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Taking the bitter with the sweet: Relationship of supertasting and sweet preference with metabolic syndrome and dietary intake

Gabrielle Turner-McGrievy, PhD, MS, RD[1,2],
1700 Martin Luther King Jr. Blvd, CB#7294, Chapel Hill, NC 27599-7294, USA

Deborah F. Tate, PhD[1,3,4],
1700 Martin Luther King Jr. Blvd, CB#7294, Chapel Hill, NC 27599-7294, USA

Dominic Moore, MPH[4], and
School of Medicine CB# 7295, The University of North Carolina at Chapel Hill, Chapel Hill, North Carolina 27599-7295, USA

Barry Popkin, PhD[1]
406f University Square East, Campus Box 8120, Chapel Hill, NC 27514, USA

Abstract

Objective—Results examining the effects of tasting profile on dietary intake and health outcomes have varied. This study examined the interaction of sweet liker (SL) and supertasting (ST) (bitter taste test through phenylthiocarbamide (PTC)) status with incidence of metabolic syndrome.

Materials/Methods—Participants (n=196) as part of baseline testing in a behavioral weight loss study completed measures assessing SL and ST status, metabolic syndrome, and dietary intake.

Results—SLs were more likely to be African American. More women than men were STs. There was a significant interaction between ST and SL status as associated with metabolic syndrome, after adjustment for demographic characteristics. This interaction was also significantly associated with fiber and caloric beverage intake. Post-hoc analyses showed that participants who were only a ST or SL appeared to have a decreased risk of having metabolic syndrome compared with those who have a combination or are neither taster groups ($p = 0.047$) and that SL+ST consumed less fiber than SL+non-ST ($p = 0.04$).

Corresponding author: Gabrielle Turner-McGrievy, 800 Sumter Street, Suite 216, Columbia, SC 29208, Phone: 803-777-3932, Fax: 803-777-6290, brie@sc.edu.
[1]**Department of Nutrition**, The University of North Carolina at Chapel Hill
Present address and affiliation: Department of Health Promotion, Education, and Behavior, The University of South Carolina, 800 Sumter Street, Suite 216, Columbia, SC 29208 USA
[3]**Department of Health Behavior and Heath Education**, The University of North Carolina at Chapel Hill
[4]**Lineberger Comprehensive Cancer Center**, The University of North Carolina at Chapel Hill

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Conclusions—Assessing genetic differences in taster preferences may be a useful strategy in the development of more tailored approaches to dietary interventions to prevent and treat metabolic syndrome.

Keywords

supertaster; bitter; food preference; diet; sweet preference; metabolic syndrome

1. Introduction

Approximately 1 in 4 adults in the United States has metabolic syndrome (Ford and others 2002). Components of metabolic syndrome may include dyslipidemia, elevated blood pressure, insulin resistance, abdominal obesity, and pro-inflammatory and thrombotic states (Grundy and others 2004). Lifestyle therapies for dietary improvement and weight loss are considered an appropriate first line of treatment for metabolic syndrome, including approaches to improve lipids, insulin resistance, and hypertension (Grundy and others 2004). Tasting profile, such as sweet liking or supertasting, may be influenced by genetics, and therefore in turn, may influence dietary intake. Since genetic variations in tasting profile can affect food preference (Duffy 2007; Feeney 2011; Pirastu and others 2012), finding ways to target dietary recommendations and address individual genetic differences in dietary preferences may improve adherence to dietary recommendations. While there has been a wealth of research examining how individual tasting profiles (sweet liking vs. non-sweet liking or supertasting vs. non-supertasting) affect dietary and health outcomes (Drewnowski and others 1995; Duffy 2004; Duffy and others 2009; Tepper and others 2002), there has been little research on how tasting profiles may interact with one another to effect health and diet outcomes. Understanding the interaction of tasting profiles may help to determine a more tailored approach to dietary interventions for the prevention and treatment of metabolic syndrome.

