Urmia University

Food Safety and Packaging

2025, 1 (2): 105–114

Journal Homepage: fsp.urmia.ac.ir

FOOD Safety and Packaging

Research Article

# Influence of familiarity on consumer acceptance of value-added products from *Justicia heterocarpa* leaves

Zenorina Aloyce Swai *, Frida Albinus Nyamete, Abdulsudi Issa-Zacharia

*Department of Food Science and Agro-processing, Sokoine University of Agriculture, Morogoro, Tanzania*

## Abstract

This study investigated the sensory perception and consumer acceptability of value-added products derived from *Justicia heterocarpa*, an underutilized indigenous leafy vegetable with potential nutritional benefits. A total of 110 participants, comprising 80 semi-trained students unfamiliar with *J. heterocarpa* and 30 untrained university workers familiar with *J. heterocarpa* in term of consumption and utilization. Four samples (freshly harvested, blanched dried, unblanched dried, and fermented) were tested for consumer acceptability using a 9-point hedonic scale. The results revealed a significant influence of the panelists on flavor ($p < 0.001$) and overall acceptability ($p = 0.003$) among familiar and unfamiliar panelists. Unfamiliar panelists rated the flavor and general acceptability of the fermented vegetables higher. There were significant differences in color ($p < 0.0001$), flavor ($p = 0.0002$), and general acceptability ($p = 0.0235$) between the familiar and unfamiliar groups. Correlation analysis revealed a positive correlation between general acceptability of flavor (r = 0.81) and texture (r = 0.65). Principal component analysis identified flavor and texture as the primary drivers of overall acceptance. These findings offer valuable insights into the development of palatable processed *J. heterocarpa*. These findings underscore the importance of carefully considering the effects of different processing methods when formulating product development strategies to enhance consumer acceptance.

**Keywords**: Familiarity, Hedonic scale, Indigenous leafy vegetables, Principal component analysis, Vegetable processing.

## Introduction

Food and nutrition security pose significant challenges worldwide, especially in developing nations (FAO, 2021). Micronutrient deficiencies, or hidden hunger, are prevalent in a significant portion of the population and can adversely affect individual health and well-being. (Issa-Zacharia *et al.*, 2024; Ngungulu *et al.,* 2024). Indigenous leafy vegetables (ILVs) are valuable sources of micronutrients and phytochemicals that improve general health and ensure dietary diversity and food security at the household level in developing Countries (Issa-Zacharia *et al.,* 2024). ILVs have advantageous agricultural and commercial characteristics, including low production costs and accelerated maturity (Bokelmann *et al*., 2022). However, their ability to withstand drought, flooding, and climate change makes them attractive for current research (Bokelmann *et al.,* 2022; Bukenya *et al.,* 2023). Despite their significant potential in the fields of

* **Correspondence**: Z. A. Swai (zenorina.swai@sua.ac.tz).
https://doi.org/10.30466/fsp.2025.56347.1009
**Received**: 17 July 2025 **Accepted**: 07 August 2025 **Available online**: 15 August 2025

nutrition, economics, agriculture, and environmental contexts, there has been limited research on their cultivation, consumption, and utilization (Atuna *et al.,* 2022; Elolu *et al.,* 2023;). The utilization of ILVs is frequently constrained by high post-harvest losses of up to 50% (Elolu *et al.,* 2023), seasonal availability (Chacha & Laswai, 2020), and unstable established consumption not utilized by a significant portion of the population (Nyonje *et al.*, 2022; Zulu *et al.,* 2022).

*Justicia heterocarpa* is a popular and nutritious indigenous vegetable consumed by the '*Waluguru" people in* Morogoro rural areas of Tanzania (Swai *et al.,* 2025). The plant grows well during the rainy season in both natural habitats and residential areas (Sangija *et al.,* 2022). Processing methods, including drying, blanching, and fermentation, enhance the shelf life, safety, nutritional quality, and sensory qualities of ILVs ( Irakoze *et al.,* 2023; Owade *et al.,* 2020). A previous study on *J. heterocarpa* indicated that blanching and cooking increases the bioavailability of beta carotene while fermentation increases the total phenolic compounds (Swai *et al*., 2025). Although *J. heterocarpa* is culturally significant, its acceptance beyond Waluguru community is underexploited (Swai *et al.*,2025; Sangija *et al.,*2022). This study investigated the impact of various processing techniques on sensory attributes and consumer preferences among two distinct groups: individuals familiar with the vegetable and those unfamiliar with it. The findings offer valuable insights into the vegetable's potential for wider acceptance and its role in enhancing nutritional security.

