Consumer insight into the monosodium glutamate

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ABSTRACT. The fifth basic taste called 'umami' was recently recognized by studies related to monosodium glutamate (MSG), and this has attracted attention for enhancing the flavor of foods and because it contains only one-third the sodium of table salt, being an important option for reducing sodium intake by the population. This study evaluated the holistic perception of consumers about the MSG through the modern sensory techniques Word Association and Cata (Check All That Apply). Also a paired comparison was applied to define the consumers' gustatory perception. Two stimuli were applied on Word Association, one using the trademark Sazón/Ajinomoto and another containing only monosodium glutamate. In general, consumers associated MSG with salt, seasoning, meal and tasty. Age and stimuli caused different effects on the associations. Health-related terms were more related to older consumers. Cata results revealed the knowledge and consumption habits regarding MSG 79% of consumers perceived the umami flavor on the paired comparison.

Keywords: basic tastes, sensory analysis, enhancer, salt, umami, sodium.

Percepção do consumidor sobre glutamato monossódico

RESUMO. O quinto gosto básico conhecido por 'Umami' foi reconhecido há pouco tempo por meio de estudos relacionados com o glutamato monossódico (MSG), e este tem chamado a atenção por realçar o sabor dos alimentos e por conter apenas um terço da quantidade de sódio do sal de cozinha, sendo sua utilização importante opção para redução do consumo de sódio pela população. O objetivo desse trabalho foi avaliar a percepção holística de consumidores quanto ao glutamato monossódico por meio das técnicas sensoriais: Associação de Palavras, Cata (*Check All That Aplly*). Comparação pareada foi aplicada para descobrir a percepção gustativa dos consumidores. Dois estímulos foram aplicados na associação de palavras, um deles utilizando a marca comercial Sazon/Ajinomoto e outro apenas contendo glutamato monossódico. De forma global, os consumidores associaram MSG ao sal, tempero, refeição e sabor. A idade e estímulos provocaram efeitos diferentes nas associações. Termos relacionados à saúde apresentaram-se elencados aos consumidores com maior idade. Os resultados da Cata revelaram os conhecimentos e hábitos de consumo dos participantes no que diz respeito ao MSG. O gosto 'Umami' pelo teste de comparação pareada foi discriminado por 79% dos consumidores.

Palavras-chave: gostos básicos, análise sensorial, realçador, sal, umami, sódio.

Introduction

Salty, sweet, bitter, sour and umami are the five basic tastes, perceived in different regions of the tongue by specialized nerve receptors. Among them, umami was discovered more recently (1908 and recognized scientifically in 2000), through studies with monosodium glutamate (MSG), considered a flavor enhancer (Bellisle, 1999; Kremer, Shimojo, Holthuysen, Köster, & Mojet, 2013; Dang, Gao, Ma, & Wu, 2015).

'Umami' is a Japanese concept that means delicious, tasty. It is naturally found in salty products such as meat, fish and mushrooms. Its sensory description cannot be compared with the other tastes because it has a mix of tastes: the amino acids - glutamate and aspartame, and monophosphates - inosinate and guanylate (Baryłko-Pikielna & Kostyra, 2007; Dang et al., 2015; Singh, Hummel, Gerber, Landis, & Iannilli, 2015).

Salt (sodium chloride) is considered an essential ingredient in the development of pleasant and safe sensory products - because of its preservative power - but a reduced intake has been stimulated and became global trend due to its relationship with hypertension problems (Weiss, Gibis, Schuh, & Salminen, 2010; Campagnol, Santos, Morgano, Terra, & Pollonio, 2011; Kremer et al., 2013).

One alternative followed by Brazil since 2011 is the reduction in sodium content of food through

the National Health Plan along with the Strategic Action Plan to Combat Chronic Noncommunicable Diseases in Brazil, signed between The Ministry of Health and the Association of Food Industries (Abia). This allowed, until 2014, the removal of 7,652 tons sodium from food products. The target by 2020 is 28,562 tons salt removed, which seems possible with the advances seen so far. Products such as mayonnaise, pasta, cakes, snacks, meat products (ham, hamburger, breaded, sausage, salami and mortadella) and cookies are on the list (Nilson, Jaime, & Resende, 2012; Kopko, 2015).