1.1 Supertaster status

TAS2R38 is the best studied bitter taste receptor gene; variations in this genotype can influence the ability to taste the chemical 6-n-propylthiouracil (PROP) or phenylthiocarbamide (PTC) (Feeney 2011; Duffy and others 2004; Tepper 2008). Specifically, *TAS2R38* is involved in encoding a receptor which allows for the detection of PTC and PROP (Feeney 2011). Supertaster status or heightened tasting sensitivity, however, cannot always be fully explained by the *TAS2R38* gene (Hayes and others 2008). Those who perceive PROP or PTC as extremely bitter are generally classified as supertasters (ST) (Bartoshuk and others 2006; Tepper 2008). ST are thought to have heightened tasted perceptions and are able to discriminate small changes in the nutrient composition of foods more so than non-ST (Hayes and others 2011). Some research has shown that non-ST have a higher Body Mass Index (BMI) (Tepper and others 2008). The research in this area, however, is mixed with studies also showing no differences in BMI between ST and non-ST (Drewnowski and others 2007; Yackinous and others 2002) and no effect of *TAS2R38* genotype on BMI or dietary intake (Hayes 2010). The research examining PROP/PTC taster status and dietary fat has also been mixed, with research showing both no effect (Drewnowski and others 2007) and a propensity towards higher fat diets (Yackinous

and others 2002). Research has also shown that ST may have dietary patterns, such as decreased fat and less added sugar intake, that lower their risk for cardiovascular disease, hypertension and hyperlipidemia (Duffy 2004). Research on the consumption of bitter foods, particularly bitter vegetables, by ST has had more consistent results. ST tend to consumer fewer vegetables than non-tasters (Dinehart and others 2006; Drewnowski and others 1999; Duffy and others 2010) and, as a result, may have an increased risk for colon cancer (Basson and others 2005). ST may also consume less citrus fruits (Tepper and others 2008).

1.2 Sweet taste preference

Sweet taste preference is not only related to genotype (possibly located on Chromosome 16p11.2) (Keskitalo and others 2007) but also related to factors such as age, gender, digestive ability, dietary experiences, and appetite (Beauchamp and others 1982; Reed and others 2006). Preference for sweet solutions in laboratory settings has been associated with increased preference for sugar-sweetened desserts (Drewnowski and others 1999), alcohol dependence (Kampov-Polevoy and others 1997), impaired control over consuming sweet foods, and greater experience of mood altering effects of sweet food consumption (Kampov-Polevoy and others 2006). Other research has found the perception of sweetness intensity to be unrelated to nutrient intake, with the exception of a relationship to sodium, vitamin C, and potassium intake (Cicerale and others 2012). Findings concerning sweet liking and body weight have been mixed with some studies finding people who are overweight reporting less pleasure from consuming sweet foods than normal weight individuals and others finding no relationship between sweet preference and BMI (Donaldson and others 2009). However, some studies find that obese individuals show greater preference for foods both high in sugar and fat than non-obese individuals (Bartoshuk and others 2006).

1.3 The interaction of sweet taste preference and supertaster status

A greater affinity for sweet tastes among non-ST has also produced inconsistent results. Some studies have shown that adult PROP nontasters report enjoying sweet foods more (Duffy and others 2000) and consume more sweet foods than tasters (Duffy and others 2003). In another study that examined genetic effects on taste preferences, researchers found that children who were insensitive to bitter tastes (having the bitter insensitive allele of *TAS2R38*) preferred greater concentrations of sucrose solutions and listed carbonated beverages as their favorite drinks much more so than milk or water as compared to those who were sensitive to bitter tastes (Mennella and others 2005). Another study, however, found that ST status has no effect on affinity for sweetened solutions or preferences for sweet foods (Drewnowski and others 2001a).

1.4 Tasting profile and metabolic syndrome

Several different dietary patterns have been shown to be protective against metabolic syndrome including Mediterranean-style diets (Jones and others 2012), low-fat diets (Neuhouser and others In Press), and vegetarian and vegan diets (Rizzo and others 2011). Adherence to dietary recommendations is a strong predictor of health outcomes and weight loss (Dansinger and others 2005) and it is possible that different tasting profiles may moderate ability to adhere to healthy diets. It has been hypothesized that non-STs are at a

greater risk of cardiovascular disease (CVD) due to higher weight and greater intake of foods that are high in fat and sugar (Duffy 2004).