## Materials and Methods

### Sample collection

Fresh *J. heterocarpa* leaves were sourced from seven farmers plots in Kiroka Ward Morogoro region, Tanzania. The plots were randomly selected at different points across the plots. Harvesting involved selectively plucking tender leaves from each plant using a sharp knife during early morning hours. The harvested leaves were tied into five large bundles from each plot and stored in clean woven sulfate bags (commonly used for maize storage) and immediately transported to the Food Science and Agro-processing laboratory at Department of Food Science and Agro-processing (DFSAP), Sokoine University of Agriculture, Tanzania. Following cleaning, clipping, and sorting, the leaves collected from seven chosen plots were placed in separate perforated containers to facilitate water drainage. A composite sampling approach was employed to obtain representative samples for processing and analysis. From each plot, a predetermined weight/volume of leaves (1 kg) was randomly selected for analysis. These subsamples from each plot were then combined and thoroughly mixed on a clean surface to create a homogeneous bulk sample of 7 kg, ensuring that the final sample represented the overall collection from the study area. This composite sample was used for the subsequent processing of various *J. heterocarpa* products.

### Research design

To control the variability among panelists (blocks), we employed the Randomized Complete Block Design (RCBD) for the sensory evaluation. To avoid carryover effects, each panelist analyzed four samples at random: fresh cooked leaves (FR), blanched and then dried on shade cooked leaves (BD), unblanched shade-dried cooked leaves (UBSD), and fermented cooked leaves (FERL).

### Processing procedures

*Dried unblanched leaves*: *J. heterocarpa* leaves, after being washed, were allowed to drain on a rack and subsequently air-dried at ambient temperature for about 15 days in the shade, following the method outlined by Alassane et al. (2022) with minor modifications. Moisture content was recorded daily using a moisture meter (Denver, IR35M-0002300V1-GmbH, Göttingen, Germany) until it reached 12.38%. Dried leaves were packaged in polyethylene zip bags using an aeration packing machine (Zhejiang Huili Machinery Co., Wenzhou, China) to achieve optimal vacuum levels, thereby removing air and preventing oxidation. The vegetables were frozen (Westpoint model WBEQ-4414.GWL, Anhui Province, China) at -18 °C until the consumer acceptability day.

*Blanched dried leaves:* The leaves were blanched by securing them in a net fabric and immersing them in boiling water (87 °C) for 1 min, as previously described by Neelavathi *et al*. (2022), with minor modifications. Next, the leaves were rinsed in ice water for 1 min to stop the cooking process. The blanched leaves were then air-dried on racks at ambient room temperature (25.2 -27.6 °C) for five days. A moisture meter (Denver, IR35M-0002300V1-GmbH, Göttingen, Germany) was used to reduce the moisture content to 10.28%. After achieving a crispy texture, the leaves were vacuum-packed (Zhejiang Huili Machinery Co., Wenzhou, China). The samples were then stored in a freezer for sensory evaluation.

*Fermented leaves:* Previously trimmed and sorted leaves were washed and rinsed with distilled water and positioned in a perforated tray lined with a clean paper towel to facilitate excess water removal. Fermentation proceeded in submerged brine (1:3 vegetables: water). Salt-to-sugar ratios (3%: 3%) were employed following previously defined methods Stoll *et al.* (2021) with minor modifications. The fermenting vessels consisted of 800 mL polypropylene containers with secure seals. Locally fabricated crock pots (polyethylene bags) filled with water were used to submerge the vegetables, preventing the leaves from rising to the air interface and leading to mold proliferation during fermentation. The experiment was conducted at 25 °C. Samples were collected at 0 h, 12 h, 24 h, 36 h, 48 h, 60 h, 72 h, 84 h, 96 h, 108 h, 120 h, and 144 h. The efficacy of fermentation was assessed by measuring and recording the pH levels (HANNA HI2211; Woonsocket, RI, USA). At the fifth day (144 h) the pH dropped to <3.5, and immediately the fermented leaves were stored in the freezer (Westpoint model WBEQ-4414.GWL, Anhui Province, China) until the day of sensory evaluation.

**Preparation of samples for sensory tests**

Freshly harvested leaves (1 kg) were obtained from the Kiroka village market on the day of the test. The leaves were sorted, trimmed, washed, and cooked in a gas stove (Nikai, Model NGS5092G, Dubai, UAE) with 250 mL of water for 10 min with only a pinch of salt (0.5% by weight). Dried frozen processed vegetables (unblanched dried and blanched dried) 500 g each were soaked in 250 mL of water and 0.5% salt and then cooked in a gas cooker with a lid until they became tender. The frozen fermented samples were thawed at room temperature and cooked with brine water until soft. The cooked vegetables were served to the panelists in white polyethylene disposable cups in four coded samples (freshly harvested cooked leaves -209, blanched dried cooked leaves - 312, unblanched dried cooked leaves - 486, and fermented cooked leaves - 571).

