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Alaska Native Children Do Not Prefer Sugar-Sweetened Fruit Drinks Compared to Sugar-Free Fruit Drinks

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SEC helped develop the taste test protocols; LM conducted the statistical analyses; SH helped design the study; KS, CLR, EO, and SC helped collect data; DLC helped develop the protocol, collect data, wrote the first draft, and incorporated contributions from all co-authors. All authors reviewed and commented on subsequent drafts of the manuscript.

Structured Abstract

Background.—Alaska Native children, including children of Yup'ik descent, consume large volumes of sugar-sweetened fruit drinks, which contain added sugars that contribute to obesity, diabetes, and dental caries. To date, taste preference evaluations have not been conducted of commercially available sugar-free fruit drinks.

Objective.—The study tested the hypothesis that children would have equal preference for sugar-free versus sugar-sweetened fruit drinks.

Design.—This was an experimental two-alternative forced-choice paired preference test.

Participants/setting.—The study focused on a convenience sample of Yup'ik children ages 7 to 10 years recruited and enrolled from the Yukon-Kuskokwim Health Corporation dental clinic in Bethel, Alaska (N=89).

Intervention.—Children evaluated four different commercially-available sugar-free fruit drinks paired with the sugar-sweetened versions of each flavor. Flavor pair presentation order was alternated across children and order of presentation within each of the four pairs was randomized across pairs.

Main outcome measures.—The outcome was taste preference for the sugar-free versus sugar-sweetened version of the fruit drink.

Statistical analyses performed.—A test of equivalence was run across all four flavors and separately for each flavor using two one-sided tests.

Results.—The data failed to demonstrate equivalence of the sugar-free versus sugar-sweetened fruit drinks across all four flavors ($P=0.51$) or separately for each flavor. However, this was not because of a preference for sugar-sweetened drinks. The preference for sugar-free drinks overall and for each flavor was $>50\%$. While the lower bounds on the 90% confidence intervals were within the range of equivalence (40% to 60%), the upper bounds were outside the range of equivalence ($>60\%$). Based on post-hoc analyses, similar preferences were observed for Yup'ik and non-Yup'ik children, boys and girls, and by child's age.

Conclusions.—Taste preference findings suggest sugar-free fruit drinks may be a well-tolerated alternative to sugar-sweetened fruit drinks for Yup'ik children in Alaska Native communities.

Keywords

taste preferences; sugar-sweetened beverages; sugar-free beverages; children; Alaska Native health

Introduction

Sugar-sweetened drinks are a common risk factor for a number of childhood diseases, including obesity, diabetes, and dental caries.¹⁻³ Examples of sugar-sweetened drinks include carbonated sodas, energy and sports drinks, sweetened coffees and teas, and non-100% fruit drinks. Longitudinal data for U.S. children indicate a significant decrease in the mean proportion of total energy intake attributable to sugar-sweetened drinks, from $24.4\pm0.3\%$ in 2001-2002 to $21.1\pm0.4\%$ in 2009-2010 ($P<0.001$).⁴ Nevertheless, sugar-sweetened drinks continue to be the most common source of added sugar for U.S. children⁵

and remain popular because of easy access, low cost, demand from children, and parent perceptions that sugar-sweetened drinks are healthy.⁶

Consumption of sugar-sweetened drinks is especially problematic in Alaska Native communities.⁷ Sugar-sweetened drinks are the third most common food item, after coffee and sugar, reported on 24-hour recalls by individuals of Yup'ik descent in Western Alaska.⁸ For Yup'ik children ages 6 to 17 years in Alaska's Yukon-Kuskokwim (YK) Delta, mean added sugar intake is 193±43.6 grams per day – nearly eight times the recommended maximum of 25 grams per day by the American Heart Association and two to three times the mean daily added sugar intake for U.S. children ages 6 to 17 years.^{9,10} Sugar-sweetened fruit drinks, particularly those available in powder form, are the main source of added sugars in Yup'ik children.⁹ Powdered fruit drinks are easily transported, inexpensive, do not freeze or require refrigeration, and have a long shelf life – factors that make them particularly appealing to individuals living in cold, remote areas like Alaska's YK Delta.