Duffy et. al. proposed a conceptual framework showing how tasting profile can affect CVD risk such that variations in taste affects the sensations from foods and beverages, in turn affecting food and beverage preferences and intakes (Duffy 2007). Intakes of foods and beverages, in turn, affect components of metabolic syndrome such as hypertension, dyslipidemia, and obesity (Prescott and others 2004). Most of the studies examining CVD outcomes and tasting profile have focused on ST and have had varying outcomes (Duffy 2007). This variation could possibly be due to the interaction of sweet liker (SL) and ST. To our knowledge, no studies have examined the interaction of these four taster group patterns (supertaster and sweet preference pairs) and considered the relationship with metabolic syndrome and dietary intake among an obese population. The aim of this study was to examine the relationship and interaction of sweet liker (SL) and ST status with metabolic syndrome. A secondary aim was to explore the relationship of taster status with nutrient intake (dietary fat, carbohydrate, protein, fiber, and energy from foods and beverages). We hypothesize that these tasting patterns may have varying effects on dietary intake, which in turn affects the risk of developing metabolic syndrome. Specifically, because the goal of the main trial was to examine changes in caloric beverage intake, we aimed to examine if SL and ST interacted to affect caloric beverage intake. Because of the literature around tasting status and other dietary outcomes, such as dietary fat and fiber (Drewnowski and others 1999; Tepper 2008), has had inconsistent results, we felt that exploring the interaction between SL and ST would be important.

2. Materials and Methods

2.1 Sample and procedure

The CHOICE study is a 6-month, 3-group, randomized clinical weight loss trial comparing the replacement of caloric beverages with non-caloric sweetened beverages or water as compared to a healthy attention choices control. Methods are described elsewhere (Tate and others 2012). Briefly, overweight men and women (between ages 18-65 years; BMI between 25.0-49.9 kg/m^2) who reported consuming at least 285 kcals per day of caloric beverages were randomized to one of three conditions: (1) water provision, (2) non-caloric sweetened beverage provision, or (3) attention control. Participants were recruited through university listservs and television advertisements. Over 1,900 participants were screened for participation, of which 521 were eligible and invited to an orientation session. There were 318 participants who completed baseline questionnaires and 3 were not included in analysis due to pregnancy or moving from the area. The study was conducted in 5 cohorts. Tests of ST was added to cohorts 2-5, therefore assessments for supertaster status and sweet preference were completed on 196 participants at baseline and are included in the present analysis. Because this intervention recruited participants who were high caloric beverage consumers, this study also aimed to examine the relationship between tasting status and beverage consumption. A university Institutional Review Board approved the study and all participants provided written informed consent.

2.2 Dietary intake

Two days of unannounced, 24-hour food recalls were collected at baseline and included one weekday and one weekend day. Interviews were conducted by trained interviewers at the Nutrition Epidemiology Core of the UNC Clinical Nutrition Research Center; Grant Number: DK56350. Prior to the interview, each participant was given a set of two-dimensional food visuals, which allowed interviewees to describe portion sizes of different types of foods. They were asked to refer to these visuals during the telephone interviews. The recall consisted of a complete audit of what foods the person consumed during the previous 24 hours. For each type of food and beverage reported, the interviewer noted the amount consumed including portion size, preparation methods, and recipes. Careful assessment of all beverages was critical for this trial and the standard interview included more probes on beverages (including caloric, non-caloric, and water). For our measurements of caloric beverages, we totaled all energy (kcals) consumed from liquid sources—such as soft drinks, juices, coffee drinks, sports drinks, and milk. The elapsed time between the first and the second interview was no more than 14 days in order to minimize the possibility of changes in dietary behavior. Each interview took approximately 45 minutes. To reflect the marketplace throughout the study, dietary intake data were collected and analyzed using Nutrition Data System for Research software version 2007 and 2008 developed by the Nutrition Coordinating Center, University of Minnesota, Minneapolis, MN. Final calculations were completed using NDSR version 2008. The NDSR time-related database updates analytic data while maintaining nutrient profiles true to the version used for data collection. This software provides standardization and quality control for the interview process and incorporates the multiple-pass interview methodology.

