ABSTRACT

SIPPLE, LAUREN. Evaluation of Children's Perceptions of Fluid Milk Properties for School Meal Programs. (Under the direction of Dr. MaryAnne Drake).

Evidence suggests that adequate consumption of milk and dairy products, especially during childhood, contributes to growth and development in addition to prevention effects against numerous diseases. Unfortunately, fluid milk consumption has declined for decades and most children do not meet their daily recommended intake of dairy products. School meal programs make fluid milk accessible to millions of children each day, and therefore this context is of primary interest for increasing children's milk intake and creating lifelong milk consumption habits. It is important to understand children's perceptions of the different properties of fluid milk so that appealing products targeted toward this demographic may be developed. One area that has received little attention in this regard is fluid milk packaging.

This study identified the intrinsic and extrinsic attributes that influence children's perceptions, attitudes, and consumption of fluid milk at school, especially as they relate to fluid milk packaging. An online choice-based conjoint (CBC) survey (n=211) and four 1-hour focus groups (n=31) were conducted with child milk consumers ages 8-13 y to evaluate extrinsic attributes. The survey evaluated milk package attributes including packaging type, front-of-package graphics, package color, and labeled milkfat content. Focus groups topics included perceptions of preference, usability, health, taste, and milk consumption habits. To evaluate intrinsic properties related to packaging, three varieties of milk (unflavored fat free, unflavored low-fat, and chocolate flavored fat free) were produced and packaged in polyethylene-coated paperboard cartons, polyethylene terephthalate (PET) bottles, and high-density polyethylene (HDPE) bottles (all 250 mL). After 10-13 d of storage at 4°C under dark conditions, milks were evaluated by descriptive analysis and child acceptance testing (ages 8-13 y, n=126; n=122; and n=126 for each variety, respectively). Extrinsically, package type was the most important attribute to children ($P < 0.05$), but graphics, nutritional labeling, branding, package size, and overall familiarity also drove preferences. The ideal milk packaging build from the conjoint survey was a HDPE bottle with blue-colored packaging and a cow graphic, labeled as low-fat milk. Intrinsically, all varieties of milks packaged in paperboard cartons developed package-specific flavors, including refrigerator/stale and paperboard, after 10 d of storage. These off-flavors were not detected in HDPE or PET packaged milks. For unflavored milks, child consumers preferred the flavor of PET or HDPE packaged milks over cartons ($P < 0.05$), regardless of milkfat content, but preferences were not distinct for chocolate flavored milk. The results of this research demonstrate that children's liking and preference for milk are driven by both intrinsic and extrinsic factors and suggest that improvements are needed to increase acceptance of milk currently served in school meal programs.

Evaluation of Children's Perceptions of Fluid Milk Properties for School Meal Programs

by
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BIOGRAPHY

Lauren Sipple was born on October 26th, 1994 to Jennifer and Michael Sipple. She grew up near Green Bay, WI with her two sisters, Rachel and Claire. After graduating from Denmark High School in 2013, Lauren pursued her B.S. degree in Food Science at the University of Wisconsin-Madison. During her time at UW, she participated in all things dairy, including WCMA Student Dairy Showcase, Dairy Product Evaluation Team, NDC New Dairy Product Competition, and Wisconsin CDR's Descriptive Sensory Panel. After graduating with her undergraduate degree in 2017, Lauren's interest in dairy processing and sensory drew her to NC State to pursue her M.S. in Food Science under the advisement of Dr. MaryAnne Drake. When she's not working, Lauren loves running, and achieved a longtime goal by running her first marathon during her time at NC State. You might also find her listening to live music, exploring local breweries, or cheering on her beloved Badgers and Packers.

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INTRODUCTION

Overall fluid milk consumption in children has declined steadily since the 1970s (Dror & Allen, 2014). In a study on 448 children ages 5 to 18 y participating in the 2007-2012 National Health and Nutrition Examination Survey, school meals accounted for 77.1% of daily milk intake (Cullen & Chen, 2016). As dairy consumption during childhood and adolescence has lasting impacts on lifelong health status (Huth, DiRienzo, & Miller, 2006) and a primary predictor of lifetime milk consumption is habit developed during childhood (McCarthy, Parker, Ameerally, Drake, & Drake, 2017b), ensuring adequate consumption during primary and secondary education years is of the utmost importance. Regulatory changes regarding the availability of low-fat flavored milk are currently being made to increase overall flavor acceptance and intake of fluid milk, but there is evidence that packaging modifications could also increase milk consumption in school milk programs (USDA FNS, 2017a; Rafferty, Zipay, Patey, & Meyer, 2009).

This literature review will explain various methods and special considerations regarding sensory testing with children. Current consumption trends and health outcomes for fluid milk in children will also be reviewed, as well as current regulations relating to school milk programs. Finally, a variety of attributes impacting child consumption of fluid milk will be explored with particular attention to packaging factors. Both fluid milk packaging trends and current marketing techniques for packaging food and beverages directed toward children will be considered.

SENSORY TESTING WITH CHILDREN

Sensory testing with children is necessary as their needs and wants differ from that of adults. For instance, their preferences and/or sensory acuity for sweetness, saltiness, and texture may be different from that of adults (ATSM, 2013). The primary application of sensory evaluation with children is measuring the acceptability of foods, beverages, and other products designed to be marketed to, or used by, children. Other applications include identifying unique characteristics or functions of products for use in advertising or identification of unfilled needs or wants as part of the product development process. Evaluation of the effectiveness of different scaling methods or sensory testing methodologies with children of different ages is a more theoretical application (ATSM, 2013). The following section will discuss the development of psychological and physiological sensory capabilities in children and elaborate on objective and subjective sensory testing methods and challenges.

Cognitive Abilities

Sensory testing with children presents a unique set of challenges. Many of these challenges relate to children's cognition, which drives their ability to perform certain tasks. **Table 1.1** summarizes cognitive abilities as a function of age for school aged children. It is important to note that there is tremendous variation in the rate of cognitive development in individual children of the same age, which should be considered when developing testing methods for children (Guinard, 2000; Popper & Kroll, 2005). Younger children (ages 2-7 y) in the preoperational stage of development are particularly susceptible to a phenomenon known as "centration" in that they are only able to pay attention to one aspect of a situation at a time. In the context of food sensory testing, this manifests in children only paying attention to one attribute of a food, such as appearance, in making their judgements rather than considering all product sensory attributes (Guinard, 2000; Popper & Kroll, 2005).

Other challenges with younger children (ages 2-7 y) include limited verbal skills, short attention spans, and difficulty comprehending various sensory methods (Guinard, 2000). With regard to designing questionnaires, wording that is suitable for children is crucial (Kroll, 1990). For instance, “bitter” and “sour” are terms that are commonly confused by children as well as adults (Guinard, 2000; Moskowitz, 2002). To mitigate this effect, Liem and Mennella (2003) trained children to distinguish between three basic tastes (sweet, salty, and sour) before asking them to perform an intensity ranking activity. Younger children also have more limited vocabularies with regards to food attributes, perhaps due to lack of experience (Oram, 1998). This may lead to confusion across flavor and texture attributes (Guinard, 2000).

Young children may also have a hard time comprehending certain sensory tests. To help alleviate this confusion, many studies have implemented a practice exercise prior to the actual test. For instance, Kimmel, Sigman-Grant, & Guinard (1994) utilized a game with photos to demonstrate the principle of a paired preference test. Children were shown photos of ice cream and corn then asked to point to the food they most preferred with the hope that these skills would transfer to the actual paired preference test. In a similar approach, Léon, Couronne, Marcuz, & Koster (1999) used a different product to practice each method prior to proceeding to the main experiment and offered clarification if the task was not immediately understood. Liem and Mennella (2003) utilized solutions differing in sour intensity to acquaint children with the concept of ranking prior to asking the children to perform both preference and intensity ranking-by-elimination procedures. In each of these examples, the practice exercise demonstrated and reinforced the principles and cognitive skills required for the desired sensory test.

Physiological and Psychological Development of Olfaction and Gustation

Understanding psychological and physiological development is important as these factors may drive differences in children's food preferences and evaluation of foods. Olfactory function is well developed by the time of birth, with primary olfactory receptor formation occurring by the 8th week of gestation (Schaal, 1988). Normal infants at 28 to 32 weeks gestation regularly respond to olfactory stimuli, such as peppermint odor (Sarnat, 1978). It has been proposed that newborns may be able to differentiate between familiar and unfamiliar odors, and that they may already have developed odor preferences at birth (Soussignan, Schall, Marlier, & Jiang, 1997; Romantshik, Porter, Tillmann, & Varendi, 2007). Children's sense of smell seems to further develop with age. Additional research is needed to determine whether physiological changes play a role in this, but since developed olfactory ability is observed from a young age, measured increase in sensitivity with age is likely related to cognitive growth and experiences (Sorokowska et al., 2015). For instance, in a study of 1,036 subjects, Kobal et al. (2000) reported that subjects less than age 16 y had decreased olfactory sensitivity compared to individuals ages 16 to 55 y, even though they were evaluated to be in excellent health and have almost perfect olfactory sensitivity. Several other studies have also found sensitivity of olfactory thresholds to be lower in children than adults (Dorries, Schmidt, Beauchamp, & Wysocki, 1989; Solbu, Jellerstad, & Straetkvern, 1990; Monnery-Patris, Rouby, Nicklaus, & Issanchou, 2009). However, other studies have found that olfactory sensitivity is well developed in children, but other factors such as odor recognition, memory performance and odor naming are limited by age (Lehrner, Gluck, & Laska, 1999; Oleszkiewicz et al., 2016). These studies suggest that odor recognition may involve context-dependent memory processes and lexical knowledge, in addition to development of cognitive abilities (verbal fluency) as previously described (Engen & Engen, 1997).

The development of gustatory papillae on the tongue begins at around 6 weeks of gestation. By 17 weeks, taste cells are considered functionally mature, although they may not be fully differentiated (Witt & Reutter, 1997). Additionally, fetal human fungiform papillae only contain up to two taste buds, whereas adults may have up to 15 (Arvidson, 1979). Therefore, while infants are born with the ability to taste, the function is not at the adult level. In fact, the tongue does not reach adult size until age 15-16 y (Temple, Hutchinson, Laing, & Jinks, 2002). During mid-childhood (approximately ages 8-9 y), children have significantly higher densities of taste buds on the anterior tongue than adults, which may give children higher localized sensitivity to certain tastants (Stein, Laing, & Hutchinson, 1994; Segovia, Hutchinson, Laing, & Jinks, 2002). A study by Zhang et al. (2008) found an inverse correlation between fungiform papillae density and detection threshold of sucrose. However, whole mouth thresholds for children are generally higher than or comparable to adult thresholds (James, Laing, & Oram, 1997; De Graff & Zandstra, 1999). The lack of consensus in these studies is likely due to challenges in eliminating cognitive variables that impact child performance during threshold evaluations (Guinard, 2000).

Overall, gustatory and olfactory systems are morphologically and thus functionally mature at the time of birth. Observed development in these systems during childhood parallels neural development and brain activation patterns that allow for higher-order processing of gustatory and olfactory information. More research is needed using methods such as brain activation imaging to determine sensitive developmental periods for gustatory and olfactory function (Domínguez, 2011).

Children's Development of Food Preferences

Preference testing with children is not only critical since children's taste preferences differ from that of adults, but also because correlations have been established between food preferences in early childhood and preferences in later childhood (Skinner, Carruth, Bounds, & Ziegler, 2002), adolescence (Nu, MacLeod, & Barthelemy, 1996), and young adulthood (Nicklaus, Boggio, Chabanet, & Issanchou, 2004). Preference development can be broken into two categories: innate and learned. There is extensive evidence that taste preferences are innate (Guinard, 2000). Many studies have demonstrated children's increased food preference as sweet taste in a product increases, which is likely related to the fact that sweetness often predicts energy value in nature (Kroll, 1990; Zandstra & de Graaf, 1998; Liem, Mars, & de Graff, 2004; Cordelle, Piper, & Schlich, 2005; Laureati & Pagliarini, 2013; Mennella & Bobowski, 2015). Preference for salty tastes also appears to be innate. By contrast, children typically have an inborn aversion to sour and bitter tastes, which is likely related to innate impulse to avoid poisonous substances (Desor, Maller, & Andrews, 1975; Wardle & Cooke, 2008; Mennella & Bobowski, 2015). Kildegaard, Tonning, & Thybo (2011b) demonstrated an inverse relationship between preference of fruit beverages and perceived sour taste in children ages 9 to 14 y. Similar findings were reported by Liem and Mennella (2003) for children ages 5 to 9 y and others (Zandstra & de Graaf, 1998). While aversion to bitter taste can be observed in the neonatal stage, degree of aversion to bitter is related to the polymorphism or PROP status of bitter receptors (Menella & Bobowski, 2015).

Olfactory preferences are learned and developed over time (Schall, 1988). Parental influence may be one predictor of food preferences. Skinner et al. (2002) found that children's food preferences were significantly correlated with their mother's preferences for liked, disliked, and foods not previously tasted. Repeated exposure to particular foods is also a key driver of preference as has been demonstrated in a variety of studies (Fisher & Birch, 1995; Liem & Mennella, 2003; Wardle, Herrera, Cooke, & Gibson, 2003; Anzman-Frasca, Savage, Marini, Fisher, & Birch, 2012; Ventura & Worobey, 2013). Additionally, consequences associated with eating a particular food, such as a parent rewarding a child with a sticker for eating a vegetable, may also modify preferences (Rozin & Zellner, 1985; Birch, McPhee, Steinberg, & Sullivan, 1990; Wardle et al., 2003; Anzman-Frasca et al., 2012; Ventura & Worobey, 2013).

Quantitative Testing Methods

Due to the differences in the cognitive abilities of children, selection of age-appropriate sensory methods is paramount. There have been a number of recent studies that have successfully used a variety of traditional quantitative methods to study discrimination abilities and food preferences in children. The appropriateness of these methods for respective age groups of school aged children is summarized in **Table 1.2**. The subsequent section provides a summary of quantitative sensory as it relates to the capability and reliability of sensory testing with children of different ages.

Discrimination Testing. Discrimination testing is used to determine whether or not a perceivable difference exists between two products (Lawless & Heymann, 2010). Research on the use of children as subjects in discrimination testing is limited but developing (Garcia, 2011). This may be due in part to the fact that discrimination testing requires a higher level of cognitive ability than preference testing. Regardless, it has been demonstrated that in some cases children can perform discrimination tests such as paired-comparison, duo-trio, or ranking. Children above the age of 4 y are able to perform paired-comparison and intensity ranking tasks, while children 4 y and younger are unable to successfully complete these tasks, likely due to their less developed cognitive abilities (Guinard, 2000). Liem et al. (2004) compared the results of paired comparison and rank-order tests on children ages 4 to 5 y in discriminating differences in sweetness of orange-flavored beverages containing varying concentrations of sucrose. Five-year-old children could use both methods to successfully discriminate between all products and demonstrated a high level of consistency between the tests. Children 4 y of age, however, were not able to identify differences in sweetness, and their paired comparison and rank-order results were not significantly correlated with each other.

Kimmel et al. (1994) compared the ability of children to perform paired comparison, duo trio, and intensity ranking in discriminating the sweetness of fruit punch flavored beverages with varying sweetness. Children ages 4 to 10 y were able to consistently perform paired-comparison tests while children ages 1 to 3 y were not. It was demonstrated through testing with photos of different foods that all children ages 2 to 10 y understood the concept of duo-trio testing, yet they were unable to discriminate between a fruit punch beverage sweetened with sucrose and one sweetened with aspartame. This may have simply been related to the difficulty of comparing equisweet concentrations of the two sweetening systems in the complex beverage medium. In ranking the sweetness of 4 concentrations of sucrose in fruit punch, only children ages 6 y and older were able to successfully discriminate between the sweetness intensities. This may be due to the higher number of samples that are presented during rank-order testing (Kimmel et al., 1994). Liem and Mennella (2003) also found that children ages 5 to 9 y were able to discriminate between the intensity of sour stimuli of differing concentrations in lemon flavored gelatins using ranking-by-elimination.

Very little research is available regarding children's ability to perform tetrad tests. The potential advantage to using the tetrad test is that it is typically more powerful than triangle test; however, concerns with using this test with child subjects include fatigue (as a single tetrad test requires evaluation of four samples), adaption, and memory effects (Ennis & Jesionka, 2011; Garcia, Ennis, & Prinyawiwatkul, 2012). Garcia et al. (2012) compared children's (grades 1-6) performance and ability to complete triangle and tetrad discrimination tests using diluted and undiluted apple juice. The study found that children were able to differentiate between apple juice samples with both methods, and that tetrad testing was actually more powerful than the triangle test, even with a reduced effect size. Overall, these studies demonstrate that children age 6 y and older can successfully perform paired comparison, duo trio, triangle, tetrad, and ranking discrimination tests. Results for children 4 to 5 y, however, are conflicting (Kimmel et al., 1994). This may be a key developmental stage for cognitive ability to perform these tests, and therefore should be approached with great caution.

Affective Methods. Affective testing methods, which are the most common type of sensory methods employed with children, can be used to determine the degree of liking or disliking for a product (Lawless & Heymann, 2010). These methods, in which the child is tested as a consumer, include paired-preference tests, ranking, and hedonic scaling tests (Guinard, 2000). Léon et al. (1999) compared these 3 non-verbal hedonic methods in measuring food liking in children 4 to 10 y. For each method, biscuits with 5 different flavors of fruit jam were used as stimuli. Children ages 6 to 10 y yielded repeatable results for all methods, whereas children ages 4 to 5 y yielded results that were significantly less repeatable, perhaps due to a shortened attention span. The comparative methods (paired preference and ranking-by-elimination) were more highly correlated with one another, but the hedonic categorization method performed better in discrimination and repeatability (Léon et al., 1999).

In recent years, 5- and 7- point rating scales were the most commonly used hedonic scales to evaluate children's food preferences (Laureati, Pagliarini, Toschi, & Monteleone, 2015). It has been demonstrated in various studies that children age 4 y can successfully perform hedonic scaling tasks (Guinard, 2000). In hedonic categorical scaling, modifications may be necessary to accommodate their limited cognitive skills. A study by Kroll (1990) assessed the utilization of different rating scales with children ages 5 to 10 y, including a standard hedonic scale, a facial scale expressing degrees of like/dislike, and the Peryam and Kroll (P&K) scale, which is a child-oriented verbal scale (**Figure 1.1**). Kroll (1990) reported that the P&K scale performed significantly better in terms of discrimination than the other two scales. This may be due to limitations in comprehending the standard hedonic scale, as well as misinterpretation due to ambiguity of facial expressions using a pictorial scale (Popper & Kroll, 2005). Other issues with the pictorial face scale include the more abstract thinking required to interpret the emotion expressed by a face, as well as the fact that facial expressions are not universal across different cultures (ATSM, 2013). Other studies have been successful in using the P&K scale and facial expression scale simultaneously (Kimmel et al., 1994; Pagliarini, Ratti, Balzaretti, & Dragoni, 2003).

In addition to type of scale used, appropriate scale length may also vary based on age. Chen, Resurreccion, and Paguio (1996) evaluated the ability of children in different age groups to determine preferences between pasteurized and ultra-high temperature (UHT) milks using 3-, 5-, and 7-point facial hedonic scales. The study concluded that 3-point scales for 3-year-olds, 5-point scale for 4-year-olds, and 7-point scales for 5-year-olds to be the most appropriate and reliable for their respective cognitive developmental levels. In order to compare results using scales of different lengths, transformations to standardize results are necessary (Chen et al., 1996). Kimmel et al. (1994) reported that children as young as 4 y can use 7-point hedonic scales. Caporale, Policastro, Tuorila, & Monteleone (2009) also used a 7-point hedonic scale to determine liking of school lunch menu items in 4- to 5-year-old children. Liking in this case was significantly correlated with consumption, therefore giving validity to the measurements. Differences in the findings of these studies may be related to cognitive ability as a function of the developmental rates and formal schooling status of the children participating in each study (Chen et al., 1996).

Hedonic scales that use 5-, 7-, or 9- points are typically preferred to the 3-point scale as they have proven to be reliable and more sensitive (Laureati et al., 2015). Lakkakula, Geaghan, Zanovec, Pierce, & Tuuri (2010) offered that the utilization of a 3-point scale potentially limited their ability to obtain accurate representation of children's liking of vegetables in school lunch programs. Kroll (1990) reported that using a scale less than 9-points does not appear to offer any advantage in terms of discrimination. Regardless, the 7-point hedonic scale is often used as it addresses the concerns that longer scales may be confusing to children as there are more choices (Kroll, 1990). The 7-point hedonic scale has not only proven to yield repeatable results across multiple sessions (Pagliarini, Gabbiadini, & Ratti, 2005), but it can be used both in discriminating liking between different types of food (Pagliarini et al., 2003, 2005; Caparole et al., 2009; Laureati et al., 2011; Li, Lopetcharat, & Drake, 2015a; Li, Lopetcharat, Qiu, & Drake, 2015b), and in discriminating liking of the same food differing only on an individual attribute level, such as sweetness (Laureati & Pagliarini, 2013).

Another consideration related to scaling is the degree of use of the scale at different ages. Kimmel et al. (1994) reported that younger children tended to use the ends of a 7-point hedonic scale, while older children used the entire scale in assessing liking of food products. Pagliarini et al. (2005) found that younger children (age 7 y) tended to report higher acceptability scores than older children (age 10 y) when evaluating liking of different lunch combinations on a 7-point hedonic scale. The older children in this study also had more varied scores. Scales that are longer may be more susceptible to this phenomenon, as demonstrated by Moskowitz (2002), who found that younger children (ages 8 to 9 y) tended to use the two highest points on a 9-point hedonic scale more than teenagers in the evaluation of candy liking. This may be indicative that children may become more critical about food with age (Pagliarini et al., 2005).