The health consequences associated with sugared-sweetened drinks in children have prompted researchers to develop and test population-based interventions, though less attention has been devoted to interventions focusing on indigenous children. A systematic review of English language studies focusing on children reported significant reductions in the consumption of sugar-sweetened drinks in interventions that combined health education and access to drinking water.¹¹ Among the studies in the systematic review that reported reductions in sugar-sweetened drink consumption, most of the interventions took place in schools, where palatable water may not have been available. One of the reviewed studies involving home delivery of non-caloric drinks led to long-term reductions in sugar-sweetened drink consumption.¹² To date, the only published study focusing on indigenous children described a community- and home-based dental caries prevention trial conducted in three American Indian communities in the Pacific Northwest.¹³ The goal of the trial was to reduce consumption of sugar-sweetened drinks in newborns by promoting breastfeeding and water intake. Post-trial dental caries rates were significantly lower in children from the intervention cohort. One study limitation is that the researchers did not measure sugar-sweetened drink intake.

Many Alaska Native caregivers in YK Delta communities describe their children as having developed a habit of consuming primarily sugar-sweetened fruit drinks. Water-only interventions may not be successful at changing behaviors in children with an established preference for sweet drinks who are not accustomed to drinking water.¹⁴ Children in such communities may benefit from interventions that offer multiple alternatives in addition to water, including sugar-free drinks. Sugar-free drinks are promising for at least three reasons. First, studies have shown comparable satiety associated with sugar-free drinks.¹⁵ Second, sugar-free drinks can lead to benefits such as less weight gain compared to sugar-sweetened drinks.¹⁶ Third, sugar-free drinks are commercially available in flavors similar to the sugar-sweetened versions, which may make sugar-free drinks more acceptable to children than water and could facilitate the transition away from the sugar-sweetened versions because of familiarity.

Despite the promise of sugar-free drinks, the artificial sweeteners used in sugar-free drinks have raised concerns about potential health consequences linked to artificial sweeteners, particularly in children. The unresolved controversy over recommendations for children's exposure to artificial sweeteners is exemplified by inconsistencies in federal and professional organization recommendations. Recommendations range from the positions that artificial sweeteners are safe when part of a healthy diet, to prolonged exposures are unhealthy; some organizations provide no specific recommendations for or against artificially sweetened foods and drinks in children.¹⁷⁻²¹ Currently, artificial sweeteners used in sugar-free fruit drinks (e.g., sucralose, acesulfame-potassium) are well established as safe, based on toxicological safety data submitted to the U.S. Food and Drug Administration and other regulatory agencies worldwide.²²⁻²³

Incorporating sugar-free fruit drinks into community-based health interventions could reduce consumption of sugar-sweetened fruit drinks and ultimately prevent diseases in indigenous children, but taste comparisons with sugared fruit drinks have not yet been conducted. The goal of this study was to assess taste preferences for sugar-free versus sugar-sweetened fruit drinks in Alaska Native children. The hypothesis was that preferences for sugar-free and sugar-sweetened fruit drinks would be equivalent across four common and commercially-available flavors. Evaluating taste preferences is part of a broader effort to develop interventions aimed at reducing consumption of sugar-sweetened fruit drinks in Yup'ik children in Alaska Native communities.

Materials and Methods

Study Location and Participants.

The study was conducted in Alaska's YK Delta, which is the size of Oregon state and has 25,000 inhabitants, most of whom are of Yup'ik descent. Bethel is the regional hub of the YK Delta and is one hour by airplane from Anchorage. All individuals have access to larger grocery stores in Bethel and small convenience stores in outlying communities. Depending on the degree of acculturation, individuals may participate in Yup'ik traditions like hunting and gathering, berry picking, eating local proteins, and participating in native crafts and dance. The study focused on children recruited from the Yukon-Kuskokwim Health Corporation (YKHC) dental clinic waiting room in Bethel from January to April 2018. The clinic provides comprehensive dental care services to community members, most of whom are of indigenous descent and eligible for Medicaid. Previous work indicates that Yup'ik children recruited from the YKHC dental clinic consume an average of 50 teaspoons of added sugar per day.⁹ Almost all Yup'ik children have a history of dental caries, with rates ranging from 3% to 94% of tooth surfaces affected for children seen in this clinic.⁸ Inclusion criteria for the current study were: 1) ages 7 to 10 years; 2) caregiver consent; 3) ability to provide verbal assent; 4) English speaking; and 5) willingness to try different fruit drinks and communicate preferences. The study focused on children ages 7 to 10 years because this was the upper age range of target children for the planned intervention. Furthermore, inclusion of children in this age range ensured that participants could clearly communicate their taste preferences in a study environment. The study excluded children who on the same

day and prior to recruitment had (1) fluoride varnish applied on their teeth or (2) anesthetized hard or soft intraoral tissues from dental treatment.