According to Nilson et al. (2012), Brazilians consume, on average, 10-12 g salt per day when they should consume no more than 5 g, being 2 g of pure sodium (Weiss et al., 2010; Panouillé, Saint-Eve, Loubens, Déléris, & Souchon, 2011). In this scenario, to reduce sodium intake, another flavor enhancer is usually added to foods. The MSG has one third the sodium of cooking salt, so the use in equivalent amounts considerably reduces the amount of sodium from food. Despite the controversy that MSG is harmful –related to the Chinese restaurant syndrome, obesity and neurotoxicity - nothing has been scientifically proven. Therefore MSG is a good alternative to replace sodium in food in order to maintain flavor and palatability (Bellisle, 1999; Garrido et al., 2009; Panouillé et al., 2011; Wilkie & Phillips, 2014).

In this sense, this study aimed to evaluate the consumer perception and habits about the MSG through the modern sensory techniques called Word Association and Check All That Apply (Cata). The ability of consumers to differentiate the savory taste of umami through paired comparison was tested.

Material and methods

The tests were applied at the Food Technology Laboratory, Federal University of Technology – state Paraná, Campus of Pato Branco, to 48 consumers aged between 15 and 50 years, 20 men and 28 women. As a requirement to participate in the study, participants should not have had any contact with the discipline of Sensory Analysis.

Word association technique

To evaluate the consumer perception to monosodium glutamate, it was applied the holistic technique Word Association (WA). WA is one of the most modern and rapid techniques for sensory analysis, supported by the hypothesis that the judge being given a stimulus and asked to freely associate it with what comes to mind, it is obtained unrestricted access to the mental representations that the stimulus provides (Roininen, Arvola, & Lähteenmäki, 2006; Ares, Giménez, & Gámbaro, 2008).

In order to check for trademark influence (Sazón/Ajinomoto) on consumer perception, two stimuli were applied. A group of participants received stimulus A: 'Please write the first four words and/or phrases that come to your mind when you read: Monosodium glutamate - Sazón/Ajinomoto'. Another group received the stimulus B: 'Please write the first four words and/or phrases that come to your mind when you read: 'Monosodium glutamate'. The form containing the Word Association was delivered individually to consumers.

To avoid bias caused by a previous contact with the technique, the stimuli were presented to different groups of consumers. All associations provided by the participants were included.

Check All That Apply (Cata)

Cata analysis consists of a list of words or phrases from which the consumer, judge or respondent is asked to select which apply or respond to a question about the sample. There is also the possibility of adding non-sensory characteristics on the list, such as consumption habits, emotions and opposite terms that check the attention of the judges (Varela & Ares, 2012). To assess the knowledge and habits regarding MSG, 5 phrases were used along with their respective opposites

Paired comparison sensory test

The paired comparison sensory test was applied after Word Association and Cata to evaluate consumers umami recognition, giving two coded plastic cups (50 mL) of MSG (1.59 g L^{-1}) and salt solution (1.29 g L^{-1}) using the recognition threshold from Hong et al. (2005), asking them to circulate 'which sample represents the umami taste'.

Statistical analysis

Word Association data analysis was based on Antmann et al. (2011). All associations provided by the participants were included. Associations were grouped into different categories, which were then grouped into different dimensions. The grouping was performed by three researchers enrolled in the study. After evaluating the data, individually, they gathered to verify correlation between their rankings. The final categories and their names were determined by 'consensus' among them, considering the three independent ratings. Categories mentioned by more than 5% of the participants were included

in the analysis. The difference between stimuli was tested by t test (homogeneous variance).

On Cata data analysis was used the z test of the pair of opposite phrases. To apply a parametric test, the data were tested for normality and homoscedasticity using R 3.2.2®, also used for t-test and z-test. A multivariate correspondence analysis (CA), which is a graphical tool that explores the symmetrical structure association between variable categories (Beh, Lombardo, & Simonetti, 2011) was performed by Statistica® 12.7 to evaluate the relation between stimuli, ages and gender of the consumers.

