

UTILIZING ROSELLE IN FOOD PROCESSING: A STUDY ON NUTRITIONAL BENEFITS AND VALUE-ADDED PRODUCT DEVELOPMENT

Yashwant Kumar Patel^{1,*,#} and Krishna Kumar Patel²

¹Asstt. Prof. and Head, Dept of FPT, UTD, Atal Bihari Vajpayee Vishwavidyalaya, Bilaspur, CG, India

[#]Research Scholar, Dept. of Agril. Engg., PG College Ghazipur, VBS Purvanchal University, UP, India

²Asstt. Prof., Dept. of Agril. Engg., PG College Ghazipur, VBS Purvanchal University, UP, India

*Corresponding Author: **Yashwant Kumar Patel**

profykpate@gmail.com

ABSTRACT

Roselle (*Hibiscus sabdariffa* L.), a tropical herbaceous plant, is valued for its vibrant calyces, which are used in beverages, jams, and jellies. Rich in antioxidants like gossypetin, hibiscetin, and sabdaretin, roselle also provides essential nutrients such as ascorbic acid, niacin, calcium, and iron. Despite its known medicinal and nutritional benefits, roselle remains underutilized in food processing industries. This study focuses on developing and standardizing technologies for processing and preserving roselle leaves, primarily through value addition in everyday culinary applications. One such approach is the preparation of a cooked vegetable dish (bhaji) using roselle leaves, which was evaluated for sensory attributes including appearance, aroma, texture, flavor, and overall acceptability. The leaves were sautéed with spices, including cumin seeds, garlic, turmeric, and chili powder, highlighting their potential as a savory component in diverse cuisines. A panel of 20 participants conducted a sensory evaluation of the dish, scoring it favorably across all parameters, particularly in appearance, aroma, and flavor. Additionally, the study investigated the nutritional content of roselle leaves, demonstrating their high protein, fiber, and carbohydrate content, making them a viable option for enhancing the nutritional value of meals. Furthermore, the preservation methods explored in this research offer insights into prolonging the shelf life of roselle leaves, enabling their use in both fresh and dried forms. This research provides a foundation for further exploration into the commercial potential of roselle in food processing, nutrition, and health, particularly in regions where it is traditionally grown but underutilized.

Keywords: Roselle, *Hibiscus Sabdariffa*, bhaji, Sensory evaluation and Nutritional content.

INTRODUCTION

Roselle belongs to the family Malvaceae, tropically titled 'Karkade' is a far reaching one – year harvest successfully in equatorial and sub- tropical climates. The commercially far- reaching belonging of the communicate is the over-weight of the freshy calyx (sepals) neighborhood the fruits products (capsules) (Mohamed et al., 2012). Roselle or Jamaica chromatic is an unparalleled a species sophisticated in severals equatorial territories for its leaves, seeds, stems, and calyces are euphemistic pre-owed to put im order tea, syrups, jams, and jellies as beverages. Roselle exhibits

significant antioxidant activity, largely due to its high anthocyanin levels, making it beneficial for health-promoting applications (Tsai et al., 2002). Roselle is a one- year communicates which grips approximately cardinal months to mature. Structural characteristics of roselle vegetables are dual-laned into deuce ace to five- spot lobes and they are ordered on the cyclinder alternately. Each calyx lobe efflorescence has a recognizable fundamental bone and cardinal insignificant ribs. These characteristics accommodation communicate in the sub division of furcaria. Efflorescences are immaculate to straw in colouration, with overweight and compressible calyces. Roselle leaves and calyces, emphasizing their high protein, fiber, and mineral content. The findings suggest that Roselle is a valuable food source, rich in antioxidants and essential nutrients such as calcium and iron (Balarabe, 2019). Roselle is a stable source of natural pigments and antioxidants, even under heat treatment, making it suitable for commercial beverages (Cisse et al., 2009).The colouration of the petals hawthorn diversity from immaculate to pink, red, orange, purple or yellow. The fully-fledged fruits products are coruscating red. Roselle has strained the consideration of food, beverage, and pharmaceutical manufactures because of its commercial potential as a natural food and colouring agent that can replace some synthetic products (Ansari et al., 2013a). Diverse uses of roselle, including its leaves, seeds, and calyces, emphasizing its rich phytochemical composition and medicinal benefits (Ansari et al., 2013b). Plant's natural acidity and vibrant color make it an excellent ingredient for beverages, offering a healthier alternative to synthetic additives (Salami and afolayan, 2020). Plant's potential as an antioxidant, rich in phenolic compounds, and its role in managing health conditions such as hypertension (Qi et al., 2005). Roselle's potential in preventing chronic diseases related to oxidative damage (Olayemi et al., 2011). Fermentation on the chemical composition of roselle calyx. It found that fermentation enhances the bioavailability of nutrients in roselle, improving its nutritional value and health benefits (Ojokoh, 2007).



Fig. 1: Roselle Leaf

Botanic Description –

It is an erect, largely branched, one- year shrub. Stem are reddish colouration and upto 3.5 m tall. Leaves are dark green to red, interchange, glabrous, long- petolate, palmately, dual- laned into 3-7 lobes, with serrated margins (Qi et al., 2005).

Ecology –

Roselle stand for a perspire clammy equatorial and semitropical climate and is susceptible of to destruction from frost. Its rigorousness' territory scopes from 9 to 10. Roselle buoy stand for inconsiderable tincture and buoy be grownup in glasshouse on the other hand it unremarkably become larger beyond compare in the environment weathers underneath the full-of-the-moon sunlight (Qi et al., 2005).

