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ORAL TASTE RECOGNITION IN HEALTH VOLUNTEERS

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ABSTRACT – ***Context*** - Taste food recognition has an important role in the nutritional conditions and also allows protection of the organism integrity against foods potentially dangerous. ***Objective*** - To investigate the presence of the selective taste regions on the tongue and also the palate participation in the oral taste definition. ***Methods*** - A standard tongue divided in six regions was exposed with the four basic tastes (sweet, salted, sour and bitter), 10 times each. Thirteen volunteers were studied from both side and 34 only from one side, performing 240 tests with opened mouth and 240 with closing mouth, just after tongue sapid stimulation. A second group, with 12 volunteers, had its taste recognition studied, with and without palate isolation, using silicone prosthesis (n = 120). ***Results*** - From results, chi-square (3×2) and (2×2), nonparametric independency test with $P = 0.05$ were obtained. ***Conclusions*** - Anterior, medium and posterior regions of the tongue, at both sides, had the same taste discriminative capacity. Nevertheless, closed mouth increased immediate and late recognition capacity by palate participation. It was possible to admit that palate participation increase the sapid perception in the mouth, by recruitment of the palate taste receptors and also by fluid compression and its scattering over tongue surface.

HEADINGS – Deglutition. Taste. Tongue. Palate.

INTRODUCTION

The oral cavity is the natural door of the body intake. It is able to prepare, qualify, organize and eject the food bolus to pharynx[5].

Into the mouth foods activate not only taste but also thermal and mechanic reception. The association of these perception with others, like smell, will create the flavor sensation[9]. Gustation not only contribute with taste identification. It give subjacent information about food composition allowing regulation of somatic and visceral mechanisms related with swallowing and digestion[19].

At least four distinct kind of perception must be highlighted in the oral cavity. Mechanic-reception, thermal-reception, nosci-reception and chemical-reception[5, 18].

The mechanic perception inform about consistency, viscosity and volume required to inform the necessary motor units depolarization to obtain the appropriate mechanical efforts to sustain the swallow process (mastication and oral food transference). Thermo perception inform the temperature of solids and liquids. This kind of reception give the temperature threshold between the pleasure sensation or acceptable and uncomfortable or harmful. Nosci-reception is the perception of pain sub-modality usually transmitted by free terminal of sensorial nerve submitted to very hard mechanic, thermal or chemical stimuli. Chemo-receptors, allows the sapid qualification. Although aided by visual inspection and smell, taste is the sensory function primary responsible to qualify the food to be ingested[9, 18, 20, 33].

Recently, it was described the phenomenon by means of which some individuals perceive taste sensations after thermal stimulation of small areas of the tongue[1]. It was already show that heating or cooling small areas of the tongue can in fact cause sensations of taste. Warming the anterior edge of the tongue from a cold temperature can evoke sweetness, whereas cooling can evoke sourness and/or saltiness[6].

The taste function has an important role in the nutritional maintenance conditions in the organism[7, 28]. The taste allows to distinguish among others those foods potentially dangerous to the organism integrity[15, 21].

Many different chemicals can stimulate taste receptor activity. Even though, sweet, salt, sour, and bitter were considered the four basic tastes[3, 8, 10, 26, 32]. Besides others, metallic, astringent and more recently a taste of monosodium glutamate (umami) have been also suggested as primary taste[1, 19, 20, 21]. There is not much clear whether and how the association of sweet, salt, sour, and bitter can appropriately describes all gustatory perceptions but they have resisted as the four valid basic tastes along of the time[21].

A classic description considered our ability to taste perception as the result of the activation of taste receptors cells in the tongue[26] and point the tastes areas as three bilateral and sequential regions able to discriminate with larger specificity the four basic tastes

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(sweet, salt, sour and biter)[3, 8, 10, 12, 26, 28, 32]. Nevertheless this classic concept was already contested. The tongue would be able to realize all tastes in all regions[20].

The tastes buds are specially located in relation with tongue papillae. Scattered throughout the filiform papillae, in great number at the tip and lateral margins of the tongue dorsal surface, are several mushroom shaped small projections, fungiform papillae, each one related with few taste buds.

