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Children's perceptions of fluid milk with varying levels of milkfat

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ABSTRACT

Schools participating in federal meal programs are limited to serving skim or low-fat (≤1%) flavored and unflavored milk. Few studies have directly addressed child perceptions and preferences for milk containing different amounts of milkfat. The objective of this study was to determine whether children can differentiate between flavored and unflavored fluid milk containing varying levels of milkfat and whether preferences for certain levels of milkfat exist. Flavored and unflavored milks containing 4 different percentages of milkfat (≤0.5, 1, 2, and 3.25%) were high-temperature, short-time processed, filled into half-gallon light-shielded milk jugs, and stored at 4°C in the dark. Milks were evaluated by children (ages 8–13 yr) following 7 d at 4°C. Acceptance testing and tetrad difference testing were conducted on flavored and unflavored milks with and without visual cues to determine if differences were driven by visual or flavor or mouthfeel cues. Child acceptance testing (n = 138 unflavored; n = 123 flavored) was conducted to evaluate liking and perception of selected attributes. Tetrad testing (n = 127 unflavored; n = 129 flavored) was conducted to determine if children could differentiate between different fat levels even in the absence of a difference in acceptance. The experiment was replicated twice. When visual cues were present, children had higher overall liking for 1% and 2% milks than skim for unflavored milk and higher liking for chocolate milks containing at least 1% milk fat than for skim. Differences in liking were driven by appearance, viscosity, and flavor. In the absence of visual cues, no differences were observed in liking or flavor or mouthfeel attributes for unflavored milk but higher liking for at least 1% milk fat in chocolate milk compared with skim was consistent with the presence of visual cues. From tetrad testing, children could visually tell a difference between all unflavored pairs except 2% versus whole milk and could not detect consistent differences between milkfat pairs in the absence of visual cues. For chocolate milk, children could tell a difference between all milk fat pairs with visual cues and could tell a difference between skim versus 2% and skim versus whole milk without visual cues. These results demonstrate that in the absence of package-related flavors, school-age children like unflavored skim milk as well as milk with higher fat content in the absence of visual cues. In contrast, appearance as well as flavor and mouthfeel attributes play a role in children's liking as well as their ability to discriminate between chocolate milks containing different amounts of fat, with chocolate milk containing at least 1% fat preferred. The sensory quality of school lunch milk is vital to child preference, and processing efforts are needed to maximize school milk sensory quality.
Key words: milk, milkfat, child liking

INTRODUCTION

Dairy foods provide valuable vitamins and nutrients for all walks of life, and many dietary habits, such as drinking milk, are formed in early childhood years (Stewart et al., 2012; McCarthy et al., 2017b; The Dairy Alliance, 2020). McCarthy et al. (2017b) reported that childhood milk consumption and habit were major drivers for adult milk consumption. Declines in milk consumption with the substitution of less healthy beverages are associated with children not receiving enough dietary calcium (Johnson et al., 2002; Fayet-Moore, 2016). Even as child fluid milk consumption continues to decline, schools participating in federal meal programs, such as the National School Lunch Program and the National Breakfast Program, are limited to serving skim or low-fat (≤1%) milk (Sipple et al., 2020).

Flavored milks, such as chocolate, have a nutritional profile similar to that of unflavored white milk but with the addition of added sugar, hydrocolloids, and chocolate (Hough et al., 1997). Added sugar found in flavored milks is a concern for some parents when choosing between unflavored white milk and flavored

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milk (Li et al., 2014). However, Johnson et al. (2002) reported that children who consumed flavored milk during lunch time did not have higher added sugar intakes than other children who were not milk consumers, as nonmilk drinkers were more likely to consume fruit juice or soft drinks. Currently, chocolate milk is the most popular flavored milk for both children and adults in the United States but, as with unflavored white milk, child school meal programs that are eligible for federal compensation are limited to serving fat-free or low-fat (<1%) chocolate milk (Sipple et al., 2020). Federal guidelines limit calories per meal so the fat content, and added sugar in the case of flavored milk, are critical to the calorie count of the entire meal. The added sugar in school lunch chocolate milk remains a concern. However, wasted (unconsumed) milk in these programs also remains an issue and given the nutrients provided by milk and the potential for lifelong fluid milk consumption, ensuring that children enjoy school lunch milk remains a challenge.

Fat contributes a variety of desirable visual attributes, unique flavors, and mouthfeel to milk (Phillips et al., 1995; McCarthy et al., 2017a; Cheng et al., 2019). Higher milk fat in fluid milk is associated with increased whiteness, mouthcoating, and milkfat flavor (Phillips et al., 1995; Quinones et al., 1997; McCarthy et al., 2017b) which some consumers describe as creamier (Richardson-Harman et al., 2000). Current guidelines, such as the USDA Dietary Guidelines for Americans or American Heart Association, suggest that choosing milks lower in fat content decreases the risk of cardiovascular disease by limiting intake of saturated fat (USDA-HHS, 2015; American Heart Association, 2020). However, research suggests that higher milk fat intakes do not increase the risk of heart disease (Benatar et al., 2013) and that higher plasma dairy fatty acid concentrations were associated with a lower incident of diabetes mellitus (Yakoob et al., 2016). Vanderhout et al. (2019) concluded that parents provide and physicians recommend a variety of cow's milks for children and hold mixed interpretations of the role of cow's milk fat in children's diets, suggesting that more clarity about the effect of milk and milkfat on child adiposity is needed to help make informed decisions about cow's milk fat for children.

Few studies have directly addressed child perceptions and preferences for milk containing different amounts of milkfat or whether children can detect difference between milks at different fat contents. Kling et al. (2016) evaluated child liking (ages 3–6 yr) of unflavored low-fat (1%) versus whole (3.25%) milk and reported that child liking and preference scores were similar for both milk types. Johnson et al. (1991) and Kern et al. (1993) both reported that children's preference for higher-fat foods was driven by liking of desired flavor attributes that were positively correlated with fat content of foods. Kildegaard et al. (2011) reported a study of acidified milk products with 0.5 to 3.5% fat and 5 to 20% fruit content and found that at low fruit level, there was a preference for higher fat. However, as fruit content increased, there was no preference for higher fat content by children, and that fruit content drove preference, liking, and wanting. There was also a high correlation between liking and wanting. Thus, liking of a dairy product will drive wanting of that product. Identification of the attributes (or components) that drive liking of dairy products could be the key driver to promote consumer wants of milk and dairy products. In a review by Ventura and Worobey (2013), they indicated that shortly after birth, young infants show characteristic taste preferences: sweet and umami elicit positive responses; bitter and sour elicit negative responses. Although early likes and dislikes are influenced by these innate taste preferences, they are also modifiable as a child develops likes and dislikes of food flavors and textures. This could be opportunity for healthy dairy products that focus on development of flavor preferences for very young children. The fact that product liking by children drives preference and desire is clearly demonstrated in the school lunch program. School children like chocolate milk, and this has driven sales of chocolate milk in schools to 60% of the total sales (MilkPEP, 2017; Sipple et al., 2020). Sipple et al. (2021) evaluated child perception of school lunch packaging and child perception of the liking of fluid milk packaged in paperboard (laminated tetra bricks), high-density polyethylene (**HDPE**; opaque and flexible bottles), or polyethylene terephthalate (**PET**) packaging (clear and glass-like bottle packaging). Their study demonstrated that children ages 8 to 13 had extrinsic and intrinsic preferences for fluid milk. Children preferred milk that was packaged in HDPE or PET bottles when milks were not tasted and when milks were tasted, they also preferred the flavor of unflavored milk packaged in HDPE or PET bottles over milk packaged in paperboard cartons. In contrast, package had no effect on child acceptance of skim chocolate milk (Sipple et al., 2021). Sipple et al. (2021) evaluated unflavored skim and low-fat (1%) milk and skim chocolate milk but the role of milkfat on child liking was not determined. If children have a preference for a certain percentage of fat in milk that is currently not being offered in schools, school meal guidelines could shift to accommodate this desire to increase milk consumption or milk liking and enjoyment by school aged children.

