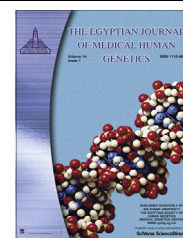




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ORIGINAL ARTICLE

Distribution of sensory taste thresholds for phenylthiocarbamide (PTC) taste ability in North Indian Muslim populations

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Abstract The ability to taste Phenylthiocarbamide (PTC), a bitter organic compound has been described as a bimodal autosomal trait in both genetic and anthropological studies. This study is based on the ability of a person to taste PTC. The present study reports the threshold distribution of PTC taste sensitivity among some Muslim populations of North India, as till now no detailed information is available. A survey was conducted among healthy individuals within the age range of 10–45 years who were randomly selected from among six populations viz; Syed, Sheikh, Pathan, Ansari, Qureshi and Saifi. The PTC tasting ability was measured using a serial dilution method of Harris and Kalmus. A bimodal distribution was observed from the graphs plotted for the PTC threshold distribution. The mean PTC threshold values (\pm SD) of the male and female individuals were calculated as 8.12 ± 0.21 and 8.39 ± 0.20 , respectively. The threshold values among the six populations ranged from 7.71 to 8.81 among males, 7.44–9.04 among females and 7.86–8.91 as combined. The results found that females show a higher mean threshold value than males, though of no statistical significance. This type of study will provide brief information on the distribution of PTC sensory thresholds among some Muslim populations of North India. This study has some physiological relevance to highlight the adaptability of endogamous groups to behavioral traits in the same place.

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1. Introduction

Researches in human population genetics have been carried out by several investigators and significant information concerning mutation, selection, random genetic drift, inbreeding, protein polymorphism and association between genetic markers and diseases in different regions of the world have been obtained [1–3].

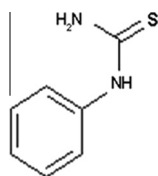


Figure 1 Chemical structure of phenylthiocarbamide.

Little is known about the genetic structure and genetic distance of Muslims in India. They belong to two major sects: Sunnis and Shias, each sect has different endogamous groups, grouped under Ashraf and Ajlaf [4]. The former is comprised of higher rank Muslims like Syeds, Sheikhs, Pathans and Mughals while the latter is comprised of Ansaris, Qureshis and Saifis. A large number of the Ajlaf may also be converts from local indigenous populations of other faiths [5,6]. Though there is no caste system in Islam, it is the social isolation that led to differentiation of groups over many generations including the difference in the gene pools. The endogamous groups among Ashrafs and Ajlaf's generally do not intermarry among themselves, thus having distinct gene pools.

Bitter perception generally occurs through bitter taste receptors located on the surface of taste cells of the tongue [7]. These receptors are encoded by T2R genes that show 25–89% of amino acid sequence identity among the 25 different members of this gene family. These differences presumably allow a wide variety of different chemical shapes, sizes, and functionalities to bind these receptors and be perceived as bitter. Psychophysical studies have showed that large individual differences in the bitterness of taste compounds exist [8]. The best known example of variation in sensitivity to a bitter compound is that of phenylthiocarbamide (PTC) (Fig. 1).

Phenylthiocarbamide (PTC), a bitter chemical synthesized by Fox [9] and has been widely used for genetic and anthropological studies [10]. Bitter-taste perception is a classically variable trait both within and between human populations [11].

The inability to taste PTC is a simple Mendelian recessive trait [12–16] wherein the individuals with two recessive alleles (tt) are non tasters for PTC and individuals with one dominant allele (Tt) or two dominant alleles (TT) are tasters for PTC. Virtually, all human populations studied to date display bimodality in sensitivity to PTC, such that approximately 75% of individuals worldwide perceive this compound as intensely

Table 1 Threshold distribution of PTC trait among males of total population among North Indian Muslims.

