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"Assessment of Gustatory Expression Patterns and Their Genetic and Hormonal Correlates Among Perimenopausal Women"

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KEYWORDS

Gustatory dysfunction, menopause, estrogen, taste perception, genetics, perimenopause.

ABSTRACT:

Background:

Taste perception plays a vital role in nutrition and quality of life. Hormonal variations during perimenopause, particularly estrogen decline, are known to influence gustatory function. However, the interaction between age, genetic sensitivity, and chemical taste perception remains underexplored.

Aim:

To evaluate gustatory expression patterns among women of different age groups and assess the influence of hormonal and genetic variations on taste perception.

Methods:

Eighty female participants were categorized into four age-based groups. Taste perception was assessed using standardized strips containing phenylthiourea (PTC), thiourea, sodium benzoate, and control paper. Tongue and palate perception, detection time, taste preference, and genetic taste sensitivity were evaluated. Statistical analysis was performed using Pearson's Chi-square test with significance set at p <

0.05.

Results:

Sweet and sour were the most preferred tastes across all groups, while bitter was least preferred, particularly in older participants. Significant age-related differences were observed for phenylthiourea ($p = 0.006$) and thiourea ($p = 0.014$) perception, with progressive delay and reduced detection in older groups. Tongue perception ($p = 0.002$), combined tongue–palate perception ($p = 0.000$), and genetic taste classification ($p = 0.001$) also showed significant age-related variation. A shift from dominant supertaster profiles in younger groups to normal taster profiles in older individuals was observed.

Conclusion:

Gustatory function declines progressively with age and is influenced by both hormonal changes and genetic predisposition. Taste assessment using chemical strips may serve as a simple, non-invasive tool for early detection of hormonal variations and sensory decline in perimenopausal women.

Introduction

Taste is a vital chemosensory modality essential for survival, nutrient selection, and overall quality of life. It shapes eating behavior, contributes to nutritional intake, and acts as a warning system for harmful substances. The human gustatory system includes approximately 2,000 to 5,000 taste buds located on the tongue, soft palate, and oropharyngeal mucosa. These taste buds mediate the five basic taste qualities: sweet, sour, salty, bitter, and umami, each processed through distinct receptor mechanisms.[1-8]

Taste transduction occurs via specialized epithelial cells within taste buds, which include Type I (supporting), Type II (receptor), and Type III (presynaptic) cells. Presynaptic cells are primarily involved in sour taste detection, while G-protein-coupled receptors (GPCRs) mediate sweet, bitter, and umami perceptions. Interestingly, salt taste receptor mechanisms remain less defined. Taste buds are not static units; they interact with salivary components and secrete synaptic, autocrine, and paracrine transmitters that contribute to gustatory signaling. These neurotransmitter variations are influenced by physiological states, notably menopause, which may alter taste response profiles in women.[9-15]

Hormonal changes—particularly the decline in estrogen during menopause—profoundly influence taste perception. Estrogens exert their effects through estrogen receptors (ERs), primarily ERα and ERβ. Although ERα is typically not expressed in healthy oral tissues, it can be induced under inflammatory conditions. ERβ, however, is consistently detected throughout the gingival and buccal mucosal epithelium, except the superficial squamous layer. This receptor- mediated modulation affects epithelial proliferation, keratinization, and mucosal integrity. As estrogen declines during menopause, oral epithelium becomes thinner and more prone to inflammation, contributing to oral discomfort and gustatory dysfunction.[15-22]

Saliva plays an equally critical role. It acts as a solvent for tastants, a medium for enzymatic activity, and a barrier against microbial insults. Estrogen also influences salivary composition; studies have shown that the menstrual cycle, pregnancy, and hormone replacement therapy (HRT) alter salivary flow, viscosity, and pH. These changes affect the delivery and interaction of tastants with receptors, especially under menopausal conditions where reduced saliva and altered mucin content are common.[23]

