Food acceptance and genetic variation in taste

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ABSTRACT

Objective To determine if individuals who taste 6-*n*-propylthiouracil (PROP), one marker of genetic variation in taste, as exceptionally bitter can also perceive sugars as sweeter, other bitters as more intense, and dietary fats as more creamy and/or viscous than do individuals who taste PROP as weakly bitter. This study examined the association between genetic variation in taste and acceptance for sweet, high-fat, and bitter foods and beverages.
Design Genetic variation was measured by perceived bitterness of PROP (influenced by genetic, hormonal, and pathologic factors) and density of fungiform papillae on the anterior portion of the tongue (influenced primarily by genetic factors). Four sweet, 3 fat, and 3 bitter groups were derived from principal components analyses of questionnaire items.
Subjects Convenience sample of healthy adults (24 women, 22 men; mean age±standard deviation=21±6 years) who did not report high dietary restraint.
Statistical analyses Pearson product moment correlations between genetic taste measures and food and beverage groups.
Results The sample showed diversity in genetic taste measures: perceived bitterness of 0.0032 mol/L PROP ranged from "weak" to well above "very strong"; fungiform papillae densities ranged from 33 to 156 papillae per square centimeter. Distribution of perceived bitterness of PROP and fungiform papillae density differed in women and men. The association between genetic taste measures and acceptance of sweet and high-fat groups differed in women and men. In women, liking of sweet and high-fat food and beverage groups decreased with increasing perceived bitterness of PROP. In men, liking of these foods and beverages increased but with increasing papillae densities. Genetic taste measures were not associated with a dislike of bitter food and beverage groups.
Applications The influence of genetic variation in taste on food intake depends on how perceptible sweet, fat, or bitter components are in foods and beverages, as well as the value of sensory factors vs other factors (eg, health, convenience) on personal dietary choices. Female supertasters of PROP bitterness may avoid high-fat or sweet foods because these oral sensations are too intense and thus less pleasant. Supertasters may taste more bitterness in vegetables but still enjoy eating them because of their healthfulness and because condiments (especially those that are salt based) can block bitterness. *J Am Diet Assoc. 2000;100: 647-655.*

Why do we eat what we do? Consumers report "taste" as an important influence when selecting foods (1). Used this way, the term *taste* involves many sensory experiences: true taste, retronasal olfaction, and oral somatosensation. True taste refers to perception of salty, sweet, sour, and bitter; retronasal olfaction means perception of olfactory stimuli from within the oral cavity; and oral somatosensation refers to perception of touch, temperature, and pain. This study examines genetic variation in taste and its potential to influence what we like to eat.

Fox (2,3) reported that some individuals could taste phenylthiocarbamide (PTC) bitterness (tasters) and others could not (nontasters). Family studies confirmed that ability to taste PTC resulted from a dominant allele (4): nontasters carry 2 recessive alleles and tasters carry either 1 or 2 dominant alleles. The taster gene appears to be located on chromosome 5 (5). In the United States, the frequency of nontasters is estimated to be 20% to 25% of the population (6). Frequency can vary by sex (6) and race (7).

Early studies used PTC thresholds to classify individuals (8) and concluded that nontasters lacked a receptor site for the N-C=S group present in PTC and 6-*n*-propylthiouracil (PROP). Thresholds reflect perception of only the dimmest sensations; thus, they may reveal little about the perceptual world (9), including the sensations of eating (10). Advances in psychophysics, primarily about how intensity and hedonic experiences vary with concentration of physical stimuli (eg, molar concentration of sucrose), have provided new insights about genetic variation in taste: intensity of many tastes, not just those with the N-C=S group, varies with perceived bitterness of PROP (11); perceived bitterness of concentrated PTC/PROP varies dramatically across tasters, which has led to subdividing tasters into medium tasters (those rating PROP as moderately bitter) and supertasters (those rating PROP as

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Table 1
Grouping of foods by principal components analysis based on ratings of liking/disliking

Food group	No. of items	Food items	Eigen value	% explained	Cronbach α
Sweets	6	Ice cream, doughnuts, cookies, cake, pie, milk chocolate	6.94	31.52	0.90
Low-calorie sweets	3	Diet soft drinks, saccharin, aspartame	2.75	12.50	0.89
Fruits	4	Apples, strawberries, oranges, lemonade	2.05	9.32	0.74
Natural sweets	4	Banana, custard, honey, fruited yogurt	1.62	7.34	0.68
Fat 1	4	Mayonnaise, bacon, sausage, whole milk	4.22	28.14	0.79
Cheese	4	Cheddar cheese, Swiss cheese, American cheese, macaroni and cheese	1.99	13.07	0.70
Fat 2	4	Butter, margarine, salty snacks (eg, chips), macaroni and cheese	1.64	10.90	0.74
Vegetables	5	Eggplant, asparagus, spinach, coleslaw, cooked cabbage	3.20	29.30	0.70
Bitter beverages	4	Coffee, decaffeinated coffee, tonic water, tea	2.11	16.30	0.70
Cruciferous vegetables	3	Raw broccoli, cooked broccoli, cauliflower	1.03	9.34	0.74

