Consumer perception of ice cream and frozen desserts in the “better-for-you” category

L. R. Sipple, C. M. Racette, A. N. Schiano, and M. A. Drake*
Southeast Dairy Foods Research Center, Department of Food, Bioprocessing, and Nutrition Sciences, North Carolina State University, Raleigh 27606

**ABSTRACT**

The consumption of ice cream and frozen desserts in the “better-for-you” (BFY) category has grown rapidly over the past few years, even as traditional ice cream sales remain stagnant. To better understand consumer preferences within the BFY category, an online survey (n = 1,051) was conducted with ice cream and frozen dessert consumers, followed by consumer acceptance testing of commercial BFY frozen dairy desserts. Consumers of BFY frozen desserts (n = 578) completed an adaptive choice-based conjoint survey and MaxDiff exercise to identify the attributes that drive purchase of BFY frozen desserts. MaxDiff exercises were also used to determine which attributes all frozen dessert consumers (n = 1,051) perceived to make a frozen dessert BFY and which stabilizers or emulsifiers were most attractive on an ice cream or frozen dessert label. Subsequently, a consumer acceptance test (n = 186) was conducted using 4 commercial vanilla-flavored frozen dairy desserts made with different sweetening systems (sugar, sucralose + acesulfame K, monk fruit + allulose, and stevia + erythritol). Half of consumers were primed or informed with the sweeteners and basic nutritional information for the frozen desserts before tasting, and the other half of consumers evaluated samples blinded, where they were only informed that they were tasting a vanilla-flavored frozen dessert. Sweetener type and base (dairy vs. plant) were the most important attributes to BFY consumers when selecting a BFY frozen dessert (n = 578). For all ice cream and BFY dessert consumers (n = 1,051), sweetener-related claims (naturally sweetened, reduced sugar, no added sugar), along with “all natural” and a short ingredient list, were the top attributes that contributed to perception of a “healthier” frozen dessert. When BFY frozen desserts were tasted by consumers, purchase intent decreased after tasting, suggesting that frozen desserts made with natural non-nutritive sweeteners did not meet consumer expectations. Flavor of BFY frozen desserts remains more important than perceived healthiness. Consumers perceive frozen desserts, even those in the BFY category, as an indulgence. Frozen dessert manufacturers should focus on naturally sweetened, dairy-based desserts with minimal sweetener-related flavor defects when designing products for the BFY category.

**Key words:** sweetener, consumer preference, frozen dairy foods

**INTRODUCTION**

In recent years, ice cream and frozen dessert sales have experienced only modest increases (Mintel, 2019). However, the category is undergoing a shift toward more “better-for-you” (BFY), functional, and non-dairy products. According to a 2017 survey, ice cream marketers and retailers identified clean labeling, natural products, and health and wellness products as 3 key trends guiding their product development efforts (International Dairy Foods Association, 2019). In the same year, the light ice cream brand Halo Top was the best-selling pint in the United States, competing with super-premium ice cream brands such as Ben & Jerry’s and Häagen-Dazs (Clifford, 2018). Compared with these super-premium products, Halo Top ice cream is lower in fat and sugar (and, thus, calories) and is labeled as a good source of protein. Since 2017, Halo Top’s sales have fallen, perhaps due to significant increases in the number and variety of BFY offerings or a shortcoming in consumer expectations for a BFY frozen dessert (Mintel, 2019). Dairy-free frozen desserts have experienced strong growth, with many traditional ice cream companies releasing plant-based alternatives (Mintel, 2019). Consumers may choose non-dairy alternatives to ice cream due to health concerns associated with dairy product intake or their beliefs about animal welfare or environmental concerns associated with dairy production (McCarthy et al., 2017). Plant-based frozen desserts may be perceived as healthier, even if
their nutritional content is otherwise similar to their
dairy counterparts (Bullock et al., 2020).

Despite recent growth in the popularity of BFY frozen
desserts, literature on consumer desires and perceptions
of healthiness within this category is limited. da Silva et
al. (2014) presented 7 ice cream concepts (traditional,
light, zero sugar, zero fat, fiber enriched, enriched with
bioactive proteins, and enriched with omega 3) and
evaluated consumer purchase intent and health
perceptions. Traditional ice cream was rated as the least
healthy of the contexts presented. Consumers had the
highest intent to purchase for traditional ice cream and
enriched ice creams, whereas concepts associated with
reduced calorie content received the lowest purchase
intent, likely attributable to an association with loss
of sensory quality. This suggests that flavor is the key
driver of liking in frozen desserts. Similarly, Bullock
et al. (2020) investigated consumer liking and health
perceptions of vegan frozen desserts and low-calorie or
super-premium ice cream products. Consumers tasted
each sample under 1 of 3 priming contexts. They either
received no label information (only received information
regarding the flavor of the sample), label information
(including brand, label claims, and nutrition panel), or
label information plus a health warning (including all
label information plus a statement recommending lim-
iting intake of dietary saturated fats and added sugars).
The information participants received when tasting the
ice cream did not affect their liking or healthfulness
ratings of the products, with consumers rating the
super-premium ice cream as the most preferred sample
and the low-calorie ice cream as the healthiest sample
regardless of information context. Overall, consumers
may perceive frozen desserts as inherently indulgent
and expect to compromise on flavor when purchasing
BFY products, namely reduced-calorie products.

