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Sweet taste perception is greater in non-Hispanic Black than in non-Hispanic White adults

Suzanne Bowser, PhD, RD¹, Nicole Farnsworth, MS, RD¹, Kate Russell, RD¹, Haley Schlechter, RD¹, Shanna Bernstein, MPH, RD¹, Amber B. Courville, PhD, RD¹, Kirsten Zambell, PhD, RD¹, Monica Skarulis, MD², and Ranganath Muniyappa, MD, PhD²

¹Nutrition Department, Clinical Center, National Institutes of Health

²Diabetes, Endocrinology, and Obesity Branch, National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health

Abstract

Objective: Research suggests a difference in sweet taste perception between non-Hispanic Black (NHB) and non-Hispanic White (NHW) adults, but limited research has examined sweet taste perception in relation to dietary intake of sweet products.

Research Methods and Procedures: This cross-sectional study examined the association between race, sweet taste perception and sweet food, beverage, and sugar consumption in healthy, NHB and NHW adults. Seven-day food records were analyzed in Nutrition Data System for Research software. Intensity of sweet taste perception was tested and the general Labeled Magnitude Scale method was used to facilitate group comparisons. Independent T-tests, Mann-Whitney tests and Pearson correlations were used to assess associations.

Results: Subjects were NHB (n=98) and NHW (n=90) adults, aged 41±1 years (mean ± SEM) with energy intake of 2271±53 kcals. BMI was higher in NHB than NHW (36±1 kg/m² vs. 32±1 kg/m², p=0.048), but no differences were observed in age, energy consumption, or total sugar intake. Sweet taste perception rating ((median (IQR) NHB: 73.5(63.9-83.0), NHW: 52.1(46.4-57.7); p=0.001) and added sugar intake (NHB: 39.4g/1000kcal (36.3-42.4), NHW: 30.0g/1000kcal (26.7-33.4); p<0.001) were greater in NHB. Perceived sweet taste intensity was positively associated with consumption of servings of sweet products among NHB (R²=0.057, p=0.018), but not NHW (R²=−0.012, p=0.314).

Corresponding author: Kirsten Zambell, PhD, RD; Nutrition Department, Clinical Center, National Institutes of Health, Building 10, Room B2-2426, 10 Center Drive, MSC 1078, Bethesda, MD 20892; 301-827-0885; zambellk@cc.nih.gov.

AUTHOR CONTRIBUTIONS

Skarulis' Muniyappa and Courville -Conception and design; Zambell, Bernstein, Bowser, Courville, Farnsworth, Russell, Schlechter, Skarulis, Muniyappa - Generation, collection, assembly, analysis and/or interpretation of data; Zambell, Bernstein, Bowser, Courville, Farnsworth, Russell, Schlechter, Muniyappa – Drafting or revision of the manuscript; Zambell, Bernstein, Bowser, Courville, Farnsworth, Russell, Schlechter, Skarulis, Muniyappa – approval of the final version of the manuscript.

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Conclusions: NHB have a higher intensity of sweet taste perception compared to NHW. The positive association of sweet taste perception and sweet product consumption in NHB suggests that a higher intensity of sweet taste perception may be associated with an increased proportion of energy consumption from added sugars.

Keywords

dietary intake; sweet product consumption; gLMS; added sugars; obesity

Introduction

In the United States, health disparities between racial and ethnic groups exist. Non-Hispanic Blacks (NHB) are disproportionately affected by obesity, type 2 diabetes, and cardiovascular disease compared to non-Hispanic Whites (NHW). In adults, NHB prevalence of obesity (46.8%) and diabetes (12.7%) is higher than in the NHW population (37.9%, 7.4% respectively) [1, 2]. The prevalence of hypertension, a major risk factor for heart disease, is also higher among NHB adults (42.1%) compared to NHW adults (28.0%) [3].

Potential contributing factors to these disparities have been examined, and may include differences in food preferences and food intake between racial and ethnic groups. While many factors may drive food preference and intake, it has been suggested that variations in taste perception between individuals or groups may be a contributing factor to differences in dietary preferences and intake of certain types of foods [4]. For example, higher taste responses to bitter taste was associated with a decreased preference for cruciferous and green leafy vegetables, while a higher taste response to sucrose was associated with a higher preference for sweet desserts [5]. Williams et al. examined these variations in taste perception between NHB and NHW and found that NHB were significantly more responsive to sweet taste stimuli than NHW [6].

