Direct Research Journal of Agriculture and Food Science

Vol. 13(1), Pp. 56-63., February 2025,

https://journals.directresearchpublisher.org/index.php/drjafs

Research Article
ISSN: 2354-4147

Comparative Studies of Chemical and Sensory Properties of Functional Neem Fruit Juice and Commercial Orange Juice

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ABSTRACT

Micronutrient deficiencies, often termed "hidden hunger," pose significant global health challenges. Underutilized local resources, such as Neem (Azadirachta indica), present opportunities to improve dietary intake and public health. Neem juice, rich in essential vitamins and minerals, has been identified as a potential nutritious beverage. This study aims to compare the nutritional composition and sensory properties of fresh Neem juice with commercially available orange juice, evaluating their potential health benefits and implications for addressing micronutrient deficiencies. Fresh Neem fruits were sourced, and juice was extracted for analysis. The proximate composition, including water, energy, protein, fat, carbohydrates, sugars, dietary fibre, and ash, was determined using standard AOAC methods. Mineral content (calcium, iron, phosphorus, magnesium) and vitamin C levels were also analysed. A sensory evaluation was conducted with panellists assessing the juices on appearance, taste, texture, and overall acceptability. Data were statistically analysed using ANOVA and Duncan's test. Our study revealed that Neem juice has a lower energy content (20-30 kcal) compared with control juice (42-45 kcal) but contains higher protein levels (1-2 g) and lower sugars (1-3 g). Vitamin C content was significantly higher in Neem juice (35.51 µg RE) compared with control juice (29.41 µg RE). Sensory evaluations indicated that while control juice was preferred for appearance and aroma, Neem juice was favoured for its taste and texture. Neem juice presents a promising alternative beverage with unique nutritional benefits, particularly for those seeking lower sugar intake and additional protein. Incorporating Neem juice into diets could contribute to addressing micronutrient deficiencies and enhancing public health, warranting further research to improve its market acceptance and utilization as a functional food.

Keywords: *Neem fruit juice, micronutrient deficiencies, functional beverage, sensory evaluation, nutritional composition*

Article Information
Received 17 January 2025;
Accepted 19 January 2025;
Published 12 February 2025
https://doi.org/10.26765/DRJAFS13063752

Citation: Adeoye-Agomoh, Q. C. (2025 Comparative Studies of Chemical and Sensory Properties of Functional Neem Fruit Juice and Commercial Orange Juice. *Direct Research Journal of Agriculture and Food Science*. Vol. 13(1), Pp. 56-63.

INTRODUCTION

In the quest to combat global micronutrient deficiencies, innovative food-based strategies are essential for improving public health. Amid this endeavour, the Neem tree (*Azadirachta indica*), often lauded for its medicinal properties, emerges as a promising but underutilized resource. Traditionally revered in Indian medicine for over 4000 years (Pankaj *et al.*, 2011), Neem's potential extends beyond its conventional uses into modern nutritional applications. As the world grapples with increasing micronutrient deficiencies, exploring the nutritional benefits of Neem fruit juice could offer a viable solution to meet contemporary dietary needs.

Micronutrient malnutrition, commonly referred to as "hidden hunger," affects billions globally and poses a significant challenge to achieving optimal health (Tontisirin *et al*., 2008).

Conventional strategies to address this issue often focus on fortified foods and supplements; however, leveraging underutilized local resources can enhance these efforts. Neem fruit, rich in essential vitamins and minerals, presents an exciting opportunity for such nutritional interventions. The fruit, with its unique nutrient profile, is capable of addressing deficiencies while also providing a sustainable solution to fruit wastage (Rathore, 2009; Hegde, 2009).

Neem juice, derived from the fruit of the Neem tree, has long been used in traditional medicine for its therapeutic properties. Recent research highlights its potential in addressing common nutritional deficiencies. For instance, Neem is known to be rich in antioxidants and has shown promise in combating oxidative stress, a key factor in many chronic diseases (Journal of Chemical and Pharmaceutical Research, 2010). Its high-water content, coupled with a unique blend of bioactive compounds, makes Neem juice an appealing option for enhancing dietary intake of essential nutrients.