Difference testing is a common way to see if consumers can detect a difference between 2 samples and has been successfully done with children (ages 6–11; Garcia et al., 2012). Tetrad testing is a relatively new difference testing technique where panelists are presented with 4 samples, 2 from one sample and 2 from the other sample, and then asked to group together the 2 samples they think are the most similar (Garcia et al., 2012). The tetrad test has greater power to detect differences than the other commonly applied difference tests: triangle or duo trio tests (Ennis and Jesionka, 2011). In terms of acceptance tests, 5- and 7-point hedonic rating scales have been most commonly used to evaluate child liking (Guinard, 2000; Laureati and Pagliarini, 2013). Guinard (2000) reported that children (as young as 4 yr old) were able to successfully evaluate products using hedonic liking scales. The objective of the present study was to determine whether children can differentiate between unflavored or chocolate fluid milk containing varying levels of milkfat and whether children have preferences for certain levels of milkfat in fluid milks. Fluid milks (unflavored and chocolate) with varying fat levels were processed followed by tetrad tests and acceptance testing with children to accomplish this goal.

MATERIALS AND METHODS

Experimental Overview

Skim and whole unflavored and chocolate milks were HTST pasteurized followed by blending and standardization to each fat content (≤0.5, 1, 2, and 3.25%). Unflavored and chocolate milks were processed on separate occasions in duplicate. Descriptive analysis with a trained panel was conducted to document sensory differences attributed to fat content within each flavor. Child tetrad difference testing was conducted in clear plastic tumblers (with visual cues) and polystyrene foam cups (without visual cues) to determine if differences between milks were driven by visual cues or flavor or mouthfeel cues. Children also participated in separate acceptance tests to document liking of unflavored and chocolate milks in separate sessions. Although children were recruited separately for acceptance and tetrad tests, the same children could participate in both acceptance and tetrad testing. The experiment was replicated twice. All sensory testing was conduction in compliance with North Carolina State University Institutional Review Board regulations.

Milk Processing

Whole and skim unflavored pasteurized milk [SCC <100,000 raw, 43 L processed per replication; fat content of skim (0.07–0.08%) and whole (3.9–4.4%)] were processed by the North Carolina State University commercial dairy facility (Raleigh, NC). Milks were HTST pasteurized at 78°C for 28 s and homogenized at 17.1 MPa in a 2-stage homogenization process (stage 1 = 13.7 MPa; stage 2 = 3.4 MPa), which was also the commercial heat treatment and process used by this facility (Douglas et al., 2000). Milkfat content of skim and whole milks was determined by a Fourier transform mid-infrared (**FTIR**) spectrophotometer (Lactoscope FTA, Delta Instruments). The FTIR milk product group was used and calibrated using modified milk samples as described by Kaylegian et al. (2006). The milks (cooled to 4°C) were filled into sanitized stainless-steel milk cans, and different milk fat blends (≤0.5, 1, 2, and 3.25%) were created using the Pearson square equation to calculate the amounts of whole and skim milk needed to reach each target fat percentage. Milks were filled into sanitized half-gallon light-shielded milk jugs (HDPE bottles; VWR) under a clean-fill hood with a high efficiency particulate air (HEPA) filter (Microthermics). Fat content and total solids of each milk were confirmed before packaging using the FTIR spectrophotometer. The process was repeated for chocolate milk in a similar manner. Whole and skim chocolate milks were pasteurized at 83.9°C for 28 s and homogenized at 17.1 MPa in a 2-stage homogenization process (the commercial heat treatment and process used by this facility for chocolate milk). Chocolate milk was made using a typical school lunch milk formulation with chocolate dairy powder PFI 178 [0.7%; cocoa, salt, carrageenan, natural flavor, silicon dioxide (anticaking agent); Profile Food Ingredients] and cane sugar (3.7%; United Sugars Corporation). Chocolate milks differed only in the amount of fat.

Chocolate milks and unflavored milk were produced on separate occasions in duplicate. The milks were stored at 4°C under black laser cloth to prevent development of light oxidized flavors. Microbiological analyses were performed on the milks at 0 and 7 d following milk production. Samples were taken from each fat type and plated in triplicate for aerobic plate count 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). Milks were evaluated by child consumers at 7 to 11 d postproduction (5 d to complete all child testing for each experimental replication) and by trained panelists at 10 d postproduction.

Total Solids, Fat, Protein, and Particle Size

Total solids were analyzed by direct forced-air method (AOAC International, 2016; method number 990.20), fat by ether extraction (AOAC International, 2016; method 989.05), total nitrogen (**TN**) (AOAC International, 2016; method 990.20), nonprotein nitrogen

(**NPN**; AOAC International, 2016; method 990.21), and noncasein nitrogen (AOAC International, 2016; method 998.05). True protein was calculated as TN − NPN × 6.38. Fat particle size was determined with a Mastersizer 2000 (Malvern) as previously described (Di Marzo and Barbano, 2016).

Color

Hunter L and a, and International Commission on Illumination (**CIE**) b* color measurement values were measured in triplicate at d 7 of storage on each milk type from each replicate using an Ultra Scan Pro Spectrophotometer (Hunter Associates Laboratory) at 4°C. Hunter L measures the degree of lightness from dark (0) to light (100), Hunter a measures the degree of redness defined by a positive number or greenness defined by a negative number, and CIE b* measures the degree of yellowness defined by a positive number or blueness defined by a negative number (Quinones et al., 1997; Cheng et al., 2018). Hunter and CIE values were collected from the reflectance data in the range of 360 to 750 nm at 5-nm intervals, illuminant A with a 10-degree observer angle (Cheng et al., 2018).

Descriptive Analysis

Seven trained panelists (2 men, 5 women, ages 23–55 yr), each with more than 70 h of previous descriptive analysis experience with dairy products, including unflavored white and chocolate milk, evaluated the milks using previously established lexicons for unflavored and chocolate milk (Lee et al., 2017; Sipple et al., 2021). Milks (30 mL) were presented in 60-mL soufflé cup with lids and randomly generated 3-digit codes. Samples were prepared with overhead lights off to prevent light oxidation. Milks were equilibrated to 15°C before evaluation. Data were collected on paper ballots. Each panelist evaluated milks from each experimental replication in duplicate in separate sessions.

