Study the relationship between blood pressure, sensitivity to taste PTC and table salt among pregnant women

Hasna A. Mohaus[1] and Asaad Y. Ayied[2*]
[1]Biology Department, Qurna College of Education, University of Basrah. Basrah, Iraq.
[2]Animal Production Department, College of Agriculture, University of Basrah. Basrah, Iraq.
*Email: asaad.yheia@uobasrah.edu.iq

Summary

The current study was conducted to find the variation in blood pressure, sensitivity of tasting PTC and table salt between a sample of pregnant and non-pregnant women (150 individuals each). A stepwise dilution method (13 concentrations) was used to measure the taste sensitivity of PTC, while three gradient concentrations were used to measure the sensitivity of taste of table salt (0.25, 0.5, 1 and 2%). The study found an increase in PTC taste sensitivity among pregnant women, as the critical threshold for taste reached 8 compared to non-pregnant women, which reached 6. With regard to the taste of table salt, it was noted that there was a lack of sensitivity to its taste among pregnant women. As it was noticed that the critical limit for salt taste increased, which reached a concentration of (2%) in the first and second periods. The percentage among pregnant women reached (40%) while returning to the normal state (salt concentration 0.5) in the third and last period compared to non-pregnant women. As for pressure, fluctuation was observed during pregnancy in general and in the first period of pregnancy in particular. The level of decline increased exponentially with the increase in the period of pregnancy. The percentage of pregnant women with high systolic pressure only was 20%, more than non-pregnant women (10%). In general, the percentage of decline among pregnant women in diastolic and systolic pressure together was 54% compared with 36% of non-pregnant women.

Keywords: PTC, Taste, blood pressure, pregnant women

Introduction

There are major types of taste among people, salt, sweet, sour, sweet, sour, and bitter, in addition to two other types, the umami (protein and amino acid taste), and the taste of fatty acid. Taste affects human life through its effect on the nutritional behavior of individuals, diseases, or weight gain (Vignini et al., 2019; Tepper & Barbarossa, 2020). The taste of bitter substances acquires special importance in human life as a means of survival by warning the human being to avoid eating toxic substances which are usually bitter. Any defect in this sense may lead to serious consequences for health (Calvo & Egan 2015; Tepper & Barbarossa 2020).

The ability to taste the bitterness of PTC is genetically based, despite its apparent simplicity, which is characterized by a great variation among individuals and societies (Ayied et al., 2014; Risso et al., 2016). It also has associations with many diseases (Li et al., 1990; Ali et al., 1994; Lee & Cohen 2014; Igbeneghu et al., 2019; Mohaus, 2019) and obesity (Akella et al 1998; Tepper et al., 2014; Turner et al., 2018). With the variation in human's nutrition behavior in health and disease (Tepper & Barbarossa 2020) among adult individuals and even among infants (Cont et al. 2019). Bitter substances can also play a role in contrasting the immune response between individuals (Grassin- Delyle et al., 2019). PTC tasting has been extensively studied as an example of the relevance of tasting for heredity. As people divided into two phenotypes depending on their taste for this substance, as some of them can taste the substance and are called taster, while others cannot sense its bitter taste, they are called non-tasters (Harries and Kalmus 1949). The gene responsible for its inheritance was discovered in 2003 (Kim et al., 2003), which encodes two types of receptor proteins. Receptors differ in one SNP base in gustatory cells. The two main types are called PAV and AVI for tasters and non-tasters, respectively, with other rare patterns present (Emerson et al., 2012). People differ among themselves in the proportions of these genotypes (Campbell, 2012 and Ahmed et al., 2015). The presence of these receptors outside the mouth was discovered in several tissues and organs, there was a difference in the level of expression at the level of the individual himself (Shaw et al., 2018). With the increasing importance of the difference in the taste of this substance and its impact on the nutritional habits of humans and the eating of food types, which is directly or indirectly related to health and diseases (Aldaz et al., 2019; Precone et al., 2019; Igbeneghu et al., 2019), the interest in studying this trait has increased.