Table 2
Subject characteristics

Variable	Women (n=24)		Men (n=22)		All (n=46)	
	Mean	SD[a]	Mean	SD	Mean	SD
Age	20.9	4.6	24.0	7.0	22.4	6.0
Height (cm)	164.1	7.9	178.8	3.1	171.1	10.8
Weight (kg)	62.3	11.1	77.4	8.1	69.5	13.9
Body mass index[b]	23.1	3.6	24.2	3.3	23.6	3.4
Restraint score[b]	9.6	3.5	10.0	12.5	9.8	3.4

[a]SD=standard deviation.
[b]Score on the restraint scale (64,65), which measures dietary restraint, disinhibition, and weight fluctuation. The scale ranges from 0 to 35; ≥15 is high dietary restraint (66).

exceptionally bitter) (6,12); and intensity of some oral somatosensory stimuli (eg, irritants, touch stimuli) varies with perceived bitterness of PROP. Psychophysical techniques that permit valid comparisons across subjects have revealed that PROP supertasters perceive the most intense sensations from a variety of oral stimuli (11). Psychophysical techniques that make invalid comparisons complicate measurement of differences between nontasters, medium tasters, and supertasters, and are responsible for many inconsistencies in the literature.

Context and ceiling effects hinder the ability to determine PTC/PROP differences. Context effects can alter sensory intensity (13,14); for example, experiencing an intense stimulus in one modality can intensify sensations from another modality. When a supertaster tastes the intense bitterness of PROP, the experience can intensify a subsequently presented stimulus, which can diminish (or abolish) PROP differences. Ceiling effects—which are characteristic of many scales—can inhibit expression of sensory intensity. Labeled scales (eg, 9-point scale in which 9="extremely strong") have ceilings that force supertasters to give erroneously low ratings. Green et al (15) developed the Labeled Magnitude Scale in which the distance between descriptors is determined empirically. Subjects placed the descriptor "very strong" slightly more than halfway between zero and "strongest imaginable." Using this scale, supertasters describe saturated PROP as considerably more intense than "very strong" or "extremely strong" (11).

These psychophysical problems are apparent in studies that scale tastants and somatosensory stimuli in individuals of varying status related to PTC/PROP. In sweetness of sucrose, most studies indicate PTC/PROP differences (11,16-23); however, the size of the difference may have been underestimated in some studies because of context effects (24) and ceiling factors (21,25-27). In a similar analysis of tasting of bitter, some studies reported associations between bitterness of PTC/PROP and quinine bitterness (11,17,28-32) whereas others failed to do so (16,19,24,25,33-36). Some of these studies were influenced by context (24) or ceiling effects (25,36). In other studies (16,24,33,34), perceived bitterness of PROP was normalized to the saltiness of sodium chloride (NaCl). We now know the NaCl tastes saltier to supertasters (37), so the size of differences among PROP groups would be reduced. In 2 studies (19,35), PROP tasters rated quinine as more bitter than did nontasters, but the differences were not statistically significant. In studies of oral somatosensory stimuli, perceived bitterness of PROP was associated with the burn of oral irritants (38-41) and the creaminess and/or viscosity of high-fat milk products (42), salad dressings (40), and oil (41). One study failed to find a PROP difference with dairy fat (21), but the study used a scale with a ceiling effect.

A number of studies examined the relationship between tasting PTC/PROP and food acceptance; results were not consistent. Some of the inconsistency is a result of genetic taste classification. Supertasters cannot be identified in studies that classify by using PTC/PROP thresholds (43-51) or scales with ceiling effects (52-55). Studies that use traditional category scales for assessing liking and disliking (eg, 9-point hedonic scale) may have psychophysical limitations such as ceiling effects.

Classification of genetic variation in taste may benefit from advances in understanding the neuroanatomic systems that support taste and oral somatosensation. The anatomy of the anterior portion of the tongue is involved in variation in taste and perception of oral burn and touch. For example, PROP supertasters have the most fungiform papillae, which are structures on the tongue that hold taste buds (6,40,56,57). Fungiform papillae receive innervation from taste (chorda tympani nerve, cranial nerve VII) and somatosensory (trigeminal nerve, cranial nerve V) neurons (58,59). Chorda tympani neurons synapse with cells in taste buds; trigeminal neurons

surround taste buds without synaptic contact (58,59). People with a high density of fungiform papillae have a genetic propensity to experience the most intense sensations from taste and some oral somatosensory stimuli. These papillae are formed early in gestation (60) and remain intact unless the trigeminal nerve is damaged (T. Janjua and S. Schwartz, unpublished data, 1997). Thus, even though fungiform papillae density may be a relatively stable measure of genetic endowment, it may not fully reflect oral sensory function.