Results and discussion

As expected, the data from Word Association sensory analysis were not normal by Shapiro-Wilk test (p-value = 3.252×10^{-6}), although the F-test indicated that the variances were homogeneous (p-value = 0.555). With all the assumptions met, it was possible to apply the parametric t-test (assuming homogeneous variances) on the data.

Table 1 shows the dimensions and categories obtained from the technique Word Association. Nine dimensions were established for the two stimuli by consensus among the three researchers who participated in the data analysis process. The dimensions were: 'trademark, flavor enhancer, hedonic, sensory attribute, health, food, attitude/behavior, study/research and leisure'.

Table 1. Differences between stimuli A and B for dimensions and categories.

Dimensions Categories	Total mention	Stimulus A	Stimulus B	T-test
Trademark		n = 24	n = 24	α = 0.05
Ajinomoto	4	0	4	0.0373*
Flavor enhancer				
Seasoning	15	11	4	0.0294*
Salt	33	16	17	0.7616
Enhancer	9	3	6	0.2769
Preservative	7	2	5	0.2285
Hedonic				
Tasty/Good/Satiety	14	8	6	0.5355
Different	6	2	4	0.3935
Sensory attribute				
Flavor	8	3	5	0.4493
Odor	3	0	3	0.0764
Taste	5	4	1	0.1630
Health				
Water retention/Pressure	4	4	0	0.0373*
Food safety	4	2	2	1.0000
Fear/Bad/Hazard	5	1	4	0.1630
Food				
Meal	14	9	5	0.2123
Popcorn	5	4	1	0.1630
Pasta/Noodles	4	3	1	0.3064
Attitude/Behavior				
Doubts	4	1	3	0.3064
Study/Research				
Chemistry/Sensory	5	1	4	0.1630
Leisure/Recreation				
House/Couch	2	2	0	0.1550
Fun/Movies	2	0	2	0.1550

*Significantly different (p ≤ 0.05). Stimulus A: Monosodium glutamate - Sazón/Ajinomoto. Stimulus B: Monosodium glutamate.

The results indicated the most cited categories for both stimuli, standing out salt with a total of 33 mentions, followed by seasoning (15), tasty (14) and meal (14). The fact that salt has been widely mentioned indicates the strong relationship of MSG with savory products and suggests its use as seasoning, judging by the number of citations of this association. This fact may be related to the existing synergy between MSG and salt, in the salty taste (Bellisle, 1999; Baryłko-Pikielna & Kostyra, 2007). The synergism between MSG and sodium (NaCl) is well established, but there is a ratio (MSG $NaCl^{-1}$) for every food that makes sodium replacement tolerable.

Kurihara and Kashiwayanagi (2000) demonstrated that the canine taste nerve responses to umami substances were truly enhanced by salts, and NaCl proved more effective than sodium phosphate on that purpose. The term satiety that appeared may be a negative idea about MSG, related to Chinese restaurant syndrome and fullness. Recent studies have shown that MSG is potentiated in protein rich-food (high energy protein food) because of the interaction of amino acids, providing satiety sensations soon after ingestion but not fullness sensation (Masic & Yeomans, 2013) unlike what was thought.

The results highlighted the power of Ajinomoto as the trademark that comes to mind when the stimulus is only MSG (mentioned by stimulus B, p ≤ 0.05). A negative cognition cited only on stimulus A was water retention, showing the concerning about health related with the trademark.

There is no other report about water retention on MSG studies, but obesity has been mentioned in many studies and perhaps this is the connection between MSG and water retention. Although recent papers (Jinap & Hajeb, 2010) have shown that glutamate did not increase food intake or induce obesity, in fact, MSG was associated with body weight gain suppression and fat deposition by Kondoh and Torii (2008). Ebert (2009) rejected the supposition based on many scientific studies with human and animals about the relationship between MSG and obesity. Nevertheless, the idea remains among consumers, which explains the negative view, mainly related to the trademark.