Pregnancy represents a special stage in a woman's life, and many changes occur during pregnancy to keep or create the optimum environment for the development of the fetus and ensure that he gets enough feed (Cameron, 2014). Several studies have indicated a change in many of the woman’s senses during pregnancy: the sense of hearing, smell, and vision increases in women during pregnancy, and taste is also one of the important senses in which women found to differ in the pregnancy stage (Shind & Pazare, 2017). Despite the separation of the sense of smell and taste system, they are involved in initiating food behavior (Precone et al. 2019; Nordin et al., 2004). Studies have also shown that most or many saliva contents of proteins and hormones rise during pregnancy (Muramatsu & Takaesu 1994), while the pH and saliva flow rate decrease (Laine et al., 1988). The degree to which these changes affect taste during pregnancy is still not fully defined. The results of some studies on pregnant females indicate that taste variation during pregnancy may play a role in the optimal development of the fetus (Hussain et al., 2016). Most pregnant women have a change in their taste during pregnancy (Kuga et al., 2002; Dando & Choo 2017). Taste is generally associated with pressure through its effect on nutritional behavior in eating certain types of food or on the physiological level in the metabolism variance. It is believed that the difference in the taste of table salt is the most prominent role in this field (Kogure et al., 2019, Clarke & Bernstein, 2001). It was also found that variations in PTC taste sensitivity could play a role as well (Mohaus & Ayied 2018). Hypertension disorders in pregnancy (HDP) is a systolic blood pressure ($\geq$140 OR $\geq$ 90 mmHg)) and diastolic blood pressure (or both). It appears in women who have had a previous history of infection or develop disease during the second half of pregnancy (Dando & Choo, 2017). The pregnant women hypertension is one of the conditions that is a harmful to the life of the mother and the fetus, may lead to the death of mothers or fetuses and causes weight loss, premature birth, ectopic growth or death of the fetus inside the womb (Alarm, 2013). The state of natural pressure is associated with good health of pregnant women, which requires eating balanced meals.

Therefore, understanding or studying the effect of taste on nutritional choices during pregnancy will be an important thing to achieve.

Given the increasing emergence of pregnancy hypertension cases and their negative effects on the life of the mother and the fetus, as well as helping to find early diagnosis and treatment method, it is of the utmost importance in overcoming the risks of this disease and therefore it is necessary to identify and discover the relationship between the state of pressure between pregnant women and taste the food salt NaCl and PTC.

Materials and Methods

Prepare the PTC material

A 0.13 g of PTC was weighed with a sensitive digital scale, and then the weighted substance was dissolved in 100 ml distilled water to prepare solution No. 1, which represents the highest concentration. Half of the solution number (1) was diluted with an equal volume of water to get solution No. (2). The dilution process continues in the same way to reach solution No. (13), which represents the lowest concentrations, meaning that each solution is half the concentration of the solution that precedes it (Harris & Kalmus 1949). Boiled distilled water was used as a control solution. The PTC-taste sensitivity test papers were prepared by dipping the filter papers with a diameter of (125) mm with each of the previously prepared and numbered solutions (1-13) as well as the control solution and then left to saturate completely. Papers were dried and cut into small scraps with dimensions of 3 x 1.3 cm and kept in sterile and clean Petri dishes inside metal cans (Ayied et al., 2014). Before performing the test, it must first be confirmed that there is no prior feeling of bitterness by the individual who wants to know the threshold of taste for his PTC material by placing a filter paper set on the back of the tongue, then a filter paper saturated with solution No. (13), which represents the lowest concentration up to Solutions with a higher concentration until the individual feels the bitterness of the substance, and then the number of this solution is recorded to represent a threshold for the taste of the PTC substance for this individual (Ayied et al., 2014). The critical limit of PTC taste between the two groups (taster vs non-taster) was determined, then the phenotypic patterns of this substance's taste quality were determined based on the binomial distribution of the critical boundary for the taste of individuals (Al-Ani, & Abdulla 1999; Omari 1986).

