FULL-LENGTH ARTICLE

Variations in Tasting Phenylthiocarbamide (PTC) in Selected Individuals from Ethiopia: Implications for Human Health

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ABSTRACT
The present study aimed to examine the PTC tasting ability in selected individuals from Ethiopia. It involved 465 participants representing four ethnic groups. A total of 69 individuals from Amhara (30 females and 39 males), 52 from Agnuak (3 females and 49 males), 59 from Nuer and 285 (60 females and 225 males) from Oromo were recruited. The investigation was made using a series of graded concentrations of PTC dissolved in pure water and the results were recorded. The participants were analyzed for the distribution of tasters and non-tasters for PTC. The frequency of dominant and recessive alleles of PTC gene was calculated using Hardy-Weinberg methods. The result showed that the frequency of tasters (82.80%) were significantly higher than that of non-tasters (17.20%) in all populations. Likewise, frequency of tasters among males (83.06%) and females (82.61%) were significantly higher than the frequency of non-taster males (16.94%) and females (17.39%). This shows that PTC tasting ability varies as a function of sexes. In all populations, the frequency of T allele (0.59) is higher than the frequency of t allele (0.41). Recognition threshold for PTC in 465 participants of both sexes were determined (at 8 and 9 solutions) and indicated that the taste ability distribution is bimodal. Based on the present data on diet, an association between the ability to taste PTC and food preferences have been observed among the studied populations. With this regard, further comprehensive study on various populations is needed, which could have significant public health importance.

Keywords: Food preference; Non-tasters; Polymorphism; PTC; Tasters; Threshold

INTRODUCTION

Human population genetics is concerned with the study of populations in terms of frequencies of various genetic markers and the factors that determine the change in gene frequencies over a period of time (Hussain *et al*., 2014). Of various genetic markers (genetically inherited trait), the best widely studied example of a genetically controlled variable in human is the ability to taste Phenylthiocarbamide (PTC), an organic compound that either tastes extreme bitter or is tasteless (Kim and Drayna, 2004; Merritt *et al*., 2008). According to these authors, the variation in the ability to taste PTC is maintained in all human population tested and is the simplest yet striking example of a trait that varies widely in human populations and has been considered as an important genetic marker in the investigations of population genetics. Variation in the ability of tasting PTC was first discovered accidentally (Fox, 1932). Subsequent studies have reported that human populations can be classified into two groups, such as tasters and non-tasters. In human populations tested so far, being tasters and non-tasters depend on their genes (Guo and Reed**,** 2001). Accordingly, the tasting ability of PTC is one of the highly variable traits in humans and the phenotypic variation has been largely determined by genetic variation in a single gene, TAS2R38 (bitter taste receptor gene) located on chromosome 7 at position 34 (7q34) (Reed *et. al*., 1999; Drayna, 2005). The allele for PTC tasting is mostly dominant

over the allele for non-tasting. From the entire human populations, around 70% of the population can taste PTC while the remaining 30% cannot (Guo and Reed, 2001; Drayna, 2005).

The phenotypic frequency of PTC taster and non-taster is found to vary in a different population of the world as a function of ethnicity and geographic locations (Wooding *et. al*., 2004; Fareed *et al*., 2012). These authors have reported that, in most populations, majority of individuals are tasters, and the frequency of non-tasters are small and varies considerably from as low as 5% in sub-Saharan Africa to as high as 40% in India. This variation is widely used and considered as an important tool in the human genetic diversity and anthropological studies (Kim and Drayna, 2004; Fareed *et. al*., 2012; Hussain *et al.*, 2014). Besides, the variation in the ability to taste PTC has also been shown to be associated with variation in dietary adaptations (food preferences and choices) in the human history and thus may have important implications in human health (Bartoshuk *et al*., 1994; Wooding *et. al*., 2004; Campbell *et. al.*, 2012). These studies have indicated that variation in PTC taste trait might alter dietary preferences to substances known to affect human health and could strongly correlate with susceptibility to diet and non-diet related diseases (e.g., cancer, blood pressure, malaria infection, gastritis, and other diseases risk). Thus, a study of this phenotypic marker would have implications for disease prevention and public health. Moreover, human bitter-tasting capacity has an important role, as it protects us from ingesting naturally toxic substances which typically taste bitter (Drewnowski and Rock, 1995; Tepper, 1998; Kim and Drayna, 2004; Wooding *et al*., 2004; Iqbal *et al*., 2006).