Other commonly utilized methods in affective sensory testing with children include paired comparisons, ranking, and rating. Liem et al. (2004) found that 4- and 5-year-olds could consistently identify differences in preference of orange flavored beverages with different sugar concentrations using rank order testing and paired preference testing. Both methods demonstrated increased preference with increasing sugar concentration, and for 5-year-olds, paired preference and rank order results were significantly correlated. There was no correlation between the tests for 4-year-olds, suggesting changes in cognitive abilities at these ages. Leon et al. (1999) had similar results, with consistency in the results given by children ages 4 to 10 y between paired preference and ranking by elimination for biscuits with different flavors of jam. The correlations between the paired preference and ranking methods suggests that children ages 4 y and older (Guinard, 2000) and perhaps as young as 3 y (Popper & Kroll, 2005) can give reliable results for these types of tests. Additionally, Kildegaard et al. (2011b) used multiple ranking and hedonic rating on a 5-point facial scale for liking to assess preferences of different fruit drinks in children 9 to 14 y and found agreement between the results of these scores. This consistency was also demonstrated by Liem and Zandstra (2010) who found consistency between multiple ranking and hedonic liking scores for children 6 to 9 y when they were presented with different margarine treatments. The abundance of literature regarding the use of children in affective sensory testing demonstrates that children ages 4 y and older can indicate product preferences, and children ages 6 and older can effectively provide hedonic quantitative measures of product liking.

Evaluating Children's Values, Emotions, and Product Perceptions

Conjoint Analysis. Conjoint analysis is a technique that systematically varies product features by forcing participants to make trade-offs based on product features (Orme, 2014). This makes conjoint a useful method for evaluating consumer value and preferences for the different features of a food product. Conjoint analysis has proven to be a useful tool to investigate consumer expectations and perceptions of food products, both when related to packaging and label design (Deliza, Macife, & Hedderley, 2003; Mahanna, Moskowitz, & Lee, 2009; Ares & Deliza, 2010) or to product concepts and attributes (van der Pol & Ryan, 1996; Olsen, Kildegaard, Gabrielsen, Thybo, & Møller, 2012; Jervis, Jervis, Guthrie, & Drake, 2014). Many studies have shown that conjoint analysis is a reliable method for use with children, and that it can determine their food preferences and the importance of specific attributes, especially those that are visually apparent (Olsen et al., 2012; Jervis et al., 2014; Ares et al., 2016). The use of pictures to represent a familiar food in conjoint analysis with children has proven to produce reliable results consistent with product choice and preferences (Jarmillo et al., 2006; Vereecken, Vandervorst, Nicklas, Covents, & Maes, 2010; Olsen et al., 2012).

A study by Ares et al. (2016) with children ages 6 to 12 y found that utilization of rating-based conjoint (also known as full-profile conjoint, conjoint value analysis, or CVA), in which the child must do an individual liking evaluation for each concept on a 7-pt hedonic scale, may not be sensitive enough to determine significant effects. This may be due to their limited cognitive abilities and attention span (Guinard, 2000). By contrast, choice-based conjoint (CBC) increased the children's ability to discriminate between concepts, and therefore can be used to identify package design variables that influence children preferences for food products (Ares et al., 2016). These results, combined with the fact that CBC took less time, suggest that CBC is easier for children than CVA. Adaptive choice-based conjoint (ACBC) has also been successfully utilized with children ages 8-17 y (Jervis et al., 2014)**.** In ACBC, the respondent first specifies their preferred product attributes in a build-your-own exercise, and the ACBC design displays product concepts relevant to the respondent based on this design. The advantage to ACBC is that it only carries relevant product attributes and levels into the conjoint exercise, making them more engaging, realistic, and relevant to participants in addition to generating more accurate predictions than CBC (Orme, 2014). Kim, Lopetcharat, & Drake (2013) demonstrated that conjoint can be used with adults to determine what packaging information attributes are drivers of liking in a fluid milk product. While fat content, sugar content, and brand were drivers of liking for chocolate milk in adults, children likely have different drivers of liking as they are less likely to act on nutritional knowledge (Story & Resnick, 1986; Kim et al., 2013; Li et al., 2015a).

Focus Groups. Qualitative research methods are useful in subjectively exploring consumer attitudes, emotions, motivations, perceptions, concerns, and opinions about food products and their functional characteristics. Focus groups are the most common type of qualitative research technique (Lawless & Heymann, 2010). Special considerations must be made when running focus groups with children with regard to the group composition and environment, as standards that have been established for adults do not translate well to children due to cognitive, linguistic, social, and psychological differences (Gibson, 2007, 2012). For children under the age of 10 y, small groups of approximately 3 to 6 children are recommended to encourage conversation as this replicates the form of communication in which children naturally talk to one another in small groups and creates a safe peer environment (Mauthner, 1997; Gibson, 2007). Focus groups with older children can be successful with as many as 8 participants (Horner, 2000). Care must also be taken to appropriately present the topic and introduce the researcher to build rapport and trust (Gibson, 2012). With regards to age, it may be best to conduct interviews with children age 7 y or older due to cognitive competencies reached at this point. It is also important to keep the age of participants in a group close to minimize social and cognitive differences. Keeping the group homogenous in terms of gender is also a frequent recommendation (Mauthner, 1997; Gibson, 2007).

While focus groups with adults are more informal and unstructured, this approach may not yield complete or coherent results with children (Irwin & Johnson, 2005; Gibson, 2012). Therefore, more structure and direction in the form of follow-up questions and verbal cues are necessary to encourage thoughtful and detailed responses (Gibson, 2012). Caution must be used in clarification and assisting conversation, however, as it is important to minimize leading a child to protect the integrity of data collected in focus groups (Irwin & Johnson, 2005). To maintain interest and concentration, it may be helpful to utilize exercises and activities that enable participants to work together (Mauthner, 1997; Gibson, 2007). This may help the focus group to last 45 to 90 minutes, depending on the children's age range (Gibson, 2007).

In the context of food research, focus groups with children may be used to generate base knowledge for development of child-appropriate methods. For instance, Jervis et al. (2014) demonstrated that focus groups with children were effective in helping to develop appropriate lexicons for use in surveys. Focus groups have also been used to assess the role of food habits, likes and dislikes, health and nutrition beliefs, meal patterns, view about home food environment, and the roll of peers and school in food choice of children and adolescents (Neumark-Sztainer, Story, Perry, & Casey, 1999; O'Dea, 2003; Burgess-Champoux, Marquart, Vickers, & Reicks, 2006, Thompson, Gerard, & Drake, 2007; Fitzgerald, Heary, Nixon, & Kelly, 2010). Focus groups have been conducted with adults to determine attitudes toward milk packaging as a precursor to quantitative approaches (Hollywood, Wells, Armstrong, & Farley, 2013). In the context of this research, Thompson et al. (2007) utilized focus groups with both children and adults to evaluate their perceptions regarding preferences, brand awareness, healthfulness, and usage of chocolate milk.

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Testing Conditions

The facility design in which testing with children is conducted should minimize distractions. For example, colorful decorations may act as distractions (Guinard, 2000). Additionally, depending on the age of children being tested it may be appropriate to use shorter tables and chairs to make children more comfortable during testing (ATSM, 2013). The method with which the test is administered must also be considered. Children 8 y and older may be able to participate in a self-administered test, but younger children benefit if the test is administered directly by an adult (Kroll, 1990). In the interview format, the relationship of the interviewer with the child should be considered. Popper and Kroll (2005) suggested that children less than 4 y may benefit from having their parent as the interviewer as children gave a larger span of average ratings for an orange drink when this was the case, suggesting that children may feel more comfortable with this approach. This method may be adopted as long as there is little risk of bias (e.g. all products look the same), but in samples that appear to differ in quality or nutritional content, the risk of bias by the parent increases. After the age of 5 y, the child can be interviewed by an unfamiliar researcher with little effect on average ratings. In most cases, the presence of the parent or primary caregiver should be discouraged or interaction with the child limited. The interviewer should use language that is appropriate for the age group and provide emotional support and clarification for the child as necessary. They should also be trained to avoid any unconscious feedback to the child that may bias their results (ATSM, 2013).

Legal and Safety Considerations

Ethical protocols are a fundamental concern with testing children. Since children cannot consent to participate in the test, written parental consent is required to protect the child. The child must still verbally assent to the test. Approval must be obtained from appropriate legal advisors or corporations concerned with the rights and welfare of human subjects in research (e.g. Institutional Review Board for human subjects in research). The parent must be informed of the purpose of the study, the procedures involved, risks, benefits, assurances of confidentiality, compensation, right to refuse or withdraw, as well as disclosure of the personal or financial interests of the investigator, and the parent must provide permission for the child to participate and verify that the child has no food allergies (Guinard, 2000; ATSM, 2013).

MILK CONSUMPTION TRENDS OF CHILDREN

The overall consumption of milk by children and adolescents ages 2-18 y has decreased significantly since the 1970s in terms of the proportion of children consuming milk, the number of servings consumed per day, and the proportion of each serving size (Sebastian, Goldman, Ens, & LaComb, 2010; Dror & Allen, 2014). This trend has also been observed in children participating in school lunch programs, with only 66 percent of NSLP participants consuming milk in the 2014-2015 school year compared to 75 percent during the 2004-2005 school year (USDA FNS, 2018,2019).

Milk consumption is associated with age, with a smaller proportion of children consuming milk as they get older (Maillot, Rehm, Vieux, Rose, & Drewnowski, 2018) (**Figure 1.2)**. However, the overall trend of decline in consumption within the last decade remains consistent across age groups (MilkPEP Consumption Database). One of the possible explanations of the age-related difference is a shift in beverages consumed. A cohort study that followed 291 students from third to eighth grade found that the percentage to which milk contributed to overall beverage intake dropped from 69.1% to 51.4%, while soft drink contribution increased from 6.9% to 24.7% (Lytle, Seifert, Greenstein, & McGovern, 2000). These results suggest that soft drinks displace milk in the diets of school-aged children (**Figure 1.3)**. Forshee and Storey (2003) observed a similar trend, finding that fluid milk consumption was negatively associated with age, while carbonated beverage consumption was positively correlated with age. With regards to access to carbonated beverages in the schools, 23 percent of school food authorities had “Pouring Rights Contracts” in the 2014-2015 school year. These contracts gave soft drink manufacturers exclusive rights to sell beverages other than milk in designated locations while allowing the schools to make revenue off of the sale of these beverages (USDA FNS, 2019). Additional evidence of milk being displaced by other beverages in school meal programs was provided in a 2019 study by the USDA. The study found that when schools sold competitive foods other than milk on an a la carte basis, one-third of students who consumed these competitive foods reported beverages other than milk or 100 percent fruit juice. Bottled water was the most commonly reported, followed by sports/energy drinks and juice (not 100% juice) drinks (USDA FNS, 2019). Additionally, schools that offered competitive foods (other than milk) on an a la carte basis also experienced significantly higher waste of dairy; that is, dairy foods and beverages that children took but did not consume (USDA FNS, 2019).

In both children and adolescents, plain milk consumed as a beverage is the largest contributor to dairy and milk consumption (Sebastian et al., 2010; Green, Turner, Stevenson, & Rumbold, 2015). In children ages 2 to 11 y, flavored milk is the second largest contributor followed by plain milk added to cereal (Sebastian et al., 2010). This trend is reversed in adolescents ages 12 to 19 y; plain milk added to cereal is the second largest contributor to milk consumption followed by flavored milk as a beverage (Sebastian et al., 2010). Overall consumption of plain milk with at least 1% fat has decreased significantly while consumption of flavored milk with added sugar (regardless of milkfat content) has increased significantly since the National Health and Nutrition Examination Surveys (NHANES) in 1989-1991 (Dror & Allen, 2014). Regarding milkfat content, only 20% of children were found to regularly consume lowfat and skim milk (Kit, Carroll, & Odgen, 2011). Recently, a shift in the type of milk consumed, based on milkfat content, has occurred (**Figure 1.4**). A larger proportion of children ages 2 to 17 y are consuming whole milk, with a smaller proportion consuming skim milk (MilkPEP Consumption Database). A slight reduction in the amount of reduced fat 2% milk has also been observed among children 2 to 12 y, but not in teens ages 13 to 17 y.

MILK CONSUMPTION AND CHILDREN'S HEALTH

The importance of milk in the diets of children cannot be overstated, which makes the recent decline of milk consumption a concern. The Dietary Guidelines for Americans 2015-2020 recommends that children 4 to 8 y consume 2.5 cup-equivalents of fat-free and low-fat dairy, while adolescents ages 9 to 18 y are recommended to consume 3-cup equivalents (USDHHS & USDA, 2015). Unfortunately, the consumption of dairy products falls short of these recommendations for children 4 years of age and older (Quann & Adams, 2013). Key nutrients that dairy products provide include calcium, phosphorus, vitamin A, vitamin D (in products fortified with vitamin D), riboflavin, vitamin B_{12}, protein, potassium, zinc, choline, magnesium, and selenium (USDHHS & USDA, 2015). Fluid milk is the number one single-food contributor to the intake of calcium, potassium, phosphorus, and vitamin D in children older than 2 y of age (Rafferty & Heaney, 2008).

In the United States, an estimated 72% of dietary calcium comes from dairy products such as milk, yogurt, and cheese, as well as other foods containing dairy products (Institute of Medicine, 2011). The bioavailability of calcium in dairy products is high, aided by the content of Vitamin D, casein, and milk casein phosphopeptides, which have positive effects on calcium absorption, and lactose and phosphorus content, which have a positive effect on calcium utilization. Still, the absorption of calcium from dairy products rarely exceeds 40% of total ingested calcium (Guéguen & Pointillart, 2000).

Vitamin D, another essential nutrient in milk, also plays a vital role in skeletal development and maintenance throughout life by upregulating calcium absorption in the small intestine and increasing its bioavailability (Holick, 2006; Kaushik, Sachdeva, Arora, Kapila, & Wadhwa, 2014). Severe chronic vitamin D deficiency can lead to rickets, but fortunately fortification of milk with Vitamin D has mostly eradicated rickets in the US (Holick, 2006; Yeh, Barbano, & Drake, 2017). Milk, in addition to having naturally high levels of calcium, is a good vehicle for fortification with these nutrients (Kaushik et al., 2014; Yeh et al., 2017).

Due to calcium and vitamin D content, milk and dairy product consumption is influential on peak bone mass achieved, and therefore skeletal integrity and susceptibility to bone loss (Sandler et al., 1985). This makes milk consumption during childhood and adolescents crucial to bone health (Weaver, 2010). Black, Williams, Jones, and Goulding (2002) found that children who avoided drinking milk long-term were more likely to have inadequate calcium intake and poor bone health, including lower bone area and bone mineral density, compared to children that consumed milk. Children who consume ≥2 servings of dairy per day had higher bone mass, area, and density than children who consumed less (Kalkwarf, Khoury, & Lanphear, 2003; Moore, Bradlee, Gao, & Singer, 2008). About 85 to 90% of final adult bone mass is acquired by age 18 y in females and around age 20 y in males (Huth et al., 2006). Attaining a high peak bone mass is important for bone health, as decreased bone mineral density (BMD) is associated with increased risk of bone fracture (**Figure 1.5**) and osteoporosis (loss of bone mass due to a higher rate of bone resorption than deposition) in later life stages (Marshall, Johnell, & Wedel, 1996; Huth et al; 2006). While dairy consumption throughout all life stages is also necessary for maintenance of BMD and BMC, formation of dairy consumption habits in early childhood is important as this likely influences consumption later in life (Kelder, Perry, Klepp, & Lytle, 1994; Eysteinsdottir et al., 2014; McCarthy et al., 2017b).

In addition to its impact on bone health, milk consumption can also be associated with a lower risk of cardiovascular disease, hypertension, colon cancer, and type 2 diabetes (Weaver, 2010; Huth et al., 2006). Milk components including calcium and whey protein may also play a role in weight control, though further research is warranted due to inconsistent findings regarding dairy intake and weight, particularly for children and adolescents (Huth et al., 2006; Spence, Cifelli, & Miller, 2011; Abargouei, Janghorbani, Salehi-Marzijarani, & Esmaillzadeh, 2012; Rautiainen et al., 2016; Dougkas, Barr, Reddy, & Summerbell, 2019). Since approximately 60-80% of total dairy servings consumed by children comes from fluid milk, fluid milk consumption plays an important nutritional role in children (Nicklas, O'Neil, & Fulgoni, 2013; Quann, Fulgoni, & Auestad, 2015).

Due to the growth of the plant-based milk alternative (PBMA) beverages segment over the past decade (Sethi, Tyagi, & Anurag, 2016), it is worth addressing nutritional differences between dairy milk and PBMAs. Common PBMAs include almond, soy, rice, and coconut beverages. In addition to providing an alternative to consumers who cannot consume regular milk due to lactose intolerance or dairy protein allergies (Mäkinen, Wanhalinna, Zannini, & Arendt, 2016; Sethi et al., 2016), drivers of consumption for PBMAs include health factors/concerns, beliefs about animal mistreatment, and environmental reasons (McCarthy et al., 2017b). Palacios et al. (2010) found that younger children (ages 8-12 y) were more likely to accept soy milk beverages than older children (ages 13 – 16 y), consistent with the observation that food preferences are formed in younger children and emphasizing the role of milk consumption in early childhood to cement milk habits in adult life. Health implications of substituting PBMAs for dairy milk in this group of children should also be considered. The composition of PBMAs can vary greatly as these products are not subject to the same compositional standardization regulations as dairy milk. Most PBMAs, besides soy-based products, are lacking in protein content relative to dairy milk (Mäkinen et al., 2016). Additionally, PBMAs are not usually a complete protein source, meaning that have limiting essential amino acids (amino acids the body cannot synthesize; in the case of PBMAs, typically methionine and cystine) and also have a lower protein digestibility-corrected amino acid score (PDCASS) relative to dairy milk (Friedman, 1996; Jeske, Zannini, & Arendt, 2017; Chalupa-Krebzdak, Long, & Bohrer, 2018). PDCASS is an indicator of protein quality and value to general human health. Since dairy products are the primary source of calcium in the human diet, another concern of substituting dairy for PBMAs is adequate calcium consumption. PBMAs are typically supplemented with calcium, either in the form of tricalcium phosphate or calcium carbonate. Zhao, Martin, and Weaver (2005) compared the bioavailability of calcium in these two forms in fortified soymilk relative to dairy cow's milk and found that only calcium carbonate exhibited similar calcium bioavailability to dairy milk. The absorption of calcium in tricalcium phosphate was only ~75% that of dairy milk (Zhao et al., 2005). However, the amount of bioavailable calcium in these plant-based milk alternatives is highly variable, a problem that is exacerbated due to issues with settling due to poor solubility of calcium (Sethi et al., 2016). Other vitamins and minerals fortified in PBMAs may also be lost or destroyed during processing of these beverages, such as during decanting or thermal processing steps (Mäkinen et al., 2016).

Given these nutritional differences between dairy milk and PBMAs and the essential nutrients that dairy milk can consistently provide, it is generally not recommended that children substitute PBMAs for dairy milk except in the case of a medical condition (Singhal, Baker, & Baker, 2017). School meal programs only allow non-dairy milk substitutes to be served to students with medical or special dietary needs upon written request by the student's medical authority, parent, or guardian. The non-dairy milk substitutes provided to these students must meet nutrient requirements which require these beverages to be fortified with calcium, protein, vitamin A, vitamin D, riboflavin, vitamin B-12, magnesium, phosphorus, and potassium to the levels present in dairy milk (USDA FNS, 2008).

REGULATIONS FOR MILK IN SCHOOL MEAL PROGRAMS

Federal assistance programs that provide milk to children in schools have been in place since the 1940s (USDA FNS, 2017). Over the years, these programs became a part of the National School Lunch Program (NSLP) and the School Breakfast Program (SBP). These programs serve nearly 30 million students every day. Schools, child care institutions, and eligible camps that do not participate in these programs can participate in the Special Milk Program (SMP). Schools that participate in the NSLP, SBP, or SMP can receive cash subsidies for reimbursable meals or milk pints served, provided that nutrition standards codified in CFR Parts 210 and 220 are met. The reimbursement is intended to reduce the price of milk for children (USDA FNS, 2012b). To meet nutritional standards, schools participating in the NSLP and SBP are required to offer one cup of milk per day to students as a part of their breakfast and/or lunch meal pattern(s). All milk must be pasteurized and fortified with Vitamins A & D and students must have at least two options of milk, which can be fat free or low-fat varieties of flavored or unflavored milk (USDA FNS, 2012a). Non-dairy milk options are only offered to students with special medical or dietary considerations, and the alternative provided must provide a nutritional profile comparable to that of dairy milk. From 2012-17, USDA regulations required that only fat free flavored milk could be offered though these programs (USDA FNS, 2018). Low-fat flavored milk was restricted due to concerns regarding saturated fat, sugar, and calorie content. However, the "Flexibilities for Milk, Whole Grains, and Sodium Requirements" interim rule put in place in 2017 granted Child Nutrition Program operators the flexibility to offer flavored low-fat (1%)

milk. The rule has been fully implemented as of the 2019-2020 school year. Based on flavored low-fat milk offering and purchase data prior to 2012, it is expected to encourage child consumption of fluid milk. The ruling is meant to address concerns of Child Nutrition Program operators and industry partners regarding declining milk consumption in NSLP participants in elementary, middle, and high school (USDA FNS, 2018). The decision is also based on recent studies that have found that removing flavored milk from schools resulted in significant declines in milk consumption (Quann & Adams, 2013).

