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Relationship between 6-n-propylthiouracil (PROP) taster status, dietary intake and dental caries among young adult subjects

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ABSTRACT

Introduction: Previous studies have established an association between 6-n-propylthiouracil (PROP) taster and dietary intake. However, those studies mostly emphasised on macronutrients. The present study examined the dietary intake, including macro- and micronutrients, and caries experience among university students according to their PROP taster status. **Methods:** A total of 158 university students participated in this study. PROP taster status was determined using filter paper method. Dietary intake was collected using 24-hour diet recall method. Oral health examination was conducted to determine dental caries experience. **Results:** The results showed that majority of subjects were supertasters. No significant differences (p>0.05) were found in the macronutrient intakes among supertasters, medium tasters, and non-tasters. Significant differences (p<0.05) were found in the intakes of micronutrients, namely pantothenic acid, vitamin D, magnesium, manganese, and fluoride. There were no significant differences among group tasters in the dental caries experience scores of decayed (D), missing (M), and filled (F) teeth. **Conclusion:** In general, this study indicated that all group tasters had no difference in macronutrients intake and caries experience, but supertasters had significantly lower intakes of some micronutrients as compared to non-tasters and medium tasters. This suggested that PROP taster status could have some influence on micronutrient intakes.

Keywords: caries, dietary intake, macronutrients, micronutrients, PROP, young adults

INTRODUCTION

A healthy diet is crucial in maintaining optimum health. Poor dietary intake is said to be the factor contributing to increasing prevalences of obesity and non-communicable diseases. Dietary intake can be influenced by various factors, including social (such as family and friends), physical (such as food availability and affordability), and macro level environment (such as food marketing and cultural norms) (Osei-Kwasi *et al.*, 2020). In addition, previous work has shown that there is

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a connection between taste sensitivity with food acceptance and consumption (Cattaneo *et al.*, 2019).

The ability to taste the bitter compound 6-n-propylthiouracil (PROP) is genetically determined. The degree of sensitivity to PROP can be used as a criterion to classify an individual into a non-taster, medium taster or supertaster (Robino *et al.*, 2014). Some studies suggested that supertasters are more sensitive to taste compounds, and therefore, can perceive compounds, such as caffeine, sucrose, pepper, and fat, with greater intensity (Von Atzingen & Silva, 2012).

The difference in taste sensitivity plays an important role in food selection and preference, as well as dietary patterns (Yackinous & Guinard, 2002). Individuals with high taste sensitivity (supertasters) are suggested to avoid certain kinds of foods because the taste of food is too intense for them. Hence, supertasters could be a cause of picky eating, which leads to eating an unbalanced diet (Martha & Gary, 2010). On the contrary, non-tasters can appreciate taste at a higher concentration, which may lead them to choose foods with stronger taste or higher concentration of flavours, such as high sugary foods. High sugar intake in foods and beverages in an individual with a preference to sweetness can lead to diabetes and obesity (Jacques *et al.,* 2019).

Difference in the PROP taster status contributes to variation in food acceptability (Lim *et al.*, 2021), which in turn, may affect dietary intake. Reports have shown that taste perception may influence nutrient intakes and food selection. The results on nutrient intakes vary, with some reporting significant difference in the intakes of energy and carbohydrate (Cattaneo *et al.*, 2019) and fat (Yackinous & Guinard, 2002), while others found no significant difference in dietary intakes among tasters (Borazon *et al.*, 2012). PROP tasting is also associated with micronutrients intake. According to Inoue *et al.* (2017), PROP tasters consume greater amounts of dietary sodium. It is postulated that the intake of sodium serves as a masking for the taste of bitterness.