**Consumer acceptability test**

The sample comprised 110 volunteers, of whom 59 were male and 51 were female. The panelists involved 80 semi-trained students from the Department of Food Science and Agro Processing at Sokoine University of Agriculture, aged between 21 and 27 years, who were unfamiliar with *J. heterocarp*a, and 30 untrained university workers aged between 21 and 55 years who were familiar with *J. heterocarpa.* The test was conducted in two sessions on a single day at Samia Suluhu Teaching Complex under controlled conditions in early July 2024. We asked the participants to rate the four coded samples of *J. heterocarpa products* (freshly harvested cooked leaves - 209, blanched dried cooked leaves - 312, unblanched dried cooked leaves - 486, and fermented cooked leaves - 571). The assessment utilized a 9-point hedonic test adapted from Yang and Lee (2018), with 1 denoting extreme dislike, 5 indicating neutrality, and 9 denoting extreme like. Each participant was assigned an ID number to ensure anonymity. The initial session included semi-trained panelists, specifically third-year students enrolled in the Bachelor's program in food science and technology. The subsequent session featured untrained individuals acquainted with *J. heterocarpa*. A short explanation of the sensory attributes and the intensity scale was provided before the consumer test to ensure that all participants could fully engage in the tasting session, which lasted an average of one hour. All participants evaluated the samples in a randomized sequence. The participants were instructed to pause for 60 s between samples and use water to cleanse their palate.

**Statistical analysis**

The raw data were analyzed using R software (R Core Version 14.2.3), and an independent t-test was used to determine whether there was a statistically significant difference in the sensory attributes between those who were familiar with *J. heterocarpa* and those who were not. One-way analysis of variance (ANOVA) and post hoc Tukey's Honestly

Significant Difference (HSD) test at a significance level of p< 0.05 were used to show the significant variation among the variables. Pearson's correlation and principal component analyses (PCA) were performed to assess the relationships and associations between the samples and sensory attributes. Data are reported as mean values of determinations ± standard deviation (SD).

## Results

**Impact of familiarity of *J. heretocarpa* on sensory perception**

**Table 1** presents the independent t-tests used to compare the mean sensory attributes between the familiar group (*J. heterocarpa*) and the unfamiliar group. No significant differences were observed between familiar and unfamiliar groups regarding color, odor, and texture, with p-values of 0.6555, 0.2825, and 0.3555, respectively. However, a notable significant difference was observed in flavor ($p < 0.001$) and general acceptability ($p = 0.003$), with the unfamiliar group scoring a higher rating than the familiar group.

**Sensory acceptability of *J. heterocarpa* samples**

The sensory acceptability of the four *J. heterocarpa* samples was evaluated by unfamiliar panelists (**Table 2**), and notable differences were identified in color and flavor. Sample 209 differed significantly from sample 571 but did not differ significantly from the other two samples. In terms of flavor, Sample 571 (fermented) was significantly different from all other samples, indicating the preference of the unfamiliar group for the product.

**Table 3** presents the sensory acceptability of *J. heterocarpa* by the familiar group. In terms of color, sample 571 differed significantly from the other samples. There was a significant difference in flavor between samples 209 and 486. There were no significant differences in the odor, texture, flavor, and general acceptability across all samples. Fresh leaves (209) had a higher color rating than fermented leaves (571).

**Table 4** demonstrates the combined sensory acceptability of both panelists (familiar and unfamiliar), while **Table 5** indicates the ANOVA results for sensory attribute differences across samples with *J. heterocarpa.* There was a significant variation in the sensory attributes of color ($p < 0.0001$). Flavor ($p = 0.0002$) and general acceptability ($p = 0.0235$) showed substantial variation across the samples. No significant differences were observed for odor ($p = 0.644$) and texture ($p = 0.235$).

**Correlation analysis**

Correlation analysis (**Table 6**) revealed strong positive correlations between general acceptability and flavor (r = 0.81), whereas a moderate positive correlation between general acceptability and texture (r = 0.65) was observed ($p < 0.05$). Moderate positive correlations were identified between general acceptability and odor (r = 0.52) and color (r = 0.39) of the water. The findings indicate that flavor and texture are the primary determinants of overall acceptability.

**Table 1:** Sensory attribute differences by familiarity (T-Test ).

| Attribute | t-value | Df | p-value | Mean (Familiar) | Mean (Unfamiliar) | Significance |
|---|---|---|---|---|---|---|
| **Color** | 0.447 | 260.5 | 0.6555 | 6.788 | 6.727 | |
| **Odor/Smell** | -1.077 | 293.2 | 0.2825 | 6.394 | 6.531 | |
| **Texture/Mouthfeel** | -0.925 | 292.3 | 0.3555 | 6.188 | 6.313 | |
| **Flavour/Taste** | -5.083 | 321.6 | 6.33E-07 | 5.806 | 6.563 | ** |
| **General Acceptability** | -3.04 | 293.5 | 0.0026 | 6.106 | 6.531 | * |

Df= Degree of Freedom. * indicates statistical significance at p<0.05; ** indicates high statistical significance at p<0.01.

### Principal component analysis

The initial two principal components accounted for approximately 77% of the total variance, with PC1 contributing 60% and PC2 contributing 17%, respectively (**Fig. 1**). PC1 was predominantly influenced by color and odor, whereas PC2 was influenced by flavor, texture, and overall acceptability of the samples.

