Adv. Hort. Sci., 2026 40(3): 335-344

DOI: 10.36253/ahsc-20316
https://oaj.fupress.net/index.php/ahs

AHS
Advances in Horticultural Science

# Functional foods and sensory analysis: Evidence from a magnesium-enrichment radish study

**I. Bravo [1] (*), E.K. Twum [1], I. Colamatteo [1], C. Beni [2], E. Iannucci [1], L. Cappelli [1]**

[1] *LAMeT, University of Cassino and Southern Lazio, viale dell'Università, 03043 Cassino (FR), Italy.*

[2] *CREA-IT, Centro di Ricerca Ingegneria e Trasformazioni Agroalimentari, Via della Pascolare, 16, 00015 Monterotondo (RM), Italy.*

*Key words:* Food quality, magnesium biofortification, organoleptic assessment, radish, sensory analysis.

**Abstract: Evidence from the literature highlights a strong consumer preference and/or purchase intention for fortified food products due to their health benefits. They prefer enriched food products with an increase of micronutrients and a better nutritional profile, specific for their needs. Yet sensory appeal remains a key driver to their final acceptance and at the same time, there are few evidence in literature regarding organoleptic aspect of horticultural fortified. Investigating sensory profiles is therefore critical to developing enriched food products that meet both health expectations and hedonic preferences. This paper aims to evaluate organoleptic aspects of a radish plant enriched with magnesium, and a combination of magnesium and zeolite solution, using a trained panel of tasters. Data collected were analyzed using the Co-efficient of Variation, Analysis of Variance (ANOVA), and Tukey's Honestly Significant Difference (HSD) tests. Treatment samples with magnesium solutions increased magnesium concentrations relative to the control sample. The estimated increase is 27.2% in swollen root and 58.4% in leaf. In fact, the treatment significantly altered the sensory profiles of the radish plant. Both magnesium and magnesium and zeolite samples significantly exhibited lower bitterness and crunchiness intensity while showing an increase intensity of spiciness. Notably, the treatment samples were perceived as spicier but less bitter than the control sample. Sensory profiles of functional foods are altered by incorporation of nutrients and foliar treatments, ultimately having the ability to affect the hedonic preferences of potential consumers. The study produces new data on the topic of sustainable product innovation in the agri-food industry, delineating new opportunities for future research. Finally, it addresses the gap in the literature on fortified vegetable sensory evaluation. A further hedonic analysis with a larger number of panelists along with surveys assessing consumer willingness to consume and purchase these products are needed.**

OPEN ACCESS

(*) **Corresponding author:**
ilenia.bravo@unicas.it

**Citation:**
BRAVO I., TWUM E.K., COLAMATTEO I., BENI C., IANNUCCI E., CAPPELLI L., 2026 - *Functional foods and sensory analysis: Evidence from a magnesium-enrichment radish study* - Adv. Hort. Sci., 40(3): 335-344.

**ORCID**:
BI: 0000-0001-7830-6147
TEK: 0000-0001-7146-9189
CI: 0009-0008-3085-0088
BC: 0000-0002-2056-8598
IE: 0000-0003-0227-7209
CL: 0000-0002-0893-2609

**Copyright:**
© 2026 Bravo I., Twum E.K., Colamatteo I., Beni C., Iannucci E., Cappelli L. This is an open access, peer reviewed article published by Firenze University Press (https://www.fupress.com) and distributed, except where otherwise noted, under the terms of CC BY 4.0 License for content and CC0 1.0 Universal for metadata.

**Data Availability Statement:**
All relevant data are within the paper and its Supporting Information files.

**Competing Interests:**
The authors declare no conflict of interests.

Received for publication 9 December 2025
Accepted for publication 21 March 2026

## 1. Introduction

Consumers in recent years, driven by increased life expectancy and

improved quality of life, have begun to understand the nexus between food composition and well-being status. They are becoming more aware of the consequences related to purchasing decisions and the food choices they make (Smeding *et al*., 2023; Yang *et al*., 2023). This has led to the adoption of eating habits based on targeted and tailor-made diets with reference to effective nutritional needs of each individual. A growing cohort of consumers are also considering socially responsible consumption style such as waste reduction, reuse, recycling, and responsible agricultural practices to avoid or minimize environmental impacts (Prendergast and Tsang, 2019; Hosta and Zabkar, 2021).

Therefore, the need to transition towards more sustainable diets has become a shared priority for both consumers and the economic market. Sustainability is no longer seen as just an environmental issue, but a complex commitment that intertwines perceived quality, global concerns, product innovation, and ethical behavior.

Among new trends is an increase in the consumption of functional food products with high nutritional content. These products are developed by incorporating nutritional substances with the ability to induce a specific physiological benefit (Dotto and Chacha, 2020).