Diet is an important factor in oral health. High consumption of carbohydrate and sugar without any proper oral hygiene care may contribute to dental diseases such as dental caries and periodontal disease. The multifactorial interactions between the tooth structure, the microbial biofilm formed on the tooth surface and sugars, as well as salivary and genetic factors, can influence the development of dental caries (Pitts & Zero, 2016). Therefore, non-tasters who have higher frequencies and concentration of sugar intake in their dietary intake are more susceptible to dental caries (Arakawa *et al.,* 2021). Micronutrient intake, such as fluoride, is an important element to reduce caries risk as it is recognised and recommended by the US Food and Drug Administration (FDA) for the prevention of dental caries (Carey, 2014).

Studies on the Malaysian population regarding their taste sensitivity status are limited. The factors underlying dietary behaviour is crucial to determine the problem surrounding the status of PROP taster among Malaysians. Since different culture exhibit different lifestyles and dietary patterns, it is therefore worthwhile to study the association between PROP taster status with dietary intake and caries experience in Malaysian subjects. Previously, we have reported about the food preference of different taste food groups, namely sweet, salty, sour, and bitter among university students based on their PROP taster status (Syathirah Hanim *et al.*, 2020). As a continuation, the dietary intake and caries experience were determined in this study. The

present study also extended the results on micronutrients, which were scarcely reported.

MATERIALS AND METHODS

Subjects

This was a cross-sectional study in which 158 undergraduate students (aged between 19 to 25 years) participated through convenience sampling in the state of Kelantan, Malaysia. Power and Sample Size Calculation (PS) Software was used to calculate the sample size of this study, which resulted in a total of 144 subjects. After taking into account a 10% drop-out, a finalised number of 158 subjects were recruited for this study. The inclusion criteria were undergraduate students and free from any diseases or conditions that could alter taste sensation, such as ageusia and hypogeusia. Subjects were excluded if they were a smoker or taking long term medication for chronic diseases. All subjects gave their consent to participate in this study. This study was approved by the Human Research Ethics Committee of Universiti Sains Malaysia (Ref No: USM/JEPeM/18070313).

PROP taster classification method

Subjects were instructed to avoid consuming a large meal and drinking strong tea or coffee for at least one hour before the tasting session. Taste sensitivity was obtained by using PROP test paper (3cm in length) to detect the perception of bitter substrate. A PROP taste paper (PL Precision, Northampton) with 20 microgram of PROP concentration was placed on the tongue of the subjects for 30 seconds. Then, subjects were asked to rate the sensation perceived (intensity of bitterness) using the Green's Labeled Magnitude Scale (LMS) (Green, Shaffer & Gilmore, 1993). Previously, subjects were given instructions on how to use the Green LMS. The rating scale ranged from 0 to 100, with 0 representing barely detectable sensation and 100 was the strongest imaginable sensation of any kind. The subjects were identified as non-taster, medium taster, and supertaster if they scored <12 mm, 12-60 mm, and >60 mm, respectively.

Dietary intake

Dietary intake was conducted after subjects completed the PROP test. The 24-hour diet recall method was used to assess dietary intake. A face-to-face in-depth interview was conducted to recall in detail all the foods and drinks the subjects have consumed during the previous 24 hours. This method was chosen because it is an established method that is widely used to determine food intake and was considered the best to be used based on the feasibility and resources allocated for this study. The interview was conducted for three days in a week; 1-day diet recall for weekend and 2 days diet recall for weekdays. The interview was conducted at a time that was convenient for both the researcher and participant, typically out of school schedule. The subjects were asked to recall all foods and drinks consumed and assisted in estimating their portion sizes. To ensure that the data obtained were as accurate as possible, subjects were probed to get specific information, such as the brand consumed, type of food consumed (wholemeal, low-fat), and details on preparation and cooking methods.

