green pastures and organic feed
			USDA organic
			Acid and bleach-free processing
			Commitment to the highest organic standards and animal care practices
			Organic for you and the environment

Table 3-3. (continued).

Healthy Clusters			
Cluster Name	**Cluster Abbreviation**	**Size**	**Top 10 Label Claims**
Happy Cows, Conscious Farming (Cluster H1)	Cows Cluster	314	Commitment to the highest organic standards and animal care practices
			Humane treatment of cows
			Minimally processed milk sourced from grass-fed, pasture-raised cows
			Cows freely graze on green pastures and organic feed
			Good for wildlife and the environment
			Milk 100% sourced from sustainable US farms
			Commitment to sustainable agriculture
			High-quality, complete protein with all 9 essential amino acids in every serving
			Environmentally sustainable practices
			Real dairy
			Heavy metal free
			Cows fed a balanced grain-based diet
			Organic for you and the environment
			Made from a few, simple ingredients
Simple Ingredients, Minimal Processing (Cluster H2)	Simple/Minimal Cluster	361	No artificial sweeteners, flavors, or colors
			All-natural
			Minimally processed milk sourced from grass-fed, pasture-raised cows
			Made from a few, simple ingredients
			Made with milk from cows not treated with rBGH or rBST
			Contains no preservatives
			High-quality, complete protein with all 9 essential amino acids in every serving
			The only ingredient is real milk
			Real dairy
			USDA organic
			Minimally processed
			Contains probiotics – supports digestive health
			Heavy metal free
			Acid and bleach-free processing

Table 3-3. (continued).

Fitness and Nutrition First (Cluster H3)	Fitness Cluster	225	High-quality, complete protein with all 9 essential amino acids in every serving
			Helps reduce post-workout muscle breakdown and protect gains in strength and lean muscle mass
			Contains probiotics – supports digestive health
			No artificial sweeteners, flavors, or colors
			More bioavailable and easily absorbed than other proteins
			Provides a slow and sustained release of amino acids
			Contains only easily digestible A2 milk proteins
			100% transparent label that fully discloses the dose of each active ingredient
			Slow rate of absorption – keeps you satisfied longer
			Produced with Grade A milk
			Heavy metal free
			Real dairy
			Made from a few, simple ingredients
			Minimally processed milk sourced from grass-fed, pasture-raised cows

Table 3-4. Age breakdown of consumer definition clusters (determined by latent class clustering of MaxDiff data for sustainable, natural, and healthy MaxDiff exercises) (n=900)

	Sustainable			Natural		Healthy		
	Cows	Simple/Minimal	Environmental	Cows	Simple/Minimal	Cows	Simple/Minimal	Fitness
Millenials (18-34)	32.5%a	10.2%c	57.3%a	51.0%a	49.0%b	37.9%a	34.0%b	28.1%a
Gen X (35-54)	29.8%a	27.8%b	42.4%b	44.1%ab	55.9%ab	32.9%a	46.4%a	20.7%a
Boomers & Silent Generation (55+)	27.4%a	42.5%a	30.1%c	37.0%b	63.0%a	29.5%a	46.6%a	24.0%a

Consumers are expressed as a percentage of each age group. Columns that do not share a letter indicate a statistical difference between age groups (P < 0.05).

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CHAPTER FOUR: PARENTS' IMPLICIT PERCEPTIONS OF DAIRY MILK AND PLANT-BASED MILK ALTERNATIVES

ABSTRACT

Dairy product consumption is motivated by both familiarity and habit. Milk consumption decreases with age, but milk consumption during childhood and adolescence increases the chances of lifetime milk consumption. Understanding how parents perceive dairy milk and other dairy foods further enables development of dairy-positive messaging that aligns with their perceptions. The objective of this research was to understand parents' belief systems around fluid dairy milk and plant-based alternatives (PBAs). This goal was accomplished by assessing parents' implicit attitudes towards dairy milk and PBAs with an implicit bias exercise (n= 331), followed by qualitative interviews to understand explicitly stated purchase motivations and guided recall of information heard about dairy milk and PBAs to better understand external influences on milk perception (n=88). The majority of parents (73.4%) implicitly associated dairy milk with positive attributes compared to those with a positive association with PBAs (13.8%) or with a neutral bias (12.7%). The stronger a parent's implicit bias towards PBAs, the more likely they were to purchase these products either alongside or as a replacement for dairy milk. Eighty-five percent of parents in our study could recall drinking milk at home as a child, and 58% remembered encouragement from their parents to drink milk. However, only 38% encouraged their own children to drink milk (the majority – 55% - were neutral towards their children's milk consumption). Generally negative media messaging towards dairy milk and positive messaging towards PBAs may contribute to this trend, even if consumers are not explicitly aware of their perception changes. Seventy seven percent of parents felt generally

confident in choosing dairy milk or PBAs for their children. However, only 26% of parents felt nothing about dairy milk or PBAs was confusing. Sources of uncertainty about dairy milk included hormones and antibiotics, animal welfare, ecological sustainability, potential contamination, and intolerances or allergies. By addressing the most commonly encountered and recalled concerns about milk from parents, dairy producers may be able to increase trust and implicit bias towards dairy over PBAs.

INTRODUCTION

Fluid milk consumption has steadily declined in the United States since the 1970s, with a 15% decline in sales since 2012 (Dror and Allen, 2014; Mintel Group Ltd., 2019). At the same time, sales of plant-based milk alternatives are increasing. Sales of plant-based milk alternatives increased 9% in 2018 as sales of dairy milk decreased 6%, with plant-based alternative milks projected to comprise 18.5% of the total milk market share by 2023 (Mintel Group Ltd., 2019; Plant Based Foods Association, 2018). Consumer motivations for switching from dairy to plant-based alternatives are complex. Plant based alternatives (PBAs) often use messaging related to sustainability, naturalness, and human treatment of animals, emphasizing how these products are ethical/socially conscious alternatives that fill the same role as traditional dairy (Franklin-Wallis, 2019; Crawford, 2020; Fuentes and Fuentes, 2017). In general, dairy consumers are biased towards believing PBAs are more sustainable than their dairy counterparts (Schiano et al., 2020). McCarthy et al. (2017a) conducted means-end chain (MEC) interviews with both dairy and nondairy milk consumers, and they reported that nondairy consumers had a unique value ladder for plant-based milk alternatives, believing these products were a more moral choice due to animal treatment and environmental effects. However, consumer understanding of health and sustainability as they apply to the dairy category is complex and involves extensive cognitive overlap (Schiano et al., 2021a). Outside of a desire for conscious consumption, consumers may switch from a dairy product to a PBA for variety, due to a dairy allergy or sensitivity, to follow a special diet (such as a vegan or vegetarian diet), or because they are unsure of the differences between dairy and plant-based products (Schiano et al., 2021a; McCarthy et al., 2017a; Haas et al., 2019). Consumers, especially younger consumers, may also lack the basic dairy processing and composition knowledge needed to make nutritionally sound judgements about dairy and dairy alternatives (Schiano et al., 2021b).

Dairy product consumption is motivated by both familiarity and habit (McCarthy et al., 2017a; Stewart et al., 2012). Although milk consumption decreases with age, dairy consumption during childhood and adolescence increases the chances of lifetime milk consumption (Huth et al., 2006; Lytle et al., 2000; Forshee and Storey, 2003; McCarthy et al., 2017a). As repeated childhood exposure to foods results in development of preferences for those foods, childhood is a key phase of life for driving dairy loyalty (Ventura and Woroby, 2013; Wardle et al., 2003; Anzman-Frasca et al., 2012; Sipple et al., 2020). However, this loyalty developed during childhood is not necessarily lifelong. A subset of consumers, dubbed “conflicted health seekers” (CHS), express concern about the health and sustainability of their food, which may lead them to consume less dairy foods (O’Brien, 2020; Spaeth-Bauer, 2020). If parents make the switch from dairy milk to PBAs, they may also switch their children’s diets, preventing dairy habit formation. These parents may consider plant-based alternatives healthier despite published statements and guidelines from pediatricians encouraging caution or recommending primarily dairy milk (Healthy Eating Research, 2019; Rosen, 2020; Sipple et al., 2020). The American Dietary Guidelines recommend that children consume fat-free or low-fat dairy daily (2.5 cup equivalents/day for children 4-8 y and 3 cup equivalents/day for children 9-18 y) (UHDHHS and

USDA, 2015). Plant-based milk alternatives may serve a similar dietary role as dairy milk, but they are not nutritionally equivalent. In particular, most PBAs lack the vitamin and protein content of dairy milk, are not nutritionally complete protein sources, and have lower protein digestibility-corrected amino acid scores (PDCASS) than their dairy counterparts (Mäkinen et al., 2016; Friedman, 1996; Jeske et al., 2017; Chalupa-Krebzdak et al., 2018). Despite their concerns, consumers conflicted or uncertain about dairy consumption can change their opinion based on marketing messaging. Previous messaging targeted at CHS consumers by global communications firm Edelman was used to create the “Undeniably Dairy” marketing campaign, which decreased purchase intent for dairy alternatives among the campaign’s audience by 6% (Edelman, 2020). Understanding how parents perceive dairy milk and other dairy foods further enables development of dairy-positive messaging that aligns with their perceptions. In turn, this process may increase the chances that their children are exposed to milk consumption at an early age and prove key for dairy’s success in an evolving marketplace.

Consumer decision making may involve both high effort and low effort processes and strategies. Food and beverage purchase often involves low-effort decision making, where consumers rely on heuristics (subconscious decision making shortcuts) and preexisting biases to make quick decisions rather than consciously evaluating options and tradeoffs (Hoyer et al., 2013). During low-effort decision making, consumers rely more on implicit attitudes (underlying and unknown) rather than explicit attitudes (consciously and directly expressed) (Friese et al., 2006). Implicit attitudes can be influenced and changed over time by experiences or marketing efforts (Gibson, 2008, Pokhrel et al., 2016, Czyzewska and Ginsberg, 2007). The implicit association test (IAT) is a computerized test that uses reaction time as a proxy to measure subconscious association between items in two categories (in our case: positive vs. negative and dairy milk vs. plant based milk alternatives) (Carpenter et al., 2019). While we outline these procedures in detail in the methods section of this paper, the basic underlying premise of the IAT is that reaction times to categorize two items together (eg. positive and dairy milk) will be shorter if the implicit association between those categories is stronger, and longer if the implicit association between those categories is weaker (Carpenter et al., 2019). The IAT has been applied successfully to study consumer attitudes and behavior towards consumer package goods (CPG) products, including fluid milk and beverages in general (Harwood and Drake, 2020; Maison et al., 2001; Maison et al., 2004; Gibson, 2008). Investigating implicit as well as explicit consumer attitudes can lead to a more robust analysis of consumer perception, including perception of dairy milk and plant based alternatives. Consumer implicit attitudes are not necessarily correlated with explicitly stated beliefs when consumers evaluate whether beverages are healthy or natural (Maison et al., 2001), two key aspects of beverage perception. Prediction of food and beverage purchase behavior improves when implicit measures are incorporated relative to exclusive use of explicit attitude measures (Maison et al., 2004). Furthermore, it is speculated that implicit attitudes affect how receptive a consumer is to marketing messaging delivered in different formats (Madhavaram and Appan, 2010). Understanding the implicit attitudes of parents towards dairy milk and PBAs offers valuable insight on their decision-making processes which can be further used to guide messaging development and marketing campaigns.

In contrast to the IAT, qualitative interviewing techniques measure explicit consumer attitudes and beliefs. Qualitative methods are often used in consumer packaged goods studies to gain deep insight in a flexible way into consumer attitudes, which can elaborate on/clarify results from previous quantitative work or develop hypothesis to test in further quantitative work (Jervis and Drake, 2014). Interviewing techniques have been used with success within the dairy category (McCarthy et al., 2017a, McCarthy et al., 2017b, Schiano et al., 2021b). Interviewing techniques ensure data quality by encouraging participants to elaborate on and describe their beliefs thoroughly. One such technique is laddering, which involves the interviewer asking participants tailored probing follow up questions (eg "Why is [attribute] important to you?") in a semi-structured interview format (Rynolds and Gutman, 2001). As interviewing techniques assess participant explicit attitudes, they can be combined with the IAT (which assesses consumer implicit attitudes) to form a more complete picture of consumer perception. The objective of this research was to understand parents' belief systems around fluid dairy milk and PBAs. This goal was accomplished by assessing parents' implicit attitudes towards dairy milk and PBAs, as well as explicitly stated purchase motivations. To better understand external influences on milk perceptions, guided recall of information heard about dairy milk and PBAs was also conducted.

MATERIALS AND METHODS

Experimental Overview

To investigate parents' implicit and external attitudes towards dairy milk and PBAs, we conducted a two-part study. First, parents completed an online survey including an implicit association test (IAT) to determine their implicit bias for or against dairy milk and PBAs. A subset of participants were then invited to one-on-one in-depth follow-up interviews. All survey and qualitative interview procedures were conducted in compliance with the North Carolina State University Institutional Review board regulations.

Participant Recruitment

Participants were recruited from a database of >11,000 US consumers managed by the Sensory Service Center (North Carolina State University, Raleigh). Only participants over 18 years of age or older were able to enter the survey. Respondents were disqualified if they were not a parent/guardian of a child under the age of 18 y living in their household, had not consumed fluid dairy milk as a child, or had not purchased either fluid dairy milk or PBAs within the past 3 months. Survey respondents were compensated with an entry into a drawing for 1 of 1 $100 Target gift cards, 1 of 2 $50 Target gift cards, or 1 of 5 $20 Target gift cards. Once participants had completed all parts of the online survey and IAT, they were asked if they were interested in participating in a follow-up interview. Interview participants were recruited from those who indicated they wanted to participate in the online interview, had access to a device capable of running Zoom video conferencing software (Zoom Video Communications, Inc., San Jose, CA), and showed a bias towards either dairy milk or PBAs (as determined by IAT results analyzed using the procedures below). Qualitative interview participants were compensated with an additional $20 Target gift card. Initial recruitment and the online survey portion of this study were conducted in February 2020, before the COVID-19 pandemic had reached the United States. The qualitative interviews were conducted later in Spring 2020, when much of the country was under lockdown to prevent spread of the disease. Steps were taken to ensure dramatic temporary changes to consumer shopping habits did not impact results of the interview portion, as described below.

Online Survey and Implicit Association Test (IAT)

An online survey was developed and hosted on the Qualtrics (Qualtrics, Provo, UT) software platform. Consumers were asked demographic questions including purchase of dairy products and PBAs. Respondents were disqualified if they did not drink fluid milk as a child, were not the parent or guardian of a child under the age of 18 who lived in their household, or did had not purchased either dairy milk or PBAs within the past 3 months. Consumers were then presented with an online IAT survey comparing dairy fluid milk with plant-based milk alternatives constructed using the iatgen web-based tool developed by Carpenter et al. (2019) as well as the recommended test administration procedure for this tool. See Carpenter et al. (2019) for full details on replicating this method and a comprehensive overview of web-based IAT survey design using the iatgen tool. Stimuli for each beverage type (dairy milk and nondairy milk alternatives) included 6 commercial product images representing the range of products available in that category. Ten terms each were used as positive and negative stimuli in order to represent a range of milk/milk alternatives category attributes. Positive stimuli used were: wholesome, good for you, nutritious, healthy, natural, safe, nourishing, high-quality, and trustworthy. Negative stimuli used were: unwholesome, bad for you, unhealthy, unnatural, unsafe, misleading, and low-quality. Selection of category attributes was intended to capture a range of angles related to milk production, health, and sustainability, as concern over these topics defines the conflicted health seeker consumer segment (Schiano et al., 2020; Schiano et al., 2021a, Harwood and Drake, 2020).

The IAT consisted of 7 parts ("blocks") as described by Carpenter et al. (2019). In each block, participants were shown a series of stimuli (either positive/negative attributes or product photos) and asked to press a key with either their left or right hand (the "E" and "I" keys) to sort that stimulus into the appropriate category. Categories were fixed in the upper left and right side of the screen and were matched with another category. For example, a participant's screen might show "Dairy" and "Positive" to the left of the screen while "Plant-Based" and "Negative" appear to the right side of the screen. If then shown a photo of a container of dairy milk, the panelist must press the “E” key as quickly as possible to sort the stimulus. The structure of the blocks was counterbalanced to account for order effects and included appropriate practice tasks to familiarize respondents with the exercise as well as to clear learned associations between categories and sides of the screen (Nosek et al., 2005; Greenwald et al., 1998). Incorrect responses were required to be corrected before continuing, with response time recorded once the stimulus was sorted correctly (Greenwald et al., 2003). The full structure of the IAT exercise is shown in **Table 1.**

Qualitative Interviews

Thirty to forty-five minute semi-structured qualitative interviews were conducted. This method of interviewing has been used successfully within the dairy category by authors including McCarthy et al. (2017b), Schiano et al. (2021b), and Vaarst et al. (2002). Only survey respondents who displayed a clear bias for or against dairy milk (n= 56 parents biased towards dairy and n=32 parents biased against dairy) were included in follow-up interviews (those with a D score between -0.15 and 0.15 were excluded as it indicates no significant bias). Interviews were completed within a 60 day period following the online survey. Interviews were conducted and recorded using the Zoom video conferencing software (Zoom Video Communications, Inc.) and notes were taken from recordings in order to minimize distractions to panelists. During the interviews, a moderator facilitated the discussion through the use of a pre-established moderator guide (**Figure 1),** but asked follow-up questions tailored to panelist responses. Laddering techniques were utilized to gather additional details and identify motivations behind stated behavior. As this research overlapped with the start of the COVID-19 2020 pandemic, the researchers took steps to minimize the impact of the pandemic on qualitative interview responses. The moderator acknowledged that the COVID-19 pandemic may have affected grocery shopping habits (in particular due to widespread grocery shortages early on in the pandemic) and asked participants to comment on how their habits had changed but requested that participants answer the interview questions about the type of milk they would typically purchase prior to the pandemic. First, participants were asked to recall the milk they drank growing up, as well as to describe the milk they currently purchased for their household. Participants were then asked to elaborate on whether they encouraged their children to drink dairy milk or PBAs, important attributes when choosing beverages for their children, and attributes of beverages they would prefer their children avoid. Finally, parents were asked to recall information they had heard regarding milk or PBAs from sources including their children's pediatrician or other doctors, organizations of health professionals, government sources, the news media, online blogs, advertising, social media, and word of mouth. Follow up questions were asked to evaluate how much parents trusted each source and how confident they felt in general about making judgements about the health and nutritional value of milks for their children.

