Applied Biological Research 24(2): 168-174; (2022)
DOI: 10.5958/0974-4517.2022.00020.9

RELATIONSHIP BETWEEN TASTE SENSITIVITY OF PHENYLTHIO-CARBAMIDE AND OBESITY AMONG MALE AND FEMALE POPULATION OF UDAIPUR, RAJASTHAN (INDIA)

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(Received 26 November, 2021; accepted 28 March, 2022)

ABSTRACT

The present study was aimed to assess the prevalence of phenylthiol-carbamide (PTC) taste sensitivity, and its relation with obesity among the male and female population of Udaipur, Rajasthan (India). The study was carried out on 235 individuals (94 males and 141 females) aged ≥ 40 years. The food preferences were recorded through personal interview method, and standard anthropometric procedures were followed to measure anthropometric variables. Body mass index (BMI) and waist to hip ratio (WHR) were also calculated. The subjects were asked to taste PTC solution and classified as tasters and non-tasters. The overall tasters among the studied population were 169 (71.9%). Distribution of PTC taste sensitivity were more frequent among female (taster = 60.35%, non-taster = 59.09%) than male (taster = 39.6%, non-taster = 40.9%). The PTC taster's both male and female, showed higher BMI as compared to the non-taster individuals. Considering the life style variables, the smoking status showed a significant difference between tasters and non-tasters ($\chi2$ = 3.97; p = 0.047), but no difference was observed for alcohol consumption ($\chi2$ = 0.77; p = 0.381). The present study provides background information about PTC taste sensitivity's phenotypic frequency distribution which may serve as useful interactions of taste sensitivity with other associated lifestyle variables.

Keywords: Alcohol consumption, BMI, smoking, taste sensitivity, waist to hip ratio

INTRODUCTION

The taste sensitivity of phenylthiocarbamide (PTC), an organo-sulfur-thiourea containing a phenyl ring and chemical group N-C-S, is used as a phenotypic variable trait by anthropologists in understanding the human evolution and population variation for their characteristic bitter taste (Kim *et al.*, 2004). Each individual has a unique taste perception due to genetics, culture, ethnicity, personal, and environmental factors in which the determinants of dietary intake and food choices are highly associated with their taste perception (Barragan *et al.*, 2018; Bawajeeh *et al.*, 2020). The taste sensitivity is also used in many disease association studies associated with different eating behavior as food preferences vary according to the ones' bitter-taste perception (Zehentner *et al.*, 2021). Reports reveal that taste perception is altered in obese individuals, which, in turn, affects their consumption rate (Bartoshuk *et al.*, 2006). It is reported that obese individuals have significantly lower taste perception for salt, umami, and bitter taste modalities as compared to non-obese individuals (Overberg *et al*., 2012). Moreover, bitter taste is considered as an unpleasant and identifies potentially harmful compounds to avoid. Individuals with lower PTC taste thresholds seem to have more food dislikes than less-sensitive individuals (Fischer *et al.*, 1963). With the increasing perception of bitter taste, a decrease in the preferences for sweet and high fat food is observed (Duffy *et al*., 2000).

Worldwide, the prevalence of obesity has nearly tripled between 1975 and 2016 (WHO, 2020). Obesity is a multifactorial disease with abnormal or excessive fat accumulation. It is a significant risk factor responsible for cardiovascular diseases, diabetes, and some forms of cancers. Reports reveal the associations of obesity with lifestyle habits like physical inactivity, sedentary behaviour, diet, and sleep duration (Japas *et al.*, 2013). Some individuals tend to have different taste acuity, leading to different food acceptability and eating behaviour which might be the causal factor of obesity (Monteleone *et al.*, 2017; Spinelli *et al.*, 2021). However, no clear association has so far been established between food preference and taste perception as reported in a systematic and meta-analysis study (Bawajeeh *et al.*, 2020). Therefore, it is imperative to understand and establish the association (if any) between taste perception and food preferences. Understanding the association between one's taste perception and obesity would help, to some extent, control the global epidemic of obesity. Hence, the present study was aimed to assess the prevalence of PTC taste sensitivity among the male and female population of Udaipur, Rajasthan (India). Attempt has also been made to assess the association, if any, between PTC sensitivity and food preferences as well as to explore the relationships of taste sensitivity with anthropometric characteristics and physical activity.

