



METHODOLOGICAL IMPLICATIONS FOR THE DESIGN OF SENSORY TASTINGS OF FRESH GARLIC IN MEXICO

IMPLICACIONES METODOLÓGICAS PARA EL DISEÑO DE LAS DEGUSTACIONES SENSORIALES DE AJO FRESCO EN MÉXICO

Blanca Isabel Sánchez-Toledano¹, Juan José Figueroa-González¹,
Dora Ma. Sangerman-Jarquín^{2*} and Jorge Alonso Maldonado-Jáquez³

¹National Institute of Forestry, Agricultural and Livestock Research. (INIFAP), Zacatecas Experiment Station, Calera de Víctor Rosales, Zacatecas, Mexico. ²INIFAP, Valle de Mexico Experiment Station, Texcoco, Estado de Mexico, Mexico. ³INIFAP, La Laguna Experiment Station. Matamoros, Coahuila, Mexico.

*Corresponding author (sangerman.dora@inifap.gob.mx)

SUMMARY

In order to reduce the production gap, optimize growing times and yields, and find new markets, a plant breeding program for garlic has been implemented in Mexico; however, the agroclimatic conditions of Mexico give this product distinctive characteristics compared to garlic from other origins; hence, it is important to know their sensory acceptability. To perform a sensory analysis it is necessary to consider the best vehicle and palate cleanser for each product analyzed, as well as to define the lexicons and sensory wheels according to the specific product. The aim of this study was to develop a reliable method for sensory evaluation of fresh Mexican garlic through a comprehensive methodological approach, which includes the determination of the most suitable vehicle and the palate cleanser for the sensory evaluation of fresh garlic in Mexico; likewise, it is intended to develop an appropriate lexicon to establish a sensory wheel adapted to this product. With the help of a group of expert panelists, different vehicles and palate cleansers for sensory analysis in garlic were evaluated. The sensory descriptors were examined by the evaluators and analyzed using non-parametric methods appropriate to these type of study. Results indicate that mashed potatoes with water were the best-rated vehicle, making it a reliable tool for future studies, as it minimizes potential interference during product assessment. On the other hand, green apples and lemon water were the best-rated palate cleansers. A sensory wheel was defined for fresh Mexican garlic, which will provide knowledge applicable to the design of sensory protocols for garlic produced in Mexico.

Index words: *Allium sativum* L., palate cleanser, sensory descriptors, vehicle.

RESUMEN

Con el fin de reducir la brecha de producción, optimizar los tiempos de cultivo y los rendimientos, y de encontrar nuevos mercados, se ha implementado un programa de mejoramiento genético de ajo en México; sin embargo, las condiciones agroclimáticas de México imparten a este producto características distintivas en comparación con los ajos de otros orígenes; por lo tanto, es importante conocer su aceptación sensorial. Para realizar un análisis sensorial es necesario considerar el mejor vehículo y limpiador de paladar para cada producto analizado, así como definir los léxicos y ruedas sensoriales de acuerdo con el producto específico. El objetivo de este estudio fue desarrollar un método fiable para la evaluación sensorial del ajo fresco mexicano a través de un enfoque metodológico integral, que incluye la determinación del vehículo más adecuado y el limpiador de paladar para la evaluación sensorial de este producto fresco en México; asimismo, se

pretende desarrollar un léxico apropiado para establecer una rueda sensorial adaptada a este producto. Con la ayuda de un grupo de panelistas expertos, se evaluaron diferentes vehículos y limpiadores de paladar para el análisis sensorial del ajo. Los descriptores sensoriales fueron examinados por los evaluadores y analizados mediante métodos no paramétricos apropiados para este tipo de estudios. Los resultados indicaron que el puré de papa con agua fue el vehículo mejor calificado, lo que lo convierte en una herramienta confiable para estudios futuros, ya que minimiza la posible interferencia durante la evaluación del producto. Por otro lado, las manzanas verdes y el agua con limón fueron los limpiadores de paladar mejor valorados. Se definió una rueda sensorial para el ajo fresco mexicano, lo que permitirá contar con conocimientos aplicables al diseño de protocolos sensoriales del ajo producido en México.

Palabras clave: *Allium sativum* L., descriptores sensoriales, limpiador de paladar, vehículo.

INTRODUCTION

Garlic (*Allium sativum* L.) is a versatile food ingredient and condiment, recognized for its distinctive and appetizing taste in various cuisines around the world. This vegetable contains more than 200 chemical compounds with multiple properties, including fat-soluble vitamins (A, K and E), water-soluble vitamins (C, B1, B2, B3, B6 and B8), and minerals (Ca, Fe, Mg, P, K, Na and Zn) (Melguizo-Rodríguez *et al.*, 2022). These particularities have shown that garlic extracts exhibit beneficial effects on health, including hypolipidemic, antiplatelet, anti-inflammatory, anticancer and immunomodulatory properties (Melguizo-Rodríguez *et al.*, 2022; Verma *et al.*, 2023).

Global garlic production is led by China (73.8 %), India (10.4 %), Bangladesh (1.7 %), South Korea (1.3 %) and Egypt (1.2 %) (FAO, 2025). In the Americas, garlic is mainly produced in the United States of America, Brazil, Argentina, Peru, Mexico, Guatemala and Chile, with the United States of America being the country with the highest yield for this crop, at 17.6 t ha⁻¹ (FAO, 2025). The largest garlic-producing

states in Mexico are Zacatecas (55.5 %), Guanajuato (11.3 %), Nuevo León (7.9 %), Puebla (5.6 %) and Sonora (5.3 %) (SIAP, 2025).