Of particular interest is Mucin 1 (MUC1), a large transmembrane glycoprotein expressed in the salivary glands and oral epithelial surfaces. MUC1 plays a structural and signaling role: it anchors salivary proteins, maintains mucosal hydration, and forms part of the epithelial defense. Its extended glycan chains facilitate muco-adhesion, allowing the salivary pellicle to bathe taste buds and preserve receptor sensitivity. MUC1 also functions as a sensory transducer—environmental stimuli cause ligand-mediated cleavage, activating its

cytoplasmic domain and initiating intracellular signaling. Altered MUC1 expression has been associated with conditions such as burning mouth syndrome and dry mouth, both prevalent among menopausal women.[24-26]

Genetic factors further modulate taste sensitivity. Polymorphisms in taste receptor genes such as TAS2R38 influence bitter taste perception (e.g., response to phenylthiocarbamide). Individuals carrying specific alleles are categorized as non-tasters, medium tasters, or supertasters, each demonstrating varying dietary preferences and health risks. These genetic variations, when combined with hormonal shifts, create a complex profile of gustatory response, particularly relevant in perimenopausal populations.[27]

Despite preserved taste perception on the tongue, studies indicate a notable decline in palatal sensitivity in postmenopausal women. Reduced sensitivity to sweet compounds like sucrose correlates with reported dietary changes, including decreased preference for carbohydrate-rich foods.[25-28]

Taken together, the interplay of hormonal decline, altered mucosal and salivary physiology, genetic variability, and taste receptor plasticity presents a compelling framework for understanding gustatory dysfunction in perimenopausal women. Exploring these changes not only enhances clinical diagnostics but also contributes to targeted nutritional and therapeutic interventions.

the assessment method employed in this study is simple, minimally invasive, cost-effective, and time-efficient, making it a practical tool for early detection of hormonal fluctuations. Such diagnostic approaches can support timely clinical interventions aimed at improving quality of life and nutritional well-being in this population.

METHODOLOGY AND MATERIALS

1. Study Design

This study employed a cross-sectional, comparative design to investigate variations in taste perception across different age groups, with a focus on menopausal status in female participants. The research assessed general taste perception, specific taste detection (sweet, salty, sour, bitter), and genetic predispositions related to taste sensitivity.

2. Participant Selection

Participants were divided into two primary age groups: premenopausal and postmenopausal women. All participants provided informed consent before enrollment. Inclusion criteria involved self-reported health status and absence of conditions or medications known to affect taste perception. A detailed menstrual and medical history was also obtained.

3. Questionnaire

A structured questionnaire was used to assess subjective taste perception, mouth sensations, and menopause-specific symptoms. The questionnaire was divided into three parts:

Table:01 Questionnaire Structure

Section	Question
a. General Questions	1. Menstrual history
	2. Experience of taste loss (onset and duration)
	3. Presence of any triggering events
	4. Changes in temperature sensation in the mouth
	5. Salivation issues
b. Specific Taste Questions	1. Can you perceive the sweetness of ice cream?
	2. Are you able to detect the saltiness of potato chips?
	3. Can you identify the sourness of lemons?
	4. Are you able to taste the

Section	Question
	bitterness of coffee?
	5. Which taste do you prefer the most?
c. Menopause-Related Questions	1. Duration of amenorrhea
	2. Perception of taste intensity before vs. after menopause
	3. Changes in dietary habits following menopause

4. Genetical Assessment

Participants underwent genotype analysis for taste perception using standard phenotype-genotype correlations based on their ability to detect substances such as PTC (Phenylthiocarbamide), Thiourea, and Sodium Benzoate.

TABLE 02 **Genetical Assessment**

Taster Type	Genotype	Taste Perception Profile
Normal Tasters	_____	Cannot taste differences in any of the tested compounds
Standard Supertasters	__s	Can taste PTC
Recessive Supertasters	ss	Can taste PTC and Thiourea, but not Sodium Benzoate
Dominant Supertasters	S __	Can taste PTC, Thiourea, and Sodium Benzoate

5. Taste Testing

Each participant was exposed to standard concentrations of four basic taste substances (sweet, salty, sour, and bitter) under controlled conditions using commercially available taste strips. **Strip A served as the control paper strip**, designed to assess baseline oral sensory response and exclude false-positive taste perception.

