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The influence of PROP taster status on habitual sweet food consumption and dietary intake amongst obese and non-obese adults

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ABSTRACT

Introduction: Ability to taste 6-n-propylthiouracil (PROP) predicts both taste sensitivity and food preferences, with PROP tasters being more sensitive to sweet taste in foods, which may lead to less intake of sugary foods. However, when obesity progresses, the individual's sense of taste and eating patterns may change. The aim of this study was to evaluate if PROP taster status affected habitual sweet food consumption and nutritional intake in obese and non-obese people. **Methods:** A total of 88 obese and 92 non-obese Malay male and female participants aged 20-45 years were classified into PROP non-tasters, medium tasters, or supertasters by using PROP filter paper screening procedure. Sweet food consumption was assessed using food frequency questionnaire (FFQ), while dietary intake was measured by using 3-day food diary. Data were analysed using General Linear Model (GLM) Analysis of Covariance (ANCOVA) to compare for differences and associations among variables. **Results:** Overall, there was no significant association between body mass index groups and PROP taster status (p>0.05). No significant differences were found on any habitual sweet food intake and dietary intake according to PROP taster status in both obese and non-obese participants (p>0.05). However, there was a significant difference (p<0.05) in fruit intake according to PROP taster status among obese participants. **Conclusion:** The findings suggest that PROP taster status does not play a role in nutrient intakes among obese and non-obese individuals.

Keywords: dietary intake, obesity, PROP taster status, sweet food consumption

INTRODUCTION

The availability of various types of energy-dense food that are cheap and palatable have contributed to overconsumption among consumers. It is notable that most foods that are high in fat and sugar contents tend to provide pleasurable effect and are often significantly associated with weight gain and chronic diseases (Luger *et al.*, 2017). A study by Teo *et al.* (2021) showed that individuals with higher energy-dense consumption had significantly higher body weight and body mass index (BMI), as well as increased serum cholesterol and risk for hypertension.

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Moreover, it was reported in several countries, such as Spain, Brazil, and France, that reducing energy-dense food intake could decrease mortality rate due to cardiovascular disease or non-communicable diseases (Blanco-Rojo *et al.,* 2019). Therefore, finding a useful biomarker in individuals who are at risk to certain dietary pattern could provide a useful approach in developing effective and reliable intervention programmes for the prevention of obesity and chronic diseases.

Taste is a primary aspect in determining our food preferences and dietary changes. However, inter-individual variations on taste perception are wide and complex as the perception of taste modalities appears to be mediated by many different mechanisms (Proserpio *et al.*, 2017; *Tepper et al.*, 2017). The relationship between taste perception and dietary behaviour or eating habit is always triggered by taste sensitivity. People with low taste sensitivity needs higher stimuli or component to achieve the optimal point, which stimulates the hedonic component of taste sensation known as palatability or pleasantness. For instance, individuals who are sensitive to bitter taste may avoid eating brassica vegetables, while those who are less sensitive to fatty taste are more tempted to eat burger and pizza more frequently (Barajas-Ramirez *et al.*, 2016; Deshaware & Singal, 2017).

The ability to taste bitterness of 6-n-propylthiouracil (PROP) is one of best known examples of taste variability influenced by genetic, and it has been used as a general index of oral chemosensory perception, particularly taste sensitivity (Tepper *et al.*, 2019). Many research have shown that PROP tasters are more sensitive to various taste modalities compared with PROP non-tasters. It has been hypothesised that PROP tasters dislike foods with intense sensory qualities of sweet and fattiness, which consequently influence their dietary behaviours and weight regulation. Furthermore, several studies have suggested that PROP non-tasters show higher preferences for dietary sweet and fat (Tepper *et al.*, 2017; Keller *et al.,* 2014), therefore more likely to report lower diet quality and have higher risk of cardiovascular diseases (Sharafi *et al.*, 2018).

Notably, obesity or weight status may affect individuals' taste perception and dietary intake. Many studies have reported that obese participants have lower taste sensitivity compared to non-obese participants (Hardikar *et al.*, 2017). It was speculated that obese individuals tend to have higher preference for sweetened and fatty foods compared to non-obese participants as they need intense taste/flavour to achieve their hedonic breakpoint (Donaldson *et al.*, 2009; Proserpio *et al.*, 2017). However, this assumption is not well explained as findings in previous studies have been inconsistent. Several factors were highlighted for the inconsistencies such as metabolic signal disruption, cognitive eating behaviour, and genetic background (Dastan *et al.*, 2015; Guido *et al.*, 2016). In regard to genetic background, many studies have demonstrated that PROP taster status is a reliable indicator for individuals' taste perception, food intake and preferences (Nagai *et al.*, 2017, Dioszegi *et al.*, 2019).