Various studies have shown an increased preference for and intake of sweets in Black populations. Schiffman et al. reported that Black young adults had a greater desire for more intense sweet tastes than White young adults [7]. Mennella et al. found that NHB children and their mothers had a greater preference for cereals with higher sugar content compared to NHW [8]. In addition to data showing differences in preference for sweet foods, National Health and Nutrition Examination Survey (NHANES) data from 2005-2010 indicate that NHB consumed a larger percentage of their total calories from added sugars than NHW [9]. Given the existing body of research, it seems plausible that differences in sweet taste perception may be related to a preference for sweet food and beverage products, which in turn, may influence dietary consumption of these products.

Individuals with diets high in added sugar are at increased risk for obesity [10]. The prevalence of type 2 diabetes and cardiovascular disease is strongly associated with obesity [11], so diets high in added sugar that contribute to obesity, also may increase the risk of several chronic diseases. A greater preference for sweet food and beverages, leading to greater intake of added sugar among NHB adults may be a contributing factor to health disparities. Though differences in taste perception between NHB and NHW have been studied, the effect of these differences on actual dietary intake and specific health outcomes

requires further exploration. Our study aimed to examine sweet taste perception and the consumption of sweet foods, beverages and sugar in NHB and NHW adults, and to evaluate whether sweet taste perception is associated with dietary intake.

Methods

Subjects were enrolled in a natural history study conducted at the National Institutes of Health (NIH) Clinical Center in Bethesda, MD ([clinicaltrials.gov](https://clinicaltrials.gov/ct2/show/study/NCT00428987) identifier NCT00428987). Study recruitment began in January 2007 and is ongoing. The trial was approved by the NIH National Institute of Diabetes and Digestive and Kidney Diseases' Institutional Review Board (IRB). Informed consent was obtained from all subjects during the screening visit, and all procedures were carried out in accordance with IRB regulations.

Population:

Male and female healthy volunteers (n=188) over the age of 18 were recruited through the NIH Patient Recruitment and Public Liaison Office. Age, sex, race, and smoking history were self-reported and subject demographic data was obtained from medical records. Only NHB and NHW subjects were included in this analysis. Subjects were excluded from study participation if they were pregnant or breastfeeding, had a BMI < 18.5 kg/m², or a current unstable medical condition including cardiac ischemia, severe respiratory insufficiency requiring oxygen therapy, hepatic, or cardiac failure. Potential subjects with significant physical limitations or psychiatric conditions that could prevent participation in study procedures were also excluded. Data from the baseline study visit were used for this cross-sectional analysis. Height was measured in centimeters using a wall stadiometer (Seca 242, Hanover, MD, USA) and weight was measured in kilograms using a calibrated digital scale (Scale-Tronix 5702, Carol Stream, IL, USA). BMI was calculated as kg/m². Dual X-Ray Absorptiometry (GE Healthcare, Chicago, Illinois) was used to measure percent body fat.

Dietary Assessment:

Dietary intake was assessed using food records, which each subject was instructed to complete for seven days prior to their visit. Food records were collected and reviewed by nutrition staff for accuracy. To reflect the marketplace throughout the study, dietary intake data were collected using Nutrition Data System for Research software versions 2007 through 2015, developed by the Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN. Food records were analyzed for average daily intake of energy, macronutrients, total sugar, added sugar, and total servings of sweet products. Total servings of sweet products included: fruit and fruit juices, flavored milk and sweetened beverages, yogurt, cereals, meal replacement supplements, snack bars, miscellaneous desserts, and sugar sweetened spreads, syrups, and sauces.

Taste Perception Swallow Test:

To evaluate taste perception the generally labeled magnitude scale (gLMS) was used, which combines the labeled magnitude scale for oral sensations with a process of magnitude matching [4]. To complete this process, subjects completed a perceived intensity questionnaire using previously experienced light stimuli, which is independent of taste, as

described by Bartoshuk. [12]. Subjects were asked to rate the brightness of the brightest light ever seen, a well-lit room, and a dimly lit room on the gLMS. The gLMS score for light (0 to 100) was used to normalize results of the swallow test (perceived intensity of taste), also rated on the gLMS, and facilitate across group comparisons of taste perception. The swallow test was completed by swishing a pharmaceutical grade solution in the mouth for 30 seconds, spitting out the solution, and swallowing the residual solution left in the mouth. This swallow test reflects real world taste perception, as it includes stimulation to taste receptors in both the mouth and throat, modeling normal dietary intake. Following the swallow test, subjects rated perceived intensity of sweet taste using the gLMS scale. Swallow ratings were normalized using the subject's rating of the brightest light they have ever seen, by dividing the swallow rating by the brightest light rating and multiplying it by 100.