The chemical markers employed included **Strip B (Phenylthiourea – a bitter taste marker commonly used to assess genetic sensitivity to bitterness), Strip C (Thiourea – a bitter sensitivity marker reflecting intermediate bitter receptor responsiveness), and Strip D (Sodium Benzoate – a salty/savory taste marker used to evaluate sodium-related taste perception)**.

Participants were instructed to refrain from eating, drinking (except water), smoking, and using oral hygiene products for at least one hour prior to testing. Each strip was placed sequentially on the tongue and palate under standardized conditions. Subjects were asked to identify the perceived taste quality and rate the intensity using a Likert scale. The time to taste perception was also recorded to assess detection latency. All assessments were conducted under uniform lighting and environmental conditions to minimize external sensory bias.

6. Statistical Analysis

Data were analyzed using **SPSS version 21.0**. Descriptive statistics summarized demographic and clinical data. **Pearson's Chi-Square test** was used to compare categorical variables, such as taste perception between pre- and postmenopausal groups. Statistical significance was considered at **$P < 0.05$**.

RESULTS

A total of 80 female participants were enrolled and categorized into four age-based groups: Group A, Group B, Group C, and Group D. The distribution of participants across the four groups was comparable, ensuring balanced representation for age-based comparison. Taste preference, perception, and genetic sensitivity were assessed using standardized chemical taste strips containing phenylthiourea (PTC – bitter taste marker), thiourea (bitter sensitivity marker), sodium benzoate (salty/savory marker), and a control paper strip. All participants completed the protocol, and no missing data or adverse events were recorded during the study.

Taste Preference Patterns (Graph 01)

Analysis of preferred taste among the four groups revealed that sweet and sour were the most favored tastes across all age categories. Group A demonstrated the highest preference for sweet, followed by sour. Group B showed comparable preference for sweet and sour, with moderate inclination towards salty taste. Group C exhibited a higher preference for sour compared to other tastes. Group D displayed the highest preference for sour taste and a complete absence of preference for salty taste. Bitter taste was the least preferred across all groups, with minimal representation particularly in Groups C and D.

Taste Perception Using Strip A (Control) (Graph 02)

Taste perception using Strip A, which served as the least reactive or control stimulus, showed uniformly low response across all groups. The majority of participants in Groups A, B, C, and D reported no taste perception. A very small proportion of participants in Groups B and D detected taste at 10 seconds, while Group C showed minimal perception beyond 20 seconds. Statistical analysis demonstrated no significant association between age group and taste perception for Strip A (p = 0.417).

Taste Perception Using Strip B – Phenylthiourea (Graph 03)

Significant variation in taste perception was observed with Strip B containing phenylthiourea (PTC). Group A exhibited the highest sensitivity, with more than half of participants perceiving taste at 20 seconds. Group B showed detection at both 20 and >20 seconds. Group C demonstrated moderate perception, while Group D had the highest proportion of participants reporting no taste perception. The association between age group and perception of Strip B was statistically highly significant (p = 0.006). Mean detection time showed a progressive increase from Group A to Group D, indicating delayed gustatory response with advancing age.

Taste Perception Using Strip C – Thiourea (Graph 04)

Strip C, containing thiourea, revealed progressive decline in taste sensitivity with increasing age. Group A showed maximum detection, predominantly at 20 seconds, followed by Group B. Group C exhibited a wider distribution of detection times, whereas Group D demonstrated delayed and reduced perception, with most responses occurring beyond 20 seconds or not detected at all. The association between age and perception of Strip C was statistically significant (p = 0.014). A similar age-related increase in mean detection time was observed for this strip.

Taste Perception Using Strip D – Sodium Benzoate (Graph 05)

Taste perception using Strip D impregnated with sodium benzoate showed highest detection in Group A, followed by Group B. Group C exhibited variable responses, while Group D had the highest proportion of participants reporting no taste perception. However, the association between age group and taste perception for Strip D was not statistically significant (p = 0.271).

Perception on the Tongue (Graph 06)

Assessment of taste perception localized to the tongue demonstrated a significant decline with increasing age. Group A showed a balanced distribution between presence and absence of perception. In contrast, Group B showed nearly complete absence of tongue perception. Groups C and D also demonstrated predominantly absent perception, with Group D showing approximately 90% absence. This association was statistically significant (p = 0.002).