Dental caries experience

Dental caries experience was performed after the dietary intake session. Subjects were asked to sit on a portable dental chair with adequate lighting from a portable light with the examiner seated in front of the chair. The subjects' teeth were examined in an orderly sequence from one tooth to the next adjacent tooth with the help of a disposable mouth

mirror; starting from 18 (third molar of upper right) to 28 (third molar of upper left) for the upper jaw, and 38 (third molar of lower left) to 48 (third molar of lower right) for the lower jaw. Disposable probes were used if food debris needed to be removed in detecting dental caries. All non-sharp disposable instruments were disposed in a sharps bin. Hand disinfectant was used before gloving and post-intra-oral examination was carried out for each respondent. The criteria used to diagnose a tooth's status and the coding number was based on World Health Organization (WHO) protocols (WHO, 2013). Dental caries experience was constructed on decayed, missing, and filled teeth (DMFT) index. The assessment scores were recorded per tooth on the DMFT index form. The dental caries experience of each subject (DMFT) was determined by adding the scores of decayed (D), missing (M), and filled (F) teeth. The minimum DMFT score was 0, while the maximum DMFT score was 32. A DMFT score of 0 indicated no decayed, missing or filled tooth, which reflected very low or no caries experience; a DMFT score of 32 indicated highest severity in caries experience.

Statistical analysis

The Nutritionist Pro™ Diet Analysis Software using the Malaysian food database was used to analyse the nutrient intakes of the participants. All data collected were entered and analysed using IBM Statistical Package of Social Science (SPSS) version 24.0. One-way analysis of variance (ANOVA) test was used to assess the significant difference in mean for dietary intake and caries experience among non-tasters, medium tasters, and supertasters. PROP bitterness rating was correlated with dietary intake and caries experience using Spearman's rank correlation. The value of $p<0.05$ was considered as statistically significant.

RESULTS

Table 1 shows the demographic characteristics of participants in the present study. A total of 158 undergraduate students took part in this study. Majority of subjects were females, which constituted about 79.7%, while 20.3% were male students. Malays (79.1%) constituted the highest number of participants, followed by Chinese (10.8%), other ethnic minorities (5.7%),

Table 1. General characteristics of the participants, *n* (%)

	Non-tasters (n=37)	*Medium tasters (n=34)*	*Supertasters (n=87)*	*Total (n=158)*
Gender				
Female	29 (23.0)	25 (19.8)	72 (57.1)	126
Male	8 (25.0)	9 (28.1)	15 (46.9)	32
Race				
Malay	28 (22.4)	27 (21.6)	70 (56.0)	125
Chinese	3 (17.6)	4 (23.5)	10 (58.8)	17
Indians	3 (42.9)	1 (14.2)	3 (42.9)	7
Others	3 (33.3)	2 (22.2)	2 (22.2)	9
Age (years)				
19 - 22	17 (17.7)	21 (21.9)	58 (60.4)	96
23 - 26	20 (32.3)	13 (20.9)	29 (46.8)	62