Although human PTC taste ability is variable and hypothesized to have a dietary adaptation, little is known about the nature of PTC tasting ability variation and genetic signature of selection in ethnically diverse populations with different diets, particularly from Africa (Campbell *et. al.*, 2012). In Ethiopia, too, there is no prior information on variation in the ability to taste PTC and signature of selection where there are ethnically diverse populations with different dietary adaptations. Therefore, this study is the first attempt to study the distribution of phenotypic variation in the ability to taste PTC and related issues in selected individuals from Ethiopia. Hence, the present study was designed to examine the frequency distribution of PTC tasting ability as a marker to see the gender and individual differences among and within student populations of Jimma University, to determine the PTC detection thresholds and examine the association of PTC taste ability with food preferences and diseases, and further link with ethnicity and some environmental features. The present study has significance in generating baseline information to the study of PTC tasting. At the first place, it will help to evaluate whether the frequency distributions of tasters and non-tasters among and within selected individuals of Ethiopian are in accord with the frequency distribution of the world populations or not. It also examines whether males and females differ in their ability to taste PTC or whether they have different or the same detection threshold level of PTC tasting. Secondly, it will help to see whether a food preference by an individual of ethnic groups has influenced their ability to taste PTC and the correlation of their feeding habits with the bodily diseases of the study participants.

MATERIALS AND METHODS

The study populations

The present study was conducted on summer students from the Department of Biology, College of Natural Sciences, Jimma University, from December to August 2015. Each participant provided fully informed consent to participate in the study and completed a questionnaire related to their self-declared ethnicity, language, region, and questions about diet and health. The study participants were categorized into self-declared regional and ethnic groups. These include Oromo, Amhara, Nuer and Agnuak currently living in Oromia, Amhara and Gambella National Regional States of Ethiopia. A total of 285 individuals from Oromo, 69 from Amhara, 59 individuals from Nuer and 52 individuals from Agnuak ethnic groups, all aged between 22-52 years, were recruited. This made a total of 465 (373 males and 92 females) study participants representing four different ethnic group and three different geographic regions of Ethiopia.

Sampling strategies

The study involved genetic sampling approach. Since the study involved human subjects, the number of samples was determined based on the study subjects' willingness to participate in the study, their availability, available time, and cost; and not on statistical sampling method that involve calculations. The source population is regarded as just one of the many replicate populations that could have descended from the same founder populations. Although evolutionary forces are kept constant, the replicate populations would differ by phenotypes because different genes may be transmitted at each locus between generations for the different replicates. Thus, there would be variations between replicate populations due to genetic sampling that has made these populations different from all others that descend from the founder population. The phenotype data that would be generated from these sample size would enable to capture the required diversity of the selected population and is representative according to the principle of genetic sampling as described in National Academy of Sciences (NAS, 1997). In this study, each ethnic group was considered as a population.

Exclusion-inclusion criteria

The study participants were summer in-service students of Jimma University aged between 22 - 52 years. During recruitment, the age of each participant was asked before taking the consent. The first reason for this was that the study participants within this age range could provide their full consent to participate in the study and give more reliable information about their own food preference and self-perceived associated diseases rather than the lower age groups. The second reason is that individuals within this age range can recognize PTC detection threshold more accurately and discriminate bitter taste from other taste modalities, which decrease as age increase (>60). This would significantly minimize the expected false positives, especially among lower and higher age groups.

PTC taste testing

PTC taste test was used to determine whether they have the genes responsible to taste PTC or not. Standard serial dilution method was employed following the techniques of Harris and Kalmus (1949) to assess the PTC taster and non-taster phenotypes. A stock solution containing 0.13% of PTC was prepared by dissolving 0.13gm of PTC powder in 100ml distilled water (solution-1) and serial dilutions were made up to the number thirteen. Serial dilution from 1 through 14 was prepared by taking 50ml of a solution and adding 50ml of distilled water to it to make solution 2 which is diluted as ½ solutions 1. Since solution numbers of PTC represent serial dilutions by 1/2 of a solution containing 0.13 gm per 100 ml of distilled water, solution 1 has 0.13 gm per 100 ml; solution 2 has 0.065 gm per 100 ml, etc. The least diluted solution was numbered as dilution number 1 and the most diluted solution was numbered as dilution number 14 (Table 1).