MATERIALS AND METHODS

A cross-sectional study was carried out on male and female population of Udaipur, Rajasthan (India), in the year 2016. Five villages namely Shobhagpura, Eklingpura, Manwa Khera, Pula circle, and Ayad colony were chosen through lottery methods. A household survey with a simple random method was conducted, and 235 individuals of age ≥40 years (mean age 51.54±2.12) recruited because obesity is mostly prevalent in people aged > 40 years. The studied population consisted of 94 males (mean age 53.05±13.29) and 141 females (50.04±12.97). The other inclusion criteria were individuals with no medication, no family history of chronic diseases and native resident of village. At the same time, those individuals who are under medication, suffered from any chronic diseases, non-native group, and age <40 years were excluded from the study.

The present study was commenced after seeking the approval from the institutional ethical committee and the written consent was obtained from each respondent or at least one of their care-givers after explaining them the objectives of the study. Informal interviews were conducted and data pertaining to the different aspect of an individual's life such as socio-demographic profile, lifestyle variables, preference of food, physical activity, etc. were collected using standardized interview schedule. For food preference, a list of several food items was presented to the participants to indicate their preference by recording likes and dislikes in consumption. The most common food items preferred by participants were recorded under bitter, sweet, and soya product categories. Moreover, some common native food items which were not in the above categories were grouped separately under the heading, "native items". For the lifestyle variables, the present study recorded data on substance abuse (smoking or alcohol consumption), sleeping hours (≥8 or <8), working hours (≥8 or <8), daily exercise, milk and tea consumption. Anthropometric measurements were taken from each of the participants and body mass index (BMI) and waist to hip ratio (WHR) were calculated to assess obesity. Phenotyping of tasters and non-tasters of PTC was done using standard method developed by Harris and Kalmus (1949).

The statistical analysis of data was performed using MS EXCEL and SPSS software (17.0 version). All the values were expressed as percentages, mean and standard deviation wherever necessary. Comparison was made between tasters and non-tasters on the considered anthropometric and life style variables using t-test and $\chi 2$ statistics. Statistical significance was set at $p<0.05$.

RESULTS AND DISCUSSION

Various studies have been conducted on different aspects of PTC in India such as frequency distribution of PTC tasters and non-tasters, genetics of PTC, association of PTC with life style activity and taste preference, effect of age on PTC, sex differences of PTC tasting ability as well as association of obesity with PTC sensitivity. The overall frequency of PTC tasters (71.91%) among the studied population was higher than non-tasters (28.08%). Females showed higher prevalence of tasters (60.35%) than males (39.64%). Moreover, the higher prevalence of non-tasters was seen in females (59.09%) than males (40.90%). However, the prevalence of taster and non-tasters did not differ significantly between male and female ($p = 0.859$). Comparison was made between PTC tasters and non-tasters with parameters like preference of food intake, association of family history of diseases (hypertension, diabetes and CVD) as well substance abuse (smoking and alcohol consumption). With respect to sex, the frequencies of non-tasters were relatively higher among female (59.1%) than male (40.9%), although the difference was insignificant ($p = 0.86$). Incidence of family history of complex diseases (including hypertension, diabetes and CVD) and food intake (vegetarian and non-vegetarian diet) between tasters and non-tasters showed no significant difference ($p>0.05$). Substance abuse, smoking status was significantly higher among non-tasters than tasters ($\chi2 = 3.97$; $p = 0.047$). However, no difference observed between tasters and non-tasters for alcohol consumption ($\chi2 = 0.767$; $p = 0.381$) (Table 1).