Table 2. Mean dietary intake among non-tasters, medium tasters, and supertasters

Dietary Intake	*Mean±SD*			*p-value*	*Correlation of PROP score and dietary intake (r)*
	Nontasters (n=37)	*Medium tasters (n=34)*	*Supertasters (n=87)*		
Macronutrients					
Energy (kcal)	1313±76	1408±76	1340±46	0.802	0.025
Protein (g)	37.2± 3.4	38.8±3.6	36.5±2.2	0.84	-0.031
Carbohydrate (g)	111.4±7.3	112.7±9.4	114.5±6.1	0.952	-0.009
Fat (g)	42.3±4.4	51.6±5.0	51.4±4.6	0.443	0.005
Sugar (g)	27.9±4.8	32.0±4.9	27.3±3.1	0.055	-0.054
Vitamins					
Thiamin (mg)	0.53±0.10	0.55±0.10	0.41±0.04	0.177	-0.109
Riboflavin (mg)	0.66±0.14	0.77±0.17	0.55±0.08	0.680	-0.009
Niacin (mg)	5.24±0.62	4.99±0.69	5.17±0.36	0.909	0.045
Pantothenic acid (mg)	0.54±0.08[a]	0.43±0.07[ab]	0.35±0.03[b]	0.018	0.172*
Pyridoxine (mg)	0.37±0.05	0.31±0.04	0.32±0.02	0.321	-0.050
Folate (µg)	45.24±6.25	48.08±7.45	53.53±9.01	0.816	-0.038
Cobalamin (µg)	0.60±0.10	0.64±0.11	0.85±0.27	0.701	-0.089
Vitamin C (mg)	15.17±2.50	14.62±2.37	11.45±1.49	0.313	-0.152
Vitamin A (µg)	31.26±5.07	29.14±6.46	26.97±4.32	0.871	-0.072
Vitamin D (µg)	0.29±0.06[a]	0.17±0.07[ab]	0.14±0.03[b]	0.028	0.180*
Vitamin E (mg)	1.75±0.29	1.37±0.26	1.65±0.18	0.328	-0.011
Vitamin K (µg)	4.75±1.60	4.76±1.80	4.53±0.86	0.617	0.068
Trace elements					
Calcium (mg)	307.54±61.36	326.49±63.49	263.79±38.00	0.321	-0.061
Iron (mg)	6.60±0.80	6.28±0.97	6.71±0.71	0.816	-0.056
Iodine (µg)	12.51±6.96	3.26±0.81	9.21±2.46	0.126	-0.078
Zinc (mg)	2.65±0.54	3.41±0.92	2.31±0.27	0.313	-0.087
Selenium (µg)	10.42±3.10	20.92±5.12	14.74±2.43	0.871	0.041
Phosphorus (mg)	335.06±81.31	800.47±41.76	372.57±56.97	0.701	0.004
Sodium (g)	0.18±0.05	0.13±0.04	0.11±0.02	0.328	-0.011
Potassium (g)	0.67±0.09	0.61±0.08	0.52±0.04	0.617	-0.116
Magnesium (mg)	78.09±16.64[ab]	103.15±31.19[a]	53.65±5.26[b]	0.032	0.177*
Manganese (mg)	0.47±0.18[ab]	0.51±0.35[a]	0.32±0.07[b]	0.016	-0.130
Fluoride (mg)	0.02±0.04[ab]	0.04±0.07[a]	0.01±0.02[b]	0.012	-0.135

p-value in bold indicates a significant difference ($p<0.05$) with different letters in a row showing significant differences
r value with (*) indicates significant difference at p<0.05

and Indians (4.4%). Majority of subjects were in the range of 19 to 22 years old (75.0%). Results regarding taster status indicated that more than half of the subjects were supertasters (55.1%), followed by non-tasters (23.4%) and medium tasters (21.5%).

The daily dietary intakes of energy and nutrients for all three groups of tasters are shown in Table 2. There were no significant differences (p>0.05) detected in macronutrients, namely total energy, carbohydrate, protein, and fat intakes among students in different groups. The mean daily energy intake was 1314 kcal, 1409 kcal, and 1340 kcal for non-tasters, medium tasters, and supertasters, respectively. No significant difference (p>0.05) was found in total sugar intake.

In terms of micronutrients, this study showed that the mean dietary intake of most vitamins was not significantly different among non-tasters, medium tasters, and supertasters, except for panthothenic acid (vitamin B5) and vitamin D (Table 2). Significant differences (p<0.05) existed between non-tasters and supertasters for both vitamins, in which non-tasters had significantly higher intake of panthothenic acid and vitamin D compared to supertasters. Table 2 also showed that the elements magnesium, manganese, and fluoride had significant differences (p<0.05), whereby medium tasters had significantly higher intake of these elements compared to supertasters. There were significant correlations between PROP bitterness rating and panthothenic acid (r=0.172), vitamin D (r=0.180), and magnesium (r=0.177).

Table 3 shows the caries experience of students according to their group tasters. The prevalence of dental caries among the students was 57.6% and the mean DMFT score was 1.71. In each of the group taster, there were more subjects with caries, which were 56.8%, 58.8%, and 57.5% for non-tasters, medium tasters, and supertasters, respectively. There was no significant difference (p>0.05) found in caries experience in DMFT score and the mean of D, F, and M scores among students in different group tasters. No correlation was found between PROP bitterness rating and caries experience too.