Plasma Lipid and Glucose:

Fasting blood work was collected at baseline visit for measurement of hemoglobin A1c (HbA1c) and lipids (total cholesterol, LDL cholesterol, HDL cholesterol, triglycerides). In order to assess endogenous insulin secretion sensitivity, the Frequently Sampled Intravenous Glucose Tolerance Test was performed and Insulin Sensitivity Index (SI) was calculated [13]. Any blood samples that were hemolyzed could not be analyzed and therefore lipid and SI data were not available for all subjects.

Statistical Analysis:

Data were analyzed using the Statistical Package for Social Sciences (SPSS, version 22.0). Age, BMI and dietary intake are described as means $\pm$ standard error of the mean (SEM). Independent sample t-tests were used to evaluate differences of normally distributed variables between groups. Mann-Whitney tests were performed to examine differences with data that were not normally distributed (median(IQR)). ANCOVA analyses were done to examine associations between perceived sweet taste and sweet product consumption between races. Significance for all analyses was determined at $p < 0.05$.

Results

Subjects were NHB (n=98) and NHW (n=90) adults aged 41 ± 1 years (Table 1). There were no significant differences in age, sex, body fat percentage, history of smoking, total cholesterol, LDL cholesterol, or HDL cholesterol between groups. BMI was higher in NHB than in NHW ($p=0.048$). Triglycerides were lower in NHB than NHW ($p=0.04$). SI was lower in NHB than in NHW and HbA1c was higher ($p<0.001$).

Energy intake was similar across groups with a mean of 2270.7 ± 53.4 kcals (Table 2). In addition, no differences were observed between NHB and NHW in the percentages of energy from carbohydrates, fat or protein, but NHW had a higher percentage of energy from alcohol ($p=0.017$). NHB had a greater consumption of added sugar than NHW ($p<0.001$), but there was no difference in total sugar consumed.

Sweet taste perception rating (Figure 1) was greater in NHB than NHW [NHB: 73.5 (63.9 - 83.0); NHW: 52.1 (46.4 - 57.7); $p=0.001$. Added sugar intake, in grams/1000kcal, (Figure

2A) was also greater in NHB [NHB: 39.4 (36.3 - 42.4); NHW: 30.0 (26.7 - 33.4); $p < 0.001$], though sweet product consumption, in servings/day (Figure 2B), was not different between races [NHB: 6.9 (5.9 - 7.9); NHW: 5.6 (4.9 - 6.3); $p = 0.07$]. Perceived sweet taste, was positively associated with sweet product consumption among NHB but not among NHW ($R^2 = 0.057$, $p = 0.018$ and $R^2 = 0.012$, $p = 0.314$, respectively) (Figure 3).

Discussion

In our study, we found that NHB have a higher sweet taste perception than NHW. We sought to determine whether these differences in sweet taste perception were related to dietary sweet product intake. Though NHB had a higher sweet taste perception, there were no differences in sweet product consumption, average daily energy or total sugar consumption between NHB and NHW. However, NHB had a higher intake of added sugar compared to NHW, suggesting that the proportion of energy from added sugar is higher in NHB, which is consistent with NHANES data (2005-2010) [9].

Higher sweet taste perception in NHB may be a contributing factor to the higher dietary added sugar intake that we observed. Research has suggested that the desirability of sweet taste is an inherent biological response, and has demonstrated a strong relationship between sweet taste and the palatability and acceptance of food [14]. As an example, Low et al. found that higher preferences for sucrose in water were positively correlated with higher preferences for sweet desserts [5]. However, some studies have indicated that this relationship varies based on different thresholds for taste perception. Looy et al. found that adults could be categorized into two distinct groups: sweet likers, who indicated increased liking with increased concentrations of sweet, and sweet dis-likers, who showed increased dislike with increased concentrations of sweet [14]. Our study did not distinguish likers versus dis-likers to determine preference for sweets, rather we examined the perceived intensity of sweet taste, though examining preference would add to our interpretation of results.