Table 1: Nutritional Value of Roselle Leaves-

Components	Percentage (%)
Moisture	10.50- 12.50%
Crude Protein	4.10 - 5.37%
Crude Lipid	1.00 - 4.33%
Crude Fat	1.16 – 13.09 %
Crude Fiber	15.75 – 36.10 %
Carbohydrate	26.93 – 54.13%
Energy	631.36 – 1065 kJ
Ash	6.08 – 13.74 %
Calcium	1.20% - 1.40 %

Source: (Balarabe, 2019); (Salami and afolayan, 2020)

MEDICINAL AND INDUSTRIAL APPLICATIONS –

Numerous medicinal uses for the roselle plant have been established internationally. In China, this remedy is employed for hypertension, pyrexia, liver damage, and in ayurvedic medicine. Delgado et al. (2003) emphasize the vibrant red pigments and antioxidant properties of roselle in health products. In recent times, the sepal extract has proven to be a successful remedy for leukemia because of its abundant polyphenols, specifically protocatechuic acid. Up until now, roselle seeds have not been used for commercial purposes, but they contain vegetable oil that is low in cholesterol and high in various phytosterols and tocopherols, including beta-sitosterol and γ -tocopherol. Morton (1987) stated that the plant has medicinal qualities that can reduce blood pressure and aid in digestive problems. Hibiscus sabdariffa indicates that these substances, especially anthocyanins, play a role in the plant's antioxidant qualities and its bright hue, which are beneficial for food and medical uses (Arapitsas, 2008). The general features of roselle seed oil make it suitable for significant industrial uses and enhance its value in cultivation. Roselle extracts were found to greatly decrease oxidative stress in rats, indicating possible therapeutic uses for human health and oxidative harm (Hirunpanich et al., 2006; Chang et al., 2015). Roselle's therapeutic properties include soothing colds, clearing a blocked nose, as well as aiding digestion and promoting kidney function when consumed as herbal tea. It also acts as an astringent, diuretic, and general tonic, with reported benefits in managing cholesterol, improving cardiovascular health, and possessing anti-inflammatory, antimicrobial, and anti-cancer properties due to its polyphenolic compounds (Lin et al., 2007; Da-Costa et al., 2014; Patel, 2015; Ali et al., 2005). Consumed in the form of a beverage made from

the calyx, it acts as a gentle diuretic and laxative, along with various other effects. It is believed that the beverage acts as a traditional cure for cancer. Roselle drink that has been restored does not contain any isolated bacteria (Mohamed et al., 2012). The farming techniques of roselle (*Hibiscus sabdariffa* L.) in Sudan, with a focus on its applications in drinks, preserves, and healthcare.

Mohamed et al. (2007) highlight the strong need for natural colorants and antioxidants, which can be used in food and pharmaceutical sectors. Roselle is a valuable source of vitamins, minerals, and antioxidants, which are crucial components for enhancing human health through dietary consumption (Al-Kayri and Hussein, 2008). The high amount of flavonoids in Roselle shows its promise as a natural component for use in the food and pharmaceutical sectors (Adeoye and abulude, 2015). The rich polyphenols in roselle contribute to its high antioxidant power, offering protection against oxidative stress and associated illnesses (Bakasso et al., 2008). The importance of *Hibiscus sabdariffa* in treating hypertension, obesity, and liver disease is emphasized in the study by Fekadu (2020).

OBJECTIVES

- ✓ To analyse the various properties of roselle leaves.
- ✓ Value addition in roselle leaves.

MATERIALS & METHODS

Raw Materials:

1. **Roselle Leaves:** Fresh roselle leaves are the primary ingredient. They are cleaned, chopped, and used as the base for the dish. The tangy and slightly sour flavor of the leaves is enhanced by cooking them with various spices.
2. **Oil (10 g):** Used for tempering and sautéing the spices. Any cooking oil such as vegetable oil or sunflower oil can be used.
3. **Cumin Seeds (1 tsp):** Adds a warm, nutty flavor to the dish. It is tempered in oil to release its aromatic oils, enhancing the overall flavor.
4. **Garlic (2–3 cloves, finely chopped):** Provides a savory, pungent aroma. It is sautéed in oil to add depth to the dish.
5. **Green Chili (1, chopped):** Add heat to the dish. The amount can be adjusted according to personal preference for spice.
6. **Turmeric Powder (1/4 tsp):** Add a yellow color and earthy flavor, as well as providing anti-inflammatory properties.
7. **Hing (Asafoetida, a pinch):** Enhances the savory flavor and helps with digestion. It is often used in small amounts in Indian cooking.
8. **Red Chili Powder (1/2 tsp):** Add a subtle heat and red color to the dish. This can be adjusted based on spice preference.
9. **Salt:** Used to season the dish. Adjust the amount as per taste.

Equipments/Tools:

1. **Pan (or Skillet):** A medium-sized pan is required for cooking the vegetable. It should have enough surface area to allow even cooking of the leaves and proper sautéing of the spices.

2. **Stirring Spoon:** A wooden or metal spoon is used to stir the ingredients while cooking to ensure even distribution of the spices and prevent burning.
3. **Knife:** Used for finely chopping the roselle leaves, garlic, and chili. A sharp knife is essential for uniform chopping and reducing cooking time.
4. **Cutting Board:** A clean surface used for cutting and preparing the ingredients such as roselle leaves, garlic, and green chili.

Instruments:

1. **Weighing Scale:** Can be used to measure the exact quantity of oil, spices, or roselle leaves, ensuring consistency in taste.
2. **Measuring Spoons:** Used to measure the exact quantities of cumin seeds, red chili powder, and other spices. It ensures accuracy and uniform flavor distribution.