The PCA biplot (**Fig. 2**) indicates that the first two principal components (Dim1 and Dim2) accounted for 77.5% of total variance in sensory attributes (Dim1:60.4%, Dim2:17.1%). Dim1 was predominantly linked to color and odor, and Dim2 was chiefly affected by flavor, texture, and overall acceptability of the product. This indicates that these two dimensions encompass the primary sources of variation in the sensory profile of *J. heterocarpa.*

**Table 2:** Sensory acceptability of *J. heterocarpa* samples-unfamiliar panelists.

| Sample | Color | Odor/smell | Texture/mouth feel | Flavor/taste | General acceptability |
|---|---|---|---|---|---|
| **209** | 7.12 ± 1.31$^{a}$ | 6.33 ± 1.24$^{a}$ | 6.40 ± 1.49$^{a}$ | 5.53 ± 1.77$^{a}$ | 5.96 ± 1.47$^{a}$ |
| **312** | 6.73 ± 1.33$^{ab}$ | 6.34 ± 1.24$^{a}$ | 6.25 ± 1.34$^{a}$ | 5.76 ± 1.56$^{a}$ | 6.11 ± 1.41$^{a}$ |
| **486** | 6.96 ± 1.20$^{a}$ | 6.58 ± 1.42$^{a}$ | 5.98 ± 1.44$^{a}$ | 5.39 ± 1.69$^{a}$ | 5.91 ± 1.59$^{a}$ |
| **571** | 6.33 ± 1.66$^{b}$ | 6.31 ± 1.75$^{a}$ | 6.13 ± 1.72$^{a}$ | 6.55 ± 1.78$^{b}$ | 6.44 ± 1.72$^{a}$ |

Means ± SD, values within the same column with different superscript letters are significantly different from each other (p<0.05) Key: 209 (fresh harvested cooked leaves),312 (blanched dried cooked leaves) 486 (unblanched shade dried cooked leaves) and 571 (fermented cooked leaves).

**Table 3:** Sensory acceptability of *J. heterocarpa* familiar panelists.

| Sample | Color | Odor/smell | Texture/mouth feel | Flavor/taste | General acceptability |
|---|---|---|---|---|---|
| **209** | 7.26 ± 0.68$^{a}$ | 6.71 ± 0.97$^{a}$ | 6.48 ± 1.26$^{a}$ | 7.00 ± 1.10$^{b}$ | 6.68 ± 1.17$^{a}$ |
| **312** | 7.06 ± 0.80$^{a}$ | 6.28 ± 0.92$^{a}$ | 6.16 ± 1.05$^{a}$ | 6.56 ± 1.11$^{ab}$ | 6.22 ± 0.83$^{a}$ |
| **486** | 6.78 ± 0.83$^{a}$ | 6.50 ± 0.84$^{a}$ | 6.16 ± 0.85$^{a}$ | 6.13 ± 0.79$^{a}$ | 6.28 ± 0.73$^{a}$ |
| **571** | 5.84 ± 1.87$^{b}$ | 6.69 ± 1.60$^{a}$ | 6.47 ± 1.54$^{a}$ | 6.59 ± 1.78$^{ab}$ | 6.97 ± 1.82$^{a}$ |

Means ± SD, values within the same column with different superscript letters are significantly different from each other ($p < 0.05$). Key: 209 (fresh harvested cooked leaves), 312 (Blanched dried cooked leaves) 486 (unblanched shade-dried cooked leaves) and 571 (fermented cooked leaves).

## Discussion

This study aimed to evaluate the sensory attributes of value-added products derived from *J. heterocarpa* and understand the key drivers of consumer acceptability. A combination of statistical methods, including t-tests, ANOVA, correlation analysis, and PCA, was employed to provide a comprehensive analysis of the sensory data. Familiar and unfamiliar consumers rated the sensory attributes differently, with flavor ($p$ <0.001) being highly significant between unfamiliar consumers. Furthermore, unfamiliar panelists scored a significantly high mean for the general acceptability ($p$= 0.0026) of the *J. heterocarpa* value-added products. Moreover, the processing methods used for fermented leaves affect the acceptability of their color and taste. Flavor and texture are highly correlated and associated with general consumer acceptability of food products. These results clarify the sensory characteristics of *J. heterocarpa* and their implications for product development and vegetable marketing.

### Influence of familiarity on the sensory attributes of *J. heterocarpa*

There was a significant difference in flavor and general acceptability in the unfamiliar group, suggesting a potential novelty effect on the results. Neophobia, or the reluctance to try new foods, can influence sensory perception, although some research contradicts this statement by linking it to the fact that consumers are programmed from an early age to prefer familiar foods (Tuorila & Hartmann, 2020). Individuals unfamiliar with *J. heterocarpa* likely lack pre-existing negative associations, making them more receptive to its flavor profiles. Unfamiliar flavors may initially be perceived as more exciting or enjoyable (Davis & Running, 2023). Conversely, repeated exposure may lead to a more critical evaluation as expectations and preferences evolve over time. This contrasts with the familiar group, who, based on prior experiences, may have developed more nuanced or even negative perceptions, potentially affecting their overall liking. The conducted study (Nacef *et al.,* 2019) supports this, demonstrating that consumers prefer familiar products to unfamiliar ones. Familiarity is a multidimensional concept related to personal experiences with a product that affects food product acceptability, purchases, and consumption (Jeong & Lee, 2021).

