Original Article

Recent Research in Science and Technology 2016, 8: 24-29
http://scienceflora.org/journals/index.php/rrst/
doi: 10.19071/ rrst.2016.v8.3028

Perception and preference of umami-taste-containing foods based on olfaction and (or) gustation

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Received: 11.11.2015
Accepted: 19.04.2016
Published: 21.04.2016

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ABSTRACT

This study aimed at testing the ability to perceive and identify smells and tastes and determining the role of olfaction in the perception and preference of foods containing umami taste in both sexes. It covered a sample of 28 naive subjects aged 12-65 years, men and women, chosen at random, belonging mainly to the city of Meknes (Morocco). Our study consisted of three experimental tests: One test of smelling and two tests of tasting, with or without a disturbing odor. The tests were carried out according to the IMANOR standard ISO 6658:2007. Qadid (air-dried salted meat) was similar to plain meat with respect to perception and preference. This food would not be able to represent the umami taste. The presence of a strong lemon smell reduced cheese identification by gustation. This food would contribute to flavor more by its taste than by its smell. Women were the more effective in detecting onion by gustation as well as by olfaction, whereas men were more efficient in detecting cheese by both routes. However, it seems that the impact of olfaction on choice is not gender dependent.

KEY WORDS: Food, gustation, olfaction, perception, preference, Qadid, umami

INTRODUCTION

Human food consumption is motivated by the need to feed as well as by pleasure ("hedonic hunger") (Lowe and Butryn, 2007). Olfactory and gustatory systems play an important role in the process of recognition and selection of food. The smell brings much information on the status of food and its edibility (Stevenson, 2010; Hummel *et al.,* 2011). It also allows anticipating the taste. However, disorders of taste and smell significantly affect not only the perception of the sensory characteristics of foods but also the quality of human life (Miwa *et al.,* 2001; Temmel *et al.,* 2002; Santos *et al.,* 2004; Frasnelli and Hummel, 2005; Stevenson, 2010; Hummel *et al.,* 2011).

Sensory perceptions, and determinants of food choice, are influenced by several factors (Gravel, 2013; Belloute and Diouri, 2015) including gender and among others. The difference between women and men in odor perception has been the subject of several research works. Khebbeb (1996), Weylon (1974), and Doty *et al.* (1985) showed that the girls have more identification abilities of odors than boys. However, Bailey and Powell (1884) showed that the sense of smell seems to be more delicate in men than in women. These results coincide with those found by Bailey and Nichols (1884). Larsson *et al.* (2000) found that gender had no effect on detection or identification of olfactory information. In the other hand, Belloute and Diouri found, in a survey, that both sexes reported that olfaction is important in food choice.

In this survey (Belloute and Diouri, 2015), respondents declared a preference for the umami taste, which was presented to them as the taste of dried meat or ripe tomato (Bellisle, 1999; Eisenbrand, 2006). It was not known whether their preference for Qadid (salted and spiced dried meat) was due to its umami taste or to the accompanying ingredients.

This study was designed to:

- Determine the preference of the subjects vis-à-vis the umami taste, and assess the ability of Qadid to represent this taste;
- Determine the role of olfaction in the perception and preference of umami-taste-based foods;
- Test the ability, of both sexes, to identify real and familiar ingredients.

MATERIALS AND METHODS

Our study was composed of three experimental trials. In the first trial, subjects were asked to smell the food samples. Then, they were asked to taste these specimens in the presence (second trial) or in the absence of a disturbing odor (third trial). The tests were performed according to ISO Standards IMANOR 6658:2007 (NM) (IMANOR, 2007).

Study Population

The study involved 28 naïve subjects (persons who do not meet any particular requirement (AFNOR, 1992), recruited at random from people who agreed to participate, aged 12-63 years, and mainly belonging to the city of Meknes (Morocco). It included 16 men and 12 women who have never participated in a sensory analysis test. The subjects were diversified with regard to cooking practice and experience. Subjects' distribution is shown in Table 1.