From a socio-economic point of view, this crop is important as it employs a large amount of labor throughout the entire production process, especially during the Autumn-Winter season, which is when sources of employment in rural agricultural areas decline (Heredia and Heredia, 2000). In this sense, in order to try to reduce the production gap, optimize cultivation times and yields and find new markets, the National Institute of Forestry, Agricultural and Livestock Research (INIFAP, for its acronym in Spanish) has implemented a garlic breeding program, of which varieties have been developed for different environments in the country, including INIFAP 94, Tacatzcuáro, Tinguindín and Chino Blanco for El Bajío area (Macías *et al.*, 2021), San Marqueño and Orión for Aguascalientes and Zacatecas, and CEZAC-06, with excellent adaptation in the states of Aguascalientes, Durango, Chihuahua, Coahuila and Zacatecas (Reveles-Hernández *et al.*, 2009).

The intensity of garlic taste and aroma is directly related to its sulfur compounds, such as allicin. Variations in the climate and soil conditions of Mexico, especially in regions such as Zacatecas and Aguascalientes, influence the development of these compounds, resulting in a more complex and distinctive flavor profile compared to garlic grown elsewhere. As a result, Mexican garlic is valued in cooking for its flavor and aroma intensity (Dhall *et al.*, 2023); therefore, it is important to know its sensory acceptability. The design of new varieties or the implementation of postharvest management techniques according to consumer taste represents the foundations of the entire food industry, since the acceptability of a product is equal to consumer satisfaction (Coste *et al.*, 2010; Tadesse, 2024); nonetheless, to perform a sensory analysis it is necessary to consider the best vehicle and palate cleanser for each product analyzed. Conceptually, sensory vehicles are neutral or semi-neutral edible matrices that allow the uniform application of an ingredient of interest (in this case, garlic) and contribute to standardizing texture, release of volatile compound and sensory perception (Chen *et al.*, 2020; Johnson and Vickers, 2004; Torricella *et al.*, 2020).

On the other hand, palate cleansers are foods or beverages that must be consumed between samples to neutralize the palate and eliminate residual flavors, odors or textures, which allows for a restart of the assessment from a sensory baseline that is as neutral as possible (Severiano, 2025). The main palate cleanser that evaluators have is saliva; nevertheless, another input is regularly used to remove residual flavors between samples, which ensures that the evaluation of each sample is independent of the

previous one (Bless *et al.*, 2024).

Similarly, there must be a sensory lexicon to homogenize criteria for describing the properties of a food (Lawless and Civille, 2013). For this purpose, there are tools such as the sensory wheel, which graphically represents descriptive vocabulary, where specific terms of sensory attributes are collected, categorized and organized, visually showing the characteristics of the food (Xia *et al.*, 2025). The importance of lexicons and sensory wheels lies in their function as normalizing and visualizing tools for sensory description, facilitating communication between researchers, producers and consumers about food sensory characteristics (Wang and Liu, 2025). In the food industry, these tools support product quality control, new product development and marketing, thereby improving product competitiveness (ISO, 2012).

To address this topic, the present study aims to develop a reliable method for the sensory evaluation of fresh Mexican garlic through a comprehensive approach, which includes the determination of the most appropriate vehicle (carrier matrix) and palate cleanser for the sensory evaluation of fresh garlic in Mexico. Also, it is intended to develop a lexicon suitable for establishing a sensory wheel adapted to this product. This will improve the accuracy and reproducibility of the tasting tests.

MATERIALS AND METHODS

Selection and training of evaluators

The study was conducted at the Sensory Analysis Laboratory of the Zacatecas Experiment Station of INIFAP. The facilities have 12 tasting booths according to the ISO-22000 protocol (Paries *et al.*, 2022). In this way, an atmosphere was offered that allows for a functional and objective analysis of the study; in other words, a quiet space, free from odors, noise, with a pleasant temperature (20-24 °C), relative humidity of 45-75 %, and individual booths for judges that minimize eye contact and facilitate concentration. It also features uniform lighting that does not alter the visual perception of the product.

The panel formation was carried out in three stages: 1) pre-selection, at this stage, 40 people were selected for their skills in detecting some sensory properties; in several sessions, they were trained and taught the discipline of sensory analysis, periodically evaluating various products with the aim of knowing how to identify organoleptic and sensory characteristics. For this purpose, the methodology set out in Regulation (EU) No 1169/2011 of the European Parliament was applied; 2) selection of panelists; of the total, only 24 people were recruited for their olfactory-

gustatory sensitivities and ability to objectively identify subtle differences between foods; and 3) finally, the panelists completed a total of 120 hours of training over three months, focusing on sensory evaluation techniques, flavor recognition, aromas, and rating methods.

To maintain objectivity, each evaluator was asked to refrain from eating spicy foods or caffeine at least 2 h prior to each evaluation and avoid using fragrances, strong odors or residue before each assessment.