At the side of the base of the tongue there is a localized area with a series of folds denominated as foliate papillae. Between the folds, a deep clefts are lined with epithelium, showing a lot of tastes buds embedded in them. Lie at the posterior third of the tongue there are a few circular and large papillae in a V-shaped formation; each one surrounded by a expressive cavity where there are several tastes buds. Nevertheless, various similar corpuscle were found in the palate, vallecula, epiglottis, pharyngeal wall and also in the larynx[12, 17, 21, 22, 28, 30]. When in the pharynx and larynx the admitted function are related with aspiration protection[29].

It was already said that no taste perception could be demonstrated on the hard palate except in the region close to the border between the hard and soft palate, where the threshold values were very high compared with those for the soft palate[22]. Taste buds have been found in the palates of fetuses and newborn but there is some uncertainty in the literature about taste buds permanence in the palate of the human adult. Nevertheless, clinical studies have demonstrated taste perception in the palate of the human adults and, from biopsies, one or two taste buds were already found on subjects aged between 25 and 44 years old[23].

The tongue afferent innervations are done, in its posterior third, by glossopharyngeal nerve responsible for taste and general sensibility. The two anterior thirds, by facial nerve, responsible for taste conduction and trigeminal one, responsible for its general sensibility[3, 4, 19, 26, 32].

Each taste bud is connected with the terminals of sensory nerve fibers belong to three different cranial nerves, connected to the brain[26]. For most of taste buds on the soft palate and towards the front of the tongue come from *chorda tympani* a division of the facial nerve. Nevertheless, Ikeda et al.[14] consider the gustatory function of the soft palate independent of the tongue and innervated by the greater petrosal nerve also a branch of facial nerve. Glossopharyngeal innervate taste buds in the back of the mouth and vagus nerve in the vallecula and pharynx[4, 8, 21, 31].

Nutrition and swallowing are influenced by gustative integrity. The importance of this function justify the several gustative tests proposed in the clinical investigation.

Electrogustometry, widely used, is especially useful in estimating the efficiency of sensory pathways through the observation of electric excitability thresholds response determined by irritation of taste buds area with electrical current of different intensity. However, to examine taste sensitivity more laboriously, the application of sapid substances has the advantage to be the physiological stimuli[16]. Some tests were applied to analyze the tongue surface several areas using separately the four sapid solution throughout pipette, filter paper or swab[2, 13, 27]. Other tests aiming to reproduce the everyday experience in the sapid qualification employ pastilles[12, 22] or flavored wavers made from flour and water with the four basic tastes[13].

In the present study we have two basic aims. The first was to investigate, using the four basic sapid solution, the presence of the selective taste areas on the tongue and the second if there are palate participation in the taste definition.

METHODS

This study has been developed in full agreement with the ethical guidelines proposed by the World Medical Association (WMA, declaration of Helsinki, 1995, amended by the 52nd WMA General Assembly, Edinburgh, UK, October, 2000). Our protocol was previously approved by the Ethics Committee for Scientific Investigation of the Federal University of Rio de Janeiro (UFRJ), RJ, Brazil, and all volunteers gave their informed consent to participate.

It were studied, in two groups, 59 healthy adults from both sexes. The first group was formed with 47 individuals 34 women and 13 man from 18 to 35 years old. A second group with 12 individuals was formed by 8 woman and 4 man from 20 to 27 years old.

The 47 individuals of the first group were submitted to taste experiment involving the four basic tastes (sweet, salted, sour and bitter) over three or six tongue regions with opened mouth (OM) (procedure 1) and closed (procedure 2).

A standard tongue was built with each one of the six regions being exposed 10 times for each one of the four basic tastes. Thirteen volunteers were studied from both side and 34 from left or right side performing 240 tests in the procedure 1 and 240 in the procedure 2.

The used solutions were composed by deionizers water and saccharose - 0,7 Mol (sweet); sodium chloride - 0,9 Mol (salted); acetic acid - 0,3 Mol (sour); quinine sulfate - 0,01 Mol (bitter). With analytic pipette Gilson P 200, 25 μL of each solution was dripped, in distinct times, over each one of the six regions defined in the tongue: RP = right posterior region; RM = right medium region; RA = right anterior region; LP = left posterior region; LM = left medium region; LA = left anterior region. The six tongue regions do not correspond to enervation by each of the cranial nerves sub-serving taste. They intent to reproduce the classic concept of the anterior, medium and posterior tongue gustative areas. Before and after each trials a copious rinse with deionized water was used (Figure 1).