While no differences were seen in sweet product consumption between groups, differences in types of specific sweet products consumed could possibly explain the higher intake of added sugar in NHB. In our study, sweet products included all sweet-tasting foods, regardless of other characteristics such as whole versus processed food or naturally occurring versus added sugar contents in food. Both fresh fruit and sugar-sweetened beverages were considered sweet products, yet fresh fruit has health benefits associated with increased consumption of vitamins, minerals, fiber, and antioxidants, while consumption of sugar-sweetened beverages has been associated with negative health consequences [15].

It is notable that we found an association between sweet taste perception and sweet product consumption in NHB, though not in NHW. It is possible that the relationship between perception and preference, and therefore consumption, differs by race. As previously discussed, though an innate preference for sweet taste is widely recognized, distinct categorization of “sweet likers” and “sweet dis-likers” has been identified. It is possible that categorization of sweet liking status may differ by race or that rejection thresholds may differ by race, though this has not been thoroughly examined in the literature. There is also

evidence that the association between perception and preference for taste may be food specific [16] and therefore analysis of taste perception, race and intake of sub-categories of sweet products, such as sweet liquids or sweet solids, may reveal different relationships. Finally, studies have shown that taste preference is affected by exposure to cuisines, which could potentially account for racial differences in the relationship between taste perception, preference and intake [17].

As indicated, many factors other than taste perception affect taste preferences, and similarly, factors other than simple preference impact food selection and intake; psychological and cultural factors as well as socioeconomic status likely play a role [18],[19]. A lower intake of added sugar may represent a culturally determined response rather than a difference in taste perception. For example, cultural and societal pressures to achieve a lean body type may cause individuals to decrease added sugar consumption regardless of taste perception. Additionally, many individuals may consume artificially sweetened products in an effort to reduce caloric impact. Artificial sweeteners provide an intense sweet taste without the addition of calories, which may reflect a preference for sweet taste without an effect on caloric intake. Artificial sweeteners were not examined in this study, and this may be an important area for further research. Moreover, food and beverage cost and access greatly influence dietary intake. Individuals with limited access to healthy food may have a higher intake of processed sweet products regardless of sweet taste perception.

In addition to these factors, physical activity has been shown to play a role in dietary intake, but this was not evaluated in our study [20]. Our study is limited by lack of data on physical activity, socioeconomic status and measures of factors motivating dietary intake. As these variables have the potential to modify the relationship between taste perception and intake, and therefore disease risk, they would be useful to measure in future studies. Our study also did not seek to measure taste preference, which is likely a key component in attempting to understand the complicated relationship between perception and intake. Additionally, this study only examined intake of sweet products that were not sweetened with artificial sweeteners, as the relationship between taste perception and artificial sweetener intake may be distinct from that between taste perception and intake of foods sweetened with caloric sweeteners. However, this is an area for further exploration.

In our study NHB had a higher BMI than NHW, which could be a confounding factor. Multiple publications have explored associations between taste and BMI, however findings have been inconsistent in terms of the relationship between taste threshold or sensitivity and BMI, with some studies finding no association and others findings differences by BMI with only certain taste sensations.[21-23] In addition, in our study there was no difference between NHB and NHW in body fat%, which is a more precise indicator of true adiposity. To further minimize potential confounding by BMI, dietary variables were all adjusted for energy intake, which is highly correlated to BMI. It should also be noted that our study population had an average BMI that falls within the obese range and is higher than the average BMI in the US.[24] Given the uncertainties regarding associations between BMI and taste, it is impossible to determine whether our results would persist in a population of more normal BMI. Future studies should aim to include more subjects of normal BMI to explore whether differences we observed between races holds true.

Our study also has many strengths. We used the gLMS scaling methodology, which is considered the gold standard for assessing taste perception [12]. Our findings are consistent with previous research that used this methodology and demonstrated higher taste sensations for sweet in NHB compared to NHW [6]. Our subject population consisted of a large number of NHB and NHW participants from the Washington D.C. metro area who had very similar characteristics. In addition our study used nutrition data from rigorously collected seven-day food records which are a validated measure of usual dietary intake [25, 26]. Most studies looking at taste perception are not collecting data on dietary intake and therefore, are only able to report on associations between liking and wanting and taste perception. This study was able to further that information to examine foods that participants actually consumed.

