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The Influence of Taste Sensitivity on Fruit and Vegetable Intake among Young Adult Subjects

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***Abstract*— Individual food preferences are crucial predictors of food intake and can be highly influenced by taste sensitivity and perception. It is well known that fruit and vegetables have a variety of tastes and are not only dominated by bitterness. This study aimed to investigate the relationship between taste sensitivity and fruit and vegetable intake. Sensitivity for three basic tastes (e.g sweet, sour, and bitter) was measured using the staircase method whereby individual's sensitivity to the bitter compound 6-n-propylthiouracil (PROP) known as PROP taster status was determined by PROP disc determination. Food frequency questionnaire (FFQ) was used to record the fruit and vegetable intake of subjects. All data were analysed either using one way ANOVA or Pearson correlation at 0.05 confidence level. A total of 80 respondents were involved in this study and it was discovered that among them, 2.5% were PROP nontasters (n=2), 42.5% were medium tasters (n=34), and 55.0% were supertasters (n=44). PROP supertasters were found to have higher sensitivity on bitterness, whereby supertasters had higher bitter intensity ratings ($p<0.05$) compared to nontasters and medium tasters. In terms of fruit and vegetable intake, the highest consumed fruit was banana while the highest consumed vegetable was onion. Except for onion ($p=0.044$), no significant difference ($p>0.05$) was obtained between PROP taster groups and fruit and vegetable intake. Pearson correlation indicated that sweet sensitivity was positively correlated with durian intake ($r=0.305$) whereas bitter sensitivity was positively correlated to the intake of long bean ($r=0.221$). No significant relationship was present between sour taste sensitivity on the fruit and vegetable intake.**

***Keywords*— Taste Perception, Basic taste sensitivity, PROP Taster Status, Vegetable Consumption, Fruit Intake**

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I. INTRODUCTION

Fruits and vegetables are a wide range of plant foods with varying levels of energy and nutrients. They have long been included in dietary recommendations due to their high concentrations of vitamins, particularly vitamins C and A; minerals, including electrolytes; and, more recently, phytochemicals, particularly antioxidants. Furthermore, fruits and vegetables are suggested as sources of dietary fiber [1] Eating more fruits and vegetables increases nutrient intake, lowers the risk of heart disease, stroke, and some malignancies, and aids in weight management when substituted for more energy-dense foods [2]. Nonetheless, most nations still fail to meet the daily quota for fruits and vegetables. For example, only 12.3% and 10.0% of American adults polled fulfilled the recommended intakes of fruits and vegetables, respectively [3]. Meanwhile, the average daily intake of fruits and vegetables in Europe was also deficient, with Denmark having the lowest intake of just 2.6 parts and the United Kingdom having the greatest at 4.3 portions [4]. Furthermore, 94.9% of Malaysian adults do not eat enough daily fruits and vegetables, according to the National Health and Morbidity Survey 2019 [5].

Taste perception and preference are among the many factors that can contribute to a lack of consumption of fruits and vegetables. People's eating habits and food choices are greatly influenced by food flavor, which has significant effects on nutrition and health [6]. The chemosensory gustatory system mediates taste perception, mostly experienced on the tongue. It begins when substances called tastants attach themselves to the taste-receptor-cells (TRC) that are gathered in taste buds inside the gustatory papillae. The brain receives gustatory information from the nerve fibers attached to the TRCs. Humans often perceive five tastes: sour, salty, umami, sweet, and bitter [7].

Individual differences in taste sensitivity and other sensory impressions are significant. Genetic variations in genes related to the five fundamental taste characteristics and the most recently discovered fat taste modality are partly accountable for this [8]. 6-n-propylthiouracil (PROP) responsiveness is one of the most researched and well-understood genetic origins of individual diversity in oral experience. TAS2R38 haplotypes, a member of the TAS2R bitter taste receptor gene family, have an impact on it. Meanwhile, PROP responsiveness has long been employed as a generic indicator of sensitivity to a range of sensory inputs. In addition, three subject groups have been identified, and PROP response is indicated as PROP taster status. PROP nontasters (pNTs) consider this substance to be weak or tasteless, PROP medium tasters (pMTs) consider it to be moderately bitter, and PROP supertasters (pSTs) describe it as exceedingly bitter [9]. pSTs are more sensitive and have a lower a preference for numerous oral stimuli than pNTs. This includes additional bitter chemicals, sweet stimuli, sour compounds, umami flavor, irritants, high-fat or high-energy diets, astringent substances, and fruits and vegetables. As a result, individual differences in taste perceptions may have an impact on food intake and consumption [10].

Fruits and vegetables contain different types of tastes, not only bitterness, and individual differences in taste sensitivity may affect people’s food preferences and consumption [6,9]. Previous studies have shown that PROP supertasters, who are more sensitive to bitter compounds like glucosinolates, often eat fewer bitter vegetables such as broccoli and Brussels sprouts. However, these results are not always consistent across studies [11–14]. The influence of PROP taster status on fruit consumption is less studied because fruits usually taste sweet or sour and are less bitter. Still, some fruits with bitter or astringent tastes may be affected by taste sensitivity. Most studies so far have been done in Western countries, so the findings may not apply to Southeast Asian populations where food habits and culture are different. Therefore, the present study aims to investigate the relationship between PROP taster status, basic taste sensitivities (bitter, sweet, and sour), and the consumption of both fruits and vegetables among Malaysian adults. It is hypothesized that individuals with higher taste sensitivity, particularly PROP supertasters, will have lower overall intake of fruits and vegetables compared to medium tasters and nontasters.