Solution no.	Syed	%	Sheikh	%	Pathan	%	Ansari	%	Qureshi	%	Saifi	%	Total	%
1.	–	–	–	–	–	–	–	–	–	–	–	–	1	0.5
2.	–	–	1	2.6	1	1.7	–	–	–	–	–	–	3	1.5
3.	–	–	1	2.6	1	1.7	–	–	–	–	–	–	4	2.0
4.	3	7.5	3	7.8	3	5.1	–	–	2	6.4	1	4.7	10	5.0
5.	6	15.0	4	10.5	5	8.6	3	10.3	3	9.6	2	9.5	20	10.0
6.	7	17.5	6	15.7	10	17.2	4	13.7	2	6.4	5	23.8	30	15.0
7.	4	10.0	4	10.5	8	13.7	5	17.2	4	12.9	3	14.2	28	14.0
8.	4	10.0	4	10.5	6	10.3	3	10.3	4	12.9	3	14.2	26	13.0
9.	4	10.0	2	5.2	4	6.8	4	13.7	3	9.6	1	4.7	15	7.5
10.	3	7.5	1	2.6	3	5.1	2	6.8	2	6.4	3	14.2	10	5.0
11.	2	5.0	5	13.1	4	6.8	3	10.3	4	12.9	2	9.5	14	7.0
12.	4	10.0	4	10.5	6	10.3	4	13.7	5	16.1	1	4.7	19	9.5
13.	1	2.5	1	2.6	3	5.1	–	–	1	3.2	–	–	11	5.5
14.	2	5.0	2	5.2	4	6.8	1	3.4	1	3.2	–	–	8	4.0
Total	40		38		58		29		31		21		199	

Table 2 Threshold distribution of PTC trait among females of total population among North Indian Muslims.

Solution no.	Syed	%	Sheikh	%	Pathan	%	Ansari	%	Qureshi	%	Saifi	%	Total	%
1.	–	–	–	–	2	3.2	–	–	–	–	–	–	1	0.4
2.	–	–	–	–	2	3.2	–	–	–	–	–	–	1	0.4
3.	1	3.0	1	2.7	3	4.8	–	–	1	3.8	2	8.6	6	2.7
4.	1	3.0	1	2.7	2	3.2	2	9.5	1	3.8	1	4.3	11	5.0
5.	2	6.0	2	5.4	6	9.6	1	4.7	–	–	1	4.3	18	8.1
6.	5	15.1	5	13.5	12	19.3	2	9.5	2	7.6	4	17.3	34	15.4
7.	6	18.1	5	13.5	11	17.7	5	23.8	2	7.6	3	13.0	31	14.0
8.	4	12.1	2	5.4	6	9.6	3	14.2	6	23.0	1	4.3	20	9.0
9.	2	6.0	2	5.4	2	3.2	1	4.7	4	15.3	1	4.3	15	6.8
10.	1	3.0	3	8.1	2	3.2	2	9.5	2	7.6	2	8.6	16	7.2
11.	3	9.0	2	5.4	4	6.4	1	4.7	2	7.6	4	17.3	22	10.0
12.	3	9.0	5	13.5	4	6.4	2	9.5	3	11.5	1	4.3	23	10.4
13.	4	12.1	2	5.4	3	4.8	2	9.5	2	7.6	2	8.6	10	4.5
14	1	3.0	4	10.8	3	4.8	–	–	1	3.8	1	4.3	12	5.4
Total	33		37		62		21		26		23		220	

Table 3 Threshold distribution of PTC trait among combined total population among North Indian Muslims.