The procedure 1 implied in taste recognition with the OM and the tongue gently kept out of the mouth. The procedure 2 implied in the tongue internalization after sapid solution exposition. The taste recognition were done with closed mouth (CM). The procedures were done in the sat down position. The volunteers were oriented to indicate the recognized taste choosing a card with taste designation as soon as possible. The answers were register by procedures, region, kind and time of identification.

Time were controlled by digital chronometer for two observer. The identification were defined as immediate

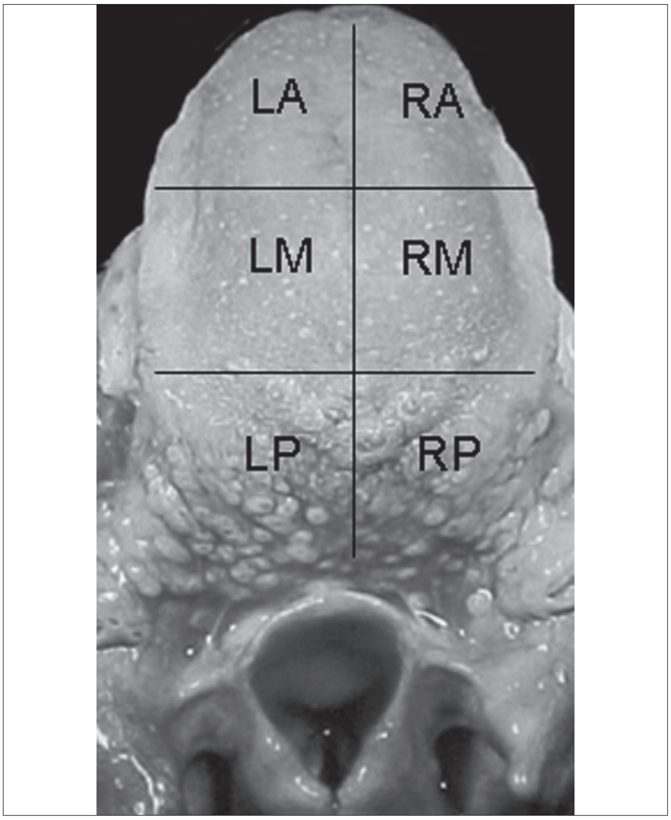

FIGURE 1. Back tongue superior view show the right and left regions tested with the four basic flavor were RP = right posterior region; RM = right medium region; RA = right anterior region; LP = left posterior region; LM = left medium region; LA = left anterior region

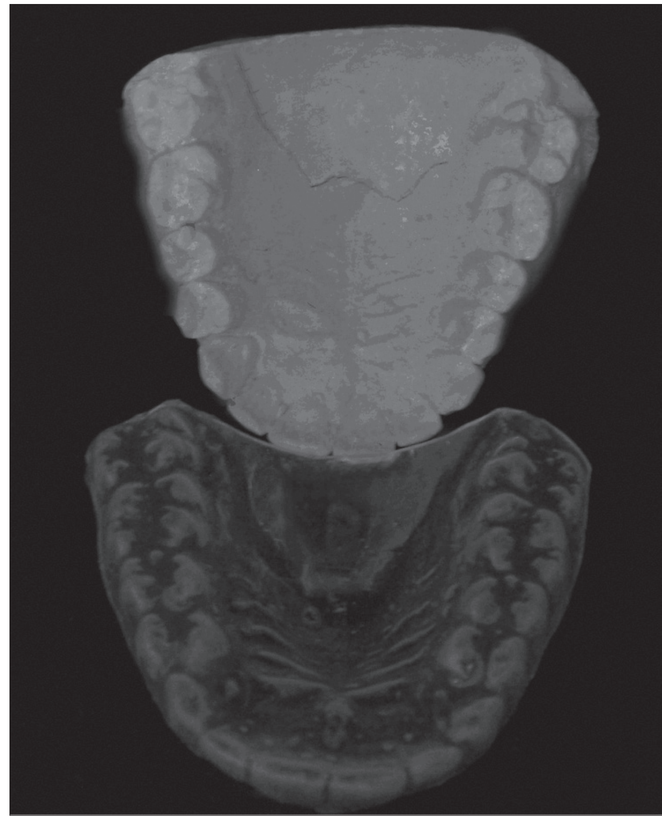
FIGURE 2. Sample of plaster mold (up) and derived silicone prosthesis (down) used to isolate the palate