Nowadays, the interest in integrating diets with fortified foods, also proves to be a great opportunity for the food industry, as small and medium-sized businesses can find greater profitability through the commercialization of innovative and functional products as well as increase their competitiveness (Hermundsdottir and Aspelund, 2021). In fact, many authors state that the global size of the functional foods market is increasing, covering various food categories (i.e bakery and dairy products, meat, fish, eggs, fats and oils) with a compound annual growth rate of 6.9% and is expected to rise to 597.1 billion dollars by 2032 (Martirosyan *et al*., 2022; Mudondo *et al*., 2025;). It is expected that this increase of the functional foods market is linked to a greater importance given to health and quality food products which generates an alternative to medical formulations. Indeed, the literature presents a very large number of contributions aimed at analyzing consumer attitudes towards innovative products, use of novel ingredients, and implementation of sustainable production processes (Nazzaro *et al*., 2024). Recent functional food formulations involve the addition of nutrients to improve a specific functionality (e.g., digestion, learning ability), reduction or replacement of an ingredient to reduce a source of health risk (e.g., "lactose-free" and "gluten-free"), or an increase of the bioavailability of a component normally present in the food. These formulations include a wide range of compounds such as bioactive peptides, phenolic compounds, carotenoids, lipids, vitamins, dietary fibers, fatty acids, minerals, prebiotics, and probiotics (Yao *et al*., 2020).

Among the foods subject to enrichment, fruit and vegetables are the most studied categories, as they are sources of polyphenols and other compounds with antioxidant action which are necessary to prevent the excessive accumulation of free radicals (Tadesse and Emire, 2020).

However, the sensory profile of these horticultural product is still being fully explored, especially in relation to their various functional applications.

The creation of innovative functional foods involves all facets of the food supply chain, including cultivation using sustainable methods and technologies. This allows, novel product development, and revitalize underutilized and genetically diverse varieties, and support waste management (Lee *et al*., 2024; Onawo and Egboduku, 2025).

Furthermore, not all food innovations are accepted by consumers, especially in terms of organoleptic characteristics, and survive in markets. Consequently, it is important to understand the extent consumers embrace these new products form new eating habits and overcome limits related to food techno-neophobia (Zamparo *et al.*, 2023).

*Consumer behavior theory*

According to Kotler and Keller (2016) "consumer buying behavior is the study of the ways of buying in order to satisfy their needs", and is determined by the cultural, personal, social, and psychological factors (Qazzafi, 2020).

The food quality is a key factor in their decision-making process and plays an important role to determinate the perception of a specific product; and it is influenced by various characteristics. The values sought and expected by consumers have an impact on the desirable aspects of quality and the way in which product/service attributes are perceived and evaluated (Wang *et al.*, 2020).

Food quality can also be considered as a

multidimensional construct which is characterized by four essential dimensions that are interconnected: the hedonic properties of food, convenience, health, and the production process (Sadilek, 2019).

The perception of food quality has an objective and a subjective aspect; the first regard nutraceutical composition and food safety, while the second aspect refers to process attributes including origin, as well as other organoleptic attributes such as taste. For consumers to form a quality judgement of a particular food product, they must draw from any quality cues available or information stimuli and can be predictive of the desired attribute and ascertained through the senses prior to consumption (e.g., food certificates or organic production) (Steenkamp, 1990).

In fact, consumers are willing to pay a premium price for goods considered to be ethically superior, respectful of health, environmentally friendly, and innovative with symbolic and communicative values rather than material values (Valaskova *et al*., 2018).

Despite safety control associated with innovative food products, consumers tend to have difficulty accepting and purchasing them, when unfamiliar technologies are used in production. (Bánáti, 2011). This skepticism leads to consumers boycotting newly developed products which is often caused by lack of information and knowledge availability regarding production methods (Krystallis *et al*., 2007). The trade-off between risks, perceived quality and benefits is the major factor that determine consumer acceptance or rejection of novel food (Sajdakowska *et al*., 2018).

The aim of this study is to evaluate the sensory profile of magnesium-enriched radish obtained through a sustainable cultivation approach based on targeted foliar fertilization, using a trained sensory panel.

## 2. Materials and Methods

*Sensory analysis*

Sensory analysis is part of food science and has the primary aim of providing an 'objective' measure of the sensory quality of food items. It consists of a set of techniques and conditions that measure and evaluate, using one or more of the human senses, certain characteristics of specific products. Sensory analyses are performed by a panel of selected and trained tasters who have completed training courses and passed examinations in accordance with Regulation (EC) No. 640/2008 and other national and international laws, enabling them to carry out sensory analysis of a product under controlled conditions.

Through the use of a specific tasting score sheet the tasters record the intensity of a descriptor, in a graduate scale from 0 (no intensity) to 10 (maximum intensity), with which the items on the sheet are perceived in their evaluation of the food product. The taster then gives a final judgement on the basis of the individual scores given to each attribute, determining the overall sensory quality of the product (Meilgaard *et al*., 1999; Alvarez and Blanco, 2000). The attributes measured address one or more of the following aspects: visual, auditory, somesthetic, kinesthetic, olfactory, chemesthetic, and gustatory (Lawless and Heymann, 2010; Lawless and Civille, 2013). The panelists undergo specific training depending on the attributes to be analyzed and they learn how to use a pre-established sensory language used during evaluations. Each attribute has a description and a specific reference to allow the taster to identify and measure the sensory attribute (Drake *et al*., 2023).