Experimental Conditions

The experiment was conducted in 2 days; April 4, 2015, and April 5, 2015, in a well-ventilated room. The trials were held in the middle of the afternoon for the 1st day and the middle of the morning for the 2nd day because sensory acuity is maximal at these times (IMANOR, 2007).

The lighting conditions were not taken into consideration because we were interested in olfactory and gustatory stimuli only. Subjects were blindfolded to eliminate a possible influence of visual stimuli.

Foods Used

Because of its aromas and ingredients diversity, pizza was chosen to test the subjects' ability to identify odors and tastes in real food.

Four pizzas were prepared the following section:

Pizza 1 (negative control): This containing dough, red pepper, spices, ground beef, and grated edam and mozzarella cheeses.

Table 1: Description of the study population

Variable	Number
Age groups	
12-23	9
24-35	5
36-47	6
48-65	8
Sex	
Men	16
Women	12

Pizza 2: It was identical to Pizza 1, except that 50% of the ground beef was replaced with ground Qadid.
Pizza 3: It was identical to Pizza 1, except that 100% of the ground beef was replaced with ground Qadid.
Pizza 4: It was identical to Pizza 1, except that edam cheese was replaced with parmesan cheese.

In the four pizzas, we used red pepper and onion instead of tomato sauce to test the ability of subjects to identify ingredients without anticipating them.

Food Presentation

Before tasting, the pizza samples were covered by greaseproof paper and wrapped in aluminum foil to keep them warm and to prevent subjects from seeing or smelling them.

Design of Experiment

The four pizzas were prepared on the eve of the testing session. These samples were cut into pieces (≈ 3 cm Ñ× 3 cm ≈ 8.7 g) and cooked, just before the start of the tests, in a separate room. Care was taken to ensure that there is a maximum uniformity among samples.

Subjects entered the test room individually at random (a woman followed by a man or the opposite).

Subjects were asked to refrain from smoking, taking snacks, and using perfumes at least 1 h before the test. Subjects suffering from a cold or other diseases were not allowed to participate.

1st test

The four pizzas were successively presented, in a random order, to the previously blindfolded subject. The latter was asked to smell the pizzas and to answer the following questions:

1. What are the food ingredients that you can identify?
2. What is your appreciation rating (a score from 0 to 10) of the food?

The objective of the first question is to test the ability of subjects to perceive and identify smells. Some studies reported that people have difficulty in evoking odor images (Stevenson *et al.*, 2007), but in our studies, we used real and familiar food products.

2nd test

After 1-2 min, he or she was then asked to eat, in the presence of a strong smell of lemon (grated lemon zest near the nose), a piece of each pizza randomly chosen (independently of the first-test order). This odor was

introduced to disrupt or disturb, not to eliminate, sample smelling. The same above questions were then asked.

3rd test

The subject was asked to rinse the mouth (with boiled and cooled tap water) to avoid the saturation and masking phenomena (IMANOR, 2007). Subjects were asked to taste pieces of the same pizzas in normal conditions (without disturbing odor). After each tasting, subjects were asked the same questions.

During the tasting (2nd and 3rd tests), subjects were asked to roll the piece in the mouth and then to raise the aromas into the nasal cavity by slowly exhaling through the nose. After each test, we made sure subjects were still willing to continue participating in the experiment.

Statistical Analysis of the Data

Data were statistically analyzed by SPSS Statistics 20.0 software (Meulman and Heiser, 2011) and by the R. 3.0.3 software (Core Team, 2014).

The study of the relationship between quantitative variables was carried out by the correlation test and the principal component analysis (Morrison, 1988). The relationship between a categorical variable and a quantitative variable was tested, either by the analysis of variance (ANOVA) (Bertrand, 1986; Stafford and Bodson, 2006), or by Student's (independent or paired) *t*-test (Carricano *et al.*, 2010), after ensuring that their conditions are met.

In ANOVA, the model used contained, in addition to the factors studied and their interactions, the "Block" variable with two levels, represented by the 2-day sessions. The block was then removed from the model whenever it was not significant.