II. MATERIAL AND METHODS

A. Subjects.

This exploratory study used a cross-sectional design, with respondents selected using a purposive sampling method. Subjects were recruited from the Universiti Malaysia Sabah (UMS) campus. Subjects must be in good health, free from chronic diseases (e.g hypertension, cardiovascular diseases) and food allergies, not under any medication that impair taste or smell sensitivity, and not pregnant or lactating. Before being admitted into the study, subjects underwent a questionnaire screening. All subject gave written informed consent, and the study had been approved by the Medical Research Ethic Comittee, Universiti Malaysia Sabah [Ref. No. JKEtika 3/21 (21)]. This study's sample size was calculated based on formula by [11] at a margin of error of 0.05 and 80% statistical power. Hence, a minimum of 72 subjects is required to achieve at least 80% statistical power.

B. Sensory Test

The sensory evaluation was divided into 2 sessions to determine the subjects’ taste sensitivity and PROP taster status of the subject. The subjects were told not to eat or drink anything for at least an hour before the test, and they were told not to smoke for two hours. Every subject completed the tests in a booth on their own. Three digit random numbers were used to code each sample. Prior to tasting any of the samples, they had to rinse their mouths with filtered water and wait 30 seconds between taste sensations. In taste sensitivity test, subjects were asked to rate the taste intensity of different tastant solutions with 3 different concentrations. The diluted solutions were prepared a day before the test and stored in a refrigerator. The dilution of the solutions corresponded to D6 (High), D4(Medium), and D2(low) dilutions, respectively as stated in the sensory analysis methodology of ISO-standard 3972 [12]. **Table 1** shows the dilution concentration of each tastants in grams per litre.

TABLE 1
TASTE STIMULI AND CONCENTRATION LEVELS

Basic Taste	Taste Compound	Low (g/L)	Medium (g/L)	High (g/L)
Sweet	Sucrose	0.94	2.59	7.2
Sour	Citric Acid	0.2	0.31	0.48
Bitter	Caffeine	0.09	0.14	0.22

Meanwhile, paper disc screening test was used to evaluate the PROP taster status. This procedure uses two paper discs, one impregnated with PROP solution (0.50 mmol/l) and the other with NaCl (1.0 mol/l). The paper disc was to be placed in the center of the participants' tongues for one minute, then removed. Before tasting another paper disc, participants were required to cleanse their palates with water and plain biscuits, and NaCl paper discs were rated before to PROP. The general labelled magnitude scale (gLMS) was used to score the taste intensity of all stimulus used in this study. Supertasters (ST) were defined as those who scored more than 100 mm, nontasters (NT) as those who scored less than 15 mm, and medium tasters (MT) as those who scored the PROP disc's intensity on the gLMS between 16 and 55 mm [6]. This scale ranges from ‘no sensation’ at the lowest point (0 cm) to ‘the strongest imaginable sensation of any kind’ at the highest point (15 cm) **(Figure 1)**.

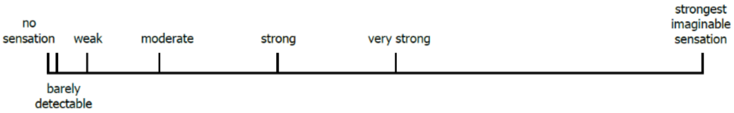

Fig 1.General Labelled Magnitude Scale (gLMS) And Descriptors

C. Fruit and Vegetables Intake Measurement

The food frequency questionnaire (FFQ) was used to assess the subjects' vegetable and fruit intake. The FFQ was derived from Malaysian Adult Nutrition Survey (MANS) 2014 with minor modifications. The fruit and vegetable items were organized according to their major basic taste namely sweet, sour and bitter [13, 14]. In total, this FFQ consisted of 33 fruit and vegetables items. Subjects were asked how many times they had eaten each items in the preceding two months, as well as how many servings they consumed overall. The participants were thoroughly briefed on how to successfully complete the FFQ. They were asked to describe how they consumed their meal or food in standard portions, such as common portions (e.g., one whole banana) or standard household measurements (e.g., a medium-sized bowl of spinach). Each participant was given a standard Malaysian food serving booklet as a guide on portion amounts. The frequency of intake for each food item was reported using servings per day. The conversion into daily servings was obtained by multiplying the frequency of intake conversion factor by the amount of servings per intake for each subject [15].

The quality of the modified FFQ was evaluated by assessing content validity and inter-rater reliability. Content validity was checked by a group of nutrition experts who reviewed the changes to make sure they were culturally appropriate and matched local eating habits [37]. Inter-rater reliability was tested by having 30 participants complete the FFQ with two different trained interviewers on separate occasions. The answers were compared using intraclass correlation coefficients (ICC), which showed a high level of agreement, following standard methods for checking FFQ reliability [38].

D. Statistical Analysis

All the data collected were analysed using the IBM Statistical Package for the Social Sciences (SPSS) version 28.0 and significant differences were determined at a significance level of $p<0.05$. The descriptive analysis was used to observe the proportion of PROP taster status among the subjects. On the other hand, the one-way ANOVA test was used to measure the differences in taste sensitivity as well as fruit and vegetable intake between different PROP taster groups. Lastly, Pearson's correlation method was used to determine the relationship between taste sensitivity and fruit and vegetable intake.

