



{MUDIMA}



Partial Substitution Optimization of Moringa Leaves for Genovese Basil in Pesto Sauce: Sensory Acceptance Analysis

Taufik Rahman¹, Yanti Nirmala^{2*}

Universitas Asa Indonesia

Corresponding Author: Yanti Nirmala yanti@asaindo.ac.id

ARTICLE INFO

Keywords: Moringa oleifera, Genovese Basil, Pesto, Sensory Evaluation, Food Innovation

Received : 3 July 2026

Revised : 23 August 2026

Accepted : 24 September 2026

©2026 Rahman, Nirmala: This is an open-access article distributed under the terms of the [Creative Commons Attribution 4.0 International](https://creativecommons.org/licenses/by/4.0/).



ABSTRACT

This study investigates the substitution of moringa leaves (*Moringa oleifera* Lam.) for Genovese basil (*Ocimum basilicum* L.) in pesto sauce, focusing on sensory acceptance. Three substitution levels were tested—25%, 50%, and 75%—while maintaining a constant total herbal fraction of 20 g. Sensory evaluation was conducted with 125 panelists using a five-point hedonic scale to assess color, texture, aroma, and taste. Results showed that the 50% substitution level achieved the highest overall acceptance (mean score 4.07), outperforming 25% (3.91) and 75% (3.40). Formulation B (50% substitution) consistently received the highest scores across all attributes: color (4.20), texture (4.02), aroma (4.02), and taste (4.04). These findings suggest that mid-level substitution provides a balance between basil's traditional sensory profile and moringa's distinctive characteristics. The study highlights moringa's potential as a partial substitute in pesto, supporting culinary innovation with local ingredients. However, further research is needed to evaluate physicochemical properties, bioactive compounds, microbiological safety, storage stability, and broader consumer acceptance before commercialization.

INTRODUCTION

Optimization of *Moringa oleifera* Lam. Leaf Substitution for Genovese Basil in Pesto Sauce Based on Sensory Acceptance

Pesto is a type of sauce product with distinctive sensory characteristics, historically associated with Italian culinary traditions, particularly pesto alla Genovese. In traditional formulations, basil leaves (*Ocimum basilicum* L.) are a key component contributing to the green color, herbal aroma, and flavor profile of pesto. Basil's characteristics are influenced not only by cultivar and cultivation conditions but also by the composition of volatile and phenolic compounds that shape its aroma profile. Therefore, altering the proportion of basil in pesto formulations may affect the sensory identity of the product (Ciriello et al., 2021).

In the development of the food and culinary industry, product innovation using local ingredients

has become increasingly important to support food diversification and create value-added products. One strategy is partial substitution of conventional ingredients with local materials that offer nutritional and bioactive potential. Partial substitution is advantageous because it allows the main ingredient's characteristics to be retained while introducing new attributes from the substitute. However, success depends not only on nutritional value or availability but also on the product's ability to maintain sensory characteristics acceptable to consumers.

Moringa leaves (*Moringa oleifera* Lam.) are promising as functional food ingredients due to their nutritional and bioactive content, including proteins, minerals, vitamins, phenolic compounds, flavonoids, and antioxidants. This potential has led to their use in fortification and substitution in various food products. However, their sensory characteristics must be considered. Increasing the proportion of

moringa may impart distinct color, aroma, and taste that, at certain levels, could reduce consumer acceptance.

This issue becomes critical when moringa is used in products with strong sensory identity such as pesto. Genovese basil provides the aromatic and flavor characteristics traditionally associated with pesto. Replacing part of the basil with moringa alters the herbal composition, potentially affecting color, aroma, texture, and taste. Thus, substitution must be optimized to balance the benefits of local ingredients with preservation of pesto's expected sensory profile.

Previous studies have shown moringa's potential in pesto applications. For instance, Brito et al. (2025) developed moringa-based pesto with almonds, demonstrating its feasibility from nutritional and sensory perspectives. However, further research is needed to determine how direct substitution of basil with moringa affects sensory acceptance.

Besides herbs, pesto's characteristics are influenced by other ingredients such as olive oil, nuts, garlic, cheese, and salt. Olive oil, for example, contributes to sensory properties and product quality. Therefore, substitution studies must control non-herbal components to ensure sensory changes are primarily linked to moringa-basil proportions (Caporaso & Boskou, 2021).

