International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 10s, 2025
https://theaspd.com/index.php

Physicochemical Characterization Of A Lemon-Based RTD Functional Beverage Fortified With Caralluma Fimbriata

Karthika Periyasami[1*],Sobhana Ganapathy[2],Harini Nallasivam[3],Poongodi Vijayakumar[4]
[1]*Assistant Professor, Department of Food Science and Nutrition, Periyar University, Salem, Tamil Nadu*
[2,3]*M.Sc., Department of Food Science and Nutrition, Periyar University, Salem, Tamil Nadu*
[4]*Professor, Department of Food Science and Nutrition, Periyar University, Salem, Tamil Nadu*
**Assistant Professor, Department of Food Science and Nutrition, Periyar University, Salem, Tamil Nadu*
karthikafsn@gmail.com

Abstract: *The study aims to create a functional beverage made from Caralluma Fimbriata, an underutilized medicinal plant with health-promoting benefits. The beverage contains 0.5% and 1% Caralluma Fimbriata powder in a lemon juice base with natural sweeteners, to address obesity control. The formulations were tested for physicochemical parameters such as moisture content, pH, total soluble solids (TSS), ash, titrable acidity, ascorbic acid concentration, browning index, color features, and turbidity over 0, 3, and 7 days of refrigeration. Results indicated that all samples retained acceptable stability and quality attributes throughout the storage period. The study highlights the feasibility of utilizing* Caralluma Fimbriata *in functional beverage development, offering a natural, health-focused alternative to conventional drinks. This research also contributes to the value addition of underutilized medicinal plants and supports innovation in functional food product development.*
Keywords: *Underutilized plant, Caralluma Fimbriata, RTD beverage, physicochemical analysis.*

INTRODUCTION

Since ancient times, medicinal plants have been vital to human nutrition and health as sources of food, bioactive substances, and therapeutic agents. For different conditions (Anwar *et al.*, 2022). Only 10% of the roughly 250,000 species that make up the plant world have had their therapeutic potential studied scientifically. Researchers are always looking for novel species with functional and therapeutic potential in response to the increased demand for natural and plant-based therapies. These plants are particularly vital in primary healthcare, especially in rural areas where access to modern medicine is limited (Kumar & Jnanesha, 2016). Their growth and medicinal value are significantly influenced by ecological factors such as soil composition, temperature, water availability, and genetic variation. Additionally, aromatic medicinal plants play a crucial role in traditional practices like aromatherapy, which has been in use for centuries.India recognized as one of the world's richest regions for medicinal plants, is home to approximately 8,000 species. Traditional medicine remains the primary healthcare source for around 65% of the Indian population (Shi *et al.*, 2021). Ayurvedic and Unani medicinal systems heavily rely on forest-derived plant resources, with nearly 80% of medicinal plant demands being met through wild harvesting. However, rapid deforestation, population expansion, overexploitation, and the introduction of invasive species have led to the depletion of several medicinally important plants, pushing many toward endangerment. In recent years, medicinal plants have gained widespread global recognition due to concerns over the adverse effects of synthetic drugs (Kumar & Jnanesha, 2016). The increasing reliance on plant-based medicine has placed immense pressure on natural ecosystems, making it imperative to develop conservation strategies to protect endangered medicinal species.Medicinal plants contain several bioactive components like polyphenols, flavonoids, isoflavonoids, terpenoids, carotenoids, phytosterols, and glucosinolates. These chemicals have several therapeutic applications, including anti-cancer, anti-aging, anti-diabetic, analgesic, anti-allergic, anti-inflammatory, and hepatoprotective. Medicinal plants play an important role in medication research by providing essential medicinal components, both directly and indirectly.Among these medicinal plants, *Caralluma Fimbriata* has garnered significant attention for its nutritional and therapeutic potential (Anwar *et al.,* 2022). *Caralluma* R. Br. (Sensu lato) belongs to the Apocynaceae family and has 13 species and five variants in India, including many native to South India. These plants are well adapted to arid conditions, thriving in rocky crevices and thorny shrubs.