The NSLP, SBP, and SMP provide billions of half pints of milk to school children every year, and participants in the NSLP are two to three times more likely to consume milk than their non-participant peers (USDA FNS, 2019). It is worth noting that while these programs give children access to milk, over one quarter of the milk served in the NSLP and almost half of the milk served in the SBP is wasted – that is, it is discarded and not consumed – which has undesirable nutrition, economic, and environmental implications (Blondin, Cash, Goldberg, Griffin, & Economos, 2017; USDA FNS, 2019).

FACTORS AFFECTING CHILDREN’S PERCEPTION AND CONSUMPTION OF MILK

Composition and Processing Factors

Milkfat Content. There is little literature available on the effect of milkfat content on child liking or consumption of milk. However, it is well established that varying milkfat content impacts sensory properties of fluid milk including color, mouthfeel attributes (thickness, creaminess, residual mouthfilm, etc.), aroma, and flavor (Tamsma, Kurtz, Bright, & Pallansch, 1969; Phillips, Mcgiff, Barbano, & Lawless, 1995; Frøst, Dijksterhuis, & Martens, 2001; Chojnicka-

Paszun, de Jongh, & de Kruif, 2012; McCarthy, Lopetcharat, & Drake, 2017a). Kling, Roe, Sanchez, and Rolls (2016) evaluated children's (ages 3-6 y) liking and intake of low-fat (1% fat) versus whole (3.25% fat) milk. To evaluate liking, the two milk types were presented to children one at a time and children were asked to rate the milks on a 5-point cartoon face scale, then indicate their preferred milk. The study reported that children's (n=107) liking and preference scores were similar for both low-fat and whole milk. To determine whether fat content influenced children's milk intake when served as part of a school meal, Kling et al. (2016) served the different milk types to children in a clear plastic container with their lunch. The meal was constant in composition and portion size for all children and treatments. The study also found that fat content did not significantly impact the amount of milk that children (n=125) consumed with a meal. This is interesting as other studies have found that children prefer foods that are higher in fat content (Johnson, McPhee, & Birch, 1991; Kern, McPhee, Fisher, Johnson, & Birch, 1993; Kildegaard, Løkke, & Thybo, 2011a).

Many more studies have been performed regarding milkfat preference and consumption in adults, and by contrast, these studies have found that fat level influences milk liking. There have been a number of studies that have found that preference in milkfat are associated with the type of milk that is typically consumed (Tuorila, 1987; Chapman & Lawless, 2005; Chung, 2009; Bakke, Shehan, & Hayes, 2016; McCarthy et al., 2017a). For instance, McCarthy et al. (2017a) found that consumers preferred milk that had a higher fat content than what they usually consumed, citing that it had better appearance, flavor, thickness, or creaminess. However, the study also found that while skim and low-fat milk drinkers preferred 2% milk over skim, they did not prefer milk that was any higher in fat as it was perceived as too thick, fatty, and heavy. This result suggests that consumers prefer milk that has similar sensory characteristics to milk they have consumed for a long period of time (McCarthy et al., 2017a). The effect of milkfat percent typically consumed might not be as great in children, especially those who are younger, as such habits and preferences may not be well established yet (Ventura & Worobey, 2013). Regarding milk consumption, Robb, Reynolds, and Abdel-Ghany (2007) found that consumption of low-fat milk was positively associated with age, likely due to greater emphasis on low fat consumption.

Flavored Milk and Sweeteners. The majority of children prefer flavored milk over plain milk as it is perceived as more palatable than plain milk (De Pelsmaeker, Schouteten, & Gellynck, 2013; Fayet-Moore, 2016), and as such, flavored milk is positively associated with a higher overall milk intake (Johnson, Frary, & Wang, 2002; Nicklas, O'Neil, & Fulgoni, 2017). Thompson et al. (2007) found that chocolate milk was the most popular flavored milk among children, while other commonly consumed flavored milks included strawberry and vanilla. The primary argument for serving flavored milk in schools is that removal of flavored milk from school lunch programs results in lower overall milk consumption (Patterson & Saidel, 2009; Quann & Adams, 2013; Hanks, Just, & Wansink, 2014; Henry et al., 2015). Quann and Adams (2013) and Hanks et al. (2014) observed that when flavored milk was removed from elementary schools, not only was less milk purchased but more of the milk that was purchased was thrown away. In a study with children in grades 1 through 8, Henry et al. (2015) also found that overall more students chose to drink milk when both chocolate and plain were available. Although milk consumption was the lowest when only plain milk was offered, the percentage of students consuming plain milk rose from 3% to 14% when both flavored and plain milk were offered. However, a grade effect was observed with students in grades 5 through 8 consuming milk less often after chocolate milk removal than children in grades 1 through 4. Similarly, Davis et al. (2017) found that the mean amount of milk consumed among kindergarten to second grade students was only 0.3 oz less overall, and 0.4 oz less for chocolate milk drinkers when children chocolate milk was removed as a beverage option from school lunch. The results of these two studies may suggest that younger students are more apt to switch to plain milk when flavored milk is no longer offered, but that this effect does not occur with older children whose nutritional needs continue to benefit from fluid milk consumption.

Children who consume flavored milk tend to have lower intakes of soft drinks and fruit juice compared to non-consumers of milk (Johnson et al., 2002). This makes flavored milk a very important component of dairy intake in children and adolescents. Besides having higher amounts of added sugar, flavored milk has essentially the same nutritional profile as plain milk. Due to its impact on increased overall consumption, however, flavored milk has the potential to increase the intake of several essential nutrients, including calcium, phosphorus, potassium, Vitamin D, and Vitamin A (Johnson et al., 2002; Murphy, Douglass, Johnson, & Spence, 2008; Nicklas et al., 2013; Henry et al., 2015). As previously discussed, consumption of these nutrients during childhood and adolescents are crucial to the lifelong health.

The consumption of flavored milk by children is met with health concerns, particularly related to obesity and dental caries due to added sugar. Unrestricted consumption of beverages containing fermentable sugars, such as milk, can contribute to tooth decay in children (Çolak, Dülgergil, Dalli, & Hamidi, 2013). However, Murphy et al. (2008) reported that adjusted intakes of added sugars were comparable for children above the age of 5 y regardless if the children consumed flavored or unflavored milk. A study by Dunning and Hodge (1971) found that drinking chocolate milk with added sugar was not significantly associated with incidence of dental caries when compared to plain milk. Conflicting data exists on the impact of drinking flavored milk instead of plain milk on adiposity and energy intake. Although some studies say that drinking flavored milk over plain milk is not related to energy intake in children over the age of 5 y or the weight status of children (Murphy et al., 2008; Nicklas et al., 2013), other studies suggest that energy intake may be increased by flavored milk consumption (Noel, Ness, Northstone, Emmett, & Newby, 2013; Patel et al., 2018). Therefore, further research is needed to investigate the relationship between flavored milk consumption and body composition. Regardless, overall available research suggests that the nutritional benefits of the nutrients provided by milk outweigh the health concerns of flavored milk (Institute of Medicine, 2010; Li & Drake, 2015; Nicklas et al., 2017). Additionally, due to its carbohydrate, protein, water, and electrolyte content, chocolate milk may aid in recovery from endurance exercise. Several studies have demonstrated enhanced muscle protein synthesis, glycogen restoration, rehydration, reduced muscle soreness, and even enhanced performance (e.g. increased time to exhaustion) when chocolate milk is consumed post-exercise compared to a placebo or other recovery beverages containing carbohydrate, protein, and fat (Pritchett & Pritchett, 2013; Amiri, Ghiasvand, Kaviani, Forbes, & Salehi-Abargouei, 2019; James, Stevenson, Rumbold, & Hulston, 2019; Russo et al., 2019). An additional advantage to chocolate milk for exercise recovery is that it is often less costly than other over-the-counter recovery beverages (James et al., 2019).

The USDA does not have limits on added sugar or total carbohydrates for flavored milk served in school meal programs. This decision was made to prevent restrictions in menu planning and was based on an Institute of Medicine report entitled School Meals: Building Blocks for Healthy Children which recognizes that milk significantly contributes to calcium, phosphorus, potassium, riboflavin, and Vitamin D nutrient targets (Institute of Medicine, 2010;

USDA FNS, 2012a). Instead, the maximum calorie levels allowed in school meals is thought to limit foods and beverages with high levels of added sugar and forces schools to opt for unflavored milk or flavored milks containing less sugar (USDA FNS, 2012a). Due to the health concerns associated with added sugar and calorie restrictions in school lunch programs, sugar reduction in milk for these school lunch programs is of great interest. There are three general approaches to sugar reduction in milk: 1) direct sucrose reduction; 2) the use of sugar substitutes to preserve sweet taste; and 3) removal/hydrolysis of the natural milk sugar lactose (McCain, Kaliappan, & Drake, 2018).

The threshold of detection of difference for sucrose reduction in chocolate flavored milk has been determined to be approximately 6.7%, meaning that direct sucrose reduction without changes in sensory perception is feasible within this percent reduction (Oliviera et al., 2016). Additionally, parents prefer flavored milk with reduced sugar for their children over milk with no sugar added or regular sugar content (Kim et al., 2013; Li, Lopetcharat, & Drake, 2014). A study by Li et al. (2015b) investigated the impact of direct sucrose reduction on child (ages 5-13 y) acceptance of chocolate skim milk. While the study confirmed that all ages of children preferred the milk with the highest sucrose concentration, it also reported that sucrose reductions up to ~30% (from a 205 m*M* concentration, or 16.8g added sugar + 12g lactose = 28.8 g total sugar per 8 oz serving of milk) were accepted by children. Similar results have also been reported for adults (Li et al., 2015b; Oliveira et al., 2016). Sucrose reduction beyond ~30% had linear negative impacts on overall liking, sweetness liking, and chocolate taste liking for all ages of children. Likewise, Buczkowski, Smith, and Turner (2018) found that among children ages 4-10 y, there was no difference in liking of chocolate milk with 30% sucrose reduction compared to a control, whereas a 40% reduction of sucrose resulted in significantly lower liking scores.

Henry et al. (2015) studied the impact of replacing 1% fat chocolate milk containing 25 g of sugar with a 25% reduced sugar formulation containing no artificial sweeteners on student (grades 1 through 8) milk consumption during lunch. By contrast, this study found that the percentage of students that purchased milk was lower and more milk was wasted when the reduced sugar chocolate milk was offered in the place of the standard milk. However, the reduced sugar chocolate milk was still chosen more frequently than plain milk (Henry et al., 2015). Gradual reduction of sugar from flavored milk has been recommended as to not decrease child acceptance or consumption of milk (Olivera et al., 2016).

The use of non-nutritive sweeteners is an option that has the potential to reduce the sugar content of flavored milk while maintaining sweetness and acceptance of sugar-reduced products. The use of these alternative sweeteners to reduce sugar content of flavored milk would not only lower caloric content of milk without compromising milk consumption, but also could reduce the risk of dental caries as these non-nutritive sweeteners cannot be metabolized by oral microflora (Miele et al., 2017; Gupta et al., 2013). Li et al. (2015a) reported that parents placed the most importance on sweetener type when purchasing chocolate milk for their children. Parents were more likely to be accepting of natural non-nutritive/non-caloric sweeteners for sugar reduction as these are preferred over milk sweetened with sucrose, or with artificial sweeteners (i.e. synthesized sweeteners such as aspartame, acesulfame, and saccharin) (Li et al., 2015a). This may be due to a lack of parental recognition of artificial sweeteners, the belief that these sweeteners are not safe for their child to consume or the current general emphasis on a natural label and natural sweeteners (Sylvetsky, Greenberg, Zhao, & Rother, 2014; Parker, Lopetcharat, & Drake, 2018; Smith, Wells, Scarbecz, Vinall, & Woods, 2019). While there are 6 artificial high-intensity sweeteners that have been approved by the FDA as food additives (saccharin, aspartame, acesulfame potassium (Ace-K), sucralose, neotame, and advantame), only natural high intensity sweeteners (stevia and monk fruit extract) have received "Generally Recognized as Safe" (GRAS) notice (FDA, 2014). The FDA has also granted GRAS notice to D-psicose, more commonly known as allulose, which is a naturally occurring monosaccharide. Although allulose is only 70% as sweet as sucrose, there is growing interest in the use of this sugar as it is virtually indigestible and unfermentable, and therefore the FDA has made it exempt from being included in the "Total Sugars" and "Added Sugars" declarations when it is used as an ingredient (FDA, 2019).

While these factors make the use of natural non-caloric sweeteners enticing, one of the main disadvantages of these high-potency sweeteners, called so due to their intense sweetness relative to sucrose, is that they tend to have off-flavors, including bitter and metallic tastes as well as lingering sweetness, which make them less acceptable than sucrose to consumers (DuBois & Prakash, 2012; McCain et al., 2018; Parker et al., 2018). For this reason, they are often used in blends with other non-nutritive sweeteners, or with caloric sweeteners such as sucrose (DuBois & Prakash, 2012; Miele et al., 2017; Parker et al., 2018), which offsets some of the benefits of using non-caloric sweeteners. Another concern regarding non-nutritive sweeteners is the clarity of labeling. In 2016, the FDA revised its requirements for the Nutrition Facts label on food and beverages to include "added sugars"; however, this does not include non-nutritive sweeteners. In the United States, the FDA requires that non-nutritive sweeteners only be declared in the ingredients (FDA, 2014). In some cases, ingredients with natural non-nutritive sweetener components such as stevia can even be labeled as "natural flavor", which may raise concerns about labeling transparency. There is argument that due to negative consumer perceptions, particularly of artificial non-nutritive sweeteners, that labeling requirements similar to that of

Canada be adopted, including the declaration of non-nutritive sweeteners on the front of packaging, as well as the amount of non-nutritive sweetener per serving and the amount of sugar that would be necessary for sweetness equivalency (Sylvetsky & Dietz, 2014). Finally, the price of non-nutritive sweeteners is significantly higher than that of sucrose, which in 2019 cost ~$0.45/lb. This is particularly a concern for natural offerings such as monk fruit extract, which can cost in excess of $200/lb, whereas artificial sweeteners may range in cost from ~$1.50/lb for sugar alcohols (erythritol) to ~$30/lb for sucralose (T. Grady, personal communication, October 31, 2019). However, since the non-nutritive sweeteners used in flavored milk are typically high in sweet taste intensity relative to sucrose (McCain et al., 2018), their usage rates in flavored milk are much lower than sucrose, making a direct cost comparison of challenging. In the case of the school lunch system where every penny counts, even an increase of one cent per carton could mean the difference of a school system choosing a flavored milk or not.

Few studies have examined child acceptance of these alternative sweeteners in flavored milk specifically. Li et al. (2015a) produced chocolate skim milks including a sucrose control (from 51.4g/L sucrose, or 12.3g of added sugar + 12g lactose = 24.3g total sugar per 8 oz serving of milk) as well as 25%, 50%, 75% and 100% reduced sucrose milks that contained stevia leaf or monk fruit extracts added at concentrations to obtain the same sweetness in these milks as in the sucrose control. The reduced sugar formulations selected for acceptance testing with children, in addition to a sucrose control, were 25% reduced sugar milk + monk fruit extract and 25% reduced sugar milk + stevia extract. This study reported that there were no differences in overall liking, sweetness liking, or chocolate flavor liking for the sucrose control, reduced sugar/monk fruit, or reduced sugar/stevia sweetened flavored milks for children ages 8-13 y. Another study (Castillo, Milgrom, Coldwell, Castillo, & Lazo, 2005) examined the use of xylitol and sorbitol to sweeten plain (unflavored) milk. In this study, children preferred milk sweetened with xylitol over milk sweetened with sorbitol. Both sweetened milks were preferred over plain milk due to the sweet taste. Finally, a study with children ages 1.5 to 5 y comparing consumption of aspartame-sweetened and sucrose sweetened chocolate milk found that intake of these milks was not significantly different, and found that overall energy (calories) consumed when the milks were served at lunch was less when children consumed the aspartame-sweetened milk versus the sucrose sweetened milk (Wilson, 2000). The results of these studies suggest that the use of non-nutritive sweeteners in sucrose-reduced milk provides products that are still acceptable to children.

Another method for sweetening milk which could allow for sugar reduction is lactose hydrolysis with β-galactosidase (lactase). Hydrolysis of this disaccharide into its monomers (glucose and galactose) increases milk sweetness (Zadow, 1986; Mahoney, 1998; Adhikari, Dooley, Chambers IV, & Bhumiratana, 2010). Although its acceptance has not explicitly studied with children, Li et al. (2015b) found that young adults did not have a significant difference in overall liking of chocolate milk sweetened with sucrose (150 m*M* or 12.3g of added sugar + 12g lactose = 24.3 total sugar per 8 oz serving of milk, determined to be the lowest acceptable sweetness,) and lactose-hydrolyzed chocolate milk with 10 g added lactose/mL. However, the authors found that the amount of lactose that needed to be added to achieve sweetness in a lactose-hydrolyzed milk that was comparable to that of regular sucrose-sweetened chocolate milk was too high for the lactose-hydrolyzed milk to be considered "reduced-calorie". This suggests that lactose hydrolysis may not be a viable option for sweetening chocolate milk due to the inherent bitterness of cocoa; however, it may be more practical for naturally sweetening other flavored milks, such as vanilla (Li et al., 2015b). Membrane filtration, which is subsequently discussed, is another option for lactose reduction although unlike lactose hydrolysis this method does not increase sweetness of the milk (McCain et al., 2018).

Heat Treatment. Milk is heat treated at a variety of different temperatures to maintain product quality and safety, and the processing time and temperature can have significant impacts on milk sensory characteristics. These differences in sensory properties have been shown to impact child acceptance of fluid milk products (Chen et al., 1996; Chapman & Boor, 2001; Lee, Barbano, & Drake, 2017). In conventional pasteurization, fluid milk must be heated to 72°C for 15 s (FDA, 2017). Higher-heat shorter time (HHST) pasteurization, is processed at 89-100°C for 1 to 0.01 s (FDA, 2017), and ultra-pasteurization (UP) is defined as heating to at least 138°C for 2 s. If UP is applied with aseptic filling, that produces a product that does not have to be refrigerated and is deemed aseptic, shelf stable or ultra-high temperature (UHT) processed milk (FDA, 2017). Utilizing UHT and UP approaches significantly extends the shelf life of the milk beyond that of conventionally pasteurized milk (Chapman, Lawless, & Boor, 2001). The use of an extended shelf life or shelf-stable milk could have the potential to reduce milk waste in school meal programs (Beckerman, Blondin, Richardson, & Rimm, 2019). This proposed option will only work provided that children liked the aseptic milk, which has not been demonstrated in peer reviewed research to our knowledge.

Chapman and Boor (2001) reported that children ages 6 to 11 y significantly preferred 2% milkfat HTST pasteurized milk to UHT milk, and UHT milk was preferred over UP milk. Similarly, Chen et al. (1996) found a preference for 2% HTST pasteurized milk over UHT milk in children ages 3 to 5 y. Lee et al. (2017) found that children had significant preference for HTST milk compared to UP milk, regardless of the fat content or if it was produced by direct steam injection or indirect heating. UHT and UP milk are significantly higher in cooked flavor than HTST milk due to the release of volatile sulfur compounds from denaturation of whey proteins during heat treatment (Colahan-Sederstrom & Peterson, 2005; Al-Attabi, D'Arcy, & Deeth, 2009, 2014; Lee et al., 2017; Jo, Carter, Barbano, & Drake, 2019). Cooked flavor, as well as increased astringency, also identified in UP milk, are perceived as off-flavors that are disliked by most consumers and commonly limit consumer acceptance of UHT and UP milk (Perkins & Deeth, 2001; Liem, Bolhuis, Hu, & Keast, 2016; Lee et al., 2017; Jo et al., 2019). The preference for HTST milk in children may also be due to familiarity as HTST milk is commonly served in the home, daycare, or school. Children prefer foods that are familiar. Young children, especially those 2 to 5 y, tend to exhibit food neophobia, an unwillingness to eat and dislike of novel foods (Ventura & Worobey, 2013). However, child preferences for novel foods or flavors increases with repeated exposure, with 8 to 15 exposures necessary to observe such an effect (Birch & Marlin, 1982; Sullivan & Birch, 1990).

Membrane Filtration. Membrane filtration is a feasible and economic way to fractionate milk components by molecular size (Poulsen, 1978). In fluid milk, ultrafiltration (UF) is commonly used to increase or standardize protein concentrations while decreasing lactose concentrations. There is not much research available regarding the effects of membrane filtration on the sensory properties and consumer acceptance of fluid milk. Research suggests, however, that varying total protein concentration in fluid milk elicits differences in appearance rather than flavor attributes (Poulsen, 1978; Rattray & Jelen, 1996; Quiñones, Barbano, & Phillips, 1997, 1998; Cheng, Barbano, & Drake, 2019a,b). However, varying the type of protein (i.e. serum protein and casein) in milk beverages does produce flavor differences, namely increased cooked/sulfur and cardboard/doughy flavor in beverages containing more serum protein as a percentage of the total protein (Cheng et al., 2019b). Serum protein removal can be achieved through microfitration. It is worth noting that the UF milk brand Fairlife®, which has 50% more protein, 30% more calcium, and 50% less sugar than regular milk, experienced a 79% growth in dollar sales in 2016, suggesting high consumer acceptance for UF milk products (Watson, 2017). This observation is also likely due to continually growing consumer interest in added value and functional dairy beverages as well as increased protein (Özer & Kirmaci, 2010; Harwood & Drake, 2018, 2019). More research is necessary to determine consumer acceptance of UF milk products for both adults and children.