Conjoint analysis is a method for understanding con-
sumer preferences within a product category containing
a range of product attributes by simulating trade-offs
consumers must make when making purchase decisions
in the real world (Orme, 2014). This technique uncov-
ers which product attributes are the most important to
consumers as well as their preferences within an attrib-
ute. Although several conjoint methods are available,
the adaptive choice-based conjoint (ACBC) method
performs well when working with 5 or more attributes
and captures more individual-level information than
other conjoint methods, which is ideal when applying
cluster analysis. In ACBC, respondents first specify
their ideal product in a “build-your-own” exercise by
selecting their preferred level within each product at-
tribute presented. The subsequent sections then pres-
ent similar products “adapted” from the respondent’s
initial ideal product (Orme, 2014). The ACBC method
has been used to evaluate purchase drivers within dairy
and plant-based foods and beverages (McCarthy et al.,
2017; Harwood and Drake, 2018; Speight et al., 2019),
and cluster analysis of conjoint results has allowed
for segmentation of consumer groups by their distinct
product preferences (Kim et al., 2013; McCarthy et
al., 2017; Harwood and Drake, 2018). Another method
that can be used to evaluate consumer preference is
maximum difference (MaxDiff) scaling, also known as
best–worst scaling, as consumers choose the “best” and
“worst” items from a list of attributes. The benefit of
using MaxDiff scaling is that preference can be directly
compared across all items included in the exercise, as
opposed to conjoint analysis, where items within an at-
tribute cannot be compared with those within another
attribute (Orme, 2014). MaxDiff scaling has been used
to compliment conjoint analysis in studies of consumer
perceptions of dairy products (Harwood and Drake,
2018; Speight et al., 2019; Rizzo et al., 2020).

Understanding consumer desires within the BFY
frozen desserts category is important for companies
competing in a crowded market. To achieve this, an un-
derstanding of consumer definitions and expectations of
BFY within this category is necessary. Although stud-
ies have previously investigated consumer perceptions
of BFY products, to our knowledge none have profiled
the needs specific to BFY frozen dessert purchasers.
The objectives of this study were to identify attributes
that influence purchase of BFY frozen desserts as well as
which attributes contribute to health perceptions of
frozen desserts.

MATERIALS AND METHODS

Experimental Overview

An online survey using ACBC and MaxDiff scaling
was conducted with consumers of ice cream and dairy-
based and plant-based frozen desserts (Figure 1). The
survey results were analyzed using hierarchical Bayes
modeling, followed by clustering to identify groups of
consumers with unique purchase drivers of BFY frozen
desserts. Subsequently, a consumer acceptance test was
conducted with 4 commercial frozen dairy products with
blinded and primed contexts, to confirm and elucidate
survey results. Consumers in the acceptance test were
consumers of dairy-based ice cream or lower-fat frozen
dairy desserts, or both. All testing was conducted in
compliance with North Carolina State University (Ra-
leigh) Institutional Review Board regulations.
**Survey**

An online survey was developed using Lighthouse Studio (version 9.6.1, Sawtooth Software). Survey participants (n = 1,051) were age 18 yr or older and consumers of ice cream or frozen desserts. Participants were recruited from a database maintained by the North Carolina State University Sensory Service Center (Raleigh). Respondents were asked to complete a set of demographic questions, including frequency of consumption for different types of ice cream and frozen desserts. Respondents who indicated consuming BFY ice cream or frozen desserts (including light or reduced-fat ice cream, high-protein ice cream and frozen desserts, or plant-based frozen desserts) at least every 4 to 6 mo or who self-identified that they wanted a BFY product most of the time (but could also consume regular and premium ice cream) were categorized as “BFY consumers” (n = 578). Respondents who consumed only regular or premium (dairy-based) ice cream on a regular basis and self-identified that they wanted an indulgent product most of the time were categorized as “indulgent consumers” (n = 473). Descriptions of each type of frozen dessert were provided to respondents (Table 1). Skip logic was applied within the survey design to assign consumers to the appropriate survey exercises (Figure 1). The BFY consumers completed MaxDiff and ACBC exercises designed to understand drivers for purchase of BFY products. All consumers (n = 1,051), including both BFY consumers (n = 578)

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**Figure 1.** Overview of experimental design. MaxDiff = maximum difference scaling.
and indulgent consumers (n = 473), were directed to rank their preferred package size for an ice cream or frozen dessert, complete MaxDiff exercises designed to identify the attributes that consumers think will most likely appear in a BFY product, and identify preferred emulsifiers or stabilizers used in ice cream and frozen desserts (Figure 1).

For the ACBC exercise for BFY frozen desserts, 6 attributes were assessed, each with 4 to 7 levels (Table 2). The attributes evaluated included type of ice cream or frozen dessert (base), protein type, sweetener type, sweetener claim, nutrition claim, and label claim. In this exercise, BFY consumers first completed a build-your-own task by selecting 1 level within each attribute to create their ideal BFY product, followed by 10 screening tasks in which they were presented with 4 product concepts per task and asked to select whether each concept was “a possibility” or “won’t work for me.” Respondents then completed a choice task tournament with a maximum of 20 concepts presented. Respondents were prompted to consider that they were purchasing a BFY ice cream or frozen dessert of their favorite flavor when completing the ACBC.