We hypothesised that PROP taster status could explain the variation in food consumption among obese and non-obese individuals. Therefore, the objective of this study was to explore the effect of PROP taster status on habitual sweet food consumption and dietary intake of sweet and fatty foods among obese and non-obese participants.

MATERIALS AND METHODS

Participants and data collection

This exploratory study used a comparative cross-sectional design, with respondents recruited using a purposive sampling technique. The participants were recruited around Universiti Putra Malaysia (UPM) campus and Serdang district area. The inclusion criteria for participants included aged 20-45 years, in good health, no chronic diseases, no food allergies, not taking any medications that interfered with taste or olfactory perception, not pregnant or lactating, with BMI more than 30 kg/m^2 for obese participants, while BMI less than 18.5 kg/m^2 and not more than 25 kg/m^2 for non-obese participants (WHO, 2021). Participants were screened using a questionnaire prior to their admittance in this study. The appropriate sample size was determined by calculating power using the G*Power 3 software (Faul *et al.*, 2007). To attain 80% statistical power with a medium effect size and a type I error of 0.05, 65 participants per group was required (Choi, 2014). All participants provided written informed consent and the study was approved by the Ethics Committee for Research Involving Human Subjects, Research Management Centre, UPM [Ref. No. RMC/1.4.18.1 (JKEUPM)/ F2]. All data collection was carried out from March until October 2019.

PROP taster status determination

PROP taster status was determined via the paper disc screening test based on Zhao, Kirkmeyer & Tepper (2003). This method employed two paper discs, one impregnated with sodium chloride (NaCl) (1.0mol/l) and the other with PROP solution (0.50mmol/l). Participants were instructed to place the paper disc in the centre of their tongue for 1 minute and then remove the paper. NaCl paper discs were evaluated first, followed by PROP; participants were required to cleanse their palates with water and plain biscuits before tasting another paper disc. They were asked to rate the bitterness intensity of PROP and saltiness of NaCl using general Labelled Magnitude Scale (gLMS). Participants who rated the PROP disc's intensity on the gLMS between 20 and 100 mm were categorised as medium tasters (MT), whereas those who rated less than 20 mm were classified as non-tasters (NT), and those who rated more than 100 mm as supertasters (ST). However, if the PROP disc rating was borderline, the NaCl rating was used to reconfirm the participant's actual PROP taster status. If a participant's PROP rating was borderline at 20mm and the NaCl disc rating was much lower (at least a 30mm difference on the gLMS), the participant was then classified as a non-taster; if participant rated the PROP at 100mm and gave a much higher rating to the NaCl, he/she was then classified as a supertaster.

Habitual food intake measurement

Food frequency questionnaire (FFQ) was used to measure habitual sugary food intake among the participants. The FFQ for sugary food was adapted from Nik Shanita, Norimah & Abu Hanifah (2012) with slight modifications, where food items were arranged based on their food category and sensory characteristics similarities, respectively. Several additional Malaysian food items that were classified as high-sugar foods (i.e., >15% of energy from total sugar) were also included (Sigman-grant & Morita, 2003; Sia *et al.*, 2013). In total, 42 sugary food items were included in the sugary food FFQ, which were regrouped further into five food groups.

Participants were asked regarding the frequency of intake for each of the food items over the past two months and the number of servings per intake. The participants were thoroughly briefed on the correct procedure of filling up the FFQ. They were asked to describe the intake of their food/meal using standardised serving, which included either natural portions (e.g., 1 slice of pizza, 1 slice of orange, and 1 whole banana) or usual household measurements (e.g., 1 medium bowl of rice, 1 tablespoon of sugar, and 1 glass of full cream milk). A standard Malaysian food serving booklet was given to all the participants as guidance for food serving sizes. The frequency of intake for each food item was reported based on servings per day. Conversion into servings per day was calculated by multiplying the conversion factor of the frequency of intake with the number of servings per intake for each subject (Norimah *et al.*, 2008).