We have chosen, to study the perception and preference of foods, the following variables: Number of ingredients detected by gustation with a normal olfaction ("I.GN"), number of true ingredients detected by gustation with normal olfaction ("TI.GN"), and food rating based on gustation with normal olfaction ("R.GN"). To study the role of olfaction in food choice, we have selected the following variables: Number of ingredients detected by olfaction ("I.O"), the number of true ingredients detected by smell ("TI.O"), and food rating based on olfaction ("R.O").

To study the role of olfaction in taste perception, we have adopted the following variables: Number of ingredients detected by gustation with disturbed olfaction ("I.GD"), number of true ingredients detected by gustation with disturbed olfaction ("TI.GD"), and food rating based on gustation with disturbed olfaction ("R.GD").

RESULTS

The Role of Olfaction in Food Perception and Preference

Positive and significant correlations were observed (Figure 1 and Table 2):

- Between the number of ingredients and the number of true ingredients identified during the three tests. Therefore, we considered, in the remainder of this article, the true ingredients only
- Between the rating of samples based on olfaction and the rating based on gustation (with and without disturbance).

The mean comparison of some variables is shown in Table 3.

Ground beef was the only ingredient that was more identified ($P < 0.001$) by gustation than by olfaction. Olfaction disturbance prevented the identification of cheese ($P = 0.011$) by gustation.

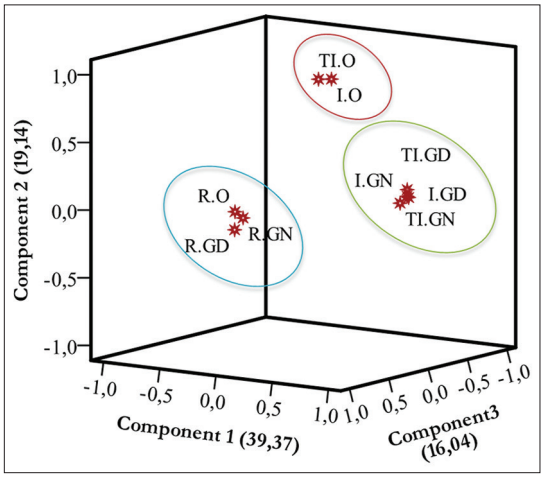

Figure 1: Principal components analysis of the variables studied. R: Rating, O: Olfaction, I: Number of ingredients detected, TI: Number of true ingredients detected, GN: Normal gustation, GD: Gustation with a disturbing odor

Table 2: Correlation matrix between different variables

Pair of variables	*r*	*P* value
I.O/TI.O	0.817	<0.001
I.GN/TI.GN	0.875	<0.001
I.GD/TI.GD	0.741	<0.001
TI.GD/TI.GN	0.584	<0.001
R.O/R.GN	0.343	<0.001
R.O/R.GD	0.350	<0.001
R.GD/R.GN	0.434	<0.001

R: Rating, O: Olfaction, I: Number of ingredients detected, TI: Number of true ingredients detected, GN: Normal gustation, GD: Gustation with a disturbing odor

Table 3: Mean comparison of different variables by paired *t*-test

Variable pair	Mean difference	Significance (bilateral)
TI.GN-TI.O	0.857	<0.001
R.GN-R.O	0.734	<0.001
TI.GN-TI.GD	0.786	<0.001
R.GN-R.GD	−0.00446	0.974

R: Rating, O: Olfaction, TI: Number of true ingredients detected, GN: Normal gustation, GD: Gustation with a disturbing odor

Food Perception and Preference in Both Sexes

The only significant difference found between the two sexes ($P = 0.039$) concerned the rating of the four pizzas based on olfaction (R.O). The average rating of women (7.89) was higher than that given by men (7.07).

The results show that there is no difference between sexes in the number of ingredients detected. However, by examining each ingredient separately, we found that men detected cheese by smell more than women ($P = 0.016$), whereas women had a greater olfactory recognition performance for Qadid and onion (respectively, $P = 0.040$ and 0.003). On the basis of tasting, more men have detected parmesan ($P = 0.045$), whereas more women have detected onion ($P < 0.001$). Parameters representing olfaction efficacy (TI.O), on the one hand, and preference (R.O and R.GN), on the other, were not more correlated in one sex than in the other.