Data Analysis. All analyses were performed at a significance level of 0.05. IAT data was analyzed using the iatgen web-based analysis tool (Carpenter et al., 2019; Greenwald et al., 2003). Responses with unusually long response times (greater than 10,000ms) or those with more than 10% of response times under 300ms were removed from the analysis and scored as missing. D-scores were calculated from raw response times in blocks 3, 4, 6, and 7 using the iatgen tool, which uses the procedure described by Greenwald et al. (2003). Negative D-scores indicated a positive bias towards dairy milk while positive D-scores indicated a positive bias towards plant-based milk alternatives. D-scores were segmented based on the strength of the implicit bias (Greenwald et al., 2003; Rooth, 2010). Scores between -0.15 and 0.15 were considered neutral/no bias. Scores |0.15|-|0.35| were considered a slight bias, scores |0.35|-|0.65| were considered a moderate bias, and scores greater than |0.65| were considered a strong bias (Greenwald et al., 2003). Analysis of variance (ANOVA) with Fisher's mean separation was used to determine if D-scores varied with gender (XLSTAT version 2019.2.1, Addinsoft, Paris, France). ANOVA was then run in XLSTAT with age, gender, income, and their interactions as model parameters. The adjusted R^2 value was used to select an appropriate model. To determine if implicit association predicted purchase of either dairy milk or PBAs, binary logistic regression was run in RStudio (version 1.1.463) with D-score as an independent variable and purchase as a dependent variable. Separate binomial regressions were run for purchase of dairy and PBAs. To create the probability figure, probability formulas were generated from logistic regressions in JMP Pro 15.2.0 (SAS, Inc., Cary, NC). Probability formulas were used to calculate the probability a participant would purchase dairy milk or plant based alternative (PBA) given an IAT D-score from -1.5 to 1 (the range of D scores seen in our data).

For qualitative interviews, note-based analysis was used to identify key points. Notes for each question were manually coded into thematic categories using QDA Miner 6 Version 6.0.5 (Provalis Research, Montreal, Canada). Coded data was reviewed and frequencies of themes were calculated. To better clarify ideas, qualitative interview data was analyzed in three separate parts:

1. Experiences with and memories of milk consumed as a child
2. Current milk purchase habits and feelings about milk and PBAs as beverages for their children
3. Prompted recall of information heard about dairy milk and PBAs

In order to ensure data represented the majority of respondents, themes mentioned by less than 3 of the panelists in an interview part were excluded from results (Reynolds and Gutman, 2001). Chi-squared analysis in XLSTAT was used to determine if differences existed in the percentages of participants biased for pr against dairy who stated a particular theme. To explore co-occurrence of themes in part 3 of the qualitative interviews (prompted recall of information heard about dairy milk and PBAs), themes were clustered in QDA Miner 6. Silhouette analysis was conducted to determine the number of clusters (Rosseeuw, 1987), which were then projected onto a 2D biplot using QDA Miner 6.

RESULTS

Survey Demographics and Psychographics

A total of 345 parents completed the survey and IAT activity. Fourteen IAT evaluations were dropped due to excessive speed within exercises, leaving 331 usable survey responses (Table 2). Once outliers were removed, the average survey completion time was 10 minutes. Of the respondents, 23.9% were male and 76.1% were female. The majority of participants identified as Caucasian (75.2%), followed by Black/African American (17.2%), Asian (4.8%), Latino or Hispanic (4.8%), and other (1.2%) (ethnicity was asked in a check-all-that-apply format so the total does not sum to 100%). Because all participants were parents or guardians of a child under the age of 18 who lives in their household, ages skewed heavily towards middle age: 0.9% of the participants were 18-24 y, 21.1% were 25-34 y, 45.6% were 35-44 y, 29.6% were 45-54 y, 2.7% were 55-64 years old, and no participants were ages 65 or older. Ages of children also varied: 39.9% of participants had at least one child ages 0-5 y, 52.9% had at least one child ages 6-12 y, and 41.1% had at least one child ages 13-17 y. The majority of respondents purchased dairy milk only (62.8%), followed by purchase of both dairy milk and

PBAs (31.7%), with just 5.4% of respondents purchasing only PBAs (5.4%). The percentage of respondents who purchase both dairy milk and PBAs was lower than seen in previous studies on general consumer populations (Schiano et al., 2020; Schiano et al, 2021a), which may indicate parents are less likely to purchase PBAs than dairy consumers in general.

Implicit Association Test (IAT)

D-scores were calculated to assess whether an implicit bias existed towards dairy milk or PBAs. For analysis purposes, dairy milk was assigned the arbitrary negative direction (-) while PBAs were assigned the arbitrary positive direction (+). A negative D-score thus indicated a bias (positive implicit perception) for dairy milk, while a positive D-score indicated a bias for PBAs. The mean D-score was -0.393 ($P < 0.0001$) indicating the average association between dairy milk and positive attributes was stronger than the association between plant-based milk and positive attributes (**Table 2**). Of the respondents who completed the IAT, 73.4% were biased towards dairy milk, 13.8% were biased towards PBAs, and 12.7% had no bias. The distribution of IAT results is shown graphically in **Figure 2.** Female respondents were on average less biased towards dairy milk than male respondents (mean D-scores of -0.361 and -0.492, respectively) ($P < 0.05$). Age and income did not affect implicit bias towards dairy milk ($P > 0.05$). In a previous study of implicit association of conventional vs. nonconventional dairy (organic, pasture raised, and locally farmed), age did not impact implicit association (Harwood and Drake, 2020). However, a greater bias was shown towards locally farmed milk by those with higher incomes, and those with children showed a greater bias for organic milk (Harwood and Drake, 2020). It is possible that demographics influence implicit association for or against dairy vs. PBAs as well, however, these effects may not be shown in this study due to the targeted recruitment (parents who consumed milk during childhood).

Implicit association affected purchase likelihood of both dairy and PBAs. Respondents more strongly biased towards dairy milk were more likely to purchase dairy milk ($P=0.0009$). Similarly, respondents more strongly biased towards PBAs were more likely to purchase PBAs ($P<0.0001$). The probability of purchase of dairy milk or PBAs at D-scores ranging from -1.5 to 1 is graphically displayed in **Figure 3.** At no D-score was the probability of purchase of PBAs higher than that of dairy milk, indicating that parents who consumed milk as children are currently more likely to purchase dairy milk than PBAs regardless of their internal bias. However, 26% of these parents that consumed milk as children had no bias or were biased towards PBAs, suggestive of a conflict concerning positive attributes and dairy milk.

Qualitative Interview Demographics

A total of 88 one-on-one interviews were conducted, each lasting approximately 15-25 minutes. N=56 participants (63.6% of the total) were biased in favor of dairy milk while n=32 participants (36.4% of the total) were biased in favor of PBAs. Survey respondents with no bias were not selected for follow-up interviews. Qualitative interview participants were 24% male and 76% female. The age distribution was similar to that seen in the initial online survey: 1% of the participants were 18-24 y, 21% were 25-34 y, 46% were 35-44 y, 30% were 45-54 y, 3% were 55-64 years old, and no participants were ages 65 or older. A range of children's ages were again represented: 40% of the interview participants had at least one child 0-5 y, 53% had at least one child 6-12 y, and 41% had at least one child 13-17 y.

Childhood Milk Experiences

The majority of qualitative interview participants drank milk at school (69%) or at home (85%) as children. Sixty-seven percent of participants consumed milk at both home and school during childhood. Parents/family was the most common source of encouragement to drink dairy milk as a child (58%), followed by school (12%), ads/marketing (10%), dentists (3%), and the government (1%). Two percent of participants could remember encouragement to drink dairy milk but could not remember from where, while 13% of participants couldn't recall specific encouragement to drink dairy milk. There was no difference in childhood milk consumption or encouragement between participants biased for and against dairy ($P > 0.05$). Participants' recall of milk experiences in childhood were consolidated into 9 themes stated by at least 3 participants. These themes were: milk builds strong bones (35%), milk was the "norm" or default to drink (24%), milk is healthy (22%), milk helps children grow strong (10%), drinking a local brand of milk (9%), milk leads to strong and healthy teeth (8%), milk is healthier than other beverage options (5%), drinking milk because someone else liked it hedonically (3%), and drinking milk because someone forced them to (3%).

Present Day Milk Experiences

The majority of participants (n=61, 69.3%) purchased both dairy milk and PBAs, followed by purchase of only dairy milk (n=16, 18.2%), and purchase of only PBAs (n=11, 12.5%). Together, n=77 participants (88%) purchased any kind of dairy milk while n=72 (82%) purchased any kind of PBA. The most common PBA or milk purchased was almond PBA (64%), followed by reduced fat (1% or 2% fat) dairy milk (49%), whole dairy milk (36%), oat PBA (19%), soy PBA (17%), skim dairy milk (13%), coconut PBA (9%), cashew PBA (7%), nut blend PBA (3%), pea PBA (2%), flax PBA (1%), and plant blends (1%). Of the participants who purchased dairy milk, 62% stated they had no brand preference, while 34% stated they preferred a specific brand (the remaining 4% did not mention brand when prompted for more information about their dairy milk purchase). Of those that purchased PBAs, although a similar percentage stated they preferred a specific brand (36%), just 36% stated they had no brand preference. The majority (72%) did not mention brand when probed for additional details about the PBA products they purchased. Variety-seeking behavior for PBA purchase (ex: seeking out newly available brands and products) was noted for 11% of PBA purchasers versus 3% of dairy milk purchasers for dairy milk purchase. Variety-seeking behavior is common for low-effort purchase decisions driven primarily by hedonic desires (which is often the case for food purchase) (Hoyer et al., 2013) and has been demonstrated specifically within the dairy category (McCarthy et al., 2017a; Schiano et al., 2021a). McCarthy et al. (2017a) conducted means-end-chain interviews with dairy and nondairy milk consumers, finding a desire for variety was a key driver for PBA purchase, consistent with results from this study. Other factors contributing to choice of dairy milk among dairy purchasers were: organic (34%), no hormones/antibiotics (17%), long shelf life/expiration date (9%), preference for local milk (5%), DHA fortification (4%), lactose-free (4%), and non-GMO (4%). Other factors contributing to choice of PBAs among PBA purchasers were: organic (11%), only familiar/pronounceable ingredients (10%), protein content (6%), and all-natural ingredients (4%). Of particular note is the greater focus on organic shown by the dairy milk purchasers vs. the PBA purchasers. Probing for information related to organic dairy milk led to a range of additional themes (explored below), while probing for further information about organic PBAs did not produce consistent responses or themes. This result suggests that the idea of organic dairy is better defined by parents, and potentially more valued than organic PBAs. Additionally, a short list of familiar ingredients was a priority for 10% of PBA purchasers. This concern was not seen for dairy milk purchasers, although dairy milk purchasers showed more concern about contamination from hormones, antibiotics, or feed for cows.

Opinions on organic milk were stated by both parents who purchased organic products and those who did not. Five themes specifically related to organic milk were identified: organic dairy milks are safer/more pure than conventional (12%), organic dairy milk is better for you/healthier than conventional (10%), organic dairy milk is free of hormones (10%), organic dairy milk is better for cow welfare than conventional (8%), and organic dairy milk is overhyped (3%). Many of these themes were previously stated by organic milk consumers for reasons that they chose organic over conventional milk (Harwood and Drake, 2018). Intolerances, allergies, and special diets were also common themes in interviews, both among parents who purchased PBAs and those who purchased only dairy milk. Twenty-two percent of participants mentioned a milk intolerance in their household and 13% mentioned having a milk intolerance themselves, although this did not preclude these participants from purchasing dairy milk. Three percent mentioned choosing PBAs because of a health condition (ex: high blood pressure) in their household, and 3% mentioned the same because of a health condition they have themselves. Three percent of participants mentioned a PBA allergy (as with dairy allergies/intolerances, this did not prevent participants from purchasing PBAs, although it did determine which PBAs were purchased). Overall, these results suggest that while allergies/intolerances in the household do affect purchase of milk and milk alternatives, they do not completely exclude PBAs or dairy milk. Allergies/intolerances lead some households to purchase multiple fluid milk products, although quantitative follow up research is needed to characterize this relationship. Three percent mentioned seeing PBAs as a vegetarian option, although only a single participant mentioned choosing PBAs specifically as a vegan option. Additional themes (positive and negative) mentioned by participants about dairy milk were: the dairy industry needs more transparency (15%), dairy fat is healthy (13%), concern about animal welfare of cows (10%), concern about hormones or antibiotics in dairy milk (9%), dairy milk has contaminants from animals (5%), there is contradicting info about milk health (3%), dairy milk today is not the same as it was in the past (3%), and dairy milk from small farms is better (3%). Additional themes mentioned by participants about PBAs (positive and negative) were: concern about hormones in soy (7%), almond milk is bad for the environment (7%), PBA producers need more transparency (7%), PBAs are expensive (5%), PBAs are lower calorie than milk (5%), PBAs are more sustainable than dairy (5%), and PBAs are more pure than dairy (3%). These themes parallel concerns that lead consumers to choose organic fluid milk (Harwood and Drake, 2018) as well as PBAs (McCarthy et al., 2017a).

Qualitative interview participants were probed as to whether they encouraged their children to drink dairy milk or PBAs and whether they believed these products were healthy **(Figures 4-5).** The majority of respondents (60%) believed dairy milk was healthy compared to 38% for PBAs. Only a small percentage of participants believed either product was not healthy (6% for dairy milk, 14% for PBAs, with the rest taking a neutral stance). Despite this tendency to believe that dairy milk was healthier and consuming milk as children themselves, the majority of respondents were neutral when it came to encouraging their children to consume either beverage (55% for dairy milk, 82% for PBAs). Thirty-eight percent of participants encouraged their children to consume dairy milk compared to 18% of participants for PBAs. Just 8% of participants actively discouraged their children from drinking dairy milk, and none of the participants discouraged their children from drinking PBAs. More participants biased towards PBAs said they discouraged their children to consume dairy milk than participants biased towards dairy milk ($P < 0.05$). All parents in this study consumed dairy milk as children; however, these parents have not maintained a positive association with dairy milk over time. These results suggest that parents' who are conflicted about dairy or exploring plant-based options will be over time less likely to purchase dairy milk and encourage their children to consume it. Further research is needed to quantitatively characterize the relationship between dairy milk and PBA purchase and encouragement, conflicted opinions towards dairy milk, and marketing messaging.

Thirteen themes were identified from parents' responses to what factors were important when choosing beverages for their children in general. These were: avoid high sugar or added sugar (52%), avoid soda (18%), healthy (17%), natural/nothing artificial (16%), nutrient content (15%), only water or milk as beverage options (9%), no caffeine (8%), something their children would enjoy (8%), organic (7%), simple/minimal ingredients (6%), affordable (3%), and long shelf life (3%). When parents were asked if they generally felt confident about choosing a milk or milk alternative for their children, 77% agreed they were generally confident. However, when asked whether they found anything about milk or milk alternatives confusing as a follow-up, only 26% found nothing confusing about these products. Nine themes were identified when parents were asked to elaborate on aspects of milk or PBAs that they found confusing. These were: confusion due to the number of dairy and nondairy milk options available (15%), uncertainty about bias in information sources (9%), confusion about how dairy is processed (8%), confusion about the ingredients in dairy milk or PBAs (8%), confusion about product labeling (5%), confusion about hormones in dairy or PBAs (5%), confusion about the definition of organic or how organic standards are maintained (5%), confusion about the differences between dairy milk and PBAs, confusion about how PBAs are processed (3%), and uncertainty about whether marketing can be trusted (3%). These points of confusion suggest potential areas for marketing messaging to target to improve consumer understanding and confidence.

Information Sources

Sources of information about milk and PBAs for qualitative interview participants are shown in **Figure 6.** There was no difference in sources of information between participants biased towards dairy and participants biased towards PBAs ($P > 0.05$). The most common source for information about dairy milk was their child's pediatrician or other doctors (62%), followed by advertising (29%), the news/media/blogs (27%), word of mouth (24%), the government (19%), other health professionals or organizations of health professionals (17%), and social media (17%). For PBAs, the most common information source was social media (40%), the news/media/blogs (25%), word of mouth (21%), advertising (17%), and their children's pediatrician or other doctors (12%). Only 1% of interview participants could recall hearing about PBAs from the government or from an organization of health professionals.

Panelist recall of specific information they had heard about dairy or PBAs was consolidated into 35 themes mentioned by at least 3 panelists (Figure 7). To better understand the co-occurrence of themes in qualitative interviews, these 35 themes were grouped into 6 clusters using silhouette analysis (average silhouette coefficient = 0.4, 5 misclassified) (Figure 7). Themes in the same cluster were likely to occur together (be mentioned by the same panelists). If two themes are in a cluster, it suggests that parents who have heard of one of these themes is likely to have heard of the other, providing insight into the patterns of information parents receive about milk and milk alternatives. Cluster 1 themes included: heard PBAs are better for beauty or skin health (2%), heard about dairy milk in a fitness context (3%), recalled a specific brand of dairy milk from ads (6%), saw advertising about grass-fed dairy milk (3%), heard about dairy protein (3%), and saw a recipe with dairy milk (3%). Cluster 2 themes included: heard PBAs are better than dairy (14%), heard about calcium in dairy milk (7%), heard PBAs fit a vegan/vegetarian lifestyle (5%), heard government recommended servings of milk through the Food Pyramid or MyPlate (15%), saw dairy advertising during childhood but not now (7%), mentioned a dairy marketing campaign no longer running (14%), and saw PBA advertising but can't recall a specific brand (24%). Cluster 3 themes included: saw ads from a dairy industry association (ex: Real California Dairy) (6%), recalled a specific brand of PBAs from ads (10%), saw dairy advertising but can't recall a specific brand (14%), saw a grocery promo (ex: weekly coupons) for PBAs (6%), heard about milk options for people with allergies/intolerances (13%), participated in a Facebook group for moms (5%), heard about a dairy industry scandal (3%), heard about dairy fat (32%), and saw a grocery promo (ex: weekly coupons) for dairy milk (5%). Cluster 4 themes included: saw a recipe that included PBAs (5%), prefers information from evidence-backed sources (6%), and heard info focusing on or produced by dairy farmers (5%). Cluster 5 themes included: heard about the controversy over whether PBAs should be called milk (3%), heard about hormones in soy (3%), heard dairy milk is less healthy than PBAs (3%), heard dairy milk is bad for you (7%), heard almond milk is bad for the environment (5%), heard conflicting info about dairy milk and healthiness (6%), heard dairy milk is bad for animal welfare (5%), heard dairy milk is less sustainable than PBAs (3%), and heard drinking dairy milk is unnatural (3%).