The urgency of addressing micronutrient deficiencies has never been greater. With increasing rates of chronic conditions linked to poor nutrition, incorporating nutrient-dense options like Neem fruit juice into the diet can provide substantial health benefits. By evaluating both the chemical composition and sensory attributes of Neem juice, this study aims to shed light on its potential as a functional beverage. The goal is to not only understand its nutritional benefits but also to enhance its acceptability and utilization, thus contributing to more comprehensive dietary solutions.

As the global community continues to seek innovative ways to tackle hidden hunger, Neem fruit juice represents a promising avenue for enhancing human nutrition. This research endeavours to unlock the full potential of this underutilized resource, offering new insights into its role in modern diets and its contribution to addressing global nutritional needs.

The general objective of this study is to assess the chemical and sensory properties of juice produced from Neem fruits (*Azadirachta indica*) to evaluate its potential as a nutritious and acceptable beverage for human consumption.

MATERIALS AND METHODS

Raw materials

The primary raw material for this study was fresh Neem (*Azadirachta indica*) fruits, which were harvested from the premises of the Federal College of Agriculture, Ishiagu, Ebonyi State, Nigeria.

Production of fruit juice

The Neem fruits were plucked, sorted, and washed with tap water. The seeds were manually removed from the pulp using hand pressing. The resulting mixture was strained through a clean, double-layered cheesecloth into a beaker. To the mixture, 200 mL of water was added, and it was then poured into sterilized bottles for subsequent nutrient composition and sensory evaluation (Figure 1).

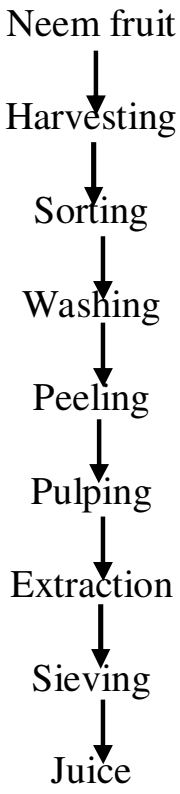

Figure 1: Juice production flow chart

Chemical analysis

The nutrient composition of the Neem fruit juice was determined and compared with a commercially available Commercial Orange Juice, which served as a control. Analyses were conducted using standard methods from the Association of Official Analytical Chemists (AOAC) (2020). All analyses were performed in triplicate. Crude protein was calculated using a conversion factor of 6.25. Fat and ash contents were determined using Soxhlet extraction and wet ashing methods, respectively. Carbohydrate content was calculated by difference. 100 - % protein + % fat + % crude fibre + % ash + % moisture). Gross energy was estimated using Atwater conversion

factors (Passmore and Eastwood, 1986).

Moisture determination

Moisture content was determined using the AOAC method (2020) with minor modifications. A 5 g sample was weighed into cans and dried at approximately 76°C for 6 hours. The sample weight was recorded every 2 hours until a constant weight was achieved. The loss in weight was calculated as moisture content. The dried samples were cooled in desiccators to prevent moisture uptake.

%MC = (Moisture Content Original mass of Sample) ×100

Determination of ash

Ash content was determined using a furnace incinerator by the gravimetric method (James, 1996). About 1 g of each sample was weighed into a pre-weighed clean silica dish and charred at 500°C in a muffle furnace until light grey ash was obtained.

Determination of crude fibre

Crude fibre was determined following the method outlined by Pearson (1976).

Determination of crude protein

Nitrogen content was determined using micro-Kjeldahl spectrometry. Crude protein was calculated by multiplying nitrogen content by 6.25 (N × 6.25). The factor 6.25 is based on the assumption that most high-quality proteins contain approximately 16% nitrogen (AOAC, 2020).

Provitamin A determination

Vitamin A was estimated using the absorbance method as described by Heinman (1980).