Experimental design, vehicles and palate cleansers

Vehicles and palate cleansers studied by Coste *et al.* (2010) were tested for dry and freeze-dried garlic. Four vehicles or carrier matrices were evaluated for sensory analysis of Mexican garlic: 1) mashed potatoes with water, 2) mashed potatoes with milk, 3) cream cheese, and 4) roasted, unsalted bread with tomato. The palate cleansers were: 1) green apples, 2) parsley, 3) water with lemon, 4) bread (unsalted, toast), and 5) mineral water (Torricella *et al.*, 2020). Vehicles and palate cleansers were presented with three-digit numbers and offered monadically and in a balanced order. Garlic was placed in proportional amounts in each of the vehicles and palate cleaner (2 g), and each test was performed in duplicate. The different vehicles and palate cleansers were rated using a 5-point Just-About-Right (JAR) scale: 1 = very unpleasant, 2 = unpleasant, 3 = just the way I like, 4 = more than I like, and 5 = much more than I like. This scale is widely used in sensory evaluation studies to capture the acceptability and perceptual adequacy of different products and attributes (Astudillo and Chevez-Ponce, 2021; Widiandi *et al.*, 2024). In essence, it is based on an ordinal rating that reflects positive or negative assessments (Di Monaco *et al.*, 2004).

Questionnaire on the acceptance of sensory descriptors by evaluators

Different garlic varieties were used ('Barretero' from Zacatecas and 'San Marqueño' from Aguascalientes). These varieties have yields above the national average. In both varieties, garlic with low commercial value (size 6) and high commercial value (size 9) was used. Each panelist was provided with a bulb and a clove of garlic, depending on the attribute to be evaluated. This was carried out independently, in an individual sensory booth and under blind conditions. The samples were presented monadically, following a design in complete and balanced blocks to prevent bias from the order of presentation (Su

et al., 2021). These samples were identified with three-digit random numbers and presented to the judges with an assessment form containing a series of attributes to be evaluated. The check-all-that-apply method was used to verify the recognition coverage of consumer perception of garlic sensory attributes (aroma, texture, pungency, spiciness, bitterness, aftertaste, color, taste). Based on the data obtained, the percentage of recognition of an attribute was calculated according to the evaluator perception and transformed into a five-point scale, called the attribute acceptance index. For an attribute with a recognition percentage of 45 % or higher, five points were assigned; from 44.4 to 35 % four points; between 34.4 and 25 % three points; from 24.4 to 15 % two points; and between 14 % and 1 %, only one point (Marques *et al.*, 2022). In general, the study was validated and approved by a social science ethics committee. It was conducted in accordance with the principles set out in the Declaration of Helsinki, with special care to protect personal information as required by Mexican standards. The panelists signed a consent form that was read aloud.

Data analysis

Given the nature of the data, a series of non-parametric methods suitable for sensory studies with small samples were used (García *et al.*, 2024; Mertler *et al.*, 2021). The overall means for each group (vehicles and palate cleansers) were calculated in order to obtain an initial description of the central tendency of the ratings. The statistical procedure facilitated the identification of relevant patterns (Bautista-Díaz *et al.*, 2020). To identify differences, the Kruskal-Wallis test was applied, which is used to compare independent groups for ordinal scale data or data that do not meet the normality assumption (Johnson, 2022). The analysis was performed independently for vehicles (carrier matrices used to present garlic) and palate cleansers (substances used to cleanse the palate between samples). For each factor, a grouping variable was constructed based on the average of the ratings given by each panelist to the different vehicles and palate cleansers. The variable served as the basis for applying the Kruskal-Wallis test when differences were found ($P \leq 0.05$) (Horie *et al.*, 2024; Johnson, 2022). Finally, to identify significant associations between classification variables (vehicles and palate cleansers) a Spearman correlation analysis was performed. The data obtained from the panelists were organized and processed in a database structured in Microsoft Excel version 16.94 and the statistical analyses were performed in the Statistical Package for the Social Sciences (SPSS) version 29.

RESULTS AND DISCUSSION

Evaluation of sensory vehicles and palate cleansers

The evaluation of the vehicles used for the tasting of fresh Mexican garlic showed clear differences in their ability to facilitate an adequate assessment of the sensory attributes of the product (Figure 1). Among the vehicles evaluated, mashed potatoes with water obtained the highest mean (4.67 ± 0.48) and was the only vehicle that showed statistical differences ($P \leq 0.05$), establishing itself as the only vehicle evaluated differently (in this case, favorably) from the rest, suggesting high acceptability and consistency among panelists. This suggested that mashed potatoes can generate good interactions between flavor compounds and ingredients from different food domains (Rababah *et al.*, 2025). Thus, this matrix was perceived as a neutral medium, without dominant flavors, with a uniform texture and adequate capacity to release the compounds of garlic without interference; hence, the importance of volatile organosulfide compounds in garlic, such as allicin, is related to proper storage conditions to preserve the organoleptic quality of garlic bulbs (Shen *et al.*, 2025). On the other hand, bread with tomato obtained the lowest mean (2.08), accompanied by the greatest dispersion in responses (± 1.18). The combination reflects lower acceptability because tomato induces acidic and sweet flavors that distort the organoleptic profile of garlic. In this way, the sweet flavor of tomato overshadows the distinctive sulfurous smell of garlic bulbs (Cherdchu and

Chambers, 2014).

In this regard, Coste *et al.* (2010) found similar results and concluded that mashed potatoes with water is the most appropriate vehicle for evaluating both dried and freeze-dried garlic, and in this case, they are also suitable for sensory evaluation of fresh garlic. They also pointed out that vehicles with high acidity interfere in the determination of sensory descriptors of garlic. This is of utmost importance since the choice of an inappropriate vehicle can increase the complexity of perceived characteristics or completely change sensory attributes (Dziki *et al.*, 2022).