Taste table salt

The taste sensitivity of table salt was measured among pregnant and non-pregnant women using a simple method of Nishimoto et al. (1996) and Michikawa et al., (2009). The method included preparing solutions with concentrations of salt starting from the highest concentration of 2%, which was prepared by dissolving 2 g of sodium chloride crystals in 98 ml of boiled distilled water to the lowest 0.125%. The sensitivity of taste was examined, starting from tasting the lowest concentration to the highest concentration through the following gradient concentrations (2%, 1%, 0.5% 0.250, 125%).

Women samples

A PTC and table salt taste sensitivity test were performed among (150) pregnant women (the experimental sample) attending health centers for pregnant care and (150) non-pregnant women (control sample). Information was recorded for every pregnant and non-pregnant woman. Personal data included: measurement of pressure (systolic and diastolic blood pressure), weight, length, and pregnancy duration for pregnant women which divided into three periods (**1-3**,**4-6,7-9**) for three months each , in addition to age and disease.

Results

Table (1) shows the distribution of critical limits for pregnant and non-pregnant women. The results showed an increase in the sensitivity of PTC taste among pregnant women, as the critical limit for taste among pregnant women reached 8 compared to 6 of non-pregnant women.

Table (1): Critical taste level distribution of pregnant and non-pregnant women for PTC.

PTC taste level	Pregnancy Duration (mo.)			Total pregnant number (%)	Non-pregnant women number (%)
	1-3	4-6	7-9		
0	3 (6.67)	9 (20)	6 (10.00)	18 (12)	6 (4)
1		3 (6.67)		3 (2)	3 (2)
2	6 (13.30)			6 (4)	12 (8)
3	12 (26.70)		12 (20.00)	24 (16)	9 (6)
4			6 (10.00)	6 (4)	18 (12)
5					12 (8)
6			3 (5.00)	3 (2)	33 (22)
7	3 (6.67)		3 (5.00)	6 (4)	15 (10)
8	18 (40.00)	15 (33.30)	18 (30.00)	51 (34)	3 (2)
9		3 (6.67)		3 (2)	6 (4)
10		3 (6.67)		3 (2)	15 (10)
11	3 (6.67)	6 (13.33)	3 (5.00)	12 (8)	15 (10)
12		6 (13.3)	9 (15.00)	15 (10)	3 (2)
Total	45 (100)	45 (100)	60 (100)	150 (100)	150 (100)

With regard to the taste of table salt (Table 2), less sensitivity was noted for its taste among pregnant women, as a high critical limit was noted, as the highest percentage of salt taste for pregnant women was (40%) at a concentration of (2%) of salt in the first and second periods, while returning to the normal state when concentration of 0.5% in the third and last period.

Table: (2) Table salt taste sensitivity of pregnant and non-pregnant women, number (%)

Pregnancy	Pregnancy period (mo.)	Number	Concentration of salt (%)/No. (%)				
			2 No. (%)	1 No.(%)	0.5 No. %)	0.25 No. %)	0.125 No. (%)
Pregnant	1-3	45	18(40)	6(13.3)	9(20)	0	12(26.6)
	4-6	45	18(40)	3(6.6)	9(20)	9(20)	6(13.3)
	7-9	60	12(20)	9(15)	18(30)	15(25)	6(10)
	Total	150	48(32)	18(12)	36(24)	24(16)	24(16)
Non-pregnant		150	12(8)	18(12)	27(18)	33(22)	60(40)

As for pressure, fluctuation was observed during pregnancy in general and in the first period of pregnancy in particular (Table 3).

Table (3). Pressure variation of pregnant and non-pregnant women

Pregnancy	Stage of pregnancy	Number	Pressure fluctuation	Systolic pressure	Diastolic pressure
Pregnant	1-3	45	18	18	18
	4-6	45	3	27	3
	7-9	60	6	36	9
	Total	150	27(20)	86(54)	27(20)
Non-pregnant		150	0	64(36)	15(10)

The level of its decrease has increased exponentially as the pregnancy period increases. It was observed that the percentage of women with high systolic pressure was higher in pregnant women 20% than non-pregnant women 10%. In general, the percentage of decline among pregnant women in diastolic and systolic pressure together was 54% compared to 36% non-pregnant women (Table 4).