The activities were started with the weakest PTC solution in the order of increasing concentrations. Starting from the highest diluted and works down toward the most concentrated; the subject was given 0.16mg/l using a small spoon till he/she first says that he/she perceives a definite bitter taste. In other words, the subjects were given a two-fold dilution series of PTC, starting with the weakest concentration and going up until they say they can taste it. This gives an approximate value for the threshold. The threshold levels for PTC were then recorded for each of student participants (males and females) and they were considered as PTC tasters. Raw PTC score represents the point in a successive dilution taste test at which individuals were able to detect the bitter taste of PTC. An individual, who was unable to taste any solution including 1, was designated as a PTC non-taster. The detail of each participant regarding major food items preferred in their diet and experienced diseases in their life was collected using a brief questionnaire. Each student who accepted to participate in the study (willing to taste PTC solution and to fill the questionnaire) was asked to fill the consent format.

Table 1. The concentrations of PTC solution used in the study

Solution numbers	PTC (mg/l)	Solution numbers	PTC (mg/l)
1	1300.00	8	10.16
2	650.00	9	5.08
3	325.00	10	2.54
4	162.50	11	1.28
5	81.25	12	0.64
6	40.63	13	0.32
7	20.31	14	0.16

Statistical methods and data analysis

The phenotype of each individual was recorded for PTC taste ability. SPSS (Statistical Package for the Social Science, SPSS Inc., IBM SPSS statistics) version 20.0 for Windows was used to assess the phenotypic frequency distribution of non-tasters and tasters' individuals in the study populations. The degree of association between PTC taste ability and diet preferences and self-reported diseases from the study populations was subjected to Chi-square tests. The statistical significance of these values was assessed using the bootstrap method in which observed values are compared with the expected ones (Excoffier *et al*. 2002). The Hardy-Weinberg method was used to determine the allele and genotype frequencies (Mourant *et al*. 1976).

Ethical aspects

The present study was approved by Research Ethics Committees of Addis Ababa University, College of Natural Sciences, Department of Microbial, Cellular and Molecular Biology. Also written informed consent was obtained from each study participant.

RESULTS

Ethnicity and sex distribution of the study participants

Four hundred and sixty-five individuals were selected from four ethnic groups: 69 from Amhara (39 males and 30 females), 52 from Agnuak (49 male and 3 female), 59 from Nuer (all males), and 285 from Oromo (225 males and 60 females). This made 373 male and 92 female participants (Table 2).

Table 2. Total number of samples, ethnic groups, gender, and numbers of participants involved

Ethnic groups	Male	Female	Total
Amhara	39	30	69
Agnuak	49	3	52
Nuer	59	-	59
Oromo	225	60	285
Total	373	92	465

The frequency of tasters and non-tasters

Table 3 shows the number and percentage of PTC tasters and non-tasters. It also shows overall alleles and genotype frequencies in individuals from Ethiopia. The results indicated that the numbers and percentages of PTC tasters are considerably higher than PTC non-tasters in all population. That is, in the overall population, the numbers of PTC tasters (385) and PTC non-tasters (80) phenotypes were found to be far apart with the overall frequency of 82.80% and 17.20%, respectively. Likewise, the numbers of males PTC tasters (309) and non-tasters (64) (with a frequency of 82.84 and 17.16%, respectively) and the number of females PTC tasters (76) and non-tasters (16) (with a frequency of 82.61 and 17.39%, respectively) were significantly different ($\chi 2$ =0.031, df = 1, t= 0.860). Under the

assumption of HWB equilibrium, the allele and genotype frequencies distribution of the overall non-tasters (t allele and tt genotype) and tasters (T allele, Tt and TT genotype) in all population was also calculated using phenotype frequencies.

Table 3. The number and percentage of PTC tasters and non-tasters and overall allele and genotype frequencies; $\chi^2 = 0.031$, df = 1, t = 0.860

PTC taste ability	Total	Overall %	Female	%	Male	%
Tasters (T)	385	82.80	76	82.61	309	82.84
Non tasters (t)	80	17.20	16	17.39	64	17.16
	Allele frequency		Genotype frequency			
	t	T	Tt	Tt	TT	
	0.41	0.59	0.17	0.48	0.35	

Ethnic wise, whereas the frequencies of PTC taster in Amhara, Agnuak, Nuer, and Oromo were 86.96, 78.8, 84.8, and 82.4%, respectively, the frequencies of non-tasters in Amhara, Agnuak, Nuer, and Oromo were 13.04, 21.2, 15.2 and 17.6%, respectively. The taster frequency of four different populations showed that the percentage of taster frequency was more frequent than that of the non-tasters. The Chi-square test for comparison showed significant differences ($\chi^2 = 1.536$, df = 3, $p < 0.05$) among ethnic groups (Table 4).