Study Procedures.

The study was approved by the University of Washington Institutional Review Board and the YKHC Human Studies Committee and Executive Board. A study staff member described the study procedures and obtained written consent from caregivers and verbal assent from children. Each participant was seated at a table in a private dental clinic operatory. Study staff administered the taste test. Caregivers were permitted to accompany the child to the operatory but did not participate in the test. During the taste test, caregivers completed a 12-item survey available in English or Yup'ik. Each study visit lasted approximately 20 minutes. Children received a sticker and a \$10 gift card as a thank you for participating.

Caregiver Survey.

The survey included the following demographic items: child's age and sex, whether the child was Yup'ik, caregiver age and sex, caregiver's relationship to child, home town, number of children living in the household and corresponding ages, and how much the household follows the traditional Yup'ik way of life (a lot/some/not at all). There were also four items that measured the child's eating behaviors. Caregivers were asked if the child was generally a picky eater (no/sometimes/yes). To assess food neophobia, three items from the non-stimulating subscale of the Food Situations Questionnaire (FSQ) were adapted.²⁴ Caregivers rated on a modified Likert-type scale how they believed their child would feel about: 1) trying a dinner item prepared by the caregiver the child had never tasted before; 2) eating a new kind of sandwich for lunch; and 3) trying a new food item at a family friend's home. The first two questions were unchanged from the original FSQ, but the third item was reworded to be equivalent in concept but culturally relevant to individuals of Yup'ik descent. The survey was refined to improve wording and translated into Yup'ik by a member of the research team who is a native Yup'ik speaker.

Drink Preparation.

The study involved four commercially-available sugar-sweetened fruit drink powder mixes in the following flavors: Orange Tang® (Kraft-Heinz Foods Company, Chicago, IL), and Cherry, Grape, and Tropical Punch Kool-Aid® (Kraft Foods Group, Inc., Northfield, IL). The four flavors were chosen because of their local availability and popularity with Yup'ik children. The sugar-sweetened fruit drinks were purchased in Alaska. Sugar-free water enhancers in the same flavors were purchased from stores in Seattle, WA.

For each of the four sugar-sweetened fruit drinks, a separate 32-ounce Nalgene® water bottle was used to mix each powder with room temperature bottled distilled water purchased from a grocery store in Bethel. To ensure consistency across batches, an electronic balance (ScoutPro; Ohaus, Parsippany, NJ) was used to weigh the powder mix. Each drink was prepared following directions on the packaging (2.95g powder/1oz water for Orange Tang® and 2.10g powder/1oz water for the Kool-Aid® drinks). Bottles were hand-shaken until all the powder was dissolved. Similar protocols were used to prepare the sugar-free fruit drinks,

except that a 10mL syringe was used to measure the liquid concentrate (0.25mL concentrate/1oz water) prior to mixing with room temperature bottled distilled water.

Taste Test Procedures.

Taste preferences were assessed using a two-alternative forced-choice paired preference testing procedure, which was modified so that children could point to the preferred beverage rather than providing a written or verbal response.²⁵ Prior to taste testing, each child was taught the two-alternative forced choice preference test via verbal instruction, with an opportunity for practice that involved having the child identify his or her preference for popcorn versus onions. A laminated card with a photograph of popcorn was placed in front of the child next to a laminated photograph of onions. The child was asked to point to the picture of the food item he or she likes best. Understanding of the task was confirmed by asking “I see you like popcorn better than onions. Is that right?” or “Do you like onions better than popcorn?”. Instructions were repeated and clarified for understanding if needed. Taste testing commenced after this introductory task was complete.

Outcome.