*Case study*

The selected species was radish *(Raphanus raphanistrum* subsp. *sativus* (L.) Domin*)*, belonging to the *Brassicaceae (Cruciferae)* family, a vegetable plant with a wide range of distribution, in particular in the Mediterranean area. Radish includes only the species *Raphanus raphanistrum*, of which there are multiple subspecies and varieties in different colors. The plant is monocarpic and produces a single edible storage organ per year. It has a stem with an erect floral axis with few leaves and branched at the top. The root is of the thickened taproot type and has the ability to accumulate different quantities of nutrients within it, which will then be used during the subsequent development of the flower and enlarged hypocotyl-root complex.

This species was chosen for its widespread use, short growing cycle, and ability to absorb at different level (swollen root , roots and leaves) various types of molecules. It is also of great agronomic and commercial interest, in particular the edible storage organ. Its color is normally bright red with a variable shape (round, globular, semi-long, long). From a nutritional point of view, 100 grams of product contain 3.45 g of carbohydrates, a moderate content

of potassium, flavonoid (24.4 of QE/g), total phenols (95.8 of GAE/g), low concentrations in magnesium (0.016 mg) (Khan *et al*., 2022).

The radish plant was cultivated with seeds purchased from the local retailer and placed in polystyrene containers. The experimental design consists of 3 theses of which 1 is a control and 2 treatment combinations, with 3 replicates for each thesis, for a total of 9 samples.

During the growth phase, which occurred over a period of six weeks, the radish samples were treated twice with a foliar fertirrigation application of only 2% magnesium sulfate (sample 2), with the addition of microgranular zeolite (chabazite species) (sample 3), according to manufacturer's recommendations and studies conducted in the literature.

The magnesium was obtained from pharmacies, and the zeolite was directly purchased from the producer (Fitokem srl, Imperia, Italy). Zeolites are aluminosilicates ($AlO_4$ and $SiO_4$) naturally found in sedimentary rocks, that can be used as soil ameliorants with the effect to facilitate the improvement of physical and chemical properties, as well as alleviate heavy metal toxicity reduce nutrient leaching and their use leads to cultivation and water use efficiency (Cataldo *et al.,* 2021; Mondal *et al*., 2021).

Two foliar treatments were carried out, approximately a couple of weeks apart, one during the intermediate phase of vegetative development and the last one shortly before harvesting, when the leaves were at the peak of growth in weight and size. Given their rapid growth cycle, which can reach up to 20 days in well-adapted conditions, they were harvested in mid-October when the edible storage organ were at peak growth. After that, the samples were treated for subsequent instrumental, and organoleptic analyses was performed. Concentration analyses were performed using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). The Mg concentration was expressed as mg $kg^{-1}$ dw.

Given the limited literature available on the sensory profiles of horticultural crops, an ad hoc sensory profile model was built based on the descriptors of similar crops, to evaluate whether the various samples presented distinctions in sensory terms.

For the sensory analysis, the three different samples (control, treatment with only Mg, and treatment with zeolite and Mg,) were cleaned, trimmed, prepared in uniform portions, and served at room temperature to avoid altering the characteristics of the product (Table 1).

They were then tasted in a single session in the tasting room, by a panel made up of 10 trained tasters (officially recognised by Italian Ministry of Agricultural, Food and Forestry Policies), that operates permanently in according to the criteria set out in specific regulations.

At the beginning of the analysis, the group was given a brief introduction on the objectives of the test in question and a description of the novel evaluation sheet. In fact, regarding to the specific attributes for radish, a few evidences exist in literature; for these reasons a wide number of hypothetical attributes were added.

Table 1 - Treatments and experimental approach

| Sample | Treatment |
|---|---|
| 1 | Control |
| 2 | Solution Mg Sulfate 2% |
| 3 | Zeo + Mg |

Sample 1 is a control; Sample 2 was treated with Magnesium; Sample 3 was treated with a combination of Magnesium and zeolite solution.

The three samples were presented in a casual way to the panelists on small plates, and numbered with progressive values (number 1, number 2 and number 3) without indicating the treatment administered in a randomized design to eliminate any effect of the order of service. The panelists were asked to taste the samples and fill in the sheet immediately following the codes written on the cards. They evaluated the color, flavour, taste, and consistency attributes of the samples to be analyzed. The flavour was evaluated for intensity of fruitiness and herbaceousness, sweetness, acidity, and bitterness. The consistency was described and analyzed in terms of compactness and juiciness. Subsequently, the results of the attributes selected, were summarized during a round table discussion (open panel), where other perceived aromatic scents (floral, woody, citrus, etc.), previously not considered, were identified. The results of the sensory evaluations were estimated using the coefficient of variation (CVr). It is a dispersion index that allows the evaluation of the dispersion of data around the mean

value, with a dimensionless quantity. According to the regulations governing sensory tests, an evaluation whose CVr% is less than 20 can be considered reliable. All the values obtained from the panel test are within the CVr limit.

