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Psychophysical Measurement of 6-*n*-Propylthiouracil (PROP) Taste Perception[a]

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ABSTRACT: The ability to taste 6-*n*-propylthiouracil (PROP) is genetically determined. PROP tastes moderately bitter to 'medium tasters' (MT), intensely bitter to 'supertasters' (ST), and tasteless to 'nontasters' (NT). The psychophysical method used to characterize PROP status should capture the entire range of perception, while minimizing context, ceiling and other effects. Magnitude estimation successfully captures the variability in PROP perception, but requires normalization and may be difficult to conduct in industrial settings. Two labeled scales were tested as part of three separate studies (S1, S2 and S3) to measure perceived intensity of PROP and sweeteners. All studies included reportedly healthy volunteers aged 21–62 years recruited at Cultor Food Science in Groton, CT. In S1 [$n = 163$ (55 males, 108 females)], subjects rated perceived intensity of PROP-saturated paper and sucrose (1.0 M) on the Labeled Magnitude (Green) Scale (LMS) [labeled line with descriptors (no taste—strongest imaginable)]. In S2 [$n = 152$ (49 males, 103 females)], subjects rated perceived intensity of sucrose (1.0 M) and PROP solutions (0.001 M, 0.0032 M) on the LMS. In S3 [$n = 136$ (48 males, 88 females)], subjects rated perceived intensity of sucrose (1.0 M) and PROP solutions (0.001 M, 0.0032 M) on a 9-point category scale (1 = not at all; 9 = extremely). In all experiments, water rinses were included between each tastant and PROP was the final stimulus. Statistical analyses included descriptive statistics, regression analysis, and ANOVA. In S1 and S2, those with higher PROP perception perceived sucrose more intensely [(S1: $r = 0.32$; $p < 0.001$); (S2: $r = 0.25$; $p < 0.01$)]. A higher frequency of females were ST than males. Also, the PROP effect on sweet perception was most evident in female ST. This apparent sex difference may be the result of hormonal variation associated with menstruation. As well, in S1 and S2 subjects aged 20–40 years, females had significantly greater variance among sucrose intensity ratings than males ($F = 3.66$; $p < 0.01$), which may be due to hormonal changes with menses. The S3 results failed to show either the positive correlation between PROP and sucrose perception or the sex difference. Thus of the two labeled scales, the LMS appears to be better for assessing PROP perception, as it is continuous and also minimizes ceiling effects. Future research will extend these studies by including sucrose and high intensity sweetener concentration series.

The ability to taste 6-n-propylthiouracil (PROP) is genetically determined. PROP tastes intensely bitter to 'supertasters,' moderately bitter to 'medium tasters,' and tasteless to

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'nontasters,'[1] PROP perception correlates with the taste perception of various primary taste quality compounds, including sweet, sour, bitter, and salty (see Bartoshuk *et al.*[2] for a review). Sucrose is sweeter to tasters than nontasters.[3] Saccharin is also perceived as sweeter, as well as more bitter, to PROP tasters than nontasters.[1]

That PROP tasters may be more sensitive to primary taste qualities and other tastants in foods and beverages than nontasters underscores the potential significance of PROP perception to the flavor and food industries. If the PROP-associated variability in the perception of simple tastants applies to mixtures, the PROP response may be of interest for panelist selection and flavor and food evaluation. Screening potential taste panelists for PROP perception prior to testing would ensure an adequate distribution of non-, medium-, and supertasters. This would be particularly relevant in the evaluation of new food ingredients (*e.g.,* high-intensity sweeteners) and new food formulations (*e.g.,* confections).

However, the assessment of PROP taster status is difficult, particularly in the industrial setting. The psychophysical method used to characterize PROP status should capture the entire range of perception. However, the scaling techniques often used are associated with context, ceiling, and other effects.[4] Magnitude estimation successfully captures the variability in PROP perception, but requires time-intensive training and data normalization and may be difficult to conduct in industrial settings.

The objective of the present study was to assess PROP status and sucrose perception in an industrial setting to compare two labeled scales: the Labeled Magnitude Scale (LMS)[5] and a 9-point category (partition) scale. The LMS or Green scale is a novel scale recognized for use in academic laboratories and clinical settings. The 9-point category scale is the technique of choice for descriptive analysis to evaluate new food ingredients and formulations in industrial settings.

All studies were conducted at Cultor Food Science Research and Development Department in Groton, CT. One hundred and sixty-three reportedly healthy volunteers aged 21–62 years recruited at Cultor Food Science participated in 3 separate studies. All panelists were untrained in descriptive analysis testing.

The stimuli in the 3 studies included sucrose (1.0 M) and PROP [paper (approximately 1.2 mg) or solutions (0.001 M, 0.0032M)]. All stimuli were prepared with deionized water several hours prior to testing. The scales used in the study include the Labeled Magnitude Scale (LMS) [labeled line with descriptors (no taste—strongest imaginable)] and a 9-point category scale (1 = not at all; 9 = extremely).

In experiment 1 (S1) [n = 163 (55 males, 108 females)], subjects rated the perceived intensity of PROP-saturated paper and sucrose on the LMS. In experiment 2 (S2) [n = 152 (49 males, 103 females)], subjects rated the perceived intensity of sucrose and PROP solutions on the LMS. In experiment 3 (S3) [n = 136 (48 males, 88 females)], subjects rated the perceived intensity of sucrose and PROP solutions on a 9-point category scale. In all experiments, water rinses were included between each tastant and PROP was the final stimulus. Statistical analyses included descriptive statistics, analysis of variance (ANOVA), and simple regression analysis.