The results of the Kruskal-Wallis analysis applied to the palate cleansers. Parsley, bread and mineral water showed significant differences; in this case, there was a greater variability in the perception of the options. Parsley leaves contain a high amount of essential oils; for example, β -phellandrene, α -terpinolene, 1,3,8-p-menthatriene, myristicin and elemicin, which affect sensory acceptance by panelists (Xu *et al.*, 2022). On the other hand, aroma and other properties of bread are affected by the ingredients, enzymatic reactions during dough fermentation, and thermal reactions during baking (Barker *et al.*, 2021), which, together with the organoleptic properties of garlic, did not favor it as an efficient carrier for fresh garlic evaluation. In contrast, mineral water, due to its carbonation, enhances salinity or acidity, inhibiting other flavors. In addition, it decreases the perception of sweet flavors, and this influences its suppression (Vidal *et al.*, 2016). Mineral

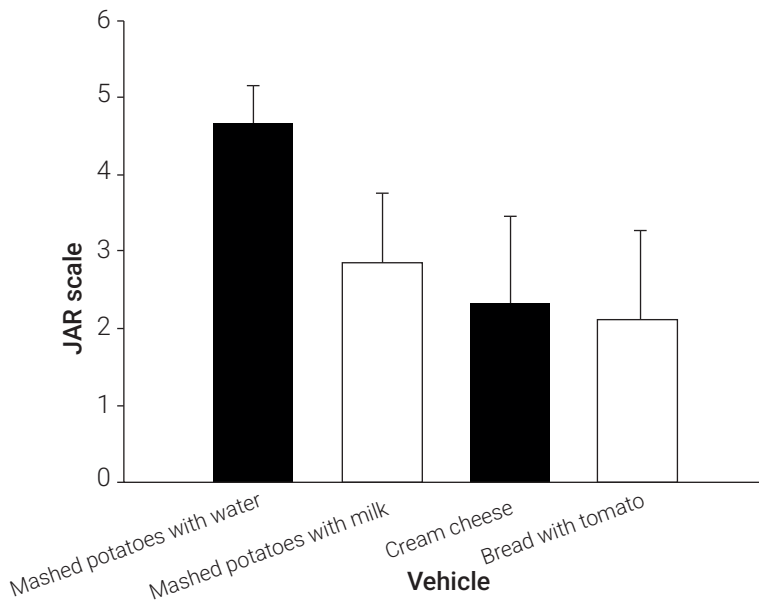


Figure 1. Mean scores (\pm standard deviation) given to the different vehicles used in the sensory evaluation of Mexican garlic.

water had the lowest mean score (1.17 ± 0.56), indicating low acceptance and limited efficacy as a palate cleanser, but with homogeneous ratings. This perception is related to its low ability to remove intense compounds, since it does not provide astringent or acidic elements that favor the cleansing of the palate; on the contrary, it enhances flavors. These findings are consistent with the report by Pannitteri *et al.* (2020), who mentioned that some palate cleansers are not able to restore the oral environment until after 15 min.

On the other hand, green apples and lemon water showed no significant differences; their ratings were homogeneous, reflecting greater consistency and sensory stability. Similarly, green apples (4.67 ± 0.48) and lemon water (4.54 ± 0.72) obtained the highest means and statistical differences ($P \leq 0.05$), accompanied by low standard deviations (Figure 2), showing a favorable and consistent rating from panelists. Both products were effective as palate cleansers, facilitating the neutralization of

persistent flavors between samples and allowing a clearer assessment of garlic sensory attributes. The effectiveness of apples and lemons can be attributed to their natural acidity, water content and astringent properties, which promote the elimination of residual volatile compounds; however, care should also be taken with the accumulation of astringency in the oral cavity, as this effect may have an impact on sensory perception of food (Fischer *et al.*, 1994), even when there are stimuli derived from oral manipulation or due to the stimulus of ingestion, which affect the salivation rate (Pannitteri *et al.*, 2020). This has significant practical implications, and therefore, as with vehicles, an appropriate choice must be made, since each palate cleanser will behave differently in the presence of various foods, thus, good selection improves the accuracy of the sensory response, particularly in foods with strong flavors (Kitsawad and Nguyen, 2014), such as fresh Mexican garlic.

The Spearman correlation coefficients between vehicles and palate cleanser used in the sensory evaluation of

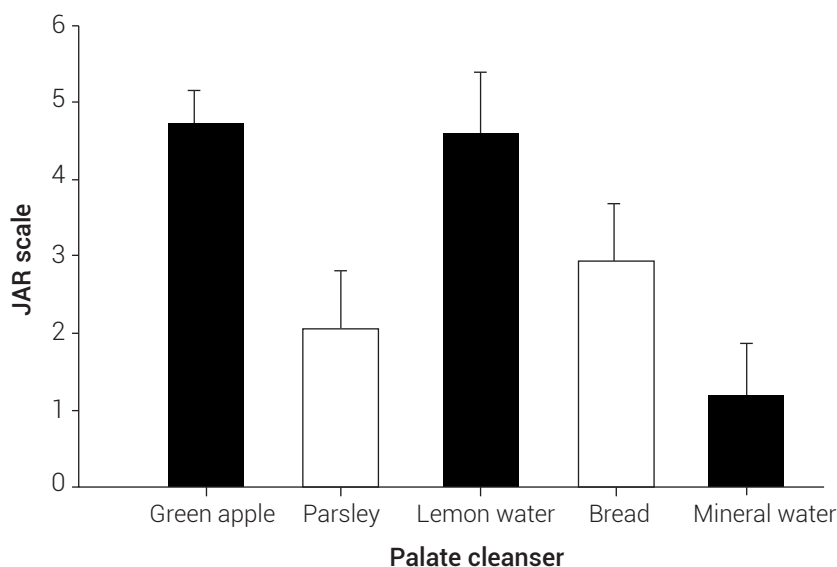


Figure 2. Mean (\pm standard deviation) scores given to the different palate cleansers used for the sensory evaluation of Mexican garlic.