Traditionally, *Caralluma* species have been consumed as famine food, known for their appetite-suppressing properties, and recognized for their medicinal benefits (Griggs, 2016). Historically, hunting tribes consumed *Caralluma* cactus to relieve hunger and thirst on long trips. Despite its extensive use across centuries in the Indian subcontinent, no adverse effects have been reported. The plant is classed as a vegetable in The Wealth of India and recognized by the Indian Health Ministry's extensive database of therapeutic plants. It is used as an ethno-medicinal and nutritional plant for different ailments in the tribal region of Sangamner tehsil of Ahmednagar district India (Shekhar, 2024).The Ready-to-Drink (RTD) beverage industry has significant potential for growth, with various categories such as RTD Water, RTD Tea, RTD Carbonates, and others. RTD Water leads the market with 85.1%, followed by RTD Tea at 8.7%, and RTD Carbonates at 3.0%. Other RTD beverages like coffee, juice, energy drinks, and fitness drinks also contribute to the sector's diversity. (Junaedi, 2020). Ready-to-drink beverages provide convenient and portable options for busy consumers. They also allow for creative packaging and new ingredients, including carbonation. This category covers both refrigerated and shelf-stable beverages. Shelf-stable items are in higher demand due to their ease of distribution and storage (Greenland *et al.,* 2023).Lemon juice plays a significant role in the formulation of Ready-to-Drink (RTD) beverages derived from herbal plants, particularly due to its multifaceted advantages (Thakur *et al.,* 2024). First and foremost, it enhances the flavor profile, providing a refreshing and tangy taste that balances the earthy and sometimes bitter notes of herbal extracts. This flavor enhancement increases the overall sensory appeal, making the beverage more enjoyable for consumers (Wang *et al*., 2019). In addition to flavor, lemon juice adds nutritional benefits, being rich in vitamin C, which can enhance the absorption of phytochemicals present in herbs, thus promoting their health effects. Moreover, the natural antimicrobial properties of lemon juice contribute to preservation, inhibiting the growth of spoilage microorganisms and extending the shelf life of RTD beverages (Shuaib *et al.,* 2021). Its acidic nature also helps maintain the stability of various herbal components, protecting their antioxidant properties throughout storage.
The synergistic effects of combining lemon juice with herbal extracts can yield beverages that support immune function and overall health, making them appealing to health-conscious consumers (Gupta *et al.,* 2023). Additionally, lemon juice aids in hydration, making it an ideal ingredient for beverages designed to replenish electrolytes and provide a refreshing drink. As consumer trends increasingly favor natural and functional ingredients, the inclusion of lemon juice in herbal RTD beverages serves as an attractive selling point, highlighting both health benefits and the natural origins of the product (Kumar & Jnanesha 2016). Overall, lemon juice not only enhances the flavor and nutritional profile of herbal-based RTD beverages but also contributes to their safety and market appeal (Gajanan, 2020).
Caralluma Fimbriata is a medicinal plant recognized for its appetite-suppressing, anti-diabetic, and antioxidant properties (Astell, 2016). Despite these benefits, its large-scale cultivation and commercial use remain limited due to a lack of standardized techniques and value-added products. This study aims to enhance the utility of *Caralluma Fimbriata* by developing a Ready-to-Drink (RTD) beverage designed to improve its stability, bioavailability, and therapeutic potential. The findings will support innovative product development in the herbal and functional food industries. This study intended to evaluate the physicochemical features of a ready-to-drink beverage derived from *Caralluma Fimbriata*.

MATERIALS & METHODS

Selection of samples

Mature *Caralluma Fimbriata* samples were sourced from a faraway region in Coimbatore, Tamil Nadu, where local farmers grew them. Plant resources were obtained from persons utilizing traditional gardening methods. The selection was based on the maturity of the plant, ensuring that the succulent stems were fully developed and healthy, which is ideal for both phytochemical analysis and product development. The samples were checked to ensure they were clean and free from any visible pest damage, diseases, or physical harm.

Product development

The ready-to-drink (RTD) beverages were prepared from *Caralluma Fimbriata* as follows.

Caralluma Fimbriata powder preparation

Fresh and healthy *Caralluma Fimbriata* plant was selected washed twice with fresh water and finely chopped as it was kept oven dry at 70 °C until its surface was turned crisper. It is then ground finely into powdered form (Razzak *et al.*, 2023).

Preparation of *Caralluma* drink

The powder was used for the RTD formulations. The other raw materials such as lemon juice, preservatives, and glass bottles were also purchased from the local market. The powder of the *Caralluma* extract was bitter and to compensate for the bitter taste, sugar was added to the formulations of RTD.