2.3 BMI and metabolic syndrome

Height was measured at baseline using a calibrated, wall mounted stadiometer (Perspective Enterprises, Inc., Kalamazoo, MI). Weight using a digital scale and circumference measures of the waist were collected, while participants were clothed in a light-weight hospital gown. Two measurements were taken of the waist and the mean value was used for analysis. If the difference between the two measurements taken at each site exceeded 1.0 centimeter, a third measurement was obtained. Resting blood pressure was measured using a GE Dinamap ProCare 100 following standard procedure. After a 5-min rest, blood pressure was measured two times with participants seated; the average of the two measurements was used. Use of hypertensive medications was assessed by self-report. Blood samples were collected for measurement of plasma glucose and lipids according to standard protocol.

Metabolic syndrome was assessed using ATP III criteria (Grundy and others 2004). The one exception was the use of the American Diabetes Association cut point for fasting glucose (≤ 100 mg/dl) versus the ATP III criteria of (≤ 110 mg/dl) (Grundy and others 2004). This lower cut point was used because this was a recommended modification of the ATP III criteria by the American Heart Association (AHA) and the National Heart, Lung, and Blood, Institute (NHLBI) (Grundy and others 2005). Participants who were hypertensive (as evidenced by being on blood pressure medications) at baseline were categorized as meeting the blood pressure requirement, regardless of their current blood pressure reading as recommended in the modification by the AHA/NHLBI (Grundy and others 2005).

2.4 Assessment of taster status

A behavioral preference task using varying levels of sucrose solutions and associated questionnaires was employed to assess sweet preference in the diet and has been described elsewhere (Kampov-Polevoy and others 2006). Other studies have used similar methods for assessing sweet preference (Mahar and others 2007). Briefly, participants were asked to abstain from alcohol for the 24 hours prior to the assessment and food or beverages 12 hours before the assessment and to abstain from smoking one hour prior to the test. To estimate each subject's sensitivity and hedonic response to sweet taste, five concentrations of sucrose solution (0.05, 0.10, 0.21, 0.42, and 0.83 M) were presented five times in a predetermined random order (25 total tastings) used for all participants. The order was the same across participants. Participants were instructed to sip the solution, swish it around their mouth, and spit it out. They were then asked to rate sweet intensity by answering the question, “How sweet was the taste?” and marking the answer on a 200-mm analogue scale, with extremes labeled as “Not sweet at all” and “Extremely sweet.” Participants were also asked to rate each solution's pleasurableness, answering the question, “How much do you like the taste?” and marking the answer on a 200-mm analogue scale with the poles labeled “Disliked very much” and “Liked very much” and the midpoint labeled “Neither liked nor disliked.” Participants rinsed with distilled water between each taste. To determine the preferred concentration, five scores for each tested solution were averaged. Participants who give the highest score for 0.83 M sucrose solution were classified as SL based on Kampov-Polevoy's protocol (Kampov-Polevoy and others 2006).

In order to measure ST status, participants were asked to assess responsiveness to PTC using established procedures (Joiner and others 2004) by tasting two small sheets of paper (6 × 50mm). The first was an untreated control test paper and the second sample was a sheet of PTC-impregnated filter paper (Precision Laboratories, Waukegan, IL). Participants placed each strip of paper on their tongue, allowing it to moisten. Participants were instructed on the use of a labeled magnitude scale (LMS) (Bartoshuk and others 2006). Participants were told to rate the perceived sensation using the LMS (100-point), ranging from “barely detectable” to “very strong” to “strongest imaginable.” Those rating the taste test as “very strong” or above were categorized as ST. The control strip was used as a reference standard and allowed participants to acclimate to the taste of the plain filter paper prior to tasting the PTC-impregnated paper.