These values were then recorded in an excel file and the averages were represented with the characteristic spider web graph.

For a robust analysis, we applied the Analysis of Variance (ANOVA) and Tukey's Honestly Significant Difference (HSD) tests. To assess the appropriateness of using one-way ANOVA, additional analyses were conducted to evaluate the potential influence of panelist effects on the sensory evaluation results. A two-way ANOVA including panelist as a factor was performed for each of the nine sensory attributes. The panelist effect was not statistically significant for any attribute (all $p>0.05$), indicating that differences among panelists did not contribute meaningfully to the observed variation in sensory scores. The findings suggest that observed differences were primarily attributable to treatment effects rather than individual panelist differences.

Furthermore, mixed-effects models treating panelists as random effects were fitted for each sensory attribute. The results were consistent with those obtained from the one-way ANOVA. The intraclass correlation coefficients (ICCs) were negligible across all sensory attributes (all ICCs < 0.001; approximately zero), indicating minimal within-panelist dependence and virtually no clustering of observations within panelists.

In addition, all evaluations were conducted under standardized conditions by trained panelists, and the order of sample presentation was randomized to minimize potential carryover, learning, and fatigue effects. Collectively, these findings indicate that panelist-related variability had a negligible influence on the sensory evaluation outcomes and support the use of the one-way ANOVA.

## 3. Results and Discussion

Two different treatments - only Magnesium (S2) and a combination of Zeolite and Magnesium (S3) were conducted with respect to the control (S1). However, for these two treatments both the leaves and enlarged hypocotyl-root complex of the plant were analyzed in order to verify whether the Magnesium (Mg) translocated and accumulated preferentially. Instrumental analysis revealed that the leaves absorbed a greater amount of Mg than the control, as predicted by foliar fertigation. At the same time, the treatments (S2 and S3) increased magnesium concentrations compared to the control (S1), both in the swollen roots and leaves. In particular, the treatment with only Mg solution (S2) increased the Mg concentration about 27.2% in swollen root and 58.4 in leaf respectively (Table 2).

From the sensory analysis, compared to the control (S1), the treatments on the radish samples seem to have given the product more balanced and harmonious characteristics and an overall positive opinion from the tasters. The treatments affected both the structure, especially the crunchiness, and the flavor, with spicy notes prevailing over bitterness. The spicy sensation refers to the pungent scent, characterized by burning or tingling sensations, which are caused by chemical molecules (such as capsaicin in chili peppers or oleocanthal in EVOO) with an "irritant or stimulating" action.

Table 2 - Concentration of Mg (mg $kg^{-1}$) in radish

| Sample | Swollen root conc. Mg (mg $kg^{-1}$) | Leaves conc. Mg (mg $kg^{-1}$) |
|---|---|---|
| Control | 72.31 | 315.41 |
| Mg treatment | 99.34 (+27.2%) | 758.55 (+58.4%) |
| Zeo + Mg treatment | 87.63 (+17.5%) | 728.67 (+56.7%) |

Value concentrations of magnesium in the homogenized samples under different treatment, along with the percentage variation relative to the control.

The results from the organoleptic evaluation were statistically analyzed with ANOVA and Tukey's Honestly Significant Difference (HSD) test (Table 3).

The ANOVA test was used to determine whether at least one sample mean of radish plant sensory attribute differs significantly from the others. The results support the rejection of the null hypothesis, indicating that at least one sample mean of all attributes differ significantly across the Control (S1), Mg treatment (S2), and Zeo+Mg treatment (S3) samples, with the exception of savory attribute. This suggests that tasters' evaluations of the attributes, on average, varied across the three samples, except for savory attribute, where no significant difference was observed.

Table 3 - Comparison of sensory attributes among the three samples

| Attribute | Control (S1) | Mg treatment (S2) | Zeo+Mg treatment (S3) | ANOVA F-value | P-value |
|---|---|---|---|---|---|
| Herbaceous | 2.95 ± 0.33 a | 2.26 ± 0.31 c | 3.99 ± 0.38 b | 64.84 | 0.0000 * |
| Vegetal notes | 6.46 ± 0.27 a | 3.05 ± 0.34 c | 4.02 ± 0.38 b | 273.73 | 0.0000 * |
| Bitter | 3.66 ± 0.41 a | 2.50 ± 0.48 c | 2.09 ± 0.33 b | 38.64 | 0.0000 * |
| Savory | 4.52 ± 0.40 a | 4.15 ±0.57 a | 4.19 ± 0.39 a | 2.47 | 0.1038 |
| Crunchiness | 5.62 ± 0.42 a | 3.61 ± 0.37 b | 3.61 ± 0.37 b | 90.14 | 0.0000 * |
| Succulence | 6.01 ± 0.40 a | 4.11 ± 0.38 c | 2.62 ± 0.44 b | 171.92 | 0.0000 * |
| Texture | 5.36 ± 0.39 a | 3.56 ± 0.35 c | 3.00 ± 0.25 b | 133.81 | 0.0000 * |
| Spicy | 2.83 ± 0.41 a | 5.42 ± 0.29 b | 4.46 ± 0.42 b | 120.51 | 0.0000 * |
| Fruity | 5.77 ± 0.57 a | 2.98 ± 0.35 c | 3.20 ± 0.34 b | 127.97 | 0.0000 * |