III. RESULT AND DISCUSSION

E. Subjects' Characteristics

A total of 80 subjects were involved in this study 63 of the subjects were female (78.3%) while 17 of them were male (21.3%). Most of the subjects were Chinese (55.0%), followed by Malays (20.0%) and other minorities (15.0%), and Indians (5.0%). The subjects' ages ranged from 19 to 28 years old. Majority of the subjects were categorized as supertaster (55.0%) followed by medium taster (42.5%) and non-taster (2.5%). **Table 2** shows the overview of the subjects' characteristics.

TABLE 2
DEMOGRAPHIC CHARACTERISTIC OF SUBJECTS

Demography		Frequency (f)	Percentage (%)
Gender	Female	63.00	78.80
	Male	17.00	21.30
Age Groups	18 - 21 years old	7.00	8.80
	22 - 24 years old	68.00	85.00
	25 years old and above	5.00	6.30
Ethnicity	Malay	16.00	20.00
	Chinese	44.00	55.00
	Indian	5.00	6.30
	Other	15.00	18.80
Prop Taster Status	Non Taster	2.00	2.50
	Medium Taster	34.00	42.50
	Super Taster	44.00	55.00

The low number of PROP nontasters was consistent with the findings of previous studies, stating that the proportion of nontasters among Asians tends to range from 6 to 10% [16,17]). Additionally, the high number of supertasters among the respondents aligned with previous study results which indicated that Asians were more likely to be PROP supertasters (18). However, the variation in PROP taster status prevalence could influenced by not only different age span discrepancies and geographic distributions but also different cut-off scores for grouping taste status [19]. As mentioned before, this study used 15 and 56 as cut-off points for nontasters and supertasters meanwhile there are studies that use other cut-off points, such as 12 and 60 [19], 15 and 67 [10] as well as 17 and 53 [20]. Hence, this could result in different varieties of PROP taster status classification among the studies' subjects.

F. Taste Sensitivity among the PROP Taster Groups

Table 3 elucidates the correlation between PROP taster status and taste sensitivities for sweetness, sourness, and bitterness. No statistically significant variations were observed in sweetness and sourness ratings across PROP taster groups ($p > 0.05$ for both attributes). A significant disparity was noted in bitter taste perception, with PROP supertasters exhibiting elevated bitterness ratings (97.73 ± 36.73, $p < 0.001$) compared to nontasters and medium tasters. Regarding sweetness sensitivity, PROP nontasters and medium tasters demonstrated comparable mean values, while PROP supertasters displayed the highest mean value. Sour and bitter sensitivities exhibited an ascending trend from nontasters to supertasters, with supertasters consistently recording the highest mean values for both attributes. Although PROP supertasters also showed trends toward increased sensitivity to sweet and sour tastes, these differences were not statistically significant in this study. The results showed that PROP supertasters had significantly greater sensitivity to bitterness compared to medium tasters and nontasters, confirming that bitterness is the primary taste influenced by PROP status. Larger and more evenly distributed samples across PROP groups are needed in future research to determine whether heightened taste sensitivity in PROP supertasters extends beyond bitterness to other basic tastes.

TABLE 3
BASIC TASTE SENSITIVITY OF DIFFERENT PROP TASTER STATUS

Taste	PROP Taster Status	N	Mean	SD	p - value
Sweet	Nontasters	2	17.00	15.56	0.171
	Medium tasters	34	17.41	14.89	
	Supertasters	44	26.14	24.00	
Sour	Nontasters	2	55.00	28.28	0.278
	Medium tasters	34	69.03	50.55	
	Supertasters	44	87.57	57.96	
Bitter	Nontasters	2	14.50	28.28	*<0.001
	Medium tasters	34	32.00	50.55	
	Supertasters	44	97.73	57.96	

* Significant level at $p<0.05$. Analysed by One way ANOVA

This outcome is supported by studies stating that those tasting PROP as very bitter, for instance supertasters, also perceive more intense sensations from other tastants such as sweet and bitter, trigeminal stimuli such as temperature, as well as oral somatosensory stimuli such as fats and irritants [18, 21,22]. Moreover, Fischer et al. [23] stated the term 'supertasting' was broadened to imply a general heightened level of oral perception of all tastes, and PROP supertasters would experience other oral sensations, such as the intensity of the four basic tastes: bitterness, salt, sour, and sweet; more intensely.

Melis et al. [10] also found a direct relationship between PROP sensitivity and electrophysiological response evoked by tastants in the taste buds of the human tongue. The largest and quickest responses were recorded in PROP supertaster subjects, who had the highest density of fungiform papillae. Whereas smaller and slower responses were observed in medium tasters and nontasters who had lower densities of papillae. In their study, supertasters displayed a more prompt and intense response to sucrose and citric acid, and a more rapid one to caffeine, as compared to medium tasters and nontasters.

G. Fruit and vegetable intake among PROP taster groups

Table 4 shows the mean, standard deviation, and p value of fruit intake between different PROP taster status. Based on the table, there were no significant differences in the intake of all the listed fruits among different PROP taster groups (p>0.05).