2.5 Statistical methods

The main trial was powered on percent weight loss comparing the attention control to each of the beverage intervention groups separately. With 100 participants per arm and alpha set at 0.05, the trial had 90% power to detect a difference of 1.8 kg with SD of 3.4 kg and 25% attrition. An examination of the continuous covariates revealed no significant problem of skewness, or deviations from normality, so therefore, standard parametric statistical methods were used. These methods included analysis of variance and chi-square tests used to explore differences between the four tasting groups within the participant characteristics of BMI and demographic characteristics. Independent samples *t* tests were used when comparing two tasting groups at a time. Logistic regression modeling was used to explore possible associations of the covariates of total energy (kcals), BMI, gender, age, and ethnicity, with

the probabilities of being a SL or a ST. In particular, logistic regression modeling was also used to explore the relationship between ST and SL preference status, with these same covariates, on the probability of metabolic syndrome, to the probability of not having metabolic syndrome. The interaction of SL and ST with metabolic syndrome (by controlling for metabolic syndrome) was explored by examining the set of two (those with metabolic syndrome and those without), two-by-two (ST yes/no by SL yes/no) contingency tables using the Cochran-Mantel Haenszel method. The Breslow-Day method was used to test the homogeneity of odds between the two two-by-two contingency tables. For each two-by-two table of SL by ST, a Fisher's exact test was calculated, and each p-value reported. Univariate General Linear Models were employed to examine the interaction of SL and ST with predicting dietary outcomes (adjusting for race, BMI, age, and energy intake). Post-hoc analyses were conducted using Tukey's HSD. The software package SPSS (SPSS for Windows, 17.0.0 2008. Chicago: SPSS Inc.) was used for all primary analyses.

3. Results and Discussion

Main outcomes of the CHOICE trial are described elsewhere (Tate and others 2012). Participants were mostly female (83%) and African American (56%) and had a mean age of 42.6 ± 11.0 years and mean BMI of 36.0 ± 5.8 kg/m^2 (Table 1). In the present study, 43% (n=85) of participants were classified as ST. This pattern is similar to what is seen among the general population (Tepper 2008). In examining sweet preference ratings, 35% (n=69) of participants were classified as SL. There was no significant difference between the ratings of PTC between SL (37.7±35.3 mm) and non-SL (47.1±36.8 mm; $p = 0.09$) or the ratings of sweet liking between ST (98.9±61.8 mm) and non-ST (107.4±62.6 mm; $p = 0.24$).

SL were 3.5 times more likely to be African American than any other ethnicity (45% of SL were black; 95% C.I. 1.72, 6.89; $p < 0.001$) and were 2.4 times more likely to be male (41% of males were SL; 95% C.I. 1.01, 5.91; $p = 0.047$). SL (40.0±10.0 years) were also younger than non-SL (43.9±11.4 years) (95% C.I. 0.94, 0.99; $p = 0.02$). Neither age, race, nor gender were significantly associated with ST status; however the percentage of women who were ST (42%) was borderline significantly greater than the percentage of men (25%) (95% C.I. 0.17, 1.01; $p = 0.054$). Demographic characteristics, BMI, and metabolic syndrome status for the four possible taster pair combinations (SL + ST; SL + non-ST; non-SL + ST; non-SL + non-ST) are presented in Table 1. There were no significant differences in demographic characteristics or incidence of metabolic syndrome among the 4 tasting groups.