PTC tasters and non-tasters had some differences in their food choices and preferences. There were a few significant differences in some food items considered in the present study. PTC tasters were more sensitive to raw cruciferous vegetables and bitter tasting foods (like bitter gourd) and beverages, while they also had a higher preference for sweet-tasting foods. However, sweet items like turnip, soya products (soya milk) and native items (mushroom) had some lower preferences among the non-tasters of both sex (Table 2).

Confounding risk factors for obesity such as sleeping hour, working hour, daily exercise, milk and tea consumption were assessed among the PTC tasters and non-tasters. Individuals with sleeping hour ≥8 and intake of milk are more frequent among non-tasters as compared to tasters. Though, the majority of tasters (91.12) were not engaged in daily exercise. The frequency of individuals with daily exercise among the non-tasters was (16.67%) doubled when compared with tasters (8.87%). Working hour and intake of tea per day showed more or less equal frequencies between tasters and non-tasters. However, no significant difference was observed between tasters and non-tasters among the studied population (Table 3).

Anthropometric variables like BMI, WC and WHR were compared between tasters and non-tasters in both male and females. The mean BMI values showed no significant difference between

Table 1: Comparison of life style Variables between PTC taster and non-taster

Characteristics		PTC taster (N = 169)	PTC Non-taster (N = 66)	χ2 (p-value)
Gender	Male	67 (39.64)	27 (40.90)	0.03 (0.859)
	Female	102 (60.35)	39 (59.09)	
Vegetarian status	Vegetarian	134 (79.28)	47 (71.21)	1.75 (0.186)
	Non-vegetarian	35 (29.71)	19 (28.78)	
Family history of disease	No	102 (60.35)	47 (71.21)	2.41 (0.120)
	Yes (HTN, diabetes and CVD)	67 (39.64)	19 (28.78)	
Substance abuse*	Smoking status			
	No	49 (73.13)	14 (51.85)	3.97 (0.047)
	Yes	18 (26.86)	13 (48.14)	
	Alcohol consumption			
	No	55 (82.08)	20 (74.07)	0.767 (0.381)
	Yes	12 (17.91)	7 (25.92)	

*Analysis of substance abuse was computed only among the male; HTN - Hypertension, CVD - Cardiovascular diseases

Table 2: PTC tasting ability in food items on both male and female population of Udaipur, Rajasthan (India)

Food items	Male		Female	
	Taster, n* (%)	Non-taster, n (%)	Taster, n (%)	Non-taster, n (%)
Bitter items				
Amaranth	40 (59.7)	16 (59.2)	83 (81.4)	34 (87.1)
Asparagus	40 (59.7)	16 (59.2)	83 (81.4)	34 (87.1)
Bell pepper	40 (59.7)	16 (59.2)	83 (81.4)	34 (87.1)
Bitter gourd	48 (71.6)	22 (81.4)	94 (92.1)	38 (97.4)
Cabbage	67 (100)	26 (96.2)	99 (97.0)	39 (100)
Mustard	56 (83.6)	22 (81.4)	89 (87.2)	36 (92.3)
Cucumber	62 (92.5)	27 (100)	91 (89.2)	38 (97.4)
Egg plant	60 (63.8)	25 (92.5)	101 (99.0)	39 (100)
Spinach	58 (86.5)	25 (92.5)	99 (97.0)	38 (97.4)
Lady's finger	66 (98.5)	27 (100)	100 (98.0)	37 (94.8)
Beans	63 (94.0)	25 (92.5)	98 (96.0)	38 (97.4)
Sweet items				
Baby corn	67 (100)	26 (96.2)	102 (100)	39 (100)
Carrot	67 (100)	27 (100)	100 (98.0)	39 (100)
Melon	67 (100)	27 (100)	101 (99.0)	38 (97.4)
Radish	63 (94.0)	26 (96.2)	87 (85.2)	28 (71.7)
Turnip	15 (22.4)	4 (14.8)	22 (21.5)	3 (7.6)
Tomato	65 (97.0)	27 (100)	101 (99.0)	39 (100)
Pumpkin	63 (94.0)	25 (92.5)	89 (87.2)	37 (94.8)
Yam	67 (100)	26 (96.2)	102 (100)	39 (100)
Soya products				
Soya pulses	19 (28.3)	3 (11.1)	51 (50)	26 (66.6)
Soya milk	63 (94.0)	22 (81.4)	86 (84.3)	16 (41.0)
Tofu paneer	63 (94.0)	22 (81.4)	92 (90.1)	36 (92.3)
Tofu curd	63 (94.0)	23 (85.1)	89 (87.2)	36 (92.3)
Native items				
Khejri	14 (20.8)	6 (22.2)	34 (33.3)	9 (23.0)
Sangri	13 (19.4)	6 (22.2)	35 (34.3)	11 (28.2)
Almond	66 (98.5)	26 (96.2)	98 (96.0)	37 (94.8)
Mushroom	3 (4.4)	0	12 (11.7)	1 (2.5)