TABLE 4
FRUIT INTAKE OF DIFFERENT PROP TASTER STATUS (SERVING/DAY)

Item	PROP Taster Status	Mean Intake (Serving/day)	P value
Apple	Nontasters	0.03±0.02	0.406
	Medium tasters	0.18±0.28	
	Supertasters	0.12±0.18	
Banana	Nontasters	0.07±0.05	0.407
	Medium tasters	0.27±0.71	
	Supertasters	0.12±0.20	
Durian	Nontasters	0.00	0.587
	Medium tasters	0.01±0.02	
	Supertasters	0.03±0.15	
Grape	Nontasters	0.18±0.15	0.912
	Medium tasters	0.11±0.36	
	Supertasters	0.10±0.21	
Guava	Nontasters	0.02±0.02	0.82
	Medium tasters	0.04±0.17	
	Supertasters	0.02±0.03	
Orange, Mandarin	Nontasters	0.09±0.08	0.897
	Medium tasters	0.13±0.38	
	Supertasters	0.11±0.19	
Mango	Nontasters	0.05±0.02	0.431
	Medium tasters	0.16±0.69	
	Supertasters	0.03±0.05	
Papaya	Nontasters	0.03±0.01	0.93
	Medium tasters	0.12±0.38	
	Supertasters	0.11±0.24	
Pear	Nontasters	0.03±0.01	0.737
	Medium tasters	0.08±0.34	
	Supertasters	0.04±0.08	
Pineapple	Nontasters	0.02±0.02	0.502
	Medium tasters	0.02±0.09	
	Supertasters	0.06±0.21	
Jackfruit	Nontasters	0.00	0.643
	Medium tasters	0.01±0.05	
	Supertasters	0.01±0.02	
Watermelon	Nontasters	0.04±0.04	0.909
	Medium tasters	0.05±0.10	
	Supertasters	0.06±0.16	

* Significant level at $p<0.05$ Analysed by One way ANOVA

Table 5 indicates the mean, standard deviation, and p value of vegetable intake between different PROP taster status. Based on the table, only onion recorded a significant difference between intake and PROP taster groups (p=0.044). It was found that PROP medium tasters (mean=0.82) and supertasters (mean=1.07) had a higher intake tendency of onions compared to nontasters (mean=0.25).

TABLE 5
VEGETABLES INTAKE OF DIFFERENT PROP TASTER STATUS (SERVING/DAY)

Item	PROP Taster	Mean Intake (Serving/day)	P value
Peas	Nontasters	0.02±0.02	0.972
	Medium tasters	0.03±0.10	
	Supertasters	0.02±0.08	
Long bean	Nontasters	0.09±0.08	0.811
	Medium tasters	0.15±0.14	
	Supertasters	0.17±0.24	
String bean	Nontasters	0.00	0.652
	Medium tasters	0.09±0.13	
	Supertasters	0.18±0.61	
Cabbage	Nontasters	0.06±0.06	0.382
	Medium tasters	0.23±24	
	Supertasters	0.32±0.46	
Broccoli	Nontasters	0.03±0.01	0.751
	Medium tasters	0.15±0.29	
	Supertasters	0.16±0.24	
Brussel sprouts	Nontasters	0.00	0.459
	Medium tasters	0.02±0.05	
	Supertasters	0.09±0.31	
Spinach	Nontasters	0.07±0.01	0.713
	Medium tasters	0.12±0.19	
	Supertasters	0.16±0.28	
Watercress	Nontasters	0.07±0.09	0.76
	Medium tasters	0.03±0.17	
	Supertasters	0.08±0.33	
Lettuce	Nontasters	0.03±0.01	0.856
	Medium tasters	0.19±0.42	
	Supertasters	0.17±0.43	
Pumpkin	Nontasters	0.00	0.656
	Medium tasters	0.04±0.07	
	Supertasters	0.04±0.07	
Bitter gourd	Nontasters	0.00	0.862
	Medium tasters	0.06±0.10	
	Supertasters	0.05±0.17	
Cucumber	Nontasters	0.16±0.02	0.856
	Medium tasters	0.18±0.22	
	Supertasters	0.26±0.91	
Carrot	Nontasters	0.09±0.08	0.43
	Medium tasters	0.34±0.35	
	Supertasters	0.49±0.77	
Potato	Nontasters	0.22±0.11	0.931
	Medium tasters	0.44±1.03	
	Supertasters	0.46±0.83	
Onion	Nontasters	1.07±1.32	0.044
	Medium tasters	0.25±0.27	
	Supertasters	0.82±1.32	
Lentil	Nontasters	0.00	0.684
	Medium tasters	0.01±0.03	
	Supertasters	0.07±0.43	
Mustard green	Nontasters	0.00	0.23
	Medium tasters	0.04±0.10	
	Supertasters	0.20±0.55	
Mung bean	Nontasters	0.00	0.834
	Medium tasters	0.02±0.03	
	Supertasters	0.02±0.05	
Ulam raja	Nontasters	0.00	0.661
	Medium tasters	0.03±0.15	
	Supertasters	0.01±0.02	
Petai	Nontasters	0.00	0.751
	Medium tasters	0.00	
	Supertasters	0.01±0.01	
Pennywort	Nontasters	0.00	0.616
	Medium tasters	0.02±0.10	
	Supertasters	0.03±0.15	

* Significant level at p<0.05 Analysed by One way ANOVA

In short, except for intake of onions, there were no significant differences found in the intake of fruits and vegetables among different PROP taster groups. This result can be supported by Catanzaro et al. [6], which found that PROP scores did not predict food preferences. The individual differences elicited from their PROP measure did not correlate with reported food preferences, in addition to no significant differences found between nontasters, medium tasters, and supertasters on reported liking for these foods. There were also no differences found in food preferences between a comparison of subjects at the high and low end of PROP sensitivity continuum.