Child Consumers

Children (ages 8–13 yr; grades third to eighth) were recruited (n = 140) with parental consent using a survey constructed in Lighthouse Studio 9 (version 9.7.2; Sawtooth Software (https://sawtoothsoftware.com/lighthouse-studio) The survey was sent to an online database of >10,000 individuals in the area of Raleigh and Durham, North Carolina, maintained by North Carolina State University Sensory Service Center. Children were recruited based on parental self-reported frequency of milk consumption (must consume milk at least 2–3 times per month) and were required to have no food allergies, intolerance, or dietary restrictions. Children that participated in the unflavored milk test (acceptance n = 138, tetrad n = 128) consumed unflavored milk most frequently and children that participated in the chocolate milk test (acceptance n = 123, tetrad n = 129) consumed chocolate milk most frequently. Children were also required to attend public or private school and to purchase and consume milk at school (chocolate or unflavored for perspective tests) to participate. For each test, half of the kids recruited consumed skim or low-fat milk most frequently and the other half of the kids consumed reduced-fat or whole milk most frequently. For each replication, sensory testing occurred on d 7 to 11 postproduction for acceptance and tetrad testing. For the first replication of unflavored and chocolate milks, acceptance testing was completed on d 7 and 8 postproduction and tetrad testing was completed on d 9, 10, and 11 postproduction. This order was then reversed for the second milk replication to prevent test order effects. Children were permitted to participate in both acceptance and tetrad testing. However, per recruitment criteria stated above, the same children could not participate in both unflavored white and chocolate milk tests.

Acceptance Test

Milks were evaluated with and without visual cues to determine the role of appearance on child liking of milks with different fat levels. The goal was 120 children to evaluate each replication of unflavored white and chocolate milk for a total of 240 children through unflavored and chocolate milks. The acceptance test took place over 2 d (1 session per child consumer each day) where the same cohort of child consumers were presented milks with and without visual cues. Both presentation formats were evaluated to better understand the role of visual cues and fat content on child liking of milk. In a school setting, the visual cues presentation would be representative if a child milk were to pour their milk out of the carton/bottle into a cup, peel off the label, consume the milk through a clear plastic straw, or if the milk was served in a clear PET bottle. The presentation without visual cues would be representative of a cardboard carton (most common in school lunch scenarios, Sipple et al., 2021) or HDPE container. Milk were blocked within visual or nonvisual cues to eliminate confusion. For the visual cue presentation, children were presented each of the 4 milks (60 mL) monadically in clear 177 mL plastic tumblers labeled with a random 3-digit blinding code. Milks were served at 4°C. For the no visual cues presentation, milks (60 mL) were prepared in the same way but served in 148-mL polystyrene foam cups with

Table 1. Mean (± SD) composition (3 replicates; % wt/wt) of unflavored white milks[1]

Sample	Fat	TP (calculated)	TS
Raw skim milk	NA	3.4 ± 0.001	9.36 ± 0.001
Raw unstandardized whole milk	NA	3.25 ± 0.001	13.1 ± 0.001
Pasteurized skim milk	0.06 ± 0.01	3.37 ± 0.03	9.41 ± 0.01
Pasteurized 1% milk	1.02 ± 0.02	3.33 ± 0.03	10.26 ± 0.03
Pasteurized 2% milk	2.0 ± 0.001	3.3 ± 0.03	11.16 ± 0.001
Pasteurized whole milk	3.24 ± 0.01	3.25 ± 0.04	12.25 ± 0.03

[1]TP = true protein (total nitrogen − NPN); NPN = nonprotein nitrogen × 6.38; NA = not applicable.

opaque lids and straws with a random 3-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 monadically under 25-W fluorescent white lights in a Williams design to prevent presentation order effects. A 2-min rest was required between samples. During the rest, each child was instructed to rinse their mouths with deionized water and to take a bite of an unsalted cracker as a palate cleanser. For the second replication of both milk types, the order of presentation of with and without visual cue days were reversed to eliminate blocking order effect.

For unflavored milks, children were asked to evaluate their liking of the color (with visual cues only) and overall liking on a modified 7-point smiley face scale where 1 = really bad and 7 = really good (Sipple et al., 2021). Furthermore, children were asked to evaluate the color (visual cues only), flavor, and thickness of the milks on a modified "smiley face" just-about-right (**JAR**) scale (1 = not enough and 5 = too much), purchase intent in regards to how much they want their mom or dad to buy each milk (where 1 = definitely do not want mom or dad to buy and 5 = definitely want mom or dad to buy), as well as how much they like the milk in comparison to school milk they currently consume (1 = "I like it a lot less" and 5 = "I like it a lot more") (Sipple et al., 2021). After all milks were presented, children were asked to select which sample they would like to take home with them, then asked to rank samples in order of preference. For chocolate milk, children were additionally asked about chocolate flavor and sweetness JAR. Data were collected using an online ballot through Compusense Cloud (Compusense). After completing both days of acceptance testing, children were compensated with a $60 gift card to a local store.

Tetrad Testing

Tetrad testing took place over 3 d and was identical to acceptance testing in that tests were conducted with and without visual cues. Each day, each child consumer evaluated 2 tetrads out of 4 possible tetrads. Before testing, to ensure each child cognitively understood the directions of the tetrad test, every child first completed a tetrad activity where the child received 4 pieces of candy that were 2 similar shades of red. The panelists were asked to group together the 2 pieces of candy they thought were most similar and if they could do this exercise, the child was then allowed to proceed with the tetrad tests. Every child that was recruited for this test was able to complete this pre-activity. Milks were prepared in the same manner as described above and each child was given 2 milk tetrads, one at a time, one with visual cues and one with no visual cues. Milks were blocked (i.e., visual and nonvisual cues were shown at one time together) within milk fat pairs. Additionally, clear plastics tumblers and polystyrene foam cups (visual cues vs. no visual cues) presentation order was rotated for each panelist to ensure differences in detection was not due to sensory fatigue, adaptation, or memory effects. A 2-min rest was enforced between each tetrad set. Data were collected using an online ballot through Compusense Cloud. After completion of

Table 2. Mean (± SD) composition (3 replicates; % wt/wt) of flavored chocolate milks[1]

Sample	Fat	TP (calculated)	TS
Raw skim milk	NA	3.43 ± 0.04	9.45 ± 0.07
Raw unstandardized whole milk	NA	3.27 ± 0.04	13.36 ± 0.12
Flavored pasteurized skim milk	0.11 ± 0.001	3.36 ± 0.03	13.32 ± 0.17
Flavored pasteurized 1% milk	1.05 ± 0.02	3.33 ± 0.05	14.2 ± 0.02
Flavored pasteurized 2% milk	1.95 ± 0.001	3.29 ± 0.09	15.07 ± 0.01
Flavored pasteurized whole milk	3.15 ± 0.02	3.25 ± 0.06	16.04 ± 0.06

[1]TP = true protein (total nitrogen − NPN); NPN = nonprotein nitrogen × 6.38; NA = not applicable.