* n = number

taster and non-tasters in both males and females. However, the mean values of WC and WHR were significantly higher in taster than non-taster males and females, respectively ($p<0.05$) (Table 4).

In present study, the frequencies of tasters were relatively higher in females (60.35%) than males (39.64%) which is in agreement with the higher frequencies of tasters than non-tasters among the Muslim populations of Uttar Pradesh (Hussain *et al.*, 2014). Similarly, the taster frequency of six different populations of Jammu and Kashmir (Gujjar and Bakarwal, Syed, Mughal, Khan, Malik, and Mir), and Manipur (Sheikh, Syed, Pathan, Mughal, Meitei and Naga) showed that the percentage of taster frequency was more frequent than that of the non-tasters (Fareed *et al.*, 2012; Shah *et al.*, 2015). Individuals with PTC taste sensitivity have higher BMI prevalence rate as compared to non-tasters in both male and female categories. Further, lower BMI prevalence rate was observed among taste blindness i.e, non-taster individuals comparing with the taster both in male and female categories. It is contrarily to the findings of Shivaprasad *et al.* (2012) reporting the existence of strong correlation between non-tasters and obesity among the Mysore population in South India. Many studies have documented that PTC sensitivity could be protecting against obesity as its tasting sensitivity was reported to be associated with lower BMI (Veluswami *et al.*, 2015; Rathod *et al.*, 2016). In general, most of the people both male and female population of

Table 3: Daily routine physical activities and food intake among the PTC-taster and non-taster population of Udaipur, Rajasthan (India)

Daily routine		PTC taster (N = 169)	PTC Non-taster (N = 66)	χ2 (p-value)
Sleeping hour	≥ 8	48 (28.40)	22 (33.33)	0.552 (0.458)
	< 8	121 (71.60)	44 (66.67)	
Working hour	≥ 8	42 (24.85)	16 (24.24)	0.048E-02 (0.922)
	< 8	127 (75.14)	50 (75.76)	
Daily exercise	No	154 (91.12)	55 (83.33)	2.93 (0.087)
	Yes	15 (8.87)	11 (16.67)	
Milk intake	No	68 (40.23)	20 (30.30)	4.01 (0.404)
	Rare	10 (5.91)	3 (4.54)	
	Once a day	57 (33.72)	31 (46.96)	
	Twice a day	29 (17.16)	12 (18.18)	
	> thrice a day	5 (2.96)	1 (1.51)	
Tea intake	No	8 (4.73)	6 (9.09)	2.67 (0.615)
	Rare	6 (3.55)	3 (4.54)	
	Once a day	11 (6.50)	5 (7.57)	
	Twice a day	62 (36.69)	26 (39.40)	
	> thrice a day	82 (48.52)	26 (39.40)	

Udaipur were engaged in physical activity like in farming, daily earning and house hold activities. Therefore, most of the subjects were involved in physically active activities with few exceptions. The prevalence of higher BMI in taste sensitive individuals may be due to the presence of less physical exercise among the taster category.