Moreover, Louro et al. [24] found in their research that individuals with higher sensitivity for sweet, bitter, and salty tastes would be the one with higher preferences for fruit and vegetables, and higher intake of low-fat dairy and salads. Although higher sensitivity to bitterness would be associated with lower preference for bitter foods, such as vegetables, it was hypothesised that these individuals were able to perceive some amount of sweetness from the complex food matrix of vegetables due to their simultaneous higher sensitivity to sweetness. This could explain the findings of this analysis as onions are able to provide not only spiciness and pungency, but sweetness as well. In fact, some species of onions are well-known for their sweet flavour both before and after cooking [25].

Although studies have found medium tasters and supertasters tend to have higher bitter ratings compared to nontasters, many studies either have not found significant differences in actual food preferences based on taster status, found differences in the opposite direction, or found differences for some foods but not others [6]. This implied that there are other factors which can be more influential towards food preferences. Some have also indicated that variations in flavour preferences among cultures are likely attributable to varied dietary experiences, rather than genetically based differences in chemosensory function [26].

Many previous studies have shown that culture may be more important than physiological sensitivity in driving the desire to consume spicy foods [26]. For instance, the shallot is commonly used as a condiment in Southeast Asian countries, including Indonesia, Malaysia, Vietnam, and the Philippines, whereas the bulb onion is widely used fresh or processed in Europe, America, and East Asia, including China and Japan [27]. This statement is also supported by Mat Zin et al. [28] where their findings on the vegetable intake among Malaysian adults indicated that onions were highly consumed daily by the majority of respondents alongside garlic. Hence this can explain the occurrence of higher onion intake within PROP supertasters and medium tasters.

H. Relationship between taste sensitivity and fruit and vegetable intake

For analysis purposes, the fruits and vegetables were divided into three groups based on their characteristic taste profiles, namely 'sweet', 'sour', and 'bitter' groups. For instance, grape, orange, mango, and pineapple were grouped as 'sour taste' fruits as these fruits mainly had sour taste components, then the correlation with sour taste sensitivity were measured. This allowed studying to what extent usual food groups based on culinary or nutritional are homogenous from a sensory point of view [29, 13].

Table 6 illustrates the relationship between sweet sensitivity and intake of sweet fruits and vegetables. It is noted that sweet sensitivity was correlated only with the intake of durian (r=0.305, p=0.006), as no significant relationship was identified between the remaining sweet fruits and vegetables.

TABLE 6
RELATIONSHIP BETWEEN SWEET TASTE SENSITIVITY AND FRUIT AND VEGETABLE INTAKE

Fruit/Vegetables	**Sweet Taste sensitivity**	
	Pearson Correlation (r)	**p-value**
Apple	-0.094	0.407
Banana	-0.137	0.224
Durian	0.305	0.006*
Guava	-0.062	0.587
Papaya	0.013	0.906
Pear	-0.117	0.300
Jackfruit	-0.016	0.890
Watermelon	0.166	0.142
Peas	-0.118	0.297
Cabbage	-0.046	0.688
Pumpkin	-0.15	0.184
Carrot	-0.061	0.592
Potato	0.021	0.856
Onion	0.059	0.601

* Significant level at p<0.05
Measured by Pearson correlation

The relationship between sour sensitivity and consumption of sour fruits and vegetables is demonstrated in **Table 7**. The table shows that there was no discernible correlation between sour taste sensitivity and sour fruits and vegetables.

TABLE 7
RELATIONSHIP BETWEEN SOUR TASTE SENSITIVITY AND FRUIT INTAKE

Fruit/Vegetables	**Sour Taste sensitivity**	
	Pearson Correlation (r)	**p-value**
Grape	-0.092	0.415
Orange, Mandarin	0.001	0.995
Mango	-0.116	0.305
Pineapple	-0.032	0.778

* Significant level at p<0.05
Measured by Pearson correlation

Table 8 shows the relationship between the consumption of "bitter" vegetables and bitter sensitivity. Long bean intake was the only item in the table that positively correlated with bitter taste sensitivity (r=0.221, p=0.049). Meanwhile, there was no significant correlation between other "bitter" fruits and vegetables and bitterness sensitivities (p>0.05).