In S1 and S2, those with higher PROP perception perceived sucrose more intensely [(S1: $r = 0.32$; $p < 0.001$); (S2: $r = 0.25$; $p < 0.01$)] (FIG. 1). A higher frequency of females were supertasters than males. Also, the PROP effect on sweet perception was most evident in female supertasters. This apparent sex difference may be the result of hormonal variation associated with menstruation. Also in S1 and S2 subjects aged 20–40 years, females had significantly greater variance among sucrose intensity ratings than males ($F = 3.66$; $p < 0.01$), which may be due to hormonal changes with menses. The results of S3 failed to show either the positive correlation between PROP and sucrose perception (FIG. 2) or the sex difference in taste responses.

Of the 2 labeled scales, the LMS appears to be the better technique for assessing

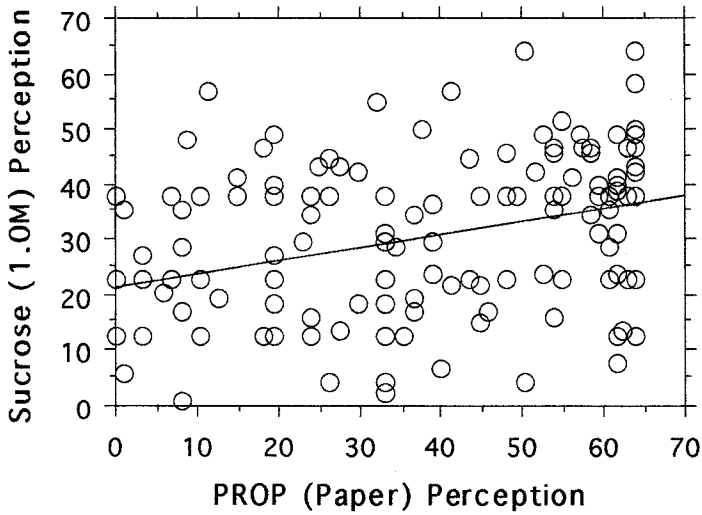

FIGURE 1. Experiment 1. Perceived sweet taste intensity as a function of PROP perception in 163 (m = 55; f = 108) subjects assessed with Green scale (r = 0.32; $p < 0.001$).

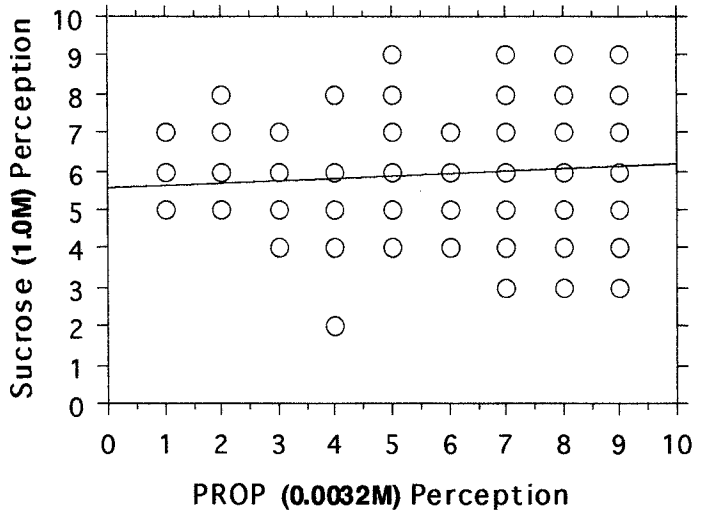

FIGURE 2. Experiment 3. Perceived sweet taste intensity as a function of PROP perception in 136 (m = 48; f = 88) subjects assessed with 9-point category scale (r = 0.09; NS).

PROP perception. It is continuous and thus prevents the loss of information often associated with category scales. The LMS also minimizes ceiling effects since it provides sufficient room at the top for extremely high perception. The scale is particularly appropriate for use in PROP studies, as it permits the classification of taster status and clearly shows the separation of medium- and supertasters. Further, the scale shows the correlations between PROP and sucrose perception, and illustrates sex differences in taste resonses. In contrast, the 9-point scale results in the loss of information, since it is categorical, and thus does not allow subjects to respond on a continuum. Further, the intervals on the category scale are not necessarily perceived as equidistant from each other. Another disadvantage associated with the 9-point category scale is that panelist may avoid selection of the 2 end points in order to reserve them for 'real extremes.'[4] The result is a cluster of responses in the center of the scale. The ceiling effect is another problem associated with this scale. This is of particular interest in the evaluation of a tastant such as PROP, which tastes extremely bitter to supertasters. Finally, as a result of these and perhaps other issues, the scale may fail to yield data that show relationships between variables, as was seen in this study.

Future research will extend these studies by assessing PROP, sucrose, and high-intensity sweetener concentration series, including aspartame, saccharin, neohesperidin dihydrochalcone (NHDC), and alitame, with the LMS technique. Eventually, studies will be conducted to assess relationships between PROP perception and sweetness intensity perception and hedonic ratings of other food ingredients and new food formations such as fat-free confections.

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