Clustering of the themes participants recalled hearing about dairy milk or PBAs suggest patterns in the messaging parents hear about milk and milk alternatives. Several trends of note appear. First, parents who recalled any negative themes were most likely to recall additional negative themes (ex: those who recalled hearing drinking dairy milk is unnatural were also more likely to express concern about hormones in soy). This suggests parents who encounter dairy-negative sensationalist media coverage are also likely to encounter negative coverage of PBAs as well. Additionally, recall of advertising for a specific brand of dairy was clustered with information about milk in a value-add context (grass-fed, dairy protein for fitness purposes). Fairlife and Horizon were the only two brands of dairy milk that participants could specifically recall advertising for, although a larger variety of dairy milk brands were purchased. On the other hand, those parents who could recall PBA advertising but not a specific brand were likely to have heard generally that PBAs are better than dairy. At the same time, these participants were also likely to recall dairy advertising from their childhood but not current dairy advertising, or believe discontinued dairy marketing campaigns were still actively running. The co-occurrence of these themes brings up concerns that positive messaging around PBAs may be slowly replacing residual positive dairy messaging from earlier marketing campaigns; however further quantitative research is needed to confirm this issue. Finally, those parents who stated they preferred evidence-backed sources of information about dairy milk and PBAs were also most likely to have heard information produced by or focused on dairy farmers. This suggests farm-forward information may be particularly accepted by these parents. Further research is needed to understand how farm education and outreach can be incorporated into dairy marketing strategies for best effect.

DISCUSSION

The majority of parents who themselves consumed milk as children implicitly associate dairy milk with positive attributes more strongly than they do PBAs. Only 13.9% of parents in this study were biased in favor of PBAs. D-scores (measures of implicit bias) from the IAT portion of this study predicted purchase of both dairy milk and PBAs – the more biased a participant was towards PBAs the more likely they were to purchase them, and vice versa. Analysis of probability formulas from logistic regression indicated that at no D-score is a parent more likely to purchase PBAs than dairy milk **(Figure 3).** While this data may suggest a rosy future for dairy milk, the outlook is not quite so straightforward. Dairy consumption is often a product of familiarity and habit, with consumption during adolescence increasing the chance of lifetime consumption (McCarthy et al., 2017a; Stewart et al., 2012; Huth et al., 2006; Lytle et al., 2000; Forshee and Storey, 2003; Sipple et al., 2020). Parents interviewed for this study expressed strong themes of milk habit and encouragement during childhood. Eighty-seven percent of qualitative interview participants could recall specific encouragement to drink milk during childhood, with 58% recalling parents or family as a source of encouragement. Twenty-four percent indicated that milk drinking was "the norm," a default behavior done by everyone they knew. However, just 38% of these participants actively encouraged their children to consume dairy milk today, with the majority taking a neutral stance towards milk consumption. Implicit associations are a product of the environment a person is exposed to over time (Dasgupta, 2013), so it is likely the overall bias towards dairy milk among parents is a lingering result of the prevalence of milk they experienced growing up and the accompanying encouragement to consume it. Implicit associations are not immune to change over time – instead, they gradually shift to reflect the current communities a person identifies with (Dasgupta, 2013). Over a third of parents in this study (37.2%) purchased PBAs either alongside or as a complete replacement for dairy milk, a figure that is lower than estimates of PBA purchase for the general population of dairy consumers (Schiano et al., 2020; Schiano et al., 2021a; Baertlein, 2015; Mintel Group Ltd., 2019), but still a concern since these parents are introducing the presence, if not the consumption, of PBAs to their children. As PBAs become more common and prevalent in the marketplace, consumer implicit attitudes (and therefore purchase likelihood) could potentially shift in favor of PBAs over dairy milk. Prolonged exposure to PBA marketing may accelerate this shift. Even a single exposure to a new brand or product (ex: through a grocery coupon) may lead consumers to believe the product is familiar to them, especially if the product is similar to those that already exist (Coates et al., 2006; Holden & Vanhuele, 1999).

Qualitative recall of where parents have heard information about dairy milk or PBAs provides further insight on the differences in messaging they receive about each product. The most common information source for dairy milk was pediatricians and other doctors (62% of participants), the most common information source for PBAs was social media (40% of participants). Overall more parents in the study could recall dairy advertising vs. PBA advertising (29% vs. 17%), but participants who purchased both products recalled PBA advertising more than dairy advertising (46% vs. 33%). Meanwhile, less than a quarter of participants who purchased only dairy milk could recall seeing advertising for either dairy milk or PBAs (19% and 25%, respectively), indicating that advertising exposure may be a key difference between parents loyal to dairy milk and those conflicted or exploring PBAs. To add further complexity, 14% of participants who believed they had seen recent advertising for dairy milk referenced a marketing campaign no longer running (ex: "Got Milk"). If participant recall of dairy advertising includes these outdated ad campaigns, it may suggest that the recall gap between current PBA and dairy advertising is larger than expected. Overall, messaging heard by parents about PBAs is generally positive, while messaging heard about dairy milk is generally negative. For example, the only negative themes about PBAs recalled by participants were almond milk is detrimental for the environment (5%) and concern about hormones in soy (3%). By contrast, negative messaging about dairy included a range of themes such as: dairy milk is bad for animal welfare (5%), heard about a dairy industry scandal (3%), drinking dairy milk is unnatural (3%), dairy milk is less healthy than PBAs (3%), and PBAs are better for beauty/skin than dairy milk (3%). As even non-conscious (subliminal) exposure to marketing messages can change implicit attitudes and behaviors over time (Courbet et al., 2014), dairy producers should carefully consider how to promote alternative, dairy-positive messaging. Further research is needed to understand how specific types of messaging shift implicit attitudes towards dairy and PBAs.

Finally, this study provides insights into parents as conflicted health seekers. CHS consumers express concern about the health and sustainability of their food, which may lead them to consume less dairy foods (O'Brien, 2020; Spaeth-Bauer, 2020). Although all parents in this study consumed dairy milk during childhood, 13.% were biased towards PBAs, with an additional 12.7% exhibiting a neutral bias. Data from qualitative interviews provided additional insight on this shift in perception and suggests that some parents in this study fit the definition of conflicted health seekers. Most parents in this study (59%) expressed that dairy milk is a healthy beverage option and just 6% expressed dairy is not healthy (the remaining 34% had a neutral stance towards dairy and health). However, parents could recall information casting doubt on the health of dairy milk, such as hearing dairy is bad for you, hearing conflicting info about the health of dairy milk, and hearing PBAs are healthier than dairy. Just 38% of parents in this study encouraged their children to drink dairy milk (the majority – 55% - were neutral towards their children's milk consumption). Confusion or uncertainty about milk may contribute to this discrepancy, as only 26% claimed to find nothing about milk or PBAs confusing. Sources of confusion concern about dairy milk included hormones and antibiotics, animal welfare, ecological sustainability, potential contamination, and intolerances or allergies. Sustainability, a key concern for CHS consumers, is reflected throughout these responses as consumers may define dairy sustainability in different ways (Schiano et al., 2021a). Segments of consumers define dairy sustainability as primarily focusing on animal welfare/conscious farming practices or by simple ingredients/minimal processing (Schiano et al., 2021a), themes that appeared repeatedly in qualitative interviews in this study. The sources of uncertainty and negative messaging recalled about dairy milk identified by this study provide potential focuses for future work investigating dairy-positive messaging for CHS parents. By addressing the most commonly encountered and recalled concerns, dairy producers may be able to increase CHS parents' trust in dairy and prevent additional shifts in overall public perception in favor of PBAs. The sources parents recall hearing information from suggests the channels to be investigated further: specifically, increasing dairy-positive information on social media and through news/media/blogs.

CONCLUSION

Consumption of milk at school lunches is a key driver of dairy loyalty later in life (Sipple et al., 2020), and meals at home represent another large potential for childhood dairy consumption. Eighty-five percent of parents in our study could recall drinking milk at home as a child, and 58% remembered encouragement from their parents to drink milk. Understanding parents' perception of and purchase intent for milk and milk alternatives is therefore a key issue for strategically positioning dairy in a changing marketplace. The majority of parents still implicitly associate dairy milk with positive attributes more than they do PBAs, but the growth of these alternatives continues to present a threat to dairy producers. The stronger a parent's implicit bias towards PBAs, the more likely they are to purchase these products either alongside or as a replacement for dairy milk. Currently, no matter their bias, parents' purchase of any type of milk product is more likely to be dairy milk than PBAs. However, implicit associations shift over time and reflect current community norms, so dairy producers should consider how to strategically market dairy products to combat potential shifts in positive perception towards PBAs. It is likely that current positive bias towards milk by parents was shaped by the high prevalence of dairy milk consumption during their childhood and accompanying strong encouragement to consume it. In the current study, more than half of parents that consumed milk as children currently take a neutral stance towards dairy milk and do not encourage their children to consume it. Generally negative media messaging towards dairy milk and positive messaging towards PBAs may contribute to this trend, even if consumers are not explicitly aware of their perception changes. Finally, the positive messages recalled by parents about dairy milk involved value-added dairy products (grass-fed and high protein). Careful consideration must be taken when planning dairy marketing messaging to ensure conventional dairy sales (and the industry as a whole) are not harmed while attempting to keep dairy competitive against PBAs.

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TABLES AND FIGURES

Figure 4-1. Moderator guide for qualitative interviews

PART ONE

1. Tell me about the milk you drank growing up.

2. Tell me about the milk or plant-based milk alternatives you currently buy.

3. Probe into whether their children consume dairy milk or plant-based dairy alternatives, asking:

    a. Do your children currently drink [dairy/plant-based alternative] milk?

    b. Do you encourage your children to drink [dairy/plant-based alternative] milk?

4. What things are important when choosing beverages for your children?

5. Is it important to you that your children avoid consuming any type of milk?

PART TWO

6. Can you recall hearing any information about milk or milk alternatives from:

    a. Your children’s pediatrician or other doctors

    b. Other health professionals or professional health organization press releases

    c. Government sources

    d. The news/media/blogs

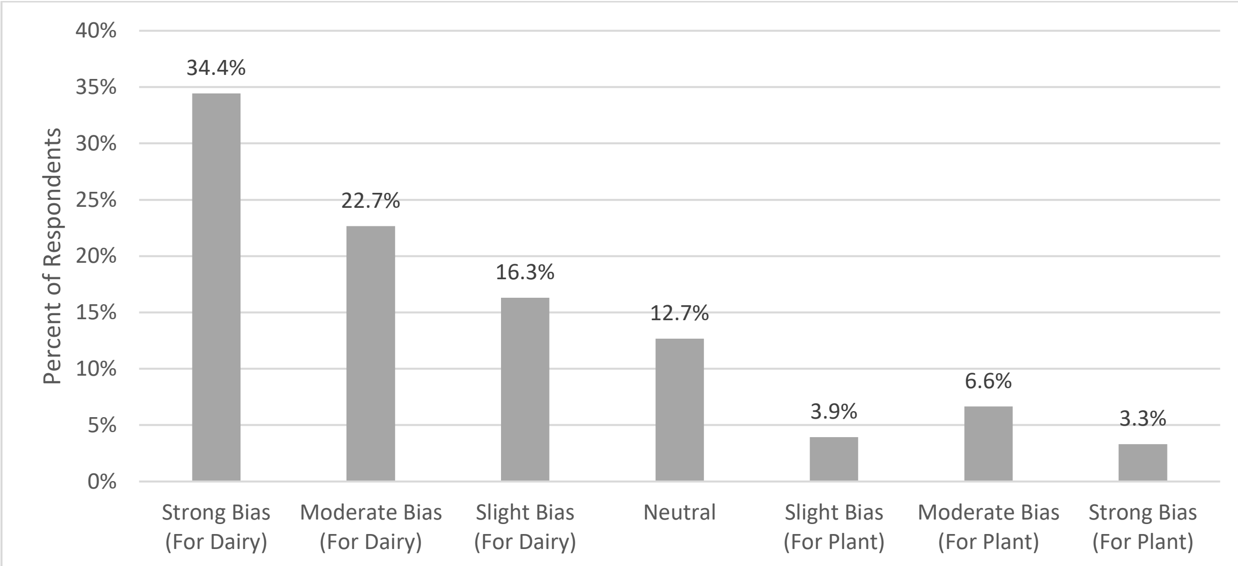
    e. Advertising (TV, online, or print)

    f. Social media

    g. Word of mouth

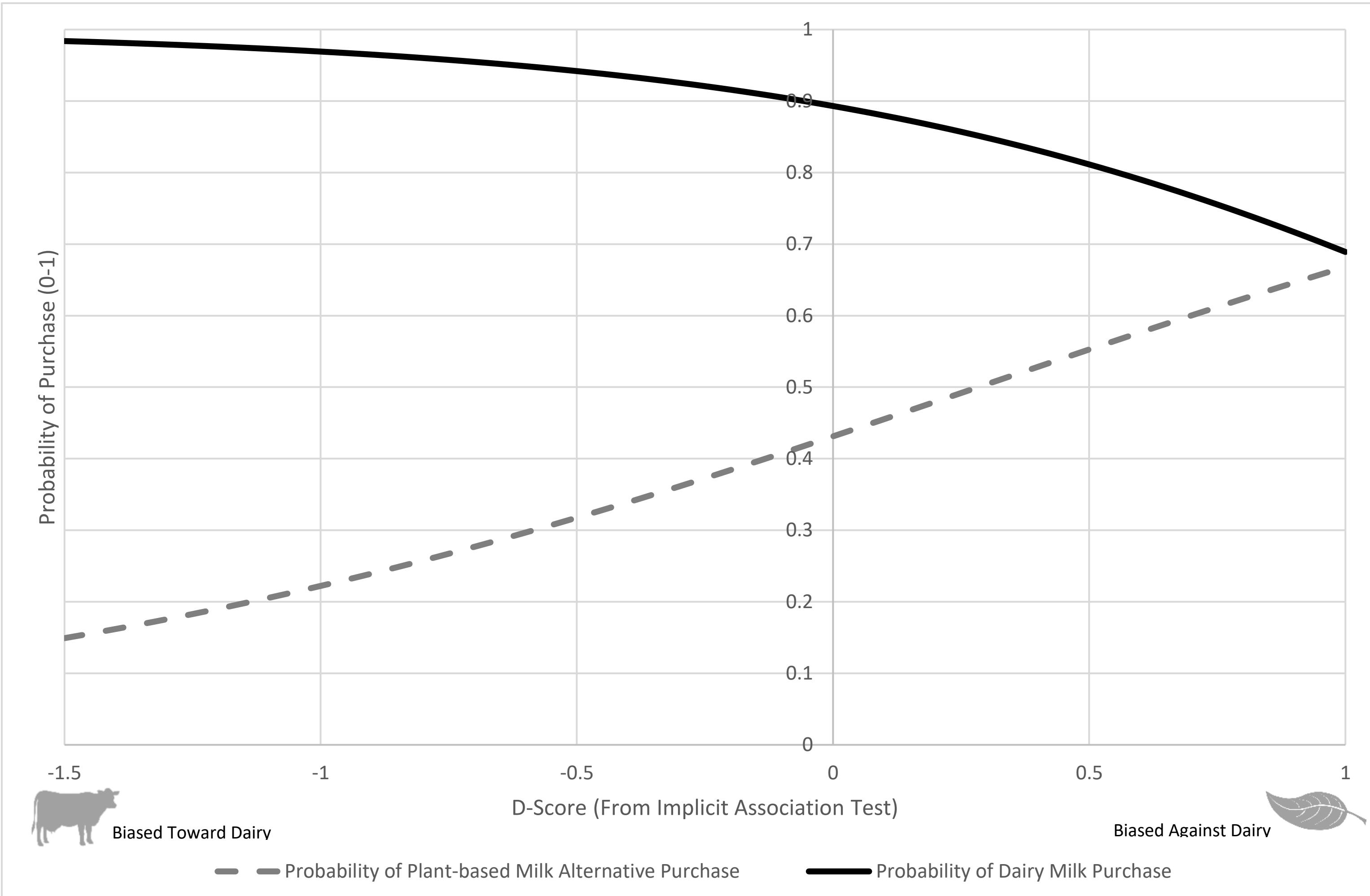
7. Do you feel confident when making judgements on the health/nutritional value of milks for your children? Is there anything you are confused about or were confused about in the past?

Figure 4-2. Distribution of implicit bias scores for and against dairy milk (n=331)



D-scores have been classified according to conventional guidelines (Greenwald et al., 2003; Rooth, 2010; Harwood and Drake, 2020).

Figure 4-3. Probability of purchase of dairy milk or plant-based alternatives by parents (n=331)



More negative D-scores indicate stronger bias towards dairy milk, while more positive D-scores indicate stronger bias towards plant-based milk alternatives.