Composition of the beverage

Table 1: Development plan for *Caralluma* functional beverage

Treatments	Formulation of *Caralluma* beverage	Sample in powder quantity
T0	Lemon juice (10%), Water (90ml), Sugar (20g), KMS (0.1g)	0 g (Control)
T1	Lemon juice (10%), Water (90ml), Sugar (20g), KMS (0.1g)	0.5g
T2	Lemon juice (10%), Water (90ml), Sugar (20g), KMS (0.1g)	1 g

The drink was prepared in different quantities of the sample and analyzed at different storage periods of the 0^{th}, 3^{rd} and 7^{th} day.

Physicochemical characterization of developed RTD beverage

Physicochemical analysis is essential to evaluate the quality, stability, and shelf-life of the developed RTD beverage. Parameters such as pH, total soluble solids (TSS), titratable acidity, viscosity, and color were measured to assess the beverage's composition and consistency.

Moisture Content

Approximately 2.0 grams of the samples were put into pre-weighted dried crucibles, which were then moved into another weighed crucible. The crucible was then dried in a 105°C oven for 3 hours. After that, it was removed and placed in desiccators for cooling. After cooling, the crucible was reweighed (Shehu *et al.*, 2022).

$$Moisture\ content\ (\%) = Loss\ in\ weight\ (g)\ /Weight\ of\ the\ sample\ (g) \times 100$$

Ash Content

Weigh 3 grams of dried samples in an air oven and place them on a plate. To make gray ash, gently heat the dish over a flame and then strongly heat it in a muffle furnace at 550±10°C. Let the dish cool in desiccators before weighing it. Heat the dish at 550±10°C for 30 minutes, then chill it in desiccators and weigh it. Repeat heating for 30 minutes, chilling, and weighing until the difference between two weighing is less than 1 mg. Keep track of the lowest weight you obtained.

$$Ash\ (\%) = Weightoftheresidue\ (g)/Weightofthesample\ (g) \times 100$$

TSS (Total Soluble Solids),The total soluble solids content (expressed in °Brix) was measured using a refractometer at 20°C. Although measurements were recorded as °Brix, they were conducted at room temperature, Ph,The pH of the samples was measured using a pH meter calibrated with standard buffer solutions of pH 7.00 and pH 4.00.2.3.5. Titrable acidity,A 10 mL aliquot of thoroughly mixed juice was diluted to 250 mL with distilled water. Titration was performed using 0.1 N NaOH, with 0.3 mL of phenolphthalein added per 100 mL of the solution as an indicator. The endpoint, indicated by a stable pink color lasting for 30 seconds (Hirdyani, 2015),*TA= volume of NaOH × Normality of NaOH) × 0.064) × 1000/ Sample volume (ml),*

Ascorbic acid

A juice sample (10–20 mL) was diluted to 100 mL using either 2% metaphosphoric acid (HPO_3) or 4% oxalic acid, then filtered. A 2–3 mL aliquot of the filtrate was transferred to a test tube, and the volume was adjusted to 5 mL using the same acid. A blank was prepared using 5 mL of acid solution and 10 mL of water. Each sample and blank was treated with 10 mL of dye solution and shaken immediately. The absorbance of the resulting pink solution was measured at 518 nm within 15–20 seconds. (Tong et al., 1995).

$AsorbicAcid\ (mg\ 100\ ml) = 0.5\ mg/V1 \times V2ml/5\ ml \times 100\ ml/weightofthesample \times 100$

2.3.7. Browning Index

The browning index (A_{420}/g sample) was determined following the method established by Demircan and Velioglu (2024). The browning index of the *Caralluma Fimbriata* juice was recorded using a spectrophotometer (U-2900/2910, Hitachi, Tokyo, Japan) at 420 nm. Higher values of absorbance at 420 nm correspond to higher browning of juices.

2.3.8. Colour analysis

Color parameters (L*, a*, b*) of both optimized and control samples were measured using a HunterLab colorimeter (CR-400, Konica Minolta Sensing Inc., Osaka, Japan). Before sample measurement, the instrument was calibrated with a white ceramic standard plate. The total color difference (ΔE) was calculated using the following equation:

$$\Delta E = \sqrt{(L_0 - L)^2 + (a_0 - a)^2 + (b_0 - b)^2}$$

where L*0, a*0, and b*0 are color parameters for the control and L* a*, and b* are color parameters for each sample.