Table 1. Matrix of Spearman correlation between vehicles and palate cleansers used in the sensory evaluation of fresh Mexican garlic.

	Cream cheese	Green apples	Lemon water	Bread
Mashed potatoes with milk	-0.405*	0.431*	-0.515*	0.125
Cream cheese	1.000	-0.295	0.307	-0.468*
Green apples		1.000	-0.542**	0.053

Asterisks indicate the significance *: $P \leq 0.05$, **: $P \leq 0.01$.

garlic show that mashed potatoes with water, identified as the best rated vehicle, show no significant correlations with any of the palate cleanser (Table 1). The absence of correlations suggests that its performance as a vehicle is independent of the palate cleanser used.

In contrast, mashed potatoes with milk, which scored the second best among vehicles (Figure 1), had a significant positive correlation with green apples as a palate cleaner (0.431). This association could be related to a sensory complementarity, in which the texture and mild flavor of mashed potatoes with milk are positively enhanced by the acidic and refreshing profile of green apples, thus, facilitating better assessment of garlic attributes. In this regard, although the concept of sensory complementarity has not been formally described, in practical terms, it is intended to describe the relationship between the properties and compounds of vehicles and palate cleansers used in sensory tests, and it can help to better understand the complex nature of certain foods (Surco and Alvarado, 2011).

On the other hand, a negative association was also detected between mashed potatoes with milk and lemon water as palate cleanser (-0.515); this interference is probably due to unfavorable sensory contrasts, which are incompatible, at least for the evaluation of foods with a strong flavor profile, such as fresh garlic; in addition, a significant negative correlation was observed between the palate cleansers green apples and lemon water (-0.542); this finding revealed that panelists tend to prefer one or the other as a method of cleansing the palate, which should be considered when designing sensory protocols, since their joint use could generate opposite effects on perception. This information is of utmost importance since the favorable development of a sensory test is closely related to the appropriate experimental and methodological design, hence, the selection of vehicles and palate cleanser is essential to ensure its success (Chigwedere *et al.*, 2022).

Based on the results obtained, it is suggested that the sensory tasting protocols of fresh garlic incorporate as vehicles mashed potatoes with water (high acceptability and stability) and mashed potatoes with milk, as a second option, due to their good performance in combination with a certain palate cleanser; similarly, the palate cleansers green apples and lemon water proved effective in cleansing the palate, showing homogeneous ratings and a high acceptance among the panelists; nonetheless, the differential interaction shown in the test suggests that their selection should be carefully considered according to the experimental design; thus, these combinations represent methodologically sound alternatives, which

can improve the accuracy, neutrality and reproducibility of sensory evaluations in products such as fresh garlic.

Lexicon and sensory wheel of fresh Mexican garlic

According to the results, the main descriptors for the evaluation of fresh Mexican garlic are those included in Figure 3. This graphical representation shows only the significant attributes (eight descriptors), representing the percentage of mentions that the descriptor obtained compared to possible total mentions. The most important attributes for the sensory evaluation of fresh garlic were taste, color, aftertaste, bitterness, spiciness, pungency, texture and aroma. This information is relevant since the use of descriptive terms requires the establishment of a standard lexicon to be applied in classical descriptive methods, such as in the current rapid methods (da Silva *et al.*, 2012). Similarly, the identified attributes have the potential to quantitatively inform the sensory attributes of garlic, reducing the time and cost of sensory testing. This information is critical for the development of new varieties and, therefore, this sensory lexicon will have an added value in the development of new products and quality assurance (De Pelsmaeker *et al.*, 2019). As noted by Su *et al.* (2021), the sensory wheel sets standards and guidelines for fresh garlic in order to promote the development of breeding programs, consumer behavior, the development of by-products and trade, as well as its usefulness as educational material.

CONCLUSIONS

A relevant finding was the identification of mashed potatoes with water as the best-rated vehicle, making them a reliable tool for future studies, minimizing potential interferences during of the product evaluation. Similarly, mashed potatoes with milk, by showing positive associations with palate-cleansing ingredients, outline a favorable sensory interaction that could be used in specific tasting designs. On the other hand, green apples and lemon water were the best rated palate cleansers; nevertheless, their mutual negative correlation indicated that they should be selected exclusively, depending on the sensory profile of the product and the objectives of the analysis. These observations provide new methodological guidelines for optimizing palate cleansing, an aspect that is often underestimated in sensory protocols; likewise, the findings provide new insights applicable to the design of sensory protocols, especially for complex organoleptic profiles, such as garlic produced in Mexico. With these results, the foundations are laid to improve methodological standardization in sensory evaluations, optimizing the selection of vehicles and palate cleansers that favor a more accurate and objective assessment.