Table 4. Comparison of PTC taste status among four Ethnic groups; $\chi^2 = 1.536$, df = 3, t = 0.674

		Ethnicity				
		Amhara	Agnuak	Nuer	Oromo	Total (%)
PTC Taste status	Non-tasters	9 (13.04%)	11 (21.2%)	9 (15.2%)	51 (17.6%)	80 (17.2)
	Tasters	60 (86.96%)	41 (78.8%)	50 (84.8%)	234 (82.4%)	385(82.8)
	Total	69	52	59	285	465

Table 5 shows the frequency of non-tasters and tasters male and female populations from Amhara and Oromo. The frequencies of non-tasters in Amhara females and males were 6.67 and 17.95% (altogether 13.04%), respectively. But the frequency of non-taster in Oromo females and males were 23.33 and 16% (altogether 17.5%), respectively. Likewise, while the frequency of PTC tasters' phenotypes in Amhara females and males were 93.33 and 82.05% (altogether 86.95%) respectively, the frequencies of tasters were 76.67 and 84 % (altogether, 82.5%) in the Oromo females and males, respectively. The highest phenotypic frequency of tasters and lowest phenotypic frequencies of non-tasters were observed in Amhara females than Oromo. The phenotypic frequencies of Amhara and Oromo male tasters and non-tasters were moderate and lie between the females' results. For the males, the frequencies were closest to each other and the overall frequency of non-taster and taster individuals in the total populations. Comparison of PTC taste ability of Amhara and Oromo populations showed differences in both sexes and ethnicity ($\chi^2 = 4.297$, df = 2, t= 0.117, for gender differences).

Table 5. Comparison of gender and PTC taste ability differences between Amhara and Oromo; χ^2 = 4.297, df = 2, t = 0.117 (for gender differences)

		Gender		
Ethnic groups	PTC taste ability	Female	Male	Total
Amhara	Non tasters	2 (6.67%)	7 (17.95)	9 (13.04%)
	Tasters	28 (93.33%)	32 (82.05%)	60 (86.96%)
	Total	30 (100%)	39 (100%)	69 (100%)
Oromo	Non-tasters	14 (23.33%)	36 (16%)	50 (17.5%)
	Tasters	46 (76.67%)	189 (84%)	235 (82.5%)
	Total	60 (100%)	225 (100%)	285 (100%)

PTC detection thresholds

Table 6 shows the distribution of the PTC tasters of the study participants along with their detection threshold value. The mean threshold detection values for tasters are calculated as 7.36±3.02, with values ranging through 1 to 14. The high number of the PTC tasters (69 and 58) was observed to have threshold values of 8 and 9. The numbers of PTC tasters (and thus the sensitivity to PTC) was observed decreasing in either direction (to the left and right) of the mode value, indicating a bimodal distribution of PTC tasting ability. As can be seen from the table, the same pattern of distribution of PTC tasting ability was observed for each tested ethnic group. The bimodal distribution of PTC taste ability is best indicated by the histogram (Fig.1).

Table 6. Overall PTC taste detection threshold distribution among the PTC tasters as per individuals of Ethnic groups

	PTC taste test threshold														
Ethnicity	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Amhara	6	2	2	5	5	7	5	13	10	1	2	2	0	0	60
Agnuak	0	0	3	1	5	9	0	11	0	0	4	2	4	2	41
Nuer	0	3	1	0	5	7	6	9	4	9	6	0	0	0	50
Oromo	13	1	14	20	21	14	17	36	44	18	20	8	2	6	234
Overall	19	6	20	26	36	37	28	69	58	28	32	12	6	8	385
Test TR	Minimum			Maximum			Mean				St. deviation				
	1			14			7.3584				3.01582				