A number of factors can affect taste bud (or taste nerve) function. Relatively common pathologic conditions (eg, viral infection, head trauma [61]) may damage taste without changing trigeminal function or papillae density. In these conditions, perceived intensity of taste stimuli would correlate highly with taste of PROP bitterness; oral somatosensatory intensity would be expected to show higher correlations with fungiform papillae density.

Hormonal variation in women may affect both taste and trigeminal function. In comparison with men, women show: a) greater variability in taste, oral creaminess, and oral burn; b) changes in oral sensation during times of hormonal change (eg, menstruation, pregnancy); and c) greater variability in taste buds per fungiform papilla (11,62,63). These changes suggest concurrent fluctuations in PROP taste and oral somatosensation without changes in density of fungiform papillae.

Examination of interactions between PROP tasting and fungiform papillae may provide greater insight into genetic variation in oral sensation. People who taste PROP as exceptionally bitter and have a high density of fungiform papillae have a different oral sensory world from those who taste less PROP bitterness relative to density of fungiform papillae. In the latter case, oral somatosensory sensations may have increased relevance to food acceptance. This study examines the contribution of genetic variation in taste to liking of sweet, fat, and bitter foods and beverages. Psychophysical techniques were selected to avoid ceiling effects in measurement of perceived bitterness of PROP and liking/disliking of foods and beverages. Genetic variation was assessed by taste of bitterness of PROP and density of fungiform papillae.

SUBJECTS AND METHODS

A convenience sample of 70 healthy adults was recruited by advertising in a university community. In one session, measures of genetic taste were conducted and subjects completed a taste-related health questionnaire, which included weight and height for calculation of body mass index (BMI, calculated as kg/m^2), a food acceptance survey, and the Restraint Scale (64,65). Ten subjects were excluded because their tone ratings (a standard for PROP ratings) suggested a hearing impairment (ie, 98 dB tone at 1,000 Hz was described as "medium" or weaker). Six women and 8 men who scored 15 or higher on the Restraint Scale (maximum possible score=35; range in this sample=1 to 24) were excluded (64,65) to remove those with high dietary restraint, disinhibition, and weight fluctuation (66). Individuals with these characteristics may report food acceptance based on nonsensory qualities such as weight or health concerns rather than on sensory qualities. The remaining 24 women and 22 men (mean age±standard deviation=21±6 years, range=18 to 40 years) represented the racial diversity of a university community: 8 Asian Americans, 7 African Americans, 24 whites, 6 Latin Americans, and 1 Asian Indian. The Yale University Human Investigation Committee approved the study protocol. Subjects provided written informed consent and were compensated for participating in the study.

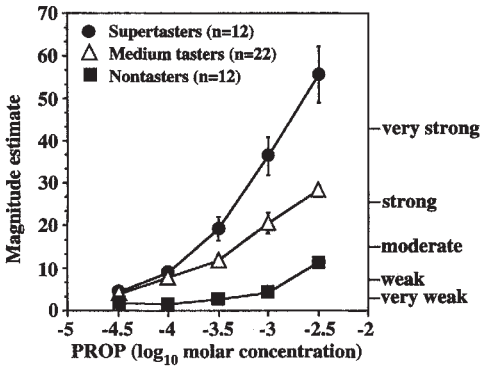

FIG 1. Magnitude estimates (±standard error) of the bitterness of 6-n-propylthiouracil (PROP) plotted against PROP concentration for nontasters, medium tasters, and supertasters. PROP magnitude estimates were normalized to the intensity of 1,000 Hz tones at 86 and 98 dB.

Taste Tests

Deionized water (16 megohms/cc, Piotech Water Systems, Research Triangle Park, NC) was used to prepare all PROP (reagent grade) and NaCl (food grade) solutions and served as a rinse before each stimulus. Subjects tasted room-temperature solutions, expectorated, and rinsed. Threshold testing preceded suprathreshold scaling.

Threshold testing Two alternative, forced-choice, up-down detection thresholds were determined for PROP solutions ranging in quarter-log steps from 0.000001 to 0.0032 mol/L (67). Concentrations were decreased only after 2 correct choices but were increased after one incorrect choice. This method ensures that the threshold (geometric mean of the last 6 of 7 reversals) is roughly halfway between chance and perfect performance.

Suprathreshold testing Subjects used magnitude estimation to indicate intensity of quarter-log steps of solutions (NaCl=0.01 to 1 mol/L; PROP=0.000032 to 0.0032 mol/L), and 1,000 Hz tones (50 to 98 dB). Subjects were instructed to rate all stimuli on a common scale of intensity (ie, magnitude matching [18,68]). The stimuli were randomized within each block and a tone series always followed a taste series: NaCl, tones; NaCl, tones; PROP, tones; PROP, tones. To prevent context effects, the PROP solutions were presented after the NaCl solutions. Subjects then assigned numbers to these adjectives: "very strong," "strong," "moderate," "weak," and "very weak" (69).