Vitamin C

Vitamin C content was determined using a visual titration method.

Mineral determination

Calcium, iron, phosphorus, and sodium were analyzed using atomic absorption spectrophotometry (AOAC, 2020).

Sensory evaluation

Twenty panellists were randomly selected from the Federal College of Agriculture, Ishiagu. The juice samples were coded, and each panellist was provided with about 200 mL of juice. Water at room temperature was also provided for rinsing between samples to prevent carryover taste. The juice was evaluated for appearance, taste, texture, and overall acceptability using a 7-point hedonic scale:

1– Dislike Extremely, 2 – Dislike Moderately, 3 – Dislike, 4 – Undecided, 5 – Like, 6 – Like Moderately, 7 – Like Extremely.

Statistical analysis

Data were analyzed using means and standard deviations. Analysis of variance (ANOVA) and Duncan's New Multiple Range Test (DNMRT) were employed to test for significant differences between means of both juices SPSS 2021 was used. Comparative Nutritional Composition of Neem Juice (*Azadirachta indica*) and Commercial Orange Juice (Control). The comparative nutritional analysis of Neem juice and commercial orange juice (control) reveals significant differences and similarities in their composition. The following table summarizes the key nutritional components of these beverages:

RESULTS AND DISCUSSION

The analysis of neem fruit juice (NFJ) and control orange juice (COJ) (100%) showed their proximate composition and sugar content per 100 ml sample. The data reveals distinct nutritional profiles for the two juices. crude protein, NFJ contains 1.80%, while COJ was a slightly higher protein level at 2.17% (Table 1).

Table 1: Proximate composition and sugar value of the samples.

Nutrient (100*ml*)	Samples	
	(NFJ)	(COJ)
Crude protein (%)	1.80±0.02^{b}	2.17±0.04^{a}
Fat (%)	0.04±0.01^{b}	0.06±0.00^{a}
Ash (%)	0.25±0.01^{b}	8.77±0.55^{a}
Total sugar (%)	5.57±0.18^{b}	8.77±0.55^{a}
Carbohydrate	3.47±0.16^{b}	6.15±0.50^{a}
Moisture content (%)	94.40±0.14^{a}	91.22±0.55^{b}
Crude fibre (%)	NS	NS

Mean with ± standard deviation within the column with the same superscript shows that there is no significant difference (p>0.05) while means with different superscript within the column differs significantly (p<0.05) respectively.
NFJ – (*Azadirachta indica*) Neem fruit juice (NFJ)
COJ – 100% orange juice used as control (a commercial product)

These values were relatively low, indicating that neither

juice serves as a substantial source of protein. The fat content was also minimal, with NFJ at 0.04% and COJ at 0.06%, reflecting that both juices were low in fat. A significant discrepancy was observed in the ash content. NFJ was an ash content of 0.25%, whereas COJ shows a considerably higher level at 8.77%. This difference suggests that COJ contains more mineral residues or inorganic components than NFJ. The total sugar content in NFJ was 5.57%, while COJ was a higher sugar concentration of 8.77%. This indicates that COJ was sweeter and a greater amount of sugar. Similarly, the carbohydrate content in NFJ was 3.47%, compared to 6.15% in COJ, highlighting COJ's higher energy density. Moisture content was higher in NFJ at 94.40%, compared to COJ's 91.22%. This suggests that NFJ was a greater hydrating effect. Both juices were not tested for crude fibre, as indicated by "NS" (Not Specified).