Solution no.	Syed	%	Sheikh	%	Pathan	%	Ansari	%	Qureshi	%	Saifi	%	Total	%
1.	–	–	–	–	2	1.6	–	–	–	–	–	–	2	0.4
2.	–	–	1	1.3	3	2.5	–	–	–	–	–	–	4	0.9
3.	1	1.3	2	2.6	4	3.3	–	–	1	1.7	2	4.5	10	2.3
4.	4	5.4	5	6.6	5	4.1	2	4.0	3	5.2	2	4.5	21	5.0
5.	8	10.9	9	12.0	11	9.1	4	8.0	3	5.2	3	6.8	38	9.0
6.	12	16.4	11	14.6	22	18.3	6	12.0	4	7.0	9	20.4	64	15.2
7.	10	13.6	8	10.6	19	15.8	10	20.0	6	10.5	6	13.6	59	14.0
8.	8	10.9	6	8.0	12	10.0	6	12.0	10	17.5	4	9.0	46	10.9
9.	6	8.2	4	5.3	6	5.0	5	10.0	7	12.2	2	4.5	30	7.1
10.	4	5.4	4	5.3	5	4.1	4	8.0	4	7.0	5	11.3	26	6.2
11.	5	6.8	7	9.3	8	6.6	4	8.0	6	10.5	6	13.6	36	8.5
12.	7	9.5	9	12.0	10	8.3	6	12.0	8	14.0	2	4.5	42	10.0
13.	5	6.8	3	4.0	6	5.0	2	4.0	3	5.2	2	4.5	21	5.0
14.	3	4.1	6	8.0	7	5.8	1	2.0	2	3.5	1	2.2	20	4.7
Total	73		75		120		50		57		44		419	

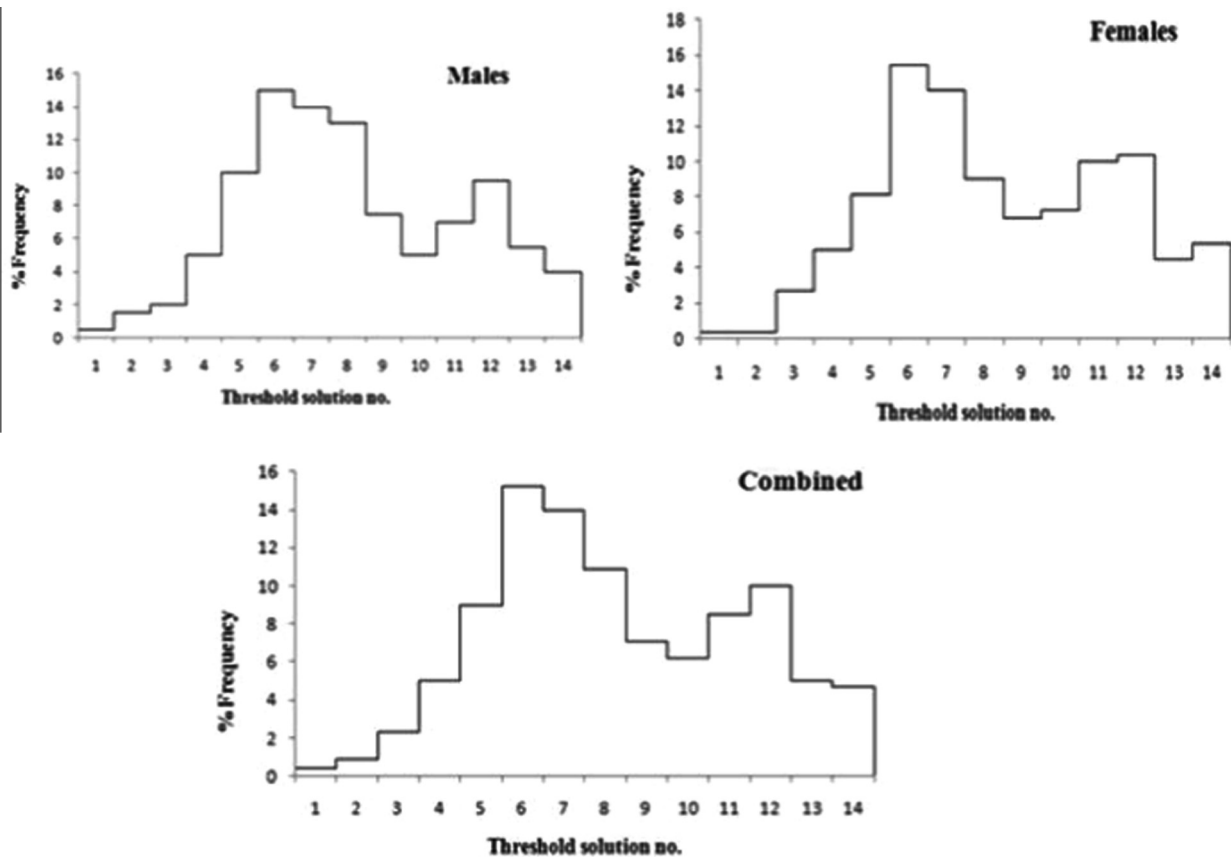


Figure 2 Graph showing threshold distribution of PTC trait among males, females and combined population groups.

bitter, while to others, this compound is relatively tasteless. This difference has led to the use of PTC in many studies on taste perception in humans [17,18] and over the past 70 years, these studies have provided many insights into the study of human psychophysics and physiology.