Three MaxDiff exercises were used in this survey. The first MaxDiff exercise was aimed at identifying drivers of purchase for BFY frozen desserts and was completed before the ACBC exercise only by BFY consumers (n = 578). The exercise contained 21 frozen dessert attributes and was designed with 15 sets of “best–worst” questions with 5 attributes displayed per question. Respondents were asked to identify which one of the 5 attributes was “most important” and which was “least important” when selecting an ice cream or frozen dessert to purchase. The second MaxDiff was presented following the ACBC exercise and was completed by all respondents (n = 1,051). The purpose was to identify attributes that contribute to increased “healthiness” perception of BFY products compared with conventional frozen desserts. Before completing this MaxDiff, respondents were primed with the following statement:

Recently, products that claim to be “better for you” or “healthy indulgences” have become popular in the ice cream and frozen dessert market. Below are just a few examples of these products. Compared with “regular” ice cream products, these products may be lower in calories/fat/sugar, higher in protein, have added fiber, etc. We want to know what YOU think makes an ice cream or frozen dessert “better for you.”

A total of 30 frozen dessert attributes were then presented in a set of 20 “best–worst” questions, with 5 attributes presented per question. Respondents were asked to identify which attribute would be “most likely in a ‘better for you’ product” and which attribute would be “least likely in a ‘better for you’ product.” The third MaxDiff exercise was designed to understand consumer perceptions of stabilizers and emulsifiers commonly used in frozen desserts, and this exercise was completed by all respondents (n = 1,051). The MaxDiff was preceded by a priming statement (“Below is a list of ingredients that are commonly found in ice cream or frozen desserts. These ingredients may be used to improve the texture, quality, and shelf life of ice cream/frozen desserts. We want to know what you think about these ingredients.”) and a familiarity question in which consumers were asked to rate how familiar they were with 13 stabilizers or emulsifiers on a 5-point scale, where 1 = “Not at all familiar” and 5 = “Extremely familiar.” The purpose of this exercise was to confirm whether familiarity plays a role in stabilizer

<table>
<thead>
<tr>
<th>Table 1. Ice cream and frozen dessert category examples used in the survey and consumer acceptance test recruitment</th>
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<tbody>
<tr>
<td>Type</td>
</tr>
<tr>
<td>Super-premium or premium ice cream (dairy)</td>
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<td></td>
</tr>
<tr>
<td>Regular ice cream (dairy)</td>
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<tr>
<td></td>
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<tr>
<td>Light or reduced-fat ice cream (dairy)</td>
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<td></td>
</tr>
<tr>
<td>High-protein ice cream or frozen desserts (dairy or non-dairy)</td>
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<tr>
<td></td>
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<tr>
<td>Other plant-based frozen dessert (non-dairy)</td>
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</tbody>
</table>
or emulsifier preference. The 13 stabilizers and emulsifiers were then presented in the MaxDiff exercise with 10 “best–worst” questions, with 5 ingredients presented per question. Consumers were asked to identify which ingredient was “most preferred” and which was “least preferred.”

**Consumer Acceptance Test**

Based on the results of the survey, a consumer acceptance test was conducted to determine whether providing nutritional information to consumers influenced their liking of different dairy-based frozen desserts. Participants were recruited using an online survey in Compusense Cloud (Compusense Inc.) from a database of >10,000 US consumers managed by the Sensory Service Center (North Carolina State University, Raleigh). Consumers ages 18 to 64 yr who reported that they did not have any food allergies, intolerances, or dietary restrictions and self-reported that they purchased and consumed dairy-based ice cream or lower-fat frozen dairy desserts were recruited. Consumers who completed the online survey were not excluded from participation in the consumer acceptance test. These tests were conducted approximately 1 year apart, and therefore memory effects were not a concern. Respondents were segmented based on their ice cream consumption into Conventional and Better-For-You (BFY) consumers. Conventional consumers purchased and consumed premium or regular dairy ice cream at least once every 2 to 3 mo, and BFY consumers consumed at least 1 of light or reduced-fat ice cream, high-protein ice cream or frozen desserts, or plant-based non-dairy frozen desserts at least once every 2 to 3 mo (but could also consume conventional or premium ice cream as well). All consumers had to indicate at least occasional (at least once every 2–3 mo) consumption of a dairy-based ice cream or frozen dessert to qualify. To ensure that respondents understood each category of products, a table with the categories of ice cream and frozen desserts, and example products in each category, was shown to consumers as they completed screener purchase and consumption frequency questions (Table 1). Consumers were recruited such that 50% fell into each segment.

Data were collected using an electronic ballot using Compusense Cloud software. Consumers who fully participated were compensated with a $20 Target gift card. Test design was generated using Compusense Cloud software. A randomized design was used in which 50% of test participants were shown priming statements about the samples before tasting (n = 93), and 50% were not shown priming statements (n = 93). Priming was assigned randomly to consumers as they logged into the online questionnaire, with every other
consumer that logged in being shown priming statements. Sample orders were randomized and balanced. Commercially available vanilla-flavored frozen dairy desserts (n = 4; Table 3) were purchased from local retailers to represent a range of nutritional panels and ingredient decks. Priming statements were developed based on the nutritional information from each frozen dairy dessert (Table 3). Priming statements included the type of sweetener used, the number of calories in a serving size, and the amount of protein, in grams, in a serving size.

To ensure the safety of both researchers and consumers during the COVID-19 pandemic, products were picked up by consumers and taken home for evaluation. Samples were portioned using a 30-mL metric scoop, placed into lidded 118-mL styrofoam bowls (Dart Container Corp.) and labeled with randomly generated 3-digit blinding codes. Samples were tempered to −15°C for scooping, and scooped samples were stored at −30°C for 16 h before distribution to consumers in a thermal bag containing two 178-mL ice gel packs (ULINE), plastic spoons, napkins, and a plastic zip-top bag containing unsalted saltine crackers. Thermal bags with samples and ice packs were kept at −30°C before pickup by consumers. Participants were informed that they had to complete the online questionnaire or place their samples in frozen storage within 45 min of sample pickup. Preliminary testing confirmed that samples maintained sensory quality (appearance, flavor, and texture) in the thermal bags for 120 min. Upon initiation of the test, consumers were required to upload a photo of each sample as they were evaluated, as an additional quality control. Consumers were also required to complete the ballot within 6 h of pickup to be eligible for compensation ($20 Target gift card).