Extrinsic Factors

Social Influence. Social interactions with parents, caregivers, school teachers and staff, and peers can all influence milk consumption and choice in children. The food choices and practices of parents and caregivers can have a powerful influence on the development of eating patterns in children by acting as a provider and model (Savage, Fisher, & Birch, 2007). For instance, the types and amount of milk consumed by children is highly related to what is provided by parents at home, although this doesn't necessarily translate to milk preference (De Pelsmaeker et al., 2013). In one study, students 10 to 16 y indicated that they believed that their parents would prefer them to drink the same type of milk that they usually consumed at home (Gummeson, Jonsson, Conner, & Svensson, 1996). Several other studies demonstrated that children demonstrated similar patterns of milk intakes for both amount (Berg, Jonsson, & Conner, 2000; Fisher, Mitchell, Smiciklas-Wright, & Birch, 2001; Johnson, Panely, & Wang, 2001; Fisher, Mitchell, Smiciklas-Wright, Mannino, & Birch, 2004) and type (Dennison, Erb, & Jenkins, 2001) consumed as their mothers, suggesting that parents serve as models of milk consumption.

In school and childcare settings, peer-modeling can also have a large impact on child food and beverage choices. Birch (1980) demonstrated that child food choices, preferences, and consumption patterns were greatly influenced by their peers, particularly in young children whose preferences were more malleable. These effects were shown to endure beyond the immediate context in which the peer modeling occurred. Peer modeling has also been demonstrated with regards to milk consumption in cafeteria settings (Connors, Bednar, & Klammer, 2001; Institute of Child Nutrition, 2016). Encouragement of milk consumption and information regarding milk nutrition by teachers and other school staff has also been proposed as a potential social influence for milk consumption (Connors et al., 2001). These studies collectively confirm the findings of McCarthy et al. (2017b) that a unique feature of milk consumption is habit.

Perceived Health Beliefs. Beliefs about health impact child attitudes towards milk (Berg et al., 2000). Children observe that milk is important for good health, particularly bone and teeth health, but were limited in their ability to explain observations that they made regarding nutrition facts (Connors et al., 2001; Marcinow, Randall Simpson, Whiting, Jung, & Buchholz, 2017). In another study with young adults, many were unaware of the health benefits of adequate calcium intake for their age group (Marcinow et al., 2017). While nutrition is considered by older children, younger children were more likely to focus on flavor alone (Gummeson et al., 1996; Connors et al., 2001). Many studies have concluded that although children are knowledgeable about good health and nutrition practices, this may not translate to food choice or dietary behavior (Story & Resnick, 1986; Trexler & Sargent, 1993; Gummeson et al., 1996; Woodward et al., 1996), as food preferences are mainly driven by taste, texture, and appearance (Stevenson, Doherty, Barnett, Muldoon, & Trew, 2007; Fitzgerald, Heary, Nixon, & Kelley, 2010; Jones, Kervin, Reis, & Gregory, 2012). For instance, while children perceive plain milk to be healthier than flavored milk, there is still a clear preference for flavored milk (De Pelsmaeker et al., 2013). One explanation that has been proposed for such observations is that children believe that making food choices based on health is only for adults, while children can make food choices based mainly on taste (Michela & Contento, 1986; Chapman & MacLean, 1993; Guidetti, Cavazza, & Graziani, 2014).

Packaging Factors

Graphics and Visual Design Factors. While the main purpose of packaging may be to contain a product and maintain food safety, the package also acts as a marketing vehicle (Harris, Schwartz, & Brownell, 2010). Visual appeal of packaging has a large impact on consumer acceptance, behavior, and purchase decisions regarding a product. Many products that are targeted at children use a cartoonish script or crayoned font to identify it as a children's food (Elliott, 2007). Colorful and "fun" packaging is more appealing to children, and in turn increases a child's purchase intention (Pires & Agante, 2011). However, it is important to note that color also creates associations and expectations relating to flavor and sensory properties, particularly in milk where colors are associated with a certain flavor or milkfat content (Connors et al., 2001; Ares & Deliza, 2010). Another impact of color as it relates to milk consumption and milk choice is gender specific coloring. One study found that changing milk packaging of low-fat plain milk from blue to pink coincided with a shift in popularity of that beverage from boys to girls

(Wechsler, Basch, Zybert, & Shea, 1998). Researchers in this study suggested using gender-neutral colors to increase overall proportion of children choosing low-fat milk.

A broad range of food and beverage products use promotional characters on packaging, most of which are licensed characters or brand equity characters, but also include celebrities and sportspersons (Hebden, King, Kelly, Chapman, & Innes-Hughes, 2011). The utilization of licensed media cartoon characters (such as characters from television shows or movies) for food and beverage packaging has been demonstrated to significantly increase the amount of time and number of times a child views a product (Ogle, Graham, Lucas-Thompson, & Roberto, 2017). Similarly, brand equity characters, which are characters created by a food manufacturer for the purpose of promoting a particular brand (e.g. Tony the Tiger for Kellogg's Frosted Flakes) have also been found to be positively associated with preference for a food product (McGale, Halford, Harrold, & Boyland, 2016). The suggested explanation for this is that both licensed characters and brand equity characters create "brand-consumer relationships" (Lawrence, 2003; McGale et al., 2016). Such promotional characters are effective in increasing a child's attention, improving children's memory and recognition of a food product, in addition to creating brand loyalty (Mizerski, 1995; Neeley & Schumann, 2004; Garretson & Burton, 2005). Children are more likely to indicate preference for foods when they are associated with characters that they like and are familiar (Kotler, Schiffman, & Hanson, 2012).

Evidence of the influence of the presence of a character on food preference and choice, however, is inconclusive. There have been multiple studies that suggest using a promotional character may increase liking, preference, purchase request, and food choice for multiple kinds of products (Roberto, Baik, Harris, & Brownell, 2010; Lapierre, Vaala, & Linebarger, 2011; Kraak & Story, 2014; Letona, Chacon, Roberto, & Barnoya, 2014). On the contrary, the presence of a character has had a counterintuitively negative impact on food choice in some studies (Ogle et al., 2017) and no impact on product preference or choice in others (Neeley & Schumann, 2004). This impact may vary depending on factors such as age, gender, and the specific character used (Ogle et al., 2017). Studies have found that younger children (ages 4-6 y) are more attracted to products with characters than older children (ages 8-11 y) (Letona et al., 2014; Ogle et al., 2017). This may be related to the characters used on food packaging. A study by Ogle et al. (2017) found that Dora the Explorer was less appealing to older children ages 8 to 9 y (because they viewed these characters as targeting younger children), but were more influenced by characters like SpongeBob SquarePants. For younger kids (ages 4-6 y), it may also be important to use congruent character-product combinations (e.g. rabbit used on carrot packaging) to increase effectiveness of unfamiliar characters (de Droog, Buijzen, & Valkenburg, 2012). Similar to age, the Ogle et al. (2017) study found differences in effectiveness of characters depending on the gender towards which they were targeted.

Labeling Factors. Several studies have demonstrated that nutrition claims can have a positive impact on child expected liking of a product, and that these claims influence health perceptions (Ares et al., 2016). Higher overall expected liking when sugar reduction claim was used, indicating an overall positive attitude toward sugar reduction (Yoo et al., 2017; Lima, de Alcantara, Ares, & Deliza, 2019). Lima et al. (2019) determined that based solely on packaging information/claims, children ages 6 to 12 y were more likely to select a sugar reduced product than a full sugar product. However, when the product was tasted, children indicated preference for the full sugar product, even when sugar reduction claims were used on the front of the package. This supports the idea that children's choice for flavored milk is sensory driven rather than health driven. Additionally, children (ages 7-12 y) were more likely than adolescents (ages 13-17 y) to describe chocolate flavored milk with a sugar reduction claim as "good for my health"; however, both groups used the phrase more often when a sugar reduction claim was present on a chocolate milk label compared to when the claim was absent (Yoo et al., 2017). Front-of-package nutrition labeling tools for children, such as a traffic light or the emoticon expressions to convey health messages, have also been found to significantly influence choice and health perceptions. For instance, the use of a red traffic light decreases health perceptions, potentially discouraging the consumption of products higher in sugar (Yoo et al., 2017), whereas a green smiley face emoticon has been shown to increase the purchase of plain fat free milk and lower the purchase of chocolate milk without impacting overall milk purchase for children grades kindergarten through 6 (Siegel et al., 2015).

Branding is an advertising method used to establish recognition and positive associations with a company name or product, with the goal of creating a lifelong customer (Connor, 2006). Brand recognition may be established as early as the age of 2 y (Valkenburg & Buijzen, 2005). There is evidence that branding can influence child perception of taste. For instance, a study on 3- to 5-year-olds found children were more likely to prefer the taste of food and drink product with McDonald's packaging compared to identical product in unbranded packaging (Robinson, Borzekowski, Matheson, & Kraemer, 2007). However, a study by Elliott, Den Hoed, and Conlon (2013) suggested that this effect may be related more so to the colorful or decorative nature of the branded wrapping rather than the brand itself. Other studies have found that television advertising of a particular brand influenced young children's food preferences, particularly in children that were overweight (Borzekowski & Robinson, 2001; Halford et al., 2008). The presence of branding alone may be enough to increase the actual intake of a particular food in children that are overweight (Keller et al., 2012).

Branding and the use of promotional characters are techniques that aren't widely used in the conventional fluid milk category (Story & French, 2004; Smith, Huang, & Lin, 2009; Keller et al., 2012). In one study with adults in in Northern Ireland, consumers viewed milk as a commodity and therefore demonstrated a lack of brand loyalty (Hollywood et al., 2013); however, it is not known if the same effect would be observed in children. Harwood and Drake (2018) evaluated U.S. consumer perceptions of various fluid milk attributes. They applied a Maximum Difference Scaling exercise where consumers had to make trade-offs among fluid milk attributes and choose the "best" and "worst" options (Louviere & Woodworth, 1990). Brand of milk was the least important attribute to consumers overall. Price was the most important fluid milk attribute to consumers, again suggesting that milk is generally perceived as a commodity (Harwood & Drake, 2018). McCarthy et al. (2017b) also reported low brand identity with fluid milk for U.S. consumers. Similar effects of brand on consumer perceptions have been observed for flavored milk. Kim et al. (2013) reported that brand had no consistent effect on liking of chocolate milk, and brand was a less important than labeled milkfat content and sugar content. It should also be noted that there is great public scrutiny regarding the ethics of using brands or promotional characters in advertising food to young children, especially because these tactics are often utilized for energy-dense, low-nutrient foods (Elliott, 2007; Harris et al., 2010). However, although research is limited, such techniques could be used to make more healthful foods more appealing to children (Keller et al., 2012).

Packaging. Packaging material and form has a large effect on the consumer experience as well as the flavor of fluid milk. Milk packaging protects against microbial contamination, light, oxygen, and helps to maintain milk nutritional value during storage (Zygoura et al., 2004). The most commonly used materials used in milk packaging today include high-density polyethylene (HDPE) jugs, polyethylene terephthalate (PET) and polycarbonate (PC) bottles, high-impact polystyrene (HIPS) tubs, low-density polyethylene (LDPE) pouches, coated paper containers, and multilayered composite materials (Karaman, Özer, Pascall, & Alvarez, 2015). Harwood and Drake (2018) reported that packaging type was of low importance to adult consumers, however, the packaging form/shape may create consumer expectations about the product (Ares & Deliza, 2010). For instance, focus groups with consumers in Northern Ireland found that paperboard and non-translucent containers were less appealing to consumers than packages that allowed them to visually observe and assess the quality of the milk product (Hollywood et al., 2013). This is consistent with results reported by Harwood and Drake (2018), who found that in trade-off scenarios, consumers preferred plastic jugs over cardboard cartons.

Glass is a much less frequently used material in milk packaging due to its weight, expensive manufacturing, recycling, and shipping costs, as well as its tendency to break (Karaman et al., 2015). It is, however, highly protective against oxygen and moisture permeation. Unless it is tinted, glass is highly susceptible to light permeation. Glass is also an inert substance, and therefore does not impart off-flavors to the milk (Karaman et al., 2015).

HDPE jugs and bottles are the most popular type of package for fluid milk products (Brody, 2015). They are cost effective, durable, and consumer friendly as they can be comfortably dispensed and reclosed. While HDPE provides a good moisture barrier, by itself it is rather ineffective at protecting against oxygen and light. Therefore, milk packaged in HDPE jugs or bottles are susceptible to both oxidation of lipids (Cladman, Scheffer, Goodrich, & Griffiths, 1998) as well as light oxidation. To combat against light oxidation, multilayer bottles with pigmented with compounds such as titanium dioxide are typically employed (Karatapanis, Badeka, Riganakos, Savvaidis, & Kontominas, 2006). PET packages have the advantage of having mechanical strength while being lightweight, as well as providing a better oxygen barrier than HDPE (van Aardt, Duncan, Marcy, Long, & Hackney, 2001; Zygoura et al., 2004; Karatapanis et al., 2006). PET bottles can also be used for extended shelf life (ESL) packaging (Brody, 2015). Karatapanis et al. (2006) found that HTST pasteurized whole milk packaged in both clear and pigmented PET bottles developed plastic and oxidized off-flavors after 5 days of storage when exposed to fluorescent light, which significantly decreased the flavor quality. Additionally, PET packages didn't provide as much light protection as pigmented HDPE botted or paperboard cartons (Karatapanis et al., 2006). A common composite package used for fluid milk packaging in Europe and North America is the tetrahedron, which was developed by Tetra Pack. It is made from a combination of paperboard, polyethylene coating, and aluminum foil. This form is commonly used for extended shelf life packaging (Brody, 2015).

Gable top paperboard cartons are a popular form of packaging for fluid milk that is a half-gallon in size or smaller (Brody, 2015). They are produced by extruding a polyethylene layer onto paperboard (Lord, 2003). Advantages to this method of packaging include resistance to moisture, cost effectiveness, and ease of graphic application (Brody, 2015). A major problem with paperboard cartons is that they are highly susceptible to flavor migration of soluble compounds from the package, namely the polyethylene coating, to the milk (Leong, Harte, Partridge, Ott, & Downes, 1992; Lord, 2003). Paperboard cartons are also a poor oxygen barrier, and they also cause stale flavors over storage time (Karatapanis et al., 2006). Gable top paperboard cartons are especially common in school lunch programs (Brody, 2015). This should be a concern because, as previously discussed, flavor is the main driver for milk consumption in children. In regard to ease of use, they are more difficult to open than other packaging types and are not reclosable (Brody, 2015).

Children's Perception of Current Milk Packaging

Very little research exists on how visual design factors of packaging influence child acceptance of milk. Hollywood et al. (2013) reported that to this point, fluid milk packaging has been mostly utilitarian, homogenous, and unexciting to consumers, and that opportunities exist to improve consumer acceptance by emphasizing aesthetic and communicative packaging aspects. One study by Valajoozi and Zangi (2016) investigated the impact of packaging attributes on both children ages 7 to 14 y and their parents in Tehran. The study found that children found the form of the packaging type (e.g. Tetrapak vs bottle), background color, and illustration to be more important than their parents did, while parents found the font style to be more important than children did. In another study, Connors et al. (2001) conducted focus groups with students ages 6 to 11 y and identified that milk packaging color, graphics, and type influenced student perceptions and experiences with milk. Children used the color of the milk package to identify the type (e.g. chocolate vs skim). Children also expressed the desire for more frequently updated graphics. In relation to package type, some students noted that it was difficult to drink out of the gable-top carton without spilling (Connors et al., 2001). A study conducted by the School Nutrition Association and National Dairy Council suggested that children purchased and consumed more milk when it was served in a variety of sizes in plastic resealable bottles (Rafferty, Zipay, Patey, & Meyer, 2009). Serving in resealable plastic bottles instead of paperboard also decreased the average number of unopened discarded containers by 33%. In focus groups with adults, similar results were reported, with consumers citing increased durability, leak protection, and resealability as advantages over paperboard cartons (Hollywood et al., 2013). While the studies discussed here provide information about which packaging factors are noticed by children, there is a lack of information regarding the *relative* importance of milk packaging factors for children.

CONCLUSIONS & OBJECTIVE

Clearly the relationship between factors affecting children's acceptance of fluid milk is complex, with flavor, environmental, and packaging factors all playing a role. The objective of this research is to investigate child drivers of liking for milk in school lunch programs, specifically those items relating to packaging and its influence on flavor acceptance and packaging aesthetic and performance preferences. Special care must be taken to ensure that testing methods are appropriate for school aged children. The benefit of this research is that it could yield actionable outcomes that, if implemented in school milk programs, could increase school children's consumption of fluid milk. Increased milk consumption in children would provide lifelong health benefits.

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Table 1.1. Cognitive abilities, behaviors, and appropriate sensory tests for children and adolescents. (Adapted from ATSM, 2013).

Skill/Behavior	Pre-School 3 to 5 years	Kindergarten - 2nd Grade 5 to 8 years	2nd Grade - 6th Grade 8 to 12 years	6th Grade - 12th Grade 12 to 18 years
Language - Verbal, Reading/Written Language, Vocabulary	Early language development. Can observe facial expressions, respond to questions and pictures. Generally reading and writing skills are not present.	Moderately developed verbal and vocabulary skills; cognitive skills increase. Early reading and writing skills vary greatly at this age. Adult assistance is advised.	Increasingly verbal, self-expression improves. Reading and written language skills increase rapidly and are sufficient for most self-administered tests at the upper limits of this age group.	Generally strong language and vocabulary skills. Reading and written language skills continue to increase. Adult level in most respects.
Attention Span	Limited, but increasing. Bright colors and movement are effective.	Limited by understanding of test and interest level. Limit tasks to <15 min.	Attention span is increasing, but holding interest is critical and sometimes difficult. Taking tests is a familiar activity.	Similar to adults, involvement and interest subject to peer pressure.
Reasoning	Limited, but beginning to be able to verbalize what is liked and what is not.	Developing with increased learning, cause/effect concepts.	Full ability for understanding and reasoning, capable of decision making.	Reasoning skills are fully developed and similar to adults.
Decision Making	Limited, but concepts of what is liked and what is not strengthen. Able to choose one thing over another.	Ability to decide is increasing but influence of adult approval is evident.	Capable of complex decisions, peer influences are a factor.	Fully capable of adult decision processes, subject to peer influences.
Understanding Scales	Understanding of simple scales beginning, sorting or identification tests more effective.	Scale understanding increasing, simple is best, use easy vocabulary.	Capable of understanding scaling concepts with adequate instruction.	Similar to adults.
Recommended Evaluation Techniques	Behavioral observations, diaries, consumption or duration measurements, paired comparison, sorting and matching, limited preference, ranking, & one-on-one interviews	Previous, plus: Simple attribute ratings, liking scales including pictorial (such as facial scale) or simple word scales, group discussions, & concept testing	Previous, plus more abstract reasoning tasks: Hedonic scales, simple attribute scaling and ratings	Capable of all adult evaluation techniques.
Adult Involvement	Primary Caregiver Trained Observer Experimenter	Experimenter or Interviewer. Generally able to handle self-administered tasks.		Adult participation not required, unless appropriate to evaluation technique.

*These chronological ages are rough guidelines; a child's development age may not be the same as his/her chronological age. Researchers should pilot their test procedure with several respondents at the youngest age target to ensure that the child can do the required test and meaningful data can be collected.

Table 1.2. Appropriateness of sensory testing methods for children ages 2+. (Adapted from Laureati et al., 2015).

Sensory Method	Age Range (Years)			
Discrimination	**2-3**	**4-5**	**6-7**	**8+**
Paired comparison	No[1,29]	Yes [1,4], No[29]	Yes[1,29]	Yes[1,14,29]
Duo-trio	No[1,29]	No[1,29]	Yes[1,29]	Yes[1,29]
Same-different	-	Yes[5]	Yes[5]	Yes[5]
Triangle			Yes[28]	Yes[28]
Tetrad			Yes[28]	Yes[28]
Intensity ranking	No[1,29]	Yes[1,17], No[29]	Yes[1,17]	Yes[1,17,19,20]
Intensity scaling	No[29]	No[29]	Yes[13, 29]	Yes[13,29]
Preference				
Paired preference	Yes[1,2,3,29]	Yes[1,4,29], No[6,7]	Yes[1,7,29], No[6]	Yes[1,6,7,26,29]
Preference ranking		Yes[1,4,8,15,16,17], No[7]	Yes[1,7,15,16,17,18]	Yes[1,7,16,17,18,19,20]
Hedonic Scales				
3-point	-	Yes[9,10,11,15,16]	Yes[15,16]	Yes[16]
5-point	-	Yes[11, 12,18,25]	Yes[13,18]	Yes[13,18,19,20]
7-point	No[1]	Yes[1,6,11,27]	Yes[1,6,11,21,22,23]	Yes[1,6,21,22,23]
9-point	-	Yes[6]	Yes[6]	Yes[6,24]

References: [1] Kimmel et al, 1994; [2] Birch, 1980; [3] Johnson et al, 1990; [4] Liem et al, 2004; [5] Thomas & Murray, 1980; [6] Kroll, 1990; [7] Léon et al, 1999; [8] Birch, 1979; [9] Birch, 1999; [10] Birch et al, 1990; [11] Chen et al, 1996; [12] Fallon et al, 1984; [13] Zandstra & de Graff, 1998; [14] James et al, 1997; [15] Poelman & Delahunty, 2011; [16] Rollins et al, 2010; [17] Liem & Mennella, 2003; [18] Liem & Zandstra, 2010; [19] Kildegaard et al, 2011b; [20] Kildegaard et al, 2011a; [21] Laureati & Pagliarini, 2013; [22] Laureati et al, 2011; [23] Pagliarini et al, 2005; [24] Moskowitz, 2002; [25] Donadini et al, 2013; [26]; Cordelle et al, 2005; [27] Caporale et al, 2009; [28] Garcia et al, 2012; [29] Guinard, 2000.