recognition when the correct taste is identified in 3 or less seconds. Late recognition when the correct recognition time was greater than 3 and less than 7 seconds. Not recognition, when the taste were not identified or the answer, right or wrong, were done after 7 seconds. Wrong identification, when the pointed taste, until the limit of 7 seconds, did not correspond to that offered.

The second group procedure (12 individuals) implied in the tongue internalization after 25 μL of each sapid solutions, were dripped near the midline on the median region of the tongue. The taste recognition were done with CM in two distinct condition, with and without palate isolation with silicone prosthesis. In this group 25 μL of insipid fluid (deionizers water) was also tested.

The silicone prosthesis for palate isolation for each volunteers were obtained by modeling of the superior arcade and palate with alginate to generate plaster mold. The laminar silicone prosthesis were built over mold and allows to isolate the palate of the tongue during taste study (Figure 2).

The second group was also observed in sat down position. The volunteers were oriented to indicate the recognized taste choosing a card with taste designation as soon as possible. The answers were register by kind and time of identification following the same methodology used in the group 1.

The results are presented in the tables from where chi-square (3×2) and (2×2) nonparametric independency test with P = 0.05 were derived. The chi square (χ^2) nonparametric tests were obtained with Statistica for Windows, StatSoft, Inc. (1996) (http://www.statsoftinc.com) following the underwrite methodology:

1- Chi-square ($(3\times2)\chi^2_{0.05}$) non-parametric independence test involving the immediate recognition of the four basic tastes versus "not immediate recognition" represented by late recognition, not identification and wrong identification with null hypothesis with H_0 = the immediate recognition of flavors is independent of the tested tongue region.
2- Chi-square ($(3\times2)\chi^2_{0.05}$) non-parametric test involving the four basics tastes recognition (immediate and late recognition (versus taste not recognition (not identified and wrong identification) with null hypothesis H_0 = the recognition of tastes is independent of the tested tongue region.
3- Chi-square (2×2) non-parametric test from Tables 1 and 2 involving the immediate recognition of basic tastes versus "not immediate recognition" represented by late recognition, not identification and wrong identification with null hypothesis asking if the immediate recognition of tastes are independent of the mouth condition (opened or closed).

TABLE 1. Answers obtained from six defined tongue regions submitted to the four basic tastes with open mouse (n = 240)

Tongue areas	Sweet				Salt				Sour				Bitter			
	I	L	NI	WI	I	L	NI	WI	I	L	NI	WI	I	L	NI	WI
RP	04	02	03	01	07	01	01	01	01	01	08	-	07	02	01	-
RM	06	-	04	-	05	-	05	-	03	02	03	02	06	01	03	-
RA	05	01	04	-	05	-	02	03	03	05	01	01	04	04	01	01
LP	07	03	-	-	05	-	-	05	04	01	04	01	07	01	01	01
LM	04	02	04	-	05	03	-	02	04	04	01	01	02	01	07	-
LA	06	02	02	-	08	01	-	01	04	03	-	03	06	03	01	-
Total	32	10	17	01	35	05	08	12	19	16	17	08	32	12	14	02
%	53.3	16,7	28,3	1,7	58,3	8,3	13,3	20	31,7	26,7	28,3	13,3	53,3	20	23,3	3,3

I = immediate recognition (≤3 seg.), L = late recognition (>3, ≤7seg.) NI = not identified (>7seg.) WI = wrong identification; RP = tongue right posterior region; RM = tongue right medium region; RA = tongue right anterior region; LP = tongue left posterior region; LM = tongue left medium region; LA = tongue left anterior region

TABLE 2. Answers obtained from six defined tongue regions submitted to the four basic tastes with closed mouth (n = 240)