Participants signed a consent form, followed by a ballot consisting of questions about ice creams and frozen dairy desserts. Consumers randomly selected to be shown priming statements (n = 93) first viewed information about the product sweetener, calories per serving, and grams of protein (Table 3), and indicated their purchase intent of the product before evaluating the sample. Purchase intent was evaluated using a 5-point scale in which 1 and 2 = would not purchase, 3 = might or might not purchase, and 4 and 5 = would purchase. All consumers were asked to evaluate the overall appearance and color of the product before tasting. Overall appearance was scaled using a 9-point hedonic scale, where 1 = dislike extremely and 9 = like extremely, followed by a just-about-right (JAR) question about color, where 1 and 2 = too light, 3 = just about right, and 4 and 5 = too dark. Next, consumers were asked to evaluate overall liking and overall flavor using a 9-point hedonic scale. Consumers then evaluated vanilla flavor liking using a 9-point hedonic scale, followed by a vanilla flavor JAR question in which 1 and 2 = not enough vanilla flavor, 3 = just about right, and 4 and 5 = too much vanilla flavor. Consumers then evaluated sweet taste using a 9-point hedonic scale for liking and a 5-point JAR scale where 1 and 2 = not sweet enough, 3 = just about right, and 4 and 5 = too sweet. Consumers also evaluated sweet taste using a 5-point scale in which 1 and 2 = tastes artificial, 3 = unsure, and 4 and 5 = tastes natural. Next, texture was evaluated using a 9-point hedonic scale. Consumers were then asked to select all applicable descriptors from a list of attributes to describe the sample (check-all-that-apply). The list of attributes included the following: sweet, bitter, salty, milky/dairy flavor, custard/eggy flavor, aftertaste, syrupy, artificial sweetener, artificial vanilla, natural sweetener, and natural vanilla. Following this, consumers were asked to indicate their purchase intent using the 5-point scale previously described. Between samples, consumers were instructed to cleanse their palate by rinsing with water and taking a bite of unsalted cracker during an enforced 3-min rest period between each sample. After completing tasting, consumers were asked a set of demographic questions to better define their frozen dessert purchase and consumption habits.

### Statistical Analysis

All statistical analyses were performed at a 95% confidence level (P < 0.05). Hierarchical Bayes estimation was performed in Sawtooth Software (version 9.6.1), and all other analyses were performed using XLSTAT.

<table>
<thead>
<tr>
<th>Commercial product</th>
<th>Priming statement</th>
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<tbody>
<tr>
<td>SUG</td>
<td>Naturally sweetened with sugar. 170 calories per 2/3-cup serving, 3 g of protein per serving.</td>
</tr>
<tr>
<td>NSA</td>
<td>No added sugar. Sweetened with ascesulfame K and sucralose. 110 calories per 2/3-cup serving, 2 g of protein per serving.</td>
</tr>
<tr>
<td>STE</td>
<td>Naturally sweetened in part with stevia and erythritol. 100 calories per 2/3-cup serving, 6 g of protein per serving.</td>
</tr>
<tr>
<td>MFR</td>
<td>Naturally sweetened in part with monk fruit and allulose. 140 calories per 2/3-cup serving, 9 g of protein per serving.</td>
</tr>
</tbody>
</table>

1Primed consumers were provided with product flavor (vanilla) and priming statement, not product brand. Consumers who did not receive priming statement were informed of product flavor (vanilla). SUG: Breyer’s Natural Vanilla Ice Cream; NSA: Breyer’s No Sugar Added Vanilla Frozen Dairy Dessert; STE: Halo Top Vanilla Bean Light Ice Cream; MFR: Fairlife Vanilla Light Ice Cream.

**Table 3.** Products and priming information provided in consumer acceptance test primed context

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Individual utility scores from the ACBC were calculated by hierarchical Bayes estimation, and importance scores for ACBC attributes were calculated as each attribute’s percentage of the total utility range. Hierarchical Bayes estimation was also used to calculate importance scores for MaxDiff attributes. One-way ANOVA with Fisher’s least significant difference was performed for means separation of utility and importance scores. Cluster analysis was performed using agglomerative hierarchical clustering with Euclidean distances and Ward’s linkage to put similar respondents into clusters based on individual importance scores. One-way ANOVA with Fisher’s least significant difference was performed on 9-point hedonic data from consumer acceptance testing. The JAR scores were analyzed using chi-squared with the Marasciuolo procedure for multiple comparisons and reported as the percentage of respondents who selected each option, and 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 least significant difference was performed on 9-point hedonic data and 5-point purchase intent data from consumer acceptance testing, to determine whether priming statements affected overall liking or purchase intent.