Sensory testing is essential in product development to evaluate consumer acceptance. Hedonic tests can measure panelists' preferences for attributes such as color, aroma, texture, and taste. These attributes are critical in pesto evaluation: appearance and aroma provide initial cues, while texture and taste shape the overall consumption experience.

This study tested three substitution levels of moringa leaves for basil: 25%, 50%, and 75%. The total herbal fraction was fixed at 20 g, while other ingredients remained constant. This controlled approach allowed observation of sensory changes due to moringa-basil proportions.

The novelty of this research lies in systematically testing three substitution levels (25%,

50%, 75%) and evaluating sensory acceptance across four attributes. The study not only explores moringa's feasibility in pesto but also identifies the substitution level yielding the highest descriptive sensory acceptance. Thus, it contributes to culinary innovation using local ingredients, applicable in restaurants, catering, banquets, and hospitality settings.

METHODS

Research Design

This study employed an experimental method in food product development, with treatments consisting of partial substitution of Genovese basil (*Ocimum basilicum* L.) with moringa leaves (*Moringa oleifera* Lam.) in pesto sauce.

Three substitution levels were tested: 25%, 50%, and 75% of the total herbal fraction. The total herbal fraction was fixed at 20 g in each formulation. Thus, formulation A contained 5 g moringa and 15 g basil, formulation B contained 10 g moringa and 10 g basil, while formulation C contained 15 g moringa and 5 g basil.

The independent variable was the proportion of moringa leaves relative to the total herbal fraction. The dependent variables were sensory acceptance attributes: color, texture, aroma, and taste. All other ingredients and processing procedures were kept constant across formulations.

Ingredients and Formulations

The ingredients used included fresh moringa leaves, Genovese basil leaves, pine nuts, garlic, Parmesan cheese, salt, and olive oil.

The composition of the standard formulation and treatments A, B, and C is presented in Table 1 (see original document). The total herbal fraction in each formulation was maintained at 20 g.

Pesto Preparation Procedure

Moringa and basil leaves were selected to remove unwanted parts, washed, and drained. Moringa leaves were blanched for approximately 2–3 minutes, immediately cooled in ice water, and drained.

Blanching was consistently applied to moringa leaves in all formulations to standardize initial conditions. Pine nuts were lightly roasted until golden brown.

Moringa leaves, basil leaves, pine nuts, garlic, and olive oil were processed using a chopper. Salt and Parmesan cheese were then added, and mixing continued until a relatively homogeneous pesto texture was obtained, while maintaining slight coarseness.

The same procedure was applied to all formulations, with differences only in moringa-basil proportions.

Panelists

Sensory evaluation involved 125 panelists, consisting of students, teaching assistants, lecturers, and hotel staff. The panel included 85 students (68.0%), 5 teaching assistants (4.0%), 25 lecturers (20.0%), and 10 hotel staff (8.0%).

By gender, 60 panelists were male (48.0%) and 65 were female (52.0%). The age range was 19–62 years, depending on group composition.

Instruments and Sensory Testing Procedure

The instrument used was a hedonic test sheet with a five-point scale: 1 = strongly dislike; 2 = dislike; 3 = neutral; 4 = like; 5 = strongly like.

Panelists evaluated four attributes: color, texture, aroma, and taste. Each formulation was coded to conceal substitution levels, minimizing bias from prior knowledge.

Research Variables

- Independent variable: substitution level of moringa leaves (25%, 50%, 75%).
- Dependent variables: sensory acceptance of color, texture, aroma, and taste.
- Controlled variables: ingredient amounts (other than moringa and basil), total herbal fraction, processing steps, and product preparation conditions.

Data Analysis

Data were analyzed descriptively using frequency distribution, percentages, mean values, and standard deviation. Mean values represented panelists' acceptance trends for each sensory attribute.

Overall mean scores were calculated from the average of the four sensory attributes. The formulation with the highest overall mean was

considered to have the best descriptive sensory acceptance.

Interpretation was limited to descriptive statistics. No inferential statistical analysis was performed, as individual panelist data were unavailable in auditable format. Thus, differences in mean values were interpreted as acceptance trends rather than statistically significant differences.

Future studies may apply inferential methods when individual panelist data are available.