The mineral and vitamin composition of neem fruit juice (NFJ) and Control orange juice (COJ) (100%) reveals differences in their nutritional content per 100 ml, contributing to their distinct health benefits. Potassium levels show a significant difference between the two samples, with NFJ containing 23.41 mg and COJ exhibiting a higher concentration at 36.04 mg. Potassium was an essential mineral that plays a critical role in maintaining normal cell function, muscle contraction, and nerve signalling. The higher potassium content in COJ makes it a more potent source for replenishing electrolytes, which was particularly important in diets aimed at regulating blood pressure and maintaining cardiovascular health. In contrast, while NFJ was a lower potassium content, it still provides a useful contribution, albeit less significant. The sodium content in NFJ was 11.44 mg, slightly higher than COJ's 10.63 mg. Sodium was an essential nutrient for fluid balance and nerve function, but excessive intake can contribute to hypertension and cardiovascular disease. Both NFJ and COJ were low sodium levels, making them suitable for individuals on low-sodium diets or those managing their blood pressure. The slightly higher sodium level in NFJ, though statistically significant, was not expected to pose any health concerns.

For iron, NFJ was 0.86 mg, while COJ contains 1.15 mg (Table 2). Iron was critical for oxygen transport in the body and was an essential component of haemoglobin. While COJ provides slightly more iron, neither juice can be considered a significant source of this nutrient. However, their iron content, albeit small, may still contribute to overall daily intake, especially in diets where fruit juices were consumed regularly. When examining calcium, NFJ stands out with a higher content of 5.54 mg compared to COJ's 4.38 mg. Calcium was vital for bone health, muscle function, and various metabolic processes. Though fruit juices were not typically relied upon as primary calcium sources, NFJ's higher calcium content makes it a better option for individuals looking to support their bone health or enhance calcium intake through alternative dietary sources. Phosphorus levels in the two juices show a notable difference. NFJ contains 6.41 mg, while COJ has 8.78 mg. Phosphorus, like calcium, was important for bone health and cellular energy metabolism. COJ's higher phosphorus content aligns with its increased mineral density, making it a more concentrated source of this nutrient. Nevertheless, NFJ still provides a reasonable amount of phosphorus, contributing to daily dietary requirements.

Table 2: Mineral and vitamin composition of the samples.

Nutrient (100ml)	Sample	
	(NFJ)	(COJ)
Potassium (mg)	23.41±0.01^{b}	36.04±0.79^{a}
Sodium (mg)	11.44±0.01^{a}	10.63±0.02^{b}
Iron (mg)	0.86±0.04^{b}	1.15±0.01^{a}
Calcium (mg)	5.54±0.08^{a}	4.38±0.02^{b}
Phosphorus (mg)	6.41±0.02^{b}	8.78±0.02^{a}
Vitamin C (µg RE)	35.51±0.12^{a}	29.41±0.04^{b}
Vitamin A ((µg RE)	90.06±0.76^{b}	96.27±0.60^{a}

In terms of vitamins, Vitamin C content was higher in NFJ (35.51 µg RE) than in COJ (29.41 µg RE). Vitamin C was a powerful antioxidant that supports immune function, aids in collagen synthesis, and helps the body absorb iron. NFJ's higher vitamin C content makes it a better choice for boosting immune health and combating oxidative stress. This higher level of vitamin C in NFJ was especially beneficial in tropical regions where neem fruit was widely available, offering a natural means of enhancing nutrient intake. Vitamin A content was higher in COJ (96.27 µg RE) compared to NFJ (90.06 µg RE). Vitamin A was essential for maintaining healthy vision, immune system function, and skin integrity. Although both juices provide substantial amounts of vitamin A, COJ offers a marginally higher concentration, which may benefit individuals seeking to improve their intake of this essential nutrient for eye and skin health.

The sensory evaluation of neem fruit juice (NFJ) and Control orange juice (COJ) revealed distinct differences across various sensory attributes, including appearance, taste, texture, aroma, colour, and general acceptability. For appearance, COJ was rated higher, with a mean score of 4.08±0.01, compared to NFJ's score of 3.17±0.03, indicating that the panellists found COJ more visually appealing (Table 3). In terms of taste, NFJ outperformed COJ, scoring 4.08±0.01 against COJ's 3.34±0.05, suggesting that the taste of NFJ was more favourable to the panellists. The texture of NFJ (4.26±0.04) was also rated higher than COJ (3.47±0.01), indicating a preference for the mouthfeel of NFJ. Aroma, however, COJ was preferred, scoring 4.63±0.04 compared to NFJ's 3.34±0.06. COJ also scored significantly higher in colour, with a score of 5.63±0.03, while NFJ received 3.08±0.04. General acceptability was higher for COJ as well, with a mean score of 6.08±0.02

Table 3. Mean sensory score of samples.