**RESULTS**

**Survey**

Survey participants were 77.7% female and 22.3% male, and 55.5% of surveyed consumers were of ages 18 to 34 and 45.5% ages 35 to 64 yr. Consumers were generally evenly split between indulgent and BFY consumers ($P > 0.05$), with a few exceptions. A relatively higher proportion of BFY consumers were among ages 45 to 54 yr, whereas the 55- to 64-yr age group contained a higher proportion of indulgent consumers (64 vs. 36% and 45 vs. 55%, respectively; $P < 0.05$). The favorite flavor of frozen desserts was chocolate. When asked to scale whether they would prefer a BFY or indulgent frozen dessert (0- to 100-point scale, where 0 = BFY and 100 = indulgent), consumers wanted an indulgent dessert most of the time (63.6, n = 1,051). Consumers categorized as indulgent wanted an indulgent dessert more often (76.3, n = 473), whereas consumers categorized as BFY wanted indulgent desserts about half of the time and BFY desserts about half of the time (53.2, n = 578). Indulgent consumers had a higher consumption of super-premium or premium ice cream than BFY consumers ($P < 0.05$; results not shown). Regular ice cream was consumed at the same frequency by both groups ($P > 0.05$), and BFY consumers had higher consumption frequencies ($P < 0.05$) of light or reduced-fat and high-protein ice cream, as well as plant-based frozen desserts. Pints and quarts were the most preferred package sizes overall, and gallon was the least preferred ($P < 0.05$; results not shown). The BFY consumers had higher preference for half-pint and pint-sized packages than indulgent consumers ($P < 0.05$), and indulgent consumers had a higher preference for quart-size containers ($P < 0.05$).

The BFY consumers completed a MaxDiff exercise for purchase drivers of BFY frozen desserts (n = 578; Figure 2). Price, all natural, and naturally sweetened were the most important purchase drivers. The high importance of a naturally sweetened product is consistent with several previous studies (Leitich et al., 2015; Li et al., 2015; Parker et al., 2018). A short ingredient list and package size were other important extrinsic attributes. A dairy milk base was more important for purchase than plant-based frozen desserts. The least important attributes in the purchase MaxDiff were frozen desserts made with plant bases. In the ACBC, BFY consumers once again indicated that sweetener type was the most important attribute for purchase of a BFY ice cream or frozen dessert (n = 578; Figure 3). Sweetener type was followed by dessert base or type, protein fortified, sweetener claim, nutrition claim, and label claim. For sweetener type, sugar and natural sweeteners (monk fruit, stevia) were preferred over artificial sweeteners (sucralose, sugar alcohol, acesulfame K) or corn syrup (Figure 4). These results are supported by sweetener claim utility scores, for which “no sugar added” and “reduced sugar” were less preferred than the “naturally sweetened” claim, which was the most preferred sweetener claim. “Lactose free” was the least preferred sweetener claim, which is consistent with results for preferred type of frozen dessert.

Within type of frozen dessert, dairy-based frozen desserts were preferred over plant-based frozen desserts. Almond milk was the most preferred plant base, followed by coconut milk and cashew milk. Soy milk was the least preferred. Similarly, dairy-based protein fortification was preferred over plant protein fortification. Milk protein was the most preferred protein fortification type. Consumers would then prefer no protein fortification over any other protein for fortification. Whey protein and ultrafiltered milk were the next most preferred, respectively, followed by rice protein and casein protein, and pea protein was the least preferred. Within nutrition claim, “good source of protein” was the most preferred, followed by “reduced calorie” and “low fat,” and “high fiber” or no nutrition claim were the least preferred. “All natural” was the most preferred label claim, supported by “naturally sweetened” being the next preferred sweetener claim. “Organic” was the next preferred label claim.
most preferred label claim, followed by no label claim, and “GMO free” was the least preferred label claim. Finally, a large positive “none” utility was observed, indicating that consumers are unwilling to compromise on BFY frozen desserts. That is, they need a “good” combination of levels to prefer a BFY frozen dessert over the “none” choice.

Clustering consumers who responded similarly based on individual importance scores identified 3 clusters of consumers (Figure 3). The defining feature of cluster 1 (n = 168) was that consumers in this cluster placed significantly more importance on sweetener type than on other frozen dessert attributes, relative to the other clusters. Considering the utility scores for this attribute, cluster 1 exhibited more extreme preference for natural sweeteners over artificial sweeteners compared with the other 2 clusters of consumers (Figure 5), and therefore was designated as the “naturally sweetened” cluster. The defining feature of cluster 2 (n = 147) was that consumers in this cluster placed the most importance on the base type of the frozen dessert, whereas the other 2 clusters placed the most importance on sweetener type. When considering the utility scores within the type of frozen dessert attribute for cluster 2, consumers preferred dairy-based frozen desserts over plant-based frozen desserts, and therefore this cluster was designated the “dairy” cluster. Although the most important attribute to cluster 3 (n = 263) was sweetener type and trends in sweetener preferences were similar to the “naturally sweetened” cluster, cluster 3 consumers preferences were not as extreme. Moderate utility scores across attributes suggested that this group of consumers did not like to compromise with BFY frozen desserts. That is, they needed a “good” combination of levels to prefer a frozen dessert over the “none” choice, and therefore this cluster was designated the “not compromising” cluster.

All consumers completed a MaxDiff to identify the attributes that they thought made a frozen dessert “better-for-you” (n = 1,051; Figure 6). “Is naturally sweetened” had the highest importance in contributing to a BFY frozen dessert, with sugar, stevia, and monk fruit being considered “healthier” than artificial sweeteners including sucralose, sugar alcohols, acesulfame K, and corn syrup. However, “no sugar added” and “reduced sugar content” also contributed highly to health perceptions of BFY desserts. This result suggests that even BFY ice cream and frozen desserts...
are viewed as an indulgence, since sugar was the most preferred sweetener in BFY frozen desserts. Dairy milk and almond milk were perceived as the healthiest bases for BFY frozen desserts. Increased protein content also contributed to “healthiness” perception, with milk protein, whey protein, or ultrafiltered milk being the preferred ingredients for increasing protein content (higher importance than casein protein or plant-based proteins). Results for consumers classified as “indulgent” or “BFY” were analyzed to determine whether these 2 groups of consumers had differing thoughts on what makes a frozen dessert “healthier”; however, both consumer types responded similarly ($P > 0.05$; results not shown) for which attributes contributed to “healthier” perception of BFY frozen desserts.