Table (4): Pressure fluctuation among pregnant women compared to non-pregnant women

Pregnancy period (months)	High diastolic and systolic pressure	Low Diastolic and systolic pressure	Pressure Fluctuation
1-3	0	3	3 (6%)
4-6	0	11	0
7-9	0	9	2 (4%)
Total	0	23	5 (10%)
Nonpregnant	5 (10%)	18 (36%)	0

Discussion

The current study indicates an increase in the sensitivity of PTC taste among pregnant women. As for the taste of table salt, the opposite has been observed (lack of sensitivity to taste it among pregnant women), as the critical limit of salt taste has been observed, which has reached a concentration of (2%) in the first and second periods, while returning to the normal state in the third period. As for pressure, fluctuation was observed during pregnancy in general and in the first period of pregnancy in particular. Pregnancy in women is associated with many physiological changes (Soma-Pillay et al 2016). Taste is of great importance in the life of a pregnant woman in both health and illness, and the sense of smell is affected by the taste, which is involved in crystallizing nutritional behavior (Doty & De Fonte, 2016). Seemingly, confusion occurs during the gestational period of salt taste (Tepper & Seldner 1999). Duffy et al (1998) found that there was a lack of salt tasting in the second and third stages of pregnancy compared to non-pregnant and pregnant women in the first stage (Brown & Toma 1986) and that some researchers indicated a decrease in the first stage (Kuga et al 2002; Clarke & Bernstein (2001). While others have indicated that pregnancy has no effect on the taste of salt (Landman et al 1980, Saluja et al 2014). With regard to bitterness tasting, Bhatia & Puri (1991) indicated an increase in the sensitivity of bitter taste to PTC in the first stage. This was also confirmed by (Duffy et al 1998) and added that it is decrease in the second and third stages of pregnancy. This increase was explained by pregnant women avoiding consuming bitter substances (which are often toxic) during this early critical period of fetal development, as they protect the mother and fetus from eating homemade food that may cause disease or contain toxins (Flaxman & Sharman2000 & Profet, 1994). It has been found that some of the most common foods that pregnant women have been reluctant to read are dangerous substances and cause fetus distortion or abortion (Profet 1994). Therefore, vomiting and nausea in the early stages of pregnancy may be associated with protecting the fetus and reducing the risk of its loss (Sipiora et al., 2000 & Hinkle et al, 2016). On the other hand, and unlike many studies that indicated a change in bitter taste during pregnancy, some indicated that pregnancy had no effect on bitter taste (Saluja 2014 & Nanou et al., 2016).

Hormones have a major role in altering the sense of taste (Loper et al., 2013). The immune system may also play a role in influencing bitter material taste or regulating response to it (Feng et al., 2015). Steroids (progesterone and estrogen) hormones act on both taste buds, it has been found that there is an increase in the level of the progesterone hormone in saliva during pregnancy, so this hormone has a direct impact on the sense of taste, and increases in the first three months. This is one of the indicators of the reasons for the increased sensitivity of the taste of pregnant women at this stage compared to others (Sultana et al., 2011). That steroid hormones show a change in the level of electrolytes and that these changes lead to an impact on the nervous system and thus the effect on taste (Bhatia & Puri1991; Faas et al., 2010). The constant change of gustatory cells makes them susceptible to the hormonal and nutritional status of females during their life stages (Shiffman 1983) and the massive change in the gestational stage of women and the high level of steroid hormones that may affect the growth of gustatory buds and gustatory cells (Yucel et al., 2002). It may be one of the reasons for the increased sensitivity of women at this stage to the types of taste, especially the time when it plays a role in protecting the fetus from harmful substances, which are often bitter. Researches vary in its results when studying taste during pregnancy. The only studies that examined women's taste for the period before , during and then after pregnancy showed that bitter taste increases in the first three months of pregnancy and that the taste of table salt decreases in the second and third periods (6-4), (7-9) (Bhatia & Puri1991; Duffy et al., 1998). While other studies have not supported the reduction in salt-tasting sensitivity (Landman et al., 1980, Saluja et al., 2014). Generally, tasters differ from non-tasters with a number of differences, including the difference in the level of some hormones and metabolic substances (Wang et al. 2014), and that this variation may indicate that both taster and non-taster of PTC have a different physiological system of their own, which in turn is affected on his/ her overall responses to external or internal influences, including the stage of pregnancy in women .PTC tasting ability may affect pressure stability especially at females (Mohaus & Ayied 2018) . The response to bitter material taste is influenced by immunity (Feng et al., 2015), which increases during pregnancy towards sensitivity to bitter materials specifically, as the opposite may also be true, which indicates the importance of studying this characteristic for future studies in this field.