Values are presented as mean ± standard deviation. Means within a row with different letters differ significantly according to Tukey's HSD test ($p<0.05$). * denote 5% significance level.

Prior to conducting the Tukey HSD test, a test of homogeneity of attributes across samples was conducted using Levene's, Brown-Forsythe, and Brown-Forsythe tests. This was necessary to determine the appropriate post-hoc procedure to follow. Results revealing equal variances are consistent with the application of Tukey HSD while unequal variances are consistent with Games-Howell test. The results revealed that all p-values of attributes across the three samples were greater than 0.05, thus we failed to reject the null hypothesis of equal variances. Consequently, we applied the Tukey's HSD test that allows post hoc comparisons among samples and identifies the specific pairs of samples that differ significantly.

The Tukey's HSD test revealed significant differences between all pairs of samples - S2 vs S1; S3 vs S1; and S3 vs S2 - across all attributes, except for savory attribute. S3 vs S1 exhibited significantly higher herbaceous values than S2 vs S1 (mean difference = 1.04, 95% CI [0.66, 1.42]).

In fact, relative to the control sample (S1), S2 revealed a significant reduction of herbaceous intensity (Fig. 1). The finding suggests that the sample treated with Zeo + magnesium exhibited higher herbaceous intensity than the control sample. This could possibly be explained by an enhanced accumulation of compounds (i.e. aldehydes) associated with herbaceous sensory notes by the sample treated with magnesium, and consequently they may have developed features perceived by panelists.

This result can be compared with Gautam *et al*. (2025), where the effect of biologically synthesized magnesium oxide nanoparticles on radish was evaluated. The study reported that magnesium treatments may influence carbohydrate, flavonoid, phenolic, and tannin contents in radish; however, these parameters were not assessed in the present study.

Relative to S1, the treated samples (S2 and S3) exhibited lower vegetal notes intensity. The mean difference for S2 vs S1, and S3 vs S2 are -3.41 and -2.44 respectively. This suggests that in terms of vegetal notes such as aromas, flavors or scent, the treatment of Radish plant with magnesium sulfate or microgranular zeolite (chabazite species) may have little influence on consumer perception and preferences relative to no treatment.

In terms of bitterness, a comparison between S2 and S1 showed a mean difference of −1.16 (95% CI [-1.6193, -0.7007]), while that of S3 and S1 showed a mean difference of −1.57 (95% CI [-2.0293, -1.1107]).

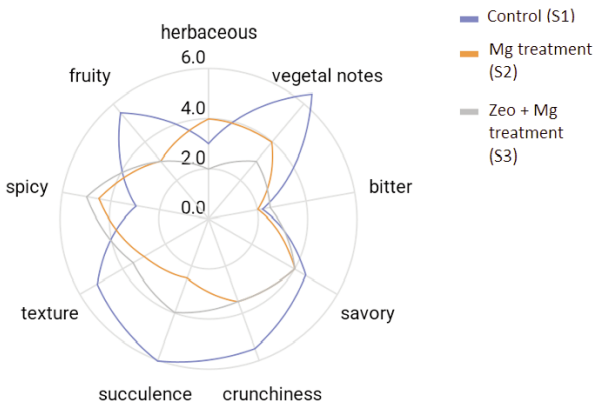



Fig. 1 - Sensory profile of radish. The Mg treatments have influenced the aromatic profile, in particular, in gustatory and tactile aspects.

These findings indicate that both treated samples (S2 and S3) were perceived as significantly less bitter than the control sample (S1). The larger reduction in bitterness observed for S3 suggests that the combination of zeolite and magnesium treatment exhibit a greater decrease in bitterness intensity compared with both magnesium-only treatment and the control. The results can be explained by a decrease of tannins compounds, that may influence flavor, color, and nutrient absorption, and at the same time, they are subject to variation due to factors such as ripeness and food processing methods, as suggested by previous studies (Cosme *et al*., 2025; Gautam *et al*., 2025).

Similarly, S2 and S3 were perceived as significantly less crunchy than the control sample (S1). The mean difference between S2 and S1, and S3 and S1 is -2.01 respectively. This suggests that the treatment samples exhibited the same degree of reduction in crunchiness.