Tongue areas	Sweet				Salt				Sour				Bitter			
	I	L	NI	WI	I	L	NI	WI	I	L	NI	WI	I	L	NI	WI
RP	08	02	-	-	10	-	-	-	05	01	02	02	09	-	01	-
RM	09	01	-	-	06	04	-	-	08	01	01	-	09	01	-	-
RA	06	01	02	01	09	-	-	01	09	01	-	-	08	01	01	-
LP	10	-	-	-	07	-	-	03	10	-	-	-	10	-	-	-
LM	09	01	-	-	10	-	-	-	10	-	-	-	10	-	-	-
LA	09	01	-	-	10	-	-	-	09	01	-	-	08	01	01	-
Total	51	06	02	01	52	04	-	04	51	04	03	02	54	03	03	-
%	85	10	3,3	1,7	86,7	6,7	-	6,7	85	6,7	5	3,3	90	5	5	-

I = immediate recognition (≤3 seg.), L = late recognition (>3, ≤7seg.) NI = not identified (>7seg.) WI = wrong identification. RP = tongue right posterior region; RM = Tongue right medium region; RA = Tongue right anterior region; LP = Tongue left posterior region; LM = Tongue left medium region; LA = tongue left anterior region

TABLE 3. Answers obtained from tongue median region exposition to the four basic tastes and also insipid fluid with and without palate isolated by coating (n =120)

	Sweet				Salt				Sour				Bitter				Insipid			
	I	L	NI	WI	I	L	NI	WI	I	L	NI	WI	I	L	NI	WI	I	L	NI	WI
without	12	-	-	-	09	01	01	01	11	01	-	-	06	02	02	02	03	02	04	03
with	06	05	01	-	06	03	01	02	08	02	-	02	04	04	03	01	02	05	05	-

I = immediate recognition (≤3 seg.); L = late recognition (>3, ≤7seg.); NI = not identified (>7seg.) WI = wrong identification. Without = palate exposed ; with = palate isolated by coating

4- Chi-square (2×2) non-parametric test from Tables 1 and 2 involving the recognition (immediate and late recognition) of basic tastes versus not recognition represented by not identification and wrong identification with null hypothesis asking if recognition of tastes are independent of the mouth condition (open or closed).
5- Chi-square (2×2) non-parametric test involving the immediate recognition of the four basic tastes versus not immediate represented by late recognition, not identification and wrong identification with null hypothesis asking if the immediate recognition of tastes are independent of the tongue side (left or right)
6- Chi-square (2×2) non-parametric test involving the recognition (immediate and late recognition) of the four basic tastes versus not recognition (not identification and wrong identification) with null hypothesis asking if the recognition of tastes are independent of the tongue side (left or right)
7- Chi-square (2×2) non-parametric test from Table 3 involving the immediate recognition of the four basic tastes and insipid fluid versus not immediate and also chi-square (2×2) involving recognition (immediate recognition and late recognition) versus not recognition (not identification and wrong identification) with and without palate isolated by silicone coverage.

RESULTS

During procedures we were not able to identify any considerable difference in the taste identification performance between woman and man. Bitter and candy were the taste more clearly recognized. Wrong identification occurred more frequently with salty and sour.

Table 1 organize the results obtained from tongue exposition to each one of the four basic tastes, with the mouth kept open. Table 2 gathers the data obtained with the mouth being closed immediately after tongue exposition of each one of the four basic tastes. Table 3 shows the answers obtained from tongue median region exposition to the four basic tastes and also insipid fluid with and without palate isolated by silicone coverage.

Statistical analysis from Tables 1, 2 and 3 showed that:

1. The immediate recognition of the each one of the four basic tastes were independent of the tongue right and left

tested region: with the OM (right side chi-square = 0.5013 df = 4 P<0.9734 - H_0, accepted); (left side chi-square = 4.9123 df = 5 P<0.4267 - H_0, accepted). With the CM (right side chi-square = 0.0000 df = 5 P<1.0000 – H_0, accepted), (left side chi-square = 1.8018 df = 5 P<0,8758 - H_0, accepted).