TABLE 8
RELATIONSHIP BETWEEN BITTER TASTE SENSITIVITY AND VEGETABLE INTAKE

Fruit/Vegetables	**Sour Taste sensitivity**	
	Pearson Correlation (r)	**p-value**
Long bean	0.221	0.049*
String bean	-0.017	0.883
Broccoli	0.005	0.965
Brussel sprouts	0.079	0.488
Spinach	0.015	0.892
Watercress	-0.08	0.478
Lettuce	-0.083	0.466
Bitter gourd	-0.05	0.66
Cucumber	-0.022	0.85
Lentil	-0.026	0.822
Mustard green	0.077	0.496
Mung bean	0.208	0.063
Ulam raja	-0.012	0.919
Petai	0.02	0.859
Pennywort	0.021	0.85

* Significant level at p<0.05
Measured by Pearson correlation

Based on the findings, the effect of taste sensitivity towards fruit and vegetable intake was present, but minimal. According to Louro et al. [24] , this may be contributed by the consumption method. Fresh fruits are typically consumed without undergoing any cooking or processing procedures, whereas vegetables are usually consumed cooked rather than raw, with diverse cooking procedures that could mask the original taste. Most fruits are prepared in ready to-eat form whilst retaining the organoleptic characteristics of fresh fruits in terms of aroma, flavour, taste, colour and texture[30].

This statement is also supported by Syathirah Hanim et al. (2020) where their study indicated a similar lack of relationships between taste sensitivities and food preference. They stated that a possible description for their finding was that the culinary aspect had overshadowed the bitter vegetable acceptance as suggested by other previous studies. They mentioned that in Malaysia, most vegetables that represent the bitter food group are not eaten raw, but mostly eaten in the cooked form to reduce bitterness. For instance, bitter gourd, which is known as a bitter vegetable, was commonly cooked with egg and added with some seasoning to balance the bitter taste. Subsequently, this reduces the effect of the taste intensity towards bitter taste sensitivity.

Those statements can be supported by the research of Abdul Manaf et al. [19] whose study focused on the sweet taste preference (STP) status. Although there were positive correlations between STP status and certain types of sweet or sour foods, they stated that it could be due to variations in personal choice. The preferred level of taste was food-specific, and the taste can be either pleasing or displeasing depending on factors such as the intensity of tastes [31,32]. Additionally, they found no correlation between STP status and bitter food preference, as well as no relationship between bitter taste and other tastes as indicated on their PCA plot. This enhances the fact that although present, taste sensitivity is not the main influence towards food preferences.

Besides that, food choices can be influenced by multiple factors, and this makes it challenging to predict a habitual diet if physical activity, cultural practices, socioeconomic status, and food access are not taken into consideration. Hence, it is indicated that a single marker, be it phenotypic or genotypic, is insufficient to fully characterise orosensory responses related to diet and health [33]. This is similar to the findings of Sandell et al. [34] where the effects of taste preferences may be overpowered by strong health-related, cultural, psychological or economic factors in some circumstances.

Sociodemographic factors, for instance food purchase choices, can be another contributing factor to poor dietary intake, including inadequate fruit and vegetable intake. For example, the individuals in the low socio-economic status group consumed foods of lower nutritional value and had lower-quality diets that generally cost less, compared to their higher socio-economic counterparts who consumed more fruit and vegetables. A recently published local data regarding the Federal Territory of Kuala Lumpur showed that 89.5% of B40 Malaysian adults did not consume adequate daily amounts of fruit and vegetables, with price, availability, and taste being the top three factors affecting food purchase choices [35, 36].

IV. CONCLUSION

This study demonstrated that taste sensitivity, as indicated by PROP taster status and responsiveness to basic tastes, had minimal influence on overall fruit and vegetable intake among participants. Although PROP supertasters exhibited heightened sensitivity to bitter, sweet, and sour tastes, these differences were not strongly reflected in dietary patterns, with the exception of higher onion intake among supertasters and medium tasters, and limited associations between sweet sensitivity and durian intake, and bitter sensitivity and long bean intake. Future research involving larger sample sizes and more diverse populations is warranted to further explore the relationship between taste sensitivity and food preferences. A deeper understanding of this relationship may contribute to the development of more effective nutrition intervention programs by incorporating individual taste profiles to promote healthier eating behaviors.

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USE OF ARTIFICIAL INTELLIGENCE (AI) TOOLS STATEMENT

The authors declare that OpenAI's ChatGPT was used to assist in the editorial process of this manuscript, specifically in improving grammar, structure, and formatting. All intellectual and analytical contributions are the original work of the authors. The AI tool did not contribute to the scientific analysis or interpretation of the results. We used Grammarly (Grammarly Inc., 2025) to improve the clarity and grammar of the manuscript. The authors reviewed and approved all changes.

CONFLICT OF INTEREST

Authors declare no conflict of interest to disclose.

REFERENCES

[1] J.L Slavin, & B Lloyd “Health benefits of fruits and vegetables.” Advances in nutrition (Bethesda, Md.) vol. 3,4 506-16. 1 Jul. 2012, doi:10.3945/an.112.002154.

[2] L.V. Moore & F.E Thompson, F. E. “Adults Meeting Fruit and Vegetable Intake Recommendations - United States, 2013” MMWR. Morbidity and mortality weekly report, 64(26), 709–713.2015. https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6426a1.htm?TB_iframe=true&width=921.6&height=921.6

[3] S.H. Lee, L.V. Moore, S. Park, D.M. Harris, & H.M Blanck.”Adults Meeting Fruit and Vegetable Intake Recommendations — United States, 2019”. MMWR. Morbidity and Mortality Weekly Report, 71. 2022. https://www.cdc.gov/mmwr/volumes/71/wr/mm7101a1.htm

[4] M. Shahbandeh”Daily fruit and vegetable consumption in Europe 2021, by country. Statista”. Retrieved September 4, 2022, from 63 https://www.statista.com/statistics/1280528/daily-fruit-and-vegetable-consumption-europe/

[5] C. T. Chong, W. K. Lai, A. A. Zainuddin, M. Pardi, S. Mohd Sallehuddin, and S. S. Ganapathy, “Prevalence of Obesity and Its Associated Factors Among Malaysian

Adults: Finding From the National Health and Morbidity Survey 2019," Asia Pacific Journal of Public Health, vol. 34, no. 8, pp. 786–792, Oct. 2022, doi: 10.1177/10105395221129113.