In order to examine the relationship of tasting status and metabolic syndrome, a logistic regression model was run using metabolic syndrome as the dependent variable, adjusting for age, race, gender, BMI, and total energy intake, and including ST, SL, and interaction term of ST × SL. The interaction between SL and ST was significant (95% C.I. 0.18, 0.82; $p = 0.01$) as was BMI (Table 2). Using the Cochran-Mantel Haenszel method to help examine the set of two two-by-two contingency tables (to control for metabolic syndrome), the significance ($p = 0.04$) of the interaction between SL and ST by metabolic syndrome status that was seen in the logistic regression modeling ($p = 0.02$) was confirmed. For each two-by-two table of SL by ST, a Fisher's exact test was calculated. Interestingly, the number of those who were classified as SL+ST or non-SL+non-ST was much smaller than the number

that would be expected by chance alone for those who did not have metabolic syndrome, but the opposite was true for those who had metabolic syndrome. The Breslow-Day test for the homogeneity of odds confirms this difference in the two tables by giving significant evidence that the odds were not homogeneous between the two two-by-two contingency tables ($p = 0.047$).

Models controlling for age, race, gender, BMI, and total energy were also used to explore the relationship between ST and SL status with energy from food, energy from caloric beverages, and macronutrient intake (Table 3). The interaction between ST and SL was significant for fiber intake ($F(1, 193) = 5.46$, $p = 0.02$) and caloric beverages ($F(7, 194) = 4.41$, $p = 0.04$). Post-hoc analyses to examine the differences among the four tasting groups for fiber and caloric beverages were not significant. So while the interaction between ST and SL was significant, it is unknown which of these tasting pairs was driving the differences.

This exploratory study points to a potential interaction between ST and SL that may be associated with metabolic syndrome. This interaction between ST and SL was also significantly associated with fiber and caloric beverage intake, suggesting that tasting patterns may interact in their effect on both dietary intake and disease risk. In the present study, 38% of participants met criteria for metabolic syndrome. Overweight and obese participants in this sample who are only ST or SL appear to have a decreased risk of meeting criteria for metabolic syndrome compared with those who have a combination or are neither taster groups. Research has shown that there is a possible relationship between taster status and weight, with those who are STs having a lower BMI than non-tasters (Tepper and others 2008). The relationship between taster status and health outcomes, weight, and dietary intake has been mixed, however, with studies showing variable results (Drewnowski and others 2007; Tepper 2008). Among overweight and obese participants in the present study, there was not a significant interaction between taster groups and BMI.

The relationship between taster status and the different criteria that compose metabolic syndrome (such as elevated BMI, blood glucose, and blood pressure) is thought to be mediated by dietary intake (Duffy 2007). For example, female non-ST are more likely to consume greater energy intake when presented with an unlimited amount of food than ST (Tepper and others 2011). SL tend to have diets that are higher in sugar (Duffy 2007) and sweet desserts (Drewnowski and others 1999) and non-ST have diets that are higher in fat (Duffy 2007). Both of these consumption patterns have been shown to increase the risk of dislipidemia (Duffy 2007). ST also tend to be vegetable avoiders, having diets that are lower in dietary fiber (Drewnowski and others 1999) and diets high in fiber are protective against metabolic syndrome (Hosseinpour-Niazi and others 2011). In addition, ST may consume more dietary sodium (putting them at higher risk of hypertension), both because ST may prefer saltier tastes and because salty foods may mask a food's natural bitterness (Hayes and others 2010). The present study sought to explore the relationship between ST and SL with dietary variables. The interaction between ST and SL was significant for caloric beverages and fiber, suggesting that caloric beverages and fiber may be two important dietary targets to focus on when examining dietary intake and metabolic syndrome by tasting patterns. Larger trials should explore if changing caloric beverage and fiber intake mediates changes in metabolic syndrome incidence.

This study found that the direction of dietary intake was consistent with the pattern of metabolic syndrome occurrence in this study sample and points to lower intakes of fiber and higher intakes of caloric beverages among SL+ST followed by non-SL+non-ST as compared to ST or SL only. Further examination of the dietary patterns and risk of developing metabolic syndrome among people who are only SL (but not ST) or only ST (but not SL) is warranted. Particularly among ST+SL, it is possible that the potential negative dietary patterns of being both a SL (high consumption of added sugars) and ST (avoidance of vegetables) is what is driving the association with an increased risk of metabolic syndrome. In addition, the association of metabolic syndrome with being both a non-ST and non-SL may have been related to lower fiber intake.