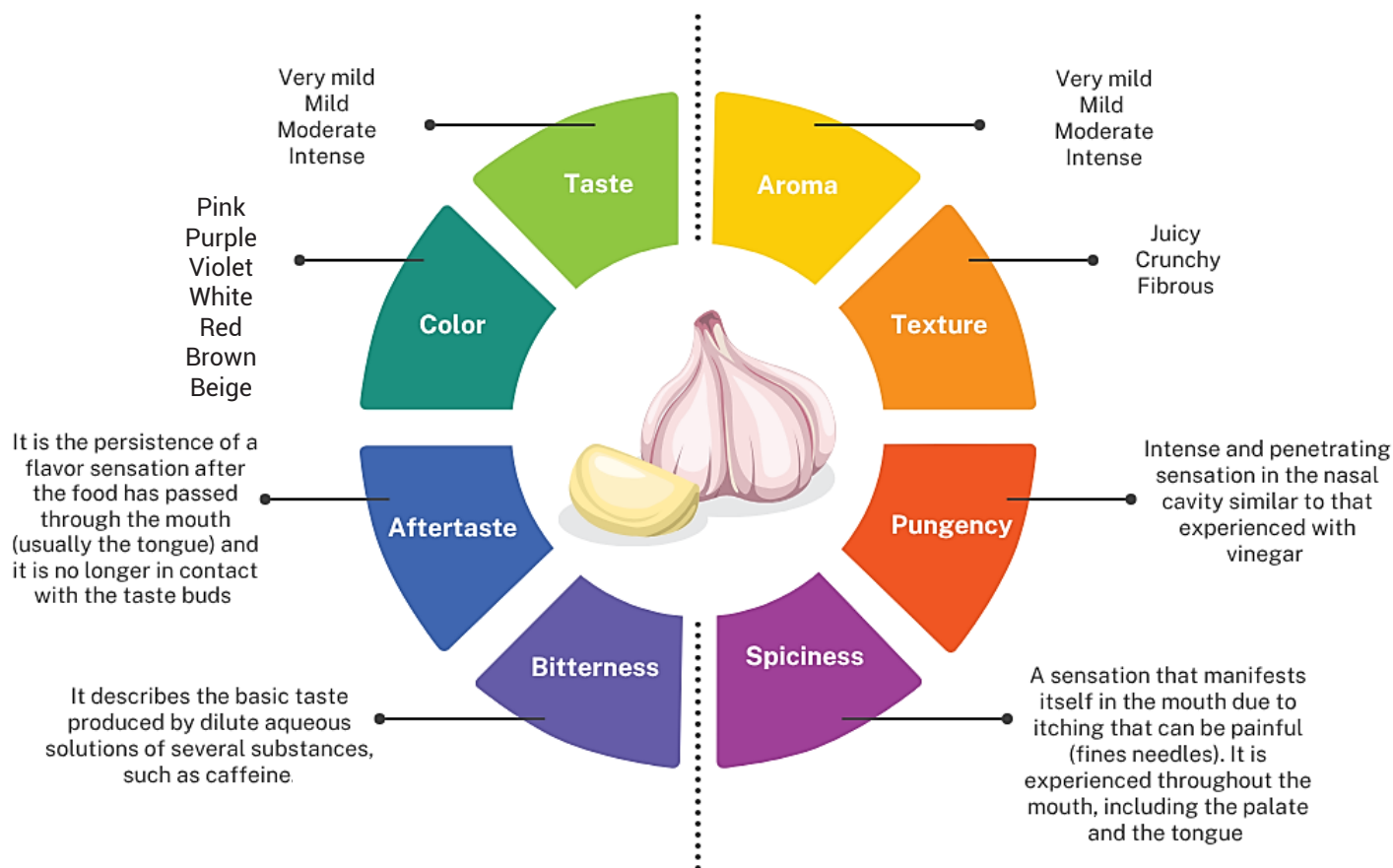


Figure 3. Sensory wheel of Mexican garlic.