Conclusion

Pregnant women become more sensitive to PTC during the first three months. During the first and second three months, pregnant women taste to salt decreased then they return to normal in the last three months of pregnancy. The pressure fluctuates among pregnant women at a higher rate than among non-pregnant women, and their rate of decline increases steadily with pregnancy.

References

1. Al-Ani, B. A., & Abdulla, N. F. (1999). Association between PTC tasting and specific populational characteristics in Iraq. Ibnal-Haitham J. Pure App.Sci.,11(2):23-32.
2. Ahmed F A. W. Ayied A. Y. Mohaus H. A. (2015) Molecular Genetic Study of PTC Tasting in Basra Population/Iraq. Journal of Natural Sciences Research Vol.5, No.22, 2015.
3. Ayied AY., Ahmed F. A. W. & Mohaus H. A. (2014). A Study of Phenylthiocarbamide Polymorphism Among Basrah Population/ Iraq. IJSR., 3 (10): ISSN No 2277 - 8179
4. Alarm international program "hypertension in pregnancy". (2013). 35(2):121–124. fourth edition.
5. Aldaz KJ, Flores SO, Ortiz RM, et al. (2019) Influence of Phenylthiocarbamide taster status on sensory perceptions of fruits, vegetables nuts. FASEB J 33: 590–596.
6. Ali, S.G.M.; Azad Khan, A.A.K.; Mahtab, H. & Muhibyllah, M. (1994). Association of phenylthiocarbamide taste sensitivity with Diabetes mellitus in Bangladesh. Hum.Hered.,44:14-17.
7. Bhatia, S.; Sirca, S.S. & Choria, B. K. (1990). Gustatory of differences in hypothyroid and hyperthyroid taster and non-tasters. India J. Physiol & Pharm.,34(3):201-205.
8. Bhatia S, and Puri R. (1991). Taste sensitivity in pregnancy. Indian J Physiol Pharmacol. 35(2):121–124.