PROP ratings were normalized with the tone ratings that followed the NaCl series. A normalization factor for each subject was calculated from the geometric mean of 86 and 98 dB tones divided into the arithmetic mean of all geometric means. The raw data were then multiplied by the normalization factor to provide a comparable scale for all subjects (70).

Fungiform Papillae Counts

To visualize fungiform papillae, a vital stain (methylene blue) was applied to the anterior portion of the tongue (71). Subjects

Table 3
Correlations[a] between food acceptance groups and genetic taste measures

Food group	Mean[b]	SD[c]	6-*n*-Propylthiouracil bitterness			Fungiform papilla density		
			All (n=46)	Women (n=24)	Men (n=22)	All (n=46)	Women (n=24)	Men (n=22)
Sweets	82.1	30.6	−0.30*	−0.57***	0.08	−0.01	−0.21	0.27
Fruits	92.8	30.3	−0.02	−0.43*	0.43*	−0.14	−0.29	−0.01
Natural sweets	70.4	43.6	−0.13	−0.61***	0.35	−0.17	−0.26	−0.11
Low-calorie sweets	−14.5	77.0	−0.10	0.16	−0.22	−0.07	−0.15	0.1
Average for sweet group	81.7	28.1	−0.18	−0.64***	0.40†	−0.14	−0.30	0.02
Fat 1	40.0	59.9	−0.29	−0.54**	0.43*	0.02	−0.05	0.31
Cheese	58.7	45.3	−0.18	−0.54**	0.22	0.31*	−0.05	0.69***
Fat 2	62.0	41.1	−0.06	−0.29	0.23	0.10	−0.21	0.52*
Average for fat group	53.5	38.6	−0.24	−0.59***	0.34	0.16	−0.12	0.62***
Vegetables	21.1	46.1	0.11	0.13	0.09	0.52***	0.50*	0.56**
Cruciferous vegetables	31.1	49.9	0.19	0.12	0.20	0.22	0.21	0.20
Bitter beverages	26.7	53.0	0.08	−0.04	0.12	0.20	0.05	0.30
Average for bitter group	26.3	35.5	0.17	0.11	0.16	0.43***	0.38†	0.45*

[a]Pearson product moment correlation coefficients.
[b]Mean liking/disliking for food groups: 0=neither like nor dislike; 132=extremely like; and −132=extremely dislike.
[c]SD=standard deviation.
†$P<.1$; *$P\leq.05$; **$P\leq.01$; ***$P\leq.005$.

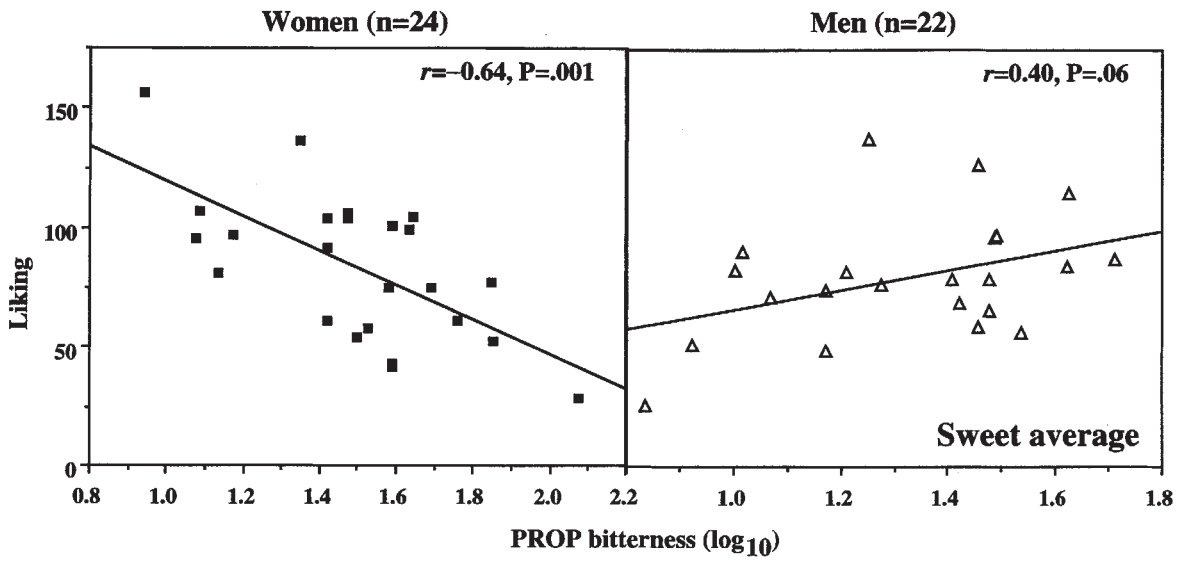

FIG 2. Scatterplots of association between 6-n-propylthiouracil (PROP) bitterness and liking for an average of 3 sweet groups (sweets, fruits, natural sweets) in 24 women (left) and 22 men (right). On 200-mm preference scale, 0 is "neither like nor dislike" and 132 is "extremely like."