Demographic factors associated with SL and ST status was also explored as part of this study. In the present study, SL were younger than non-SL. Our population, however, consisted mostly of adults in middle age, which makes examining age-related taste changes difficult. Some research has shown that there is a reduction in taste and smell perception with age (De Jong and others 1996; Schiffman 1993; Murphy 1993; Weiffenbach and others 1982). Children's preference for sweetness can also be more easily altered by prior consumption of sweet foods; however this effect has not been seen in adults (Liem and others 2004). Although distinguishing levels of sweetness may decrease with age, preference for sweets appear to be high in children, decreases in adulthood, but then increase again in late adulthood (De Jong and others 1996). The present study also found that men were more likely to be SL than females. Research has shown that gender plays no role on sweet preference for children (James and others 1999) but that men prefer higher concentrations of sucrose than women (Reed and others 2006). Race and ethnicity also have been shown to be associated with sweet preference. In the present study, African Americans were three times more likely to be SL than other racial groups. Other studies have shown similar results with people of African descent demonstrating significantly greater affinity for sucrose than other racial groups (Mennella and others 2005; Pepino and others 2005; Reed and others 2006). Our results showed that there was no association of age or race with ST status but there was a trend for gender effects with women being more likely to be ST than men. Previous research has shown ST status to be a stable trait, though gender, and possibly age, may affect ability to taste bitter substances (Tepper 2008). Some studies show that PTC or PROP sensitivity declines with age at a very slow rate (Drewnowski and others 2001b; Whissell-Buechy 1990). Although there doesn't seem to be a difference in bitter taste sensitivity among male and female children, after puberty, females tend to be more sensitive to PROP/PTC than males (Mennella and others 2010).

The present study has several strengths including a diverse sample and use of a behavioral tasting task to assess SL status. We also used clinical measures of metabolic syndrome and dietary recalls to assess nutrient and food intake, which has been shown to be a reliable way to obtain dietary data (Tran and others 2000). The present study also has some limitations. All participants in the sample were overweight or obese, which limited our ability to examine if tasting status was predictive of normal weight. The findings here are also limited to the population we examined, which included only those who reported consuming at least two servings of caloric beverages at baseline and were not alcohol abusers. Our assessment of ST status was only done by a taste test of PTC. There are other methods that may provide

more accurate results, especially when used in combination, such as using PROP or quinine, counting the number of fungiform papillae, and genotyping for *TAS2R16* and *TAS2R38* receptors (Duffy 2004; Tepper 2008). And while there may be other methods of assessing tasting preference, participants in our study were completing numerous measurements at assessment time points (such as body composition, lab work, etc.) which limited the ability to do lengthy sensory testing. For example, a forced choice test for assessment of sensitivity to PTC can take 30 minutes to complete (Lawless 1980). Sweet preference and supertasting was assessed using two different scales (visual analog scale for sweet and a labeled magnitude scale for bitter). Using the same scale may have improved the generalizability between the two. The order of sweet solutions, while random, was the same for each participant. Ideally, the ordering of the presented solutions should be counterbalanced across participants. Although the total number of participants was somewhat large in this study, there were only a small number of participants in each taster group, which may have limited the ability to test differences in all explored outcomes among the four groups.

4. Conclusion

This exploratory analysis points to a possible interaction between ST and SL status with metabolic syndrome. This interaction may allow for greater specificity in examining tasting patterns with dietary and health-related outcomes. There was also a significant interaction between taster groups for fiber and caloric beverage intake. Testing people for these tasting profiles may assist with tailoring dietary recommendations, particularly around fiber and caloric beverage intake. Specifically, counseling those individuals who are both SL and ST or are non-SL and non-ST on ways to increase fiber and decrease caloric beverage intake as a way to modify metabolic syndrome risk may be needed. Future research studies should explore how dietary variables may change over time and modify risk of developing metabolic syndrome. Assessing genetic differences in taster preferences may be a useful strategy in the development of more tailored approaches to dietary interventions to prevent and treat metabolic syndrome.