Furthermore, we observed that the treatment sample S2 and S3 statistically decreased the degree of succulence relative to the control sample (S1), among the tasters (mean difference = -1.9, 95% CI [-2.3543, -1.4456]; -3.39, 95% CI [-3.8444, -2.9356]). This suggests that magnesium and Zeo+Mg treatment may be unfavorable in enhancing the characteristics associated with juiciness or moisture retention, ultimately resulting in a less succulent sensory experience for consumers.

The finding can be attributed to micro-zeolite capacity to improve water retention and nutrient availability in horticultural systems. According to Contreras-Martínez *et al.* (2026), however, its influence on plant physiological responses may vary depending on plant species and application rate.

Regarding the texture attribute, we found that both treatment samples (S2 and S3) significantly reduce the intensity of texture relative to the control sample (S1). Although both exhibit a reduction in texture, S2 showed greater reduction in texture than S3, implying a significant difference in treatment samples.

Moreover, the results indicate that sample S2 and S3 were perceived as significantly spicier than S1 (mean difference = 2.59, 95% CI [2.1718, 3.0082]; 1.63, 95% CI [1.2118, 2.0482]). The higher perception of spiciness observed in treated samples may be associated with changes in the concentration of pungent compounds, such as isothiocyanates, although no chemical characterization was performed to confirm this hypothesis. The finding is consistent with Gunjal *et al.* (2026), who applied foliar treatments and highlighted an enhancement of antioxidant activities compounds (i.e. total phenolics, flavonoids, chlorophyll, carotenoids, anthocyanins), to indicate a strong association among growth and biochemical composition, under controlled foliar nutrition.

Finally, the analysis showed that the treated samples (S2 and S3) exhibited lower degree of fruitiness relative to the control sample (S1). The mean difference is -2.79, 95% CI (-3.2708, -2.3092) and -2.57, 95% CI (-3.0508, -2.0891) respectively.

These results demonstrated first, that the aromatic profile can be modified by dosage of nutrients and foliar treatments applied, and second that the zeolites can regulate and drive the reaction mechanisms and the catalytic activity with effect on texture and structure (Thangaraj and Lee, 2025).

Finally, the identification and quantification of the compounds responsible for the organoleptic aspect can influence the consumption of the product.

Neophobic individuals tend to have unfavorable perceptions and lower expectations regarding the taste of new food products, such as functional foods, thus they resist trying or consuming them (Yaşa Özeltürkay *et al*., 2025). Previous research has suggested that the acceptance of these foods depend on the type of base product that serves as the vehicle for the specific ingredient and to their commercial and market value (Lu *et al*., 2020).

Furthermore, for the enrichment food consumption, the positive perceptions of health benefits related to the fortifier increased consumers' willingness to buy such innovative products, while under sensory profile the attributes considered more relevant were foods' taste and texture (Embling *et al*., 2024).

However, the type of food produced, processing and the physio-chemical properties of the active ingredients (for example solubility, chemical interactions and stability) could influence the effective functionality of nutraceutical foods and, consequently, their health benefits may not be recognized by the human body. Furthermore, some nutraceuticals can negatively influence the chemical and sensory properties over time, or the shelf life of foods, and can lead to undesirable effects in the case of interactions with other food components.

Therefore, it is essential to focus information about the functionality of these foods, emphasize the health and environmental benefits of enrichment foods, linked to sustainable agriculture practices (Russo *et al*., 2020).

In fact, from a circular economy perspective, the use of active compounds from agriculture waste and by-products as a source of nutritional added-value compounds can be crucial for functional food production and to sustainable development. For example, organic waste from vinary chains, thanks to their high content of polyphenols, has attracted increasing interest to improve their nutritional value, as well as to enhance sensory properties, by increasing the acidity, bitterness, and purple color attributes (Almanza-Oliveros *et al*., 2024). Nonetheless, it is important to evaluate the food matrix, including texture of the original product and how it can be incorporated in the design of a new product to obtain a tasteful and balanced flavor without affecting the appearance and appeal of the product (Theagarajan *et al*., 2019). Finally, according to Gunjal *et al*. (2026), these findings demonstrate the potential of Magnesium targeted foliar sprays to optimize the nutritional and sensory quality of radish plant.

## 4. Conclusions

Nowadays consumers show a positive attitude towards innovative foods and their positive effects on human health, in particular, when they are informed of the benefits linked to the intake of the functional element.

The present study demonstrated that foliar Mg biofortification effectively increased Mg accumulation in radish tissues and significantly modified the sensory profile of the product. The treatments altered several sensory attributes, reducing bitterness and increasing perceived spiciness, while also affecting texture-related properties such as crunchiness and succulence.

Therefore, nutrient-based biofortification strategies can influence not only the nutritional composition but also the organoleptic characteristics of horticultural products.

Further studies involving larger consumer panels, hedonic tests, and additional nutritional and phytochemical analyses are required to assess the market potential and functional value of biofortified vegetables.