DISCUSSION

The results of the present study showed that the group with the highest and lowest number of subjects were supertasters

Table 3. Caries experience among non-tasters, medium tasters, and supertasters

Caries experience	*Mean±SD / n (%)*			*p-value*	*Correlation of PROP score and caries experience*
	Nontasters (n=37)	*Medium tasters (n=34)*	*Supertasters (n=87)*		
Caries experience				0.984	-0.003
No (DMFT=0)	16 (43.24)	14 (41.18)	37 (42.53)		
Yes (DMFT≠0)	21 (56.76)	20 (58.82)	50 (57.47)		
DMFT	1.54±1.92	2.38±3.01	1.52±2.07	0.312	-0.035
D	0.32±0.75	0.38±1.07	0.22±0.56	0.502	-0.072
M	0.14±0.42	0.26±0.57	0.17±0.55	0.564	0.012
F	1.16±1.71	1.74±2.31	1.13±1.66	0.241	0.035

DMFT, Decayed, Missing and Filled Teeth; D, Decayed; M, Missing; F, Filled
All data were not significant at p<0.05.

and medium tasters, respectively. The same result was reported by Karmakar *et al.* (2016) among school children, in which supertasters constituted the highest number, while medium tasters the lowest number. However, among university students, a previous study found medium tasters to be the majority (Gunawardane, Ariyasinghe & Rajapaske, 2016). In general, the proportion of tasters (medium and supertasters) were higher in the present study. As indicated by Robino *et al.* (2014), approximately 75% of the world population are considered as tasters, either medium or supertasters. The difference in the prevalence of PROP taster status could be due to the difference in geographic location and age discrepancy (Syathirah Hanim *et al.*, 2020).

The present study showed that there was no evidence that different groups of tasters differed in terms of their macronutrients intake. However, in general, most of the participants, regardless of their taste sensitivity level, failed to meet the Recommended Nutrient Intake for Malaysian (RNI). It is not surprising as this has been reported before that university students have poor dietary habits (Shahril, Dali & Lua, 2013).

The results regarding energy and macronutrient intakes among non-tasters, medium tasters, and supertasters from previous studies were inconsistent. Previously, no significant relationship between PROP taster status and food consumption in Filipino adolescents was reported (Borazon *et al.*, 2012). Yackinous & Guinard (2002) reported no significant difference in energy intake among all three group tasters of healthy college students, but found an association between PROP sensitivity and fat intake. According to their data, women in medium taster and supertaster groups derived a greater percentage of their dietary energy from fat. Cattaneo *et al.* (2019) too established a relationship between bitter taste sensitivity and total energy and carbohydrate intakes. Our findings, however, did not find any significant relationship between PROP taster status and macronutrients intake.

Low fruits and vegetables consumption is a major contributing factor for nutritional deficiency (Augusto, Cobayashi & Cardoso *et al.*, 2014). According to Chong *et al.* (2017), lower consumption of vegetables resulted in low intake of vitamins and minerals among Malaysian children. It is not surprising if this pattern also applies to university students as food intake pattern during childhood may continue into adulthood. Previously, low consumption of vegetables among medium tasters and supertasters were reported in a few studies (Dinehart *et al.,* 2006; Duffy *et al.*, 2010). Thus, it is not unexpected if the significant difference in micronutrients intake among group tasters in the present study could be due to low consumption of vegetables.

Drewnowski *et al.* (1999) reported that PROP taster status in young women was associated with reduced preference for bitter vegetables, such as Brussel sprouts, cabbage, and spinach, which in turn was related to respondents' dietary measures of reduced intakes of beta-carotene, carbohydrate, and fibre. In the present study, supertasters had significantly lower intakes of micronutrients, namely vitamin D, panthothenic acid, magnesium, manganese, and flouride compared to non-tasters or medium tasters. Of these micronutrients, pantothenic acid, vitamin D, and magnesium were found to be correlated with PROP bitterness rating. These micronutrients could be present in foods rejected by supertasters

due to their bitterness or unpleasant flavour. Avoidance of such foods might lead to supertasters having insufficient intake of these micronutrients. As suggested by Drewnowski *et al.* (1999), some phytochemicals with potential chemopreventive actions are bitter in taste and found in bitter vegetables and fruits. However, based on our previous study, there was no significant difference in the preference for bitter vegetables, such as broccoli, cabbage, and Chinese kale among the same subjects as the present study (Syathirah Hanim *et al.*, 2020). However, as this was a cross-sectional study, it limits causality.