Kim et al. [10] have identified that a small region on Chromosome 7q has a gene that encodes a member of the TAS2R bitter taste receptor family. A major locus on 7q35–q36 and a secondary locus on Chromosome 16p have been localized by genome scan for PTC taster gene [19]. Bufe et al. [20] dem-

onstrated that alleles of hTAS2R38 code for functionally different receptor types that directly affect perception of bitterness containing compounds. The ability to taste PTC is a dominant genetic trait, and the test to determine PTC sensitivity is one of the most commonly used genetic tests on humans. Many workers have reported that human populations show a tremendous variation in the frequency of tasters which ranges from 10% to 98% [21]. Identification of PTC gene has provided the basis for a new, integrative investigation of PTC taste sensitivity [22].

Table 4 Combined threshold chart of tasters for different Muslim populations of North India.

Population	Male			Female			Combined		
	Sample size	Modal value (6–12)	X ± SE	Sample size	Modal value (6–12)	X ± SE	Sample size	Modal value (6–12)	X ± SE
Syed	40	6	8.53 ± 0.42	33	7	8.5 ± 0.51	73	6	8.24 ± .35
Sheikh	38	6	8.03 ± 0.52	37	5	8.70 ± 0.55	75	6	8.36 ± .38
Pathan	58	6	8.33 ± 0.41	62	6	7.44 ± 0.41	120	6	7.86 ± .29
Ansari	29	7	8.59 ± 0.46	21	7	8.29 ± 0.60	50	7	8.46 ± .36
Qureshi	31	12	8.81 ± 0.50	26	8	9.04 ± 0.53	57	8	8.91 ± .36
Saifi	21	6	7.71 ± 0.49	23	6	8.39 ± 0.91	44	6	8.07 ± .42
Combined	199	6	8.12 ± 0.21	220	6	8.39 ± 0.20	419	6	8.26 ± .14

X = Mean.

SE = Standard error.

Some studies on Muslim populations have been attempted earlier in Uttar Pradesh [23]. Hence in the present study we made an attempt to analyze the threshold distribution for phenylthiocarbamide among some Muslim populations of North India. Males and Females of different populations have also been compared for the taste sensitivity of this trait.

2. Materials and methods

Subjects (both sexes) belonging to different populations of Uttar Pradesh, North India were observed for phenylthiocarbamide taste sensitivity. A survey was conducted among healthy individuals within the age range of 10–45 years who were randomly selected from six populations viz; Syed, Sheikh, Pathan, Ansari, Qureshi and Saifi.

The method to distinguish tasters from non-tasters was adopted as per the sorting technique of serial dilutions of

Harris and Kalmus [16], because of its superiority in discerning the threshold level of the individual with near perfection.

A solution of 0.13% of PTC was prepared by dissolving 130 mg of the material in 100 ml of water (solution 14). The serial dilution from 1 through 14 was prepared taking 50 ml of solution and adding 50 ml of distilled water to it to make the solution 13 which is diluted to half of 14. The last solution was the most dilute and designated as solution no. 1. The dilution is used for noting the threshold value. The dilution number when tasted positive was recorded. If an individual did not taste even the solution 14 (strongest), he was designated as non-taster. After the test, the participant was asked to spit out the chemical and rinse the mouth with water. Information on caste, sect, consanguinity and biradari was noted. Threshold levels for PTC were then recorded for males and females of each population. The distribution of the frequency of tasters and non-tasters is usually bimodal with antimode recording the lowest frequency separating the two distributions. The