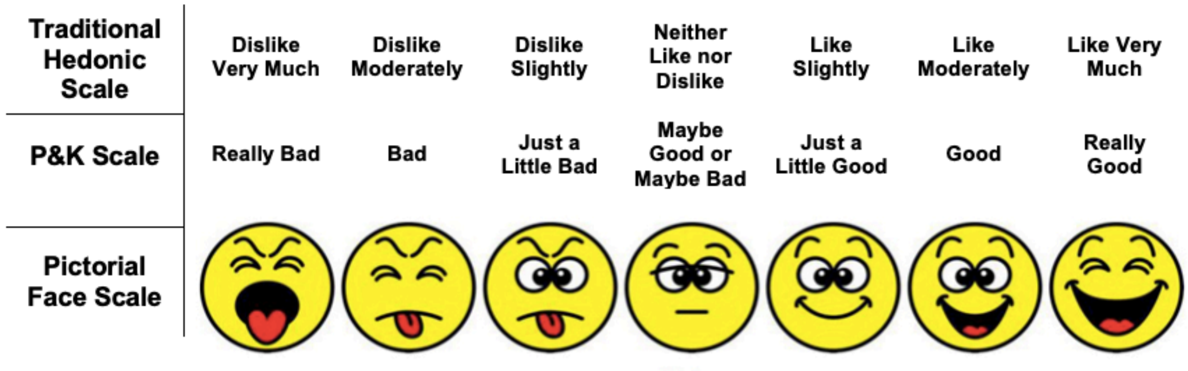

Figure 1.1. Traditional and child-oriented hedonic scales used in affective testing. Adapted from Kroll, 1990.

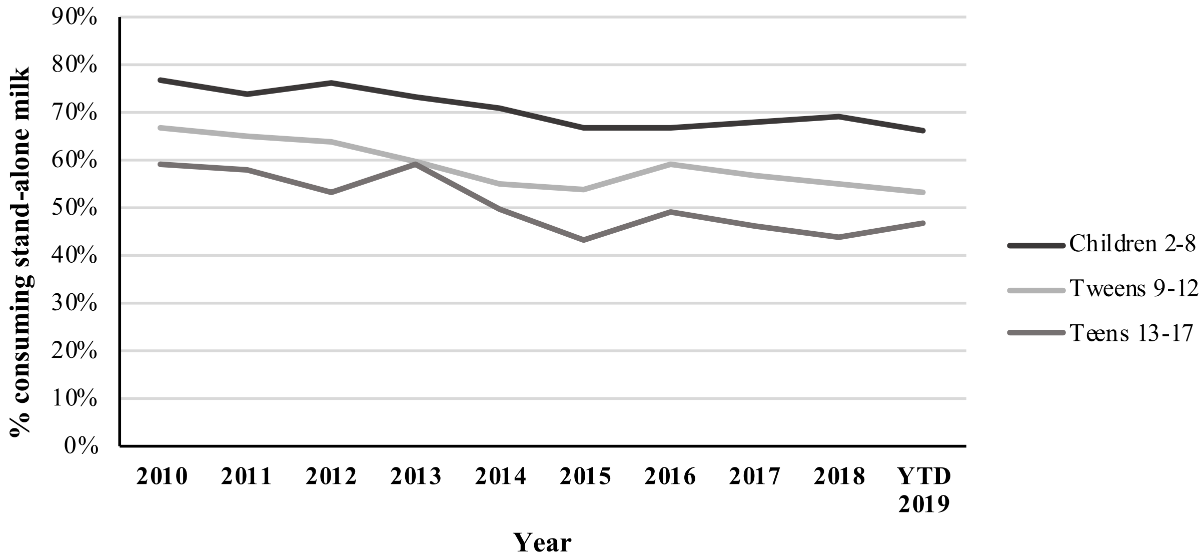

Figure 1.2. Percentage of children consuming stand-alone milk (milk in a glass) over time as a function of age. Adapted from MilkPEP Consumption Database.

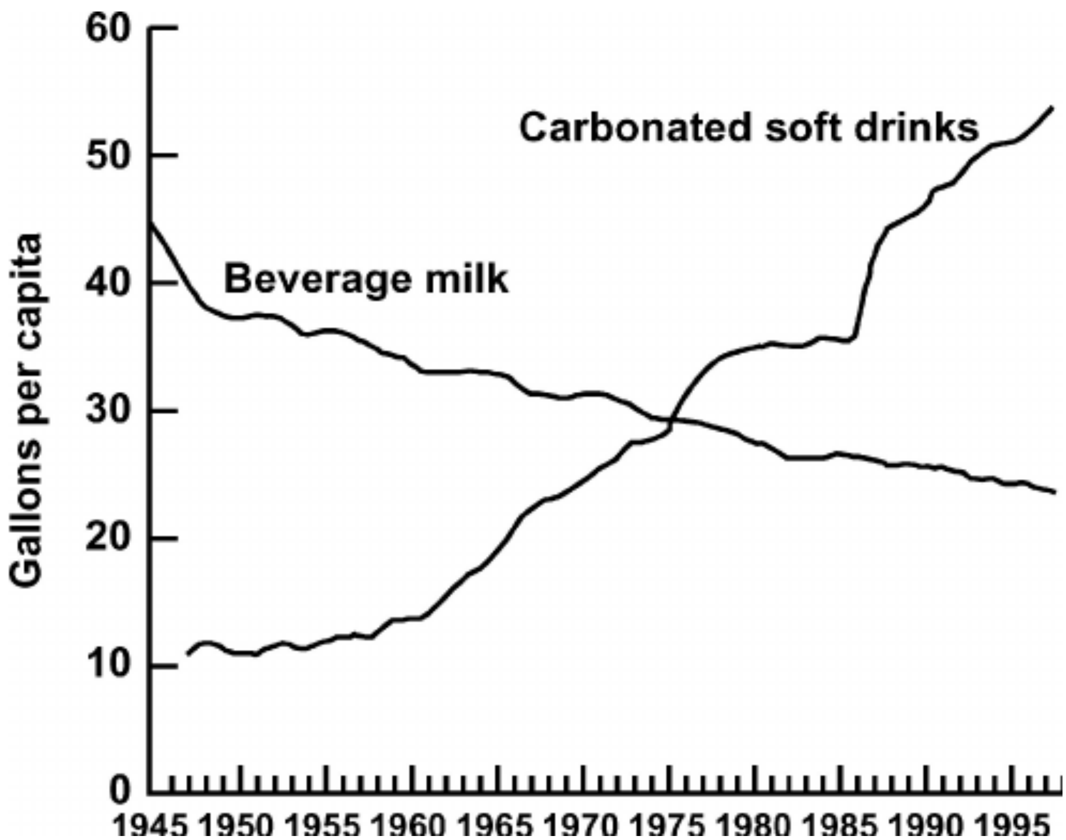

Figure 1.3. Milk consumption compared against soft drink consumption since 1945. Taken from Huth et al., 2006.

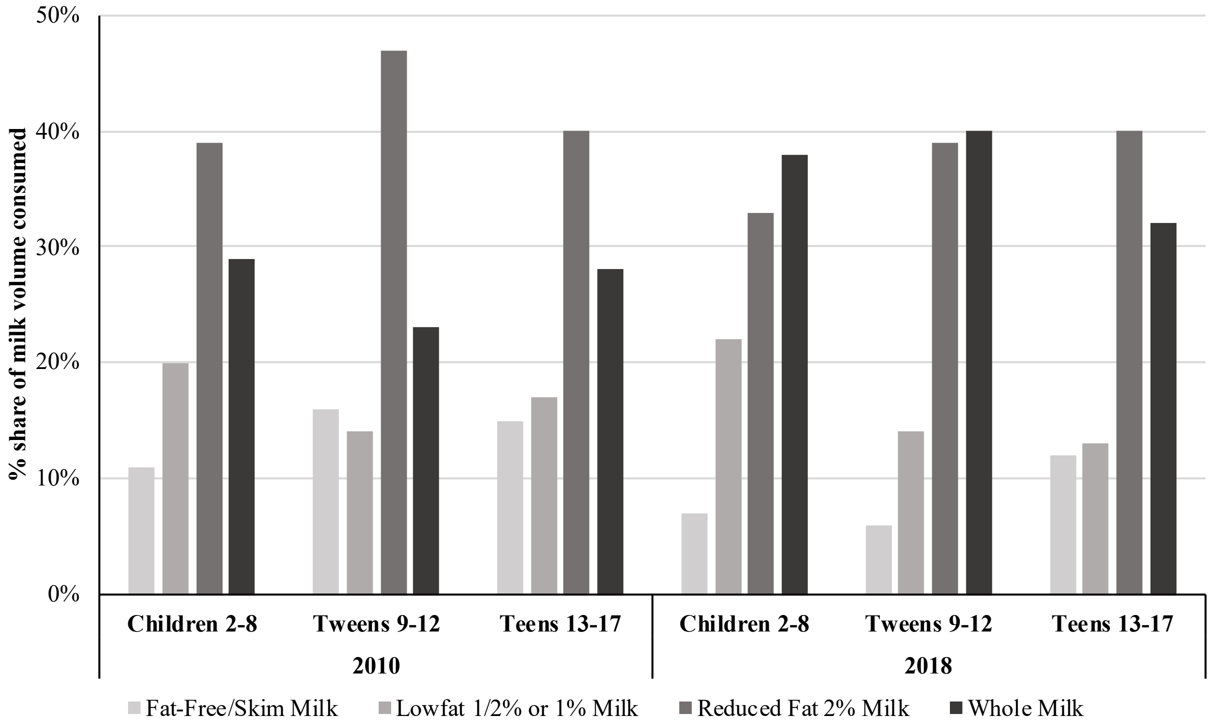

Figure 1.4. Share of milk consumption by milkfat content during 2010 and 2018 for children of different age groups. Adapted from MilkPEP Consumption Database.

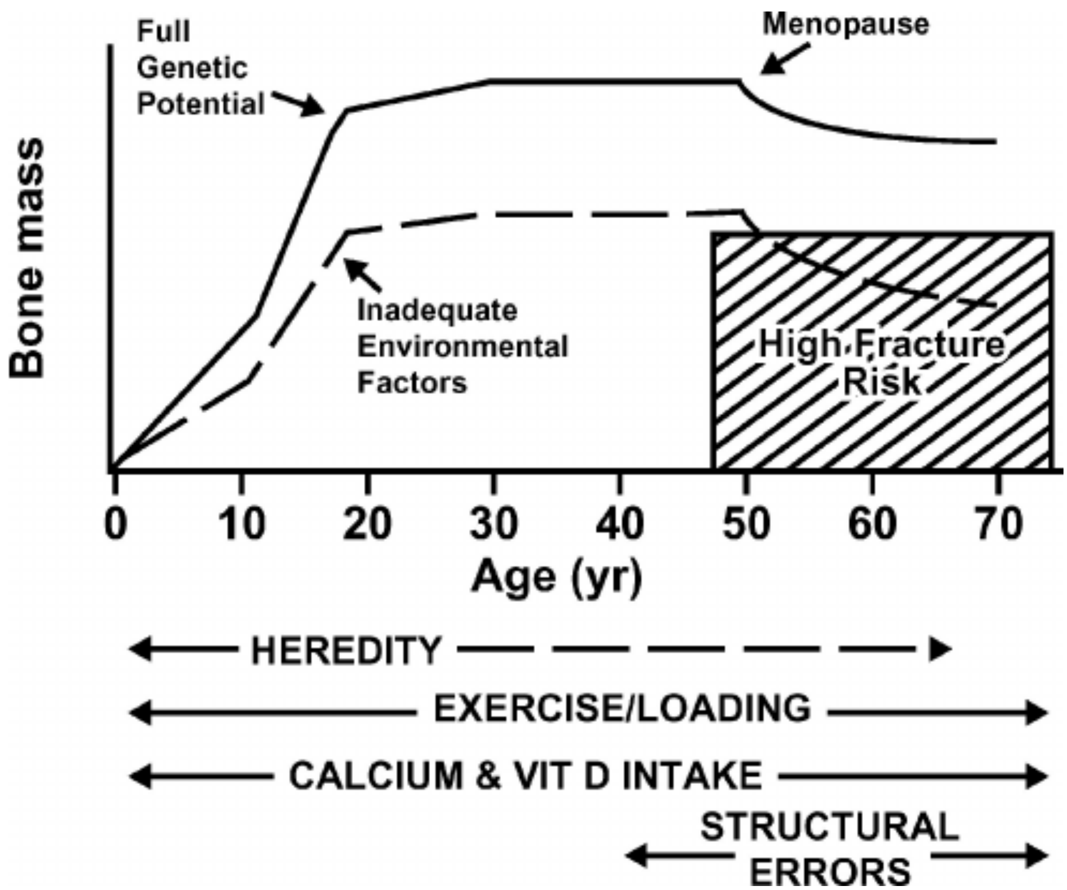

Figure 1.5. Calcium, (as well as Vitamin D, genetics, and physical activity,) influence peak bone mass achieved and therefore fracture risk later in life. Taken from Huth et al., 2006.

CHAPTER 2: CHILDREN'S PERCEPTIONS OF EXTRINSIC AND INTRINSIC ATTRIBUTES OF FLUID MILK FOR SCHOOL MEAL PROGRAMS

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ABSTRACT

School meal programs in the United States feed approximately 30 million children each day and account for the majority of child milk intake. Dairy consumption during childhood and adolescence has lasting impacts on lifelong health status, so it is important for schools to ensure adequate consumption in this life stage by offering an appealing product. This study identified the intrinsic and extrinsic attributes that influence children's perceptions, attitudes, and consumption of fluid milk at school, especially as they relate to fluid milk packaging. An online choice-based conjoint (CBC) survey (n=211) and four 1-hour focus groups (n=31) were conducted with child milk consumers ages 8-13 y to evaluate extrinsic attributes. The survey evaluated milk package attributes including packaging type, front-of-package graphics, package color, and labeled milkfat content. Focus groups topics included perceptions of preference, usability, health, taste, and milk consumption habits. To evaluate intrinsic properties related to packaging, three varieties of milk (unflavored fat free, unflavored low-fat, and chocolate flavored fat free) were produced and packaged in polyethylene-coated paperboard cartons, polyethylene terephthalate (PET) bottles, and high-density polyethylene (HDPE) bottles (all 250 mL). After 10-13 d of storage at 4°C under dark conditions, milks were evaluated by descriptive analysis and child acceptance testing (ages 8-13 y, n=126; n=122; and n=126 for each variety, respectively). Extrinsically, package type was the most important attribute to children ($P < 0.05$), but graphics, nutritional labeling, branding, package size, and overall familiarity also drove preferences. The ideal milk packaging build from the conjoint survey was a HDPE bottle with blue-colored packaging and a cow graphic, labeled as low-fat milk. Intrinsically, all varieties of milks packaged in paperboard cartons developed package-specific flavors, including refrigerator/stale and paperboard, after 10 d of storage. These off-flavors were not detected in

HDPE or PET packaged milks. For unflavored milks, child consumers preferred the flavor of PET or HDPE packaged milks over cartons ($P < 0.05$), regardless of milkfat content, but preferences were not distinct for chocolate flavored milk. The results of this study demonstrate that children's liking and preference for milk are driven by both intrinsic and extrinsic factors and suggest that improvements are needed to increase acceptance of milk currently served in school meal programs.

Keywords: fluid milk, children, packaging, conjoint analysis, consumer acceptance

INTRODUCTION

Milk and dairy products provide essential nutrients to the diet, including protein, vitamins, and minerals. In the United States, milk comprises the majority of dairy consumption and is the primary source of calcium, potassium, and Vitamin D in the diets of children ages 2-18 y (Keast et al., 2013; USDHHS and USDA, 2015). The nutritional profile that milk provides not only contributes to growth and development in children and adolescents, but also to weight management and risk reduction of chronic diseases such as osteoporosis, hypertension, dental caries, and colorectal cancer (Huth et al., 2006; Dror and Allen, 2014; Kang et al., 2019).

Due to the nutrient density of dairy foods, the U.S. Dietary Guidelines for Americans recommend that children ages 2-3 y consume 2 cup-equivalents (**cup-eq**), ages 4-8 y consume 2 ½ cup-eq, and ages 9-17 y consume 3 cup-eq of dairy daily (USDHHS and USDA, 2015). In order to ensure that school meals are meeting current dietary recommendations, milk is a required component of federal school meal programs, including the National School Lunch Program and School Breakfast Program (IOM, 2010; USDA FNS, 2012). In 2018, these programs provided nearly 5 billion lunches and 2.4 billion breakfasts to students, respectively (USDA ERS, 2019). These school meals account for the majority of children's (ages 5-18 y) milk intake (Sebastian et al., 2010; Cullen and Chen, 2017). Schools that participate in these programs receive cash subsidies for the reimbursable meals that they serve, provided they meet the codified federal nutrition standards in 7 CFR Parts 210 and 220. These standards require that participating programs must offer one cup of milk as a part of each meal. At least two options of fluid milk must be available, which can be fat-free or low-fat milk (unflavored or flavored), and all milk must be pasteurized and fortified with vitamins A and D (USDA FNS, 2012). From 2012-2017, programs could only offer flavoring in fat-free milk; however, serving flavored low-fat milk was initially made allowable by interim rule from 2017-2019 and codified beginning in the 2019-2020 school year by the USDA Food and Nutrition Service, reasoning that it might improve child milk consumption (USDA FNS, 2018). Milk substitutes may only be offered to students with medical or special dietary needs and must provide nutrients comparable to that of dairy milk (USDA FNS, 2012).

Despite its nutritional health benefits and accessibility in schools, an overall decline in dairy milk consumption has been observed, in terms of the proportion of children consuming milk, the number of servings consumed per day, and the proportion of children consuming milk in schools (Sebastian et al., 2010; Dror and Allen, 2014; USDA FNS, 2019). Although children 3 y and younger typically consume the recommended amount of dairy servings, all other age groups, children and adults included, fall below the recommended daily dairy intake (USDHHS and USDA, 2015). Additionally, a study by the USDA Food and Nutrition Service during the 2014-2015 school year found that 41% and 29% of milk observed on school breakfast and lunch trays was wasted, respectively (USDA FNS, 2019). McCarthy et al. (2017b) reported that one of the primary drivers of adult fluid milk consumption was habit, suggesting that establishing childhood milk consumption will also increase lifetime milk consumption. Therefore, a primary area of interest for improving overall milk consumption is investigating ways to improve child liking and consumption of milk served in schools. In order to do so, it is important to understand child milk preferences in order to create fluid milk products that are appealing to children.

Several demographic factors influence child milk intake, including age, sex, ethnicity, and dietary patterns. Children drink less milk as they age, and females tend to consume less milk than males. African American children also consume less milk than their Caucasian or Hispanic counterparts (Fiorito et al., 2006; Storey et al., 2006; Sebastian et al., 2010; Dror and Allen, 2014). Children that consume other beverages (including sweetened beverages, fruit juice, and plant-based milk alternatives) consume less milk, while children who consume breakfast tend to consume more milk due to higher milk consumption at breakfast than other meals (Dror and Allen, 2014; Morency et al., 2017).

Factors associated with the milk itself, including composition and manufacturing methods, can also affect child milk consumption. Flavoring of milk is positively associated with a higher overall milk intake, as the majority of children find flavored milk to be more palatable than plain milk (Johnson et al., 2002; De Pelsmaeker et al., 2013; Fayet-Moore, 2016; Nicklas et al., 2017). Removing flavored milk from schools has been demonstrated to result in a significant decline in school milk consumption (Quann and Adams, 2013). However, there are concerns with increased caloric intake from added sugars present in flavored milk (Noel et al., 2013; Patel et al., 2018). Sugar reduction, use of alternative non-nutritive sweeteners, and lactose hydrolysis have been studied as possible solutions to address these concerns without significantly impacting child liking of flavored milk (Castillo et al., 2005; Li et al., 2015a,b; Oliviera et al., 2016). Although few studies have evaluated children's liking of milk with different milkfat contents, a study by Kling et al. (2016) with children ages 3-5 y found that both liking and consumption were similar for low-fat (1% fat) and whole (3.25% fat) milk. Milk processing, particularly the heat treatment method used, may also impact child milk liking. Studies have demonstrated that like adults, children prefer milk produced using high-temperature short-time (**HTST**) pasteurization over ultra-pasteurized (**UP**) or shelf stable (ultra-high temperature processed, **UHT**) milk, likely due to the undesirable cooked/sulfur flavors associated with the release of volatile sulfur compounds caused by UHT and UP processing (Chen et al., 1996; Chapman and Boor, 2001; Lee et al., 2017; Jo et al., 2019).

One area that has received little attention in regard to children's perception of fluid milk is its packaging. Currently, school meal program operators must publicly solicit bids from potential suppliers when procuring fluid milk. In order to be eligible for federal reimbursement of school meals, these programs must award a firm fixed price contract to the bidder with the lowest price per 2 CFR 200.320 (OMB, 2014). As a result, most school meal programs serve milk packaged in cartons due to the relatively low cost of paperboard compared to other milk packaging materials, limiting the ability of program operators to offer other packages as a part of school meals. However, research suggests that milk and dairy packaging influence child perception and consumption of these products (Connors et al., 2001; Ares and Deliza, 2010; Enax et al., 2015; Valajoozi and Zangi, 2016; Elliot, 2018). A pilot study by Rafferty et al. (2009) suggested that improving milk packaging, such as offering milk in plastic resealable bottles instead of paperboard cartons or offering milk in various serving sizes, could increase milk consumption in schools. Packaging has both extrinsic properties and also contributes potential intrinsic properties (flavor contributions) to milk that influence consumer perceptions (Leong et al., 1992; Kim et al., 2013). The purpose of this study was to investigate the importance of the extrinsic factors (package type and appearance) and intrinsic factors (flavor) of fluid milk, particularly those associated with milk packaging, in regard to child acceptance.