Figure 4-4. Do parents encourage their children to consume dairy milk or plant based milk alternatives? (n=88)

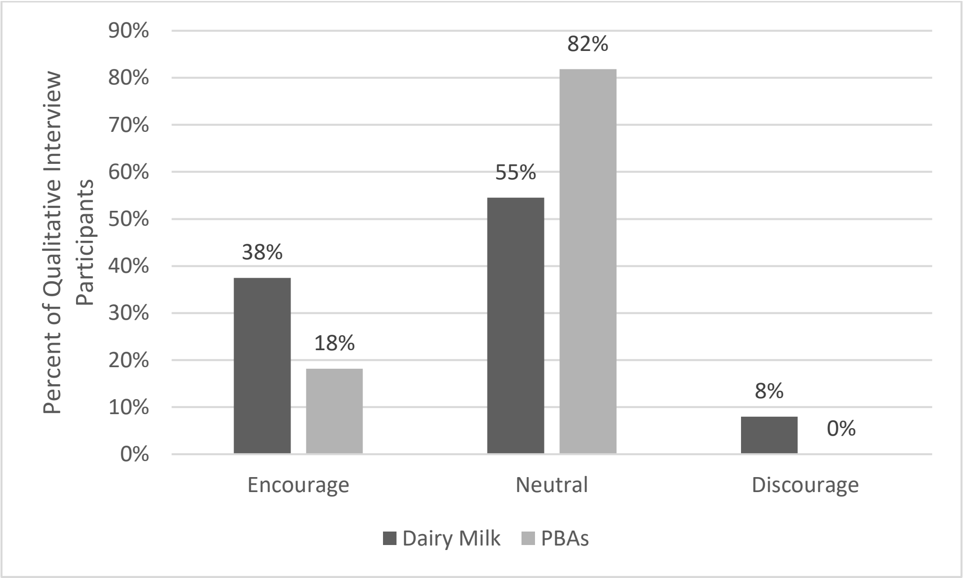


Figure 4-5. Do parents believe dairy milk and plant based milk alternatives are healthy? (n=88)

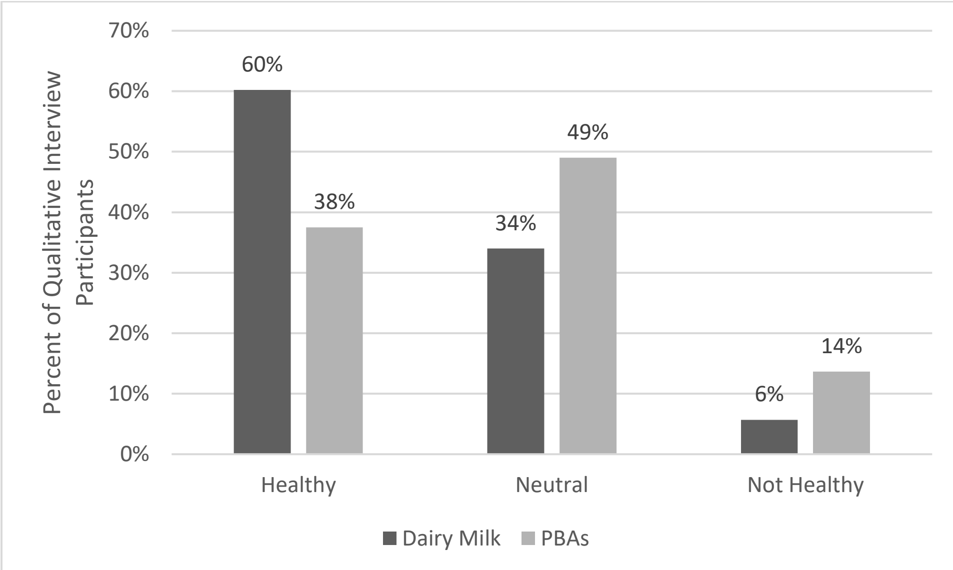


Figure 4-6. Sources of information about dairy milk and PBAs from qualitative interviews (n=88) with parents

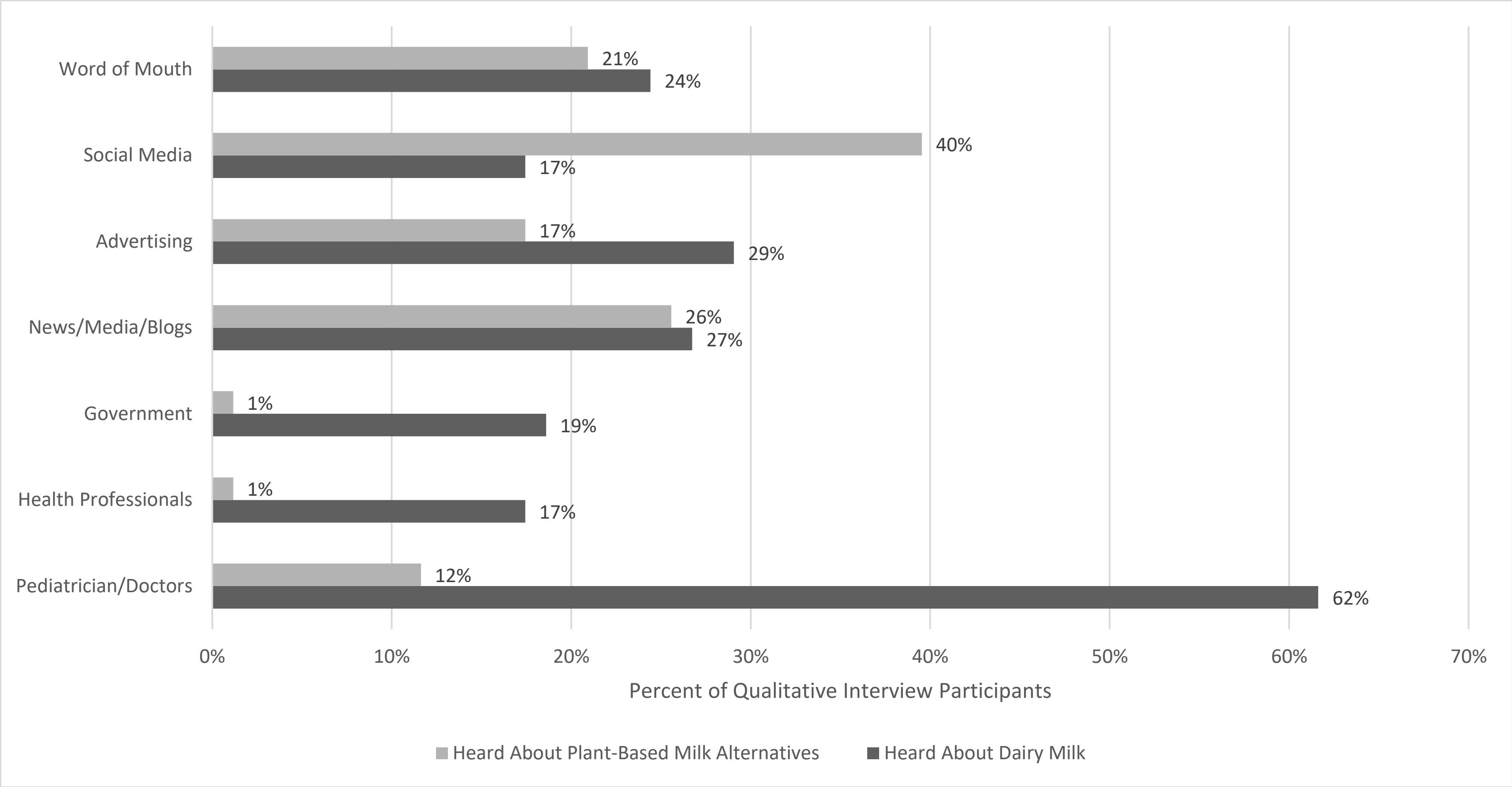
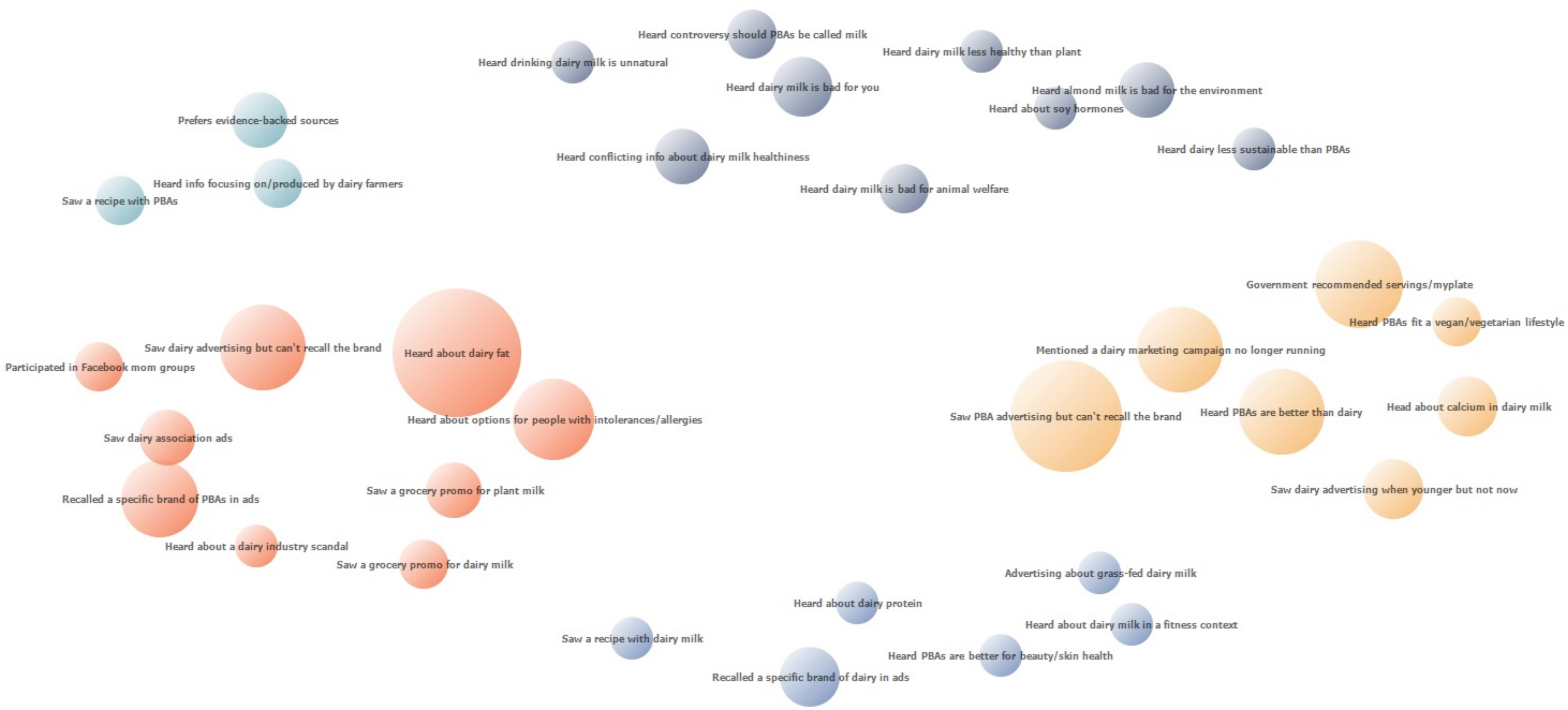


Figure 4-7. Co-occurrence of themes from qualitative interviews with parents: what participants have heard about dairy milk and plant-based alternatives (n=88)



Larger circles indicate more common themes. Themes were clustered using silhouette analysis – circles that share a color indicate themes are within the same cluster.

Table 4-1. Example overview of implicit association test (IAT) (adapted from Harwood and Drake, 2020)

Targets	6 images each of commercial fluid dairy milk and plant-based milk alternatives
Categories	Positive: wholesome, good for you, nutritious, healthy, natural, safe, nourishing, high-quality, trustworthy Negative: unwholesome, bad for you, unhealthy, unnatural, unsafe, misleading, low-quality

Block	**No. of Trials**	**Category**	**Left-key Response***	**Right-key Response***
1	20 practice	Category sorting	Dairy Milk Images	Plant-based Milk Images
2	20 practice	Category sorting	Positive	Negative
3	20 practice	Combined block	Dairy Milk Images + Positive	Plant-Based Alternative Images + Negative
4	40 collected	Combined block	Dairy Milk Images + Positive	Plant-Based Alternative Images + Negative
5	40 practice**	Category sorting	Plant-Based Alternative Images	Dairy Milk Images
6	20 practice	Combined block	Plant-Based Alternative Images + Positive	Dairy Milk Images + Negative
7	40 collected	Combined block	Plant-Based Alternative Images + Positive	Dairy Milk Images + Negative

*Presentation of targets and categories was balanced for position among participants (Nosek et al., 2005)

**Lengthened Block 5 practice set is intended to clear learned behavior based on positioning of earlier blocks (Nosek et al., 2005)

Table 4-2. Implicit Association Test (IAT) results

Total N	345
Valid N[1]	331
Mean D-Score[2]	-0.393
D-Score 95% CI	(-0.44532, -0.3411)
D-Score Standard Deviation	0.482
P-value	< 0.00001
Effect Size (d)	-0.814
Reliability	0.889

[1]Valid N = number of responses after dropping those with excessive completion speed.

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CHAPTER FIVE: CONSUMER UNDERSTANDING OF FLUID MILK AND CHEESE PROCESSING AND COMPOSITION

ABSTRACT

Ultrafiltration and microfiltration are two types of membrane filtration commonly used by the dairy industry. Filtered milk products are becoming increasingly common, but there is concern that consumers unfamiliar with these processing methods may form negative uninformed perceptions of cheeses made with these milks. There are many studies which address the chemical and physical properties of cheeses made with filtered milk, but to our knowledge, there are none which address consumer perception of these products. Similarly, ultrapasteurization is becoming more common for U.S. dairy products. Although previous work has characterized consumer liking of ultrapasteurized milks, few have investigated understanding and perception of this process. The objective of this study was to explore consumer understanding of milk processing and constituents, particularly as it relates to milk use as an ingredient in cheese. To achieve this goal, we investigated the following 4 questions: (1) Does the average dairy product consumer (DPC) understand the basic ingredients and nutrients in fluid milk and cultured dairy products? (2) Does the average DPC understand the basic processes for fluid milk and cultured dairy products? (3) Do different processes impact consumer perception or purchase intent? (4) Does explaining a process change consumer understanding of, beliefs about, and purchase intent for dairy products? Qualitative interviews (n=54) and an online survey (n=1210) were conducted with dairy product consumers. Survey responses paralleled those from one-on-one interviews. The average dairy product consumer could recall key words related to dairy processing, composition, nutrients, and ingredients, but was largely unfamiliar with these subjects. Highly educated and older consumers were more likely to have a better understanding

of dairy composition and nutrition, particularly lactose content of milk and Cheddar cheese and the source of fluid whey and whey protein. Processing-related descriptors (ex: ultrapasteurized or ultrafiltered) in ingredient statements were likely to be overlooked on labels (especially for familiar products), as just 34% of dairy product consumers read the labels on dairy products often or always before purchase. The majority (>80%) of dairy product consumers were unfamiliar with ultrafiltered or microfiltered milk, but uninformed perceptions were generally positive. Consumers unfamiliar with processing methods are likely to assume those methods increase the price of a dairy product. For the majority of consumers, purchase intent for fluid milk and cultured dairy products was not impacted when non-conventional processing terms such as ultrafiltered or microfiltered are included in the ingredients statement. This impact was consistent for fluid milk and Cheddar cheeses but not for cottage cheese, suggesting the possibility of product specific effects. Providing respondents with a definition of filtration increased consumer understanding of, positive beliefs about, and purchase intent for fluid filtered milk and cheese made with filtered milk. Educating consumers through on-package labeling and other marketing messaging should be investigated for dairy products incorporating processes such as ultrapasteurization or filtration.

INTRODUCTION

In April 2020, the U.S. Food and Drug Administration (FDA) reopened the comment period on a proposed rule issued in 2005 which amended the definitions of “milk” and “nonfat milk” used in cheese and cheese product manufacture to allow for the use of ultrafiltered (UF) milk (FDA, 2020). As part of invitation for further comments, the FDA specifically raised questions regarding the declaration of UF milk on cheese labels. While UF milk products are becoming increasingly common, the FDA expressed questions as to whether there are situations in which consumers would not purchase cheese labeled with UF milk as an ingredient, or whether labeling cheese with UF milk would be misleading instead of informative (FDA, 2020). The FDA's call for comments raises broader questions about consumer understanding of dairy processing technologies. Consumers generally tend to be uninformed about innovative or non-conventional food processes, which in turn can introduce undue suspicion (Deliza et al., 2003; Cardello, 2003). Animal-based foods (including dairy foods) may be under more uninformed scrutiny than other product categories due to perceived higher safety risk (Cardello et al., 2006).

Ultrafiltration (UF) and microfiltration (MF) are two types of membrane filtration commonly used by the dairy industry (Tetrapak, 2020). Ultrafiltration separates macromolecules in milk such as proteins from smaller molecules such as lactose, minerals, and water-soluble vitamins. The larger milk proteins (casein and serum proteins) are retained by the membrane as retentate while the smaller molecules, lactose and minerals, pass through the membrane and are referred to as permeate (Tetrapak, 2020). Microfiltration uses a larger pore size, keeping fats, bacteria, and casein proteins in the retentate while whey proteins and smaller molecules pass through in the permeate. Although UF and MF change the composition of milk, they do not necessarily alter the composition of cheese because cheese making is a process of separation and concentration. Retentates from UF or MF of milk may be used concentrated or at the original protein content of milk. These filtration processes offer the dairy industry increased flexibility to customize products that emphasize valued nutrients and for modern cheese making. Filtered milk has relatively recently entered the consumer market in the United States. For some manufacturers, UF milk is a selling point. Fairlife LLC, a manufacturer of UF milk products, reached over $500 million in retail sales in 2019 and was acquired in full by the Coca-Cola Company (The Cocoa-Cola Company, 2020). Other commercial UF milks are also available in the US market, with packages featuring claims such as “50% less sugar than regular milk”, “lactose-free”, “13g protein per serving”, and “75% more protein than regular milk”. Higher protein content is correlated with increased price and consumer desirability for fluid milk (Gulverson and Wohlgenant, 2014). Including UF or MF milk on a cheese ingredients statement could mislead consumers into believing that the cheese has the same nutritional advantages promoted on fluid UF milk labels. On the other hand, some consumers are becoming increasingly concerned with unfamiliar ingredients and processes on ingredient statements, as evidenced by the growth of the clean label movement (Asioli, 2017). If consumer familiarity with UF or MF of fluid milk is low, introducing an unfamiliar word on a cheese ingredients statement could introduce unnecessary confusion or concern for consumers.