In terms of caries experience, there was no significant difference found among all tasters and no significant correlation established between PROP taster status and caries experience in the present study. It has been reported that sweet preference is associated with bitter taste sensitivity to PROP, in which PROP tasters are more likely to dislike sweet taste, while non-tasters prefer sweet flavour (Arakawa *et al.*, 2021). Preference for sweetness on the other hand is reflected by high sugar intake, which has been linked to dental caries (Bashyam *et al.*, 2020). Thus, it has been suggested that non-tasters would probably have higher caries experience than supertasters. A study by Jyothirmai, Naganandini & Aradhya (2011) among 15-year-old children observed that decayed teeth in non-tasters were statistically significant compared to medium tasters and supertasters. A weak relationship between taste sensitivity and caries experience was also found in Saudi Arabia, Italy, and Mexico among 669 school children aged 13–15 years in a cross-sectional, multi-centre survey (Ashi *et al.,* 2017).

A study by Gunawardane *et al.*, (2016), which also focused on university students, resulted in a similar finding as the present study, in which no significant difference in caries experience was observed among the group tasters. Hence, most of the participants could be classified as having good dental status, which indicated that they had a very low caries experience in their life based on DMFT scores of lower than 5.0 (WHO, 2013). However, a study conducted by Saw *et al.*, (2012) among Malaysian adults showed that the DMFT score was higher than 5.0. It is suggested that the subjects for this study were predominately healthy university students and studying at a health campus might have exposed them to increased knowledge and attitude towards oral health care. This was supported by Kumar *et al.*, (2010), which found that university students studying health sciences reported significantly higher scores towards better oral health attitudes and behaviours compared to other university students. However, we do not reject the idea that the lack of association for caries experience in this study could be due to the subjects mostly coming from similar background without much diversity.

The PROP taster status in this study was found to be unrelated with caries experience. This was also supported by the dietary intake results, which found no correlation between major macronutrients and PROP taster status. Carbohydrate and sugar are the main dietary causes for dental caries. The normally synergistic relationship between the resident microbiota and the host is dynamic and can be perturbed by the frequent consumption of fermentable dietary carbohydrates, especially sucrose (Sheiham & James, 2014). However, in this study, there were no significant differences among the three taster groups in terms of macronutrients intake. Hence, it reflected no significant differences in dental caries among these groups.

CONCLUSION

The present study indicated that PROP taster status does not affect macronutrient intakes among non-tasters, medium tasters, and supertasters. However, some of the micronutrients, namely panthothenic acid, vitamin D, magnesium, manganese, and flouride consumed were significantly lower for supertasters when compared to non-tasters and medium tasters. The present study observed no difference in caries experience among all group tasters. This study suggested that PROP taster status has some influence on micronutrient intakes. However, since this was a cross-sectional study, direct causable relationship cannot be established. Nevertheless, this knowledge may enhance our understanding on the relationship between PROP taster status and dietary intake, and further intervention studies should be conducted to explore the effects of PROP taster status on dietary intake and food selection.

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Authors' contributions

SHAH, conducted the study, analysed and interpreted the data, assisted in drafting and reviewing the manuscript; RH, assisted in the analysis of dietary intake and reviewed the manuscript; NS, assisted in the analysis of caries experience and reviewed the manuscript; MAM, principal investigator, prepared the draft and reviewed the manuscript.

Conflict of interest

The authors have no conflict of interest.

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