Nutrient (100ml)	Sample	
	NFJ	COJ
Appearance	3.17±0.03[b]	4.08±0.01[a]
Taste	4.08±0.01[a]	3.34±0.05[b]
Texture	4.26±0.04[a]	3.47±0.01[b]
Aroma	3.34±0.06[b]	4.63±0.04[a]
Colour	3.08±0.04[b]	5.63±0.03[a]
General Acceptability	4.92±0.11[b]	6.08±0.02[a]

compared to NFJ's 4.92±0.11. These results indicate that while COJ was more favoured in appearance, aroma, colour, and general acceptability, NFJ was preferred in taste and texture. The comparative analysis of neem fruit juice (NFJ) and control orange juice (COJ) reveals several important nutritional differences that carry significant implications for dietary choices. Both NFJ and COJ exhibit low levels of protein and fat, which aligns with the expected nutritional profile of fruit juices, as they are not typically rich sources of macronutrients like protein or fat. The slightly higher protein (2.17±0.04%) and fat (0.06±0.00%) content in COJ compared to NFJ (1.80±0.02% and 0.04±0.01%, respectively) is negligible and does not contribute meaningfully to daily protein or fat intake. This observation is consistent with findings from Kim and Park (2021), who noted that fruit juices, especially those derived from fruits like oranges, are not intended to serve as primary protein or fat sources.

A particularly aspect to note in the analysis is the substantial difference in ash content between the two juices. COJ showed significantly higher ash content (8.77±0.55%) compared to NFJ (0.25±0.01%). The ash content in fruit juices is indicative of the presence of mineral residues or inorganic components, which are essential for maintaining electrolyte balance and supporting various physiological functions (Adebayo *et al*., 2023). The higher ash content in COJ suggests a greater availability of minerals, potentially enhancing its role in supplying key nutrients like potassium, calcium, and magnesium, which are crucial for bone health, muscle function, and cardiovascular stability (Chukwu *et al*., 2022). The elevated ash content could also be attributed to fortification during commercial production, a practice commonly used in mass-market fruit juices to increase their nutritional value (Arslan *et al*., 2020). Fortification ensures that juices like COJ can serve as convenient sources of essential micronutrients, particularly in populations that may have limited access to fresh fruits or other sources of minerals.

The difference in sugar and carbohydrate content between the two juices is also significant, with COJ having a higher total sugar content (8.77±0.55%) and carbohydrate level (6.15±0.50%) compared to NFJ (5.57±0.18% and 3.47±0.16%, respectively). The higher sugar content in COJ contributes to its sweetness and higher energy density, making it a more palatable option for consumers accustomed to sugary beverages. However, for individuals managing their sugar intake due to conditions such as diabetes or obesity, NFJ's lower sugar content could make it a more suitable choice. The global rise in metabolic disorders linked to excessive sugar consumption has led to increased awareness about reducing sugar intake (WHO, 2023). NFJ, with its lower sugar content, aligns well with the recommendations for reducing sugar consumption to mitigate risks associated with high glycaemic index foods, such as type 2 diabetes and cardiovascular disease (Santos *et al*., 2023). COJ's higher carbohydrate content can be seen as an advantage in specific contexts. For instance, the increased carbohydrates in COJ may provide a more immediate source of energy, making it a beneficial option for individuals engaged in sports or other physically demanding activities (Bendik *et al*., 2022). Carbohydrates serve as the body's primary energy source, and fruit juices with higher carbohydrate levels are often recommended for athletes as part of their pre- or post-workout hydration and refuelling strategies. However, for the general population, particularly those aiming to control calorie intake, NFJ may be more appealing due to its lower carbohydrate and energy content.