Qualitative research methods including focus groups and individual or small group interviews are often used in consumer packaged goods (CPG) consumer studies to gather consumer insights on complex responses and to generate or refine a hypothesis to be tested quantitatively by follow up survey work (Jervis and Drake, 2014). These research tools can be applied alone or before or after quantitative assays with consumers since consumer quantitative responses from large format surveys can be clarified or question formats, options and or scales to be used in a quantitative test can be identified or clarified. Variations on these techniques have been used for this purpose with success within the dairy category to address topics including sustainability, plant-based milk alternatives, and milk (Schiano et al., 2020; McCarthy et al., 2017a, McCarthy et al. 2017b). McCarthy et al. (2017a) used one on one interviews with consumers to identify key values for consumer segments identified from an online conjoint analysis survey on drivers of choice for fluid milk and plant based milk alternatives. In contrast, Schiano et al. (2020) conducted focus groups with dairy consumers with high or low perceived importance of sustainability to identify parameters for large format quantitative surveys.

There are many studies which address the chemical and physical properties of cheeses made with filtered milk (Reale et al., 2020; Ong et al., 2013; Nelson and Barbano, 2005; Acharya and Mistry, 2004; Bush et al., 1983; Matthews et al., 1976). To our knowledge, there are no studies which address consumer perception of these products. Furthermore, there are few studies addressing consumer perception of filtered milk in general. Rizzo et al. (2020) recently evaluated consumer desires for lactose-free milk. Focus groups were conducted as part of this study and consumers were generally unaware of how lactose was removed from milk (eg by enzyme or filtration). When informed of the two possible ways that lactose could be removed, consumers wanted which ever approach resulted in the lowest price. Consumer perception studies related to pasteurization are more common, although they have focused on sensory drivers of liking or pasteurization as it relates to extrinsic milk qualities rather than consumer understanding of differences among pasteurization processes (Harwood and Drake, 2018; Harwood and Drake, 2020; Lee et al., 2017). Rizzo et al. (2020) documented that lactose free milk consumers did not understand the difference between conventional high temperature short time (HTST) pasteurization and ultrapasteurization (UP) although all consumers interviewed could generally define pasteurization and its purpose. The objective of this study was to explore consumer understanding of milk processing and constituents, particularly as it relates to milk use as an ingredient in cheese. To achieve this goal, we investigated the following 4 questions: (1) Does the average dairy product consumer (DPC) understand the basic ingredients and nutrients in fluid milk, cheese and cultured dairy products? (2) Does the average DPC understand the basic processes for fluid milk, cheese and cultured dairy products? (3) Do different processes impact consumer perception or purchase intent? (4) Does explaining a process change consumer understanding of, beliefs about, and purchase intent for dairy products?

MATERIALS AND METHODS

Experimental overview

All interviews and survey procedures were conducted in compliance with North Carolina State University Institutional Review Board regulations. Qualitative individual interviews were first conducted with cheese consumers followed by an online survey with cheese consumers.

Individual Interviews

Fifty-four 30-minute one-on-one interviews were conducted to establish parameters for a large quantitative consumer survey. Consumers for interviews were recruited from a database of >11,000 US consumers managed by the Sensory Service Center (NCSU, Raleigh, NC) using an online questionnaire. Demographic and purchase habit questions were asked in order to ensure all participants were over the age of 18, responsible for more than 50% of their household shopping, and consumed dairy-based cheese. Qualified respondents were segmented based on their age, education level, and label reading habits. Age segments included were under 35 years old and 35 years old and older. Education segments included were no advanced degree (less than high school diploma, high school diploma or GED), some college but no degree) and advanced degree (Associates degree or higher). Label reading segments used were reads labels often or always when buying food products, and reads labels never or occasionally when buying food products. Qualified respondents were split into 8 groups (representing all possible combinations of these segments) and 8 participants were recruited at random from each group.

Interviews were conducted using Zoom video conferencing software (Zoom Video Communications, Inc., San Jose, CA). During the interviews, a moderator facilitated discussion through the use of a pre-established question guide (**Figure 1**). The guide was used to direct the general flow of the conversation, but the moderator asked follow-up questions which varied based on the responses of the participant. Audio and video were recorded for subsequent reference. Notes were taken by the moderator from the recording in order to minimize distractions to participants. Interviews were completed within a 2 week period. Upon completion of the interview, panelists were compensated with a gift card for their participation.

Online Survey

In-depth interview responses were used to develop an online survey with self-reported cheese consumers. The survey was developed and launched using SSI Web^{TM} (Lighthouse Studio version 9.6.1, Sawtooth Software, Orem, UT). The survey link was sent to a database of >11,000 US consumers managed by the Sensory Service Center (NCSU, Raleigh, NC). Only participants over 18 years of age were able to enter the survey. Respondents began the survey with a series of demographic and attitude questions regarding their purchase of dairy products and where they typically obtained information about the food they purchased and consumed. Participants who did less than 50% of the household shopping or did not purchase cheese made with dairy milk were disqualified. Attention check questions were included throughout the survey and used to filter out respondents who did not pass these questions successfully. Following these questions, participants progressed through a series of exercises (outlined below) to evaluate their perception and knowledge of milk and cultured dairy products components and processing. Participants were instructed to take as much time as needed to complete the survey and were allowed to stop and restart the survey as many times as they liked to take breaks. Participants were informed that their responses would not affect their chances of winning a gift card and were asked to complete all questions based on their prior knowledge and first impressions rather than utilizing any outside sources. Upon completion of the survey, participants were compensated with a gift card for their participation. The following exercises are described in the order that they appeared in the survey.

Label Purchase Intent Exercise

The purpose of this exercise was to determine if adding a processing-related term to milk on an ingredients statement changed consumer purchase intent for that product. Four series (pasteurized milk, filtered milk, Cheddar cheese, cottage cheese) of three labels were developed (Figure 2). Labels were designed in Adobe Photoshop Photoshop CC 2020 version 21.2.0 20200604.r.225 2020/06/04: 02a81f3015 x64 (Adobe, Inc., San Jose, CA) to match the formatting of current US food nutrition labels. For each set of labels, the only ingredient changed was the type of milk used to make the product. For the Cheddar cheese set, the three milk options were: pasteurized milk, pasteurized ultrafiltered milk, and pasteurized microfiltered milk. For the Cottage cheese set, the three milk options were: cultured skim milk, cultured ultrafiltered skim milk, and cultured microfiltered skim milk. For the fluid milk pasteurization set, the three milk options were: pasteurized, ultrapasteurized, and ultrapasteurized shelf stable. For the fluid milk filtration set, the three milk options were: reduced fat milk, reduced fat ultrafiltered milk, and reduced fat microfiltered milk. In order to reduce survey length and prevent bias from respondents seeing multiple labels within a single set, each respondent was shown a randomized presentation of 4 labels (one from each set). Respondents who indicated they would not purchase a product based on the label shown were asked to explain why in an open-ended follow-up question.

Milk Composition Exercises

The purpose of this exercise was to determine consumer familiarity with milk composition. Respondents were asked what percentage of fat, protein, and lactose was in whole and skim dairy milk in a multiple choice format. Following these questions, respondents completed a chip allocation/constant sum exercise in which they were asked to indicate the component percentage (water, protein, carbs, fat, and minerals) in fluid whole milk.

Expected Ingredients Exercise

The purpose of this exercise was to determine if consumers were familiar with the basic ingredients in cheese and other dairy products. Respondents were presented with a list of 22 ingredients and asked to select (check all that apply, CATA) which item(s) they would expect to see on an ingredients list for Cheddar cheese, cottage cheese, cream cheese, and sour cream. Ingredients list questions were presented one at a time, in a randomized order. Each respondent evaluated all four cultured dairy product ingredients list questions.

Agreement Questions

The purpose of this exercise was to determine whether describing milk with processing-related terms (ex: ultrafiltered, ultrapasteurized) affected consumer beliefs about the resulting product, as well as to determine consumer knowledge about milk and cheese components including whey, lactose, and vitamins A and D. Respondents were asked 52 agreement questions. Agreement questions were rated on a 5pt scale where 1 or 2=disagree, 3=neither agree nor disagree, and 4 or 5=agree. Agreement questions were presented in a randomized order in sets of 6 questions per screen.

Product Differences Exercise

The purpose of this exercise was to determine how consumers expected different processes to affect the intrinsic properties of dairy products. Respondents were presented with 10 pairs of products and were asked to check if the two products differed in 12 attributes presented in a CATA format with “These products are not different” as an exclusive none option. The attributes used in this exercise were: protein, fat, water, vitamins, lactose, sugar, heat treatment, shelf life, flavor, texture, color, and price. Pairs of products presented were: pasteurized milk and ultrapasteurized milk, milk and filtered milk, filtered milk and ultrafiltered milk, milk and evaporated milk, nonfat milk and fat-free milk, lowfat milk and 1% fat milk, whole milk and nonfat milk, milk and ultrafiltered milk, milk and microfiltered milk, and ultrafiltered milk and microfiltered milk.

Definition Exercise

The purpose of this exercise was to determine if providing consumers with basic information about an unfamiliar process (milk filtration) would affect beliefs about and purchase intent for milk and cheese made using this process. Respondents were asked familiarity with the terms ultrafiltration and microfiltration as they applied to milk/dairy products. Next, they were presented with a brief definition of these terms (Figure 3). Respondents were then asked follow-up questions about how well the definition fit with their beliefs and if the information provided changed their opinions.

Data Analysis

Note-based analysis from in-depth interviews was used to identify key points from interviews. To reduce personal bias, the recorded individual interviews were watched by both the moderator and an observer, and consumer responses were discussed and compiled. Notes for each question were manually coded into thematic categories. Coded data was reviewed and frequencies of themes were calculated. Key points mentioned by two-thirds or more of participants in qualitative interviews were used for development of questions for the subsequent online surveys. Survey results were analyzed via univariate and multivariate statistics. All statistical analyses were conducted with XLSTAT version 2019.2.1 (Addinsoft, Paris, France) at 95% confidence ($P < 0.05$). Five-point scale agreement questions were analyzed with Kruskal-Wallis one-way ANOVA with Dunn's nonparametric multiple pairwise comparisons. Frequencies of responses to CATA questions were analyzed using chi-squared analysis. To analyze the milk composition constant sum question, responses were clustered using agglomerative hierarchical clustering (AHC).

RESULTS AND DISCUSSION

Respondent Demographics

Interviews

A total of 54 panelists were interviewed. Demographics matched the recruit criteria specified.

Survey

A total 1210 respondents completed the survey after those who failed to meet attention check criteria were removed. After outliers were removed, the average time to complete the survey was 45 min of active response time across 1.2 hrs (as panelists were allowed to stop and restart the survey at will). For completed viable survey respondents, 72.9% were female and 27.1% were male. Respondents represented an even distribution of ages, 24.2% of respondents 18-24 years old, 28.1% 25-34 years old, 19.5% 35-44 years old, 12.1% 45-54 years old, 11.2% 55-64 years old, and 4.9% 65 years old or older. For ease of analysis, we grouped age ranges into three categories by generation: Millennials (ages 18-34, n=520), Gen X (ages 35-54, n=312), and Baby Boomers and the Silent Generation (ages 55+, n=171). An even distribution of total annual household incomes was also self-reported (<$19,999 to >$100,000). The majority of respondents resided in North Carolina (78.0%). The most common highest education level was a Bachelor's degree (40.4%), followed by a Master's degree (26.4%), some college but no degree (17.3%), Associate's degree (6.0%), Doctorate (4.6%), high school diploma or GED (3.3%), and professional degree (2.1%). No respondents reported having less than a high school diploma. All respondents purchased dairy cheese within the past 3 months due to screening criteria. Eighty-eight percent of respondents purchased fluid milk in the past 3 months while 35.4% of respondents purchased cottage cheese within the past three months. For milk purchasers, regular (conventional) milk was the most common type purchased (87.3%), followed by organic milk (42.2%), lactose-free milk (27.5%), and grass-fed milk (20.6%). The most commonly purchased brand of fluid milk was store brand (83.0%), followed by Horizon Organic (34.1%), Organic Valley (31.0%), and Fairlife (27.1%). Cheddar, mozzarella, and parmesan were the most commonly purchased cheese types (89.8%, 86.9%, and 81.2%, respectively). The most commonly purchased brand of Cheddar cheese was store brand (79.8%), followed by Kraft (66.0%) and Sargento (60.6%). The most commonly purchased brand of cottage cheese was store brand (68.2%), followed by Daisy (40.0%) and Breakstones (33.9%).

When asked how often they read the labels on foods, 13.3% of respondents responded "Always", 36.3% responded "Often", 38.5% responded "Sometimes", and 1.7% responded "Never". When asked how often they read the labels on dairy products, 10.5% responded "Always", 23.5% responded "Often", 32.8% responded "Sometimes", 27.4% responded "Rarely", and 1.7% responded "Never". On average, respondents read the labels on dairy products before purchase less often than they read the labels on foods in general (3.1 vs. 3.5 on s 1-5 scale, respectively) ($P > 0.05$). Respondents with advanced or professional degrees (n=400) were more likely to read food labels in general than other age groups ($P < 0.05$), but were equally as likely to read dairy product labels ($P > 0.05$). When respondents were asked to select their top 3 sources of information about food purchased and consumed, the most frequently used source was food product labels, followed by family, internet searches, and learning in school/college, while the least common sources of information were food bloggers, phone apps, company websites, and the FDA website ($P<0.05$).

Does the average dairy product consumer (DPC) understand the basic ingredients and nutrients in fluid milk, cheese, and cultured dairy products?

Interview participants (who were also dairy consumers) (n=54) were largely unfamiliar with the nutrients in milk. The most commonly stated milk nutrients were vitamins (87%), calcium (74%), protein (50%), vitamin D (44%), sugar (26%), fat (22%), vitamin A (17%), lactose (15%), and carbohydrates (9%). Four percent of participants could not name any nutrients in milk. Participants (n=27) who said protein was a milk nutrient were asked how much protein an 8 oz (1 cup) serving of milk contains as a follow-up question. Only 6% of participants correctly identified 8 g of protein. Another 4% said 5g of protein, the rest of the participants who previously stated protein was a nutrient in milk were unable to guess how much. Frequently mentioned nutrients in Cheddar cheese included calcium (59%), vitamin D (44%), protein (39%), unspecified vitamins (39%), fat (31%), sugar (26%), “similar nutrients to milk” (20%), vitamin A (20%), carbohydrates (13%), vitamin C (11%), iron (9%), potassium (9%), and lactose (7%). The respondents stated label reading habits reinforced their lack of familiarity with nutrients or ingredients in milk and cheese. The majority of participants (80%) said they did not typically read the labels on dairy products, although 13% said they occasionally would read the label. Twenty percent indicated that they were not likely to read labels on familiar dairy products such as cheese, but would be more likely to read a label when buying a new product for the first time. Eleven percent indicated they were more likely to look at front-of-package information than back-of-package information. Although consumers express interest in nutrition labeling (particularly front-of-package information), the actual frequency of label reading is much lower than the self-reported frequency of label reading (Grunet and Wils, 2007). It is likely the true frequency of cheese label use is lower than indicated in these interviews.

Survey responses paralleled those from in-depth interviews. Respondents were presented a series with “select one” multiple choice questions in which they were asked how much fat, protein, and lactose was in skim and whole milk. Very few respondents correctly selected the amount of fat, protein, and lactose in skim or whole milk (1% and 1.8%, respectively). More than a tenth of respondents (11.4%) were unable to guess the percent of protein or lactose in either skim or whole milk, answering “I have no idea” to all questions except the fat percentage. Respondents were likely to over-estimate the percent protein in both skim and whole milk (Fig. 4). The distribution of responses from the whole milk composition constant sum exercise is provided in Figure 5. On average, consumers underestimated the percentage of water in milk and over-estimated the percentage of all other components.

Although consumers showed consistency in their responses between the constant sum and select one milk composition exercises, some confusion was also apparent. While over half of the respondents indicated milk is made up of 10% or more of lactose, 12.5% later disagreed that lactose is a sugar naturally found in Cheddar cheese. Despite general consumer understanding that dairy cheese is made from cow’s milk (100% of interview respondents indicated milk was an ingredient in cheese), consumers in our study did not have a clear understanding of how milk composition related to cheese composition. Consumers, not surprisingly, also did not have a clear understanding of specific proteins found in milk. Sixteen percent disagreed that milk contains whey protein while 36.3% agreed that whey protein is a plant protein. High proportions of “neither agree nor disagree” responses to these questions indicate the consumers did not necessarily strongly believe false information about whey protein, but instead were unfamiliar with these products in general and uncertain on how to formulate opinions on their composition (Fig. 6). This same confusion was reflected in interview responses. Although 90% of consumers indicated they knew what whey protein was, 25% indicated it was a plant-based protein and just 35% indicated it came from dairy (13% indicated it was a cheesemaking byproduct). Thirty-three percent of cheese consumers interviewed specifically stated whey protein is a fitness or muscle building supplement.

Education significantly impacted understanding of dairy composition with those with more formal education tending to have a better understanding of this topic. Those with an advanced or professional degree on average agreed more than those with no college degree that milk or Cheddar cheese contains whey protein ($P < 0.05$), with those with a college agree at parity with both other groups ($P > 0.05$). By contrast, those with no college degree agreed (incorrectly) more that milk does not contain whey protein, followed by those with a college degree, and those with an advanced or professional degree least likely to agree that milk did not contain whey protein ($P < 0.05$). Those with no college degree were more likely to agree Cheddar cheese did not contain whey protein than other education groups ($P < 0.05$). Education did not affect agreement on whether milk contained lactose ($P > 0.05$). Education did not affect how strongly respondents agreed milk was a good source of vitamins A and D, however respondents without a college degree were more likely to agree milk was not a good source of these vitamins ($P < 0.05$). Those with either a college degree or an advanced or professional degree agreed more that lactose is a sugar naturally found in Cheddar cheese than those with no degree ($P < 0.05$). Similarly, those with no college degree were more likely to agree Cheddar cheese did not contain lactose than respondents with more formal education ($P < 0.05$).