Dietary intake measurement

Three days food diary was used to measure the dietary intake of each subject. Food intake was recorded for two days during weekday and one day during weekend. Participants were briefed on how to fill in the food record. During the briefing, participants were asked to record all the foods that they have consumed during their previous meal (e.g., breakfast) as their practice. All drinks and foods that they have consumed were recorded in household measurements. Participants were asked, where possible, to weigh all the foods they consumed or used standard metric measuring cups or common Malaysian food serving sizes (e.g., cup, glass, Chinese bowl) to record their food intake. They were also asked to report the brand of foods consumed, type of foods (e.g., white or whole meal bread), whether fat or any other seasonings were added, method of cooking, and amount consumed per meal. Besides, if food was consumed from a new recipe or recently created by them, participants were asked to include the recipe and report the amount of each food ingredient used in the cooking (e.g., half, quarter). Apart from that, the Malaysian food portion size and measurement booklet was given to the participants as reference for meal measurement/serving purpose. The three days food records were analysed by using Nutricalc software (Nuricalc Limited, West Buckland, Devon). Information on the nutrient content of foods were obtained mainly from the Nutrient Composition of Malaysian Foods (Tee *et al.*, 1997) and also manufacturer's nutritional information (e.g., nutrition labelling). Means of energy intake (kJ), macronutrient components (gram of total fat, protein, carbohydrate) and total sugar intake were calculated. For any food items that were not available in the standard data, calculations were done based on the ingredients used in the recipe.

Statistical analysis

General Linear Model (GLM) Analysis of Covariance (ANCOVA) was used to compare the nutritional intake and habitual food intake differences related to PROP taster status and also BMI status. The independent variables were PROP taster status and BMI group, whereas the dependent variables were mean reported intake from each of the food groups and also mean nutrient intake. Covariates included in these models were age and sex. In addition, post-hoc comparisons were done with Scheffe test to compare any differences among PROP taster status. Chi-square was used to evaluate any association between categorical variables. All analyses were conducted using IBM SPSS Statistics for Windows, Version 22.0 (IBM Corporation, Armonk, NY, USA), whereby p-value ≤0.05 was considered as statistical significance.

RESULTS

Participants' characteristics

The number of participants involved in this study was 180. They comprised of 92 non-obese participants (24 males; 68 females) and 88 obese (30 males; 58 females) participants. Participants' characteristics are shown in Table 1. The mean age of the subjects was 25.8±5.7 years with majority of the participants aged 20 to 35 years old. The BMI range in this current study was 19.0 to 45.5kg/m^2, with a mean of 27.6±6.7kg/m^2. The distribution for each PROP taster status among the participants are summarised in Table 1. There was no significant association between BMI status and PROP taster status based on chi-square test conducted (p>0.05). Additionally, the number of participants were distributed equally in both obese and non-obese groups for each PROP taster status involved in this study.

The association between PROP taster status and habitual sweet food consumption among obese and non-obese participants

As illustrated in Table 2, the mean daily intake (serving size) of sweet foods were not significantly different (p>0.05) between PROP taster groups for both obese and non-obese participants. In fact, there was no effect of BMI status or PROP taster status on the consumption of sweet foods (p>0.05). In addition, there was no significant interaction between BMI status with PROP taster status for each food group intake (p>0.05) based on 2-way ANCOVA test. Interestingly, we found that STs had higher fruit intake than other tasters among obese participants (p<0.05).

The effect of PROP taster status on habitual fatty food intake among obese and non-obese participants

Table 3 shows the mean macronutrients

Table 1. Participants' characteristics between obese and non-obese groups

	Non-obese (n=92)	*Obese (n=88)*	*p-value*
Age (year)[a]	26	28	ns
Weight (kg)[a]	88.9±7.1	58.2±11.0	<0.001
Height (cm)[a]	163.0±6.4	163.5±6.5	ns
BMI (kg/m^2)[a]	21.8±2.4	33.4±3.6	<0.001
Gender [b]			
Male	24 (26.1)	30 (34.1)	ns
Female	68 (73.9)	58 (65.9)	
Marital status[b]			
Yes	56 (60.9)	20 (22.7)	ns
No	36 (39.1)	68 (77.3)	
Prop taster status			
Super taster	40 (43.5)	38 (41.2)	ns
Medium taster	35 (38.0)	27 (30.7)	
Non-taster	17 (18.5)	23 (26.1)	

ns: not significant

[a] Mean±SE; means differences analysed by *t*-test

[b] n (%); variables association analysed by Fisher exact test

and sugar intakes among obese and non-obese participants according to PROP taster status. Results from 2-way ANCOVA test showed that there were no associations between BMI status and PROP taster status with dietary and sugar intakes (p>0.05). In addition, there was also no interaction between BMI status with PROP taster status for each macronutrient and sugar intakes among the participants (p>0.05). When the data were stratified by BMI status, similar outcomes were observed for the intakes of all macronutrients and sugar among the participants, where there was no significant difference between PROP taster groups in both groups (p>0.05). However, we observed distinctive variation in nutrient intakes where the amount of intake was higher among NTs for obese participants. This pattern was also observed among MTs for non-obese participants across all components. Surprisingly, STs showed higher sugar intake in both groups, but the observations were insignificant.