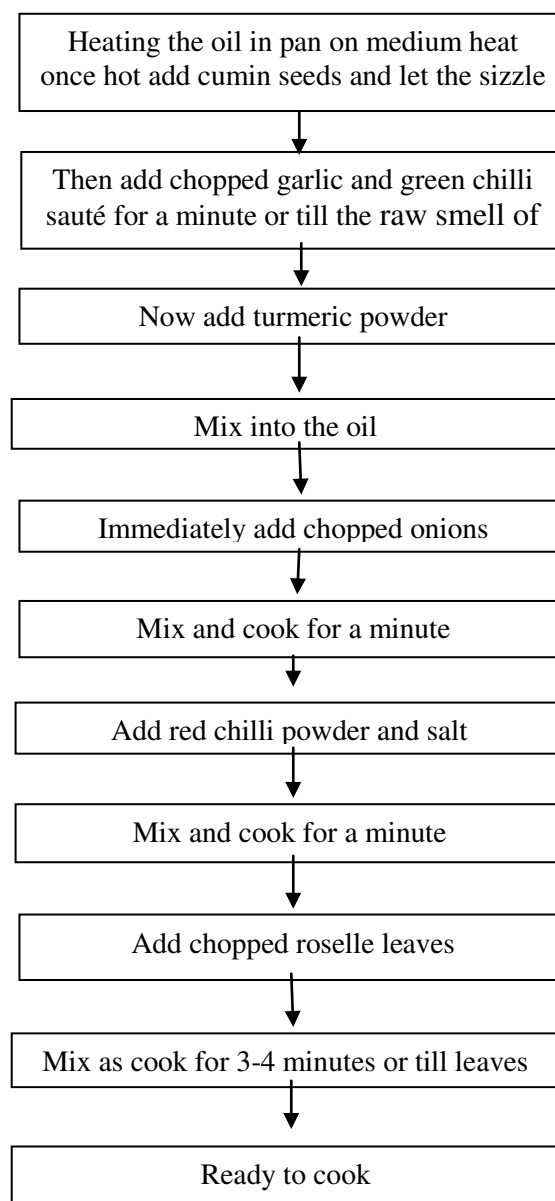


Fig. 2: Flow chart processing of cooked vegetable

PROCEDURE

Step-by-Step Procedure for Cooking Roselle Vegetable

1. **Preparation of Roselle Leaves:** First, wash the 100 g of roselle leaves thoroughly to remove any dirt or impurities. Use a knife to finely chop the cleaned roselle leaves, ensuring uniformity in size for even cooking.



Fig. 3: Roselle Leaves (washed and cleaned)

2. **Heat Oil and Tempering:** Heat a pan on medium heat and add 10 g of oil. Once the oil is hot, add 3 g of cumin seeds and let them sizzle for a few seconds until they start to crackle, releasing their aroma.

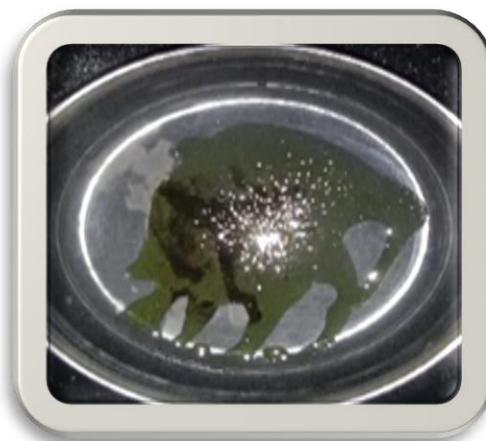


Fig. 4: Heat Oil and Tempering

3. **Saute Garlic and Chili:** Add 5 g of finely chopped garlic to the pan and sauté for about a minute or until the raw smell of the garlic disappears and it turns golden brown. Then, add 2 g of chopped green chili and sauté for another 30 seconds.



Fig. 5: Saute Garlic and Chili

4. **Add Turmeric and Hing:** Sprinkle 0.5 g of turmeric powder and a pinch (0.2 g) of hing (asafoetida) into the pan. Mix well to ensure the spices blend with the oil and garlic.
5. **Add Red Chili Powder and Salt:** Add 1.5 g of red chili powder and 3 g of salt (as per taste). Stir the mixture for a minute, allowing the spices to cook and combine with the rest of the ingredients.



Fig. 6: Addition of Spices

6. **Add Roselle Leaves:** Now, add the 100 g of finely chopped roselle leaves to the pan. Stir the leaves well so that they are evenly coated with the spices and oil.
7. **Cook the Leaves:** Cook the roselle leaves for 3–4 minutes, stirring occasionally to prevent them from sticking to the pan. As the leaves cook, they will soften and release moisture. Continue cooking until the leaves become tender and most of the moisture has evaporated. The leaves should be fully wilted and cooked, with no rawness remaining.



Fig. 7: Cooking of Leaves

8. **Final Adjustments:** Once the leaves are cooked, taste the dish and adjust the seasoning if necessary. Add more salt or chili powder if preferred.



Fig. 8: Cooked bhaji

9. **Serve:** Remove the cooked roselle vegetable from the heat and transfer it to a serving dish. Serve hot as a side dish with rice or bread.

RESULTS AND DISCUSSION

The research focused on the development and standardization of technologies for processing and preserving roselle (*Hibiscus sabdariffa* L.), with the aim of creating value-added products and improving the shelf life and usability of roselle leaves. The findings are significant in contributing to the underutilized potential of roselle in food processing, nutrition, and value addition. The nutritional analysis of roselle leaves indicated that they contain essential nutrients such as crude protein (4.10-5.37%), crude fiber (15.75-36.10%), carbohydrates

(26.93-54.13%), and ash content (6.08-13.74%). The moisture content of Roselle leaves ranged from 10.50% to 12.50%, making them suitable for drying and storage as the low moisture content reduces the risk of spoilage during processing. The research outlined various methods for the processing and value addition of roselle leaves. One significant area of investigation was the preparation of a cooked roselle vegetable (bhaji) through a standardized cooking method. The step-by-step preparation involved cleaning, chopping, and tempering Roselle leaves with spices, followed by sensory evaluation. To standardize the preparation of roselle vegetable, the process involved cooking the leaves with cumin seeds, garlic, chili, and turmeric, highlighting how Roselle can be incorporated into everyday meals. This was done using simple kitchen techniques to make it accessible to a wide range of consumers. The development of a standardized recipe for roselle bhaji expands its use beyond traditional applications like teas and jams, opening up possibilities for incorporating roselle in savory dishes.