In contrast to the negative view, also emerged positive terms related to satiety, improvement of taste and sensory attributes. Categories as tasty, flavor enhancer and flavor, with 14, 9 and 8 citations, respectively, are worth mentioning. All the studies on MSG in food mention it as a flavor enhancer and sometimes as a texture improver, depending on the food matrix and amount used

(Bellisle, 1999; Baryłko-Pikielna & Kostyra, 2007; Masic & Yeomans, 2014; Wilkie & Phillips, 2014). The preservative category is a common mistake made by consumers, once all additives and salts are considered as food preservatives, but MSG is only considered a flavor enhancer and this is why it is not possible to replace all the salt with MSG only to reduce sodium intake.

In order to better analyze the relationship between the categories produced by stimuli and gender (Figure 1); and between stimuli and age (Figure 2), a correspondence analysis was conducted.
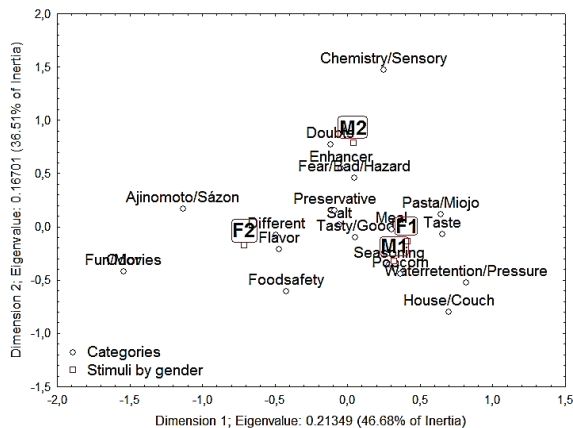
Figure 1. Correspondence analysis diagram for stimuli A and B per category and gender. F1 is stimulus 1 female, M1 is stimulus 1 male. F2 is stimulus 2 female, M2 is stimulus 2 male.
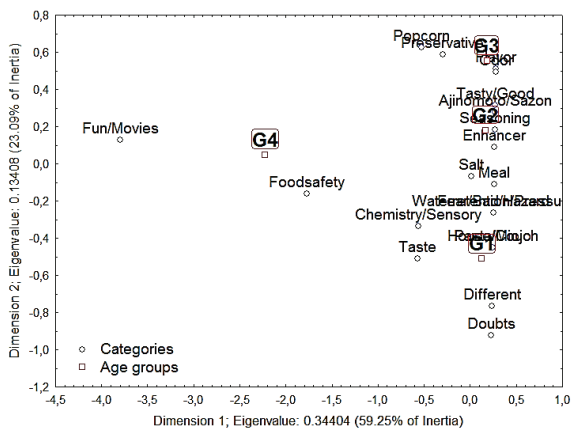
Figure 2. Correspondence analysis diagram for age groups and categories. Group 1 covers ages between 15 and 20; Group 2 covers 20-30; Group 3 covers 30-40 years and Group 4 covers 40-50.

The first two dimensions (Figure 1) described 83.19% of the association between stimulus/gender and categories. There was proximity between F1 and M1, indicating similar perception independently from gender, when the stimulus presented was A: 'Monosodium glutamate - Ajinomoto/Sazón'. This

stimulus proved to be more related with the categories: water retention, blood pressure, seasoning, meal, pasta/noodles and taste, judging by its quality indicator value, which for these associations varied from 75 to 98%. The quality indicator displays the sum of relative contributions, it is part of the variability of the axis of each dimension explained by both axes, the closer this value is to 1.0 (one represents 100%), the better the dimension 1 is represented.