Table 3. Instrumental Hunter L and a values and International Commission on Illumination (CIE) b* values for unflavored white milks at viewer angle of 10

Value[1]	White milk			
	Skim	1%	2%	Whole
L	79.0^{d}	84.3^{c}	86.3^{b}	87.4^{a}
a	−4.1^{d}	−1.4^{c}	−0.6^{b}	−0.1^{a}
b*	4.5^{c}	7.3^{b}	7.7^{a}	7.7^{a}

$^{a–d}$Means within a row with different lowercase superscript letters differ ($P < 0.05$).

[1]Luminosity (L) measures the degree of lightness from dark (0) to light (100); a measures the degree of redness (+) or greenness (−); b* measures the degree of yellowness (+) or blueness (−).

all 3 d of tetrad testing, participants were compensated with a $70 gift card to a local store.

Statistical Analysis

A one-way ANOVA with Fisher's least significant difference for means separation was performed on descriptive analysis data and 7-point hedonic data from consumer acceptance testing. The JAR scores were analyzed using chi-squared and reported as the percentage of respondents who selected each option with Marasculio procedure for multiple comparisons. Penalty analysis ($P < 0.05$) was conducted on JAR scores and overall liking. Kruskal-Wallis with Dunn's post hoc test for multiple comparisons was used to analyze 5-point non-JAR scales. Additionally, a 2-way ANOVA with Fisher's least significant difference was used to investigate potential interactions between milk fat and visual cues and between fat content normally consumed (based on parental screener responses) and overall liking scores. Tetrad test results were evaluated by chi-squared distribution to determine the P-value. All statistical analyses were performed at a 95% confidence level using XLSTAT (version 2019.3.1; Addinsoft).

Table 4. Instrumental Hunter L and a values and International Commission on Illumination (CIE) b* values for flavored chocolate milks at viewer angle of 10

Value[1]	Chocolate milk			
	Skim	1%	2%	Whole
L	44.4^{d}	48.8^{c}	55.6^{b}	60.2^{a}
a	7.7^{b}	8.9^{a}	9.5^{a}	9.0^{a}
b*	7.9^{c}	9.9^{b}	11.0^{a}	10.7^{ab}

$^{a–d}$Means within a row with different lowercase superscript letters differ ($P < 0.05$).

[1]Luminosity (L) measures the degree of lightness from dark (0) to light (100); a measures the degree of redness (+) or greenness (−); b* measures the degree of yellowness (+) or blueness (−).

RESULTS AND DISCUSSION

Proximate Analysis and Instrumental Color

The maximum diameter at which 90% of the particles were below for milkfat particle size was less than 1.26 μm for unflavored milks, indicating appropriate homogenization. Fat concentrations were within acceptable range for reported milk fat percentage (Tables 1 and 2; FDA, 2017). True protein and TS composition for all milks were within expected ranges for unflavored and flavored milks, respectively (Tables 1 and 2). At d 0, microbiological counts for all unflavored white milk and chocolate milks were <10 cfu/mL aerobic plate counts and <1 cfu CC. At d 7, unflavored white milk had <10 cfu/mL aerobic plate counts and <1 cfu CC, and chocolate milk had between 1.3×10^3 cfu/mL and 2.2×10^3 aerobic plate counts and <1 cfu CC for all fat contents.

Instrumental color differences were documented between all milk fat levels within each milk flavor (Tables 3 and 4). Consistent with Cheng et al. (2018), L values increased as fat content increased with milk appearing lighter for both unflavored white and chocolate milk with higher fat contents. As fat content increased, unflavored white milk moved from negative a value, or more green in color, to 0 (Table 3) on the a scale consistent with Phillips et al. (1995). Chocolate milk ranged from 7.7 (skim) to 9.5 (2%) with no trend observed for a values. Chocolate milks had more red color character (i.e., higher a value) than unflavored white milks. For b* values, chocolate and unflavored white milk both became more yellow (increased in b*) with increasing fat content (Tables 3 and 4) but chocolate milks had more yellowness than unflavored white milks. Reflectance data for unflavored milks was consistent with reflectance data presented by Phillips and Barbano (1997) and also confirms that as fat content increased in both unflavored white and chocolate milks there was a progressive increase in percent reflectance at all wavelengths from 360 to 750 nm with an increasing amount of light reflected as wavelength increased (Figure 1).

Descriptive Analysis

Trained panelists documented sensory differences among the milks due to milk fat. For unflavored milks, skim milk was associated with less opacity, lower sweet aromatic and cooked or milky flavors, lower viscosity and higher astringency ($P < 0.05$; Tables 5). Whole milk was the most opaque and had the highest sweet aromatic, cooked or milky, and milk fat flavors, and was the most viscous with the lowest astringency ($P < 0.05$). Milks with 1 and 2% fat scored at parity with

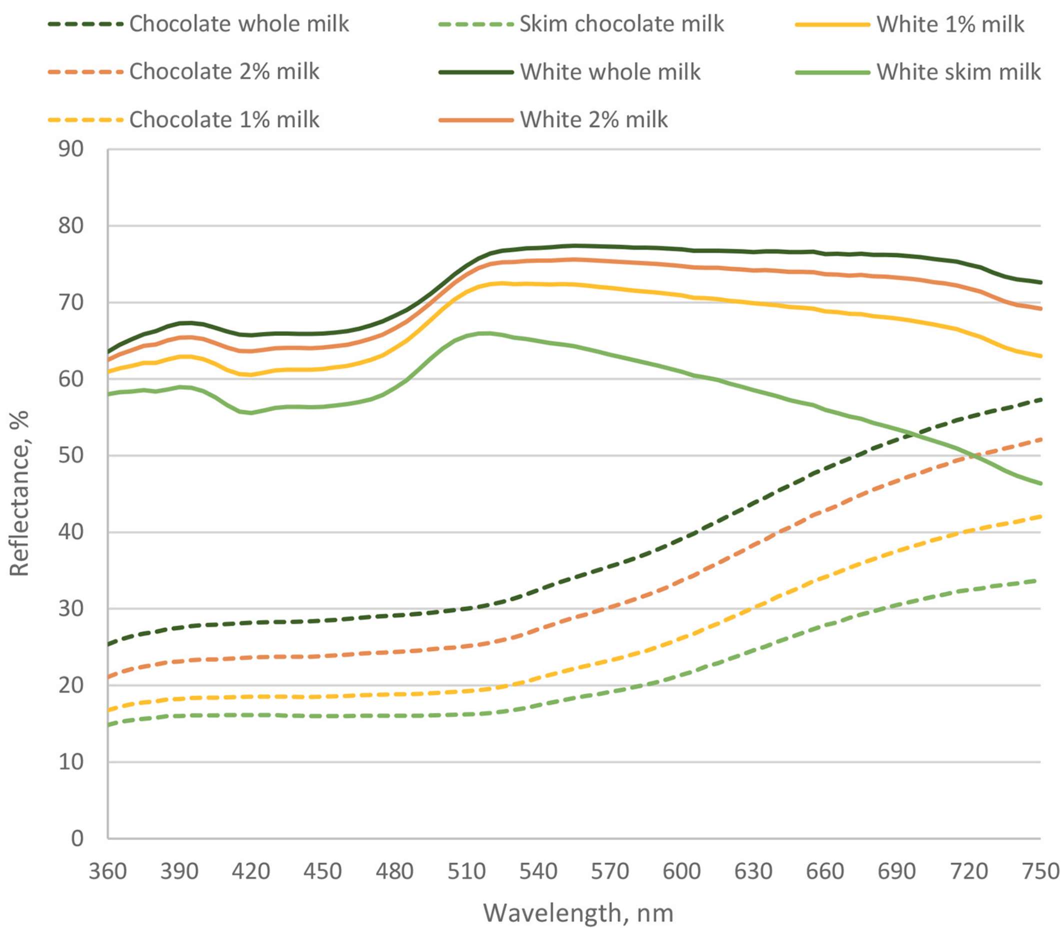

Figure 1. Instrumental reflectance curves for unflavored white and chocolate milks at a viewer angle of 10°. Data represent the average of 3 replications on 2 experimental lots of each milk.