2. The recognition of the each one of the four basic tastes were independent of the tongue right and left tested region: with the OM (right side chi-square = 0.8533 df = 5 P<0.9735- H_0, accepted); (left side chi-square = 4.1379 df = 5 P<0.5297- H_0, accepted). With the CM (right side chi-square = 3.0555 df = 5 P<0.6914 – H_0, accepted), (left side chi-square = 5.1282 df = 5 P<0.4005- H_0, accepted).
3. The immediate recognition of the all four basic tastes and each one of them are independent of the open or closed mouth condition. For all four basic tastes - (Yates corrected chi-square P = 0.0000 - H_0, rejected). For sweet taste (Yates corrected chi-square P = 0.0004 - H_0, rejected). For salt taste (Yates corrected chi-square P = 0.0011 - H_0, rejected). For sour taste (Yates corrected chi-square P = 0.0000 - H_0, rejected). For bitter taste (Yates corrected chi-square P = 0.0000 - H_0, rejected).
4. The recognition of the all four basic tastes and each one of them are independent of the open or closed mouth condition. For all four basic tastes (Yates corrected chi-square P = 0.0000 - H_0, rejected). For sweet taste (Yates corrected chi-square P = 0.0008 - H_0, rejected). For salt taste (Yates corrected chi-square P = 0.0006 - H_0, rejected). For sour taste (Yates corrected chi-square P = 0.0001 - H_0, rejected). For bitter taste (Yates corrected chi-square P = 0.0027 - H_0, rejected).
5. The immediate recognition of the four basic tastes, with the mouth open or closed, is independent of the tongue side. For the OM H_0 was accepted (Yates corrected chi-square P = 0.5186). For the CM H_0, was rejected (Yates corrected chi-square P = 0.0044)
6. The recognition of the four basic taste, with the mouth open or closed, is independent of the tongue side. H_0 was accepted to the OM (Yates corrected chi-square P = 0.1696) and to the CM (Yates corrected chi-square P = 0.1096)
7. The immediate recognition and recognition to the four basic tastes and insipid fluid is independent of the palate isolation by silicone coverage. The null hypothesis was rejected to immediate recognition (Yates corrected chi-square P = 0.0101) and accepted to recognition (Yates corrected chi-square P = 0.9604).

DISCUSSION

Nilson[24] referrer no statistically significant differences in taste threshold values between women and men on human palate. The same author[25] admitted that there was a tendency to lower thresholds for women compared to men for all four tastes on human palate. Sato et al.[27] refer women more sensitive performance to sour taste on the tongue tip and to salty and bitter tastes on the soft palate. In the studied first group practically composed by 75% of women we were not able to identify any different performance in the taste identification between women and men. In this way we do not consider gender as variable.

As already observed, older subjects generally had higher taste threshold than did younger subjects[11, 24]. Yoshinaka[34] refer that taste bud and cell density in the older age groups was lower than that of the younger age groups may influence taste systems. In this paper age were not consider as variable because all the studied volunteers could be group in the same young adult level.

The used volume and concentrations of the four basic sapid solution (sweet, salt, sour and bitter) could be considered adequate to classify the basic flavors identification as immediate, late, not identified and wrong identified.

Bitter was used in solution at least 10 time less concentrated them the other three sapid used solution. Nevertheless, in all accomplished experiments, the bitter solution was able to produce similar perception when compared to that produced by the other tastes. Bitter and candy were the taste more clearly recognized. Bitter, due its smaller concentration, can be considered as the more effective basic taste in agreement with Hammond et al.[6].

Wrong identification occurred more frequently with salty and sour. When the mouth was open, the salty wrong identification frequency is 20% and sour is 13.3%. When the mouth was closed the wrong identification decreases to salty (6.7%) and sour (3.3%).

Immediate recognition (<3 sec.) and recognition (<7 sec.) capacity obtained from the six tongue regions, with opened and closed mouth shows that each region in the same condition (open or closed mouth) has the same proportional ability to identify each one of the four basic tastes. Nevertheless, when immediate recognition and recognition were analyzed comparing OM against CM, the results shows strong increase of both, immediate recognition and recognition capacity to each one of the six tongue regions for each one taste when the mouth is closed immediately after tongue sapid stimulation.