A different behavior was found when the stimulus did not present the trademark (stimulus B) regarding gender - men and women. It is possible to observe that men who received stimulus B related the MSG with hazard/fear, doubt, and the academic area (chemistry/sensory) with quality values from 93.2 to 99.9%. Women who received this same stimulus mentioned the trademark (Ajinomoto/Sazón), as well as terms like movie/fun, taste and different, which had quality values varying between 92.8 and 99.8%. This may be related to thresholds, - as female subjects have lower thresholds for all the five basic tastes; explained by the fact that women have more fungiform papillae, more taste buds than men, - besides other characteristics, including dietary habits, smoking behaviors, alcohol consumption and hormonal factors (Prutkin et al., 2000; Hong et al., 2005; Mojet, Christ-Hazelhof, & Heidema, 2005). Figure 2 shows the CA associations between stimuli and age groups. With an explanation of 82.34%, it can be seen that Group 1 (10-20 years) associated the MSG with the categories pasta/noodles, different, doubt, and house/couch (quality values ranging from 0.89 to 0.97). All these associations are connected with food and leisure, or the way to consume MSG. Group 2 (20-30 years) wrote more health-related terms with low quality values on the CA (from 28 to 65%), as flavor enhancer, taste, satiety and seasoning. Group 3 (30-40 years) exhibited a strong relationship with the associations: popcorn, preservative and taste, counting with a quality indicator of 0.99, 0.87 and 0.95, respectively. Group 4 (40-50 years) associated food safety with MSG.

Besides that, the risk of eating something that it is not fully known and the influence of the trademark had very strong influence on the results, judging by the terms mentioned, like hazard, fear, doubts and food safety. The MSG is more frequently seen as salt, seasoning and flavor enhancer than just a preservative, which is good, because as Table 1 shows, the form that led to the term 'preservative' was stimulus B (no trademark)

that also led to other terms like 'fear, hazard and bad'. In fact, surprisingly, the trademark usually leads to more negative effects.

In order to better understand the knowledge about MSG, with respect to health, function as a food additive and the frequency of consumption, a Cata questionnaire was applied, with the phrases shown in Table 2. The results evidenced the knowledge on the relationship between salt and blood pressure, since 100% of consumers marked the sentence 'In excess, table salt alters blood pressure'. As a common knowledge, Heaney (2006) presented the worldwide efforts to lower salt consumption and the risks associated with the increased intake of salt, not only hypertension, as Word Association showed, but also cardiovascular disease, osteoporosis and kidney stones.

Table 2. Cata with the z-test applied to opposite phrases.

	Phrase	Checks	%Checks	p'	q'	z
P1	MSG does not interfere with food taste	2	4	0.427	0.573	7.634
P2	MSG enhances the food flavor	39	81			
P3	I do not usually eat foods containing MSG	13	27	0.458	0.542	3.687
P4	I usually eat foods containing MSG	31	65			
P5	I consider healthier to replace part of table salt with MSG	8	17	0.281	0.719	2.497
P6	It is not healthy to replace part of table salt with MSG	19	40			
P7	Umami is a basic taste	16	33	0.229	0.771	2.428
P8	Umami is not a basic taste	06	13			
*	Too much salt does not affect blood pressure	0	0	0.500	0.500	9.798
P9	In excess, table salt alters blood pressure	48	100			

α = 0.05 and zcrit = 1.96; *It is not possible to run CA with zero mentions.

Likewise, it is possible to notice the knowledge of the MSG function as a food additive, which has become quite clear with 81% of consumers that have marked the sentence 'MSG enhances the food flavor'. Confirming this line of thought, higher concentration of MSG led to higher levels of acceptance of garlic and salt spices, according to Rodrigues et al. (2014). Similarly, Garrido et al. (2009) analyzed dehydrated soups and concluded that food can be more accepted with MSG partially replacing salt.

It was clear the awareness about the negative effects of excess salt for health and also the flavoring function of MSG, although participants did not recognize the use of MSG as a healthy strategy for replacement of sodium chloride, because 40% out of the 57% that marked phrases related to replacement, consider it unhealthy, which is not true according to results of Garrido et al. (2009), in which soups were better accepted with MSG replacing salt and, Quadros, Rocha, Ferreira, and Bolini (2015), who tested fish burgers with MSG and less salt. Both

reduced sodium content up to 50% promoting health at the same time.

Our findings also showed that 65% of consumers usually eat food containing MSG, and considering the forms filled, it is possible to verify that among the 27% (13 consumers) that consider not eating food with MSG, 7 consumers did not know what umami is, because 3 of them checked that umami is not a basic taste; the other 4 did not check any of the two phrases regarding umami taste, which represents a lack of knowledge about the subject.