one another and were in between whole milk and skim milk for all attributes. These results align with previous studies on the effect of milk fat on milk appearance, flavor, and texture (Phillips et al., 1995; Frost et al., 2001; Francis et al., 2005; McCarthy et al., 2017a; Cheng et al., 2019). Consistent with McCarthy et al. (2017a), milks with higher fat content had higher viscosity and more milk fat flavor.

Similar trends were documented in chocolate milks for sensory attributes, sensory appearance, flavor and mouthfeel were affected by fat content ($P < 0.05$; Table 6). Chocolate skim milk was the lowest in cooked or

Table 5. Mean trained panel sensory attribute intensities for pasteurized unflavored white milks with different fat contents at 10 d postproduction[1]

Characteristic	Skim	1%	2%	Whole
Opacity	8.0[c]	10.9[b]	10.9[b]	11.9[a]
Sweet aromatic	1.5[c]	1.7[b]	1.8[b]	2.0[a]
Cooked or milky	3.1[c]	3.2[b]	3.2[b]	3.4[a]
Milkfat	ND	1.8[b]	1.8[b]	2.4[a]
Sweet taste	2.1[a]	2.1[a]	2.0[a]	2.0[a]
Astringency	1.9[a]	1.8[b]	1.8[b]	1.7[c]
Viscosity	1.9[c]	2.0[b]	2.0[b]	2.2[a]

[a–c]Within rows, means followed by a different letter represent differences ($P < 0.05$).

[1]ND = not detected. Attribute intensities were scored on a 0-to-15-point universal intensity scale (Meilgaard et al., 2016).

Table 6. Mean trained panel sensory attribute intensities for chocolate milks with different fat contents at 10 d postproduction[1]

Characteristic	Skim	1%	2%	Whole
Color intensity	8.6[a]	7.5[b]	6.7[c]	6.0[d]
Opacity	7.9[c]	10.8[b]	10.8[b]	11.7[a]
Cooked or milky	3.1[c]	3.3[b]	3.4[a]	3.5[a]
Cocoa	2.5[a]	2.3[b]	2.3[b]	2.0[c]
Milkfat	ND	1.7[b]	1.8[b]	2.4[a]
Sweet taste	5.3[a]	5.4[a]	5.4[a]	5.3[a]
Astringency	2.2[a]	1.9[b]	1.9[b]	1.6[c]
Viscosity	1.9[c]	2.0[b]	2.0[b]	2.2[a]

[a–d]Within rows, means followed by a different letter represent differences ($P < 0.05$).

[1]ND = not detected. Attribute intensities were scored on a 0-to-15-point universal intensity scale (Meilgaard et al., 2016).

milky flavor and viscosity, and the highest in cocoa flavor and astringency. Chocolate whole milk had the lightest color, was the most opaque, and was the highest in cooked or milky flavor and viscosity. Chocolate whole milk additionally had the lowest cocoa flavor and was the least astringent ($P < 0.05$). Chocolate milks with 1 and 2% fat scored at parity with one another in everything except color intensity and were in between chocolate whole milk and skim milk for all attributes.

Child Acceptance and Difference Testing

Unflavored Milk. Children that participated in the unflavored milk acceptance test (n = 138) were 52.8% male and 47.2% female and attended elementary (54.2%) or middle (45.8%) school, with an average age of 10 years (age range 8–13 yr). Based on screening information reported by parents/guardians, unflavored milk was indicated as the milk type most often consumed, with approximately half of the children consuming fat-free or low-fat milk (45.7%) and half the children consuming reduced-fat or whole milk (54.3%).

For difference tests, with visual cues, children differentiated between 1%, 2%, and whole milk compared with skim (Table 7). Without visual cues, children could not consistently differentiate between the milks with different milk fats which is consistent with what McCarthy et al. (2017a) reported for adult consumers. The just noticeable difference value for milkfat content in skim milk was 0.4% milkfat with visual cues and greater than 4% fat without visual cues (McCarthy et al., 2017a). Children preferred and had the highest overall liking scores for milks with at least 1% milk fat with visual cues (Table 8). Milks scored at parity for thickness, flavor, and comparison to school milk. With visual cues, skim milk was penalized for being too dark and too thin, and children disagreed on whether the skim milk should have more or less flavor (Table 9). Without visual cues, children had no preference and all unflavored milks scored at parity for each question ($P >$ 0.05). Additionally, without visual cues, all milks were penalized for being too thin. There was no interaction between milkfat content and visual or nonvisual presentation on overall liking ($P > 0.05$; data not shown). The milk fat content that the child currently consumed at home did affect overall liking of unflavored milks with visual cues ($P < 0.05$). Children who typically consumed 2% or whole milk had higher liking scores for all milks than children who typically drink skim milk. The results suggest that children who consume higher milk fat content have a more positive perception of milk, adding more incentive for schools to increase milk fat percentages offered in school as milk fat may increase positive attributes of milk and promote lifelong fluid

Table 7. Tetrad test results from children for unflavored white milks with different milk fat levels with and without visual cues[1]

Cue	Skim vs. 1%		1% vs. 2%		1% vs. whole		2% vs. whole		Skim vs. 2%		Skim vs. whole	
	No. correct/no. of consumers	Significant α = 0.05	No. correct/no. of consumers	Significant α = 0.05	No. correct/no. of consumers	Significant α = 0.05	No. correct/no. of consumers	Significant α = 0.05	No. correct/no. of consumers	Significant α = 0.05	No. correct/no. of consumers	Significant α = 0.05
Visual cues	34/64	Yes	29/65	Yes	31/64	Yes	24/63	No	42/64	Yes	45/63	Yes
No visual cues	25/64	No	29/65	Yes	19/64	No	32/63	Yes	16/64	No	29/63	Yes

[1]Numbers for each tetrad are compiled from tetrad tests from 2 replications of unflavored white milks.