steadied their tongues between 2 disposable plastic slides held together by nuts and bolts. Images of the tongue were videorecorded through a Zeiss operating microscope (Carl Zeiss, Inc, Göttingen, Germany) and fiberoptic light source at 60-times magnification. Fungiform papillae were counted in a 3×3-mm area to the right of the midline at the tongue tip.

Food Liking/Disliking Groups

Subjects completed an 83-item survey, that consisted of foods from all the major food groups and included foods to be used in testing study hypotheses. The hedonic scale was based on the scale developed by Marks et al (18), a 200-mm labeled line with "0" on the left, "extremely" at 132 mm, and an arrow at 200 mm to permit extension of the line. Subjects were instructed to circle "like" or "dislike" for each item and mark line length to indicate the degree of liking or disliking. If they neither liked nor disliked the food, they were instructed to circle "0." Line length in millimeters from 0 to the mark was measured and considered positive if "like" was circled and negative if "dislike" was circled.

Exploratory principal components analysis with varimax rotation (72,73) was used to extract groups from items that are conventionally considered to have a sweet taste (22 items; desserts, fruits, candies, sweeteners, sweetened beverages), are high in fat (15 items; >30% energy from fat), and have been associated with a bitter taste (13 items; vegetables, bitter beverages). The groups accounted for most of the variance of individual items (Table 1) and were given labels. Four groups (sweets, low-calorie sweets, fruits, natural sweets) accounted for 60.7% of variance in sweet items; 3 groups (fat 1, cheese, fat 2) accounted for 52.1% of variance in high-fat items; and 3 groups (vegetables, bitter beverages, and cruciferous vegetables) accounted for 54.1% of variance in bitter items. For each group, items that loaded above 0.4 (absolute value) were averaged (Table 1). All but one met a Cronbach α (74) of 0.70, which suggested internal reliability (75).

Analyses

Data were analyzed with STATISTICA (version 4.1, StatSoft, Tulsa, Okla, 1994). Genetic taste measures, food acceptance, BMI, and restraint scores were tested for sex differences using an independent t test, F distribution, and Fisher exact test. Relationships between the genetic taste measures (perceived bitterness of 0.0032 mol/L PROP or papillae density expressed as number per square centimeter) and food acceptance, BMI, and restraint scores were tested with the Pearson product moment correlation. The PROP bitterness variable was log-transformed to meet the assumptions of this correlation. Previous research has shown a sex difference in genetic taste distribution (6); therefore, analyses were focused on the relationship between genetic taste measures and food groups in women and men separately.

RESULTS

Table 2 summarizes subject characteristics. Women and men did not differ significantly in these variables. Of the total sample, 32 persons were of appropriate body weight (BMI=17 to 25), 12 were overweight (BMI=25 to 30), and 2 were obese (BMI=30 to 35). Perceived bitterness of PROP did not correlate significantly with body weight, height, or BMI in either sex. Fungiform papillae density did not correlate significantly with these anthropometric indexes in the total sample, but did correlate significantly with BMI in men (r=0.50, P<.05). The genetic taste measures did not associate significantly with restraint scores in either gender.

Genetic Taste Measures

PROP thresholds ranged from 0.0000042 to 0.00179 mol/L and had the characteristic bimodal distribution seen with up-down threshold procedures (6). Perceived bitterness of 0.0032 mol/L PROP ranged from 6.9 to 118.8 where "very weak" was 2.4 and "very strong" was 42.5. Subjects were separated into 3 groups based on perceived bitterness of 0.0032 mol/L PROP (Figure 1): 12 nontasters (5 women, 7 men), 22 medium tasters (10 women, 12 men), and 12 supertasters (9 women, 3 men). On average, women reported highest perceived bitterness for the 0.0032 mol/L PROP (t=2.29, P<.05).

Fungiform papillae density ranged from 33 to 156 papillae per square centimeter (average±standard error=75±4) and correlated significantly with perceived bitterness of PROP in the total sample (r=0.35, P<.05). Women showed greatest variance in the residuals from the regression analysis of PROP bitterness on fungiform papillae density: $F_{23,21}$=3.66, P<.01. Although the average fungiform papillae density was not significantly greater for women (t=1.31, P<.2), the distribution for men was displaced toward lower densities (Fisher exact test, P<.05).