Combined Perception on Tongue and Palate (Graph 07)

When perception on both tongue and palate was evaluated, Groups A, B, and C exhibited complete perception in all participants. In contrast, Group D showed reduced combined perception, with only 65% reporting perception and 35% reporting absence. This difference was highly statistically significant (p = 0.000).

Genetic Taste Sensitivity Assessment (Graph 08)

Genetic taste sensitivity was categorized based on responses to phenylthiourea, thiourea, and sodium

benzoate into Normal Tasters, Standard Supertasters, Recessive Supertasters, and Dominant Supertasters. Groups A and B demonstrated a high prevalence of Dominant Supertasters. Group C showed a mixed distribution, including Recessive Supertasters. Group D showed a shift toward Normal Tasters with a marked reduction in Dominant Supertaster profiles. This association between age group and genetic taste classification was highly statistically significant (p = 0.001), with a moderate to high effect size observed.

Overall Statistical Summary

Overall, statistically significant age-related differences were observed for taste perception using phenylthiourea and thiourea strips, tongue perception, combined tongue-palate perception, and genetic taste classification, indicating a progressive decline in gustatory function with advancing age.

DISCUSSION

The present study evaluated gustatory perception, taste preference, and genetic taste sensitivity across different age groups, with special emphasis on perimenopausal women. The findings demonstrate a clear age-related alteration in taste perception, with statistically significant differences observed for phenylthiourea (PTC), thiourea, tongue perception, combined tongue–palate perception, and genetic taste classification. These results support the growing body of evidence that gustatory function is influenced not only by aging but also by hormonal and genetic factors acting in concert.[19,25]

The preference pattern observed in this study, with sweet and sour emerging as the most favored tastes across all age groups, is consistent with earlier reports indicating that these taste modalities are relatively preserved with aging. Mojet et al. demonstrated that threshold sensitivity for sweet and sour remains comparatively stable across age groups, whereas bitter and salty perceptions show greater variability and decline.[25] Similarly, Yoshinaka et al. reported that older adults retain relatively better sour perception compared to other modalities.[19] However, the progressive decline in bitter and salty taste preference observed particularly in Group D in the present study suggests selective sensory deterioration rather than uniform gustatory loss. This selective impairment supports the concept that aging does not affect all taste qualities equally, a phenomenon widely described in geriatric sensory research.[25]

The minimal response observed with Strip A across all groups validates its function as a control stimulus and confirms the reliability and internal consistency of the test methodology. In contrast, Strips B and C, impregnated with phenylthiourea and thiourea respectively, demonstrated significant age-related differences. Younger participants exhibited faster and more frequent detection, while older individuals showed delayed or absent perception. These findings are consistent with prior studies indicating that bitter taste sensitivity declines with advancing age. Alves et al., in a systematic review and meta-analysis, concluded that older adults require higher concentrations of tastants, particularly bitter compounds, to elicit perception.[29]

The decline in bitter taste sensitivity may be attributed to several physiological mechanisms, including reduced taste bud density, degeneration of gustatory nerve fibers, and altered expression of bitter taste receptors (TAS2Rs).[27,31] Brown et al., using *Drosophila melanogaster* as a model, demonstrated that aging selectively impairs sweet taste detection while preserving certain fatty acid responses, suggesting modality-specific neural vulnerability.[30] This selective vulnerability aligns with the observed reduction in PTC and thiourea perception in the present study.

The increased mean detection time observed in older groups for PTC and thiourea further emphasizes the physiological delay in sensory processing associated with aging. Delayed gustatory response has been linked to diminished cortical activation in gustatory and attentional brain regions, as demonstrated by Veldhuizen et al.[31] This delayed response is clinically relevant, as it may influence food choices, appetite regulation, and overall nutritional status in perimenopausal and postmenopausal women.[24,34]

Taste perception using sodium benzoate (Strip D) did not show statistically significant variation across age groups. This suggests that certain taste modalities, particularly salty or savory sensations, may be relatively preserved or influenced by compensatory mechanisms such as central sensory processing or long-term dietary

habituation. Similar findings were reported by Mojet et al., who observed that salt perception exhibits greater interindividual variability and is less predictably affected by aging than bitter taste.[25]