milk consumption. McCarthy et al. (2017a) reported that when blinded from milk fat content, adult consumers always preferred higher-fat milk than the fat content that they self-reported they typically consumed. However, at higher than whole milk fat concentrations (6.6% milk fat), consumers who typically consumed skim milk preferred skim over milk with 6.6% milk fat in the absence of visual cues, confirming that fat affects flavor and mouthfeel properties. Consumers do not deviate too far from what they are familiar with (McCarthy et al., 2017a). When McCarthy et al. (2017a) asked consumers about milk fat preference in follow up qualitative interviews, skim milk consumers stated that milks containing 6.6% milk fat were "too thick" and "too heavy." These attributes resulted in rejection of the milk. Consistent with McCarthy et al. (2017a), Bakke et al. (2016) noted that increased fat content, blinded, did not necessarily increase adult consumer liking for all segments of the population and they also found a correlation in liking of milk with the milk fat concentration that consumers typically consumed when milks were evaluated blinded. Additionally, Bakke et al. (2016) also reported that health-conscious choices for picking lower fat milk had no effect on liking when tasting the milks blinded. Consumers always selected the higher-fat option, again confirming that fat contributes positive sensory benefits to milk beyond a more opaque and thicker appearance. Chapman and Lawless (2005) also determined that when 2 groups of consumers (2% milk fat consumers and nonfat milk consumers) were presented with milks, both groups preferred 2% milk suggesting again that nonfat milk consumers choose nonfat milk for health or nutrition beliefs as opposed to flavor preference.

Ogden et al. (2006) reported that children preferred high fat energy dense snack foods over lower fat foods when their snack intake was previously heavily controlled. Ervina et al. (2020) recently reported that 11-yr-old children who were more sensitive to differences between milk fat content preferred low-fat milks. However, the authors in this study did not report if visual cues were included. Further, the approach to determine fat sensitivity was between 0.5 and 1.5% fat milks (well beyond the just noticeable difference value of >4% reported by McCarthy et al., 2017a) and the results were from a 50:50 split in a forced choice test,

Table 8. Child (ages 8–13 yr) acceptance scores for unflavored white milk 7 d postproduction with visual cues[1]

Attribute[2]	White milk Skim	1%	2%	Whole
Color liking	4.7[b]	5.4[a]	5.6[a]	5.5[a]
Color JAR				
Too light, %	19.6[a]	11.6[a]	13.8[a]	18.8[a]
JAR, %	47.8[b]	71.7[a]	72.5[a]	73.2[a]
Too dark, %	32.6[3,a]	16.7[b]	13.8[b]	8.0[b]
Overall liking	4.9[b]	5.4[a]	5.3[a]	5.2[ab]
Flavor JAR				
Not strong enough, %	22.5[3,a]	15.2[a]	17.4[a]	17.4[a]
JAR, %	53.6[a]	67.4[a]	61.6[a]	61.6[a]
Too strong, %	23.9[3,a]	17.4[a]	21.0[3,a]	21.0[3,a]
Purchase intent	3.2[a]	3.6[a]	3.6[a]	3.5[a]
Thickness JAR				
Too thin, %	25.4[3,a]	19.6[a]	19.6[a]	17.4[a]
JAR, %	57.2[a]	66.7[a]	65.9[a]	68.8[a]
Too thick, %	17.4[a]	13.8[a]	14.5[a]	13.8[a]
Compared with school milk	3.2[a]	3.5[a]	3.5[a]	3.4[a]
Preference, %	13.0[b] (n = 18)	29.0[a] (n = 40)	31.2[a] (n = 43)	26.8[a] (n = 37)
Rank all	2.9[b]	2.4[a]	2.2[a]	2.4[a]

[a,b]Different letters in rows following means signify significant differences ($P < 0.05$).

[1]Data represent 138 consumers.

[2]Liking attributes were scored on a 7-point hedonic scale where 1 = really bad and 7 = really good. Just-about-right (JAR) questions were scored on a 5-point scale where 1 or 2 = too little, 3 = just about right, and 4 or 5 = too much. Percentage of consumers that selected these options is presented and statistical lettering was determined by chi-squared. Purchase intent was scored on a 5-point 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 with school milk question was scored on a 5-point scale where 1 or 2 = like it less, 3 = like it about the same, and 4 or 5 = like it more than school milk. Percentage of consumers who preferred each sample is presented for preference question. Statistical lettering was determined by chi-squared. Average rank is reported as the mean rank value from the ranking question where 1 = "Like the Most" and 4 = "Like the Least." A lower score indicates a better rank score.

[3]Attribute received a significant penalty.

suggesting random odds rather than true fat sensitivity. Mennella et al. (2012) reported that children had a higher sugar and a lower fat preference than their mothers for chocolate puddings, demonstrating that children prefer higher sweet taste than adults. In the nutrition realm, children's weight in association with their sensitivity to fat has been studied extensively but currently there is no evidence for a negative association between fat taste sensitivity and weight status (Cox et al., 2016). Cox et al. (2016) reported there was some evidence for an association between children who have higher liking and preference scores for fat and increased weight status based on several studies reporting a positive relationship between hedonic liking and weight status (Mela and Sacchetti, 1991; Ricketts, 1997; Duffy et al., 2009; Matsushita et al., 2009). However, Kildegaard et al. (2011) demonstrated that child liking of fermented milks with 0.5 or 3.5% fat was driven largely by the amount of fruit flavor rather than fat content suggesting that the liking score and fat relationship observed by Cox et al. (2016) may be due to flavor preferences and not necessarily due to a fat preference.

Results from the current study suggest that child preferences for different milk fat percentages with unflavored milk are based primarily on appearance. It is well established that milk fat plays an important role in visual perception of milk and that milk appearance has previously been linked to preference in adults (Phillips et al., 1995; Phillips and Barbano, 1997; Bakke et al., 2016; McCarthy et al., 2017a). Phillips and Barbano (1997) reported that as the whiteness of skim milk was increased by addition of titanium dioxide, panelists indicated that skim milk had more cream aroma and more mouthfeel demonstrating a halo effect of visible whiteness/opacity on perceived cream aroma and mouthfeel.

Sipple et al. (2021) demonstrated that cardboard cartons imparted undesirable flavors to skim milks that children disliked and that children preferred the flavor of skim milk and 1% fat milk packaged in plastic containers over either milk packaged cardboard carton containers. Trained panelists in that study documented stale and cardboard flavors in the skim and 1% milks packaged in cardboard cartons with both of these flavors not detected in milks packaged in plastic containers. The milks in the current study were filled into half-gallon light-shielded HDPE containers and then further shielded with laser cloth to prevent light oxidation. They were also evaluated within 10 d of processing. As such, these unflavored milks represent an optimal flavor quality and presumably, flavor differences only

Table 9. Child (ages 8–13 yr) acceptance scores for unflavored white milk 7 d postproduction without visual cues[1]

	White milk			
Attribute[2]	Skim	1%	2%	Whole
Overall liking	5.2	5.3	5.2	5.3
Flavor JAR				
Not strong enough, %	25.4[3]	18.1	21.7[3]	18.8
JAR, %	52.2	65.2	58.7	64.5
Too strong, %	22.5[3]	16.7	19.6	16.7
Purchase intent	3.5	3.6	3.6	3.7
Thickness JAR				
Too thin, %	29.7[3]	26.8[3]	29.7[3]	23.9[3]
JAR, %	56.5	60.9	58.7	58.7
Too thick, %	13.8	12.3	11.6	17.4
Compared with school milk	3.4	3.6	3.5	3.6
Preference	18.8% (n = 26)	24.6% (n = 34)	32.6% (n = 45)	23.9% (n = 33)
Rank all	2.6	2.5	2.3	2.5

[1]Data represent 138 consumers. Differences in liking, JAR, and purchase intent means and preference and ranking were not detected ($P > 0.05$)."