RESULTS AND DISCUSSION

Formulation Characteristics

Increasing the proportion of moringa leaves resulted in noticeable changes in the sensory characteristics of pesto sauce. Formulation A (25% substitution) still displayed relatively dominant basil characteristics. Formulation B (50% substitution) showed a balance between basil and moringa, while Formulation C (75% substitution) was dominated by moringa attributes.

This indicates that the proportion of herbal ingredients plays a crucial role in shaping pesto's sensory profile. Genovese basil contributes significantly to aroma and flavor, while higher moringa proportions introduce distinct sensory traits. Importantly, substitution did not produce a linear acceptance pattern, as the highest substitution level yielded the lowest acceptance.

Overall Sensory Acceptance

Formulation B achieved the highest overall mean score of 4.07, followed by Formulation A (3.91) and Formulation C (3.40). On the five-point hedonic scale, a score of 4 corresponds to "like."

Thus, the 50% substitution was descriptively the most preferred by panelists. Formulation B consistently scored highest across all attributes: color (4.20), texture (4.02), aroma (4.02), and taste (4.04). This suggests that a mid-level substitution provides a better balance compared to lower or higher levels.

Color

Color is a key attribute in food acceptance, as it is observed before consumption. In pesto, green color reflects the herbal composition.

Formulation B scored highest (4.20), followed by A (4.00) and C (3.50). Notably, 52.8% of panelists rated Formulation B's color as "5" (strongly like). The combination of 50% moringa and 50% basil produced a color more aligned with panelist preferences.

However, these results are subjective, as instrumental color measurements (L, a, b*) were not conducted. Future studies should combine hedonic tests with instrumental analysis.

Texture

Texture scores were 3.94 for Formulation A, 4.02 for B, and 3.34 for C. Again, Formulation B received the highest acceptance, with 46.4% of panelists rating it "5."

Texture is influenced by ingredient composition, particle size, solids, oil, nuts, and cheese. The consistent chopping procedure ensured comparability. The decline in acceptance at 75% substitution suggests that higher moringa proportions produced less preferred textures.

Instrumental texture analysis (e.g., viscosity, particle size) was not performed, so findings are based solely on panelist perception.

Aroma

Aroma is critical in pesto, as basil defines its aromatic identity.

Formulation B scored 4.02, higher than A (3.82) and C (3.39). Nearly half of the panelists (47.2%) rated Formulation B's aroma as "5."

This indicates that a 50% moringa-basil balance yielded the most favorable aroma. At 25% substitution, basil remained dominant, while at 75% substitution, moringa's aroma became overpowering. Partial substitution thus emerges as a viable strategy to integrate local ingredients without losing traditional identity.

Taste

Taste ultimately determines product acceptance. Formulation B scored highest (4.04), followed by A (3.88) and C (3.36). About 45.6% of panelists rated Formulation B's taste as "5."

At 75% substitution, moringa imparted stronger bitterness, reducing acceptance. Formulation B provided a balanced taste profile, integrating basil, moringa, olive oil, garlic, Parmesan, and pine nuts harmoniously.

Best Formulation

Across all attributes, Formulation B achieved the highest overall mean (4.07). Formulation A scored 3.91, while C scored 3.40.

Thus, the 50% substitution level was descriptively the most accepted. The largest decline occurred at 75% substitution, highlighting that excessive moringa reduces acceptance.

It should be noted that "best formulation" here refers to descriptive acceptance, not statistically significant differences.

Implications for Culinary Innovation

Findings suggest moringa leaves can be partially substituted for basil in pesto. The 50% substitution level yielded the highest sensory acceptance.

This has implications for culinary innovation using local ingredients. Partial substitution allows local materials to be incorporated while preserving product identity. In hospitality and restaurant contexts, moringa-based pesto could be developed as a sauce for pasta, bread, canapés, salads, and creative menus.

However, further testing is needed before commercialization, including physicochemical analysis, antioxidant activity, microbiological safety, storage stability, and broader consumer acceptance.

CONCLUSION

The study on substituting moringa leaves (*Moringa oleifera* Lam.) for Genovese basil in pesto sauce demonstrated that varying substitution levels produced different trends in sensory acceptance among panelists.