Nonetheless, the study enriches the current literature on enrichement foods, in particular, on sensory assessment of horticultural products obtained with a fertirrigation foliar. It provides practical knowledge on the fortification process of an enriched food, and through sensory analysis potential consumer acceptance of the product is revealed. Moreover, the study outlines practical and theoretical implications on sustainable consumption.

## References

ALMANZA-OLIVEROS A., BAUTISTA-HERNÁNDEZ I., CASTRO-LÓPEZ C., AGUILAR-ZÁRATE P., MEZA-CARRANCO Z., ROJAS R., MARTÍNEZ-ÁVILA G.C.G., 2024 - *Grape pomace. Advances in its bioactivity, health benefits, and food applications*. - Foods, 13(4): 580.

ÁLVAREZ P., BLANCO M.A., 2000 - *Reliability of the sensory analysis data of a panel of tasters*. - J. Sci. Food Agric., 80(3): 409-418.

BÁNÁTI D., 2011 - *Consumer response to food scandals and scares*. - Trends Food Sci. Technol., 22(2-3): 56-60.

CATALDO E., SALVI L., PAOLI F., FUCILE M., MASCIANDARO G., MANZI D., MATTII G.B., 2021 - *Application of zeolites in agriculture and other potential uses: A review*. - Agronomy, 11(8): 1547.

CONTRERAS-MARTÍNEZ R., PÉREZ-ÁLVAREZ S., URANGA-VALENCIA L.P., SÁNCHEZ-CHÁVEZ E., OCHOA-CHAPARRO E.H., ANCHONDO-PAEZ J.C., DÍAZ-GARCÍA M., 2026 - *Effects of zeolite-amended peat substrates on water retention and physiological-biochemical responses of Swiss chard and radish grown under greenhouse conditions*. - Not. Bot. Horti Agrobot. Cluj-Napoca, 54(1): 15056.

COSME F., AIRES A., PINTO T., OLIVEIRA I., VILELA A., GONÇALVES B., 2025 - *A comprehensive review of bioactive tannins in foods and beverages: Functional properties, health benefits, and sensory qualities*. - Molecules, 30(4): 800.

DOTTO J.M., CHACHA J.S., 2020 - *The potential of pumpkin seeds as a functional food ingredient: A review*. - Sci. Afr., 10: e00575.

DRAKE M.A., WATSON M.E., LIU Y., 2023 - *Sensory analysis and consumer preference: Best practices*. - Annu. Rev. Food Sci. Technol., 14(1): 427-448.

EMBLING R., NEILSON L., MELLOR C., DURODOLA M., ROUSE N., HASELGROVE A., WILKINSON L., 2024 - *Exploring consumer beliefs about novel fortified foods: A focus group study with UK-based older and younger adult consumers*. - Appetite, 193: 107139.

GAUTAM A., KUMAR V., GULERIA P., 2025 - *Magnesium*

*oxide nanoparticles improved biochemical and antioxidant parameters of radish to induce salt stress tolerance*. - Plant Nano Biol., 10: 100176.

GUNJAL M., SINGH J., KAUR S., NANDA V., RASANE P., 2026 - *Optimization of foliar spray treatments on radish sango microgreens: a response surface methodology approach to enhance morphological, biochemical, and antioxidant properties*. - Food Humanit., 10: 101140.

HERMUNDSDOTTIR F., ASPELUND A., 2021 - *Sustainability innovations and firm competitiveness: A review*. - J. Cleaner Prod., 280: 124715.

HOSTA M., ZABKAR V., 2021 - *Antecedents of environmentally and socially responsible sustainable consumer behavior*. - J. Bus. Ethics, 171(2): 273-293.

KHAN R.S., KHAN S.S., SIDDIQUE R., 2022 - *Radish (*Raphanus sativus*): Potential antioxidant role of bioactive compounds extracted from radish leaves-A review*. - Pak. J. Med. Health Sci., 16(9): 631-637.

KOTLER P., KELLER K.L. , 2016 - *Marketing management. 15th editions.* - Pearson Education, Boston, USA, pp. 832 .

KRYSTALLIS A., CHRYSSOCHOIDIS G., SCHOLDERER J., 2007 - *Consumer-perceived quality in 'traditional' food chains: The case of the Greek meat supply chain*. - Appetite, 48(1): 54-68.

LAWLESS H.T., HEYMANN H., 2010 - *Sensory evaluation of food: principles and practices*. - Springer Science & Business Media, New York, USA, pp. 596.

LAWLESS L.J., CIVILLE G.V., 2013 - *Developing lexicons: A review*. - J. Sensory Stud., 28(4): 270-281.

LEE J.H., KIM M.J., KIM C.Y., 2024 - *The development of new functional foods and ingredients*. - Foods, 13(19): 3038.

LU Z.X., HE J.F., ZHANG Y.C., BING D.J., 2020 - *Composition, physicochemical properties of pea protein and its application in functional foods*. - Crit. Rev. Food Sci. Nutr., 60(15): 2593-2605.