The study conducted by Bawajeeh *et al., (*2020) reported consistent findings with the present study. Individuals who are sensitive to bitter tastes often have a lower preference for bitter-tasting food and a higher preference for sweet-tasting food. Moreover, a study among the Taiwanese population revealed the preference for sweet food items was high among women compared to the males of 40-59 years (Wang *et al.,* 2019). However, the differences in the male and female perceptions towards sweet items did not show significant differences in their taste sensitivity in the present study. Regarding bitter food preference, male and females showed differences in their food choices in present study. In females, all the listed bitter food items were more preferred by non-tasters than tasters, except lady's finger. Similar findings were reported regarding bitter food items from the study conducted in Kangra valley, Himachal Pradesh, where the taster women reported lower preference for vegetables than non-taster individuals (Sharma and Kaur, 2014).

Studies have shown that the preference/avoidance of bitter fruits and vegetables, as well as sweet foods, added fats, spicy foods and alcoholic beverages had an association with PTC taste sensitivity implying that dietary behaviour may be influenced by the ability to taste or unable to taste PTC (Gandhi *et al.,* 2012). The PTC tasters on one hand are less likely to smoke and on the other they eat less cruciferous vegetables like broccoli that are important sources of nutrition (Wooding *et al*., 2004). Moreover, tasters have other oral sensations, for example they perceive more fattiness in foods; whereas non-tasters do not discriminate, they may be eating diets with high fat and or energy content and consequently become more obese. also, genetic taste sensitivity may be responsible for the development of dietary patterns and by extension, weight differences. Gandhi *et al.* (2012) studied the tasting ability of PTC in Punjabi population which had higher per capita

Table 4: Comparative analysis of taster and non-tasters with respect to anthropometric variables

PTC status	Male (n, 94) mean ± SD			Female (n, 141) mean ± SD		
	BMI	WC	WHR	BMI	WC	WHR
Taster	25.52 ± 4.28	94.83 ± 5.20	0.92 ± 0.51	24.86 ± 4.72	85.55 ± 13.3	0.90 ± 0.07
Non-taster	25.06 ± 5.23	90.29 ± 8.90	0.90 ± 0.04	24.82 ± 4.16	84.00 ± 10.4	0.80 ± 0.05
t-test (p-value)	0.44 (0.659)	3.08 (0.003)	0.84 (0.203)	0.05 (0.963)	0.65 (0.514)	8.15 (0.0001)

BMI: Body mass index, WC: Waist circumference, and WHR: Waist hip ratio income and were adapted to western dietary pattern with traditional culinary habits and reduced physical activity. They observed that PTC tasting ability did not influence BMI, WHR, and WC in taster and non-taster groups and non-tasters had lower BMI and WC than tasters. Keller *et al.* (2002) proved that tasters have high daily fat intake than non-tasters. However, in our study no significant difference in BMI was found in both taster and non-taster. However, CDC growth charts (2000) and Shivaprasad *et al.* (2012) showed that tasters have less BMI than non-tasters. The in-significant association between BMI and PTC sensitivity observed in the present study is supported by Saraswathy *et al.* (2011) who reported no relation between BMI and PTC tasting ability.

In present study, no significant relationship was noted between PTC taste sensitivity and obesity with respect to anthropometric variables like BMI, WC and WHR. This may probably be due to the daily engagement of population in physically active works. Thus, most subjects fell under normal BMI category, irrespective of PTC taste sensitivity. Obesity is the outcome of various risk factors including genetics, life style, exercise, physical activity, food habits, preferences and socio-environmental conditions. One of the major limitations of present study was the small sample size. Therefore, in depth studies are desired taking larger sample size to understand the relation between phenotypic variation of PTC sensitivity and diseases associated with taste perception.

Acknowledgements: The authors are grateful to the people who participated voluntarily in the present study. We are thankful to Snata Chakraborty, Kumud Kushwaha and Muzivolu Tunyi for their immense support and help during data collection.

Ethical statement: The present study was carried out as a part of M. Sc dissertation as prescribed in the syllabus of M.Sc. Anthropology, Department of Anthropology, University of Delhi and the work was approved by the Departmental Ethical Committee.

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