9. Brown JE, Toma RB. (1986). Taste changes during pregnancy. Am J Clin Nutr. 43(3):414–418.
10. Calvo SS, and Egan JM. (2015). The endocrinology of taste receptors. Nat Rev.Endocrinol. 11(4):213–227.
11. Cameron EL. (2014). Pregnancy and olfaction: a review. Front Psychol. 5:67.
12. Choo, E and Dando, R. (2017). The Impact of Pregnancy on Taste Function Chemical Senses., V 42, 4
13. Clarke SN, and Bernstein IL. (2001). NaCl preference increases during pregnancy and lactation: assessment using brief access tests. Pharmacol Biochem Behav. 68(3):555–563.
14. Cont G., Paviotti G, Montico M, Paganin P, Guerra M, Trappan A, Demarini S, Gasparini P, and Robino A et al. (2019) TAS2R38 bitter taste genotype is associated with complementary feeding behavior in infants. Genes & Nutrition 14:13.
15. Dinehart ME, Hayes JE, Bartoshuk LM, Lanier SL, Duffy VB. (2006) Bitter taste markers explain variability in vegetable sweetness, bitterness, and intake. Physiol Behav. 2006;87:304–13.
16. Doty R L. and De Fonte T P .(2016) .Relationship of Phenylthiocarbamide (PTC) Taster Status to Olfactory and Gustatory Function in Patients with Chemosensory Disturbances. Chemical Senses, 2016, Vol. 41, No. 8
17. Duffy VB, Bartoshuk LM, Striegel-Moore R, Rodin J. (1998). Taste changes across pregnancy. Ann N Y Acad Sci. 855:805–809.
18. Emerson J. A. (2012) Identification of Human Polymorphisms in the Phenylthio carbamide (PTC) Bitter Taste Receptor Gene and Protein. Tested Studies for Laboratory Teaching Proceedings of the Association for Biology Laboratory Education. 33, 246–250,
19. Faas MM, Melgert BN, de Vos P. (2010). A brief review on how pregnancy and sex hormones interfere with taste and food intake. Chemosens Percept. 2010;3(1):51-6.
20. Feng P, Jyotaki M, Kim A, Chai J, Simon N, Zhou M, Bachmanov AA, Huang L, Wang H. (2015). Regulation of bitter taste responses by tumor necrosis factor. Brain Behav Immun. 49:32–42.
21. Feng P, Huang L., and Wang H., "Taste bud homeostasis in health, disease, and aging, 2013 Chemical Senses, 39 (1):3–16.
22. Flaxman SM, and Sherman PW. (2000). Morning sickness: a mechanism for protecting mother and embryo. Q Rev Biol. 75(2):113–148.
23. Grassin-Delyle S, Salvator H, Mantov N, Abrial C, Brollo M, Faisy C, Naline E, Couderc L-J and Devillier P. (2019) Bitter Taste Receptors (TAS2Rs) in Human Lung Macrophages: Receptor Expression and Inhibitory Effects of TAS2R Agonists. Front. Physiol. 10:1267. doi: 10.3389/fphys.2019.01267.
24. Hansen R, & Langer W. (1935). Uber geschmacksveranderungen in der schwangerschaft. Klin Wochenschr. 14:1173–1177.
25. Harris, H. and Kalmus, H. (1949). The measurement of taste sensitivity to (PTC).Ann.E.UGEN.,15:2431.
26. Hayes JE, Wallace MR, Knopik VS, Herbstman DM, Bartoshuk LM, Duffy VB. (2011) Allelic variation in TAS2R bitter receptor genes associates with variation in sensations

from and ingestive behaviors toward common bitter beverages in adults. Chem Senses. 36: 311–9.