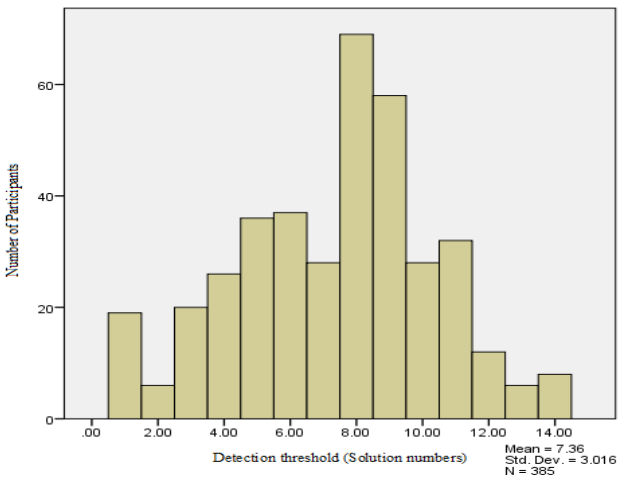

Fig. 1. Histogram showing distribution of PTC taste sensitivity threshold for tasters

PTC tasting ability and food preferences

Table 7 shows the association of PTC tasting ability and preference for some food type. As it can be seen from the table, the PTC tasters are associated with food items that are usually consumed such as bread, injera, meat, milk, porridge, and vegetables than non-tasters (Table 7a). However, non-tasters showed associations for meat, milk and vegetables but lack of preferences for bread, injera and porridge. That is, PTC non-tasters do not like to have these food items that PTC tasters like to consume usually. These indicate that food preferences are very much diminished in PTC non-tasters than tasters. Moreover, a health-related questionnaire was used to collect information about the diseases (chronic or recurrent infections) that the participants are living with. Each participant was asked whether he/she has a disease in their life or not. The result of the survey indicated that some diseases are found to be associated with PTC taster than PTC non-tasters in the tested population. PTC taster individuals were found to be associated with malaria, BP, gastritis and other diseases than non-tasters (Table 7b).

Table 7. Associations of PTC taste ability to food preference (a) and some associated disease (b) among the tested populations.

a. PTC taste ability-food preferences; $\chi^2 = 18.311$, df = 5, t= 0.011

		Food types						
	Allele	Bread	Injera	Meat	Milk	Porridge	Vegs	Total
Taste	t	0	0	36	12	0	32	80
ability	T	11	72	137	40	43	82	385
Total		11	72	173	52	43	114	465

b. PTC taste ability- some associated diseases

		Some associated diseases										
	Allele	No claim	Asthma	BP	Gastric	Headache	Kidney	Malaria	Sinus	Typhoid	Tooth decay	Total
Taste ability	t	58	1	0	2	2	2	10	0	0	5	80
	T	274	9	6	17	2	4	51	10	5	7	385
Total		332	10	6	19	4	6	61	10	5	12	465

DISCUSSION

This study is the first attempt on Ethiopian populations and it was aimed to determine the PTC tasters and non-tasters frequency distribution among different ethnic groups in the country. In addition, it was aimed to determine the PTC detection threshold value, examine the association of PTC tasting capacity with major participant's preferred diet and then evaluate the susceptibility to some diseases due to their diet habits.

The frequency of PTC tasters and non-tasters

The present study revealed that the percentage of tasters' frequency was significantly higher than that of the non-tasters. Out of the 465 study participants, 385 were tasters (82.80) and 80 were non-tasters' phenotypes (17.20 %). This is a result close to that of the Brazilian participants studied by Azevedo *et al*. (1965) and it is in agreement with the study report made by Guo and Reed (2001). PTC tasting ability is quite a variable characteristic in human populations. It has been witnessed in several types of research carried out previously that the distribution of PTC non-taster is different with values ranging between 2.3-36.5% (Africa), 5.1-23% (China), 4.8-66.7% (India) and 2.0-27.5% (Asia), 4.1-20% (Turkey) (Tepper and Nurse, 1998; Tepper, 1998; Guo *et. al*., 1998; Saraswathi *et. al*., 2011). When compared, the PTC non-taster frequency value obtained from the present study are at the medium of

the results obtained from African population as reported in a previous study and lower than the results reported from a population of India. This might be due to the differences in the genetic makeup of the populations which might have been shaped by types of food items (Indian diets are spicier than that of Ethiopia) people are consuming, which in turn has an implication on the taste ability of individuals in a population. In other words, the adaptation of different individuals of a population to different food items might act as selective pressures that result in variable PTC taste ability frequencies.