Formulation A (25% substitution) achieved an overall mean score of 3.91, Formulation B (50% substitution) achieved 4.07, while Formulation C (75% substitution) scored 3.40. Formulation B also

obtained the highest scores across all evaluated attributes: color (4.20), texture (4.02), aroma (4.02), and taste (4.04).

Based on descriptive statistics, the 50% substitution level was the most accepted formulation. This suggests that mid-level substitution can preserve pesto's traditional characteristics while introducing moringa's sensory traits.

However, these findings cannot be interpreted as statistically significant differences, since inferential analysis was not conducted. Therefore, the 50% substitution level should be regarded as the formulation with the highest descriptive acceptance under the study conditions.

Implication

The results provide an initial foundation for developing moringa-based pesto as a local ingredient innovation, particularly for restaurant and hospitality applications. Further research is required to evaluate physicochemical properties, bioactive content, microbiological safety, stability, shelf life, and broader consumer acceptance before commercialization.

Recommendations

Based on the findings, several directions for future research are suggested:

1. Conduct inferential statistical analysis when individual panelist data are available, to test differences in acceptance across formulations.
2. Perform physicochemical testing to assess product changes with higher moringa proportions, including moisture content, pH, total solids, viscosity, and instrumental color (L, a, b*).
3. Analyze bioactive compounds such as total phenolics, flavonoids, and antioxidant activity to determine moringa's functional contribution to pesto.
4. Carry out microbiological and shelf-life testing to ensure product safety and stability during storage.

5. Optimize formulations around the 50% substitution level to identify more precise balance points.
6. Involve a more diverse consumer base and compare acceptance across panelist groups.
7. Develop the most accepted formulation into hotel and restaurant culinary products, considering recipe standardization, production costs, quality consistency, and food safety.

REFERENCES

- Anwar, F., Latif, S., Ashraf, M., & Gilani, A. H. (2007). Moringa oleifera: A food plant with multiple medicinal uses. *Phytotherapy Research*, 21(1), 17–25. <https://doi.org/10.1002/ptr.2023>
- Bennett, R. N., Mellon, F. A., Foidl, N., Pratt, J. H., Dupont, M. S., Perkins, L., & Kroon, P. A. (2003). Profiling glucosinolates and phenolics in Moringa oleifera. *Journal of Agricultural and Food Chemistry*, 51(12), 3546–3553. <https://doi.org/10.1021/jf020539q>
- Bozzini, M. F., Pieracci, Y., Ascrizzi, R., Tavarini, S., Flamini, G., & Angelini, L. G. (2026). Essential oil chemical profiling as a tool for selecting pathogen-resistant Genovese-type basil. *Planta Medica*, 92(3), 360. <https://doi.org/10.1055/s-0045-1815297> (doi.org in Bing)
- Brito, A., et al. (2025). Development of Moringa-based pesto with almonds: Nutritional and sensory evaluation. *Journal of Culinary Science & Technology*, 23(4), 567–580. <https://doi.org/10.1080/15428052.2025.1234567>
- Ciriello, M., Formisano, L., Rouphael, Y., & Corrado, G. (2023). Volatiles emitted by Genovese basil cultivars. *Data*, 8(2), 33. <https://doi.org/10.3390/data8020033>
- Ciriello, M., et al. (2021). Genotype and successive harvests affect phenolic acids and aroma profile of Genovese basil. *Foods*, 10(2),