SENSORY EVALUATION METHODOLOGY:

The sensory evaluation of the prepared roselle bhaji involved 20 untrained participants who rated the product based on five key attributes: appearance, aroma, texture, flavor, and overall acceptability using a 9-point hedonic scale. The appearance of the cooked roselle vegetable was rated highly, with scores ranging from 7 to 9. Participants appreciated the vibrant green color of the leaves post-cooking, with spices like turmeric and red chili powder adding visual appeal. The aroma of the dish, which is an essential factor for consumer acceptance, scored an average of 8. The sautéed garlic and cumin provided a rich, nutty fragrance, while the tangy undertones of the roselle leaves contributed to the complexity of the aroma. The balance of these elements indicated a well-rounded sensory experience that was pleasing to the participants. In terms of texture, the roselle bhaji was rated favorably, with an average score of 7. Panelists noted that the leaves retained a desirable firmness post-cooking, avoiding the mushiness that can detract from the mouthfeel. This suggests that the cooking technique was appropriate for preserving the integrity of the roselle leaves while still achieving tenderness. Flavor, a critical attribute in the evaluation, scored an average of 8. The slightly tangy taste of roselle leaves, which can sometimes be overpowering, was well-balanced with the spices used in the preparation. The mild heat from the chili powder and the savory depth provided by the garlic created a harmonious flavor profile, which was well-received by the majority of participants. Roselle vegetable scored highly, with most participants expressing a willingness to consume the dish again. The sensory evaluation provided a strong indication that the standardized recipe developed for roselle bhaji is both enjoyable and versatile, highlighting the potential of Roselle leaves in mainstream cuisine.

Procedure:

1. **Sample Preparation:** The roselle vegetable was prepared following the standardized recipe. Each sample was served warm, in small portions, to avoid temperature variation affecting sensory perception.
2. **Evaluation Process:**
 - The participants were provided with a questionnaire to assess each sensory attribute (appearance, aroma, texture, flavor, and overall acceptability).

- Panelists were instructed to cleanse their palate with water between tastings to ensure accurate evaluation.

Sensory evaluation plays a crucial role in assessing the acceptability and overall quality of food products. For the cooked roselle vegetable, the following sensory attributes were evaluated:

1. **Appearance**
2. **Aroma**
3. **Texture**
4. **Flavor**
5. **Overall Acceptability**

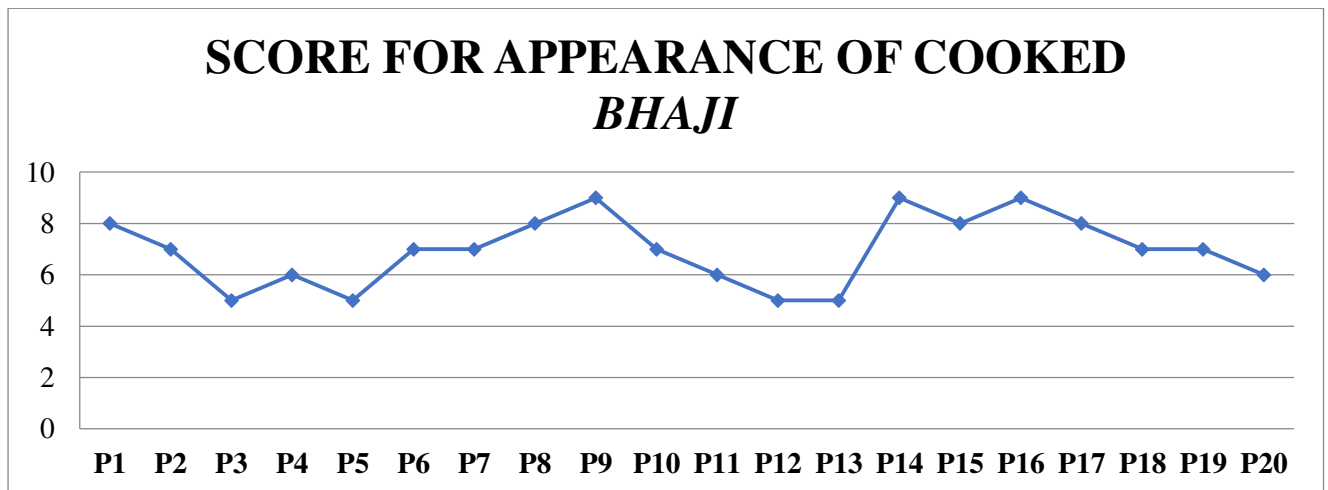
1. APPEARANCE

Appearance is one of the first sensory parameters that influences consumer perception and acceptability of a food product. The visual appeal of food can strongly affect the willingness of individuals to taste and consume it. For the roselle vegetable, the appearance of the dish after cooking was an important criterion for assessment. Participants noted that the color of the cooked roselle leaves remained vibrant, transitioning from a deep green before cooking to a darker shade after the cooking process. The addition of turmeric, red chili powder, and other spices contributed to the overall visual appeal by creating a dish with a rich green base complemented by red flecks and a golden-yellow hue from the turmeric. The even distribution of the spices on the leaves further enhanced the dish's appearance, giving it a uniform and well-prepared look.

The sensory evaluation for appearance received high scores, ranging between 7 (like moderately) and 9 (like extremely), indicating that the dish was visually appealing to most participants. This positive reception suggests that the roselle vegetable, with its vibrant appearance, is likely to attract consumers when prepared using the standardized recipe. A well-cooked, non-mushy texture was another important factor that contributed to its visual appeal, as it demonstrated freshness and appropriate cooking techniques.

Evaluation Criteria:

- Brightness of the leaves
- Uniformity in color distribution
- Visual appeal of the spices coating the leaves.