Table 2. Daily intake (in standard servings) of sweet food groups in obese and non-obese participants according to PROP taster status

Type of sweet food	*Standard serving*	*Obese subject*				*Non-obese participants*			
		ST	*MT*	*NT*	*p-value*	*ST*	*MT*	*NT*	*p-value*
Self-prepared drink	Glass	0.53±0.16	0.55±0.09	0.68±0.18	0.796	0.35±0.04	0.34±0.04	0.40±0.18	0.858
Processed beverages	Glass	0.14±0.03	0.20±0.04	0.13±0.02	0.385	0.36±0.24	0.10±0.02	0.06±0.13	0.446
Bakery products and confectionary	Piece	0.30±0.05	0.34±0.06	0.51±0.18	0.278	0.26±0.04	0.32±0.07	0.25±0.12	0.745
Traditional cake	Piece	0.06±0.01	0.06±0.02	0.07±0.03	0.919	0.03±0.01	0.04±0.01	0.03±0.01	0.573
Fruit	Piece	0.44±0.13	0.27±0.11	0.12±0.03	0.044	0.19±0.04	0.23±0.07	0.12±0.03	0.491

ST: supertaster; MT: medium taster; NT: non-taster
Data reported as mean±standard deviation, significant differences at p<0.05 by post-hoc Scheffe test; within group

DISCUSSION

The purpose of this study was to test the associations between PROP taster status and BMI status with habitual sweet and dietary intakes. The hypothesis that PROP taster status may be associated with human food preference and nutritional intake was first proposed by Drewnowski & Rock (1995). Since then, several studies have been conducted in investigating this hypothesis, particularly on food preferences among individuals, resulting in mixed findings. The present study extended previous studies by focusing on habitual food intake and nutritional status that were more relevant to body weight maintenance. In addition, this present study also took into consideration the variation of BMI status, which could drive the effect of PROP taster status among individuals.

The current study found that supertasters comprised the most prominent individuals in both obese and non-obese groups. Additionally, our finding also showed that the number of participants were distributed somewhat equally in both obese and non-obese groups for each PROP taster status. This finding somewhat

Table 3. Daily energy, macronutrients and sugar intakes in obese and non-obese participants according to PROP taster status

Dietary intake	*Obese*				*Non-obese*			
	ST	*MT*	*NT*	*p-value*	*ST*	*MT*	*NT*	*p-value*
Energy (kcal)	1931±108	1830±81	2129 ±202	0.317	1707±77	1848±78	1808±1256	0.438
Carbohydrate (g/day)	235±15.6	220±10.2	266±33.1	0.312	216±11.2	236±11.7	224±19.6	0.464
Protein (g/day)	80±4.5	71±4.2	83±6.2	0.286	64±3.4	67±3.5	67±5.2	0.867
Fat (g/day)	73±4.4	71±4.6	82±6.0	0.309	65±3.0	70±3.5	70±4.8	0.458
Sugar Intake (g/day)	36±3.3	35±3.6	33±4.2	0.863	37±3.8	36±4.3	24±4.5	0.170

ST: supertaster; MT: medium taster; NT: non-taster
Data reported as mean±standard deviation, significant differences at $p<0.05$ by post-hoc Scheffe test; within group

contradicted with earlier understanding which supported the idea that supertasters tended to be thinner (ectomorph), whereas non-tasters were more likely to have heavier body type (endomorph) (Guido *et al.*, 2016). However, several follow-up studies conducted among various populations corroborated with our findings, which found no association between BMI and PROP taster status (Barajas-ramírez *et al.*, 2016; Borazon *et al.*, 2012), whereby the proportion of supertasters was highest in their studied population (Dastan *et al.*, 2015). This disparity in research findings could be attributed to variances in the prevalence of PROP taster status across the population, driven by disparities in age spans and geographic dispersion. It could also be because of the different cut-off scores for categorising taste status (Hanim *et al.*, 2020).