[2]Liking attributes were scored on a 7-point hedonic scale where 1 = really bad and 7 = really good. Just-about-right (JAR) questions were scored on a 5-point scale where 1 or 2 = too little, 3 = just about right, and 4 or 5 = too much. Percentage of consumers that selected these options is presented and statistical lettering was determined by chi-squared. Purchase intent was scored on a 5-point 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 with school milk question was scored on a 5-point scale where 1 or 2 = like it less, 3 = like it about the same, and 4 or 5 = like it more than school milk. Percentage of consumers who preferred each sample is presented for preference question. Statistical lettering was determined by chi-squared. Average rank is reported as the mean rank value from the ranking question where 1 = "like the most" and 4 = "like the least." A lower score indicates a better rank score.

[3]Attribute received a significant penalty.

due to fat content differences. In contrast, Sipple et al. (2021) confirmed distinct sensory and liking differences in unflavored skim and 1% fat milks in cardboard cartons compared with milks packaged in plastic containers. Our current results suggest that in the absence of package-related or light oxidation off flavors and no visible cues, children like unflavored skim milk as much as low-fat, reduced-fat or whole milks.

Chocolate Milk Results. Children who participated in the chocolate milk acceptance test (n = 138) were 50.0% male and 50.0% female and attended elementary (51.2%) or middle (48.8%) school, with an average age of 10 yr (age range 8–13 yr). Based on screening information reported by parents or guardians, flavored milk was indicated as the milk type most often consumed, with half of the children consuming fat-free or low-fat milk (50.0%) and half the children consuming reduced-fat or whole milk (50.0%).

Consistent with tetrad results with unflavored milk, children could consistently differentiate between all chocolate milks with all milk fat combinations with visual cues ($P < 0.05$) (Table 10). Without visual cues, children could consistently differentiate between skim and 2% or whole chocolate milk. Because chocolate milk has a more complex flavor and mouthfeel compared with unflavored white milk, children could be more sensitive to fat-related differences between the milks. The sugar content of chocolate milks in the current study was constant, but the school lunch formulation used in the current study has a low amount of added sugar (8.8 g per 237-mL serving) and children may have experienced a similar sensitivity to fat-related sensory differences. Children had the highest overall liking scores for chocolate milk with at least 1% milk fat with or without visual cues ($P < 0.05$; Tables 11 and 12). In terms of color liking and JAR, chocolate milks with 1 and 2% fat scored the highest, significantly higher than skim milk and whole milk. Chocolate milks with fat had higher flavor JAR scores and were ranked higher than skim milks. For other questions, such as those about chocolate flavor JAR, sweetness JAR, thickness JAR, comparison to school milk, purchase intent, and preference, chocolate milks scored at parity ($P > 0.05$). Similar results were seen without visual cues with children giving the highest scores to milks with at least 1% fat.

Skim chocolate milk was penalized for being too dark, for strong flavor, too chocolatey, not sweet enough, and too thin. Chocolate milk with 1% fat was penalized for being too strong in flavor, and not chocolatey enough and too chocolatey, suggesting that children did not like the chocolate flavor but were unsure how to verbalize their dislike. As with skim chocolate milk, 1% fat chocolate milk was also penalized for not being sweet

Table 10. Tetrad test results from children for chocolate milks with different milk fat levels with and without visual cues[1]

Cue	Skim vs. 1%		1% vs. 2%		1% vs. whole		2% vs. whole		Skim vs. 2%		Skim vs. whole	
	No. correct/no. of consumers	Significant α = 0.05	No. correct/no. of consumers	Significant α = 0.05	No. correct/no. of consumers	Significant α = 0.05	No. correct/no. of consumers	Significant α = 0.05	No. correct/no. of consumers	Significant α = 0.05	No. correct/no. of consumers	Significant α = 0.05
Visual cues	46/64	Yes	41/64	Yes	44/65	Yes	30/65	Yes	53/64	Yes	50/63	Yes
No visual cues	19/64	No	21/64	No	17/65	No	22/65	No	33/64	Yes	30/63	Yes

[1]Numbers for each tetrad are compiled from tetrad tests from 2 replications of unflavored white milks.

enough, and for being too thin. Both 2% and whole chocolate milk were penalized for being too light in color and for not being chocolatey enough. Without visual cues, the chocolate milks received similar penalties with the exception of skim and whole milk were noted for being too thick. There was not a significant interaction between milk fat and visual cues and the milk fat content the child currently consumed had no effect on overall liking for chocolate milk ($P > 0.05$; data not shown). In contrast to unflavored white milk, differences between milk fat were seen with and without visual cues for chocolate milk, suggesting that sensory properties other than appearance contributed to child liking. Trained panelists documented aromatic, viscosity, and astringency differences among the chocolate milks with different fat contents. As previously noted, these sensory differences may be more evident to children in chocolate milks than in unflavored milks.

Flavored milk is an important component in the school lunch program, as many children choose to consume flavored milk as opposed to unflavored white milk (Yon et al., 2012). Thompson et al. (2004) reported adult consumer drivers of liking for chocolate milk were cocoa aroma, and cocoa, cooked/eggy and malty flavors. In the current study, trained panelists noted increased cooked/milky flavor in chocolate milks with increasing fat content which might play a role in increased child liking for chocolate milks containing at least 1% milkfat in the absence of visual cues. Trained panelists also documented increased viscosity and decreased cocoa flavor and decreased astringency in 1%, 2%, and whole chocolate milks compared with skim chocolate

Table 11. Child (ages 8–13 y) acceptance scores for chocolate milk 7 d postproduction with visual cues[1]

	Chocolate milk			
Attribute[2]	Skim	1%	2%	Whole
Color liking	5.1[c]	5.6[a]	5.6[ab]	5.2[bc]
Color JAR				
Too light, %	6.5[c]	17.1[bc]	23.6[3,ab]	39.8[3,a]
JAR, %	45.5[b]	71.5[a]	68.3[a]	58.5[ab]
Too dark, %	48.0[3,a]	11.4[b]	8.1[bc]	1.6[c]
Overall liking	5.2[b]	5.7[a]	5.8[a]	5.7[a]
Flavor JAR				
Not strong enough, %	13.0[a]	14.6[a]	10.6[a]	14.6[a]
JAR, %	57.7[b]	65.0[ab]	76.4[a]	74.0[ab]
Too strong, %	29.3[3,a]	20.3[3,ab]	13.0[b]	11.4[b]
Chocolate flavor JAR				
Not chocolatey, % enough	17.9[a]	20.3[3,a]	21.1[3,a]	22.0[3,a]
JAR, %	54.5[a]	59.3[a]	61.8[a]	59.3[a]
Too chocolatey, %	27.6[3,a]	20.3[3,a]	17.1[a]	18.7[a]
Sweetness JAR				
Not sweet enough, %	22.0[3,a]	22.0[3,a]	17.9[a]	16.3[a]
JAR, %	59.3[a]	63.4[a]	66.7[a]	66.7[a]
Too sweet, %	18.7[a]	14.6[a]	15.4[a]	17.1[a]
Purchase intent	3.6a	3.9[a]	3.9[a]	3.9[a]
Thickness JAR				
Too thin, %	24.4[3,a]	22.8[3,a]	20.3[a]	15.4[a]
JAR, %	62.6[a]	65.9[a]	67.%[a]	69.1[a]
Too thick, %	13.0[a]	11.4[a]	12.2[a]	15.4[a]
Compared with school milk	3.5[a]	3.9[a]	3.8[a]	3.9[a]
Preference, %	21.1[a] (n = 26)	25.2[a] (n = 31)	23.6[a] (n = 29)	30.1[a] (n = 37)
Rank all	2.8[b]	2.42[ab]	2.37[a]	2.41[ab]

[a–c]Different letters in rows following means signify significant differences ($P < 0.05$).