MATERIALS AND METHODS

Experimental Overview

This study was designed to evaluate child perception of extrinsic and intrinsic fluid milk properties as they pertain to school milk. An online conjoint survey was used to evaluate the importance of extrinsic properties (including package type, package color, front-of-package graphics, and labeled milkfat content) to child consumers (ages 8-13 y). Focus groups were subsequently conducted with children to verify and elucidate survey results regarding extrinsic factors. Evaluation of intrinsic properties contributed by package materials was conducted by producing three varieties of milk and packaging each milk variety into three different materials commonly used for milk packaging (**Table 2.1**) at a volume typical for school lunch milk. Consumer acceptance testing with children and descriptive analysis with a trained panel were conducted on these milks to identify differences in flavor properties and child liking and preference.

Participants

All testing was conducted in compliance with North Carolina State University Institutional Review Board (NCSU IRB) regulations. Parents of children ages 8-13 y were contacted using an online database of >10,000 consumers from the greater Raleigh/Durham/Chapel Hill, NC area maintained by the Sensory Service Center at NCSU. Children whose parents reported that they did not have any food allergies, intolerances, or dietary restrictions, who attended public or private school, and who consumed milk purchased at school could qualify for this study. Additional qualification criteria for the survey, focus groups, and consumer acceptance tests is subsequently specified.

Extrinsic Milk Properties

Choice-Based Conjoint Survey

A traditional full-profile choice-based conjoint (**CBC**) survey was created using Lighthouse Studio (Sawtooth Software version 9.6.1, Orem, UT). Olsen et al. (2012), Jervis et al. (2014), and Ares et al. (2016) have previously used conjoint techniques to analyze child preferences for food products and label design of food products. Children (n=250) ages 8-13 y that consumed plain (unflavored) fat free or low-fat milk at school at least once or twice a week were recruited to participate (based on survey responses from their parents), and a total of 211 participants came to the NCSU campus to complete the CBC survey.

The CBC survey included four attributes, with 2 to 6 levels per attribute (**Table 2.2**). The milk packaging attributes assessed in the survey were packaging type, labeled milkfat content, front-of-package graphics, and package color. Within the packaging type attribute, the levels included paperboard carton, polyethylene terephthalate (**PET**) bottle, high-density polyethylene (**HDPE**) bottle, box with straw, box with cap, and pouch. Labeled milkfat content attribute levels were chosen to represent the milk varieties that are allowed to be served in schools by federal regulation (USDA FNS, 2012), which include fat free and low-fat (1%) milk. Within the front-of-package graphics attribute, levels included milk, a cow, and a licensed character. Within the color attribute, levels included blue, pink, and gold. All packaging concepts were presented in the context of plain (unflavored) milk. To facilitate children's understanding of the attributes presented in this survey, milk packaging attributes were visually represented in a single image by displaying one level for each attribute to create a composite milk packaging concept (**Figure 2.1**). A total of 108 images representing all possible product builds from the selected milk packaging attributes and their respective levels were created using Photoshop® CC (Adobe, San Jose, CA).

Children were seated at desks with dividers in a classroom to take the survey. Each child was provided with an iPad to complete the conjoint exercise. During the survey, children were asked to complete 15 choice tasks. Each choice task presented three randomized packaging concepts, and children were prompted to select which of the three milks they would want to drink as follows: "Here are three different milks for you to choose from. Out of the three, please pick the one you would want to drink". Trained moderators were present for the duration of the survey to explain the conjoint exercise and to answer any questions. Each child was allowed to take as much time as they needed to complete the survey, the average time was 15 minutes. At the conclusion of the survey, participants received a $40 gift card to a local store.

Focus Groups

Focus groups were conducted to verify survey results and to elucidate child perceptions towards fluid milk packaging. Children ages 8-13 y that consumed milk purchased at school at least 1-2 days per week and were plain (unflavored) fat free or low-fat milk consumers (n=31) were recruited and participated in focus groups. A total of four focus groups lasting approximately 1 h were conducted at the NCSU Dept. of Food Science, with 5 to 10 children participating in each focus group. The participants received a $60 gift card to a local store as compensation for their participation.

Focus groups were led by an experienced moderator using a discussion guide (**Figure 2.2**). Upon their arrival, children were presented with six commercial milks containing between 1-2 servings of unflavored low-fat (1 or 2% milkfat) milk and asked to select their "favorite".

These samples were procured from the Raleigh, NC area and represented a variety of packaging types (including bottle, carton, and box), brands, graphics, and nutrition claims. The children's selections were discussed at the start of the focus group ("Why did you choose that particular container of milk to drink?"). Next, all six commercial milks were placed in front of each child. The children were asked to look at the package and discuss how likely they would be to consume each product if it were served in their school's cafeteria, as well as their perceptions of the health, taste, and usability of each product. Children were then given a sheet of paper and asked to rank all the milk containers from their most favorite to their least favorite. These rankings were discussed to determine the criteria children used to rank the samples. Finally, children's milk consumption habits (frequency and occasions) as well as perceptions of the milk packaging currently served in their schools were discussed. Video and audio of the focus groups was recorded for later reference, and one observer took notes during each focus group. These items were subsequently reviewed to determine the common themes and key takeaways from the focus groups.

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Sample Preparation

Unflavored and chocolate milks were obtained and processed by the North Carolina State University commercial dairy facility (Raleigh, NC, USA). Unflavored milk was pasteurized at 81.1°C for 28 seconds and homogenized at 13.8 MPa in a 2-stage homogenization process (Stage 1=10.3 MPa; Stage 2=3.4 MPa), while chocolate milk was pasteurized at 83.9°C for 28 seconds and homogenized at 6.2 MPa in a 2-stage homogenization process (Stage 1=3.4 MPa; Stage 2=2.8 MPa). A total of three types of milk (unflavored fat free milk, unflavored 1% low-fat milk, and chocolate flavored fat free milk) were separately produced in duplicate on two separate occasions. Chocolate milk was formulated with 94.2% skim milk, 4.9% extra fine granulated pure cane sugar (United Sugars® Corporation, Clewiston, FL), and 0.9% cocoa blend (cocoa processed with alkali, salt, carrageenan, and vanillin; The Benjamin P. Forbes Co, Broadview Heights, OH).

Fat content and total solids of each milk was confirmed prior to packaging using a Fourier Transform Mid-Infrared (**FTIR**) spectrophotometer (Lactoscope FTA, Delta Instruments, Drachten, Netherlands). The FTIR milk product group was used and calibrated using modified milk samples as described by Kaylegian et al. (2006). Microbiological analyses were performed on milks at 0 d and 10 d post-production. Samples were taken from each package type and plated in triplicate for aerobic plate count (**APC**) and coliform count (**CC**) and allowed to incubate at 35°C for 24 and 48 h, respectively, using Petrifilm™ plates (Aerobic Count Plates and Coliform Count Plates, 3M™, St. Paul, MN).

Three package types commonly used for fluid milk were selected for descriptive analysis and child consumer acceptance testing: polyethylene terephthalate (PET) bottles (Corning®, Big Flats, NY), high-density polyethylene (HDPE) bottles (VWR®, Radnor, PA), and low-density polyethylene coated paperboard gable top cartons (Evergreen Packaging, Cedar Rapids, IA). The barrier properties of each material are indicated in **Table 2.3**. Each container had a 250 mL volume and was filled with 225 mL (±5 mL) of milk. Paperboard cartons were filled using a Model EQ3 Quart Cross-Section Filler (Evergreen Packaging, Cedar Rapids, IA). To fill PET and HDPE bottles, milk was collected from a bag-in-box line into a sanitized milk can, then sanitized stainless-steel cups were used to fill the milk into bottles under a clean-fill hood with a HEPA filter (Microthermics, Raleigh, NC). Milks were then stored at 4°C under black laser cloth to prevent development of light oxidation flavors. Milks were evaluated by trained panelists following 10 d and by child consumers following 12-13 d at 4°C. Our goal was to evaluate possible package-imparted flavors while still within a typical shelf life for HTST fluid milk, thus representing what would be realistic within a scenario for milk served in school meal programs.

Descriptive Analysis

Seven trained panelists (2 males, 5 females, ages 23 to 55 y), each with at least 60 h of previous experience with the descriptive analysis of dairy products, including milk, evaluated milks from each replicate in duplicate. An established lexicon for fluid milk flavor (Lee et al., 2017; McCarthy et al., 2017a) was applied using the Spectrum^{TM} descriptive analysis method (Meilgaard et al., 2007). Additionally, chocolate flavored milks were evaluated for cocoa flavor. Each milk was poured into a lidded 60 mL soufflé cup with a randomly generated 3-digit code and tempered to 15°C. Samples were prepared with overhead lights off to prevent light oxidation. Paper ballots were used for data collection.

Child Acceptance Testing

Children ages 8-13 y that consumed milk purchased at school at least 2-3 times per month were recruited per test. Children that participated in the unflavored fat free milk test (n=126) or the unflavored low-fat milk test (n=122) were consumers of unflavored fat free or low-fat milk, and children that participated in the fat free chocolate milk test (n=126) had to be consumers of flavored fat free or low-fat chocolate milk. Testing was conducted at the NCSU

Dept. of Food Science. Data were collected using an electronic ballot through Compusense Cloud software (Compusense Inc., Guelph, Canada).

During each test, children were presented with milk from each packaging treatment for a total of 3 samples. Milk (60 mL) at 4°C was poured into a 148-mL Styrofoam cup with a random three-digit blinding code. In addition to microbial quality analyses on milks (described previously), each milk was screened by an experienced milk judge as it was poured for children to ensure no spoilage or atypical flavors. Samples were prepared and poured with overhead lights off to prevent light oxidation. Samples were served one at a time under 25 W fluorescent white lighting conditions and in a Williams design to prevent presentation order effects. A two min rest with deionized water and an unsalted cracker as palate cleansers was required between samples. Children were asked to evaluate their liking of the appearance, aroma, and overall liking on a modified 7-point smiley face scale where 1 = Really Bad and 7 = Really Good (Kroll, 1990). For all milk types, a just-about-right (**JAR**) question was asked for flavor (1 or 2 = Not Strong Enough, 3 = JAR, 4 or 5 = Too Strong), and an additional sweetness JAR question was asked only for chocolate flavored milk (1 or 2 = Not Sweet Enough, 3 = JAR, 4 or 5 = Too Sweet). Children were also asked their purchase intent on a 5-point scale (1 = Definitely do not want mom or dad to buy, 5 = Definitely want mom or dad to buy) and their liking of the sample compared to the milk they usually drink at school on a 5-point scale (1 = I like it a lot less, 5 = I like it a lot more). After tasting all three samples, children were asked to indicate their preferred sample (the sample they would most like to take home with them) and then asked to rank all three samples in order of preference. After completing the test, participants were compensated with a $40 gift card to a local store.

Statistical Analysis

Hierarchical Bayes (**HB**) analysis was used to determine individual utility scores from the conjoint survey. K-means clustering was then conducted to put similar respondents into clusters. One-way ANOVA with Fisher's least significant difference (LSD) for means separation was used to analyze overall importance and utility scores, as well as differences in scores between clusters. Logistic regression was used to identify associations between demographic data and cluster membership.

One-way ANOVA with Fishers LSD for means separation was performed on descriptive analysis data and 7-point hedonic data from consumer acceptance testing. JAR scores were analyzed using chi-square with the Marasculio procedure for multiple comparisons and reported as the percentage of respondents who selected each option, while 5-point non-JAR scales were analyzed using Kruskal Wallis with Dunn's post-hoc test for multiple comparisons. Two-way ANOVA with Fisher's LSD was used to identify any effects of gender, age, school level, or screener-reported milk consumption habits on overall liking scores from consumer acceptance testing. All statistical analyses were performed at a 95% confidence level and all but HB regression (Sawtooth Software version 9.6.1, Orem, UT) were performed using XLSTAT (version 2019.3.1; Addinsoft, New York, NY, U.S.A).

RESULTS AND DISCUSSION

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Choice-Based Conjoint Survey

A total of 211 children ages 8-13 y completed the CBC survey. Subsequent to HB analysis, respondents with a root likelihood value below 0.333 (n=22) were removed prior to conserve the quality of the data (Orme, 2014). Children included were 52.4% male and 47.6% female and attended elementary (44.4%) or middle (55.6%) school, with an average age of 10.7 y. Based on screening information provided by parents/guardians, the type of milk most often consumed at school was flavored milk (61.5%) over unflavored milk (38.5%), with at-school milk consumption typically being comprised of low-fat milk (85.7%) over fat free (14.3%) milk. Additionally, screening information indicated that at school, child participants typically consumed milk from a paperboard carton (96.2%). The resulting zero-centered utilities from the remaining participants (n=189) indicate relative desirability of attribute levels, with higher utility scores being more desirable. Based on the highest utility score within each attribute, the ideal fluid milk package was an HDPE bottle with a cow graphic on the front of the package, blue in color and labeled as low-fat (**Figure 2.3**).

Importance scores are indicative of the impact a particular attribute has on choice of a milk package concept. Of the attributes evaluated, package type had the highest importance ($P < 0.05$), followed by the front-of-package graphics ($P < 0.05$) (**Figure 2.4**). The color of the package and labeled milkfat content scored at parity ($P > 0.05$) with the lowest importance scores of the attributes studied ($P < 0.05$) (**Figure 2.4**). The zero-centered mean utility scores for the entire population sampled revealed that within packaging type, HDPE was the most preferred ($P < 0.05$), followed by the PET bottle and carton, which scored at parity (**Table 2.4, Figure 2.3**).

The pouch was the least preferred of the package options ($P < 0.05$) (**Figure 2.3**). Based on focus group discussions, lower desirability of box and pouch-style packaging may be due to an association with juice packaging ("people might confuse them with juice") or unfamiliarity of this packaging option for fluid milk. Regarding the front-of-package graphics, the cow and milk graphics scored at parity ($P > 0.05$) and were preferred ($P < 0.05$) over the use of a licensed character. Use of specific licensed character may depend on demographics/age of child and the specific character used. Children liked the use of imagery that was related to the product itself (cow). Blue was preferred over pink and gold package color ($P < 0.05$). However, color utilities must be interpreted with caution as there is typically an association between package color and the type (e.g. milkfat content, flavor) of the milk. Finally, low-fat received the highest utility score for labeled milkfat content (**Table 2.4, Figure 2.3**).

Importance scores were subjected to k-means clustering with two distinct groups identified. These clusters were denoted as the packaging cluster (n=140) and the milkfat cluster (n=49) based on their importance and utility scores. The ideal builds for each cluster were the same as the ideal build overall (n=189), with exception of labeled milkfat content for the packaging cluster. The packaging cluster was characterized by a significantly higher importance on package type as well as front-of-package graphics than the milkfat cluster ($P < 0.05$) (**Figure 2.4**). Within the package type attribute, the packaging cluster exhibited significantly higher preference for HDPE bottles, PET bottles, and cartons than the milkfat cluster, whereas the milkfat cluster was more accepting of the box with straw and pouch options, suggesting that the milkfat cluster is more accepting of less familiar or less common packages (**Table 2.4**). The distinguishing factor for the milkfat cluster was a higher importance placed on labeled milkfat content ($P < 0.05$) (**Figure 2.4**), with a preference for low-fat milk. The milkfat cluster also had a lower preference for pink packaging than the packaging group; however, this may be related to the representation of milkfat content by package color.

Logistic regression was utilized to check for association between demographics and cluster membership. No association of gender, age, or school type (elementary or middle school) on cluster membership was detected ($P > 0.05$). Consumption of a particular type of milkfat (e.g. fat free vs low-fat) as reported by parents during screening was also not a predictor of cluster membership ($P > 0.05$). However, an effect of the milk flavor children most often consumed at school on cluster membership was observed, with unflavored milk consumers more frequently affiliated with the milkfat cluster and flavored milk consumers more frequently affiliated with the packaging cluster ($P < 0.05$). This effect may be due to familiarity (e.g. knowing what to look for) with milkfat since the product builds represented in the survey were of unflavored milk rather than flavored.

Little research exists on child preferences for milk packaging type, but packaging type/form has been shown to influence children's preferences for other food products. For instance, when offered yogurt/pudding in a tube and in a cup, nearly all male children chose product in a tube and all female children chose the cup packaging (Elliot, 2009). The study indicated that preferences for the product were based on the expectations of taste and function shaped by the different packaging forms. Children's preference for milk bottled in HDPE containers echoes results from studies with adult consumers that have indicated a preference for plastic jugs over cardboard cartons (Harwood and Drake, 2018). A study by Hollywood et al. (2013) found that the preference for plastic containers was related to the fact that they were more easily resealed than cardboard cartons and that the product could be seen through the plastic, which increased their trust of the product's safety. Regarding front-of-packaging graphics, the cow and milk graphics had a higher utility than the licensed character. This is an interesting finding as many studies have found that the use of media characters typically increases children's product preference (see review by Kraak and Story, 2015). de Droog et al. (2012) found that congruent characters were received more positively by children than incongruent characters (i.e. a character not related with the product) when the characters were unfamiliar, but that a familiar character was as preferred as a congruent character. The milk-milk or cow-milk character-product congruence may have resulted in a higher preference for these options. It might also suggest that either children were either unfamiliar with the media character used in this study or the specific character used was simply not preferred. Additionally, Letona et al. (2014) found that younger children (4-6 y) were more likely to prefer food in a package with a licensed character than older children (7-11 y), so perhaps the age range of the children evaluated also had an influence.

The relatively low importance of labeled milkfat content was surprising, as previous studies have indicated that flavor/taste is the primary driver in product preference and selection of foods and beverages for children (Elliot, 2009; Letona et al., 2014). For instance, a study by Hill and Tilley (2002) also found that while children had distinct ideas of their ideal cereal package, a few children noted that packaging alone wouldn't prompt them to purchase a cereal. While research regarding children's milkfat preferences in fluid milk is lacking, adults have been reported to prefer low-fat (1%) milk over fat free milk in both flavor and labeling contexts (McCarthy et at., 2017a,b; Harwood and Drake, 2018). Additionally, 2018 fluid milk consumption data indicates that low-fat milk comprises a larger share of the milk consumed by children ages 2-17 y than skim milk (D. Colbert, personal communication, Oct. 17, 2019). Studies have previously found that consumers, including children, can draw associations between the color of a package and what it conveys about the type/flavor (e.g. color coding) of foods and beverages; however, the role of color codes on product choice in children is unclear and could be product specific (Connors et al., 2001; Gollety and Guichard, 2011; Piqueras-Fiszman and Spence, 2011). Specific to milk, Connors et al. (2001) reported that children used carton color as a shortcut to differentiate between four types of milk. Therefore, the preference for blue colored packaging across the population may have been related to a preference for its represented milk type, that being low-fat milk. The packaging cluster in particular, for which a relatively low importance of labeled milkfat content was observed in this study, may rely on color rather than labeled milkfat content in selection of fluid milk type.

Focus Groups

Results from focus group "favorite" and ranking activities of commercial milks are in **Table 2.5**. The majority of children (over 90%) indicated that a bottled milk was their favorite of the six commercial options available (4 bottles, 1 box, 1 carton). This result was consistent with results from the conjoint survey, as well as packaging preferences identified in adults by Harwood and Drake (2018). The most frequent reasons children cited for selecting a particular milk as their favorite included familiarity (e.g. parents had previously purchased it) or the appearance of the package (including package type and graphics). The size of the container, and thus the number of servings, was occasionally noted as a driver for selection, and was related to amount of milk children perceived they could or wanted to consume. Flavor and/or previous experiences with a certain type of milk also had a role in children's ranking. For instance, a few children (n=3) noted that they thought milk from cartons tasted "funny" due to the paper packaging or had negative associations with a milk brand or package in which they had previously tasted spoilage or off-flavors.

Regarding usability, bottles with twist-off caps were most frequently cited as the easiest of the packaging types to open (n=15), and children valued their re-sealability for preventing incidents of spilling. Conversely, cartons were most frequently mentioned as the most difficult type of package to open (n=18), and bottles with caps featuring a pull-tab or overwrap were also seen as barriers to opening. Nutritional labeling and claims impacted children's perceived healthiness of the milk. The presence of vitamins, calcium, increased protein content (ultra-filtered milk), low-/reduced-fat labeling, and organic labeling positively influenced health perceptions (n=20), while higher levels of calories or sugar detracted from health perceptions (n=7). One of the commercial milks was from a quick-service restaurant, which many children (n=18) associated with decreased healthiness. This suggests that branding can influence children's health perceptions. Expiration date was also associated with the health or quality of the milk; nearly all children conveyed that they would not consume milk that was at or past the expiration date, and further expressed desire for expiration date to be more clearly or prominently labeled on the package.

Focus groups revealed that the majority of children (n=28) were served milk in cartons at school, although some children's schools offered milk in bottles (n=3) or in bulk dispensers with reusable cups (n=2), which was consistent with the demographic of children recruited for the conjoint survey and consumer acceptance tests. Children whose school only offered cartons expressed interest in other packaging options, particularly bottles (n=21). Regarding consumption of milk outside of school, children indicated that they consumed milk at breakfast with cereal (n=13), with a meal (n=15), as a snack (n=11), or before bed (n=3). These results for drinking occasion are consistent with children interviewed by Thompson et al. (2007) in a study regarding child consumer perceptions of chocolate milk. Focus group results were also consistent with the conjoint results in that children could be categorized into two groups based on their responses and attitudes regarding milk and milk packaging. Most children (n=23) found packaging type and graphics important, indicating that these traits would influence their consumption intent. The second segment of children (n=6) was much smaller and included children that believed "milk is milk"; that is, while preferences for certain packaging types and other extrinsic attributes were discernable, these factors were not important drivers of milk consumption as these children considered the consumable product to fundamentally be the same. A few children (n=2) were not categorized due to limited responses.