27. Hinkle SN, Mumford SL, Grantz KL, Silver RM, Mitchell EM, Sjaarda LA, Radin RG, Perkins NJ, Galai N, Schisterman EF. (2016). Association of nausea and vomiting during pregnancy with pregnancy loss: a secondary analysis of a randomized clinical trial. JAMA Intern Med. 176(11):1621–1627.
28. Hussain A, Zhang M, Üçpunar HK, Svensson T, Quillery E, Gompel N, Ignell R, Grunwald Kadow IC. (2016). Ionotropic chemosensory receptors mediate the taste and smell of polyamines. PLoS Biol. 14(5):e1002454.
29. Igbeneghu C, Olisekodiaka JM, Onuegbu JA, et al. (2019) Phenylthiocarbamide taste perception among patients with type 2 diabetes mellitus. Asian J Med Health 6:1–5.
30. Kaiser LL, Allen L, and ADA. (2009). Position of the American Dietetic Association and American Society for Nutrition: obesity, reproduction, and pregnancy outcomes. J Am Diet Assoc. 109(5):918–927.
31. Keller KL, Steinmann L, Nurse RJ, Tepper BJ. (2002) Genetic taste sensitivity to 6-npropylthiouracil influences food preference and reported intake in preschool children. Appetite.;38:3–12.
32. Kogure, M, Hirata T, Nakaya, N, Tsuchiya, N, Nakamura T, Narita A, Miyagawa, K, Koshimizu, H, Obara, T, et al. (2019). Multiple measurements of the urinary sodium-to-potassium ratio strongly related home hypertension: TMM Cohort Study. Hypertension Research https://doi.org/10.1038/s41440-019-0335-2
33. Kuga M, Ikeda M, Suzuki K, Takeuchi S. (2002). Changes in gustatory sense during pregnancy. Acta Otolaryngol Suppl. 122(4):146–153.
34. Laine M, Tenovuo J, Lehtonen OP, Ojanotko-Harri A, Vilja P, Tuohimaa P. 1988. Pregnancy-related changes in human whole saliva. Arch Oral Biol. 33(12):913–917.
35. Landman J, Weir F, Golden M, Golden B, Hall J, Jackson A. (1980). Taste acuity and pica during pregnancy. W I Med J. 29(4):212.
36. Lee RJ, Cohen NA (2014) Bitter and sweet taste receptors in the respiratory epithelium in health and disease. J Mol Med 92: 1235–1244.
37. Li, Z.L.; Mclntoch, J. H.; Byth, K.; Stuckey, E.; Stiel, D.& Piper, DW. (1990). Phenylthiocarpamide taste sensitive in chronic Peptic ulcer. Gastroenterology. 99(1):66-70.
38. Loper H. B., Sala La M., Dotson C., and Steinle, N. (2015). Taste perception, associated hormonal modulation, and nutrient intake," Nutrition Reviews, 73 (2): 83–91.
39. Magee, L A. Pels A, Helewa M, Rey E, Dadelszen P v, (2014) "Diagnosis, Evaluation, and Management of the Hypertensive Disorders of Pregnancy: Executive Summary, J Obstet Gynaecol Can;36(5):416–438.
40. Michikawa, T., Nishiwaki, Y., Okamura, T., Asakura, K., Nakano, M. and Take-bayashi, T. (2009) The Taste of Salt Measured by a Simple Test and Blood Pressure in Japanese Women and Men. Hypertension Research, 32, 399-403.
41. Mohaus H A . (2019) . Dental Caries among Tasters and Non-Tasters of PTC Substance in Students of Qurna Population . J Molecular Biology Research; Vol. 9, No. 1; 2019 .