For each of the four paired comparisons, the child evaluated a sugar-free fruit drink flavor and the sugar-sweetened version of that same flavor. Flavor presentation order was alternated across children and order of presentation within each of the four pairs (i.e., sugar-free version first or sugar-sweetened version first) was randomized across pairs (see Randomization section below for further details). For each paired comparison, two, 30mL plastic medicine cups containing 10mL of each drink were presented to the child. The cups were presented by placing them on a laminated placemat with a dividing line down the center. One side of the placemat was labeled “1” and the other side was labeled “2”. The participating child was first asked to sip the entire 10mL content of the medicine cup placed on side 1 and to hold the liquid in his or her mouth while the examiner counted to three out loud. Children were then instructed to swallow the drink, take two sips of distilled water, and then repeat the procedure with the medicine cup on side 2. After sampling both drinks, the child was asked to point to or say the number corresponding to the drink he or she preferred. As required by a forced-choice procedure, children were asked to indicate a preference for cup 1 or 2 even if he or she indicated equal preference for the two drinks. The child’s answer was recorded by the examiner on a data collection sheet, which was kept out of sight of the participant. The taste test protocol was repeated until all four paired comparisons between drinks were completed. A one-minute break was enforced between each of the four paired comparisons.

Sample Size and Power.

A priori power calculations were conducted to ensure an adequately powered sample size. A minimum sample size of 88 participants was sufficient to have at least 80% power to demonstrate equivalence (i.e., no preference) between the sugar-free drinks and sugar-sweetened drinks based on two one-sided tests across all four flavors, a $\pm 10\%$ margin of equivalence around 50%, an intraclass correlation coefficient of 0.20 among the four preference ratings within an individual, and a 0.05 significance level.^{26,27}

Randomization.

The order of the taste testing was designed to achieve a balanced design with all possible treatment orders among the four flavors (presented first, second, third or fourth) and between the sugar-free or sugar-sweetened drinks (sugar-free drink presented first or second for each flavor). Each order was replicated twice (2×48 orders) and the orders were randomized. An exception to the randomizations was the last eight orders that were selected to maintain balance for first-order carryover effects, if only 88 individuals were enrolled.^{28,29}

Data Management and Analyses.

Data were entered from raw data collection forms into an Excel spreadsheet by one of two researchers. All entered data were subsequently verified for accuracy by the second researcher. After generating descriptive statistics on the study population, tests of equivalence were run across all four flavors and separately for each flavor using two one-sided tests (TOST). This method tested the null hypothesis that there is a preference with the alternative hypothesis that there is no preference. A p-value < 0.05 was used to reject the null hypothesis and demonstrate equivalence. In addition, 90% confidence intervals are reported for the preference for the sugar-free drink, where an upper bound ($<60\%$) and lower bound ($>40\%$) indicated equivalence and is equivalent to the TOST method. Given an apparent trend for a preference for the sugar-free drinks, post-hoc 95% confidence intervals (CI) were used to describe preferences for the sugar-free drinks. Logistic regression with a binary outcome indicating whether the participant preferred the sugar-free drink (1) or the sugar-sweetened drink (0) was used to perform TOST for the intercept. The null hypotheses were intercept $< \ln[(0.5 - \delta)/(0.5 + \delta)]$ and intercept $> \ln[(0.5 + \delta)/(0.5 - \delta)]$, where $\ln$ is the natural logarithm and $\delta = 0.1$. Generalized estimating equation methods were used to fit the logistic regression for tests across all four flavors to account for clustering by individual.³⁰ Post-hoc tests were run to assess for subgroup differences in preferences between Yup'ik and non-Yup'ik children, between boys and girls, and by age.

Results

Descriptive Characteristics.

Eighty-nine children were recruited into the study and the mean age of participants was 8.3 ± 1.1 years (Table 1). Approximately 46% of participants were female and 88.8% were Yup'ik. The mean age of caregivers was 39.5 ± 9.7 years, 71.9% were female, and over 90% of caregivers were the child's mother or father. Over 55% of children were from households that lived in Bethel and 44.9% were from other communities in the YK Delta. The mean number of children per household was 3.6. Nearly 90% of caregivers reported that his or her household followed the traditional Yup'ik way of life "a lot" or "some". In terms of child eating behaviors, 53.9% of children were rated by their caregivers as picky eaters, but less than 6% of children were described as being likely to respond negatively ("NO! NO!") to any of the three FSQ items.