MARTIROSYAN D., LAMPERT T., EKBLAD M., 2022 - *Classification and regulation of functional food proposed by the Functional Food Center*. - Funct. Food Sci., 2(2): 25-46.

MEILGAARD M.C., CARR B.T., CIVILLE G.V., 1999 - *Sensory evaluation techniques*. - CRC Press, Boca Raton, FL, USA, pp. 416.

MONDAL M., BISWAS B., GARAI S., SARKAR S., BANERJEE H., BRAHMACHARI K., HOSSAIN A., 2021 - *Zeolites enhance soil health, crop productivity and environmental safety*. - Agronomy, 11(3): 448.

MUDONDO J., HAPPY K., GANG R., BAN Y., KANG Y., 2025 - *From nature to nutrition: exploring the synergistic benefits of functional foods and herbal medicines for holistic health*. - Appl. Biol. Chem., 68(1): 17.

NAZZARO C., STANCO M., ULIANO A., MAROTTA G., 2024 - *Consumers' acceptance and willingness to pay for enriched foods: Evidence from a choice experiment in Italy*. - Future Foods, 10: 100405.

ONAWO O.L., EGBODUKU W.O., 2025 - *Highlighting the untapped potential of neglected and underutilized crop species for sustainable food security*. - J. Underutilized Legumes, 7(2): 73-93.

PRENDERGAST G.P., TSANG A.S., 2019 - *Explaining socially responsible consumption*. - J. Consum. Marketing, 36(1): 146-154.

QAZZAFI S., 2020 - *Factor affecting consumer buying behavior: A conceptual study*. - Int. J. Sci. Res. Dev., 8(2): 1205-1208.

RUSSO V., SONGA G., MARIN L.E.M., BALZARETTI C.M., TEDESCO D.E.A., 2020 - *Novel food-based product communication: A neurophysiological study*. - Nutrients, 12(7): 2092.

SADILEK T., 2019 - *Perception of food quality by consumers: literature review*. - Eur. Res. Stud. J., 22(1): 57-67.

SAJDAKOWSKA M., JANKOWSKI P., GUTKOWSKA K., GUZEK D., ŻAKOWSKA-BIEMANS S., OZIMEK I., 2018 - *Consumer acceptance of innovations in food: A survey among Polish consumers*. - J. Consumer Behav., 17(3): 253-267.

SMEDING A., GAUTHERON F., QUINTON J.C., 2023 - *When ethics also matter: Influence of taste, health, and ethical attributes on food decisions traced with a novel mouse-tracking paradigm*. - Appetite, 189: 107006.

STEENKAMP J.B.E., 1990 - *Conceptual model of the quality perception process*. - J. Bus. Res., 21(4): 309-333.

TADESSE S.A., EMIRE S.A., 2020 - *Production and processing of antioxidant bioactive peptides: A driving force for the functional food market*. - Heliyon, 6(8): e04675.

THANGARAJ B., LEE Y.K., 2025 - *Review on recent development in catalytic cracking of waste polyolefins: Effect of zeolite-based catalysts and reaction parameters*. - Fuel, 380: 133220.

THEAGARAJAN R., MALUR-NARAYANASWAMY L., DUTTA S., MOSES J.A., CHINNASWAMY A., 2019 - *Valorization of grape pomace (cv. Muscat) for development of functional cookies*. - Int. J. Food Sci. Technol., 54(4): 1299-1305.

VALASKOVA K., KLIESTIKOVA J., KRIZANOVA A., 2018 - *Consumer perception of private label products: An empirical research*. - J. Competitiveness, 10(3): 149-163.

WANG E., AN N., GAO Z., KIPROP E., GENG X., 2020 - *Consumer food stockpiling behaviour and willingness to pay for food reserves in COVID-19*. - Food Secur., 12(4): 739-747.

YANG W., TANTIWAT W., RENWICK A., REVOREDO-GIHA C., WANG L., 2023 - *The role of credence attribute claims in food product launch–a comparative study of New Zealand and Australia*. - Br. Food J., 125(7): 2588-2609.

YAO M., XIE J., DU H., MCCLEMENTS D.J., XIAO H., LI L., 2020 - *Progress in microencapsulation of probiotics: A*

*review*. - Compr. Rev. Food Sci. Food Saf., 19(2): 857-874.

YAŞA ÖZELTÜRKAY E., DOĞRUL Ü., OĞUZ S., YALÇINTAŞ D., GÜLMEZ M., 2025 - *Examining the role of food technology neophobia in shaping consumer attitudes and intentions to purchase genetically modified foods*. - Sustainability, 17(14): 6416.

ZAMPARO G., CUNICO P., VIANELLI D., MORETTI A., 2023 - *It is unnatural! The role of food neophobia and food technology neophobia in shaping consumers' attitudes: a multimethod approach*. - Br. Food J., 125(6): 2275-2293.