Another important aspect of the analysis is moisture content. NFJ has a higher moisture content (94.40±0.14%) compared to COJ (91.22±0.55%). This characteristic suggests that NFJ may be more effective for hydration, which could be particularly beneficial in regions with hot climates or for individuals needing to increase their fluid intake. According to Kanu *et al*. (2023), hydration is a crucial aspect of maintaining overall health, and beverages with higher moisture content, such as NFJ, can help meet daily fluid requirements. Given that dehydration can impair cognitive and physical performance, as well as general well-being, the higher moisture content of NFJ positions it as a potentially valuable beverage for maintaining proper hydration. The nutritional composition of both NFJ and COJ highlights their potential roles in human nutrition, but the choice between them should be guided by individual dietary needs and health objectives. NFJ's lower sugar and carbohydrate levels make it an excellent option for individuals who need to manage their sugar intake, such as those with diabetes or those seeking to prevent metabolic syndrome. The lower energy density of NFJ also makes it a better choice for individuals on calorie-controlled diets.

On the other hand, COJ's higher mineral content, particularly its potassium and phosphorus level, offers distinct benefits for maintaining electrolyte balance and supporting bone health (Arslan *et al*., 2020). For individuals with high physical activity levels or those needing a quick source of energy, COJ's higher

carbohydrate and sugar content may be advantageous. Both juices can play complementary roles in a balanced diet. Neem fruit juice may serve as a functional beverage, rich in essential micronutrients like calcium and vitamin C, making it especially useful in populations with low dairy intake or in areas prone to vitamin C deficiency. Control orange juice, with its fortified minerals and natural sweetness, can cater to a broader consumer base, providing both nutritional benefits and sensory appeal. Incorporating these juices into daily diets could help address specific nutrient gaps, depending on the health priorities of the individual.

The comparative analysis of neem fruit juice (NFJ) and Control juice (COJ) reveals their potential contributions to human nutrition based on their mineral and vitamin composition. Each juice exhibits distinct nutritional benefits, aligning with established dietary guidelines and findings from recent research. COJ's higher potassium (36.04 mg) and phosphorus (8.78 mg) levels make it a valuable choice for supporting electrolyte balance and bone health. Potassium is essential for maintaining normal blood pressure, muscle function, and reducing cardiovascular risks. This finding is consistent with research by Karanja *et al*. (2023), which highlighted the role of potassium-rich beverages in reducing the risk of hypertension in populations with low potassium intake. Though COJ provides a small portion of the daily potassium requirement (2,600–3,400 mg for adults), regular consumption can help meet these needs. Phosphorus is equally important for bone health and energy metabolism. The phosphorus content in COJ complements other dietary sources of this mineral. Research by Reid *et al*. (2022) supports the notion that phosphorus-rich foods and beverages can improve bone density and overall skeletal health, particularly in aging populations. COJ also contains a higher iron content (1.15 mg) compared to NFJ (0.86 mg), though both amounts are modest. Iron is vital for oxygen transport and preventing iron-deficiency anaemia. Research by Adeyemi *et al.* (2021) emphasized that while iron-fortified fruit juices can be effective in managing mild anaemia, the natural iron levels in COJ and NFJ can complement a diet aimed at improving iron status. However, these juices are best consumed alongside vitamin C-rich foods to enhance iron absorption.