Intrinsic Milk Properties

At 0 d all milks had an APC of <10 cfu/mL and no detected coliforms (<10 cfu/mL), and at 10 d all unflavored milks had an APC of <10 cfu/mL while chocolate milks had no detected coliforms and APC of $2.7x10^3$ cfu/mL, $3.0x10^3$ cfu/mL, and $3.5x10^3$ cfu/mL for paperboard carton, PET bottles, and HDPE bottles, respectively. Results from FTIR analysis confirmed that unflavored fat free milk contained <0.1% milkfat and 9.0% total solids (**TS**), unflavored low-fat milk contained 1.0% milkfat and 10.2% TS, and fat free chocolate flavored milk contained <0.1% milkfat and 14.3% TS.

Descriptive Analysis

Descriptive analysis revealed key differences among milks in different package types after 10 d of storage at 4°C, and these differences were consistent across fat free unflavored, low-fat unflavored, and fat free chocolate milk (**Table 2.6**). General milk flavors (cooked/milky, milkfat flavors, and basic tastes) were generally consistent across package within a fat content and flavor (unflavored vs chocolate). Paperboard and refrigerator/stale flavors, which are packaging-related flavors, were not detected in any milk types packaged in HPDE or PET but were present in carton packaging. Cardboard flavor was identified in all chocolate milks, possibly attributed to the cocoa flavor at a baseline level, but cardboard flavor was significantly higher in milk packaged in cartons than from milk packaged in HDPE or PET ($P < 0.05$). Overall, milk packaged in HDPE and PET had similar flavor profiles, whereas milk packaged in cartons was characterized by cardboard and refrigerator/stale flavors across all milk types. These flavors were more distinct in fat free unflavored milk than in low-fat unflavored milk or fat free chocolate milk.

Child Acceptance Testing

Children that participated in the unflavored fat free (n=126), unflavored low-fat (n=122), and fat free chocolate milk (n=126) acceptance tests were 47.9% male and 52.1% female and attended elementary (66.3%) or middle (33.7%) school, with an average age of 10.3 y. Based on screening information reported by parents/guardians, flavored milk was indicated as the milk type most often consumed (67.1%), with children primarily consuming low-fat milk (77.8%) over fat free (8.3%) or whole (13.9%) milk. Screening data also indicated that overall, children typically consumed milk from a paperboard carton (75.7%) or bottle (24.1%) at school.

Child overall acceptance scores were consistent for both fat free and low-fat unflavored milk (**Tables 2.7, 2.8**), with similar trends in liking, JAR, preference, and ranking scores in relation to package type. Color and aroma liking were not different among package treatments for unflavored milk (P > 0.05); however, overall liking (**Figure 2.5**), purchase intent, liking compared to school milk, preference, and rank were significantly lower for milk packaged in cartons compared to milk in HDPE or PET bottles (P < 0.05). The flavor JAR scores indicated that unflavored milk in cartons was rated as having too much flavor more often than milk in HDPE or PET bottles (**Figure 2.6**) (P < 0.05). These results are consistent with descriptive analysis results in that the trained panel identified paperboard and refrigerator stale flavors in milk packaged in paperboard cartons, but these flavor attributes were not detected in PET or HDPE packaged milks. Collectively, these results suggest that children notice paperboard carton-related package flavors (paperboard and refrigerator/stale) flavors in unflavored fat free and 1% fat milks and that these flavors are off-flavors (e.g. they are not liked or preferred).

There were no differences in any acceptance scores for any of the packaging treatments for fat free chocolate milk (P > 0.05) (**Table 2.9, Figure 2.5**). However, milk packaged in PET bottles was ranked significantly higher than milk in cartons (P < 0.05), while ranking for milk in HDPE bottles was at parity with both cartons and PET (P > 0.05). This result suggests that although packaging does impact the flavor profile of chocolate milk as identified by descriptive analysis, the addition of cocoa and sucrose make the impact of packaging-related flavors in chocolate milk less noticeable to child consumers. It is important to reiterate once again that children were not served the milks in the acceptance test in their packages and children had no knowledge of what containers the milks were packaged in so any differences in liking and liking-related scores are presumably due to intrinsic flavor properties of the milk. The only differences among the milks was the package that they were stored in.

Overall liking (**OL**) scores were analyzed for effects of demographic and typical milk consumption. For the unflavored fat free milk acceptance test, children whose parent/guardian reported that they consumed fat free milk most often assigned lower overall liking for the milk packaged in paperboard carton (OL=2.6, n=14) than children who were reported to typically consume milk containing milkfat (OL 4.0, n=112) ($P < 0.05$); however, this result should be interpreted with caution as the sample of children who were reported to consume fat free milk most often was small. In the unflavored low-fat milk acceptance test, children whose parent/guardian reported their child typically consumed flavored milk assigned lower overall liking scores (OL=5.0, n=65) for the low-fat milk packaged in HDPE than children that were reported to consume unflavored milk most often (OL=5.6, n=57) ($P < 0.05$). Finally, an effect of school level was observed for fat free chocolate milk, with milk in cartons receiving a lower overall liking score from children in middle school (OL=5.2, n=40) than children in elementary school (OL=5.9, n=86) ($P<0.05$). This result may demonstrate that older children are more discerning of packaging flavors imparted from paperboard cartons than younger children. For instance, Li et al. (2015b) observed that older children had greater differentiation in liking scores for chocolate milks. In a study that examined the impact of age and gender in the food preferences of children ages 4-16 y, Cooke and Wardle (2005) reported that liking for sugary foods peaked at 8-11 y and declined thereafter. The study also reported a decline in liking of dairy foods with age. Furthermore, in a study where children ages 7-10 y were presented with different meal components and asked to evaluate their liking on a 7-point hedonic scale, younger children consistently provided higher liking scores, indicating that children may become more critical in their food preferences with age (Pagliarini et al., 2005). Another plausible explanation for the age-related difference in liking of chocolate milk is that scale utilization is enhanced with age. Moskowitz (2002) reported that younger children (8-9 y) tended to utilize the higher end (top 2 points) of a 9-point liking scale in comparison to older children (10-14 y) when evaluating candy colors and color combinations. This polarization could result in higher overall liking for younger children. As children age and their cognitive ability develops, their reading and task comprehension, attention span, and ability to consider multiple product attributes improves (Guinard, 2000). However, given that age-related differences were not observed for unflavored milk and that several studies have provided evidence that children of ages 8-13 y can provide consistent, repeatable liking data using hedonic scales (Guinard, 2000; Pagliarini et al., 2005; Laureati et al., 2015), it is likely that older children's preference for HDPE and PET milk is a matter of discernment rather than cognitive ability.

Consistent with trained panel results and liking scores for unflavored milks packaged in paperboard, packaging flavors have previously been documented in milks packaged in polyethylene coated paperboard cartons after 5-6 d of refrigerated storage (Leong et al, 1992; Moyssiadi et al., 2004). These flavors may be related to compounds from ink solvents used for packaging graphics on paperboard cartons (Sajilata et al., 2007). Heat sealing of gable top cartons and the consequential thermal oxidation of the polyethylene coat has also been proposed as a source of undesirable flavor compounds on beverages (Baigrie, 2003); however, Leong et al. (1992) concluded that heat-sealing temperatures were not responsible for packaging related off-flavors in milk. Paperboard cartons in this study had higher oxygen permeability than PET or HDPE packages used in this study (**Table 2.3**). A higher oxygen permeability may facilitate autoxidative reactions, whereas oxygen content will decrease over time in packages resistant to oxygen permeation (Schröder et al., 1985; Moyssiadi et al., 2004). In addition to oxygen, polyethylene is also more permeable to other volatile compounds than HDPE or PET, which could include flavor compounds from the storage environment (Nielsen and Jägerstad, 1994; Baigrie, 2003). In this study, refrigerator/stale flavor was prevalent in the paperboard carton treatment across milk types. This flavor has been documented as the primary loss of butter flavor quality in butter quarters stored at 4°C and was demonstrated to be due to transmission of volatile compounds from the refrigeration environment through the butter packaging and into the butter (Lozano et al., 2007; Krause et al., 2008). This flavor has also previously been demonstrated to decrease with increasing fat content in fluid milk (Leong et al., 1992), however, child acceptance results for fat free and low-fat (1%) milk were comparable relative to packaging type, suggesting that a small addition of milkfat does not have an impact on children's acceptance with regard to packaging-related flavors. Fluid half pints (the volume used in this study and served in school meal programs) have a high surface area-to-volume ratio compared to the larger quart, half gallon and gallon packages typically purchased and consumed by adult consumers and thus represent a worst case scenario for package-related transmission and migration off-flavors.

This study addressed intrinsic milk flavor differences that result solely from package permeability and flavor migration, but the impact of light exposure on fluid milk flavor for different packaging types should not be disregarded. Many previous studies have focused on package type and its role in protection against light oxidation flavors. Milk in transparent plastic bottles exposed to sunlight, light-emitting diode (LED) or fluorescent light develops photooxidation or light oxidized flavors resulting from photoxidation reactions of light sensitive compounds in milk (primarily riboflavin), whereas paperboard cartons and pigmented plastic bottles offer better light protection (Schröder et al., 1985; van Aaardt et al., 2001; Moyssiadi et al., 2004; Potts et al., 2017; Yeh et al., 2017). Light oxidation decreases acceptance of fluid milk in adults (Potts et al., 2017) and also decreases riboflavin and vitamin A content of the milk (Whited et al., 2002; Schiano et al., 2019). Paperboard containers provide protection from this particular milk off-flavor compared to transparent HDPE or PET containers. Therefore, the light conditions under which milk is stored must be considered if package material other than paperboard is to be considered for school milk.

Collectively, the experiments in this study demonstrate that both extrinsic (appearance/form) and intrinsic (flavor) attributes of fluid milk shape children's perceptions. Focus group discussions confirmed the findings of both of these phases of the study and also confirmed that two groups of child consumers exist: children who view milk as a commodity and a larger group of children whose consumption may be influenced by the package. The latter group of children expressed desire for more options in their school meal programs as well as for value-added milk products in their schools – for instance, milk with improved packaging form (such as in bottles) and frequently updated graphics, milk that is of superior nutritional quality (e.g. sugar reduced), and/or milk with an extended shelf life. Therefore, these results suggest that children are not currently satisfied with the milk served in their school meal programs. To remedy this issue, it is important to address both extrinsic and intrinsic properties related to packaging when designing milk for children in school meal programs. This is especially important in the case of unflavored milk as this product is more susceptible to flavor defects as a result of paperboard packaging. Even though children are influenced by extrinsic attributes, flavor remains a key driver of fluid milk consumption (McCarthy et al., 2017b). In adults, another key driver of consumption is habit; therefore, increasing milk consumption through school meal programs in childhood has the potential to increase lifelong milk consumption (McCarthy et al., 2017b).

CONCLUSION

Packaging attributes, both extrinsic and intrinsic, impact children's preferences and perceptions of fluid milk. Extrinsically, children placed the highest importance on packaging type, with preference for HDPE bottles over paperboard cartons. Trained panelists documented package-related flavors in unflavored and chocolate milks packaged in paperboard cartons following 10 d at 4°C that were not observed in milk packaged in PET or HDPE bottles. Children had lower overall liking and preference for unflavored milk in paperboard cartons compared to PET and HDPE bottles, while preference for chocolate flavored milk did not differ across packaging types. Child liking and JAR scores suggest that children can identify paperboard packaging-related flavors imparted on unflavored milk, and that these are perceived as undesirable off-flavors. Collectively, the results of this study suggest that paperboard cartons are less desirable both extrinsically and intrinsically to children than other packaging types for school milk. However, low-cost paperboard cartons currently comprise the majority of milk served in schools as a result of the federal reimbursement bidding procedure. Policy makers, school meal/nutrition programs, and fluid milk processors should consider the implications of packaging on children's milk acceptance and long-term milk consumption habits.

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Table 2.1. Milks evaluated in child consumer acceptance testing and by descriptive analysis.

Variable	Treatments
Milk Variety	Unflavored, Fat Free Unflavored, Low-fat (1% milkfat) Chocolate Flavored, Fat Free
Package Material & Form	Polyethylene Terephthalate (PET), Bottle High-Density Polyethylene (HDPE), Bottle Low-Density Polyethylene (LDPE) Coated Paperboard, Gable Top Cartons

Table 2.2. Milk packaging attributes and levels for choice-based conjoint survey.

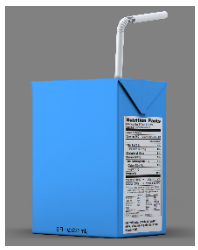
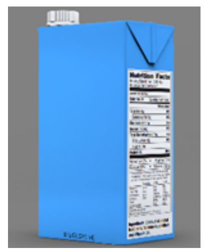
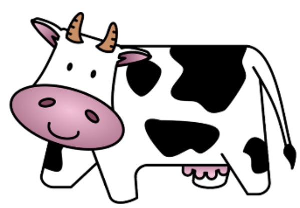
Attribute	Levels		
Packaging Type	 Carton	 HDPE Bottle	 PET Bottle
	 Box with Straw	 Box with Cap	 Pouch
Front-of-Package Graphics	 Milk	 Cow	 Licensed Character
Color	 Blue	 Pink	 Gold
Labeled Milkfat Content	**Fat Free**	**Low-fat**	

Table 2.3. Thickness and oxygen transmission rates for packaging types for fluid milks evaluated by consumer acceptance testing and descriptive analysis.

Packaging Type	**Packaging Wall Thickness** (mm)	**Oxygen Transmission Rate** (cm^3•mm/m^2•24 h•atm)
PET	1.1 ± 0.1	60
HDPE	1.3 ± 0.2	600
Carton	0.9 ± 0.2	4173

PET = polyethylene terephthalate bottle; HDPE = high-density polyethylene bottle; Carton = low-density polyethylene coated paperboard carton.

Table 2.4. Comparison of zero-centered utility scores from consumer clusters for milk packaging attribute levels based on conjoint analysis.

Attribute	Level	Overall (n=189)	Packaging Cluster (n=140)	Milkfat cluster (n=49)
Packaging Type	HDPE Bottle	59.6	66.9a	38.5b
	PET Bottle	40.8	48.3a	19.6b
	Carton	38.5	44.9a	20.1b
	Box with Cap	-6.3	-6.7a	-5.2a
	Box with Straw	-22.1	-25.8b	-11.8a
	Pouch	-110.4	-127.7b	-61.2a
Front-of-Package Graphics	Cow	14.4	16.3a	9.1a
	Milk	12.7	15.1a	5.9a
	Licensed Character	-27.2	-31.4b	-15.0a
Color	Blue	17.6	16.1a	21.9a
	Pink	-7.7	-5.9a	-12.9b
	Gold	-9.8	-10.1a	-9.0a
Labeled Milkfat Content	Low-fat	1.6	-4.7b	19.7a
	Fat Free	-1.6	4.7a	-19.7b
None		-53.6	-42.8a	-84.4a

Different letters following mean utilities in a row indicate significant differences ($P < 0.05$).
Utility scores cannot be directly compared between attributes within a column.
PET = polyethylene terephthalate bottle; HDPE = high-density polyethylene bottle; Carton = low-density polyethylene coated paperboard carton.

Table 2.5. Focus group activity ranking results for children ages 8-13 y (n=31).

Brand	Packaging Type	Size	Type	Favorite	Rank
Local	Carton	8 fl oz	Conventional	3.2%	4.7b
National	Bottle	16 fl oz	Conventional	32.3%	2.1a
National	Box with Straw	8 fl oz	Organic, UHT	6.5%	3.8b
National	Bottle	11.5 fl oz	Ultrafiltered	38.7%	1.9a
QSR	Bottle	8 fl oz	Conventional	9.7%	4.8b
Regional	Bottle	14 fl oz	Conventional	9.7%	3.7b

Mean ranks with different lettering represent significant differences ($P < 0.05$). A lower number rank indicates a more preferred sample.

Favorite represents percentage of respondents that indicated the sample was their favorite.

QSR = quick service restaurant, UHT = ultra-high temperature pasteurized (shelf stable).

Table 2.6. Descriptive analysis results for milk packaged in HDPE bottles, PET bottles, and paperboard cartons at 10 d post-production.

Milk Type	Packaging	Aroma Intensity	Sweet Aromatic	Cooked/milky	Paperboard	Refrigerator Stale	Milkfat	Sweet	Salty	Astringent
Fat Free Unflavored	PET	1.7b	1.4a	3.0a	ND	ND	ND	1.9a	1.8a	1.9a
	HDPE	1.7b	1.2a	2.9a	ND	ND	ND	1.9a	1.8a	1.9a
	Carton	2.2a	0.6b	2.9a	2.0a	2.2a	ND	1.8a	1.9a	2.0a

Milk Type	Packaging	Aroma Intensity	Sweet Aromatic	Cooked/milky	Paperboard	Refrigerator Stale	Milkfat	Sweet	Salty	Astringent
Low-fat (1%) Unflavored	PET	2.0b	1.3a	3.1a	ND	ND	1.3a	1.8a	1.7a	1.6b
	HDPE	1.9b	1.1b	3.2a	ND	ND	1.4a	1.8a	1.8a	1.6b
	Carton	2.3a	0.6c	2.9a	1.8a	1.6a	1.3a	1.9a	1.7a	1.9a

Milk Type	Packaging	Aroma Intensity	Cocoa	Cooked/Milky	Cardboard	Refrigerator Stale	Milkfat	Sweet	Salty	Astringent
Fat Free Chocolate	PET	2.5a	2.4a	3.3a	1.0b	ND	ND	6.3a	1.8a	2.2b
	HDPE	2.5a	2.4a	3.3a	1.1b	ND	ND	6.4a	1.9a	2.2b
	Carton	2.1b	2.1b	3.0b	1.8a	1.5a	ND	6.3a	1.9a	2.4a

Values represent the mean scores from duplicate panelist evaluations (n=7) from two milk processing replications. Attribute intensities were scored on a 0- to 15-point universal intensity scale (Meilgaard et al., 2007). Fluid milk attributes fall within 0 to 4 on this scale (McCarthy et al., 2017a; Lee et al., 2017). ND – not detected.

Means for an attribute within each fat content followed by a different letter represent differences ($P < 0.05$).

PET = polyethylene terephthalate bottle; HDPE = high-density polyethylene bottle; Carton = low-density polyethylene coated paperboard carton.

Table 2.7. Child acceptance scores for fat free unflavored milk packaged in HDPE bottles, PET bottles, and paperboard cartons at 12-13 d post-production (ages 8 to 13 y, n=126).

	Carton	**HDPE**	**PET**
Color Liking	5.1a	5.0a	5.2a
Aroma Liking	4.3a	4.4a	4.6a
Overall Liking	3.8b	5.0a	5.0a
Purchase Intent	2.6b	3.2a	3.2a
Flavor JAR			
Too little	27.8%a	24.6%a	21.4%a
JAR	32.5%b	54.0%a	54.8%a
Too much	39.7%a	21.4%b	23.8%b
Compared to School Milk	2.5b	3.2a	3.3a
Preference	20.6%b	42.9%a	36.5%a
Ranking	2.3b	1.7a	1.9a

Data represents 126 children.

Liking attributes were scored on a 7-point hedonic smiley face scale where 1 = really bad and 7 = really good.

Just-about-right (JAR) attribute was scored on a 5-point smiley face scale where 1 or 2 = not strong enough, 3 = JAR, and 4 or 5 = too strong. Percentage of children that selected these options is presented.

Purchase intent was scored on a 5-point smiley face scale where 1 or 2 = do not want mom or dad to buy, 3 = might or might not want mom or dad to buy, and 4 or 5 = want mom or dad to buy.

Compared to school milk was scored on a 5-point smiley face scale where 1 or 2 = like it less, 3 = like it about the same, and 4 or 5 = like it more.

Preference represents percentage of participants who preferred the sample.

Ranking values indicate the average rank of the sample where 1 = most preferred and 3 = least preferred.

Different letters in rows following means/percentages of each attribute indicate significant differences ($P < 0.05$).

PET = polyethylene terephthalate bottle; HDPE = high-density polyethylene bottle; Carton = low-density polyethylene coated paperboard carton.

Table 2.8. Child acceptance scores for low-fat (1%) unflavored milk packaged in HDPE bottles, PET bottles, and paperboard cartons at 12-13 d post-production (ages 8 to 13 y, n=122).

	Carton	**HDPE**	**PET**
Color Liking	5.3a	5.4a	5.5a
Aroma Liking	4.9a	4.8a	4.9a
Overall Liking	3.7b	5.3a	5.4a
Purchase Intent	2.5b	3.5a	3.5a
Flavor JAR			
Too little	30.3%a	21.3%a	21.3%a
JAR	34.4%b	67.2%a	64.8%a
Too much	35.2%a	11.5%b	13.9%b
Compared to School Milk	2.4b	3.2a	3.3a
Preference	14.8%b	44.3%a	41.0%a
Ranking	2.5b	1.7a	1.8a

Data represents 122 children.

Liking attributes were scored on a 7-point hedonic smiley face scale where 1 = really bad and 7 = really good.

Just-about-right (JAR) attribute was scored on a 5-point smiley face scale where 1 or 2 = not strong enough, 3 = JAR, and 4 or 5 = too strong. Percentage of children that selected these options is presented.

Purchase intent was scored on a 5-point smiley face scale where 1 or 2 = do not want mom or dad to buy, 3 = might or might not want mom or dad to buy, and 4 or 5 = want mom or dad to buy.

Compared to school milk was scored on a 5-point smiley face scale where 1 or 2 = like it less, 3 = like it about the same, and 4 or 5 = like it more.

Preference represents percentage of participants who preferred the sample.