Millennials were less likely than other age groups to consider milk a good source of protein and more likely than other age groups to agree that milk was not a good source of protein ($P < 0.05$). There was no difference in agreement between Boomers/Silent Generation and Gen X that milk is a good source of protein, but Gen X members were less likely than Boomers/Silent Generation members to agree milk is not a good source of protein ($P < 0.05$). Boomers/Silent Generation members on average agreed more than other age groups that milk contains whey protein ($P < 0.05$). There was no difference between age groups in agreement that milk does not contain whey protein ($P > 0.05$). While there was no difference in agreement between age groups that milk contains lactose, Boomers/Silent Generation members agreed less that milk does not contain lactose than other age groups ($P < 0.05$). Boomers/Silent Generation members agreed most that Cheddar cheese contains whey protein, followed by Gen X, with Millennials agreeing the least ($P < 0.05$). The reverse was seen for agreement that Cheddar cheese does not contain whey protein. Boomers/Silent Generation members were most likely to agree that Cheddar cheese or milk is a good source of vitamins A and D, followed by Gen X, then Millennials (the reverse was seen for agreement that Cheddar cheese or milk is not a good source of vitamins A and D) ($P < 0.05$). Millennials agreed more than Boomers that Cheddar cheese is a fermented food ($P < 0.05$), with Gen X at parity with both other groups ($P > 0.05$). Overall, older consumers (in particular, Boomers/Silent Generation members) have a better understanding of milk and Cheddar cheese composition and nutrition. In general, older consumers are more interested in dairy functional foods and more knowledgeable about the health benefits of dairy, which may result in a stronger understanding of dairy composition in general (Bimbo et al., 2017).

Consumer confusion about the ingredients in cultured dairy products was apparent from the expected ingredients check-all-that-apply exercise (Figs. 7-8). Roughly half of survey respondents (49%) expected to find “enzymes” in Cheddar cheese, just 18% expected to find rennet. Over half of survey respondents (54%) agreed Cheddar cheese is a fermented food, but only 39% expected to find “cultures” and 19% expected to find “probiotics”. Carob bean gum, a common stabilizer in cream cheese, was only expected by 8% of respondents. Product names may also affect expected ingredients. For example, respondents were more likely to expect cream or cultured cream in sour cream and cream cheese than Cheddar cheese and cottage cheese ($P < 0.05$). Collectively, these consumer responses indicate that the average DPC does not understand the basic composition or ingredients in fluid milk or cheese and other cultured dairy products. In general, consumers do not perform well on tasks which require them to make judgements about the nutritional value or composition of foods. Levy and Fein (1991) found that although nutrition labels were a good tool for reminding subjects about existing nutrition beliefs, they were unlikely to contribute to a more complete understanding of a food’s components or nutrition. Subjects performed well on tasks requiring them to compare nutrients between two food labels or to correlate a product’s nutrients to existing dietary guidelines, but had poor performance on tasks requiring them to identify false nutritional claims, make mathematical calculations involving nutrients, or draw implications about a product’s nutrition without dietary guidelines to serve as a model (Levy and Fein, 1998).

Does the average DPC understand the basic processes for fluid milk, cheese and cultured dairy products?

Most consumers in our interviews were able to identify key words associated with dairy processing, but had only a fragmented understanding of dairy processes. The majority (94%) of respondents in interviews indicated they knew how milk was pasteurized. When asked how milk is pasteurized, 43% of participants correctly identified that pasteurization involved a heat process. Other common responses included chemicals (13%), filtration (13%), and generic "machinery" (11%). Four percent of participants said pasteurization had to do with cows' access to pastures or grass. The majority of participants were able to relate nonfat milk to a fat removal process, but they struggled to identify what such a process would entail. Common responses included skimming (46%), boiling (29%), chemicals (9%), filtering (7%), pasteurization (6%), cooling to solidify and remove fat (6%), centrifugation (4%), and dilution (4%). The majority (74%) of participants had never heard of the term "ultrapasteurization". When probed for more detail, 29% of participants who had heard of UP milk stated it involved a higher heat treatment, while 14% said it resulted in a longer shelf life. These perceptions on milk pasteurization are similar to those expressed by consumers in a previous study (Rizzo et al., 2020). Similar to the interview participants in the current study, focus group respondents were able to identify that pasteurization was a heat treatment, but did not understand the differences between HTST and UP pasteurization or their effect on shelf life (Rizzo et al., 2020).

Ultrafiltered milk was largely unfamiliar to the interview participants, just 30% said they were familiar with the term. Twenty percent could recall seeing it on dairy product labels before, with 9% specifically citing Fairlife brand milk. Similar to ultrafiltered milk, just 24% of participants were familiar with microfiltered milk. None could recall seeing the term microfiltered or microfiltration on dairy product labels. Interview participants had mixed familiarity with evaporated milk. Confusion existed between evaporated milk and powdered milk (24% of participants said evaporated milk is milk with all water removed or milk that must be rehydrated before use). Twenty two percent of participants identified that evaporated milk is typically sold in shelf-stable cans. Participants also commented on the differences between evaporated milk and regular milk, saying it was creamier/thicker (27%), sweeter (15%), more yellow (7%), stronger flavored (6%), thinner (6%), and less water/more concentrated (10%). Although 83% of participants claimed they knew how evaporated milk was made, there was again uncertainty to the exact details of the industrial process. The majority of panelists indicated that some component of the milk was removed, with common responses including water (26%), fat (4%), and air (4%). Just 27% of participants could recall seeing evaporated milk on an ingredients statement, although 66% could recall seeing evaporated milk for sale on its own. These results aligns with survey data, in which fewer than 10% of respondents expected to find evaporated milk as an ingredient in either Cheddar cheese, cottage cheese, sour cream, or cream cheese.

When asked what Cheddar cheese is made from, all interview participants mentioned milk. Other frequently mentioned ingredients were coloring/food dye (35%), butter (13%), salt (11%), preservatives (7%), sugar (6%), rennet (6%), added flavors (6%), herbs (6%), and live cultures (6%). Nearly all (90%) participants claimed that they knew how cheese was made. Frequently mentioned specific steps in the cheesemaking process including ageing (56%, with 6% specifically saying barrel aging), curd formation (31%), fermentation (30%), ingredient mixing (26%), live culture addition (22%), a temperature change (13%), milk pasteurization

(9%), whey straining (7%), use of cheesecloth (7%), and an unspecified process similar to making butter (6%).

In the quantitative online survey, we assessed respondent understanding of processing impacts on the properties of fluid milk by presenting sets of two fluid milk products (ex: milk and ultrafiltered milk) and asking which attributes, if any, differed between these two products in a check-all-that-apply (CATA) format. A biplot of these responses is shown in Figure 9. Consumers again demonstrated uncertainty with even common processing terms. For example, over half (57.4%) of respondents indicated nonfat and fat-free milk were not different, but 35.0% of respondents believed that these two products differed in fat content. The vast majority of respondents (93.6%) believed whole and nonfat milk differed in fat content, but consumers also believed that they differed in protein, vitamin, and sugar content (32.5%, 20.4%, and 22.8%, respectively), Around one quarter of respondents correctly indicated that milk and ultrafiltered milk or milk and microfiltered milk differed in protein content (26.0% and 22.8%, respectively). While the differences between other pairs of products were driven mainly by a few attributes (ex: differences between "lowfat milk and 1% milk" or "whole milk and nonfat milk" were driven primarily by fat, and differences between "pasteurized milk and ultrapasteurized milk" were driven mainly by heat treatment and shelf life), the expected differences between milk and ultrafiltered or microfiltered milk were more evenly distributed. Less than 30% of respondents believed "milk and ultrafiltered milk" or "milk and microfiltered milk" differed in any of the attributes presented with the exception of shelf life (35.6% and 36.5%, respectively), texture (34.7% and 35.5%, respectively), and price (44.0% and 43.1%, respectively). This even distribution of responses suggests that consumer understanding of how these products differ from unfiltered regular milk remains limited.

The average DPC is familiar with common key processing words, but does not have full understanding of the basic processes associated with manufacture of fluid milk, or cheese and cultured dairy products. Previous trends have been shown in a study of raw milk cheeses that although consumers could identify that raw milk cheeses were made without pasteurized milk, 29% of respondents were unsure how this would affect possible safety of the cheese (Colonna et al., 2011). Even after they were presented with an educational statement explaining that raw milk cheesemaking processes are certified by the FDA to mitigate harmful effects, over one third of previously concerned or uncertain consumers were still unable to form an opinion on the safety of these cheeses (Colonna et al., 2011).

Do different processes impact consumer perception or purchase intent?

The majority of interview participants were unfamiliar with ultrafiltered and microfiltered milk. Uninformed perceptions about ultrafiltered milk were generally positive (65%), with fewer participants saying they felt neutral (17%), negatively (13%), or unsure (6%) about the term. When all participants were probed to elaborate on their perceptions of UF/MF milk, common themes in participant responses included healthier milk (31%), safer/cleaner milk (24%), more processing (9%), less healthy (7%), more pasteurization (6%), lactose removal (4%), and unnecessary extra processing (4%). Similar to ultrafiltered milk, just 24% of participants indicated that they were familiar with microfiltered milk. None could recall seeing the term on dairy product labels. Again, despite unfamiliarity, most participants had a positive opinion of microfiltered milk (63%), while 20% had a negative opinion, 11% expressed a neutral opinion, and 6% were unsure and could not produce an opinion at all. Common themes in responses from all participants included that microfiltered milk was similar to ultrafiltered milk (37%), further filtered than ultrafiltered milk (31%), used smaller pores when filtering than ultrafiltered milk

(15%), was healthier (15%), was higher quality milk (11%), was less filtered than ultrafiltered milk (9%), cost more than regular milk (9%), and was less healthy than regular milk (6%).

On average, survey respondents agreed that milk, Cheddar cheese, pasteurized milk, ultrapasteurized milk, ultrafiltered milk, microfiltered milk, and lactose-free milk were healthy (Fig. 10).This data aligns with previous work which suggests that the majority of dairy product consumers find both milk and cheese healthy and natural, with significantly more consumers considering milk to have these attributes than cheese (Schiano et al., 2020). However, adding processing-related terms to "milk" lowered average agreement that the resulting product was natural or healthy ($P < 0.05$). Lactose-free milk, in particular, was considered the least natural out of all options presented ($P < 0.05$). Average agreement that lactose-free milk was natural or healthy was significantly lower than that of ultrafiltered milk, further suggesting that consumers are unfamiliar with dairy processing technologies and implications since UF can be applied to reduce lactose in fluid milk ($P < 0.05$). Overall, agreement responses suggest that while overall DPCs have a positive view of milk, processing introduces uncertainty that may lead them to question this evaluation. Although consumer perception differed with processing, purchase intent was less impacted. Survey participants were presented a series of ingredients statement mockups and asked their purchase intent of the product ("label purchase intent exercise" in materials/methods) (Fig. 2, Table 1). For Cheddar cheese and filtered fluid milk, purchase intent was not impacted by the ingredients statement ($p>0.05$). For pasteurized fluid milk, purchase intent did not change between "Pasteurized 2% Milk" and "Ultrapasteurized 2% Milk", but was significantly lower for shelf-stable milk ($P < 0.05$). U.S. consumers in general do not prefer shelf-stable milk, instead expecting their milk be refrigerated even if they state a preference for longer shelf life (Rizzo et al., 2020; Harwood and Drake, 2020; Harwood and Drake, 2018). For

Cottage cheese, purchase intent for both “Cultured Ultrafiltered Skim Milk” and “Cultured Microfiltered Skim Milk” was significantly lower than “Cultured Skim Milk” ($P < 0.05$). However, when comment data from respondents who indicated that they would not purchase these products was evaluated, only one comment mentioned microfiltered milk while the rest included complaints about the inclusion of skim milk on the label or the fat content (skim). As milkfat content is a key driver for cottage cheese liking, it is possible that the results for cottage cheese were unintentionally impacted by strong consumer opinions about this attribute and the labeled ingredient skim milk (Hubbard et al., 2016). Skim milk is a standard ingredient in full fat cottage cheese, but our results throughout this survey have indicated that consumers do not frequently read ingredient labels with standard dairy products and or are not generally familiar with specific ingredients and process steps in the standard dairy products that they purchase or consume. It is possible that including an ultrafiltered or microfiltered term drew more attention to skim milk on the product labels, negatively biasing milkfat-driven consumers who saw these labels. More research is needed to understand the combined impact of milkfat and filtration on consumer liking of cottage cheese.

Label purchase intent exercise data showed that age impacted purchase intent for cottage cheese made with cultured ultrafiltered skim milk and shelf-stable ultrapasteurized fluid milk ($P < 0.05$). Purchase intent for cottage cheese made with cultured ultrafiltered skim milk was lower for Millennials (n=226, 3.6 on a 5-pt scale) than Boomers/Silent Generation (n=67, 4.0 on a 5-pt scale) ($P < 0.05$), with Gex X members at parity with both other groups (n=127, 3.7) ($P > 0.05$). Purchase intent for shelf-stable ultrapasteurized milk was lower for Gen X members (n=124, 3.6) than for Boomers/Silent Generation (n=70, 3.9) or Millennials (n=230, 3.9) ($P < 0.05$). Education impacted purchase intent for shelf-stable ultrapasteurized fluid milk, ultrafiltered fluid milk, and cottage cheese made with cultured microfiltered skim milk ($P < 0.05$). Purchase intent for shelf-stable ultrapasteurized milk was higher for those with no college degree (n=97, 4.1 on a 5-point scale) than those with an advanced or professional degree (n=133, 3.7) ($P < 0.05$), while those with college degrees scored at parity with both other groups (n=194, 3.8). Purchase intent for ultrafiltered fluid milk was higher for those with college degrees (n=180, 3.9) vs. those with no college degrees (n=74, 3.5) ($P < 0.05$), with those with advanced degrees at parity with both groups (n=129, 3.8) ($P > 0.05$). Purchase intent for cottage cheese made with cultured microfiltered skim milk was lower for respondents with college degrees (n=180, 3.5) than advanced or professional degrees (n=124, 3.9) ($P < 0.05$), while purchase intent for respondents with no college degree was at parity with both other groups (n=89, 3.6) ($P > 0.05$). Education level did not impact purchase intent for any other products. Although these results suggest demographics may impact purchase intent for dairy products with different processing methods, a limitation of this study is that in order to control bias each respondent was only shown one random label within a set of three. As only data from respondents who typically purchase each product (fluid milk, Cheddar cheese, and cottage cheese) was analyzed to ensure relevant results, we were not able to obtain a balanced sample of ages and education levels for each label set tested.

Overall, changes in processing did impact consumer perception of dairy products. However, the effects are likely both process- and product-dependent. Processing in general tends to lower perception of foods as natural (Asoli et al., 2017), which is reflected in our results by lower agreement that processed milks (pasteurized, ultrafiltered, microfiltered, lactose-free) were natural compared to milk with no processing method specified. Our results suggest pasteurization impacts perception more than filtration, with consumers in particular having a lower purchase intent for shelf-stable milks. Differences in U.S. consumer liking of milks with different pasteurization conditions has been well-documented, including lower liking for higher heat treatment and UP milks in blinded tastings as well as lower liking for the concept of higher heat treatment (Lee et al., 2017; Gandy et al., 2008; Chapman and Boor, 2002; Rizzo et al., 2020; Harwood and Drake, 2020). Filtration (both ultra and microfiltration) also decreased consumer perception of milk as natural or healthy relative to milk in general, but this impact was not different from perception of ultrapasteurized milk ($P>0.05$). Previous work with lactose-free milk suggested that lactose-free milk consumers did not have a difference in preference or purchase intent between filtered or enzyme-hydrolyzed milk, but instead were most sensitive to price increases (Rizzo et al., 2020). Consumers in the lactose-free milk study were also unfamiliar with ultrapasteurization, saying it sounded “scientific” and “expensive” (Rizzo et al., 2020). Once provided an explanation of ultrapasteurization, lactose-free milk consumers became more comfortable with ultrapasteurized milk, although they were still unwilling to pay more for the increased shelf life benefits it provided. Data from our study also suggests that dairy consumers expect unfamiliar processes to result in more expensive end products, which may in turn impact purchase intent. A large segment of consumers expected differences in cost between milk and ultrapasteurized milk (32.7%), milk and ultrafiltered milk (39.2%), milk and ultrafiltered milk (44.0%), and milk and microfiltered milk (43.1%). Although none of the consumers who indicated they would not purchase a milk or cultured dairy product made with filtered or ultrapasteurized milk indicated price as a reason for lower purchase intent, it is possible that perceived price differences may play a role.

Does explaining a process change consumer understanding of, beliefs about, and purchase intent for dairy end products?

Interview participants were largely unfamiliar with ultrafiltered and microfiltered milk, but tended to have positive uninformed perceptions (65% and 63%, respectively) with fewer participants expressing negative opinions (20% and 17%), neutral opinions (11% and 13%), or no opinion (6% for both ultrafiltered and microfiltered milk). Once interview participants were provided the definitions of ultrafiltered and microfiltered milk, 67% felt positively about these processes, 11% felt negatively, 17% felt neutral, and 5% were still unsure. Fifty-six percent also indicated that cheese made with ultrafiltered or microfiltered milk would be healthier due to the increased protein content, while 7% thought this cheese would have too much protein. The majority of participants (78%) indicated cheese that was made from ultrafiltered or microfiltered milk would not be nutritionally the same as cheese made with regular milk. Eleven percent indicated it would be the same, and another 11% were not sure. Sixty-nine percent of participants followed up by saying ultrafiltered/microfiltered milk cheese would be healthier, while 22% said it would not be as healthy. Regardless, 85% of participants said they would be willing to purchase cheese made with ultrafiltered or microfiltered milk, assuming it looked the same and tasted the same as cheese made from regular milk. Ninety-one percent were comfortable with ultrafiltered or microfiltered milk on the label of cheese that they typically purchased.

In the survey, prior to reading the definition of ultrafiltration and microfiltration (Fig. 3), the majority (83.3%) of respondents indicated they were not familiar with these terms. Age and education were not related to familiarity with ultrafiltered or microfiltered milk, however female participants were more likely to be familiar with these terms than male participants ($P < 0.05$). After the definition, 97% indicated their understanding of these terms had changed. The majority of consumers viewed UF/MF milk more positively and were more likely to purchase these products ($P < 0.05$) (Figs. 11 and 12). Education did not impact post-definition beliefs and purchase intent for UF/MF milk, but age and gender did ($P < 0.05$). On average, Boomers/Silent Generation (n=171) found the definition of UF/MF milk most different from their previous beliefs, while the purchase intent of Millennials (n=520) increased the most ($P < 0.05$). Male respondents on average found the definition more different from their prior beliefs than female respondents ($P < 0.05$), but feelings towards UF/MF milk and purchase intent were not significantly different between the groups ($P > 0.05$).