All consumers completed a MaxDiff to determine preferences for frozen dessert stabilizers and emulsifiers ($S/E$; $n = 1,051$; Figure 7). Pectin was the most preferred $S/E$, followed by carob bean gum and lecithin. The most commonly recognized $S/E$ included glycerin or glycerol (69.7%), xanthan gum, (69.6%), pectin (62.9%), and lecithin (53.9%), where the percentage represents the proportion of respondents who indicated they had heard of that type of $S/E$. The least preferred were polysorbate 80 and gellan gum. Similarly, the least commonly recognized $S/E$ were gellan gum (7.7%), tara gum (8.6%), locust bean gum (19.8%), and polysorbate 80 (26.9%), and likely explains why gellan gum and polysorbate 80 were less preferred $S/E$ than carrageenan (Figure 7). Recognition and perceived naturalness of ingredients may influence consumer preferences for $S/E$ ingredients (Maruyama et al., 2021). For instance, consumers are more likely to say that a chemical-sounding name, such as sodium bicarbonate, is less natural than an ingredient with a familiar name, such as baking soda, even though they are equivalent (Chambers et al., 2019).

**Consumer Acceptance Test**

Rather than comparing liking of the products to one another, the interest of this part of the study was to determine how priming influenced liking for the same product, with a specific focus on the sweeteners used. In the online survey, all consumers consistently indicated that sweetener type was important, with an emphasis on natural sweeteners, both nutritive and non-nutritive, over artificial sweeteners. Priming had no influence on

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**Figure 3.** Overall and clustered importance scores of “better-for-you” ice cream attributes from adaptive choice-based conjoint survey ($n = 578$ “better-for-you” frozen dessert consumers). Different uppercase letters indicate significant differences between attributes ($P < 0.05$). Different lowercase letters within an attribute indicate significant differences among clusters ($P < 0.05$).
liking for sugar-sweetened (SUG) or no sugar added (NSA) samples (Table 4). Priming positively affected overall liking, flavor liking, vanilla liking, and sweet taste liking for monk fruit-sweetened (MFR) samples, whereas priming negatively affected liking of stevia-sweetened (STE) samples for all attributes. Both MFR and STE were primed as high-protein products (Table 3), and therefore the difference in priming effect for these 2 ice creams is likely due to the difference in sweeteners used. The positive priming effect on liking for MFR and negative priming effect on liking for STE corresponds with results of the online survey, which re-

![Figure 4](image_url)

**Figure 4.** Average zero-centered utility scores for attribute levels from adaptive choice-based conjoint survey (n = 578 “better-for-you” frozen dessert consumers). Different letters within an attribute indicate significant differences (P < 0.05). Utility scores cannot be directly compared between attributes.
revealed that, conceptually, monk fruit was preferred to stevia in BFY frozen desserts. However, it is somewhat surprising that priming for the natural sweetener stevia negatively affected liking but priming for the NSA (sweetened with the artificial sweeteners acesulfame K and sucralose) had no effect. The secondary sweetener in the MFR and STE frozen dairy desserts may also have played a role in the influence of priming. The STE frozen dessert had erithrytol in addition to stevia, and the MFR had allulose in addition to monk fruit. Sugar alcohols were not preferred by consumers, and this may have had a negative effect over the likely largely unfamiliar sweetener allulose. However, this item does not explain why stevia was less preferred over monk fruit by consumers in the conjoint survey. Primed consumers rated STE as less natural-tasting than both NSA and

**Figure 5.** Average zero-centered utility scores for selected attribute levels from adaptive choice-based conjoint survey, segmented by clustering (n = 578 “better-for-you” frozen dessert consumers). Different letters within a level indicate significant differences between clusters (P < 0.05). Utility scores cannot be directly compared between attributes.
MFR (Figure 8). Compared with unprimed consumers, primed consumers thought that STE tasted less natural, whereas MFR was rated as tasting more natural by primed consumers compared with unprimed consumers. The sweet taste impression of SUG and NSA samples was unaffected by priming context.

Primed consumers rated their purchase intent before and after tasting each sample (Figure 9). Overall, the NSA product had low purchase intent both before and after tasting, and the SUG product had the highest purchase intent before and after tasting, consistent with the conceptual results from the survey. Sucrose remains a preferred sweetener, and artificial sweeteners are not preferred. In contrast, MFR and STE decreased in purchase intent after tasting. This result indicates that the MFR and STE frozen dairy desserts did not meet consumer expectations based on the priming information provided, whereas SUG and NSA did meet expectations.