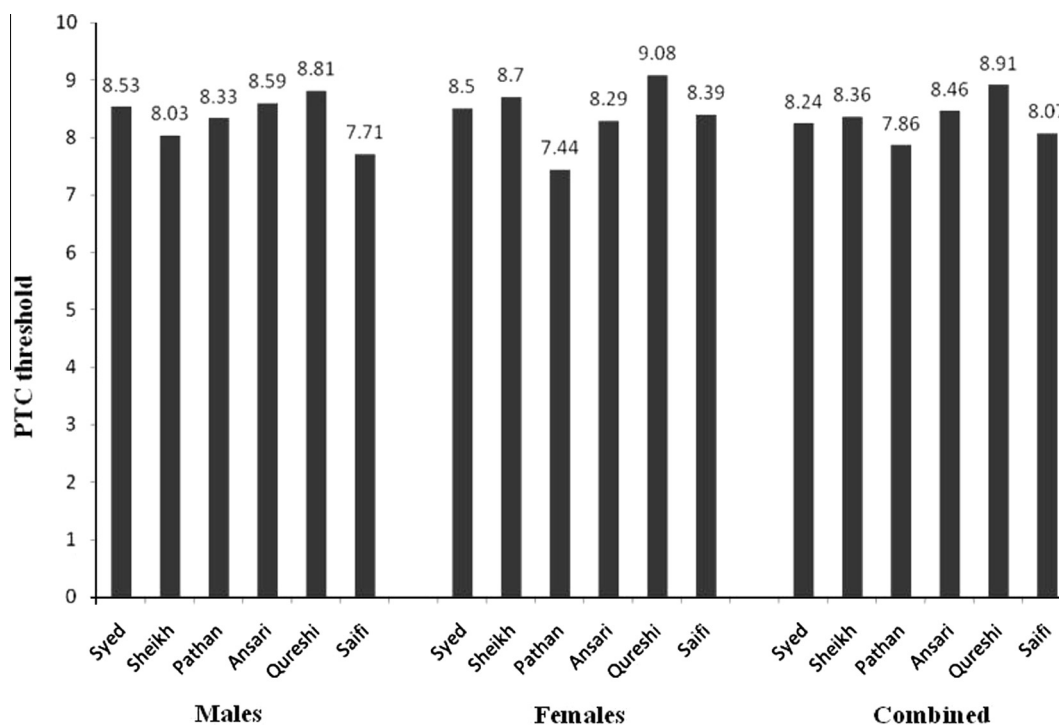


Figure 3 Graph showing mean threshold values of males, females and combined populations for PTC trait.