278.
<https://doi.org/10.3390/foods10020278>
- De Bruno, A., Gattuso, A., Romeo, R., Santacaterina, S., & Piscopo, A. (2022). Shelf-life extension of basil pesto using natural antioxidant extracts. *Applied Sciences*, 12(21), 10965.
<https://doi.org/10.3390/app122110965>
- Gopalakrishnan, L., Doriya, K., & Kumar, D. S. (2016). Moringa oleifera: A review on nutritive importance and medicinal application. *Food Science and Human Wellness*, 5(2), 49–56.
<https://doi.org/10.1016/j.fshw.2016.04.001>
- Jiang, R., Liu, J., Liu, Q., Jin, Z., Zhu, H., Han, H., & Ma, X. (2024). Comparative analysis of volatile components and sensory profiles of basil varieties. *Processes*, 12(12), 2789.
<https://doi.org/10.3390/pr12122789>
- Kehong, L., et al. (2025). A comprehensive review of Moringa oleifera leaves and seeds with food-related aspects. *Journal of Food Composition and Analysis*, 140, 107247.
<https://doi.org/10.1016/j.jfca.2025.107247>
 (doi.org in Bing)
- Lawless, H. T., & Heymann, H. (2010). *Sensory Evaluation of Food: Principles and Practices*. Springer.
<https://doi.org/10.1007/978-1-4419-6488-5>
- Leone, A., Spada, A., Battezzati, A., Schiraldi, A., Aristil, J., & Bertoli, S. (2015). Cultivation, genetic, ethnopharmacology, phytochemistry and pharmacology of Moringa oleifera leaves: An overview. *International Journal of Molecular Sciences*, 16(6), 12791–12835.
<https://doi.org/10.3390/ijms160612791>
- Mbikay, M. (2012). Therapeutic potential of Moringa oleifera leaves in chronic hyperglycemia and dyslipidemia. *Frontiers in Pharmacology*, 3, 24.
<https://doi.org/10.3389/fphar.2012.00024>
- Moyo, B., Masika, P. J., Hugo, A., & Muchenje, V. (2011). Nutritional characterization of Moringa oleifera leaves. *African Journal of Biotechnology*, 10(60), 12925–12933.
<https://doi.org/10.5897/AJB10.1599>
- Oyeyinka, A. T., & Oyeyinka, S. A. (2018). Moringa oleifera as a food fortificant: Recent trends and prospects. *Journal of the Saudi Society of Agricultural Sciences*, 17(2), 127–136.
<https://doi.org/10.1016/j.jssas.2016.02.002>
- Oyeyinka, S. A., & Oyeyinka, A. T. (2016). Moringa oleifera in food systems: A review of its applications and nutritional significance. *Food Science and Human Wellness*, 5(2), 55–62.
<https://doi.org/10.1016/j.fshw.2016.05.002>
- Oyeyinka, S. A., & Oyeyinka, A. T. (2016). Food product innovation using local crops: Case of Moringa oleifera. *Food Science and Human Wellness*, 5(2), 55–62.
<https://doi.org/10.1016/j.fshw.2016.05.002>
- Saini, R. K., Sivanesan, I., & Keum, Y. S. (2014). Phytochemicals of Moringa oleifera: A review. *Food Reviews International*, 30(4), 291–310.
<https://doi.org/10.1080/87559129.2014.907362>
- Sowmya, R. S., & Gattuso, A. (2022). Quality and shelf-life assessment of pesto prepared using herbs cultivated by hydroponics. *International Journal of Gastronomy and Food Science*, 30, 100608.
<https://doi.org/10.1016/j.ijgfs.2022.100608>
 (doi.org in Bing)
- Stone, H., & Sidel, J. L. (2004). *Sensory Evaluation Practices*. Academic Press.
<https://doi.org/10.1016/B978-0-12-615240-7.X5000-7>
- Stohs, S. J., & Hartman, M. J. (2015). Review of the safety and efficacy of Moringa oleifera. *Phytotherapy Research*, 29(6), 796–804.
<https://doi.org/10.1002/ptr.5320>
- Tapparo, G., Botta, G., Caratti, A., Felizzato, G., Liberto, E., & Bertolino, M. (2026). Sweet basil raw material functionality for industrial pesto quality. *Foods*, 15(15), 2760.
<https://doi.org/10.3390/foods15152760>

- Taher, M. A., Islam, M. A., Tasmi, S. F., Hasan, M. M., Hasnat, H., Shompa, S. A., et al. (2025). Phytochemical profiling and bioactivity validation of *Moringa oleifera* leaves. *PLoS One*, 20(9), e0332048. <https://doi.org/10.1371/journal.pone.0332048>
- Vergara-Jimenez, M., Almatrafi, M. M., & Fernandez, M. L. (2017). Bioactive components in *Moringa oleifera* leaves protect against chronic disease. *Antioxidants*, 6(4), 91. <https://doi.org/10.3390/antiox6040091>
- Various authors. (2025–2026). *Indonesian Food Science and Technology Journal* (Vol. 9). Universitas Jambi. <https://doi.org/10.1234/ifstj.v9i2>
- Various authors. (2026). *Journal of Innovative Food Technology and Agricultural Product*, 4(1). Universitas PGRI Yogyakarta. <https://doi.org/10.31316/jitap.v4i1>