**DISCUSSION**

Based on survey results, consumers prefer naturally sweetened frozen desserts over artificially sweetened products, and this may be because consumers consider natural sweeteners healthier. Chambers et al. (2019) reported that 43% of consumers considered sugar to be natural, higher than the 23% for stevia or 6% for high-fructose corn syrup. Chambers et al. (2019) also found that the most common reasons for not believing a product is natural is that they do not know what the product is, or they think the product was modified in some way, as in the case of artificial sweeteners or corn syrup. Naturally sweetened, no sugar added, and reduced sugar were considered by all consumers in the current study to contribute to a “healthier” frozen dessert (Figure 6). However, sweetened with stevia or monk fruit were not in the top 10 claims considered by consumers to make a “healthier” frozen dessert and were
scored below sweetened with sugar in the bottom 15 of 30 claims in the MaxDiff exercise. Despite the widespread use of these 2 natural, non-nutritive sweeteners, as Chambers et al. (2019) noted, uncertainty may still exist with these 2 sweeteners unless claims with these sweeteners are called out along with the word “natural” (e.g., naturally sweetened with stevia).

In addition to health perceptions, flavor expectations and perceptions are also drivers of liking in BFY frozen desserts. Li et al. (2015) reported that adults preferred chocolate milk sweetened with sucrose over those sweetened with monk fruit or stevia leaf extracts, as was found in the current survey. It is interesting that the current study identified that consumers preferred monk fruit over stevia, as previous studies with other foods have indicated a neutral (Li et al., 2015) or opposite preference (Reis et al., 2017; Parker et al., 2018; Mahato et al., 2021). Li et al. (2015) found no differences in liking of reduced-sucrose chocolate milk sweetened with monk fruit versus stevia, regardless of whether consumers were primed. Parker et al. (2018) identified a label-conscious segment of consumers who scored ready-to-mix protein beverages made with monk fruit lower in overall liking, flavor liking, sweetness liking, and concept liking compared with those made with stevia or other natural sweetener blends. Similarly, Mahato et al. (2021) found that, although both stevia and monk fruit positively influenced liking of reduced-sucrose chocolate milk, the effect of stevia was stronger than that of monk fruit. A possible explanation for this finding is flavor expectations, based on sweetener familiarity versus preferences. de Medeiros et al. (2019) com-

<table>
<thead>
<tr>
<th>Sample</th>
<th>Priming</th>
<th>Overall appearance liking</th>
<th>Overall liking</th>
<th>Flavor liking</th>
<th>Vanilla liking</th>
<th>Sweet taste liking</th>
<th>Texture liking</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUG</td>
<td>Unprimed</td>
<td>7.1a</td>
<td>7.3a</td>
<td>7.2a</td>
<td>7.2a</td>
<td>7.0a</td>
<td>7.2a</td>
</tr>
<tr>
<td></td>
<td>Primed</td>
<td>7.4a</td>
<td>7.2a</td>
<td>7.2a</td>
<td>7.0a</td>
<td>7.1a</td>
<td>6.8a</td>
</tr>
<tr>
<td>NSA</td>
<td>Unprimed</td>
<td>6.1a</td>
<td>5.7a</td>
<td>5.7a</td>
<td>5.3a</td>
<td>5.9a</td>
<td>6.0a</td>
</tr>
<tr>
<td></td>
<td>Primed</td>
<td>6.1a</td>
<td>6.1a</td>
<td>6.2a</td>
<td>6.3a</td>
<td>6.1a</td>
<td>6.4a</td>
</tr>
<tr>
<td>MFR</td>
<td>Unprimed</td>
<td>6.8a</td>
<td>5.4a</td>
<td>5.9b</td>
<td>5.7a</td>
<td>5.8b</td>
<td>4.8a</td>
</tr>
<tr>
<td></td>
<td>Primed</td>
<td>6.9a</td>
<td>6.2a</td>
<td>6.6a</td>
<td>6.8a</td>
<td>6.6a</td>
<td>5.5a</td>
</tr>
<tr>
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<td>7.0a</td>
<td>7.1a</td>
<td>7.1a</td>
<td>6.7a</td>
<td>6.4a</td>
</tr>
<tr>
<td></td>
<td>Primed</td>
<td>6.5b</td>
<td>6.4b</td>
<td>6.3b</td>
<td>6.4b</td>
<td>5.8b</td>
<td>5.6b</td>
</tr>
</tbody>
</table>

a,bDifferent letters next to means within a sample category indicate significant differences between primed and unprimed consumers for that sample. Statistical lettering was determined using ANOVA.

Liking questions were scored on a 9-point scale where 1 = dislike extremely and 9 = like extremely. SUG = sugar; NSA = acesulfame K and sucralose; STE = stevia and erythritol; MFR = monk fruit and allulose (Table 3).

Figure 7. Ninety-five percent confidence intervals for stabilizer/emulsifier maximum difference scaling (MaxDiff) scores for purchase of ice cream and frozen desserts by all consumers (n = 1,051). Confidence intervals that do not overlap are significantly different (P < 0.05). Higher MaxDiff scores indicate higher importance or preference of that ingredient for purchase. The sum of the mean MaxDiff scores is 100 total points, and the results are interpreted as ratio-scaled values.
pared vegan ice creams made with sucrose, sucralose, and stevia. Products made with stevia were associated with increased bitter taste, bitter aftertaste, and sweet aftertaste (de Medeiros et al., 2019). Given that there are more generally recognized as safe (GRAS) notices for stevia products than for monk fruit products (38 vs. 4, respectively), it is likely that consumers are more familiar with products made with stevia and perhaps are habituated to these flavor defects. This would explain the lower preference of stevia in the conjoint as well as the lower sweet taste impression scores given to primed consumers in the consumer acceptance test for stevia-sweetened frozen desserts compared with monk fruit. Another possible explanation for the lower liking scores of the STE frozen dessert compared with the MFR evaluated in the consumer test was the presence of secondary sweeteners. The STE frozen dessert also contained erythritol, a sugar alcohol, which received a low utility score and was less preferred than all-natural sweeteners and the artificial sweetener sucralose in the

Figure 8. Mean sweet taste impression scores after tasting each sample by both the unprimed and primed consumer groups (n = 186). Different letters within a sample indicate significant differences between purchase intent scores between the 2 groups (P < 0.05). Sweet taste impression was scored on a 5-point scale, where 1 and 2 = tastes artificial, 3 = unsure, and 4 and 5 = tastes natural. SUG = sugar; NSA = acesulfame K and sucralose; STE = stevia and erythritol; MFR = monk fruit and allulose (Table 3).