**Table 4:** Sensory acceptability of *J. heterocarpa* samples-combined panelists -post hoc.

| Sample | Color | Odor/smell | Texture/mouth feel | Flavor/taste | General acceptability |
|---|---|---|---|---|---|
| **209** | 7.16 ± 1.17[a] | 6.44 ± 1.18[a] | 6.42 ± 1.42[a] | 5.94 ± 1.74[a] | 6.16 ± 1.42[ab] |
| **312** | 6.82 ± 1.21[a] | 6.32 ± 1.16[a] | 6.22 ± 1.26[a] | 5.99 ± 1.49[a] | 6.14 ± 1.27[ab] |
| **486** | 6.91 ± 1.10[a] | 6.55 ± 1.28[a] | 6.03 ± 1.30[a] | 5.60 ± 1.52[a] | 6.02 ± 1.41[a] |
| **571** | 6.19 ± 1.73[b] | 6.42 ± 1.71[a] | 6.22 ± 1.67[a] | 6.56 ± 1.77[b] | 6.59 ± 1.76[b] |

Means ± SD, values within the same column with different superscript letters are significantly different from each other ($p$ <0.05) Key: 209 (fresh harvested cooked leaves),312 (Blanched dried cooked leaves) 486 (unblanched shade dried cooked leaves) and 571 (Fermented cooked leaves).

**Table 5:** Sensory attribute variation across samples.

| Attribute | Degree of Freedom (Between) | Sum Sq (Between) | Mean Sq (Between) | F value | Pr (>F) | Significance |
|---|---|---|---|---|---|---|
| **Color** | 3 | 57.6 | 19.205 | 10.94 | 6.09E-07 | ** |
| **Residuals** | 444 | 779.7 | 1.756 | | | |
| **Odor/Smell** | 3 | 3 | 1.015 | 0.557 | 0.644 | |
| **Residuals** | 444 | 808.9 | 1.822 | | | |
| **Texture/Mouthfeel** | 3 | 8.6 | 2.881 | 1.426 | 0.235 | |
| **Residuals** | 444 | 897 | 2.02 | | | |
| **Flavour/Taste** | 3 | 53.7 | 17.914 | 6.717 | 0.000193 | ** |
| **Residuals** | 444 | 1184 | 2.667 | | | |
| **General Acceptability** | 3 | 20.9 | 6.961 | 3.193 | 0.0235 | * |
| **Residuals** | 444 | 967.9 | 2.18 | | | |

* Indicates statistical significance at p<0.05; ** indicates high statistical significance at p<0.01.

**Table 6:** Correlations between sensory attributes and general acceptability.

| | Color | Odor/smell | Texture | Flavor | General acceptability |
|---|---|---|---|---|---|
| **Color** | 1 | | | | |
| **odor/smell** | 0.476 | 1 | | | |
| **texture/mouthfeel** | 0.332 | 0.439 | 1 | | |
| **flavor/taste** | 0.235 | 0.388 | 0.579 | 1 | |
| **general acceptability** | 0.386 | 0.524 | 0.651 | 0.805 | 1 |

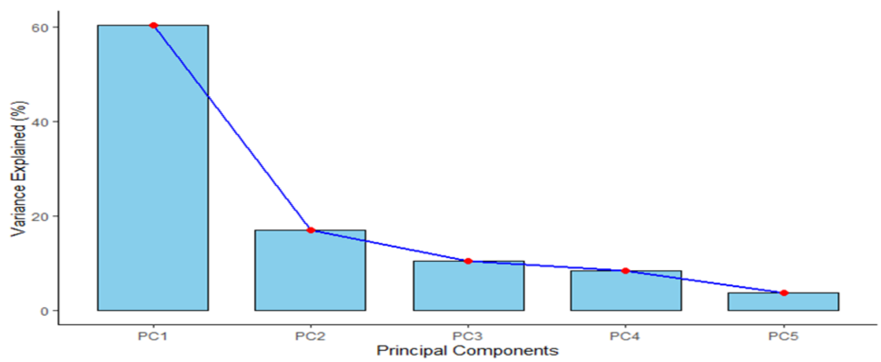


**Figure 1:** Scree plots of principal components.

**Acceptability of sensory attributes of *J. heterocarpa***

*Color:* The significant difference in terms of color made the familiar group prefer sample 209, which is likely rooted in their common consumption of this natural state. This aligns with the study conducted by Vermeir and Roose (2020), who explained that the initial perception occurs visually, and individuals form gastronomic expectations based on the visual attributes of food. The lower color rating for the fermented leaves (sample 571) could be due to the color changes that occur during submerged spontaneous fermentation, which results in high chlorophyll degradation (Swai et al., 2025). The study conducted by Sangija *et al.* (2022) on the consumer acceptability of fermented *Solanum species* reported a decrease in the preference for the color of the fermented samples. The superior ratings of the other samples suggest that blanching and direct drying of vegetables in the shade or at room temperature maintained or improved the original color of *J. heterocarpa* (Swai et al., 2025). Color significantly influences consumers' initial perceptions and expectations (Salha *et al.,* 2023). Although color preferences vary across individuals, it is crucial to pay significant attention to the color of new items, as consumers often compare them to existing market offerings (Boateng et al., 2019).