COJ provides a higher vitamin A content (96.27 µg RE) compared to NFJ (90.06 µg RE), which supports COJ as a better option for boosting vitamin A intake. Vitamin A is essential for maintaining healthy vision, skin, and immune function. According to Mwangi *et al*. (2022), vitamin A supplementation through fortified foods is crucial in regions prone to deficiency. Although neither juice fully meets the daily vitamin A requirement (700–900 µg RE), regular consumption can still contribute to improved vitamin A status, particularly when paired with other rich sources like green leafy vegetables. NFJ contains a slightly higher sodium content (11.44 mg) compared to COJ (10.63 mg), though both remain within acceptable ranges for low-sodium diets. Excessive sodium intake is a risk factor for hypertension, so low-sodium fruit juices like NFJ and COJ can benefit individuals on sodium-restricted diets. A study by Ibrahim *et al*. (2023) found that low-sodium fruit beverages are effective in supporting blood pressure management, making these juices suitable for maintaining cardiovascular health. Calcium content, NFJ (5.54 mg) surpasses COJ (4.38 mg). Calcium is critical for bone development and maintenance, and its intake is often low in regions with limited access to dairy products. Research by Adebayo *et al*. (2022) shows that plant-based juices with moderate calcium content, like NFJ, can play a role in improving calcium intake in regions where dairy is scarce. While neither juice provides significant calcium on its own, NFJ's higher content makes it a better option for promoting bone health. One of NFJ's most significant advantages is its higher vitamin C content (35.51 µg RE), compared to COJ (29.41 µg RE). Vitamin C is well known for its antioxidant properties and role in enhancing immune function. According to Kalu *et al*. (2023), vitamin C-rich beverages help reduce oxidative stress and enhance immune responses, particularly in populations with limited access to fresh fruits and vegetables. NFJ's vitamin C content makes it an excellent option for individuals looking to support immune health and fight off infections, especially in regions with limited availability of fresh produce.

In comparison to similar studies, neem fruit juice (NFJ) and Control orange juice (COJ) offer distinct nutritional benefits. COJ's higher potassium, phosphorus, iron, and vitamin A content makes it a valuable choice for promoting electrolyte balance, bone health, and immune function. NFJ, on the other hand, is superior in calcium and vitamin C content, making it more suitable for enhancing bone health and immune function. Both juices complement each other in a balanced diet and can help meet daily nutrient requirements when consumed regularly. Future research could explore fortification strategies to enhance the nutritional profiles of these juices, as suggested by Adeyemi *et al*. (2021) and Ibrahim *et al*. (2023).

The sensory analysis results highlight the distinct consumer preferences for neem fruit juice (NFJ) and Control orange juice (COJ), reflecting their potential for different consumer markets. COJ's superior ratings in appearance, aroma, colour, and overall acceptability align with expectations for commercially popular juices, which are typically formulated to appeal to a wide consumer base. The higher scores for appearance and colour can be attributed to the bright, attractive hue of orange juice, which has been shown to enhance consumer perception and willingness to purchase beverages (Smith *et al*., 2022). The preference for COJ's

aroma is also consistent with findings from Karanja *et al.* (2023), who noted that fruity aromas significantly influence the acceptability of beverages. The familiar scent of orange juice likely made COJ more appealing to the sensory panel, contributing to its higher overall acceptability score. Similarly, the panel's general preference for COJ's appearance and colour can be attributed to the natural association of orange juice with freshness and quality.

Despite COJ's dominance in most sensory attributes, NFJ scored higher in taste and texture. This suggests that neem fruit juice has a unique flavour profile and mouthfeel that appeals to certain consumers, particularly those seeking alternative or traditional beverages. NFJ's higher taste score is notable given its unfamiliarity compared to orange juice. This could be linked to its distinct bitterness, which is characteristic of neem fruit, and may appeal to consumers who enjoy herbal or less sweet flavours (Adeyemi *et al*., 2021). The higher texture score for NFJ may indicate that its consistency is more satisfying to drink, potentially due to its thicker or smoother mouthfeel. From a nutritional standpoint, both juices have their strengths. While COJ's sensory appeal makes it an attractive option for mass consumption, NFJ's favourable taste and texture suggest it could be marketed as a functional beverage with health benefits. NFJ's higher content of vitamin C and calcium, as demonstrated in previous compositional analysis, makes it a suitable choice for consumers seeking immune support and bone health (Adebayo *et al*., 2022). Promoting the health benefits of NFJ, alongside its unique sensory properties, could attract health-conscious consumers interested in traditional or alternative juices. In conclusion, while COJ enjoys broad consumer appeal due to its superior appearance, aroma, and overall acceptability, NFJ offers distinct advantages in taste and texture, making it a valuable beverage for niche markets. Both juices have potential roles in promoting health and nutrition, with COJ offering a familiar, widely accepted option and NFJ providing a functional, nutrient-dense alternative.