Perception and Preference of Umami-taste-based Foods

The results obtained by the three-way ANOVA showed no difference between the four pizzas, except for the variable TI.O. Subjects identified, by olfaction, more ingredients in the Pizza 1 than in Pizzas 2, 3, and 4 ($P = 0.023$, 0.036, and 0.022, respectively). However, no difference was observed between the Pizzas 2, 3, and 4. Based on tasting, there was no difference in the detection of ingredients.

Concerning preference indicators (R.O, R.GN, and R.GD), there was no difference among the four pizzas.

Gender had no effect on the perception and preference of umami taste. Indeed, the pizza * sex interaction was not significant for any variable.

DISCUSSION

The Role of Olfaction in Food Perception and Preference

The ingredients detected by tasting (TI.GN) were more numerous than those detected by smell alone (TI.O). These differences can be explained by the fact that in the conditions of our tasting, ingredients were detected by both gustatory and olfactory systems. The ratings followed the same trend. However, the superiority of R.GN over R.O did not seem to result from the additional identified ingredient; because TI.O was not correlated to R.O, nor was TI.GN to R.GN.

The disturbance of olfaction by the lemon smell has led to a decrease in the ability of ingredient identification (TI.GN vs. TI.GD). Lemon smell has partially played the role of nose clips which were not used in this experiment. However, the preference of the subjects did not change (R.GN vs. R.GD). This led us to inquire about the unidentified ingredient or ingredients.

The cheese was the only ingredient that was not identified due to ortho-nasal olfaction disturbance was significant. This ingredient seems either not contribute or contribute to flavor more by its taste than by its aromas which were masked by olfaction disturbance.

Food Perception and Preference in Both Sexes

Men detected cheese more than women, whereas women were more efficient in identifying Qadid and onion. This may be directly linked to sex. Indeed some studies attributed ingredients identification difference to hormonal factors (Russell *et al.*, 1980; Evans, 1995; Derntl et al., 2013). Previous studies have shown a greater performance for a variety of smells in women than in men (Toulouse and Vaschide, 1899; Larsson *et al*. 2004; Doty and Cameron, 2009). For other odors, men were as or more effective than women (Le Magnen, 1952). In this study, detection of Qadid and onion by women may be merely due to their experience with kitchen. Although subjects practicing cooking were present in both sexes in a balanced way, the extent of this practice may be greater in women, thereby explaining the obtained results. However, detection of cheese by men, both through olfaction and gestation, may allow us to conclude that gender has an influence on food perception.

The average rating of women was significantly higher than that given by men. This result may indicate a stronger influence of smell on preference. Women may also be more generous or less accurate in rating. Besides, the other ratings (R.GN and R.GD) were always numerically (although not significantly) higher in women.

Parameters representing olfaction efficacy (TI.O), on one hand, and preference (R.O and R.GN), on the other, were not more correlated in one sex than in the other. It

might then be concluded that the impact of olfaction on preference is not sex dependent.

Perception and Preference of Umami-taste-based Foods

TI.O was higher in Pizza 1 and similar in Pizzas 2, 3, and 4. These results can be explained either by the fact that the latter contain novel ingredients and are less familiar than Pizza 1, or the fact that the smell of Qadid in Pizza 2 and 3, and parmesan in Pizza 4, masks the odor of other components. Based on tasting, there was no difference in the detection of ingredients. The subjects were able to recognize the new ingredients, which were different more in their taste (umami) than in their odor.