*Odor:* No significant difference was observed in the odor. It is possible that the processing methods did not drastically alter the volatile compounds responsible for the characteristic odor of *J. heterocarpa.* The consumers perceived the smells of all samples similarly. Odor is an important component of flavor perception (Salha *et al.,* 2023; Wang *et al.,* 2019). However, opposing results were reported by Sangija *et al.* (2022), who found that the odor of fresh nightshade leaves was preferred over that of fermented nightshade leaves.

*Texture:* Texture exhibited minimal variation. This suggests that the processing and cooking methods used for the samples produced comparable textural properties. Sangija *et al.* (2022) concluded that there were no differences in texture between the fresh and fermented leaves of nightshade species. Texture is essential for food enjoyment and is a significant factor in food acceptance (Wang *et al.,* 2019).

Notable differences in flavor underscore the substantial influence of processing on taste. The unfamiliar group assigned a higher flavor rating to the fermented leaves (Sample 571). This may have resulted from the formation of desirable flavors during fermentation, including lactic acid, which imparts a sour and refreshing taste to the vegetable. During fermentation, complex compounds are decomposed, resulting in the release of simpler sugars and amino acids that enhance food flavor (Irakoze *et al.,* 2021; Sangija *et al.,* 2022; Stoll *et al.,* 2021). Sample 486, consisting of unblanched dried leaves, scored low in flavor due to a higher concentration of anti-nutrients. The addition of these substances may have resulted in a bitter and astringent taste in the vegetables (Mwanri *et al.,* 2018; Ngungulu *et al*., 2024).

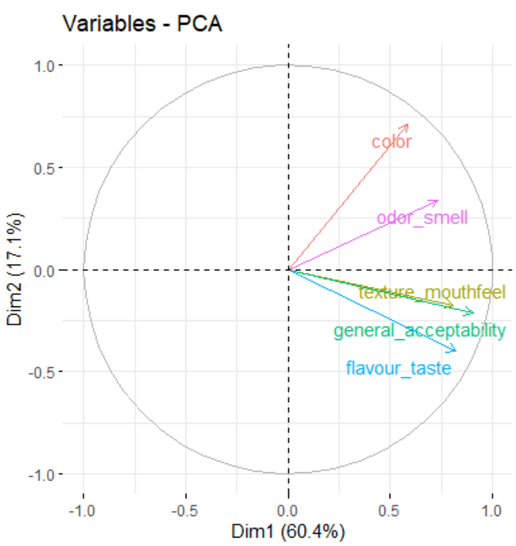


**Figure 2:** PCA biplot of sensory attributes and sample scores.

*The overall acceptability ratings:* This indicated a cumulative effect of all the sensory attributes. The trends in general acceptability were closely aligned with those of flavor, highlighting the significance of taste in the overall preference. Other factors, including cultural background, personal preferences, and emotional associations with food also influence general acceptability (Govender *et al.,* 2019; Mihafu *et al.,* 2020). Correlation and principal component analyses yielded consistent results, indicating that flavor and texture are the main factors influencing the acceptability of *J. heterocarpa*. The strong positive correlations observed between these attributes and overall liking (r = 0.81 and r = 0.65, respectively) underscore their significance. The PCA biplot illustrated that flavor, texture, and general acceptability clustered together, in contrast to the less influential attributes of color and odor. These findings highlight the significant influence of flavor and texture on consumer perception and acceptance of *J. heterocarpa* products. Flavor perception is the main factor influencing an individual's food choices, surpassing all other attributes (Salha *et al.,* 2023).

## Conclusion

This study offers understandings into the sensory perception and acceptability of *J. heterocarpa.* Familiarity seems to affect specific sensory attributes, particularly flavor. The methods of processing have a substantial effect on the acceptability of color and flavor. Flavor and texture were the main determinants of overall consumer acceptance of the products. These findings enhance our understanding of the sensory properties of *J. heterocarpa* and establish a foundation for the developing palatable and acceptable value-added products from this underutilized plant species.

## Conflicts of interest

The authors declare that no conflicts of interest exist.

## Data availability

The data produced and examined in this study can be obtained from the corresponding author upon request.

## Funding

This study was funded by the Sokoine University of Agriculture (SUA) under the Higher Education for Economic Transformation (HEET) project.

## Disclaimer

Authors hereby declare that NO generative AI technologies, such as large language models (ChatGPT, COPILOT, etc.) and text-to-image generators, have been used during the writing or editing of this manuscript.