[6] D. Catanzaro, E. C. Chesbro, and A. J. Velkey, "Relationship between food preferences and PROP taster status of college students," Appetite, vol. 68, pp. 124–131, Sep. 2013, doi: 10.1016/j.appet.2013.04.025.

[7] A. E. Sjöstrand et al., "Taste perception and lifestyle: insights from phenotype and genome data among Africans and Asians," European Journal of Human Genetics, vol. 29, no. 2, pp. 325–337, Oct. 2020, doi: 10.1038/s41431-020-00736-2.

[8] J. Diószegi, E. Llanaj, and R. Ádány, "Genetic Background of Taste Perception, Taste Preferences, and Its Nutritional Implications: A Systematic Review," Frontiers in Genetics, vol. 10, Dec. 2019, doi: 10.3389/fgene.2019.01272.

[9] C. Cattaneo, P. Riso, M. Laureati, G. Gargari, and E. Pagliarini, "Exploring Associations between Interindividual Differences in Taste Perception, Oral Microbiota Composition, and Reported Food Intake," Nutrients, vol. 11, no. 5, p. 1167, May 2019, doi: 10.3390/nu11051167.

[10] M. Melis et al., "Electrophysiological Responses from the Human Tongue to the Six Taste Qualities and Their Relationships with PROP Taster Status," Nutrients, vol. 12, no. 7, p. 2017, Jul. 2020, doi: 10.3390/nu12072017.

[11] J. Charan and T. Biswas, "How to Calculate Sample Size for Different Study Designs in Medical Research?," Indian Journal of Psychological Medicine, vol. 35, no. 2, pp. 121–126, Apr. 2013, doi: 10.4103/0253-7176.116232.

[12] ISO."ISO 3972 sensory analysis - methodology - method of investigating sensitivity of taste". Geneva, Switzerland: The International Organization for Standardization. 2011.

[13] L. Xu, E. Zang, S. Sun, and M. Li, "Main flavor compounds and molecular regulation mechanisms in fruits and vegetables," Critical Reviews in Food Science and Nutrition, vol. 63, no. 33, pp. 11859–11879, Jul. 2022, doi: 10.1080/10408398.2022.2097195.

[14] A.R. Bahauddin, Z.M. Shariff, N. Shaari, & R. Karim. "The influence of PROP taster status on habitual sweet food consumption and dietary intake amongst obese and non-obese adults," Malaysian Journal of Nutrition, vol. 29, no. 2, Jul. 2022, doi: 10.31246/mjn-2022-0103.

[15] A.K. Norimah, et al. :Food Consumption Patterns: Findings from the Malaysian Adult Nutrition Survey (MANS)". Malays J Nutr. 2008;14(1):25-39.

[16] B. J. Villarino, C. P. Fernandez, J. C. Alday, and C. G. R. Cubelo, "Relationship Of PROP (6-N-Propylthiouracil) Taster Status with The Body Mass Index And Food Preferences Of Filipino Adults," Journal of Sensory Studies, vol. 24, no. 3, pp. 354–371, Jun. 2009, doi: 10.1111/j.1745-459x.2009.00215.x.

[17] S.X. Ooi, P.L .Lee, H.Y. Law,Y.H. Say. "Bitter receptor gene (TAS2R38) P49A genotypes and their associations with aversion to vegetables and sweet/fat foods in Malaysian subjects". Asia Pac J Clin Nutr. 2010;19(4):491-498.

[18] Q. Yang, A.-M. Williamson, A. Hasted, and J. Hort, "Exploring the relationships between taste phenotypes, genotypes, ethnicity, gender and taste perception using Chi-square and regression tree analysis," Food Quality and Preference, vol. 83, p. 103928, Jul. 2020, doi: 10.1016/j.foodqual.2020.103928.

[19] A. H. Syathirah-Hanim, H. Ruhaya, S. Norkhafizah, and A. M. Marina, "Relationship Between Prop (6-N-Propylthiouracil) Taster Status and Preference For Different Taste Food Groups Among University Students," Malaysian Applied Biology, vol. 49, no. 5, pp. 53–59, Dec. 2020, doi: 10.55230/mabjournal.v49i5.1637.

[20] J. Ammann, C. Hartmann, and M. Siegrist, "A bitter taste in the mouth: The role of 6-n-propylthiouracil taster status and sex in food disgust sensitivity," Physiology & Behavior, vol. 204, pp. 219–223, May 2019, doi: 10.1016/j.physbeh.2019.02.036.

[21] J. M. Peterson, L. M. Bartoshuk, and V. B. Duffy, "Intensity and Preference for Sweetness is Influenced by Genetic Taste Variation," Journal of the American Dietetic Association, vol. 99, no. 9, p. A28, Sep. 1999, doi: 10.1016/s0002-8223(99)00486-1.