2.3.9. Clarity

Juice clarity was assessed following the method described by Bhat and Goh (2017), with minor modifications. A 10 mL portion of the juice was centrifuged at 4200×g for 10 minutes at 25°C. The supernatant was then collected, and its absorbance was measured at 660 nm using a spectrophotometer (Spectra MAX 190, Biotek, Winooski, VT, USA). Distilled water was used as a blank reference (Wang *et al.,* 2022).

Statistical analysis

The data collected from the analysis of the *Caralluma Fimbriata* ready-to-drink beverage were statistically evaluated using SPSS (Analytical Software, Tallahassee, FL, USA). A paired t-test was applied to assess the significance of variations among treatments. The objective was to establish the statistical significance ($p < 0.05$) test of the difference between the average values.

RESULT AND DISCUSSION

Lime-based RTD beverage was prepared by blending the lime juice with the *Caralluma Fimbriata* sample. The physicochemical constituents of the fresh lime juice and the lime RTD beverage are given below,

Morphometric Measurement

Using a Vernier caliper, the morphometric parameters of *Caralluma Fimbriata* were recorded. The **breadth** was found to be **0.50 cm**, and the **length** of lobes (possibly arms of the succulent stem) measured **861 mm**, totaling **86.1cm**. These dimensional measurements are important in identifying plant maturity, growth pattern, and harvesting time. Larger and well-developed stems often indicate higher phytochemical yield, which is beneficial for nutritional and therapeutic applications.

Moisture analysis

The moisture content of the raw *Caralluma Fimbriata* sample was found to be approximately 97.10% indicating very high water content. This high moisture level is typical of succulent plants like *Caralluma* adapted to arid and semi-arid regions. These findings are supported by prior studies that have reported moisture content in *Caralluma* ranging from 58% to 90% depending on the plant maturity environmental condition and drying method. Vyshali et al. (2022) reported a moisture content range of approximately 50–70% in fresh *Caralluma fimbriata*, which is comparatively lower than the values observed in the present study. This variation could be attributed to differences in soil characteristics, climatic conditions, and the environmental factors prevailing in the respective cultivation regions.

Ash content

The ash content of *Caralluma Fimbriata* was found to be **20%**, calculated by taking **2g of the raw sample** and obtaining a final ash weight of **0.4g** after incineration. The result indicates a significant mineral presence in the sample. According to Maheshu et al. (2014), the ash content of C. *adscendens var. fimbriata* was reported as 15.3 % **by taking 10g of sample**, which is slightly lower than the present study. The difference may be due to geographical variation, soil type, and processing methods. 20% ash content reflects a good concentration of mineral elements, which supports the traditional medicinal usage of *Caralluma Fimbriata* and highlights its potential nutritional value.

3.4. pH, The pH value of raw *Caralluma Fimbriata* is found to be 9 which is alkaline in nature. The pH of the RTD beverage showed an increasing trend during storage. A pH of T0 (3.0) on the 0^{th} day at the beginning indicates the beverage was highly acidic, which is normal for lemon juice because it has a lot of citric acid. This initial acidity plays a crucial role in inhibiting microbial growth. However, over the storage period, the pH increased to 5 indicating a decrease in acidity. This shift may be due to a reduction in organic acid concentration, acid degradation, chemical interaction, or influence of compounds present in *Caralluma Fimbriata* (Ali *et al.*, 2024). Microbial enzymatic activity during storage may have contributed to this change by consuming acids producing basic by-products leading to less acidic beverages over time (Chandrasekaran *et al.*, 2015).

Table 2: pH value of RTD beverage

Sample/ Variations/ Days	0^{th} day	3^{rd} day	7^{th} day
Control	3±0.00	2.9±0.05*	5±0.00*
0.5%	3.5±0.05	3.3±0.05	4±0.00*
1%	3.5±0.00	3.5±0.00	3.9±0.05*

Values are expressed as mean ± standard deviation (n = 3). An asterisk (*) indicates a statistically significant difference ($p \leq 0.05$) compared to the 0th day within the same sample group