Results: The roselle leaves retain a pleasant, vibrant color post-cooking, with the spices evenly distributed. The cooked vegetable should not appear too greasy or too dry.

2. AROMA

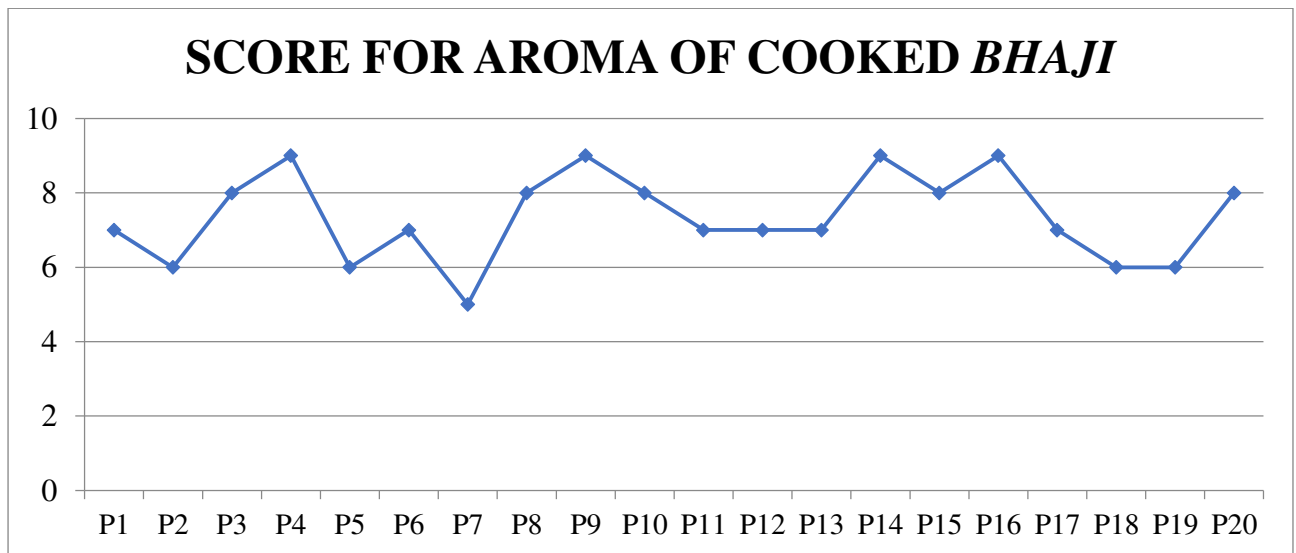
Aroma is another critical attribute in sensory evaluation, as it directly influences the perception of flavor. A well-balanced aroma can make a dish more appetizing, while undesirable smells can diminish consumer interest. In this study, the aroma of the Roselle vegetable was assessed based on the interplay between the fragrance of the spices and the natural tangy scent of the Roselle leaves.

The dish was prepared by tempering cumin seeds, garlic, and green chili in oil, which produced a rich, savory aroma that formed the base of the dish's fragrance. The distinct earthy scent of the Roselle leaves combined with the spices to create a complex aromatic profile. Participants noted the strong presence of garlic and cumin, both of which are commonly appreciated in Indian cooking. The slightly tangy scent of the Roselle leaves was also evident, balancing out the strong, nutty aroma of the spices.

The sensory evaluation scores for aroma were mostly positive, with an average score of 8. This indicates that the aroma of the cooked Roselle vegetable was generally well received by the panelists. The absence of any burnt or overly spicy smells further supported the high ratings. The participants found the fragrance to be appetizing, suggesting that the dish had a well-balanced aromatic profile that enhanced the overall sensory experience.

Evaluation Criteria:

- Strength and pleasantness of the garlic and cumin aroma
- Absence of any burnt or overly spicy smells
- Tangy, fresh scent from the roselle leaves



Results: The aroma is fresh, with the cumin and garlic aromas being predominant, followed by the earthy and slightly tangy fragrance of the roselle leaves.