The absence of a difference, with respect to preference (R.O, R.GN, and R.GD), among the four pizzas, under the conditions of our experiment, indicates that the Qadid and parmesan did not strengthen the flavor. The negative control (Pizza 1), would be already saturated (Dillon, 1991). In fact, previous studies (Yamaguchi and Takahashi, 1984; Yamaguchi, 1998, Kurihara and Kashiwayanagi, 2000, Rolls, 2009; Boutry, 2010) have shown that umami taste is optimal at precise concentrations of the responsible molecules, i.e. glutamate, inosinate, and guanilate. This hypothesis should be confirmed by an analysis of these molecules in the four pizzas. Sensory fatigue and adaptation (Hahn, 1934; IMANOR, 2007) may also explain the lack of difference. We tried to alleviate this effect by the mouth rinse before and after each sample tasting. It is also possible, although not probable that the similarity of the four pizzas originate in the pizza sample size; because the response time to a stimulus is inversely proportional to its concentration (McFadden , 1937).

Pizza 4, which was the positive control, containing parmesan, could not enhance the flavor either because of saturation or due to its unfamiliarity. Qadid, which is much more familiar, could neither improve nor worsen preference. The different attitudes toward this food reported before by Belloute and Diouri (2015), are most probably linked to the accompanying ingredients.

CONCLUSION

Qadid was similar to plain meat with respect to perception and preference. This food would not be able to represent the umami taste.

The presence of a strong lemon smell reduced cheese identification by gustation. This food would contribute to flavor more by its taste than by its smell.

Women were more effective in detecting onion by gustation as well as by olfaction, whereas men were more efficient in detecting cheese by both routes. However, it seems that the impact of olfaction on choice is not gender dependent.

REFERENCES

AFNOR. Analyse Sensorielle-Vocabulaire. ISO 5492: 1992 (E/F). Paris: AFNOR.

Bailey EH, Nichols EL. Preliminary notes on the delicacy of the special senses. NY Med J 1884;40:325.

Bailey EH, Powell LM. Some special tests in regard to the delicacy of the sense of smell. Trans Annu Meetings Kan Acad Sci 1884;9:100-1.

Bellisle F. Glutamate and the UMAMI taste: Sensory, metabolic, nutritional and behavioural considerations. A review of the literature published in the last 10 years. Neurosci Biobehav Rev 1999;23:423-38.

Belloute R, Diouri M. Preferences and aversions in Morocco and influencing factors. Int J Innov Sci Res 2015;13:463-73.

Bertrand R. The statistical data analysis. Sainte-Foy: University Press of Quebec; 1986.

Boutry C. Influence of supplementation in monosodium glutamate on gastrointestinal physiology and metabolism in rat and human. Doctoral thesis: The Institute of Sciences and Industries of the living and the environment (AgroParisTech) – France; 2010.

Carricano M, Poujol F, Bertrandias L. Analyse de données avec SPSS®. Paris: Pearson Education France; 2010.

Core Team R. R: A Language and Environment Statistical Computing. Vienna, Austria: R. Foundation for Statistical Computing; 2014.

Derntl B, SchöpfV, KollndorferK, Lanzenberger R. Menstrual cycle phase and duration of oral contraception intake affect olfactory perception. Chem Senses 2013;38:67-75.

Dillon JC. Glutamic Acid. Cahiers Nutr Diététique 1991;26:157-62.

Doty RL, Applebaum S, Zusho H, Settle RG. Sex differences in odor identification ability: A cross-cultural analysis. Neuropsychologia 1985;23:667-72.

Doty RL, Cameron EL. Sex differences and reproductive hormone influences on human odor perception. Physiol Behav 2009;97:213-28.

Eisenbrand G. Senate Commission on Food Safety (SKLM) of the German Research Foundation (DFG). The potential involvement of glutamate ingestion in chronic neurodegenerative diseases. Opinion of the Senate Commission on Food Safety (SKLM) of the German Research Foundation (DFG)-(shortened version). Mol Nutr Food Res 2006;50:1239-43.

Evans WJ, Cui L, Starr A. Olfactory event-related potentials

in normal human subjects: Effects of age and gender. Electroencephalogr Clin Neurophysiol 1995;95:293-301.

Frasnelli J, Hummel T. Olfactory dysfunction and daily life. Eur Arch Otorhinolaryngol 2005;262:231-5.