BIBLIOGRAPHY

- Astudillo T. M. P. y F. Chevez-Ponce (2021) La escala de Likert en la medición de las TIC y la exclusión social. *Brazilian Journal of Education, Technology and Society* 14:375-383, <https://doi.org/10.14571/brajets.v14.n3.375-383>
- Barker S., R. Moss and M. B. McSweeney (2021) Carbonated emotions: consumers' sensory perception and emotional response to carbonated and still fruit juices. *Food Research International* 147:110534, <https://doi.org/10.1016/j.foodres.2021.110534>
- Bautista-Díaz L., E. Victoria-Rodríguez, L. B. Vargas-Estrella y C. C. Hernández-Chamosa (2020) Pruebas estadísticas paramétricas y no paramétricas: su clasificación, objetivos y características. *Educación y Salud Boletín Científico Instituto de Ciencias de la Salud Universidad Autónoma del Estado de Hidalgo* 9:78-81, <https://doi.org/10.29057/icsa.v9i17.6293>
- Bless I., S. E. P. Bastian, J. Gould, Q. Yang and K. L. Wilkinson (2024) Development of a lexicon for the sensory description of edible in-sects commercially available in Australia. *Food Research International* 190:114574, <https://doi.org/10.1016/j.foodres.2024.114574>
- Chen Y., A. X. Huang, I. Faber, G. Makransky and F. J. A. Perez-Cueto (2020) Assessing the influence of visual-taste congruency on perceived sweetness and product liking in immersive VR. *Foods* 9:465, <https://doi.org/10.3390/foods9040465>
- Cherdchu P. and E. Chambers (2014) Effect of carriers on descriptive sensory characteristics: a case study with soy sauce. *Journal of Sensory Studies* 29:272-284, <https://doi.org/10.1111/joss.12100>
- Chigwedere C. M., J. P. D. Wanasundara and P. J. Shand (2022) Sensory descriptors for pulses and pulse-derived ingredients: toward a standardized lexicon and sensory wheel. *Comprehensive Reviews in Food Science and Food Safety* 21:999-1023, <https://doi.org/10.1111/1541-4337.12893>
- Coste E. B., A. B. Picallo, M. Bauzá y M. Sance (2010) Desarrollo preliminar de descriptores para el análisis sensorial de ajos desecados y liofilizados. *Revista de la Facultad de Ciencias Agrarias* 42:159-168.
- da Silva R. C. S. N., V. P. R. Minim, A. A. Simiqueli, L. E. S. Moraes, A. I. Gomide and L. A. Minim (2012) Optimized descriptive profile: a rapid methodology for sensory description. *Food Quality and Preference* 24:190-200, <https://doi.org/10.1016/j.foodqual.2011.10.014>
- De Pelsmaeker S., G. De Clercq, X. Gellynck and J. J. Schouteten (2019) Development of a sensory wheel and lexicon for chocolate. *Food Research International* 116:1183-1191, <https://doi.org/10.1016/j.foodres.2018.09.063>
- Dhall R. K., P. F. Cavagnaro, H. Singh and S. Mandal (2023) History, evolution and domestication of garlic: a review. *Plant Systematics and Evolution* 309:33, <https://doi.org/10.1007/s00606-023-01869-9>
- Di Monaco R., S. Cavella, S. Di Marzo and P. Masi (2004) The effect of expectations generated by brand name on the acceptability of dried semolina pasta. *Food Quality and Preference* 15:429-437, <https://doi.org/10.1016/j.foodqual.2003.07.003>
- Dziki D., W. H. Hassoon, B. Biernacka and U. Gawlik-Dziki (2022) Dried and powdered leaves of parsley as a functional additive to wheat bread. *Applied Sciences* 12:7930, <https://doi.org/10.3390/app12157930>
- FAO, Food and Agriculture Organization of the United Nations (2025) World Crop Statistics. FAOSTAT. Food and Agriculture Organization of the United Nations. Rome, Italy. <http://faostat.fao.org> (June 2025).