Taste Preferences.

Equivalence was not demonstrated in preferences between the sugar-free and sugar-sweetened drinks across all four flavors or for each flavor (Table 2 and Figure 1). Collapsing across flavors, 60.1% of children preferred the sugar-free drinks compared to the sugar-sweetened versions (95% CI: 53.5%, 66.4%). The highest preference for sugar-free over the sugar-sweetened equivalent was for Orange Tang® (67.4%; 95% CI: 57%, 76.3%), followed by Cherry Kool-Aid® (60.7%; 95% CI: 50.2%, 70.2%), Fruit Punch Kool-Aid® (58.4%; 95% CI: 47.9%, 58.4%), and Grape Kool-Aid® (53.9%; 95% CI: 43.5%, 64%).

Approximately 23.6% of children preferred all four sugar-free versions to the sugar-sweetened versions, 27% preferred three of four, 25.8% preferred two of four, 13.5% preferred one of four, and 10.1% preferred zero of four sugar-free drinks. There were no significant differences in preferences between Yup'ik and non-Yup'ik children, between boys and girls, nor by age.

Harms.

There were no harms reported by caregivers during, or after the study.

Discussion

This is the first published study to examine fruit drink taste preferences among Alaska Native children, with an emphasis on comparing commercially available sugar-free and sugar-sweetened fruit drinks. Study findings did not demonstrate preference equivalence between the sugar-free and sugar-sweetened fruit drinks. There was also no preference for sugar-sweetened fruit drinks. More than 50% of Yup'ik children preferred the sugar-free versions of all four flavors. These findings suggest that sugar-free fruit drinks may be a well-tolerated alternative to sugar-sweetened fruit drinks for Yup'ik children in Alaska Native communities.

There are no published studies to which the current findings can be compared directly, most likely because the sugar-free fruit drinks evaluated are relatively new to the marketplace. Nevertheless, the study findings have two potentially important implications for future interventions. First, given the popularity of sugar-sweetened fruit drinks like Tang® and Kool-Aid®, sugar-free versions are a possible alternative that caregivers could give children to reduce total added sugar intake. There may be less resistance to sugar-free fruit drinks among children who are familiar with the sugar-sweetened versions, especially when compared to other alternatives like water, which could help initiate the process of behavior change. Second, preference differences between sugar-free and sugar-sweetened versions were higher for Orange Tang® relative to other flavors like Grape Kool-Aid®, which suggests that some sugar-free flavors may be more palatable to children than others. Beyond the four flavors that were tested in the current study, other sugar-free fruit drink flavors are commercially available. Identifying sugar-free fruit drink flavors that are most highly preferred by children may inform the development of interventions that help to sustain behavior change by giving children different options from which to choose.

There are three main study limitations. First, it is unclear if the observed taste preferences are maintained in the long-term or if the preferences persist when the consumed volume increases. Second, the study included a convenience sample of children recruited from a dental clinic in Bethel, which limits generalizability. However, 45% of participating children lived in small, remote communities outside of Bethel, thereby introducing some geographic diversity to the study population. Further analyses indicated no significant differences in preferences across measured demographic characteristics, including sex, age, and Yup'ik background. Food pickiness and neophobia were other potential characteristics on which preferences could have varied, but preference patterns were similar by pickiness and between children with and without neophobia. Future studies should continue to examine potential subgroup differences in taste preferences. Third, the end goals of interventions to reduce sugar-sweetened beverage intake are to prevent disease and improve health outcomes. Given the high levels of sugared fruit drink consumption in communities like those in the YK Delta, it is unclear whether reducing sugar intake alone is sufficient to prevent diseases like obesity and dental caries. The multifactorial determinants of childhood diseases underscore the importance of concomitant prevention strategies like physical activity to address obesity and twice daily toothbrushing with fluoride toothpaste to prevent dental caries.^{31,32}

Conclusions

This study tested the hypothesis that children would have no preference for sugar-free versus sugar-sweetened fruit drinks. Four commercially-available fruit drink flavors were evaluated and study data failed to show preference equivalence between the sugar-free and sugar-sweetened versions across all four flavors or separately for each flavor. Additionally, there was not a preference for sugar-sweetened drinks. These findings suggest that commercially available sugar-free fruit drinks may be a well-tolerated alternative for Yup'ik children in Alaska Native communities.