## References

Alassane, C. T., Abdoulaye, T., Fabrice, Z. A., Claude, K. A. L., Souleymane, M., & Adama, C. (2022). Effect of three drying modes on nutritive and antinutritive properties of leafy vegetables consumed in Northern Côte d'Ivoire. *EAS Journal of Nutrition and Food Sciences*, 4(1), 102-111. https://doi.org/10.36349/easjnfs.2022.v04i01.011

Atuna, R. A., Djah, J., Achaglinkame, M. A., Bakker, S., Dari, L., Osei-Kwarteng, M., Mahunu, G. K., Koomen, I., & Amagloh, F. K. (2022). Types of indigenous vegetables consumed, preparation, preferences and perceived benefits in Ghana. *Journal of Ethnic Foods*, 9(1), 38. https://doi.org/10.1186/s42779-022-00154-3

Boateng, L., Nortey, E., Ohemeng, A. N., Asante, M., & Steiner-Asiedu, M. (2019). Sensory attributes and acceptability of complementary foods fortified with *Moringa oleifera* leaf powder. *Nutrition and Food Science*, 49(3), 393–406. https://doi.org/10.1108/NFS-07-2018-0192

Bokelmann, W., Huyskens-Keil, S., Ferenczi, Z., & Stöber, S. (2022). The role of indigenous vegetables to improve food and nutrition security: experiences from the project HORTINLEA in Kenya (2014–2018). *Frontiers in Sustainable Food Systems*, 6, 1–19. https://doi.org/10.3389/fsufs.2022.806420

Bukenya, R., Laborde, J. E. A., Mamiro, P., Mugabi, R., & Kinabo, J. (2023). Assessment of nutrient adequacy of complementary foods for infants and young children in Morogoro, Tanzania. *Scientific African*,19, e01567. https://doi.org/10.1016/j.sciaf.2023.e01567

Chacha, J. S., & Laswai, H. S. (2020). Traditional practices and consumer habits regarding consumption of underutilised vegetables in Kilimanjaro and Morogoro regions, Tanzania. *International Journal of Food Science,* 2020. (6), 1–10 https://doi.org/10.1155/2020/3529434

Davis, L. A., & Running, C. A. (2023). Good is sweet and bad is bitter: conflation of affective value of aromas with taste qualities in untrained participants. *Journal of Sensory Studies*, 38(3), e12820. https://doi.org/10.1111/joss.12820

Elolu, S., Byarugaba, R., Opiyo, A. M., Nakimbugwe, D., Mithöfer, D., & Huyskens-Keil, S. (2023). Improving nutrition-sensitive value chains of African indigenous vegetables: current trends in postharvest management and processing. *Frontiers in Sustainable Food Systems*,7, 1–8. https://doi.org/10.3389/fsufs.2023.1118021

Govender, L., Pillay, K., Siwela, M., & Modi, A. T. (2019). Consumer perceptions and acceptability of traditional dishes prepared with provitamin a-biofortified maize and sweet potato. *Nutrients,* 11(7), 1–21. https://doi.org/10.3390/nu11071577

Imathiu, S. (2021). Neglected and Underutilized cultivated crops with respect to indigenous african leafy vegetables for food and nutrition security. *Journal of Food Security*, 9(3), 115–125. https://doi.org/10.12691/jfs-9-3-4

Irakoze, M. L., Owaga, E. E., & Wafula, E. N. (2023). Effect of lactic acid bacteria fermentation on nutrients and anti-nutrients of African black nightshade and African spider plant. *Scientific African,* 21, e01762. https://doi.org/10.1016/j.sciaf.2023.e01762

Irakoze, M. L., Wafula, E. N., & Owaga, E. (2021). Potential Role of African fermented indigenous vegetables in maternal and child nutrition in Sub-Saharan Africa. *International Journal of Food Science*, 3400329, 1-11. https://doi.org/10.1155/2021/3400329

Issa-Zacharia, A., Majaliwa, N., Nyamete, F. A., & Chove, L. M. (2024). Diversity of Underutilised vegetables in Africa and their potential in the reduction of micronutrient deficiency: A review. *World Journal of Food Science and Technology,* 8(1), 1–13. https://doi.org/10.11648/j.wjfst.20240801.11

Jeong, S., & Lee, J. (2021). Effects of cultural background on consumer perception and acceptability of foods and drinks: a review of latest cross-cultural studies. *Current Opinion in Food Science,* 42, 248–256. https://doi.org/10.1016/j.cofs.2021.07.004

Mihafu, F. D., Issa, J. Y., & Kamiyango, M. W. (2020). Implication of sensory evaluation and quality assessment in food product development: A review. *Current Research in Nutrition and Food Science,* 8(3), 690–702. https://doi.org/10.12944/CRNFSJ.8.3.03

Mwanri, A. W., Mamboleo, T. F., Msuya, J. M., & Gowele, V. F. (2018). Oxalate, phytate and nitrate content in African nightshade, spider plant and amaranths at different stages of maturity. *African Journal of Food Science*, 12(11), 316–322. https://doi.org/10.5897/ajfs2018.1735