Conclusion

We found that NHB had a higher sweet taste perception than NHW. Though total sweet consumption did not differ by race, NHB had a higher added sugar intake, which may contribute to negative health outcomes.

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Abbreviations:

NHB	non-Hispanic Black
NHW	non-Hispanic White
gLMS	general Labeled Magnitude Scale

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HIGHLIGHTS

- Non Hispanic Blacks (NHB) consume more added sugar than Non Hispanic Whites (NHW).
- NHB have higher sweet taste perception than NHW.
- Sweet taste perception was associated with sweet product consumption in NHB.
- Differences in sweet perception may affect preference for sweets.
- Higher sweet taste perception in NHB may contribute to increased sweet intake.

Figure 1. Sweet taste perception is greater in NHB when compared to NHW (calculated as swallow/bright light score $\times$ 100). Analyzed using Mann-Whitney test, median $\pm$ IQR with $p < 0.05$.

Figure 2.

(A) Added sugar intake is greater in NHB when compared to NHW as analyzed using Mann-Whitney test, median $\pm$ IQR with $p < 0.05$. (B) The number of sweet food and beverage servings consumed per day is not significantly different between NHB and NHW. Analyzed with Mann-Whitney test, median $\pm$ IQR with $p < 0.05$. *Not including artificial sweeteners.

Figure 3.

ANCOVA analyses to compare the relationship between sweet taste perception and sweet product consumption between races. Interaction term for race $p=0.043$. Taste perception calculated as swallow/bright light score $\times 100$. *Not including artificial sweeteners.

TABLE 1:

Population Characteristics

	Non-Hispanic Black (n=98)	Non-Hispanic White (n=90)	Total (n=188)
Age (years)	41 ± 1	42 ± 2	41 ± 1
Sex			
Female	59	59	118
Male	39	31	70
BMI (kg/m ²)	36 ± 1 [*]	32 ± 1	34 ± 1
Body fat (%) ^a	40.1 ± 1.0	37.4 ± 1.2	38.8 ± 0.8
History of smoking			
Smokers	9	6	15
Non-smokers	89	84	173
Total Cholesterol (mg/dL) ^b	176.8 ± 3.1	176.1 ± 4.1	176.4 ± 2.5
LDL Cholesterol (mg/dL) ^c	108.7 ± 3.0	103.3 ± 3.5	106.1 ± 2.3
HDL Cholesterol (mg/dL) ^c	49.9 ± 1.3	52.5 ± 1.9	51.1 ± 1.1
Triglycerides (mg/dL) ^b	90.9 ± 4.3 [*]	115.5 ± 7.4	102.6 ± 4.3
Hemoglobin A1c (%) ^d	5.8 ± 0.6 [*]	5.5 ± 0.5	5.7 ± 0.1
Insulin Sensitivity Index (SI) ^e	2.9 ± 0.3 [*]	5.2 ± 0.4	4.1 ± 0.3

Data presented as mean ± SEM with exception of sex and history of smoking data, which are presented as number of subjects.

^{*} Indicates a significant difference between NHB and NHW (p <0.05)

^a total n=184, NHB n=94, NHW n=90

^b total n=183, NHB n=96, NHW n=87

^c total n=184, NHB n=96, NHW n=88

^d total n=161, NHB n=88, NHW n=73

^e total n=159, NHB n=80, NHW n=79

TABLE 2:

Dietary Characteristics

	non-Hispanic Black (n=98)	non-Hispanic White (n=90)	Total
Energy (kcal)	2330.8 ± 78.1	2205.2 ± 71.9	2270.7 ± 53.4
% Energy from Carbohydrate	46.7 ± 0.7	46.7 ± 1.0	46.7 ± 0.6
% Energy from Fat	35.3 ± 0.6	33.7 ± 0.8	34.6 ± 0.5
% Energy from Protein	16.9 ± 0.4	17.5 ± 0.4	17.2 ± 0.3
% Energy from Alcohol	1.1 ± 0.2 *	2.0 ± 0.3	1.5 ± 0.2
Added Sugar (g/1000 kcal) [#]	39.4 (36.3 - 42.4) *	30.0 (26.7- 33.4)	34.9 (32.6-37.2)
Total Sugar (g/1000kcal)	53.2 ± 1.5	49.4 ± 1.7	51.4 ± 1.2

Data presented as mean ± SEM

[#]Data presented as Median ± IQR

* Indicates a significant difference between NHB and NHW (p <0.05)