42. Mohaus H A , Ayied A Y. (2018) . A Study of the Relationship between the Taste Sensitivity of Phenylthiocarbamide (PTC) and Blood Pressure (Random Sample from the Students of Qurna College/Basrah-Iraq) . J Biosciences and Medicines, 2018, 6, 1-12 .
43. Muramatsu Y, Takaesu Y. (1994). Oral health status related to subgingival bacterial flora and sex hormones in saliva during pregnancy. Bull Tokyo Dent Coll. 35(3):139–151.
44. Nanou E, Brandt S, Weenen H, Olsen A. (2016). Sweet and bitter taste perception of women during pregnancy. Chemosens Percept. 1–12.
45. Nishimoto K, Hirota R, Egawa M, Furuta S . Clinical evaluation of taste dysfunction using a salt-impregnated taste strip. ORL J Otorhinolaryngol Relat Spec 1996; 58: 258–261.
46. Nordin S, Broman DA, Olofsson JK, Wulff M. (2004). A longitudinal descriptive study of self-reported abnormal smell and taste perception in pregnant women. Chem Senses. 29(5):391-402.
47. Omari. Y. I. (1986). Taste deficiency of phenylthiourea in Joudanian population. J. Biol. Sci, Res.,17(1): 253-265.
48. Pawellek I, Grote V, Rzehak P, Xhonneux A, Verduci E, Stolarczyk A, Closa-Monasterolo R, Reischl E, Koletzko B, European Childhood Obesity Trial Study Group. (2016) Association of TAS2R38 variants with sweet food intake in children aged 1-6 years. Appetite,107: 126–134.
49. Precone V, Beccari T, et al. (2019) Taste, olfactory and texture related genes and food choices: Implications on health status. Eur Rev Med Pharmacol Sci 23: 1305–1321.
50. Profet M. (1995). Pregnancy sickness as adaptation: a deterrent to maternal ingestion of teratogens. Adapt Mind. 327–365.
51. Risso DS, Mezzavilla M, Pagani L, et al. (2016) Global diversity in the TAS2R38 bitter taste receptor: Revisiting a classic evolutionary PROPosal. Sci Rep 6: 25506.
52. Saluja P, Shetty V, Dave A, Arora M, Hans V, Madan A. (2014). Comparative evaluation of the effect of menstruation, pregnancy and menopause on salivary flow rate, pH and gustatory function. J Clin Diagn Res. 8(10): ZC81–ZC85.
53. Soma-Pillay P, Nelson-Piercy C, Tolppanen H, Mebazaa A. (2016). Physiological changes in pregnancy. Cardiovasc J Afr 2016; 27: 89–94
54. Schiffman SS. (1983). Taste and smell in disease (first of two parts). N Engl J Med.;308(21):1275-9.
55. Shaw L, Mansfield C, Colquitt L, et al. (2018) Personalized expression of bitter ‘taste’ receptors in human skin. PloS One 13: e0205322.
56. Shinde PS, and Pazare PA. (2017). A comparative study of taste sensitivity to phenylthiocarbamide in pregnant and nonpregnant females. Natl J Physiol Pharm Pharmacol 2017;7(4):359-362.
57. Sipiora ML, Murtaugh MA, Gregoire MB, Duffy VB. (2000). Bitter taste perception and severe vomiting in pregnancy. Physiol Behav. 69(3):259–267.
58. Sultana RR, Zafarullah SN, Kirubamani NH. (2011). Saliva signature of normal pregnant women in each trimester as analysed by FTIR spectroscopy. Indian J Sci Technol. ; 4(5):481-6.

59. Tepper BJ, and Seldner AC. (1999). Sweet taste and intake of sweet foods in normal pregnancy and pregnancy complicated by gestational diabetes mellitus. Am J Clin Nutr. 70(2):277–284.
60. Tepper B. J., Banni S., Melis M., Crnjar R., and Barbarossa T I. (2014). Genetic sensitivity to the bitter taste of 6-npropylthiouracil (PROP) and its association with physiological mechanisms controlling body mass index (BMI). Nutrients, 6 (9): 3363–3381.
61. Tepper BJ, White EA, Koelliker Y, Lanzara C, d'Adamo P, Gasparini P. Genetic variation in taste sensitivity to 6-n-propylthiouracil and its relationship to taste perception and food selection. Ann N Y Acad Sci. 2009;1170: 126–39.
62. Tepper BJ, and Barbarossa I T. (2020). Taste, Nutrition, and Health Nutrients, 12, 155; doi:10.3390/nu12010155.
63. Turner A, Veysey M, Keely S, et al. (2018) Interactions between bitter taste, diet and dysbiosis: Consequences for appetite and obesity. Nutrients 10: 1336.
64. Vignini A, Borroni F, Sabbatinelli J, Pugnaloni S, Alia S, Taus M, Ferrante L, Mazzanti L, and Fabri-Hindawi M. (2019). General Decrease of Taste Sensitivity Is Related to Increase of BMI: A Simple Method to Monitor Eating Behavior Disease Markers, 2019, Article ID 2978026, 8 pages.
65. Wang R, van Keeken N M. A, Siddiqui S, Dijksman LM., Maudsley S, Derval D, van Dam P. S and Martin B. (2014). Higher TNF-a, IGF-1, and leptin levels are found in tasters than non-tasters. Frontiersin Endocrinology | Diabetes.5, Article 125.
66. Yücel F, Akdoğan I, Güven G, Ortuğ G. (2002). SEM examination of the dorsal lingual papillae of pregnant rats. Ann Anat. 184(3):251–255.