Nacef, M., Lelièvre-Desmas, M., Symoneaux, R., Jombart, L., Flahaut, C., & Chollet, S. (2019). Consumers' expectation and liking for cheese: Can familiarity effects resulting from regional differences be highlighted within a country? *Food Quality and Preference*, 72, 188–197. https://doi.org/10.1016/j.foodqual.2018.10.004

Neelavathi, R., Rani, C. I., Durgadevi, M., Ezhilmathi, S., Gnanasundari, K., Gokila, R., & Prabhu, M. (2022). Influence of blanching and drying methods on the retention of nutritional quality of dried Moringa leaves. *American Association of Textile Chemists and Colorists Review,* 22(4), 36–40. DOI: https://doi.org/10.58321/AATCCReview.2022.10.04.36

Ngungulu, T. P., Wenaty, A., Chove, B., Suleiman, R., & Mbwana, H. (2024). Effect of different processing methods on the anti-nutritive components of selected indigenous vegetables. Asian Food Science Journal, 23(8), 80–94. https://doi.org/10.9734/afsj/2024/v23i8737

Nyonje, W. A., Yang, R. Y., Kejo, D., Makokha, A. O., Owino, W. O., & Abukutsa-Onyango, M. O. (2022). Exploring the status of preference, utilization practices, and challenges to consumption of amaranth in Kenya and Tanzania. *Journal of Nutrition and Metabolism*, 2022, 2240724, 1–11. https://doi.org/10.1155/2022/2240724

Owade, J. O., Abong', G., Okoth, M., & Mwang'ombe, A. W. (2020). A review of the contribution of cowpea leaves to food and nutrition security in East Africa. *Food Science and Nutrition*, 8(1), 36–47. https://doi.org/10.1002/fsn3.1337

Salha, S. Y., Abdulsudi, I.-Z., & Lucy, C. M. (2023). Functional and sensory quality of complementary food blended with Moringa leaf powder. *European Journal of Nutrition & Food Safety*, 15(9), 13–24. https://doi.org/10.9734/ejnfs/2023/v15i91332

Sangija, F., Kazosi, M., Martin, M., & Matemu, A. (2022). Trends and Constraints in the Utilization of African Nightshade (*Solanum nigrum* complex) IN Tanzania: A case study of Kilimanjaro and Morogoro regions. *African Journal of Food, Agriculture, Nutrition and Development*, 22(6), 20623–20645. https://doi.org/10.18697/ajfand.111.22065

Sangija, F., Martin, H., & Matemu, A. (2022). Effect of lactic acid fermentation on the nutritional quality and consumer acceptability of African nightshade. *Food Science and Nutrition*, 10(9), 3128–3142. https://doi.org/10.1002/fsn3.2912

Stoll, D. A., Wafula, E. N., Mathara, J. M., Trierweiler, B., Kulling, S. E., & Huch, M. (2021). Fermentation of African nightshade leaves with lactic acid bacterial starter cultures. *International Journal of Food Microbiology*, 342, 109056. https://doi.org/10.1016/j.ijfoodmicro.2021.109056

Swai, Zenorina Aloyce, Frida Albinus Nyamete, & Valerian. C. K. Silayo. (2025). Effect of processing methods on micronutrient profile, colour, and anti-nutritive components of *Justicia Heterocarpa* (mwidu). *European Journal of Nutrition & Food Safety* 17 (2),107-24. https://doi.org/10.9734/ejnfs/2025/v17i21637

Tuorila, H., & Hartmann, C. (2020). Consumer responses to novel and unfamiliar foods. *Current Opinion in Food Science*, 33, 1–8. https://doi.org/10.1016/j.cofs.2019.09.004

FAO, IFAD, UNICEF, WFP, & WHO. (2021). The state of food security and nutrition in the world 2021: Transforming food systems for food security, improved nutrition and affordable healthy diets for all. Rome: FAO. https://doi.org/10.4060/cb4474enUNICEF

Vermeir, I., & Roose, G. (2020). Visual design cues impacting food choice: A review and future research agenda. *Foods*, 9(10), 1495. https://doi.org/10.3390/foods9101495

Wang, Q. J., Mielby, L. A., Junge, J. Y., Bertelsen, A. S., Kidmose, U., Spence, C., & Byrne, D. V. (2019). The role of intrinsic and extrinsic sensory factors in sweetness perception of food and beverages: A review. *Foods*, 8(6), 211. https://doi.org/10.3390/foods8060211

Yang, J., & Lee, J. (2018). Korean consumers' acceptability of commercial food products and usage of the 9-point hedonic scale. *Journal of Sensory Studies*, 33(6), e12467. https://doi.org/10.1111/joss.1246

Zulu, S. S., Ngidi, M., Ojo, T., & Hlatshwayo, S. I. (2022). Determinants of consumers' acceptance of indigenous leafy vegetables in Limpopo and Mpumalanga provinces of South Africa. *Journal of Ethnic Foods*, 9(1) 13. https://doi.org/10.1186/s42779-022-00128-5.