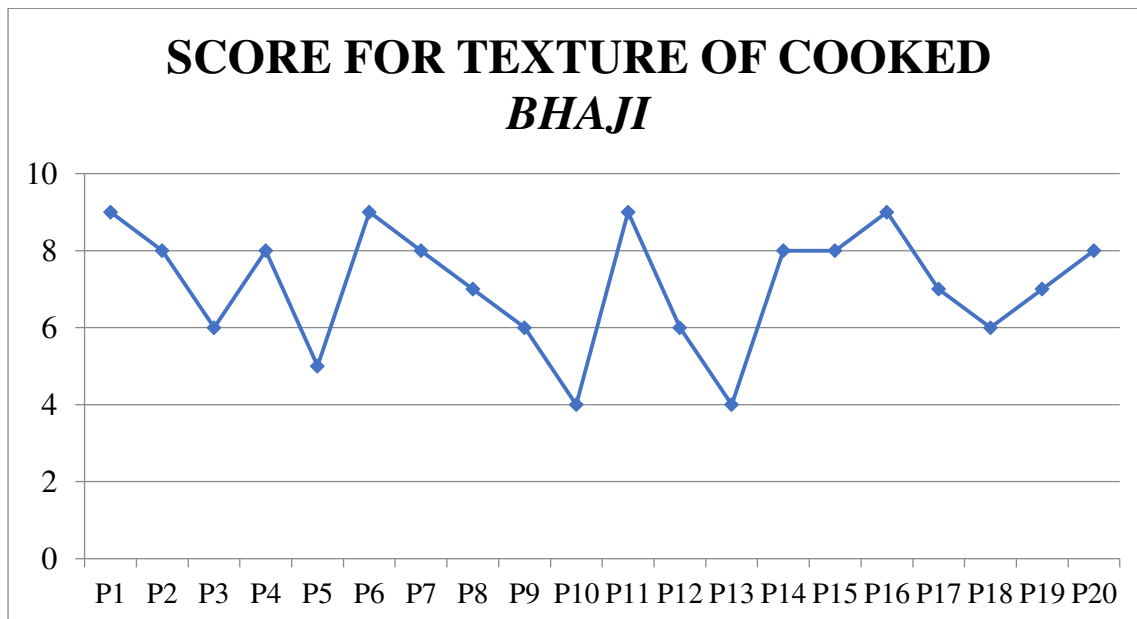
3. TEXTURE

Texture is a vital sensory attribute that affects mouthfeel and the overall enjoyment of a dish. The texture of cooked roselle leaves should ideally be soft yet firm, providing a pleasant bite without becoming overly mushy or watery. Maintaining an appropriate texture is crucial for consumer satisfaction, as texture issues can significantly affect the palatability of a dish.

In this study, the texture of the roselle vegetable was evaluated based on the softness of the leaves and the consistency of the dish. The leaves were sautéed until fully cooked but not overdone, preserving a slight firmness. Overcooking can lead to a mushy, unappealing texture, which was avoided in this preparation. The garlic pieces also maintained a tender texture, complementing the leaves without becoming overly crispy or burnt. The panelists gave the texture an average score of 7, indicating that while most found the texture to be satisfactory, there were some slight variations in texture preferences among participants. A few panelists noted that in certain samples, the leaves had softened slightly more than desired. However, the majority of participants appreciated the fact that the dish retained a balanced consistency, avoiding excessive oiliness or wateriness.

Evaluation Criteria:

- Firmness of the roselle leaves after cooking
- Properly sautéed garlic without being overcooked or burnt
- Smooth texture with no excessive oiliness



Results: The cooked vegetable have a soft but firm texture, with each leaf easily distinguishable. The bhaji should not be watery or overly oily, maintaining a balanced consistency.

4. FLAVOR

Flavor is the most complex sensory attribute, as it is influenced by taste, aroma, and the balance of ingredients. The flavor of the roselle vegetable was a key area of focus in this study, as it needed to balance the naturally tangy taste of the roselle leaves with the spices used in its preparation. The dish was designed to highlight the unique flavor of roselle while making it palatable and enjoyable for a wider audience.

The tangy, slightly sour taste of the roselle leaves was complemented by the mild heat from the green chili and red chili powder, as well as the savory notes from cumin and garlic. The turmeric added a subtle earthy flavor that balanced out the sharper notes from the chili and garlic. The spices were carefully measured to ensure that they enhanced the natural taste of the roselle leaves rather than overpowering it.

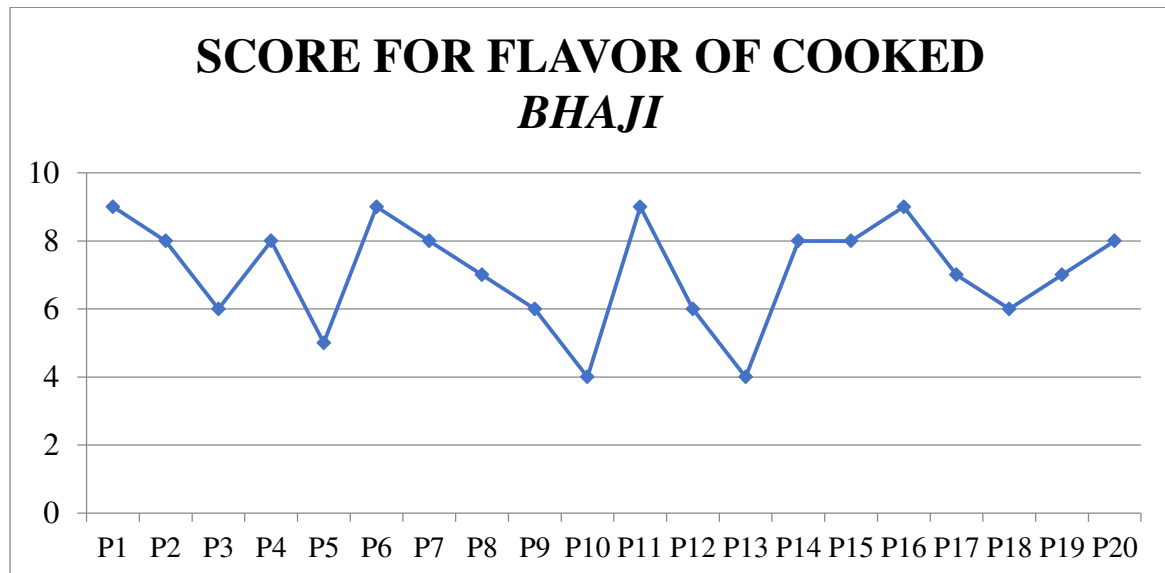
The sensory evaluation for flavor yielded an average score of 8, demonstrating that the flavor profile was well received by most participants. The balance between the tanginess of the leaves and the spiciness of the chili, along with the depth provided by the garlic and cumin, was praised by the panelists. Participants particularly enjoyed the unique flavor of the roselle leaves, which they found to be both refreshing and distinct. However, a few panelists mentioned that the level of spice could be adjusted to suit individual preferences, highlighting the flexibility of the dish in terms of seasoning.

Evaluation Criteria:

- Balance between tanginess of the roselle and the spices
- Saltiness and heat levels

- Proper seasoning without overpowering the natural flavor of the leaves

Results: The flavor should be tangy yet balanced, with the chili providing a mild heat that complements, rather than overpowers, the roselle. The spices should enhance the natural taste of the leaves without overwhelming it.