[1]Data represent 123 consumers.

[2]Liking attributes were scored on a 7-point hedonic scale where 1 = really bad and 7 = really good. Just-about-right (JAR) questions were scored on a 5-point scale where 1 or 2 = too little, 3 = just about right, and 4 or 5 = too much. Percentage of consumers that selected these options is presented and statistical lettering was determined by chi-squared. Purchase Intent was scored on a 5-point 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 with school milk question was scored on a 5-point scale where 1 or 2 = like it less, 3 = like it about the same, and 4 or 5 = like it more than school milk. Percentage of consumers who preferred each sample is presented for preference question. Statistical lettering was determined by chi-squared. Average rank is reported as the mean rank value from the ranking question where 1 = "like the most" and 4 = "like the least." A lower score indicates a better rank score.

[3]Attribute received a significant penalty.

Table 12. Child (ages 8–13 yr) acceptance scores for chocolate milk 7 d postproduction without visual cues[1]

	Chocolate milk			
Attribute[2]	Skim	1%	2%	Whole
Overall liking	5.2[b]	5.7[a]	5.8[a]	5.9[a]
Flavor JAR				
Not strong enough, %	18.7[a]	11.4[a]	9.8[a]	9.8[a]
JAR, %	61.0[a]	73.2[a]	74.0[a]	71.5[a]
Too strong, %	20.3[3,a]	15.4[a]	16.3[a]	18.7[a]
Chocolate flavor JAR				
Not chocolatey enough, %	27.6[3,a]	18.7[ab]	13[b]	13.8[ab]
JAR, %	52[b]	56.1[ab]	70.7[a]	61[ab]
Too chocolatey, %	20.3[3,a]	25.2[3,a]	16.3%[a]	25.2[3,a]
Sweetness JAR				
Not sweet enough, %	24.4[3,a]	18.7[ab]	9.8[b]	15.4[ab]
JAR, %	59.3[a]	65[a]	75.6[a]	68.3[a]
Too sweet, %	16.3[a]	16.3[a]	14.6[a]	16.3[a]
Purchase intent	3.6a	3.8[a]	3.9[a]	4.0[a]
Thickness JAR				
Too thin, %	22.0%[3,a]	16.3%[a]	17.1%[a]	11.4%[a]
JAR, %	56.9%[a]	69.1%[a]	69.1%[a]	68.3%[a]
Too thick, %	21.1%[3,a]	14.6%[a]	13.8%[a]	20.3%[3,a]
Compared with school milk	3.6[b]	3.98[ab]	4.00[a]	3.9[ab]
Preference	15.4%[a] (n = 19)	29.3%[a] (n = 36)	26.8%[a] (n = 33)	28.5%[a] (n = 35)
Rank all	2.9[b]	2.4[a]	2.4[a]	2.4[a]

[a,b]Different letters in rows following means signify significant differences ($P < 0.05$).

[1]Data represent 123 consumers.

[2]Liking attributes were scored on a 7-point hedonic scale where 1 = really bad and 7 = really good. Just-about-right (JAR) questions were scored on a 5-point scale where 1 or 2 = too little, 3 = just about right, and 4 or 5 = too much. Percentage of consumers that selected these options is presented and statistical lettering was determined by chi-squared. Purchase intent was scored on a 5-point 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 with school milk question was scored on a 5-point scale where 1 or 2 = like it less, 3 = like it about the same, and 4 or 5 = like it more than school milk. Percentage of consumers who preferred each sample is presented for preference question. Statistical lettering was determined by chi-squared. Average rank is reported as the mean rank value from the ranking question where 1 = "like the most" and 4 = "like the least." A lower score indicates a better rank score.

[3]Attribute received a significant penalty.

milks. These differences with the exception of cocoa flavor were also documented in unflavored milks but because children documented decreased liking for skim chocolate milk compared with chocolate milks with at least 1% fat content, these results suggest a flavor or mouthfeel effect due to milkfat in chocolate milk that was not noticeable to children in unflavored milk. From tetrad results, children could consistently detect differences between skim and 2% or whole chocolate milk with or without visual cues, which was not the case with unflavored milks.

Dairy products such as chocolate milk are potentially high in unwanted added sugar, and strategies to make heathier products with reduced fat, sugar, and salt, have been reported to produce unacceptable flavor in dairy products (Biguzzi et al., 2014; McCain et al., 2018). Chocolate milk has an increased caloric intake from added sugars present which naturally makes flavored milk an unwanted item for many parents, but removing flavored milk from schools results in a significant decline in school milk consumption (Quann and Adams, 2013). Recently, there has been a national push for sugar reduction in many foods including dairy foods. Studies have shown direct sugar reduction at 30%, sugar substitution with non-nutritive sweeteners, lactose hydrolysis, and ultrafiltration to be successful methods for chocolate milk sugar reduction for adults and children (Jelen and Tossavainen, 2003; USDA-FNS, 2012; Li et al., 2015a,b; Oliveira et al., 2015; McCain et al., 2018). The current study used a school lunch formulation with minimal added sugar (3.7%) for a total of only 8.8 g of added sugar per 1 cup (237 mL) serving and still received relatively high overall liking scores from children (5.2–5.8 on 7-point hedonic scale). However, as sugar content is reduced, the role of other sensory properties, such as fat, becomes more important (Keast, 2016; Wagoner et al., 2018; Mahato et al., 2020). Our current results suggest that chocolate milk in the school lunch program should contain at least 1% fat to optimize child liking.

CONCLUSIONS

Differences in liking for unflavored and chocolate flavored milks were driven by appearance, viscosity, and flavor. With visual cues, children preferred unflavored and chocolate milks with at least 1% milk fat. In the absence of other intrinsic parameters, appearance plays a key role in children's ability to discriminate unflavored milks containing different amounts of fat. Discrimination and preference among chocolate milk formulations in the current study were driven by visual as well as other fat-related sensory properties. Milk in the US school lunch program plays a vital role in child nutrition as well as potential adult consumption of fluid milk. Milk processing and packaging parameters and regulations should take these issues into account to provide fluid milk with optimum sensory quality to children in the school lunch program..

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