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Practical applications

Tasting profile, such as sweet liking or supertasting, may be influenced by genetics, and therefore in turn, may influence dietary intake. The present study found an interaction between supertasting and sweet liking status with incidence of metabolic syndrome and fiber and caloric beverage intake. Testing people for these tasting profiles may assist with tailoring dietary recommendations, particularly around fiber and caloric beverage intake, and provide a way to modify metabolic syndrome risk.

Table 1

Baseline demographic characteristics, Body Mass Index, and incidence of metabolic syndrome of the four taster pairs (sweet likers and supertasters) and for the total sample

	Sweet liker + supertaster	Sweet liker + non-supertaster	Non-sweet liker + supertaster	Non-sweet liker + non-supertaster	Total group
n	**23**	**46**	**62**	**65**	**196**
Age (mean years ± SD)	38.5 ± 11.1	40.6 ± 9.6	41.8 ± 10.6	46.1 ± 11.6 *	42.6 ± 11.0
Sex					
Female	19 (86%)	36 (78%)	58 (92%)	51 (78%)	164 (84%)
Male	3	10	5	14	32
Race, ethnicity					
Black	14 (64%)	35 (76%)	36 (57%)	26 (40%)	107 (55%)
White	7	11	24	36	78
Other	1	0	1[a]	3[a]	5[a]
Education					
Less than a college degree	13 (59%)	19 (41%)	29 (46%)	24 (37%)	85 (43%)
College degree or greater	9	27	34	41	111
Mean BMI (kg/m^2)	35.7 ± 5.4	36.9 ± 5.7	36.9 ± 6.1	34.7 ± 5.6	36.0 (± 5.8)
Meets ATP III criteria for metabolic syndrome					
Yes	12	15	20	27	74 (38%)
No	11	31	42	38	122 (62%)

[a]The total in each column does not add up to the group total due to missing ethnicity data

Table 2

Sweet liking and supertaster status as associated with metabolic syndrome

Predictor	*B*	*SE B*	OR	Significance	95% CI	
					Upper	Lower
BMI	0.07	0.03	1.08	0.01	1.02	1.14
Supertaster status × Sweet liker status	-0.94	0.38	0.39	0.01	0.18	0.82

Model included main effects of sweet liker and supertaster and was adjusted for age, race, gender, BMI, and total energy intake.

Table 3

Estimated marginal mean intakes (± SE) of food groups and nutrients by taster status and results of interaction of sweet liker and supertaster status

Food group or nutrient	Sweet liker + supertaster	Sweet liker + non-supertaster	Non-sweet liker + supertaster	Non-sweet liker + non-supertaster	Model significance level	p-value for effect of interaction between Sweet liker and Supertaster[a]
Energy from food only (kcal/day)	2016.4 ± 162.3	2218.1 ± 116.0	2031.1 ± 109.4	2031.1 ± 109.4	<0.001	$p = 0.49$[b]
Energy from beverages (kcal/day)	449.3 ± 49.5	301.9 ± 36.2	400.4 ± 33.5	402.9 ± 31.9	<0.001	$p = 0.04$[c]
Carbohydrates (g/day)	258.8 ± 9.8	256.2 ± 7.1	256.1 ± 6.6	263.6 ± 6.3	<0.001	$p = 0.47$
Fat (g/day)	86.6 ± 3.4	88.2 ± 2.4	88.8 ± 2.3	87.7 ± 2.2	<0.001	$p = 0.57$
Fiber (g/day)	14.7 ± 1.3	18.3 ± 1.0	17.3 ± 0.9	16.6 ± 0.8	<0.001	$p = 0.02$
Protein (g/day)	90.1 ± 4.3	89.4 ± 3.1	92.6 ± 2.9	84.1 ± 2.7	<0.001	$p = 0.20$

[a] Interaction of taster status was tested using univariate GLM. All models included main effects of Sweet liker and Supertaster and were adjusted for age, race, gender, BMI, and total energy intake.

[b] Model adjusted for age, race, gender, and BMI.

[c] Model adjusted for age, race, gender, BMI, and total energy intake from food.