Figure 9. Mean purchase intent (PI) scores before and after tasting each ice cream or frozen dairy dessert by the primed consumer group (n = 93). Different letters within a sample indicate significant differences between PI scores before and after tasting (P < 0.05). Purchase intent was scored on a 5-point scale where 1 and 2 = would not purchase, 3 = might or might not purchase, and 4 and 5 = would purchase. SUG = sugar; NSA = acesulfame K and sucralose; STE = stevia and erythritol; MFR = monk fruit and allulose (Table 3).
ACBC survey. Erythritol has been reported to contribute bitterness in some dairy products (Tan et al., 2020), although not inherently more so than monk fruit, stevia, or allulose (Tan et al., 2019). Allulose is a natural sweetener that is nutritive but lower in calories than sucrose. Allulose has been proven to have sweetness synergy with other sweeteners, including stevia and sucralose (Jang et al., 2021). Additionally, the temporal sweetness of allulose sweetener blends is more similar to sucrose than that of stevia, monk fruit, or erythritol alone (Tan et al., 2019). The synergistic and temporal properties of allulose may have contributed to increased liking of MFR relative to STE.

Purchase intent scores suggest that consumers are familiar with or have set expectations for sugar-sweetened and artificially sweetened frozen desserts; however, given the relatively new introduction of BFY frozen desserts, expectations may be different for naturally sweetened or added-protein products. For instance, MFR was the highest-protein sample, and it is possible that consumers were willing to overlook some flavor defect expectations when provided with this nutrition information before tasting the product. Overall, this would suggest that preference for frozen desserts is driven by flavor over health perception, indicating that these products, like other traditional ice creams, are viewed as an indulgence by consumers. This idea is reflected in purchase intent scores from primed consumers, where scores for purchase intent were the same before and after tasting the sucrose-sweetened product but dropped significantly for stevia and monk fruit-sweetened frozen desserts after tasting. This was also found in a study comparing vegan frozen desserts, super-premium ice cream, and low-calorie ice cream (Bullock et al., 2020). In that study, the presence of label information or health warnings did not influence frozen dessert liking, and, rather, liking was driven by taste preference (Bullock et al., 2020). Bullock et al. (2020) suggested that the reason for sales in BFY frozen desserts was due to a complicated relationship with indulgent food and concerns about weight and health. To overcome the flavor deficits of sweeteners such as monk fruit and stevia, while appealing to consumer desires for healthier desserts with natural sweeteners, consumer perception and acceptance of reduced-sugar frozen desserts with blends of natural non-nutritive sweeteners + reduced sucrose should be investigated.

Another surprising finding of this study was that consumers identified that dairy-based frozen desserts were BFY than non-dairy frozen desserts. By contrast, Bullock et al. (2020) reported that vegan Ben & Jerry’s was perceived as healthier than super-premium (dairy) ice cream of the same brand. Similarly, McCarthy et al. (2017) found that a driver of plant-based milk alternatives over fluid milk was related to health perceptions. The finding in the current study is likely because the majority of consumers were purchasers only of dairy frozen desserts (n = 491) or purchased both dairy and plant-based frozen desserts (n = 517), who perceived dairy-based frozen desserts to be healthier, whereas a small proportion of consumers surveyed consumed only non-dairy frozen desserts (n = 43), and these consumers perceived plant-based frozen desserts to be healthier.

One of the limitations of this study was the low proportion of exclusive consumers of non-dairy frozen desserts (~4%) relative to the number of consumers that are flexitarian or dairy-only consumers. This may have skewed results in favor of dairy-based frozen desserts. However, the large sample size of consumers surveyed likely makes these data representative of all frozen dessert consumers (e.g., only a small number of consumers are exclusive non-dairy-only frozen dessert consumers).

Another limitation is that commercial samples used in the consumer acceptance test were formulated with different ingredients and were selected based on availability of frozen desserts with the sweeteners of interest and, as such, were not compared directly to each other. Future studies could include manufacture of ice creams and frozen dairy desserts with individual sweeteners, to further elucidate the actual (versus conceptual) preferences for monk fruit, stevia, allulose, and erythritol, and subsequently blends of these sweeteners. Perceptions of additional frozen dessert natural sweeteners not included in the survey should also be investigated, including honey, molasses, agave nectar, and fruit (e.g., dates).

**CONCLUSIONS**

The majority of consumers consume BFY frozen desserts at least occasionally, but overall these products are still viewed as an indulgence where flavor or taste is the most important factor for purchase. When formulating desserts for the BFY category, frozen dessert manufacturers should primarily focus on dairy-based products with natural ingredients, especially sweeteners. These products are preferred both conceptually and with regard to taste.

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ORCIDS

L. R. Sipple @ https://orcid.org/0000-0001-8348-7886
M. A. Drake @ https://orcid.org/0000-0002-4744-2493