Consumer understanding of, beliefs about, and purchase intent for filtered milks and cultured dairy products made with filtered milk were altered by educational information ($P<0.05$). Perception of and purchase intent for ultra- and microfiltered milk products increased for both interview and survey participants after providing a basic definition of these processes. This is consistent with other food studies in which providing an explanation of processing methods has been shown to improve consumer perception, including lactose-free milk, chocolate pudding, raw milk cheeses, and irradiated beef (Rizzo et al., 2020; Cardello, 2003; Spaulding et al., 2006; Colonna et al., 2011). Front-of-package claims or messaging in particular may help to increase consumer comfort with cultured dairy products with unfamiliar processing terms in the ingredients list. Uninformed consumer purchase intentions are higher when positive label claims such as “all natural” are included in front-of-package messaging, and consumers may overlook information in the ingredients statement they perceive as inconsistent with these claims (Walters and Long, 2002).

CONCLUSIONS

The average dairy product consumer (DPC) can recall key words related to dairy processing or constituents, but they are largely unfamiliar with these subjects. On average, consumers recognized major components of milk and cheese (such as fat, protein, lactose, and vitamins), but did not know the correct percentages of each component or how they might change with processing methods. Processing-related descriptors (ex: ultrapasteurized or ultrafiltered) in ingredient statements are likely to be overlooked, especially on the labels of products a consumer feels they are already familiar with. However, consumers may express caution when they are made aware of unfamiliar processing terms. For the majority of dairy consumers, purchase intent for fluid milk and cultured dairy products is not impacted when non-conventional processing terms such as ultrafiltered or microfiltered are included in the ingredients statement. This impact was consistent for fluid milk and Cheddar cheeses but not for cottage cheese, suggesting the possibility of product specific effects. If processing-related terms are included on package or in marketing messaging, explaining them to consumers in simple terms may increase positive perception and purchase intent. Educating consumers through on-package labeling and other marketing messaging should be investigated for dairy products incorporating processes such as ultrapasteuriziation or filtration.

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TABLES AND FIGURES

Figure 5-1. Moderator guide for in-depth interviews

A. Introduction
B. Dairy products

- Pasteurized milk
  - What fat content do you purchase? Probe meaning in terms of amount of fat in an 8 oz serving.
  - Do you know how milk is pasteurized? If yes, probe if individual has heard of HTST and ultra-pasteurized and if individual know what each of these mean.
  - What other nutrients are in the milk that you buy? If individual comes up with protein and lactose, probe if individual knows how much in an 8 oz serving.
- Nonfat milk
  - What is nonfat milk?
  - Do you know how it is made? Probe if individual can generate fat is removed and how the fat is removed.
- Evaporated milk
  - What is evaporated milk?
  - Do you know how it is made?
  - Have you seen this this product alone or as an ingredient?
- Ultrafiltered milk
  - Do you know what this is?
  - Have you seen this on any dairy product labels before?
  - What do you think it means? Probe if positive or negative.
- Microfiltered milk
  - Do you know what this is
  - Have you seen this on any dairy product labels before?
  - What do you think it means? Probe if positive or negative
- Cheddar cheese (specify the kind you buy in the dairy case, briefly probe to make sure individual are focused on natural Cheddar cheese)
  - What is cheese made from?
  - Do you know how cheese is made? If individual can generate its fermented, ask what that means. If individual says has bacteria, ask what that purpose is.
  - Can you name the nutrients in cheese?
  - Do you read the ingredient label on cheese?
  - If a cheese label said ultrafiltered milk instead of milk, how would you feel? Probe positive, negative, neutral.
  - Do you have any idea how ultrafiltered milk might be made? Probe
  - If a cheese label said microfiltered milk instead of milk, how would you feel? Probe positive, negative, neutral.
  - Inform consumer that filtered milk is milk that has been passed through a membrane or filter to concentrate specific nutrients in milk prior to cheesemaking. Ultrafiltration concentrates protein in milk. Microfiltration concentrates the casein protein in milk. How does that make you feel?
  - How do you think the health or nutrition of filtered milk (UF or MF) milk compares to regular milk? probe
  - Is cheese made from UF or MF milk the same as cheese made from milk? Probe.
- Whey protein
  - Do you know what this is?
  - Are there dairy foods that whey protein is found in? Probe.

C. Wrap Up

- Would you be comfortable if the words ultrafiltered milk or microfiltered milk appeared on the ingredient label of the natural cheese that you typically purchase and consume?

Figure 5-2. Labels used in purchase intent exercises

Cheddar cheese set:

INGREDIENTS: PASTEURIZED MILK, CHEESE CULTURE, SALT, ENZYMES ANNATTO (COLOR).
CONTAINS: MILK.

INGREDIENTS: PASTEURIZED ULTRAFILTERED MILK, CHEESE CULTURE, SALT, ENZYMES ANNATTO (COLOR).
CONTAINS: MILK.

INGREDIENTS: PASTEURIZED MICROFILTERED MILK, CHEESE CULTURE, SALT, ENZYMES ANNATTO (COLOR).
CONTAINS: MILK.

Cottage cheese:

INGREDIENTS: CULTURED SKIM MILK, CREAM, SALT.
CONTAINS: MILK.

INGREDIENTS: CULTURED ULTRAFILTERED SKIM MILK, CREAM, SALT.
CONTAINS: MILK.

INGREDIENTS: CULTURED MICROFILTERED SKIM MILK, CREAM, SALT.
CONTAINS: MILK.

Fluid milk (pasteurization set):

2% REDUCED FAT MILK

Grade A
Pasteurized
Homogenized

INGREDIENTS: REDUCED FAT MILK, VITAMIN A PALMITATE, VITAMIN D_3

2% REDUCED FAT MILK

Grade A
Ultra-Pasteurized
Homogenized

INGREDIENTS: REDUCED FAT MILK, VITAMIN A PALMITATE, VITAMIN D_3

2% REDUCED FAT MILK

Grade A
Ultra-Pasteurized Shelf Stable
Homogenized

INGREDIENTS: REDUCED FAT MILK, VITAMIN A PALMITATE, VITAMIN D_3

Fluid milk (filtration set):

2% REDUCED FAT MILK

Grade A
Pasteurized
Homogenized

INGREDIENTS: REDUCED FAT MILK, VITAMIN A PALMITATE, VITAMIN D_3

2% REDUCED FAT ULTRAFILTERED MILK

Grade A
Pasteurized
Homogenized

INGREDIENTS: REDUCED FAT ULTRAFILTERED MILK, VITAMIN A PALMITATE, VITAMIN D_3

Respondents were shown a random label out of each set for a total of 4 labels.

Figure 5-3. Definition of ultrafiltration and microfiltration shown to respondents

Ultrafiltration and Microfiltration, as their names suggest, are techniques for filtering milk to concentrate specific nutrients. In these processes, milk is passed through a small porous filter at a high pressure. The filtering process removes smaller milk components such as lactose, but retains larger components like protein. Ultrafiltration (UF) concentrates all milk proteins. UF milk has higher protein content and less sugar (lactose). Microfiltration (MF) concentrates casein milk protein (milk protein that makes cheese) and removes lactose and milk whey proteins.

Figure 5-4. Protein content of milk responses from multiple choice “select one” questions (n=1210)

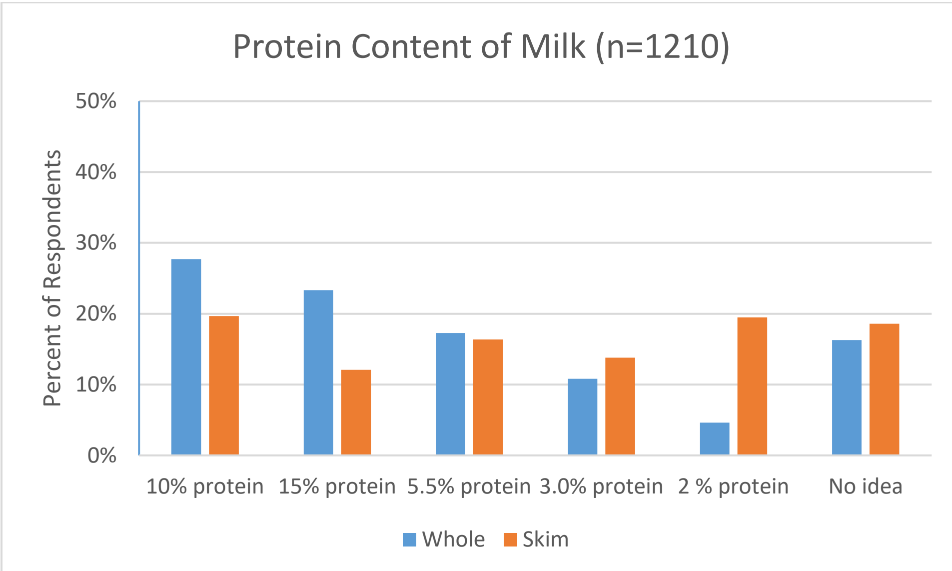


Figure 5-5. Boxplot of constant sum whole milk composition responses (n=1210)

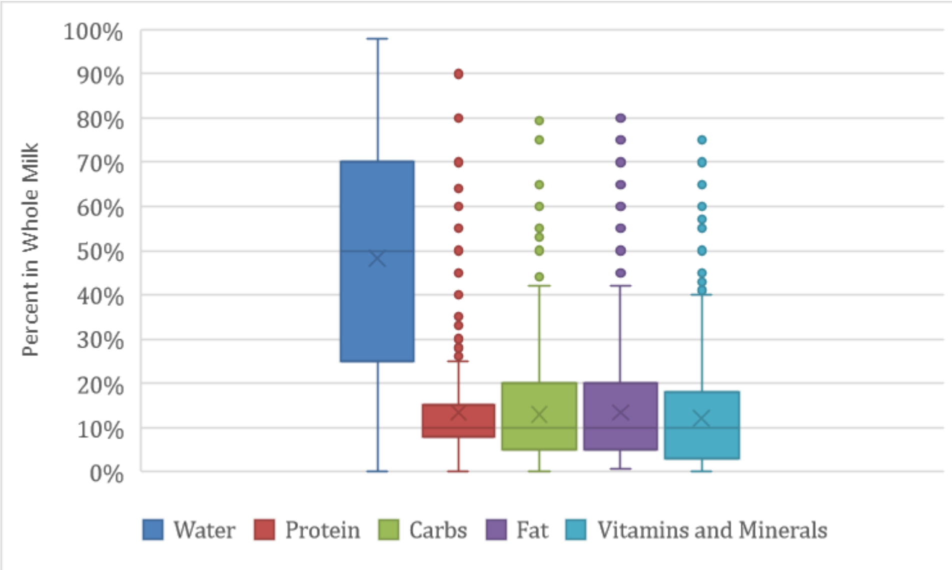
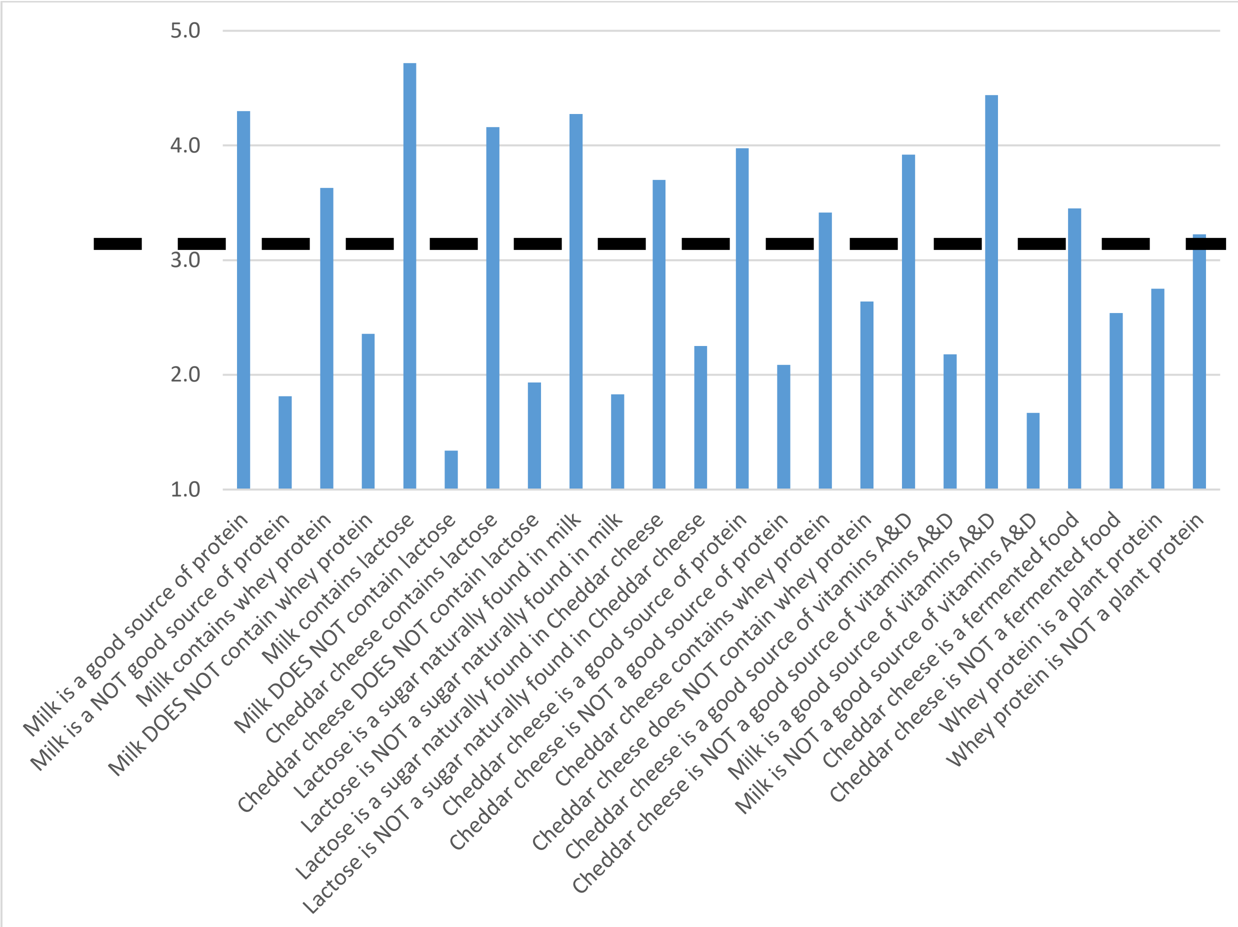
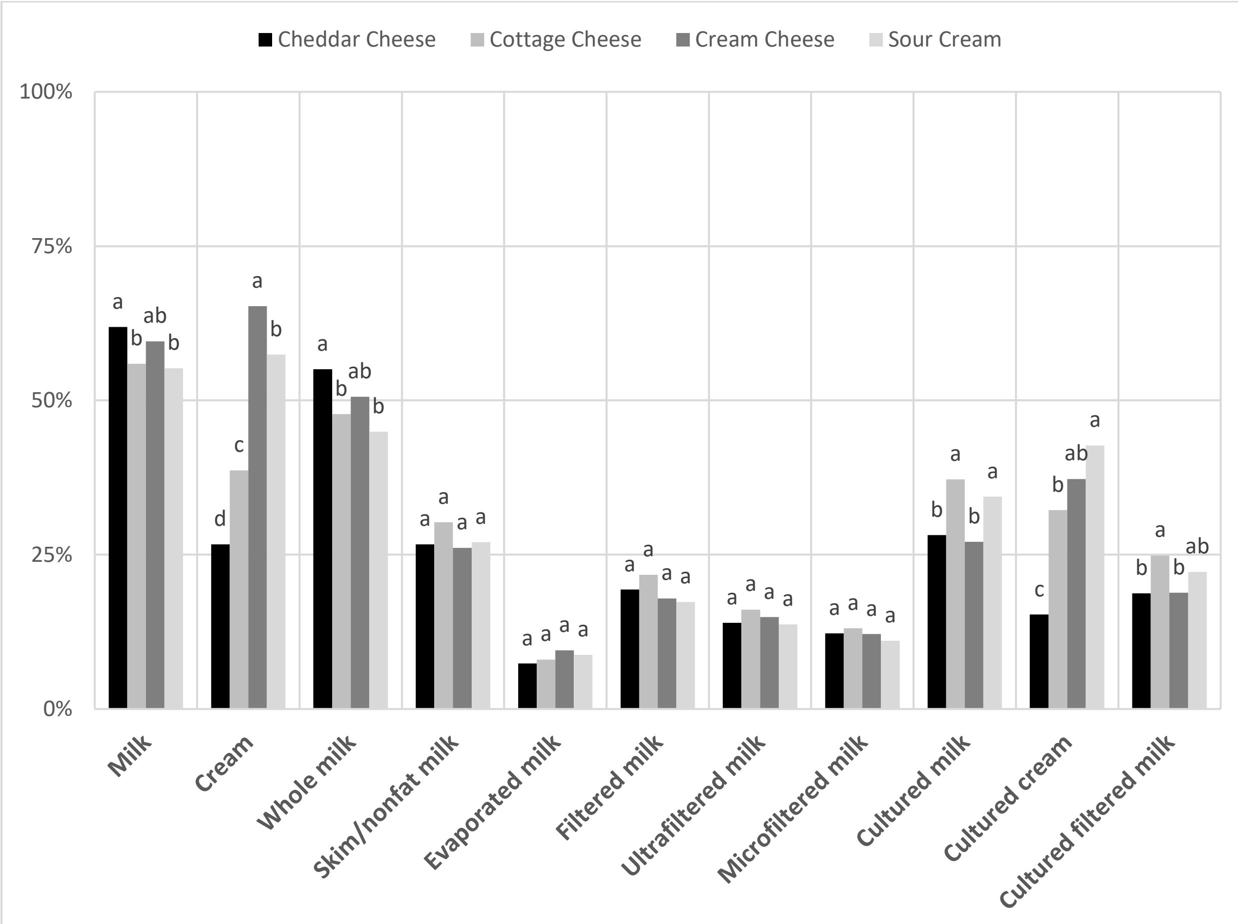


Figure 5-6. Average responses to agreement questions (n=1210)



Agreement questions were scored on a 5-point scale where 1 or 2=disagree, 3=neither agree nor disagree, and 4 or 5=agree. 3.0 (neither agree nor disagree) is represented on the figure by the dotted black line.