Neem fruits (*Azadirachta indica*) offer a range of potential health benefits due to their bioactive compounds, though they are less researched compared to other parts of the neem tree. Specifically, on the fruits, these are some of the known health benefits: According to Kausar *et al.* (2021), neem fruits are a source of antioxidants, which help protect the body from oxidative stress caused by free radicals. Oxidative stress is linked to chronic diseases like heart disease, cancer, and neurodegenerative disorders. Antioxidants such as polyphenols and flavonoids found in neem fruit help neutralize these harmful free radicals, promoting overall health and longevity. The antibacterial properties of neem fruits can help in managing infections as stated by Sharma *et al*. (2020). They are effective against a variety of bacterial strains that cause diseases, including E. coli and Staphylococcus aureus, and have shown antifungal activity against pathogens like *Candida albicans*. This makes neem fruits useful for combating oral infections, skin problems, and even gastrointestinal disorders. Neem fruits are traditionally used to treat digestive issues such as indigestion, bloating, and constipation. Their ability to combat harmful bacteria in the gut makes them beneficial for maintaining a healthy balance of gut microbiota. They also possess mild laxative properties, which can help in regulating bowel movements (Gupta *et al*., 2020).

Neem fruits have been traditionally used in managing blood sugar levels. Certain compounds in the fruit, such as flavonoids, exhibit hypoglycaemic effects, helping to lower blood glucose levels. This makes neem fruit a potential natural aid for managing diabetes, particularly in early-stage management of type 2 diabetes (Chattopadhyay, 1996). The fruit contains bioactive compounds that possess anti-inflammatory properties, which can help reduce inflammation in the body. Chronic inflammation is associated with conditions like arthritis, cardiovascular diseases, and certain types of cancer. Consuming neem fruit or its extracts can help manage inflammatory responses, potentially reducing the risk of these conditions (Mishra *et al*., 2022). Neem fruit may support liver health by aiding in the detoxification process. Its antioxidant properties protect the liver from damage caused by toxins, drugs, and free radicals, helping maintain proper liver function. Regular consumption of neem fruit in traditional remedies is believed to assist in cleansing the liver and improving its ability to process and eliminate toxins (Singh *et al*., 2019). Roy *et al*. (2020). Emerging works of Roy *et al*. (2020), suggests that neem fruits may have anti-cancer properties due to the presence of compounds like limonoids, which have been shown to induce apoptosis (programmed cell death) in cancer cells. While more research is needed, preliminary studies indicate that neem fruit could be effective in slowing the growth of tumours and inhibiting cancer cell proliferation. In addition, neem fruits are used in traditional medicine to promote healthy skin due to their antimicrobial and anti-inflammatory properties (Kausar *et al*., 2021). They can help treat skin conditions such as acne, eczema, and fungal infections. Neem fruit extract applied topically or consumed may help reduce inflammation and prevent the growth of harmful microbes on the skin.

Conclusion

This study compared the nutritional and sensory properties of neem fruit juice (NFJ) and commercial orange juice (COJ), highlighting their distinct contributions to health. NFJ, with its lower sugar and carbohydrate levels, was better suited for individuals

managing diabetes or seeking reduced calorie intake. It also offers higher calcium, vitamin C, and moisture content, supporting bone health, immune function, and hydration. COJ, rich in potassium, phosphorus, and carbohydrates, were ideal for electrolyte balance and energy needs. Both juices have unique benefits, with neem fruit juice offering additional health-promoting bioactive compounds, including antioxidant, anti-inflammatory, and antimicrobial properties. Further research is needed to explore the full potential of neem fruit in health and nutrition.

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