Ranking values indicate the average rank of the sample where 1 = most preferred and 3 = least preferred.

Different letters in rows following means/percentages of each attribute indicate significant differences ($P < 0.05$).

PET = polyethylene terephthalate bottle; HDPE = high-density polyethylene bottle; Carton = low-density polyethylene coated paperboard carton.

Table 2.9. Child acceptance scores for fat free chocolate milk packaged in HDPE bottles, PET bottles, and paperboard cartons at 12-13 d post-production (ages 8 to 13 y, n=126).

	Carton	**HDPE**	**PET**
Color Liking	5.7a	5.7a	5.8a
Aroma Liking	5.7a	5.6a	5.8a
Overall Liking	5.7a	5.9a	5.9a
Chocolate Flavor JAR			
Not Chocolatey Enough	13.5%a	11.9%a	6.3%a
JAR	63.5%a	65.1%a	66.7%a
Too Chocolatey	23.0%a	23.0%a	27.0%a
Sweetness JAR			
Not Sweet Enough	19.8%a	11.9%ab	8.7%b
JAR	64.3%a	73.0%a	69.0%a
Too Sweet	15.9%a	15.1%a	22.2%a
Purchase Intent	3.6a	3.9a	3.8a
Compared to School Milk	3.6a	3.8a	3.8a
Preference	26.2%a	40.5%a	33.3%a
Ranking	2.2b	1.9ab	1.8a

Data represents 126 children.
Liking attributes were scored on a 7-point hedonic smiley face scale where 1 = really bad and 7 = really good.
Just-about-right (JAR) attributes were scored on a 5-point smiley face scale where 1 or 2 = not strong enough, 3 = JAR, and 4 or 5 = too strong. Percentage of children that selected these options is presented.
Purchase intent was scored on a 5-point smiley face scale where 1 or 2 = do not want mom or dad to buy, 3 = might or might not want mom or dad to buy, and 4 or 5 = want mom or dad to buy.
Compared to school milk was scored on a 5-point smiley face scale where 1 or 2 = like it less, 3 = like it about the same, and 4 or 5 = like it more.
Preference represents percentage of participants who preferred the sample.
Ranking values indicate the average rank of the sample where 1 = most preferred and 3 = least preferred.
Different letters in rows following means/percentages of each attribute indicate significant differences ($P < 0.05$).
PET = polyethylene terephthalate bottle; HDPE = high-density polyethylene bottle; Carton = low-density polyethylene coated paperboard carton.

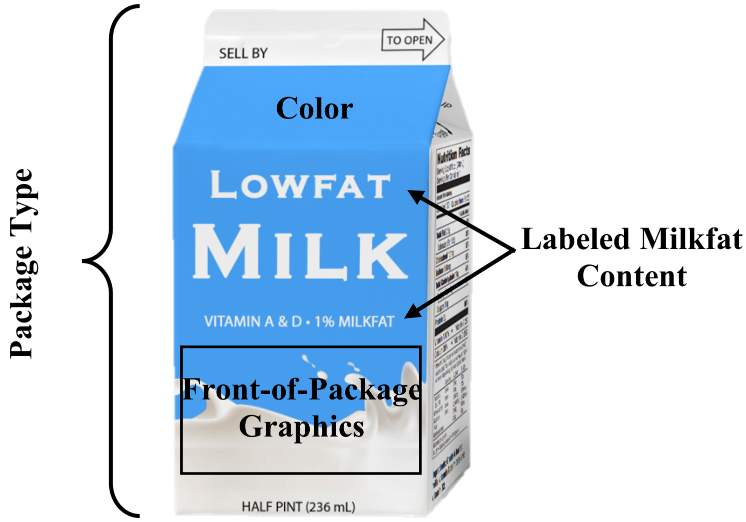


Figure 2.1. Layout of composite attributes used to generate milk packaging mockups.

FOCUS GROUP MODERATOR GUIDE

- Moderator introduction & purpose of focus group

- Participant introductions – name, grade in school, and a fun fact

- **Warm-Up Activity** *(Children asked to select their "favorite" milk from 6 commercial samples)***:**

    - Today when you came in, you chose a container of milk. We would like you to share with us why you chose that particular container of milk to drink.

- **Milk Packaging Perceptions** *(Children given all 6 commercial milk containers)***:**
    - If the milk in this container was served in your school cafeteria, how likely would you be to drink it? Why/why not?
    - Overall, which of these milks do you think is the healthiest? The least healthy? Why?
    - Overall, which of these milks do you think is the tastiest? The least tasty? Why?
    - Which of these containers do you think is the easiest to drink from? The hardest to drink from? Why?
    - I'd like you to rank these containers from your most favorite to your least favorite.
        - Why did you rank these this way?

- **Current Milk Usage and Packaging:**
    - On what occasions do you drink milk at home – e.g. meal time, snack time, etc.?
    - How often do you drink milk at school?
    - What type of container does your milk come in at school? What do you like/dislike about it?
    - Is there anything you wish you could change about the milk at your school?

Figure 2.2. Moderator guide for focus groups with children (ages 8-13 y) regarding milk packaging perceptions.

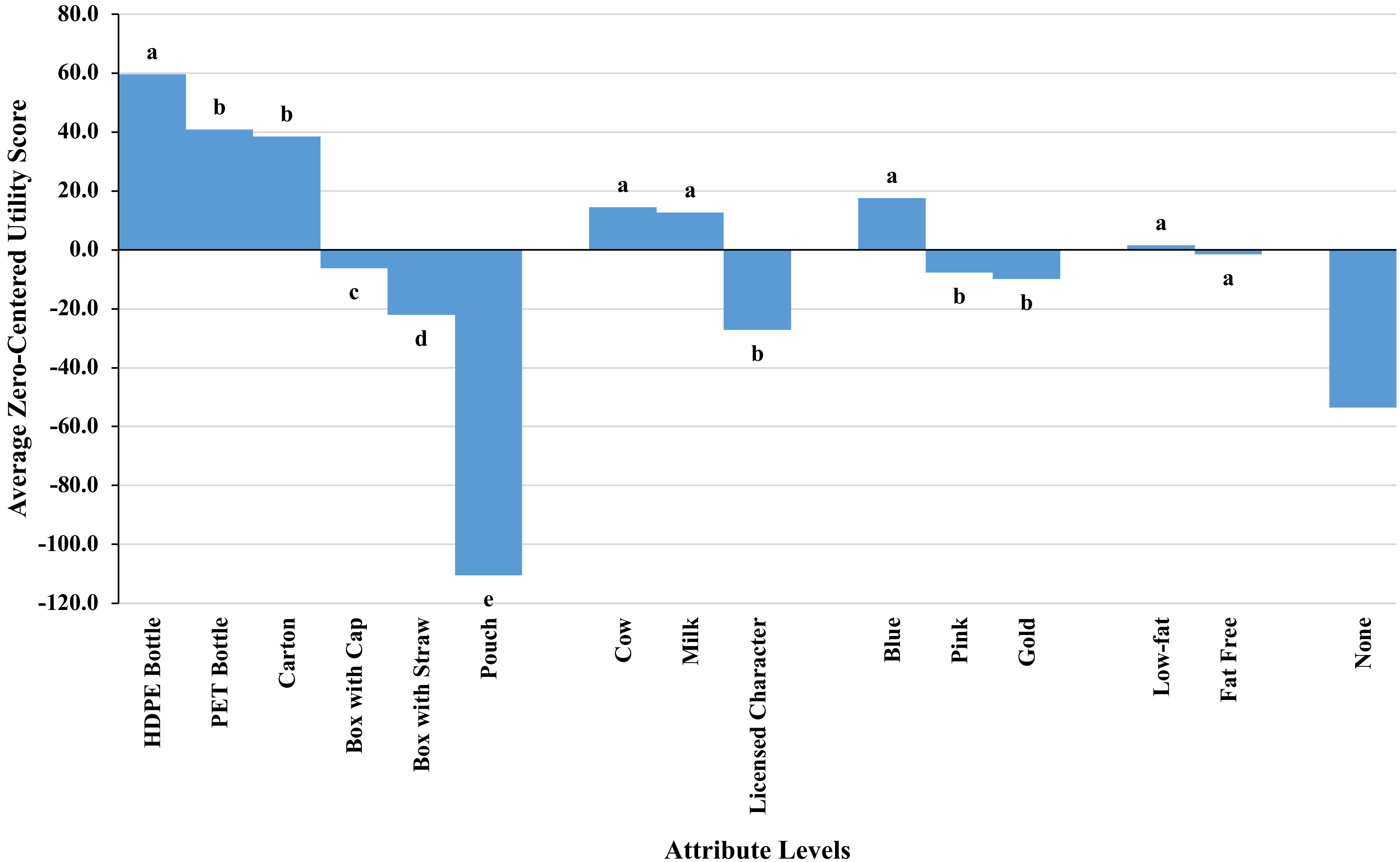


Figure 2.3. Average zero-centered utility scores for attribute levels from choice-based conjoint survey (n=189 child consumers). Different letters within an attribute indicate significant differences ($P < 0.05$). Utility scores cannot be directly compared between attributes. PET = polyethylene terephthalate bottle; HDPE = high-density polyethylene bottle; Carton = low-density polyethylene coated paperboard carton.

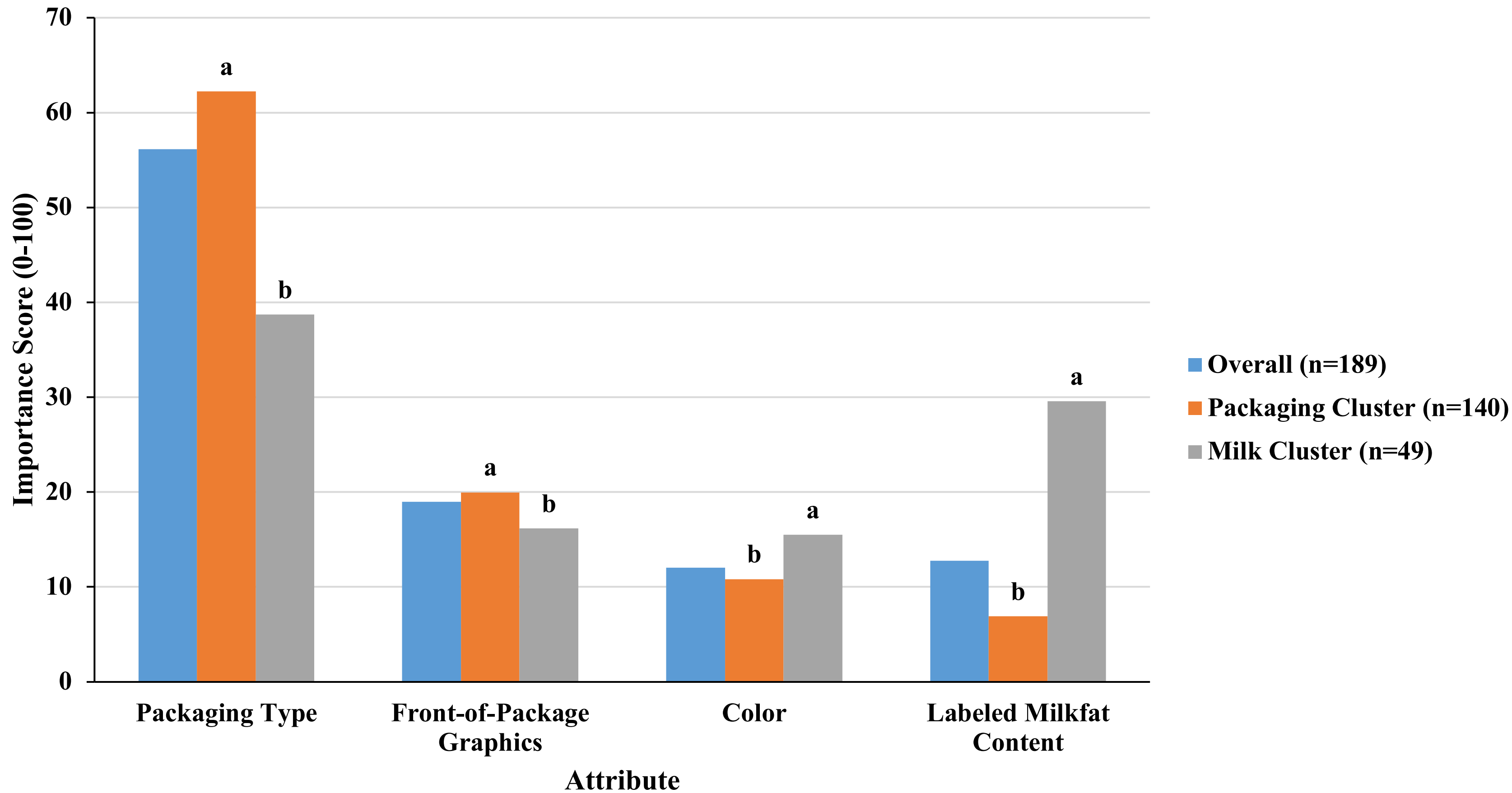


Figure 2.4. Importance scores of fluid milk packaging attributes from choice-based conjoint survey (n=189 child consumers) segmented by clustering. Different letters within an attribute indicate significant differences between clusters ($P < 0.05$).

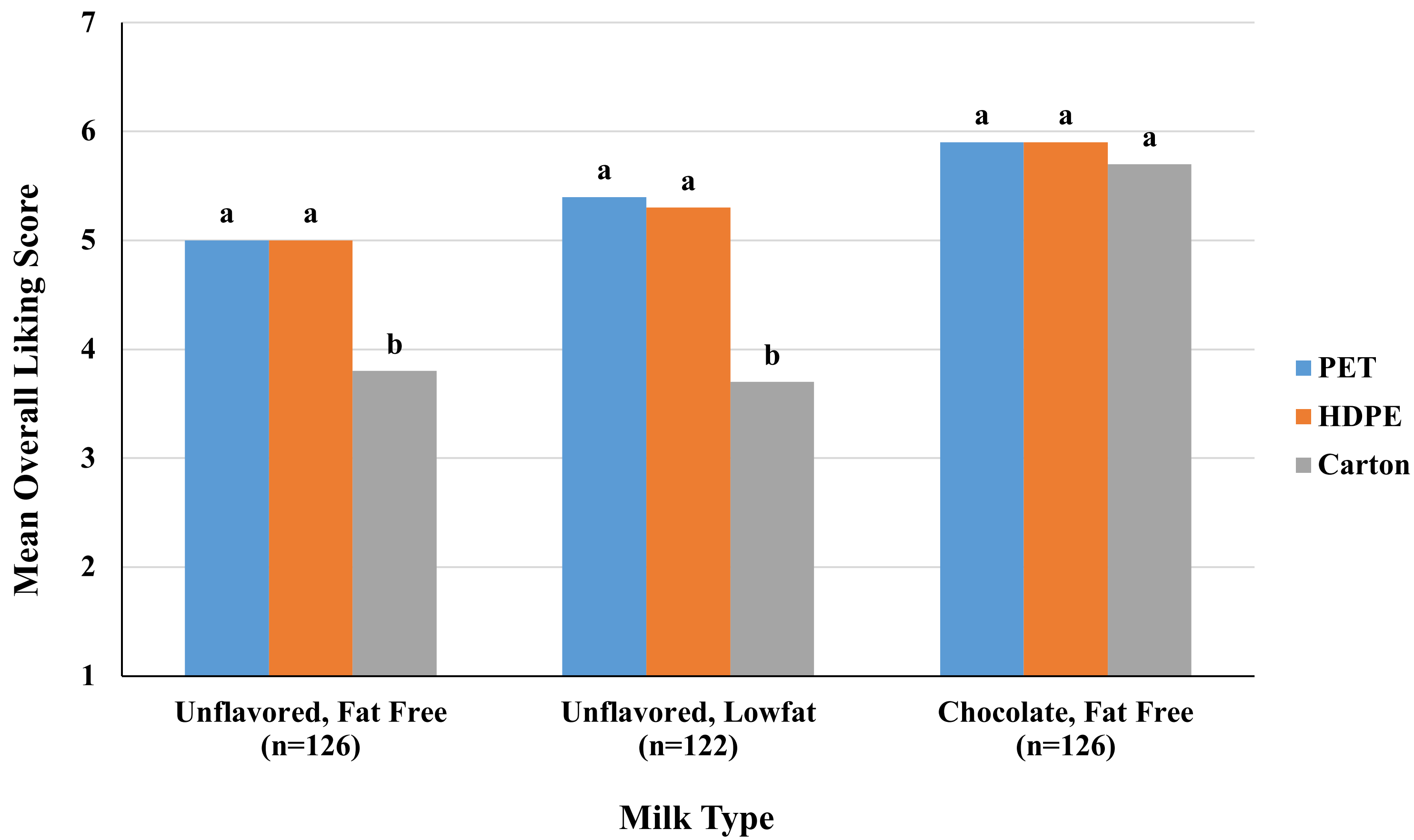


Figure 2.5. Child (ages 8 to 13 y) mean overall liking scores for milk packaged in HDPE bottles, PET bottles, and paperboard cartons at 12-13 d post-production. Overall liking was scored on a 7-point hedonic smiley face scale where 1 = really bad and 7 = really good. Different letters within a milk type indicate significant differences ($P < 0.05$). PET = polyethylene terephthalate bottle; HDPE = high-density polyethylene bottle; Carton = low-density polyethylene coated paperboard carton.

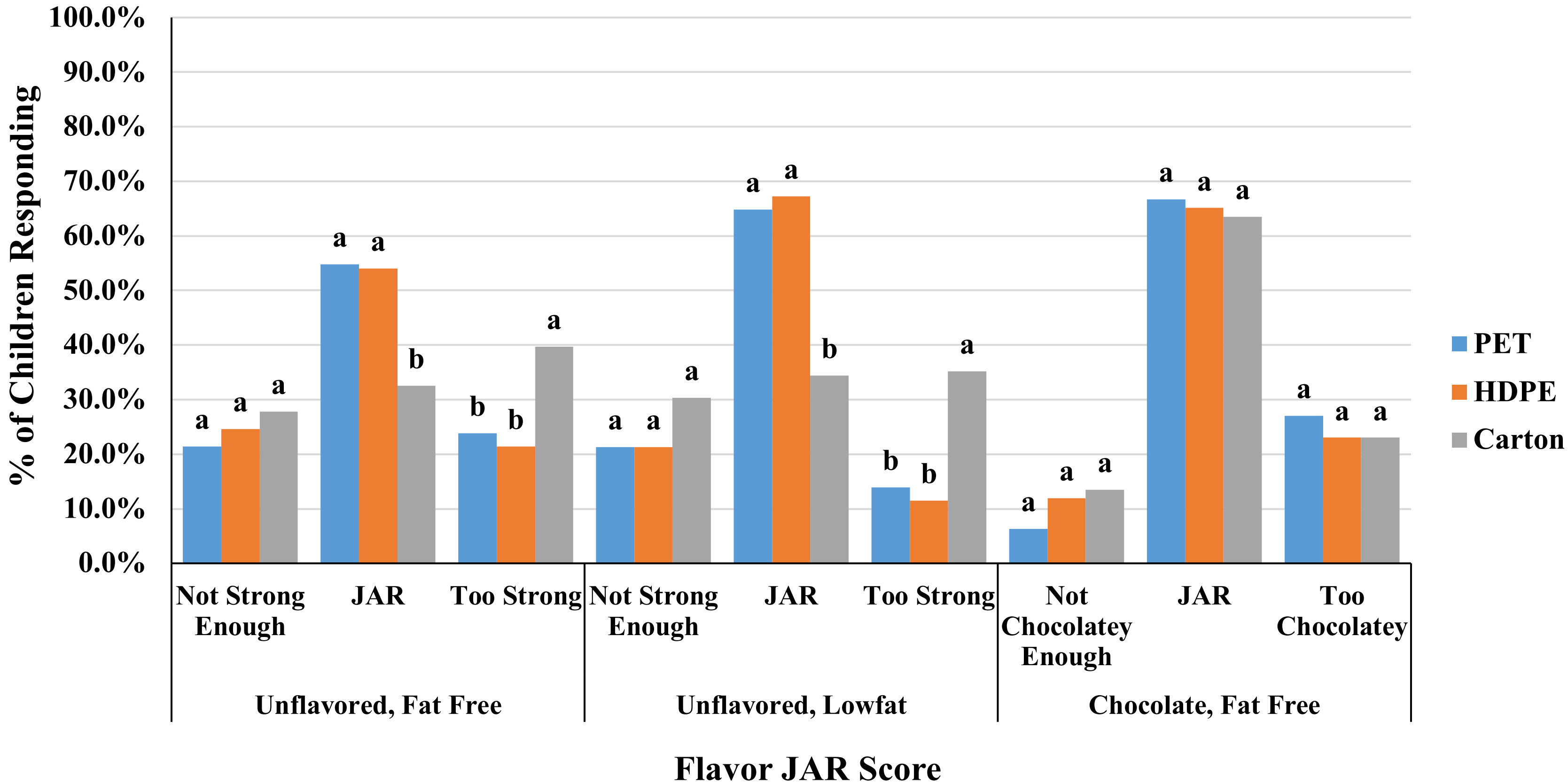


Figure 2.6. Child (ages 8 to 13 y) flavor just-about-right (JAR) responses for milk packaged in HDPE bottles, PET bottles, and paperboard cartons at 12-13 d post-production. Flavor JAR was scored on a 5-point smiley face scale where 1 or 2 = not strong enough, 3 = JAR, and 4 or 5 = too strong. Percentage of children that selected these options is presented. Different letters within a milk type indicate significant differences ($P < 0.05$). PET = polyethylene terephthalate bottle; HDPE = high-density polyethylene bottle; Carton = low-density polyethylene coated paperboard carton.