[22] C. Dinnella et al., "Individual Variation in PROP Status, Fungiform Papillae Density, and Responsiveness to Taste Stimuli in a Large Population Sample," Chemical Senses, Sep. 2018, doi: 10.1093/chemse/bjy058.

[23] M. E. Fischer et al., "The Associations between 6-<i>n</i>-Propylthiouracil (PROP) Intensity and Taste Intensities Differ by <i>TAS2R38</i> Haplotype," Lifestyle Genomics, vol. 7, no. 3, pp. 143–152, 2014, doi: 10.1159/000371552.

[24] T. Louro et al., "How Individual Variations in the Perception of Basic Tastes and Astringency Relate with Dietary Intake and Preferences for Fruits and Vegetables," Foods, vol. 10, no. 8, p. 1961, Aug. 2021, doi: 10.3390/foods10081961.

[25] T. Crowther, H. A. Collin, B. Smith, A. B. Tomsett, D. O'Connor, and M. G. Jones, "Assessment of the flavour of fresh uncooked onions by taste-panels and analysis of flavour precursors, pyruvate and sugars," Journal of the Science of Food and Agriculture, vol. 85, no. 1, pp. 112–120, Oct. 2004, doi: 10.1002/jsfa.1966.

[26] M.-J. Ludy and R. D. Mattes, “Comparison of sensory, physiological, personality, and cultural attributes in regular spicy food users and non-users,” Appetite, vol. 58, no. 1, pp. 19–27, Feb. 2012, doi: 10.1016/j.appet.2011.09.018.

[27] N. Aeni Ariyanti et al., “Comparative Study on Phytochemical Variations in Japanese F<sub>1</sub> Varieties of Bulb Onions and South-East Asian Shallot Landraces,” The Horticulture Journal, vol. 87, no. 1, pp. 63–72, 2018, doi: 10.2503/hortj.okd-066.

[28] S. H. H. B. Mat Zin, S. B. Rosnan, and C. T. M. N. B. Mohd Shafee, “A Study on The Fruits and Vegetables Consumption Patterns among Adults in Malaysia,” International Journal of Academic Research in Business and Social Sciences, vol. 12, no. 11, Nov. 2022, doi: 10.6007/ijarbss/v12-i11/15148.

[29] C. Martin, M. Visalli, C. Lange, P. Schlich, and S. Issanchou, “Creation of a food taste database using an in-home ‘taste’ profile method,” Food Quality and Preference, vol. 36, pp. 70–80, Sep. 2014, doi: 10.1016/j.foodqual.2014.03.005.

[30] M. N. Latifah, H. Abdullah, I. Ab Aziz, M. P. Nur Aida, O. Fauziah, and Y. Talib, “Fresh-cut fruit industry in Malaysia: status and challenges,” Acta Horticulturae, no. 1209, pp. 79–86, Aug. 2018, doi: 10.17660/actahortic.2018.1209.12.

[31] M. Abdul Manaf, N. N. Mohamad Zazali, and S. A. I. Abdul Wahid, “Sweet Taste Preference Status and its Association with Preference for the Four Basic Taste Modalities of Various Food,” Malaysian Applied Biology, vol. 51, no. 6, pp. 27–34, Dec. 2022, doi: 10.55230/mabjournal.v51i6.2381.

[32] V. L. van Stokkom, C. de Graaf, S. Wang, O. van Kooten, and M. Stieger, “Combinations of vegetables can be more accepted than individual vegetables,” Food Quality and Preference, vol. 72, pp. 147–158, Mar. 2019, doi: 10.1016/j.foodqual.2018.10.009.

[33] M. Trius-Soler, P. A. Bersano-Reyes, C. Góngora, R. M. Lamuela-Raventós, G. Nieto, and J. J. Moreno, “Association of phenylthiocarbamide perception with anthropometric variables and intake and liking for bitter vegetables,” Genes & Nutrition, vol. 17, no. 1, Jul. 2022, doi: 10.1186/s12263-022-00715-w.

[34] M. Sandell et al., “Genetic variation in the hTAS2R38 taste receptor and food consumption among Finnish adults,” Genes & Nutrition, vol. 9, no. 6, Oct. 2014, doi: 10.1007/s12263-014-0433-3.

[35] C. W. Eng et al., “Dietary practices, food purchasing, and perceptions about healthy food availability and affordability: a cross-sectional study of low-income Malaysian adults,” BMC Public Health, vol. 22, no. 1, Jan. 2022, doi: 10.1186/s12889-022-12598-y.

[36] L.-K. Tan et al., “Association between Adequate Fruit and Vegetable Intake and CVDs-Associated Risk Factors among the Malaysian Adults: Findings from a Nationally Representative Cross-Sectional Study,” International Journal of Environmental Research and Public Health, vol. 19, no. 15, p. 9173, Jul. 2022, doi: 10.3390/ijerph19159173.

[37] W. Willett. Nutritional Epidemiology (3rd ed.). Oxford University Press. 2013

[38] J. Cade, R. Thompson, V. Burley, and D. Warm, “Development, validation and utilisation of food-frequency questionnaires – a review,” Public Health Nutrition, vol. 5, no. 4, pp. 567–587, Aug. 2002, doi: 10.1079/phn2001318.