The significant reduction in tongue perception and combined tongue–palate perception in Group D highlights the widespread nature of gustatory decline, extending beyond localized receptor dysfunction to broader oral sensory impairment. These findings corroborate previous observations that palatal taste sensitivity is particularly affected in postmenopausal women. Delilbasi et al. and Dangore-Khasbage et al. demonstrated significantly reduced gustatory function in postmenopausal females compared to age-matched controls, attributing these changes to estrogen deficiency.[18,9]

Hormonal changes during menopause are known to influence oral mucosal integrity and salivary composition. Estrogen plays a crucial role in epithelial turnover, vascularization, and salivary gland function.[10,11,12,22] The decline in estrogen levels leads to thinning of oral epithelium, reduced salivary flow, and altered mucin composition, all of which compromise tastant solubilization and receptor interaction.[13,14,24] Pushpass et al. demonstrated that reduced mucin binding and glycosylation in older adults significantly impairs taste function, reinforcing the role of salivary components in gustatory perception.[24]

The genetic assessment in the present study revealed a marked shift from dominant supertaster profiles in younger groups toward normal taster profiles in older individuals. This suggests that although genetic predisposition plays a crucial role in taste sensitivity, its phenotypic expression may be modulated by aging and hormonal changes. Alves et al. reported that polymorphisms in TAS2R38 strongly influence bitter taste sensitivity and are associated with dietary behavior and dental caries risk.[32] Smith et al. further demonstrated that genetic variants related to sweet taste perception significantly correlate with food intake patterns, emphasizing the interaction between genotype and dietary behavior.[33]

The reduced prevalence of dominant supertasters in Group D aligns with the observed functional decline in bitter taste perception and supports the hypothesis that aging influences not only sensory reception but also gene–environment interactions related to taste. This modulation may result from reduced receptor expression, impaired signal transduction, or diminished peripheral neural transmission associated with aging.[27,31]

From a clinical perspective, these findings have significant implications. Gustatory dysfunction may contribute to altered dietary habits, reduced appetite, poor nutrition, and diminished quality of life in perimenopausal women. Zhu et al. reported that adults experiencing age-related decline in taste function had a 47% higher risk of all-cause mortality, with loss of salt and sour perception being particularly predictive.[34] This highlights the importance of early detection and intervention.

Early identification of taste alterations using simple, non-invasive chemical strips, as employed in the present study, may serve as a valuable screening tool for detecting hormonal variations and guiding dietary or therapeutic interventions. Such tools are cost-effective, time-efficient, and suitable for routine clinical use, particularly in resource-limited settings.[26]

Overall, the present study reinforces the multifactorial nature of gustatory decline, involving physiological aging, hormonal changes, and genetic modulation. It underscores the importance of incorporating taste assessment into routine oral and systemic health evaluation in middle-aged and older women. Integrating gustatory screening into preventive healthcare protocols may facilitate early diagnosis of sensory dysfunction, improve nutritional counseling, and ultimately enhance quality of life in perimenopausal and postmenopausal populations.

Conclusion

The present study demonstrates that gustatory function undergoes significant age-related changes, particularly in bitter taste sensitivity, oral perception, and genetic taste expression. Sweet and sour tastes remain relatively preserved, whereas perception of phenylthiourea and thiourea declines markedly in older age groups, accompanied by delayed detection and reduced oral sensory response.

Genetic profiling revealed a shift from dominant supertaster phenotypes in younger women toward normal taster profiles in older individuals, indicating that aging and hormonal changes modulate the phenotypic expression of genetic taste sensitivity. The observed decline in tongue and combined tongue–palate perception further confirms the widespread nature of gustatory impairment in perimenopausal women.

These findings highlight the importance of incorporating gustatory evaluation into routine oral and systemic health assessments for middle-aged and older women. The use of standardized chemical taste strips offers a practical, non-invasive, and cost-effective approach for early detection of sensory and hormonal changes, with potential implications for nutritional counseling, preventive healthcare, and quality-of-life improvement.