The numbers of males' PTC taster phenotypes were 309 and that of non-taster were 64, with a frequency of 82.84 and 17.16%, respectively. Likewise, the number of females' PTC taster (76) and non-taster (16) were significantly different, with a frequency of 82.61 and 17.39%, respectively. These indicate that the frequency of non-tasters and tasters' phenotypes are significantly varied among male and female and in all tested populations. Accordingly, male were more PTC tasters than females, with statistically significant differences (χ^2 = 0.031, df = 1, t = 0.860). From a genetic point of view, sensitivity to PTC depends on the sex of an individual. As the PTC genes are differently expressed in males and females, the former is less sensitive than the latter. However, sex difference does not affect the penetrance of the PTC genes which remains the same within each sex at all ages unless some other environmental factor, such as diseases, diet adaptations and radiation are there (Whissell-Buechy, 1990). Calculated under the assumption of HWB equilibrium, the phenotypic frequency of non-taster or recessive allele 't' and taster or dominant allele 'T' was found to be 0.41 and 0.59, respectively, in the overall population studied. The genotype frequencies distribution of the non-tasters and tasters in all population were also calculated using these phenotype frequencies. Thus, the genotype frequency of recessive (tt), heterozygote (Tt) and homozygote dominant (TT) was 0.17, 0.48 and 0.35 respectively. This study has shown that there is variation in non-taster and taster allele in four populations and that there are more PTC heterozygous (Tt) genotypes as compared to dominant (TT) and recessive (tt) homozygous genotypes, with the latter being much lesser than the two genotypes. PTC tasters and non-tasters were distributed in all the populations studied. A similar study showed that the frequency of taster (T) is about 0.50 among European populations (Kitchin *et al*., 1959). Mongoloid populations of East Asia and South-East Asia showed 0.55 to 0.95 frequency of T allele (Harris and Kalmus, 1949; Harris *et. al*., 1949). The frequency of T allele varies from 0.59 to 0.67 among Tibetan populations of North India (Sharma, 1967; Bhalla, 1972). The frequencies of taster and non-taster alleles recorded in this study were close to those reported in previous studies.

Ethnic wise, there were variations in phenotypic frequencies of PTC taste abilities within four populations of Ethiopia. The frequency of tasters was highest in Amhara (86.96%) while it is lowest Agnuak (78.8%). That is, the minimum and maximum numbers of tasters' frequency was observed in people from Agnuak and Amhara respectively. Accordingly, the frequency of tasters (84.8 and 82.4%) and non-tasters (15.2 and 17.6%) for the population from Nuer and Oromo, respectively, fall between the two populations. In general, the percentage of PTC taster was greater than that of non-tasters among the four populations of Ethiopia (χ^2 = 1.536, df = 3, $p < 0.05$). The frequency of the T allele (enable to become PTC taster) observed in this study is in total agreement with other studies (Guo and Reed, 2001; Prodi *et.al*. 2004 and Ara *et al*., 2008), where frequencies of PTC taste ability vary with an ethnic group, in which tasters are more frequent than non-taster.

In addition, the frequency of non-tasters and tasters varied between the males and females populations from Amhara and Oromo. The highest phenotypic frequency of tasters and lowest phenotypic frequencies of non-tasters were observed in Amhara female than Oromo. The reverse result was observed among Oromo females. For the males, the values are closest to each other for both groups and to the overall frequency of non-tasters and tasters' individuals in the total populations. These suggest that PTC non-tasters and tasters' frequency were significantly varied between Oromo and Amhara females, but moderate between males of these populations. Therefore, when two ethnic groups are compared, they differ in PTC phenotype as they differ in genotype. Evolutionary forces, food preferences and the types of food usually consumed could have played an important role in producing frequency difference in these populations. Thus, gender variations between sexes in the whole tested individual of a population and between the two ethnic groups was observed. In general, comparison of

PTC taste ability of different populations showed sexes and ethnicity differences and do not reveal a geographical modality of its distribution.

The detection threshold of PTC

According to this study, PTC taste detection thresholds do not vary among the four populations studied. In terms of gender also, females are found to taste PTC at similar thresholds as males, although a small number of specific differences in taste ability have long been known and well-studied as reported by Guo and Reed (2001).