Genetic Variation in Taste and Food Acceptance

Table 3 shows the mean liking/disliking ratings for the food groups and the association between the 2 genetic taste measures and these groups. In the total sample, ratings were highest for sweets, fruits, and natural sweets. Women and men did not differ significantly in mean liking/disliking ratings. Food group liking/disliking ratings did not correlate significantly with BMI or restraint scores.

Perceived bitterness of PROP showed some significant correlations with liking of sweets, fruits, and natural sweets (Table 3). For women, the significant correlations were negative; for men, the significant correlation was positive. The average rating for these 3 sweet groups is plotted against perceived bitterness of PROP in Figure 2; liking decreases with PROP bitterness for women and tends to increase for men. Fungiform papillae density did not correlate significantly with liking for the sweet groups.

The pattern of correlations between perceived bitterness of PROP and liking/disliking of fat 1, cheese, and fat 2 was similar to that for the sweet groups (Table 3). The average liking/disliking rating for the 3 fat groups is plotted against perceived bitterness of PROP in Figure 3; liking decreases with PROP bitterness for women and tends to increase for men. For men, liking increased with fungiform papillae density (Figure 4).

Neither measure of genetic variation in taste correlated significantly with liking/disliking of the bitter beverages or cruciferous vegetables. For women and men, liking/disliking of the vegetable group correlated positively with fungiform papillae density.

DISCUSSION

This study shows a relationship between genetic variation in taste and acceptance of sweet and high-fat foods that differed for women and men. The study methodology and large differences in PROP bitterness may have contributed to revealing this association in a relatively small sample of healthy, normal, and overweight adults who reported low dietary restraint. The bimodal distribution of PROP thresholds enabled sampling of

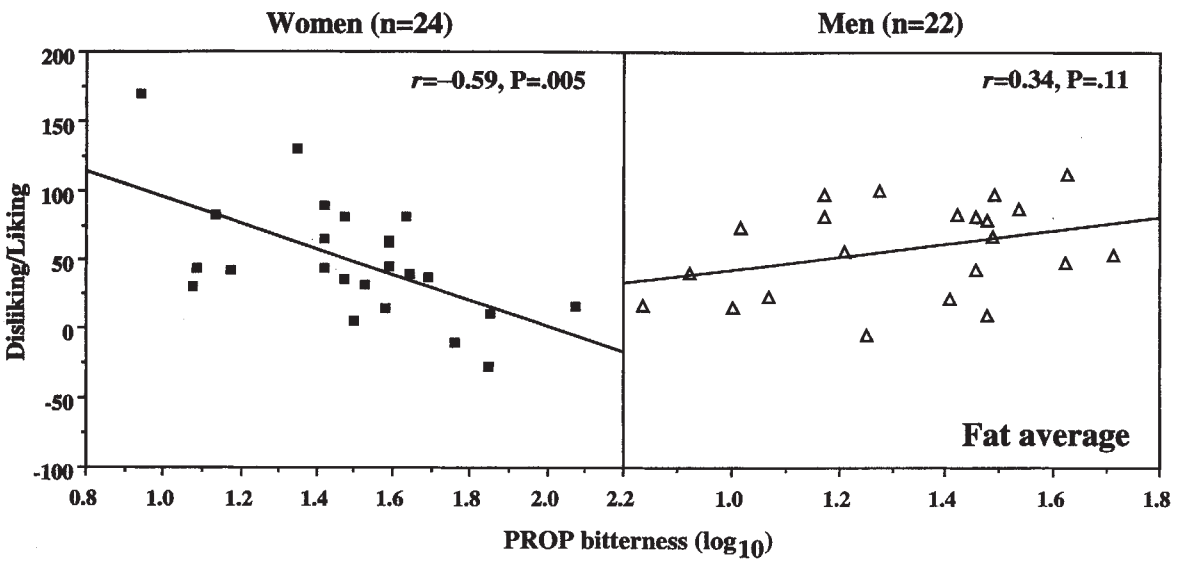

FIG 3. Scatterplots of association between 6-n-propylthiouracil (PROP) bitterness and disliking/liking for an average of 3 high-fat groups (fat 1, cheese, fat 2) in 24 women (left) and 22 men (right). On 200-mm preference scale, 0 is "neither like nor dislike" and + or –132 is "extremely like" or "extremely dislike," respectively.

both PROP nontasters and tasters. The PROP bitterness data did not show ceiling effects, equaled the range reported in a previous report (6), and demonstrated sampling of medium tasters and supertasters (Figure 1). The range in fungiform papillae density exceeded that in the study of Miller and Reedy (19). Our finding that women were more likely to perceive intense PROP bitterness has also been reported (6). The scale used to measure food acceptance could have improved the diversity of ratings by limiting ceiling effects that occur with traditional hedonic scales (eg, 9-point hedonic scale; see reference 11).