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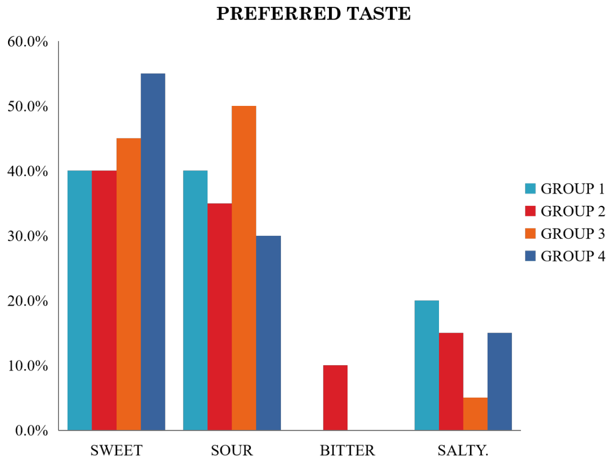
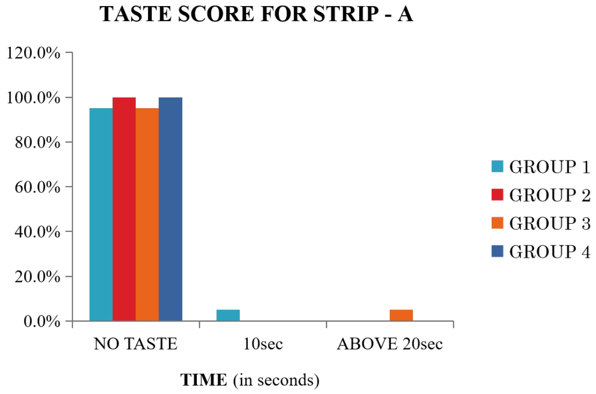
GRAPH 01 – Preferred Taste

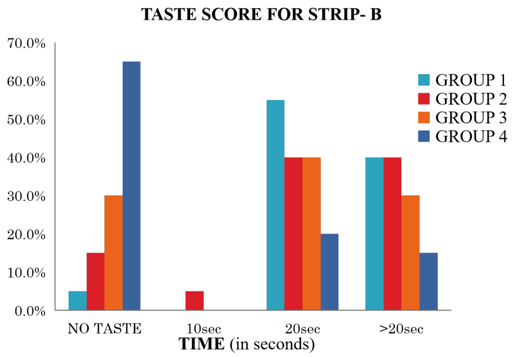


GRAPH 02-“*TASTE SCORE FOR STRIP - A*”



Inference:
p-value 0.417 > 0.05 - no significant association between age groups and strip A

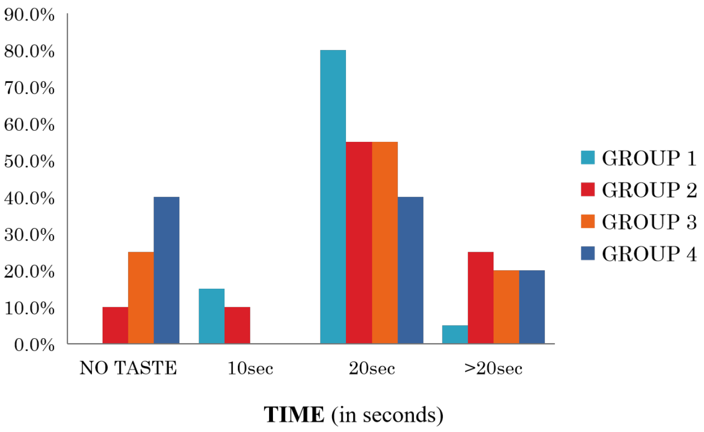
GRAPH 3-“*TASTE SCORE FOR STRIP - B*”



Inference:
p-value 0.006 <0.01 - Highly significant association between age groups and strip B