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Research Snapshot

Research Question. Do Alaska Native children, many of whom consume large volumes of sugar-sweetened fruit drinks, have similar a preference for sugar-free fruit drinks compared to the sugar-sweetened versions?

Key Findings. Study findings did not demonstrate preference equivalence between the sugar-free and sugar-sweetened fruit drinks for all four flavors tested or each separate flavor. There was also no preference for sugar-sweetened fruit drinks. More than 50% of Yup'ik children preferred the sugar-free versions of all four flavors.

Figure 1. 90% Lower and Upper Bound Preferences for Sugar-Free Fruit Drinks with Dots Indicating the Observed Preference, Error Bars Displaying the 90% Confidence Interval, and Dashed Lines Indicating No Preference (40% to 60%)

Table 1

Demographics of 89 Yukon Kuskokwim Delta children participating in fruit drink taste test

Child Demographics	
Mean age $\pm$ SD (years)	8.3 $\pm$ 1.1
Female n (%)	41 (46.1)
Yup'ik descent n (%)	79 (88.8)
Caregiver Demographics	
Mean age $\pm$ SD (years)	39.5 $\pm$ 9.7
Female n (%)	64 (71.9)
Relationship of caregiver to child n (%)	
Mother	58 (65.2)
Father	23 (25.8)
Grandmother	4 (4.5)
Aunt, uncle, foster parent, or other	4 (4.5)
Household Demographics	
Hometown n (%)	
Bethel	49 (55.1)
Other YK community	40 (44.9)
Mean number of children $\pm$ SD	3.6 $\pm$ 1.6
How much the household follows the traditional Yup'ik way of life n (%)	
A lot	34 (38.2)
Some	44 (49.2)
Not at all	9 (10.1)
Child Eating Behaviors	
Child is generally a picky eater n (%)	
No	40 (44.9)
Sometimes	1 (1.1)
Yes	48 (53.9)
How child would feel about trying a dinner item prepared by the caregiver the child had never tasted before n (%)	
NO! NO!	3 (3.4)
no	22 (24.7)
don't care	22 (24.7)
yes	33 (37.1)
YES! YES!	7 (7.9)
How child would feel about eating a new kind of sandwich for lunch n (%)	
NO! NO!	5 (5.6)
no	20 (22.5)
don't care	18 (20.2)
yes	39 (43.8)
YES! YES!	5 (5.6)
How child would feel about trying a new food item at a family friend's home n (%)	
NO! NO!	4 (4.5)

no	21 (23.6)
don't care	17 (19.1)
yes	39 (43.8)
YES! YES!	4 (4.5)

Table 2

Sugar-free fruit drink taste preferences for 89 Yukon Kuskokwim Delta children participating in fruit drink taste test ^a

Flavor	Preference ^b (%) (90% CI) ^c	P-value ^d
All	60.1 (54.5 to 65.5)	0.51
Orange Tang	67.4 (58.8 to 75)	0.92
Cherry Kool-Aid	60.7 (51.9 to 68.8)	0.55
Fruit Punch Kool-Aid	58.4 (49.6 to 66.7)	0.38
Grape Kool-Aid	53.9 (45.2 to 62.4)	0.12

^aThe null hypothesis is there is a preference (non-equivalent) and the alternative hypothesis is there is not a preference (equivalent). A p-value > 0.05 means the test fails to reject the null hypothesis (i.e., failed to show there was no preference), but this does not imply the null hypothesis is true (i.e., there was a preference). Because the upper bounds of 90% confidence intervals are outside our a priori interval for equivalence and lower bounds are inside the interval for equivalence, we cannot definitively determine that failure to show equivalence was due to a preference for the sugar-free fruit drink.

^b>50% indicates a preference for the sugar-free drink

^c90% confidence interval contained within 40% to 60% indicates equivalence

^dTwo one-sided tests (TOST) for equivalence; p-value < 0.05 indicates equivalence