In 2 studies of hedonic response to sucrose (50,76), "dislikers" of increasing sucrose concentration were more likely to be PROP tasters and "likers" were more likely to be nontasters. This effect occurred primarily in women and is consistent with our finding that women's liking for sweet foods decreased as their perception of PROP bitterness increased. Other studies of hedonic response to sucrose (26,77) and to sucrose-fat mixtures (21) do not report an association with PROP. The lack of association might involve the nontaster classification. Subjects labeled as nontasters of sucrose tasted considerable PROP bitterness; they rated PROP, on average, above the middle category on a scale from "tasteless" to "extremely." The lack of association might also involve the "disliker" classification. Looy and Weingarten (50) for example, classified subjects as dislikers only if their hedonic ratings for sucrose decreased monotonically with increasing concentration. Drewnowski and colleagues (26,77) expanded the category disliker to include subjects for whom liking of sucrose initially rose with concentration but later decreased. In the sucrose-fat study (21), disliking was an average hedonic rating of less than neutral across all concentrations of sucrose in varying levels of fat. Thus, the lack of PROP association in the studies by Drewnowski et al could have resulted from less-stringent classification of nontasters and dislikers as well as ceiling factors of the intensity and hedonic scales.

Tepper and Nurse (78) reported that nontasters of PROP liked high-fat salad dressings more than did medium tasters or supertasters, which is consistent with our finding in women. Our observation that women who were supertasters showed less liking of high-fat foods is consistent with associations between perceived PROP bitterness and less-frequent intake of high-fat foods (79), lower BMI in women or men (78,79), and lower BMI and more favorable serum lipid levels in elderly women (80). These studies involved subject pools of fewer than 100 subjects; however, the association between PROP and BMI has been reported in a sample of more than 600 people (81).

The impact of genetic variation in taste on food acceptance and ultimately food selection depends on interactions between this genetic trait and nonsensory influences. Nonsensory influences may provide some explanation of why association between genetic variation in taste and acceptance of sweet and fat differed in women and men. One influence may be dietary restraint. For example, college-aged women who are restrained eaters (82) or female dieters who have high levels of disinhibition (73) report less liking for sweet and high-fat foods. Could female supertasters in our study be restrained eaters or dieters with high levels of disinhibition?

Some data in the study address this question. First, subjects with high dietary restraint and disinhibition were excluded. Among the remaining subjects, there was no association between genetic variation in taste and dietary restraint; nor was there an association in other studies (21,26,54). Second, female supertasters of PROP did not consistently rate most liking for low-calorie foods (eg, nonnutritive sweeteners, fruits, vegetables). Nonetheless, dietary restraint is a complex concept (66) and other measures of restraint may be associated with

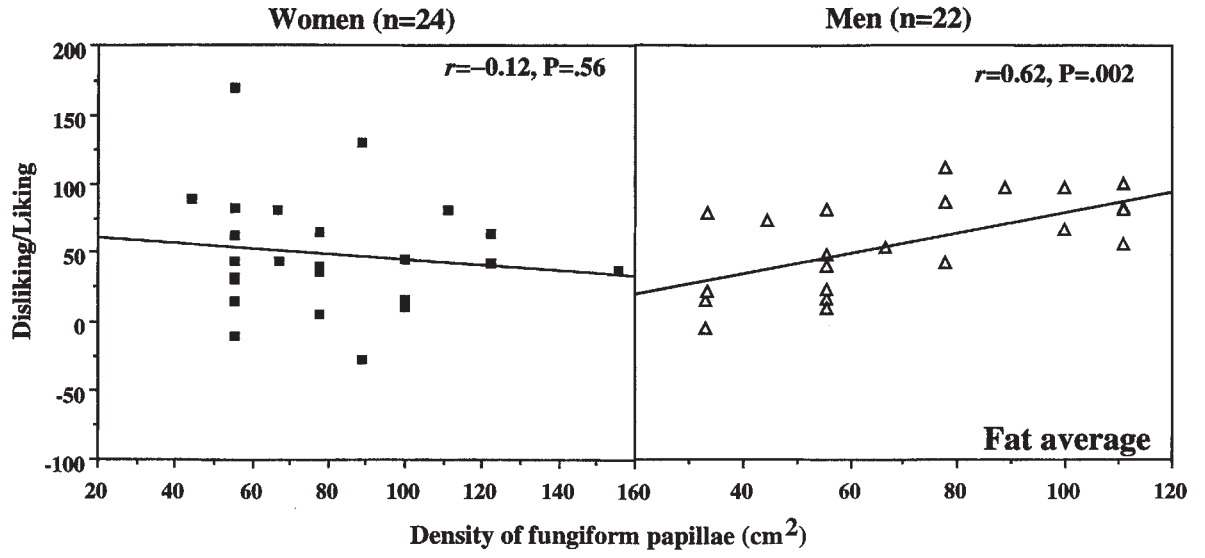

FIG 4. Scatterplots of association between density of fungiform papillae and liking/disliking for an average of 3 high-fat groups (fat 1, cheese, fat 2) in 24 women (left) and 22 men (right). On the 200-mm preference scale, 0 is "neither like nor dislike," and + or –132 is "extremely like" or "extremely dislike," respectively.

genetic variation in taste. The challenge for research is to determine how sensory variation interacts with other influences to control food acceptance.