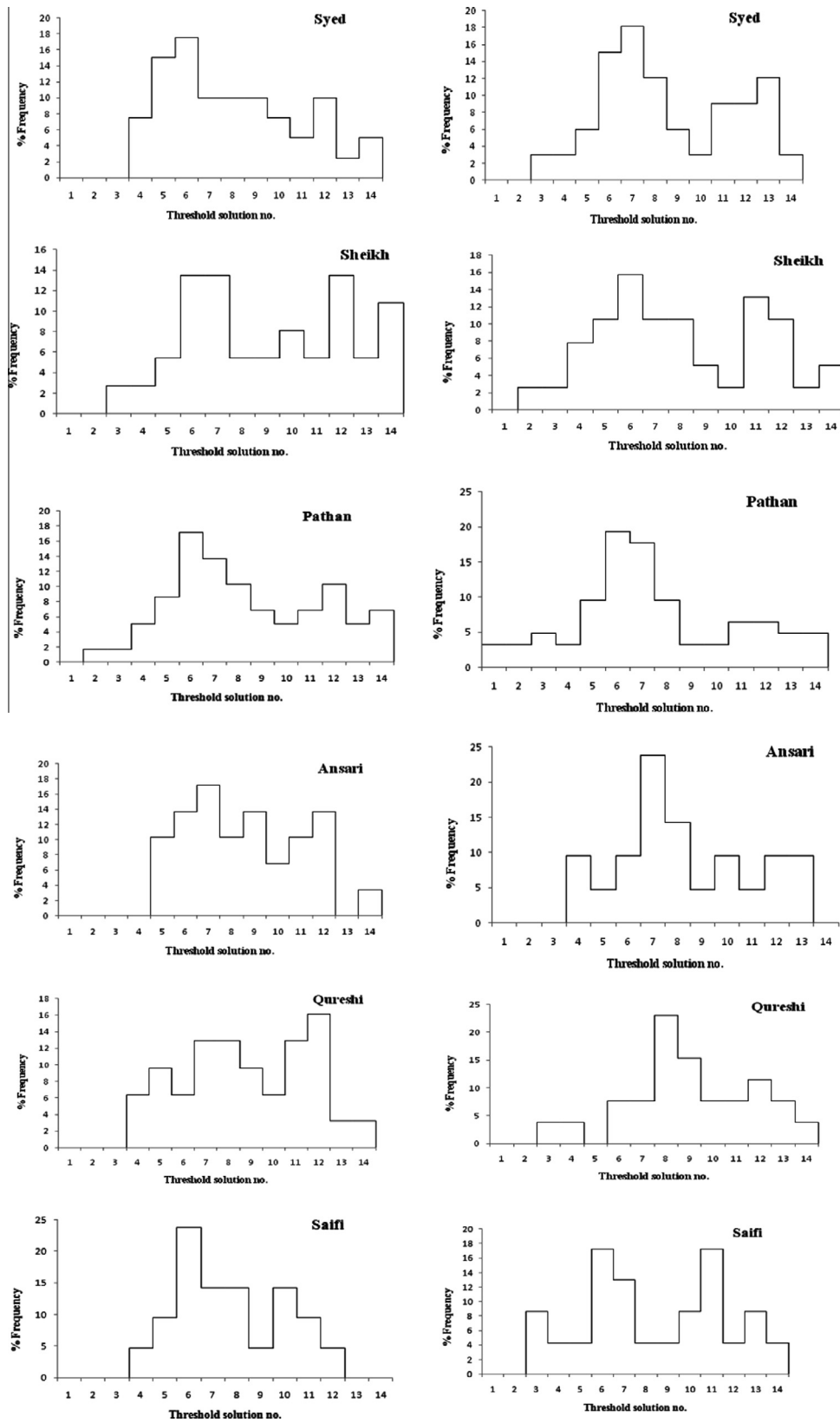


Figure 4 Graph showing frequency distribution of thresholds of PTC among different population groups. Males on the left and females on the right.

antrimodal point was taken to classify the subjects as tasters or non-tasters.

3. Results

The frequency distribution of the various threshold levels of PTC taste sensitivity among the males, females and combined populations is given (Tables 1–3). A well-defined bimodal distribution of the taste sensitivity was observed in all the communities investigated as shown (Fig. 2). The modes among the tasters were characterized by sharp peaks of solution no. 6 and the antimode lies on solution no. 7 among males, females and combined population groups of Muslims. The means and standard errors of the thresholds for males, females and combined population groups were calculated as 8.12 ± 0.21 , 8.39 ± 0.20 , 8.26 ± 0.15 , respectively (Table 4). Fig. 3 presents the threshold values among six populations which ranged from 7.71 to 8.81 in males, 7.44–9.04 in females and 7.86–8.91 as combined. The Qureshi shows the highest ones (8.81 in males and 9.04 in females), Pathan the lowest (8.33 in males and 7.44 in females) and Syed, Sheikh, Ansari and Saifi showed intermediate threshold values. In overall population, it is interesting to note that the females show a higher mean threshold value than males.

The populationwise distribution of thresholds is shown graphically in Fig. 4 where the frequencies, expressed as percentages of the total for each sex, are plotted against the threshold.

4. Discussion

The sense of taste is a strong predictor of food selection. Human infants show an innate pleasure response to sweet taste, but dislike and reject bitter-tasting foods [24]. In 1931 Fox [25] observed that to some individuals, the simple chemical compound phenylthiocarbamide (PTC), has an intensely bitter taste, while to others it is tasteless. Being a chemist he also showed that a number of other closely related substances are tested well by the PTC tasters but not by the non-tasters. The ability to taste these substances was shown by Blaklee [26] and by Synder [27] to behave as a Mendelian dominant character.