The observed results of immediate recognition and recognition capacity comparing the tongue right and left side with OM, shows similar immediate recognition and recognition capacity on both tongue side. Nevertheless, with the CM, the immediate recognition capacity was more effective in the left side with statistical significance.

Why closing mouth makes more potent tongue recognition capacity? The evident increase of immediate recognition and recognition capacity with MC allows to suppose recruitment of gustative receptors on the palate as the first hypothesis. A chemical palate contribution justified the less wrong sapid identification with CM and also the expressive increase of the immediate and late recognition of the tastes. Possibly, also explain the tongue left immediate recognition dominance over the right side. Nevertheless, it is also valid to suppose that sapid solution deposited over the tongue could be compressed between tongue and palate increasing, by fluid squeezing, the number of impressed gustative receptors on the tongue surface. In this way, the palate role would be a mechanical contribution and not chemical.

In the group 2 procedure, the taste recognition were done with CM with and without palate isolation with silicone prosthesis. In this way, the palate could be tested with and without direct contact to sapid solutions, allow to discriminate between the palate chemical and/or mechanic contribution.

The immediate recognition of the four basic tastes and insipid fluid, with and without palate acrylic coverage, shows that oral cavity accuracy to immediate recognition capacity it was dependent of palate direct exposition to tested fluid. In this way, it is licit to admit palate chemical contribution by recruitment of taste receptors already identified in young people[23]. On the other hand, late recognition capacity it was independent of palate direct exposition to tested fluids. This result allows to suppose that late recognition, with CM, could be increased by the recruitment of more quantity of taste receptors on the tongue surface determined by palate compression over tested fluid. In this way, it is possible to admit that palate contribution increase the sapid perception in the mouth by chemical and mechanic contribution.

CONCLUSION

The anterior, medium and posterior regions of the tongue, on both side, right and left, present the same discriminative capacity to identify the four basic flavors. There is no tongue region with more or less ability to discriminate the basic flavors.

The immediate and late recognition of the basic taste are increased by palate participation. It is possible to admit that oral immediate recognition were produced by stimulation of the tongue and palate taste buds. The palate participation in the late recognition is not only by taste buds stimulation on the palate. It is probably mediated by fluid squeezed between tongue and palate recruiting a more quantity of taste buds on the tongue.

Costa MMB, Santana E, Almeida J. Reconhecimento oral do gosto em voluntários sadios. Arq Gastroenterol. 2010;47(2):152-8.

RESUMO – ***Contexto*** - O reconhecimento dos gostos tem importante papel para as condições nutricionais e também para a proteção da integridade do organismo contra a ingestão de alimentos potencialmente perigosos. ***Objetivo*** - Investigar a presença na língua de regiões com capacidade seletiva para percepção dos gostos básicos e também verificar se e como o palato participa da definição dos gostos na cavidade oral. ***Métodos*** - Uma língua padrão hipotética dividida em 6 regiões teve cada umas destas, exposta 10 vezes a cada um dos quatro sabores básicos (doce, salgado, azedo e amargo). Treze voluntários tiveram sua lingual estudada dos dois lados (a direita e a esquerda) e outros 34 foram estudados somente em um dos lados, perfazendo 240 testes com a boca mantida aberta e 240 com a boca sendo fechada, imediatamente após a exposição da língua à substância sápida. Um segundo grupo com 12 voluntários teve o reconhecimento do gosto estudado com e sem o palato isolado pelo uso de uma prótese de silicone (n = 120). ***Resultados*** - A partir dos resultados, testes não-paramétricos de independência, foram obtidos qui ao quadrado (3×2) e 2×2, com $P = 0.05$. ***Conclusões*** - As regiões anterior, média e posterior da língua, dos dois lados, tem a mesma capacidade discriminativa para os gostos. No entanto, com a boca fechada e a participação do palato, ocorre expressivo aumento da capacidade discriminativa oral, com aumento das percepções, tanto da imediata quanto da tardia. Foi possível admitir que a participação do palato aumenta a percepção sápida da boca, pelo recrutamento de receptores do gosto no palato e também pela compressão e espalhamento das soluções de teste sobre a superfície da língua envolvendo maior número de receptores.

DESCRITORES – Deglutição. Paladar. Língua. Palato.

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