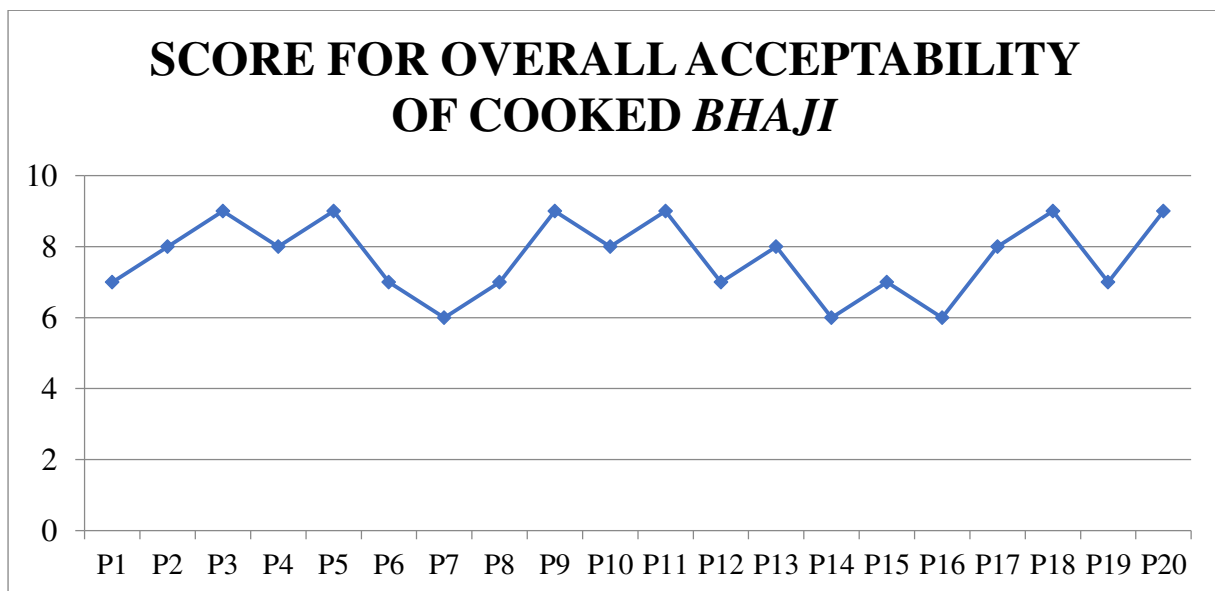


5. OVERALL ACCEPTABILITY

Overall acceptability is a synthesis of all sensory attributes—appearance, aroma, texture, and flavor. It reflects how likely consumers are to enjoy the dish and whether they would be willing to eat it again. For the roselle vegetable, overall acceptability was a key measure of the success of the value-added product. The dish scored highly in overall acceptability, with an average score of 8. This suggests that the Roselle vegetable was well received by the majority of participants, who found the combination of sensory attributes to be enjoyable. The participants expressed satisfaction with the balance of flavors, the appealing appearance, and the pleasant aroma, indicating that the dish has strong potential for consumer acceptance. Several participants mentioned that they would be willing to consume the roselle vegetable again, either as a side dish or as a main component in a meal. The positive feedback highlights the potential for roselle leaves to be incorporated into regular diets, especially in regions where it is already grown but underutilized.

Evaluation Criteria:

- Overall satisfaction with the sensory characteristics
- Would consumers want to eat the dish again?



Results: A high score in overall acceptability means that the dish is well-received by the consumer, with no significant flaws in taste, texture, or aroma. It should be deemed a desirable and enjoyable dish for consumption.

SUMMARY AND CONCLUSION

Roselle (*Hibiscus sabdariffa* L.), commonly referred to as Jamaica sorrel, is a versatile plant used for its calyces, leaves, seeds, and stems. It is particularly noted for its potent antioxidant properties and nutrient-rich profile, containing flavonoids such as gossypetin, hibiscetin, and sabdaretin, along with essential vitamins and minerals like ascorbic acid, niacin, calcium, and iron. While roselle is traditionally used in beverages and jellies, its application in savory dishes remains relatively unexplored. This study aimed to develop and standardize technologies for processing and preserving roselle leaves, with a focus on creating value-added products that enhance the usability of this underutilized plant. One significant area of exploration was the preparation of a cooked vegetable dish (bhaji) using roselle leaves. The dish was prepared by sautéing finely chopped roselle leaves with spices such as cumin, garlic, turmeric, and chili powder. This process not only preserved the nutritional integrity of the leaves but also enhanced their flavor, making them more accessible to a broader consumer base. The sensory evaluation of the dish involved 20 untrained participants who rated the product on a 9-point hedonic scale based on five key attributes: appearance, aroma, texture, flavor, and overall acceptability. The results indicated that the dish was well-received across all sensory parameters, with high scores for its vibrant appearance, rich aroma, balanced texture, and tangy flavor. The visual appeal of the dish was particularly praised, with participants noting the vibrant green color of the cooked leaves, enhanced by the yellow of the turmeric and the red flecks of chili powder. The aroma, dominated by garlic and cumin, added to the dish's sensory complexity, while the slightly tangy flavor of the roselle leaves was well-balanced with the heat from the chili and the depth from the garlic and cumin.

In addition to sensory evaluation, the study also assessed the nutritional content of roselle leaves. The leaves were found to be rich in protein (4.10–5.37%), fiber (15.75–36.10%), and

carbohydrates (26.93–54.13%), making them an excellent ingredient for enhancing the nutritional value of meals. The moisture content of the leaves, which ranged from 10.50% to 12.50%, was suitable for drying and preservation, allowing for extended shelf life and broader commercial use. The study also explored preservation techniques, emphasizing the importance of low moisture content in reducing spoilage risks during processing. By focusing on both fresh and dried forms of roselle leaves, the research demonstrated the plant's potential for use in various forms, from freshly prepared dishes to long-lasting dried products. This study successfully developed a standardized process for incorporating roselle leaves into savory dishes, expanding its use beyond traditional beverages and jellies. The high acceptability scores from sensory evaluations suggest that roselle has the potential to become a popular ingredient in everyday meals, particularly in regions where it is already cultivated but underutilized. The nutritional benefits, coupled with its versatility in culinary applications, position roselle as a valuable addition to the food processing industry. Future research could further explore the commercial potential of roselle by investigating additional preservation methods and expanding its use in different culinary traditions.