- Fischer U., R. B. Boulton and A. C. Noble (1994) Physiological factors contributing to the variability of sensory assessments: relationship between salivary flow rate and temporal perception of gustatory stimuli. *Food Quality and Preference* 5:55-64, [https://doi.org/10.1016/0950-3293\(94\)90008-6](https://doi.org/10.1016/0950-3293(94)90008-6)
- García R., B. Sánchez-Toledano, M. A. López-Santiago y R. Valdivia-Alcalá (2024) Innovación en tecnología alimentaria: caracterización hedónica de quesos funcionales con harina de frijol. *Revista Fitotecnica Mexicana* 47:43-51, <https://doi.org/10.35196/rfm.2024.1.43>
- Heredia Z. A. y E. Heredia G. (2000) Mejoramiento genético de ajo en el INIFAP. In: El Ajo en México, Origen, Mejoramiento Genético, Tecnología de Producción. Libro Técnico Núm. 3. E. Heredia G. y F. Delgadillo S. (comps.). Campo Experimental Bajío, Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias. Celaya, Guanajuato, México. pp:29-32.
- Horie F., M. Kamei, M. Nishibe, Y. Ogawa, M. Tanibuchi, N. Gotow, ... and Y. Kusakabe (2024) Flavor intensity is reduced in pureed food: a study using instrumental and sensory analyses. *Food Quality and Preference* 115:105121, <https://doi.org/10.1016/j.foodqual.2024.105121>
- ISO, International Organization for Standardization (2012) ISO 8586:2012, Sensory analysis General guidelines for the selection, training and monitoring of selected assessors and expert sensory assessors. ISO. Geneva, Switzerland. <https://www.iso.org/standard/45352.html> (July 2025).
- Johnson R. W. (2022) Alternate forms of the one-way ANOVA F and Kruskal-Wallis test statistics. *Journal of Statistics and Data Science Education* 30:82-85, <https://doi.org/10.1080/26939169.2021.2025177>
- Johnson E. A. and Z. Vickers (2004) The effectiveness of palate cleansing strategies for evaluating the bitterness of caffeine in cream cheese. *Food Quality and Preference* 15:311-316, [https://doi.org/10.1016/S0950-3293\(03\)00071-5](https://doi.org/10.1016/S0950-3293(03)00071-5)
- Kitsawad K. and T. C. Nguyen (2014) Determination of suitable palate cleansers for spicy tom yum soup. *Agro Food Industry Hi Tech* 25:28-30.
- Lawless L. J. R. and G. V. Civille (2013) Developing lexicons: a review. *Journal of Sensory Studies* 28:270-281, <https://doi.org/10.1111/joss.12050>
- Macías V. L. M., L. H. Maciel P., A. Cruz V., M. A. Galindo R. y R. F. Domínguez L. (2021) Orión: nueva variedad de ajo para la zona centro norte de México. *Revista Mexicana de Ciencias Agrícolas* 12:163-170, <https://doi.org/10.29312/remexca.v12i1.2206>
- Marques C., E. Correia, L. T. Dinis and A. Vilela (2022) An overview of sensory characterization techniques: From classical descriptive analysis to the emergence of novel profiling methods. *Foods* 11:255, <https://doi.org/10.3390/foods11030255>
- Melguizo-Rodríguez L., E. García-Recio, C. Ruiz, E. De Luna-Bertos, R. Illescas-Montes and V. J. Costela-Ruiz (2022) Biological properties and therapeutic applications of garlic and its components. *Food & Function* 13:2415-2426, <https://doi.org/10.1039/D1F003180E>
- Mertler C. A., R. A. Vannatta and K. N. LaVenía (2021) Advanced and Multivariate Statistical Methods: Practical Application and Interpretation 7th edition. Routledge. New York, USA. 350 p. <https://doi.org/10.4324/9781003047223>
- Pannitteri C., L. Corollaro and I. Caprioli (2020) Effectiveness of several palate cleansers on carry-over effect of minty chewing gums. *Chemosensory Perception* 13:106-118, <https://doi.org/10.1007/s12078-019-09271-x>
- Paries M., S. Bougeard and E. Vigneau (2022) Multivariate analysis of Just-About-Right data with optimal scaling approach. *Food Quality and Preference* 102:104681, <https://doi.org/10.1016/j.foodqual.2022.104681>
- Rababah T., M. Al-U'datt, M. Angor, A. Alsaad, Y. Akkam, S. Gammoh, ... and N. Al-Rayyan (2025) Fresh crushed garlic exhibits superior alliin and pyruvic acid stability, while fresh sliced garlic leads in phenolic and antioxidant content. *Applied Food Research* 5:100850, <https://doi.org/10.1016/j.afres.2025.100850>
- Reveles-Hernández M., R. Velásquez-Valle y A. G. Bravo-Lozano (2009) Tecnología para Cultivar Ajo en Zacatecas. Libro Técnico No. 11. Campo Experimental Zacatecas, INIFAP. Calera, Zacatecas, México. 272 p.
- Severiano P. P. (2025) Manual de Evaluación Sensorial. Facultad de Química, UNAM. Ciudad de México, México. 218 p.
- SIAP, Servicio de Información Agroalimentaria y Pesquera (2025) Anuario estadístico de la producción agrícola. Secretaría de Agricultura y Desarrollo Rural. Ciudad de México, México. https://nube.agricultura.gob.mx/cierre_agricola/ (Junio 2025)
- Shen X., L. Yao, S. Song, H. Wang, M. Sun, Q. Liu, ... and T. Feng (2025) The sensory lexicon of malt whisky new make spirit constructed by GC×GC-TOF MS. *Journal of Future Foods* 5:480-487, <https://doi.org/10.1016/j.jfutfo.2024.08.005>
- Su C., M. Yang, H. Huang, C. Kuo and L. Chen (2021) Using sensory wheels to characterize consumers' perception for authentication of Taiwan specialty teas. *Foods* 10:836, <https://doi.org/10.3390/foods10040836>
- Surco A. J. C. y J. A. Alvarado K. (2011) Estudio estadístico de pruebas sensoriales de harinas compuestas para panificación. *Revista Boliviana de Química* 28:79-82.
- Tadesse K. T (2024) The role of post-harvest management in ensuring food security in a changing world: review article. *Journal of Clinical Research and Case Studies* 2:1-14, <https://doi.org/10.61440/JCRCS.2024.v2.41>
- Torricella M. R. E. Zamora U. y H. Pulido A. (2020) Evaluación Sensorial Aplicada a la Investigación, Desarrollo y Control de la Calidad en la Industria Alimentaria. Editorial Universitaria. La Habana, Cuba. 129 p.
- Verma T., A. Aggarwal, P. Dey, A. K. Chauhan, S. Rashid, K. T. Chen and R. Sharma (2023) Medicinal and therapeutic properties of garlic, garlic essential oil, and garlic-based snack food: an updated review. *Frontiers in Nutrition* 10:1120377, <https://doi.org/10.3389/fnut.2023.1120377>
- Vidal L., L. Antúnez, A. Giménez and G. Ares (2016) Evaluation of palate cleansers for astringency evaluation of red wines. *Journal of Sensory Studies* 31:93-100, <https://doi.org/10.1111/joss.12194>
- Wang Y. and F. Liu (2025) Impact of artificial intelligence innovation on food company performance. *International Review of Financial Analysis* 103:104219, <https://doi.org/10.1016/j.irfa.2025.104219>
- Widianti E., U. Sarofa and M. A. Kurnianto (2024) Sensory evaluation of flakes from purple sweet potato flour with the addition of edamame flour using the just about right (JAR) method. *Asian Journal of Applied Research for Community Development and Empowerment* 8:261-265, <https://doi.org/10.29165/ajarcde.v8i2.440>
- Xia Y., J. Hou, J. Chen, C. Spence, J. Qian, F. Zhao, ... and F. Zhong (2025) An exploratory study on the development of a sensory wheel affiliated with the emotional lexicon for chrysanthemum infusion. *Food Research International* 201:115428, <https://doi.org/10.1016/j.foodres.2024.115428>
- Xu D., Y. Peng, F. Wu, Y. Jin, N. Yang and X. Xu (2022) Effect of fermented cream with partial substitution of soy protein isolate on bread quality and volatile compounds. *Food Bioscience* 50 Part B:102142, <https://doi.org/10.1016/j.fbio.2022.102142>