We did not find a consistent association between genetic variation in taste and acceptance of bitter beverages and cruciferous vegetables. Bitterness is a generally disliked attribute. Tasters of PTC/PROP show more disliking of grapefruit juice (54), green tea (55), and some beers (83) than do nontasters. The strength of the association between PROP tasting and acceptance of bitter foods and beverages in our study may have been too low to detect. Studies of PTC/PROP variation and liking/disliking of cruciferous vegetables (which contain chemicals similar to PTC/PROP) (48,49) report marginal associations. One reason is that bitterness in some foods and beverages may be less apparent or easily modified (eg, salty condiments on vegetables, sugar or cream in coffee). Acceptance may also be influenced by nonsensory attributes (eg, health benefits of vegetables, caffeine stimulation of coffee).

Perceived bitterness of PROP and density of fungiform papillae did not produce identical associations with food acceptance. One explanation may be methodological: the papilla count was from a small area. Our subsequent experiences (41,57) and those of others (40) suggest that a larger area will produce larger correlations between perceived bitterness of PROP and fungiform papillae density. Another explanation might be sensory. Fungiform papillae density showed significant correlations with acceptance for fat and some vegetables (eg, eggplant, asparagus, spinach). Texture may be the salient sensory characteristic of these food groups, especially in individuals who have high fungiform papillae densities without high taste function. Associations between perceived bitterness of PROP and both sweet and fat preference in women may be, in part, a result of hormonal variation. Changes in the level of the hormone estradiol have been associated with changes in preference for sweet taste in female rats (84). Cyclical increases in perceived intensity of taste and fat would substantially increase the range of perceived bitterness of PROP, which could increase correlations between PROP bitterness and preference but not between fungiform papillae density and preference.

APPLICATIONS/CONCLUSIONS

- Traditional category scales (eg, 9-point intensity or hedonic scales), although frequently used, may limit expression of perceptual experiences and feelings of liking/disliking. Scales such as that of Marks et al (18) or the more recently developed scale by Green et al (15) have ratio properties and allow subjects to provide ratings above "very strong" or "extremely strong." These changes improve comparisons across individuals (11) and permit exploration of a range of sensations and feelings. Scaling properties were important in this study and could be important in situations where category or visual analog scales traditionally have been used (eg, sensory evaluation, behavioral assessment, measuring patient or client satisfaction).
- Patterns of food acceptance and possibly food selection may reflect a genetic predisposition and not necessarily an unwillingness to make dietary changes or a misunderstanding of healthful eating. How genetic variation in taste affects level of dietary risk or response to dietary interventions is less understood. Although people can clearly override sensory influences

and base acceptance of foods on beliefs such as healthfulness, long-term success with healthful eating may depend on whether the foods and beverages are enjoyable to eat.

■ Genetic variation in taste is one of many factors that influence oral sensation. Aging, for example, and exposure to medications and chronic conditions also can modify the oral sensations (62) and influence the relationship of genetic variation in taste and food acceptance.

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QUESTION OF THE MONTH

What is a Minimum Data Set (MDS)?

Dietitians contemplating a career change to extended care have called the Knowledge Center at the American Dietetic Association (ADA) headquarters regarding terminology they've encountered as they research this area of dietetics practice. The question usually is: "What is an MDS?"

According to the ADA publication *Nutrition Care of the Older Adult: A Handbook for Dietetic Professionals Working Throughout the Continuum of Care* (1):

"Reimbursement to an extended care facility is now determined via a resident assessment instrument (RAI) known as the Minimum Data Set (MDS) that collects data for such areas as functional and physical status and sets reimbursement through a case mix classification system know as Resources Utilization Groupings (RUGS)."

This publication is an excellent resource for any dietetics professional in extended-care practice setting. In addition, the Consultant Dietitians in Health Care Facilities dietetic practice group represents 5,100 members of the ADA who specialize in providing nutrition counseling to extended health care facilities. The group is also a good resource.

For more information on the publication call 800/877-1600 ext 5000. For more information on the Consultant Dietitians in Health Care Facilities dietetic practice group, call 800/877-1600 ext 4815 or visit its Web site: www.cdhcf.org/index2.html.

This article was written by ***Eleese Cunningham****, RD, and* ***Wendy Marcason****, RD, of The American Dietetic Association's Knowledge Center in Chicago, Ill.*

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