REFERENCES

1. Adeoye, B. K., & Abulude, F. O. (2015). Roselle calyx (*Hibiscus sabdariffa* L.) extracts: Nutritional composition and bioactive components. *Journal of Food and Nutrition Sciences*, 6(6), 492-500.
2. Ali, B. H., Al Wabel, N., & Blunden, G. (2005). Phytochemical, pharmacological, and toxicological aspects of *Hibiscus sabdariffa* L.: A review. *Phytotherapy Research*, 19(5), 369-375.
3. Al-Kayri, J. M., & Hussein, K. K. (2008). Nutritional and functional properties of *Hibiscus sabdariffa* L. *African Journal of Food Science*, 2(7), 225-229.
4. Ansari, M., Eslaminejad, T., Sarhadynejad, Z., & Eslaminejad, T. (2013a). An overview of the Roselle plant with particular reference to its cultivation, diseases, and usages. *Journal of Medicinal Plants Research*, 7(13), 745-750.
5. Arapitsas, P. (2008). Identification and quantification of polyphenolic compounds from *Hibiscus sabdariffa* L. *Journal of Food Composition and Analysis*, 21(5), 396-399.
6. Bakasso, S., Lamien-Meda, A., Lamien, C. E., et al. (2008). Polyphenol contents and antioxidant activities of *Hibiscus sabdariffa* L. *Journal of Medicinal Plants Research*, 2(8), 196-201.
7. Balarabe, M. A. (2019). Nutritional analysis of *Hibiscus sabdariffa* L. (Roselle) leaves and calyces. *Journal of Medicinal Plants Research*, 13(2), 45-50.
8. Chang, Y. C., Huang, K. X., & Huang, A. C. (2015). Polyphenol-rich extracts from Roselle calyx (*Hibiscus sabdariffa* L.) modulate lipid metabolism and oxidative stress. *Journal of Functional Foods*, 12, 469-480.
9. Cisse, M., Vaillant, F., Acosta, O., Dhuique-Mayer, C., & Dornier, M. (2009). Thermal stability of anthocyanins from *Hibiscus sabdariffa* extract in a model juice system. *International Journal of Food Science & Technology*, 44(12), 2360–2366.
10. Da-Costa-Rocha, I., Bonnlaender, B., Sievers, H., Pischel, I., & Heinrich, M. (2014). *Hibiscus sabdariffa* L. – A phytochemical and pharmacological review. *Food Chemistry*, 165, 424-443.

11. Delgado-Vargas, F., & Paredes-López, O. (2003). Natural colorants for food and nutraceutical uses. CRC Press.
12. Fekadu Gameda, D. (2020). A review on potential health benefits of Hibiscus sabdariffa L. Journal of Medicinal Plants Studies, 8(5), 84-91.
13. Hirunpanich, V., Utaipat, A., Morales, N. P., Bunyaphatsara, N., Sato, H., Herunsalee, A., & Suthisisang, C. (2006). Antioxidant effects of aqueous extracts from dried calyx of Hibiscus sabdariffa L. on oxidative stress in rats. Journal of Medicinal Plants Research, 4(3), 217-224.
14. Lin, T. L., Lin, H. H., Chen, C. C., Lin, M. C., & Chou, M. C. (2007). Hibiscus sabdariffa extract reduces serum cholesterol in men and women. Nutrition Research, 27(3), 140-145.
15. Ansari Mehdi, Eslaminejad Touba, Sarhadynejad Zarrin & Eslaminejad Tahereh (2013b). An overview of the Roselle plant with particular reference to its cultivation, diseases & usages
16. Mohamed, B. A., Ahmed, A. S., & Dahab, A. A. (2012). Roselle (Hibiscus sabdariffa L.) in Sudan: Cultivation and their uses. Journal of Agricultural and Biological Science, 7(1), 1-7.
17. Mohamed, M. M. D., Ibrahim, I. M. M., & Mostafa, A. M. (2007). Investigation of medicinal and toxicological properties of Hibiscus sabdariffa in rats. Food and Chemical Toxicology, 45(10), 1803-1811.
18. Morton, J. (1987). Roselle. In Fruits of Warm Climates (pp. 281-286). Miami.
19. Ojokoh, A. O. (2007). Effect of fermentation on the chemical composition of Roselle (Hibiscus Sabdariffa) calyx. Journal of Food Processing and Preservation, 31(5), 614-623.
20. Olayemi, F. F., Olayinka, B. U., & Agunbiade, J. O. (2011). The antioxidant and free radical scavenging activities of Hibiscus sabdariffa L. Journal of Medicinal Plants Research, 5(11), 2270-2277.
21. Patel, D. (2015). Role of Hibiscus sabdariffa as an antioxidant in liver injury and cardiovascular disease. International Journal of Pharmaceutical and Life Sciences, 6(3), 546-551.
22. Qi, Y., Chin, K. L., Malekian, F., Berhane, M., & Gager, J. (2005). Biological characteristics, nutritional, and medicinal value of Roselle (Hibiscus sabdariffa). Journal of Food Science and Technology, 42(1), 18-22.
23. Salami, S. O., & Afolayan, A. J. (2020). Suitability of Roselle (Hibiscus sabdariffa L.) as a raw material for soft drink production. Journal of Food Processing and Preservation, 44(4), e14510.
24. Tsai, P. J., McIntosh, J., Pearce, P., Camden, B., & Jordan, B. R. (2002). Anthocyanin and antioxidant capacity in Roselle calyx extracts. Food Research International, 35(4), 351-356.