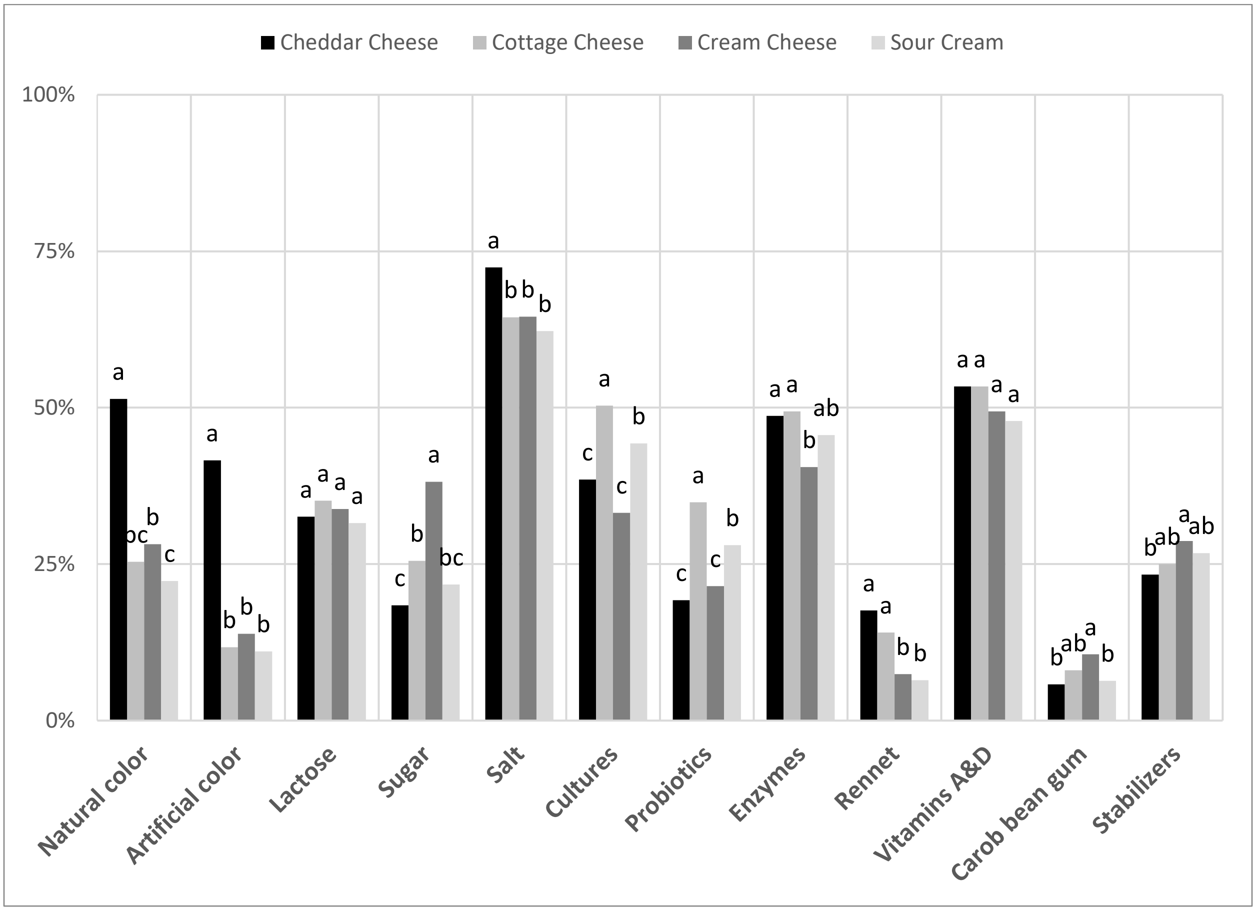
Figure 5-7. Expected ingredients in cultured dairy products (n=1210)



Percent of consumers who indicated each ingredient is expected in each product is shown.

Products that do not share a letter within an ingredient are statistically different (P < 0.05).

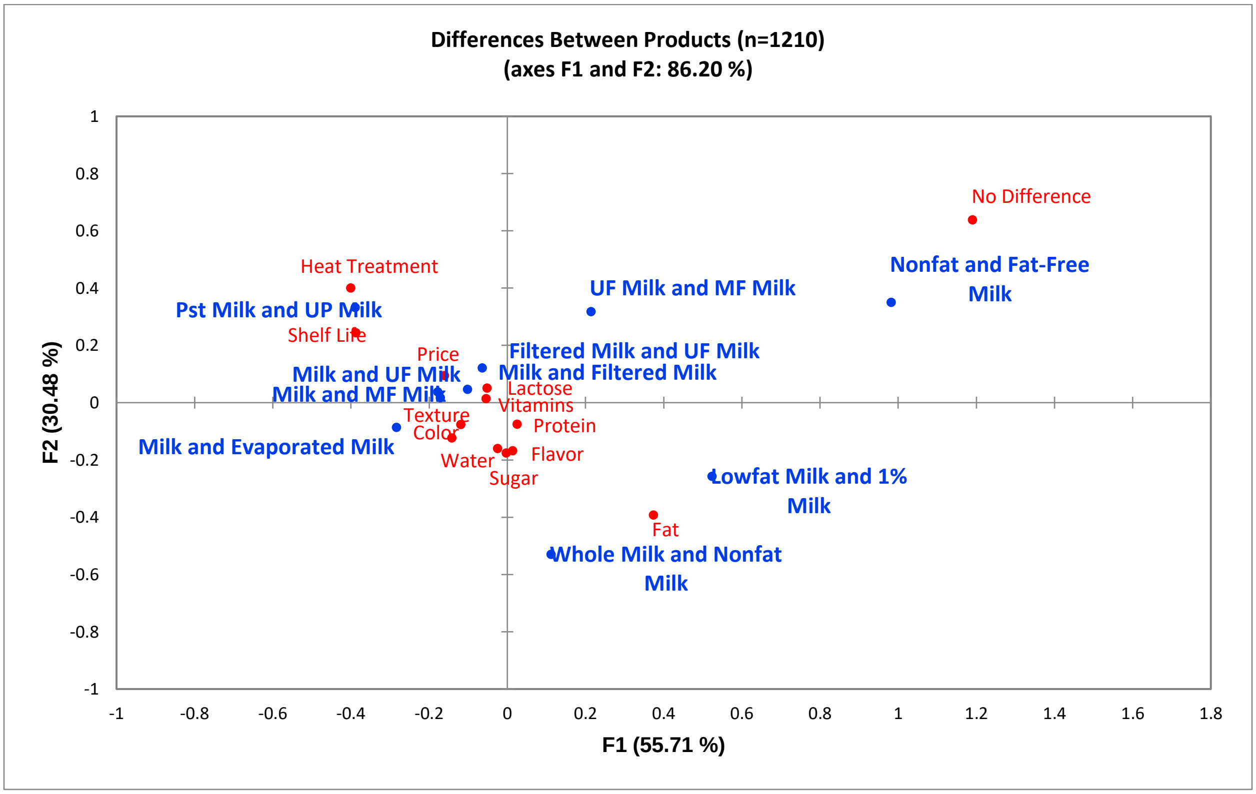
Figure 5-8. Expected ingredients in cultured dairy products (n=1210)



Percent of consumers who indicated each ingredient is expected in each product is shown.

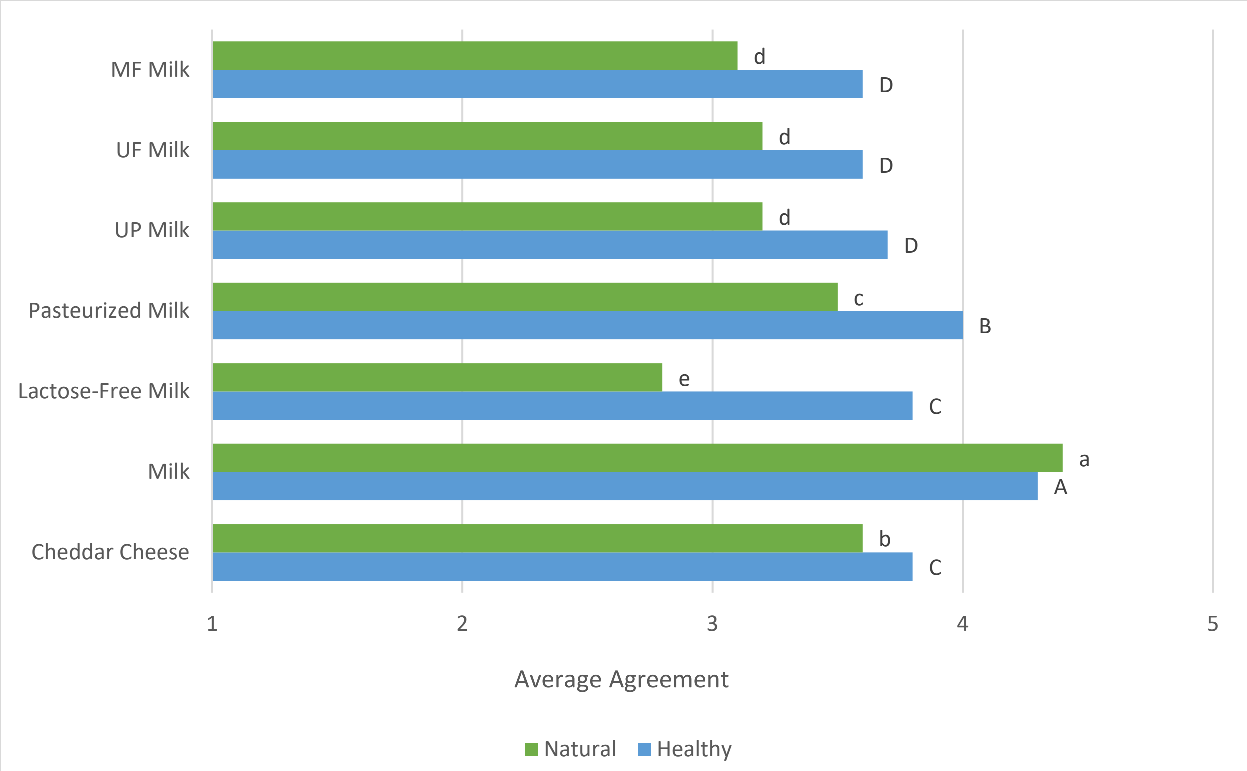
Products that do not share a letter within an ingredient are statistically different (P < 0.05).

Figure 5-9. Biplot of CATA responses to expected differences between products (n=1210)



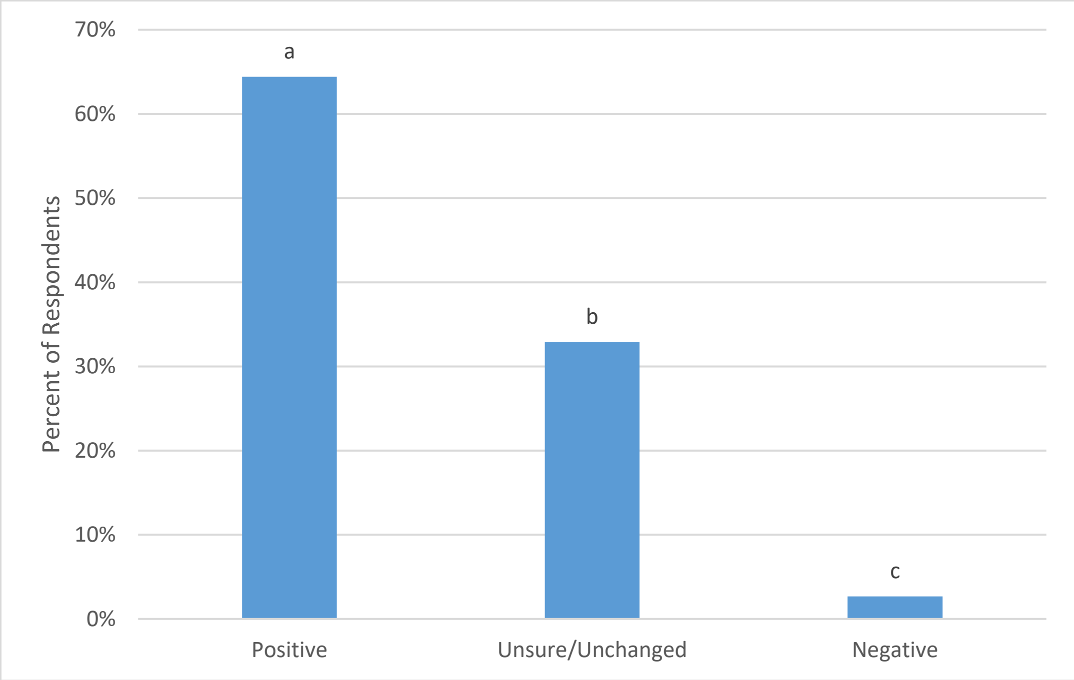
The closer two product sets are on the biplot, the more similar respondents expected the two products to be. Proximity of product pairs to attributes in red indicates those attributes explained the primary differences between the products according to respondents.

Figure 5-10. Average agreement that dairy products were natural or healthy (n=1210)



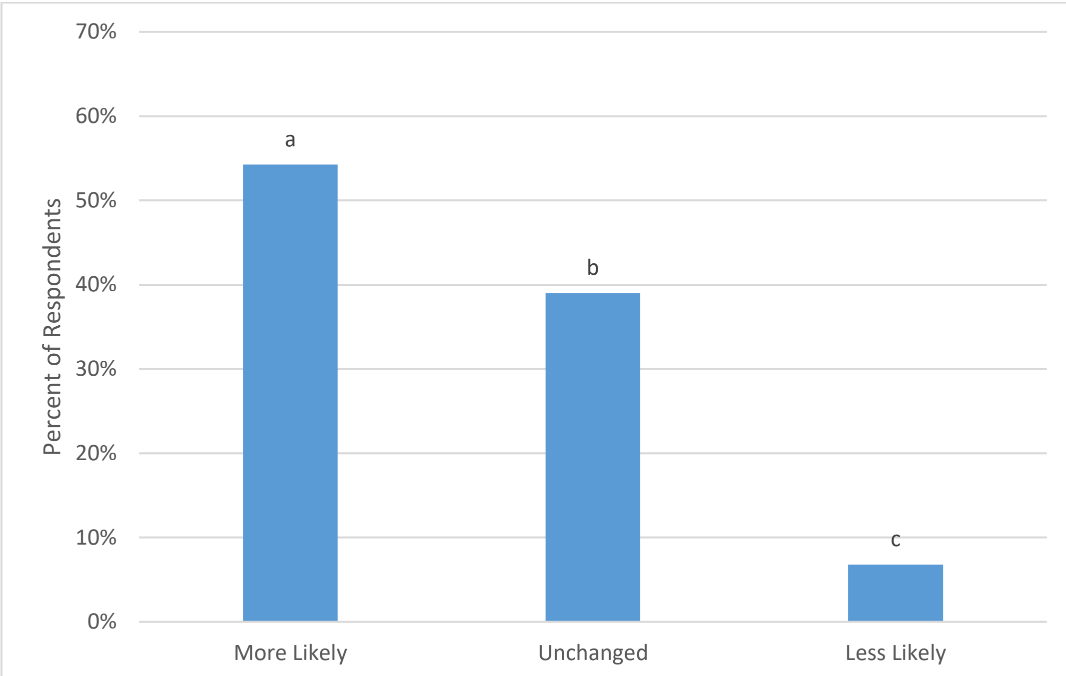
Agreement questions were scored on a 5-point scale where 1 or 2=disagree, 3=neither agree nor disagree, and 4 or 5=agree. Products that do not share a letter within a descriptor are statistically different ($P < 0.05$).

Figure 5-11. Post-Definition beliefs about ultrafiltered and microfiltered milk (n=1003)



Includes 1003 respondents who indicated that they were unfamiliar with ultrafiltered/microfiltered milk before a definition was provided. These are responses indicating how or if their understanding of the terms had changed following providing an explanation (Figure 2). Columns which do not share a letter are significantly different ($P < 0.05$).

Figure 5-12. Purchase intent for respondents' typical milk, cheese, or cultured dairy products assuming they would be made with ultrafiltered/microfiltered/filtered milk (n=1003)



Includes 1003 respondents who indicated that they were unfamiliar with ultrafiltered/microfiltered milk before a definition was provided. Respondents were asked their purchase intent for the milk, cheese, or cultured dairy products they typically buy assuming they would now be made with ultrafiltered/microfiltered/filtered milk following providing an explanation (Figure 2). Includes 1003 respondents unfamiliar with ultrafiltered/microfiltered milk before the definition who indicated their understanding of the terms had changed. Columns which do not share a letter are significantly different (P < 0.05)

Table 5-1. Product label purchase intent (n=1210)

Product Label Purchase Intent (n=1210)			
Cheddar Cheese (n=1085)	Pasteurized Milk (n=362)	Pasteurized Ultrafiltered Milk (n=360)	Pasteurized Microfiltered Milk (n=363)
	4.0a	4.0a	4.0a
Cottage Cheese (n=428)	Cultured Skim Milk (n=151)	Cultured Ultrafiltered Skim Milk (n=151)	Cultured Microfiltered Skim Milk (n=126)
	4.3a	4.0b	4.1b
Fluid Milk (Pasteurization Set) (n=1073)	Pasteurized 2% Milk (n=357)	Ultrapasteurized 2% Milk (n=337)	Ultrapasteurized Shelf Stable 2% Milk (n=379)
	4.1a	4.1a	3.9b
Fluid Milk (Filtration Set) (n=1073)	Pasteurized 2% Milk (n=380)	Pasteurized Ultrafiltered 2% Milk (n=333)	Pasteurized Microfiltered 2% Milk (n=360)
	3.9a	3.8a	3.8a

Each respondent saw one randomly presented label from each set (4 total labels). Data from respondents who indicated they did not purchase each product was removed for each product, leaving n=1085 Cheddar cheese consumers, n=428 cottage cheese consumers, and n=1073 fluid milk consumers. Data is imbalanced due to removal of non-purchaser data after random label assignment. Products that do not share a letter within a row are statistically different ($p<0.05$).

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