Two major forms of this bitter receptor gene were identified in most of the world's populations, designated as the 'major taster' form the 'major non-taster' form. These two forms differ in 3 amino acid positions, numbers 49, 262, and 296 [28].

Previous investigators noted that people who were less sensitive to this class of bitter compounds seemed to lose their sensitivity faster as they got older, concluding that gene penetrance might differ by age and genotype [29].

The ability or inability to taste the PTC is a classic inherited trait that has long been known to vary in human population. This trait is of genetic, epidemiologic and evolutionary interest and has been shown to correlate with a number of dietary preferences and thus has important implications for human health [14,12,20].

Harris and Kalmus [16] found that the distribution of PTC tasting thresholds was bimodally distributed, but there were some intermediate individuals. Other studies have found similar results, a bimodal distribution with some intermediate individuals [26,30,31,29].

Reddy and Rao [32] re-examined the genetics of PTC taste thresholds by studying 100 nuclear families. They concluded

that variability in thresholds is controlled by a major locus with incomplete dominance as well as by a multifactorial component.

The sorting technique with serial dilution method of Harris and Kalmus [16] is considered by most investigators a much more precise tool of measurement. Nearly every population shows a bimodal distribution of thresholds with a clear-cut intermediate dilution level after which threshold falls. Those who can taste solutions diluted more than this critical value are classified as tasters and those whose thresholds fall below the lowest concentration are non-tasters. By this technique, the separation point between tasters and non tasters lies between dilutions 6 and 7.

As shown in Fig. 2 recognition of threshold distribution for PTC among 199 males and 220 females showed bimodal distribution. The present investigation of this study shows that the PTC taste thresholds vary among six population groups of Muslims, the females showed higher mean threshold value than males. The mean thresholds, standard deviations and modal values among males, females and combined groups have interesting features. In nearly all population groups, the mode and antimode lie between the solution number 6 and 7 for both males and females, with the exception of Ansari and Qureshi populations in which Ansaris show the mode and antimode lying between the solution number 7 and 8 while among Qureshis the mode and the antimode lie between the solution number 8 and 9, for both male and female population groups.

Genetic approaches are rapidly yielding new information about our sense of taste. Our understanding of bitter taste has increased considerably with the discovery and study of T2R family of taste receptor genes, their genetic linkage and positional cloning studies and from studies on inherited variation in the ability to taste phenylthiocarbamide (PTC). The Sweet and Umami tastes are mediated by T1R receptors and are being studied actively. Salty and sour tastes are still poorly studied in genetic terms and represent opportunities for the future research [28]. Besides its importance in genetic and anthropological studies, PTC taste sensitivity has been shown to be important in food selection, which may affect individual metabolism and physiology [33]. It was previously used in paternity testing before the advent of DNA markers [34].

On a larger scale, the PTC gene may be illustrative of ancient genetic variation that has been proposed to underlie common disease in modern populations [35]. In addition, the mapping of the PTC genes will provide a powerful tool to examine the genetic basis for food preferences and the relationship between taste status and health outcomes [17]. Finally, PTC presents a unique opportunity for the field of bitter taste transduction. Having a known gene with a strong effect on phenotype *in vivo* provides many opportunities for studies of taste physiology, biochemical function, and molecular structure elucidation in case of human sense of taste. Such studies have a great significance in understanding the adaptability of the populations to the same region which results in their varying response to threshold of sensitivity of the same genetic trait. More such traits will be useful in looking at this problem if studied in detail.

5. Conclusion

The present paper reports the threshold distribution of PTC taste perception among some Muslim populations of North India. Our results revealed that females show a higher mean threshold value than males, but this is of no statistical consequence. Although

PTC itself has not been found in nature, the ability to taste PTC is correlated strongly with the ability to taste other naturally occurring bitter substances, many of which are toxic [36,37]. Thus, understanding the nature of the variation in bitter taste perception and its relationship to diet and other behavior aspects may have important implications for human health [38].

Conflict of interest

The authors declare that there is no conflict of interest.

Acknowledgements

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