Gravel K. Manger avec sa tête ou selon ses sens: Perceptions et comportements alimentaires. Thèse de Doctorat: Université Laval Québec, Canada; 2013.

Hahn H. Adaptation of the sense of taste. Z. Fur Sin., LXV1934; 3-4: 105-145. In 5 Smell and taste: L'année Psychol 1934;35:567-70.

Hummel T, Landis BN, Hüttenbrink KB. Smell and taste disorders. GMS Curr Top Otorhinolaryngol Head Neck Surg 2011;10:Doc04.

IMANOR. Analyse Sensorielle - Méthodologie, Lignes Directrices Générales. ISO 6658. Paris: IMANOR; 2007.

Khebbeb A. Study of food choices behaviour, depending on the view and smell in children 2 to 3 years in a manger. J de pédiatrie et de puériculture 1996;1:34-41.

Kurihara K, Kashiwayanagi M. Physiological studies on umami taste. J Nutr 2000;130:931S-4.

Larsson M, Finkel D, Pedersen NL. Odor identification: Influences of age, gender, cognition, and personality. J Gerontol B Psychol Sci Soc Sci 2000;55:P304-10.

Larsson M, Nilsson LG, Olofsson JK, Nordin S. Demographic and cognitive predictors of cued odor identification: Evidence from a population-based study. Chem Senses 2004;29:547-54.

Le Magnen J. Olfactory–sexual phenomena in humans. C R Acad Sci Biol 1952;6:125-60.

Lowe MR, Butryn ML. Hedonic hunger: A new dimension of appetite? Physiol Behav 2007;91:432-9.

McFadden HB. The influence of temperature and solution concentration on reaction-time to taste stimuli (sodium chloride). J. PS. 1937; IV: 349-363. In 5 Odorat et goût: L'année psychologique 1937;38:631-6.

Meulman JJ, Heiser WJ. IBM SPSS Catégories 20, Manuel. IBM Corporation; 2011. p. 325. Available from: http://www.ibm-spss-statistics.soft32.com/. [Last accessed on 2013 Nov 02].

Miwa T, Furukawa M, Tsukatani T, Costanzo RM, DiNardo LJ, Reiter ER. Impact of olfactory impairment on quality of life and disability. Arch Otolaryngol Head Neck Surg 2001;127:497-503.

Morrison DF. Multivariate Statistical Methods. 2nd ed. Singapore: McGraw-Hill; 1988.

Rolls ET. Functional neuroimaging of umami taste: What makes umami pleasant? Am J Clin Nutr 2009;90:804S-13.

Russell MJ, Switz GM, Thompson K. Olfactory influences on the human menstrual cycle. Pharmacol Biochem Behav 1980;13:737-8.

Santos DV, Reiter ER, DiNardo LJ, Costanzo RM. Hazardous events associated with impaired olfactory function. Arch Otolaryngol Head Neck Surg 2004;130:317-9.

Stafford J, Bodson P. L'analyse multivariée avec SPSS. Laval: Presses de l'Université de Québec; 2006.

Stevenson RJ, Case TI, Mahmut M. Difficulty in evoking odor images: The role of odor naming. Mem Cognit 2007;35:578-89.

Stevenson RJ. An initial evaluation of the functions of human olfaction. Chem Senses 2010;35:3-20.

Temmel AF, Quint C, Schickinger-Fischer B, Klimek L, Stoller E, Hummel T. Characteristics of olfactory disorders in relation to major causes of olfactory loss. Arch Otolaryngol Head Neck Surg 2002;128:635-41.

Toulouse E, Vaschide N. Mesure de l'odorat chez l'homme et chez la femme. C R Soc Biol 1899;51:381-33.

Weylon R. The taste and smell. Nouv Presse Méd 1974;3:41-3.

Yamaguchi S, Takahashi C. Interactions of monosodium glutamate and sodium chloride on saltiness and palatability of a clear soup. J Food Sci 1984;49:82-5.

Yamaguchi S. Basic properties of umami and its effects on food flavor. Food Rev Int 1998;14:139-76.