PTC taste ability and food preference

The bitter taste is one of the five basic tastes modalities. Several studies revealed that bitter taste of PTC tasting ability has been shown to associate with several dietary preferences and thus have possible health outcomes. The PTC tasting ability differences may be illustrative of ancient genetic variation that has been proposed to save the tasters. The ability to detect bitter substances helps people to avoid food containing them and is important for survival. The inability to detect PTC, on the other hand, has been associated with numbers of bodily disorders or illnesses not typically related to taste and make non-tasters more susceptible to some disease (Moberg *et. al*., 2007). Thus, the sense of bitter taste functions either to prevent ingestion of toxic substances or making the individual susceptible to disease due to the avoidance of bitter-tasting food presents a paradox. The PTC non-taster allele is common and old and supposed to confer selective advantage such as helping the individual to consume beneficial bitter-tasting compounds (Bufe *et al*., 2005). PTC presents a unique opportunity in the field of bitter taste transduction. The phenotypic variation in PTC tasting ability is thought to be genetic in origin and suggest greater illness risk for those subjects with recessive or non-taster alleles.

In the present study, the associations between PTC taste ability and some food types, and its implications to human health have been examined. Accordingly, the PTC tasters showed high preferences to consume food items such as bakery food (bread and injera), meat, milk, porridge and vegetables than non-tasters. While, non-tasters show lack of preferences for bread, injera and porridge, they like to consume meat, milk and vegetables. That is, non-tasters dislike the former three food items but like the later three. However, PTC tasters like to consume the six types of mentioned food. The result showed that preferences to foods are very much diminished in PTC non-tasters than PTC tasters, but the food preference seems selective for food having a better nutritional advantage. The lack of preference for beneficial food might have increased vulnerability of tasters to chronic illness such as BP and others (Mohaus and Ayied, 2018). In agreement with this fact, the result of the present study showed that PTC tasters' individuals are more susceptible to some disease than PTC non-tasters. Among the individuals of the study populations, BP, malaria, and gastritis are more associated with PTC tasters than non-tasters. Why PTC tasters showed a higher preference for these food items and more susceptible to these diseases than PTC non-tasters is not clear and need further detailed investigation.

The implication for human health

The present study suggested that variations in PTC tasting ability affect human health by influencing food preferences and dietary behavior of an individual. A preference for foods considered herein was associated with the increasing perception of PTC tasting and this has highlighted the relations between PTC tasting ability and some diseases like malaria, gastritis and risk factors for cardiovascular disease. The availability of simple genetic markers (PTC tasting ability) has offered insight into an individual's risk of predisposition to human illness traits. Thus, understanding the nature of the variation in PTC taste perception and its relationship to the diet may have important implications for human health.

We conclude that the ability or inability to taste PTC is a common feature of human populations easy to measure. This, in turn, would help to study variations and related issues of human populations. This study presented the tasting ability of PTC among four populations of Ethiopia. The result shows a high frequency of PTC tasters than non-tasters in the total population. When compared, the frequencies of tasters and non-tasters significantly differ for the four populations considered in the current study. Also, more males are non-tasters as compared to females. Moreover, the present paper reports the

threshold distribution of PTC tasting ability among populations of four ethnic groups of Ethiopia. The females showed almost similar mean threshold value as males and similar mean threshold value was observed for all ethnic groups and in the overall populations. Furthermore, the ability to taste or not of PTC could likely affect human health by influencing food preferences and dietary behavior. The PTC tasters were more likely to consume several of the common Ethiopian food types and were associated with risks of greater susceptibility to diseases. In contrast, the non- tasters lack food preferences and were not susceptible to diseases.

CONCLUSION

This study was attempted to analyze the interaction between PTC tasting ability variation and food preference and associated human diseases in selected individuals from Ethiopian. The study suggested that there are variations in PTC tasting ability and those variations affect human health by influencing food preferences and dietary behavior of an individual. Thus, understanding the nature of the variation in PTC tasting ability and its relationship to diet and other behavior aspects might have important implications for human health. However, this study involved a limited number of the samples which may lead to variations in statistics. Therefore, high-scale PTC phenotype-genotype association studies with a large number of study participants should be conducted in the future for the Ethiopian population. In this sense, detailed research should be made, which try to reveal the relationship between the detail diverse feeding habit and PTC perception status of Ethiopian populations. Moreover, further study of the role of PTC status in food intake and health conditions in larger, more diverse, study populations should be conducted.

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