As regards food consumption, surprisingly, our results demonstrated that there was no significant association between PROP taster status and habitual sweet food consumption among obese and non-obese participants. Previous data surrounding this area are conflicting, with some studies finding mild association between PROP taster status and habitual sweet food intake (Turner-McGrievy *et al.*, 2013, Yang *et al.*, 2019), while others finding no association (Barazon *et al.*, 2009; Catanzaro, Chesbro & Velkey, 2013; Deshaware & Singhal, 2017). Even more challenging was the fact that most studies involving PROP taster status and food consumption were circulating on food preferences among younger age and the Western population. Among children, studies by Mennella, Pepino & Reed (2006) and Keller & Tepper (2014) have reported greater intake and liking of sweet foods in PROP taster compared with non-taster children. A recent study by Hanim *et al.* (2020) also showed that there was no significant relationship between PROP rating and sweet food preference among Malaysian university students. Thus, different age group and habitual culture differences could plausibly influence individuals' habitual food consumption rather than PROP taster status (Catanzaro *et al.,* 2013).

The present study found no associations between PROP taster status with dietary and sugar intakes in both BMI groups. Previous research has demonstrated a mild association between PROP taster status and dietary intake, particularly on energy and sugar intakes; however, another study which was in line with this current work observed no association (Nagai *et al.*, 2017). To the best of our knowledge, this is the first study measuring the association between PROP taste status and dietary intake variables by considering BMI status among the participants. Interestingly, although the results did not show any statistical significance, we observed that the dietary and sugar intake patterns were consistent across PROP status among obese and non-obese participants. In obese non-tasters, energy intake and all macronutrient components were higher; however, in non-obese participants, this tendency was inverted, and medium tasters had the most. These dietary intake patterns corroborated with findings from Yacknious & Guinard (2002) and Borazon *et al.* (2012). Recently, a study by Hilmy *et al.* (2022) showed that there was no association between dietary intake and PROP score among their young adult participants, which is also in line with our findings.

Notably, the consumption of sugar was higher among the supertasters and medium tasters in both obese and non-obese groups, but no significant differences were obtained. This finding was most striking among the supertasters, who have higher taste sensitivity, which leads them to be a sweet disliker. Mennella *et al.* (2006) reported that children who had genotypes that are associated with higher bitter sensitivity liked beverages with higher sugar content and reported greater use of sugar in cereals compared with children who had bitter insensitive genotypes. In the present study, we reported supportive relationships when classifying participants by PROP phenotype, but genotype was not included. The reason for these inconsistencies across studies is not known. Albeit several studies suggesting that PROP tasters may be less likely to comply with dietary strategies as they consume less bitter-tasting cruciferous vegetables and salad greens, they may seek to mask bitter taste by the addition of fat, sugar or salt (Sharafi *et al.,* 2013*;* Keller *et al.*, 2014).

The extent that PROP taster status affects inter-individual variability in dietary status and habitual food intake remains inconclusive. PROP taster status failed to show any association with both measurements in this study. Surprisingly, we observed some interesting patterns in habitual food intake or dietary intake among PROP taster status, but the direction between both measurements was inconsistent. Similarly, Kamphuis & Westerterp-Plantenga (2003) demonstrated that there were no differences with respect to macronutrient selection and energy intake between PROP tasters and PROP non-tasters, but PROP tasters had higher hedonic values and intake on the high-fat lunch menu. This could suggest that PROP status might not have an ultimate role in food intake and preference when sensory hedonics are optimised, whereby macronutrient and energy might not be affected. In addition, in everyday life, human food consumption are based on sensory characteristics, but not determined by the nutrient content in food products (Proserpio *et al.*, 2017).

The present findings need to consider some limitations. Firstly, the present study only focused on healthy young adults, thus our findings may not be generalised to other groups (e.g., elderly subjects). Secondly, a larger sample size should be considered in future studies as a greater sample size could represent a larger population and result in statistically significant differences among PROP taster groups. Thirdly, the differences in approaches of evaluating dietary or habitual food intakes should not be overlooked. Dietary record only covered three days of food consumption, generating a distinct snapshot on dietary measurement in this study, which could result in a variation within the findings.

CONCLUSION

The present study found that PROP taster status did not influence individuals' habitual food intake (either fatty foods or sweet foods) and also energy and macronutrient intakes. This could suggest that PROP taster status does not directly affect human food intake and preferences. However, the results from this study support that this phenotype marker could have a linkage in human eating behaviour, but other factors, such as age and culture, might work together or overshadow this function.

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Authors' contributions

Ahmad Riduan B, participated in the experimental design, data collection and analysis, and drafted the manuscript; Nazamid S and Zalilah MS, involved in conceptualising the study and advised the data analysis; Roselina K, contributed on study design and supervised the data collection and analysis. All authors listed as authors have substantially contributed to the work.

Conflict of interest

The authors have no conflict of interest to declare.

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