The paired comparison test evidenced that 79% of consumers could recognize the umami taste, 85 men and 75% women got correct answers, which is a good score when considering taste recognition. However, only 14 out of the 38 consumers that selected the right sample also checked that umami is a basic taste on Cata. 4 of 38 selected that is not a basic taste, so they only selected the right answer but did not know which basic taste it is, or they really know which sample is the salty one, and selected the other as umami, being umami unknown to them. 20 of 38 did not select anything regarding umami taste on Cata, so it is possible they know the difference on the taste but do not relate the words 'MSG' and 'umami' with the taste.

Considering only the consumers that selected the correct sample in the paired test and correlating with Cata answers, the answers were divided in gender and age groups. The phrase with zero checks, 'too much salt does not affect blood pressure', must be removed from analysis because CA cannot be run. Figure 3 illustrates this relationship, thus indicating that gender affects less the answers comparing to the age, with quality values of 0.54 for both gender and 0.88 to 0.98 for age groups. This corroborates the results by Mojet et al. (2005), where a significant effect was found for age, but not for gender on taste recognition.

According to Mojet et al. (2005), elderly people need more MSG into broth to find it pleasant than young people, which is explained by the loss of sensory capabilities over years. It was detected significant differences between young and elderly women but not between young women and men for all basic tastes, except for the sweet taste, when elderly men differed from young men and women but also from elderly women, preferring higher concentrations of MSG.

Age groups 3 and 4 were better represented with quality values of 0.98 and 0.88 respectively, indicating that older people are more concerned about eating food with MSG, thinking about health issues, when they selected P3 'I do not usually eat foods containing MSG' also with a high quality

value of 0.98. Sinesio, Peparaio, Moneta, & Comendador (2010) have found interesting results, once untrained subjects distinguished the soup samples with flavor intensification (varying amount of glutamate content) but not the ingredient responsible for it (the MSG). Nowadays, many foods use MSG and people eat it even not knowing it is therein. The opposite phrases P7 and P8, regarding umami taste (quality value of 0.89 and 0.70, respectively), demonstrated that consumers were unsure if umami is or is not a basic taste, which shows a lack of knowledge about the sensory field.
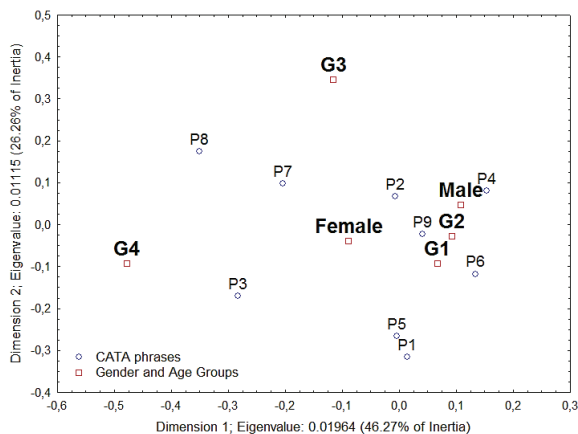
Figure 3. Correspondence Analysis Diagram for age groups and gender, correlating those who selected the correct answers in the paired test with checks in Cata analysis. Phrases are listed in Table 2.

The phrase 4 (P4) had a high quality value (0.99), strongly correlated with male subjects, so it can be said that male consumers usually eat food with MSG. The phrase P6 (quality value of 0.87) indicates that people do not consider healthy replacing salt with MSG. Further studies on the subject will increase the spread of knowledge, eliminating the negative idea about MSG, because these changes are currently taking place in many food industries around the world to reduce population sodium intake. This represents one more challenge for professionals in the food industry, tastier foods and increasingly healthy.

Conclusion

The knowledge of consumers about MSG depends on age and the information on the trademark. The terms most frequently mentioned in the Word Association were related to salt, seasoning, tasty and meal. Concern with health increases with age of the consumers and the relationship between salt and blood pressure is very clear to the

consumers, but they do not relate MSG with sodium replacement yet. The paired test showed the lack of knowledge about umami as a basic taste. There is still a strong negative idea about MSG, which is not corroborated by recent studies.

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