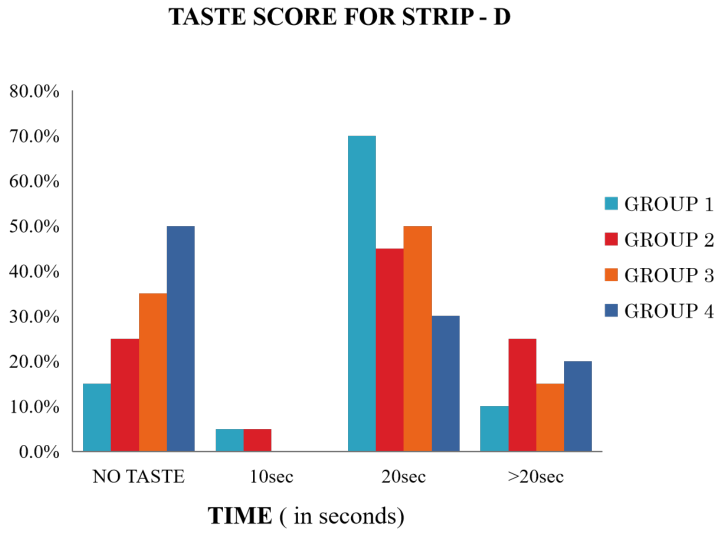
GRAPH 04-"TASTE SCORE FOR STRIP - C"

TASTE SCORE FOR STRIP - C



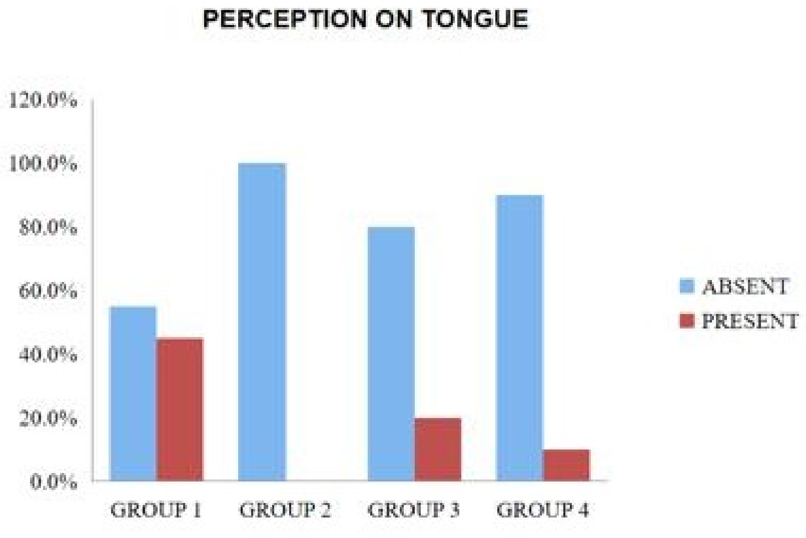
Inference:
p-value 0.014 <0.05 indicate significant association between age groups and strip C

GRAPH 05 "TASTE SCORE FOR STRIP - D"



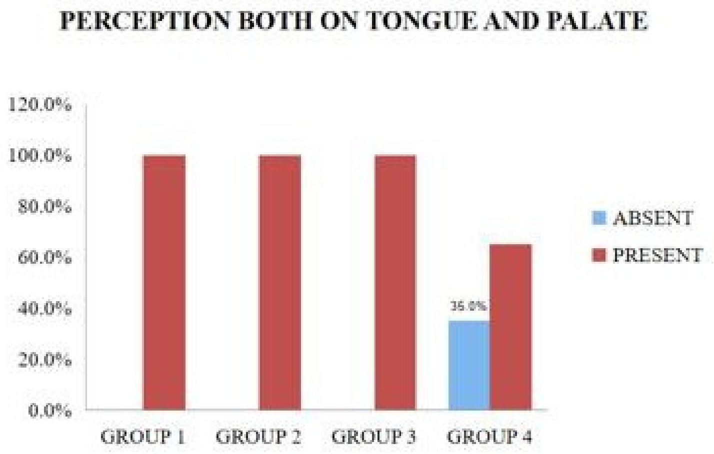
Inference:
p-value 0.271 > 0.05 - no significant association between age groups and strip D

GRAPH 06 "PERCEPTION ON TONGUE"



Inference:
p-value 0.002 > 0.05 - significant association between age groups and perception on tongue.

GRAPH 07 "PERCEPTION BOTH ON TONGUE AND PALATE"



Inference:
p-value 0.000 < 0.05 – highly significant association between age groups and perception both on tongue and palate.

GRAPH 08

"GENETICAL ASSESSMENT"