3.5. TSS

Table 3: TSS value of RTD beverage

Sample/ Variations/ Days	0^{th} day	3^{rd} day	7^{th} day
Control	16±0.00	16±0.00	10.6±0.5*
0.5%	14.13±0.1	18±0.00 *	12.63±0.05*
1%	16.2±0.00	17±0.00	13±0.00*

Values are expressed as mean ± standard deviation (n = 3). An asterisk (*) indicates a statistically significant difference ($p \leq 0.05$) compared to the 0th day within the same sample group

A decrease in TSS was observed during the storage of RTD beverages. The highest TSS was recorded in T2 (18) on day 3 and the least TSS was observed in T3 (10.6) of day 7. This reduction in TSS might be attributed to the breakdown of natural sugars in lemon juice and vitamin C (Water soluble vitamin) which is a part of TSS that gets easily lost during storage (Thamilselvi *et al.*, 2015).

3.6. Browning index (BI)

Table 4: Browning index value of RTD beverage

Sample/ Variations/ Days	0^{th} day	3^{rd} day	7^{th} day
Control	0±0.00	0.28±0.01*	0.43±0.003*
0.5%	0±0.00	0.98±0.007*	0.712±0.001*
1%	0±0.00	1.11±0.01*	1.26±0.05*

Values are expressed as mean ± standard deviation (n = 3). An asterisk (*) indicates a statistically significant difference ($p \leq 0.05$) compared to the 0th day within the same sample group

The BI indicates non–enzymatic reactions such as Millard reaction/ascorbic degradation. Browning slightly increased from 0.00 to 0.43 from day 0 to day 7 showing minimal non-enzymatic browning over time. A rapid increase was observed in the T2 sample from 0 to 0.712 (day 7) suggesting that the *Caralluma Fimbriata* addition accelerates browning during interaction between bioactive compounds like polyphenols and lemon acids. The browning index rises sharply from 0.00 to 1.26 (day 7) highest among all samples indicating a higher concentration of *Caralluma* increases susceptibility to browning because of the higher presence of reducing sugar and phenolics that favor Millard reaction (Babu *et al.*,2017).

Clarity

Clarity reflects the turbidity of the beverage. The T0 sample started with moderate clarity (0.56) and remained stable (0.09) indicating minimal sedimentation/pigment interaction. The clarity value of the T1 sample lowered throughout storage to 0.16 (day 7) shows that the beverage was less transparent due to sedimentation/particle dispersion caused by *Caralluma Fimbriata* components. The T2 sample showed high clarity reading on day 3 (1.53) but dropped on day 7 (0.28) which might be due to the initial dispersion and stabilization of particles followed by sedimentation over time (Buttice, 2012).

Table 5: Clarity difference of RTD beverage

Sample/ Variations/ Days	0^{th} day	3^{rd} day	7^{th} day
Control	0.56±0.1	0.09±0.01*	0.090 ±0.03
0.5%	0.22±0.05	0.18±0.05	0.16±0.2*
1%	0.27±0.005	1.53±0.00*	0.28±0.1*

Values are expressed as mean ± standard deviation (n = 3). An asterisk (*) indicates a statistically significant difference ($p \leq 0.05$) compared to the 0th day within the same sample group

3.8. Titrable acidity

Table 6: Titrable acidity value of RTD beverage

Sample/ Variations/ Days	0^{th} day	3^{rd} day	7^{th} day
Control	0.6±0	0.42±0.01	0.40±0.01
0.5%	1.5±0	0.5±0.00	0.38±0.02*
1%	2.53±0.05	0.6±0.01*	0.3±0.00*

Values are expressed as mean ± standard deviation (n = 3). An asterisk (*) indicates a statistically significant difference ($p \leq 0.05$) compared to the 0th day within the same sample group

During the storage period, titrable acidity exhibited a decreasing trend in the RTD beverage. The highest acidity was recorded in T2 (2.53) on the 0^{th} day while the lowest acidity was recorded in T2 (0.3) on the 7^{th} day. This decrease in titrable acidity could be due to the hydrolysis of polysaccharides into simple monosaccharides and disaccharides, which might contribute to a reduction in acidity over time (Kou *et al.,* 2024).

3.9. Coloring index

Table 7: Coloring index values of RTD beverage

Sample/ Variations/ Days	0^{th} day	3^{rd} day	7^{th} day
Control	5.59±0.17	6.17±0.04*	20.13±0.11*
0.5%	22.3±0.1	17.87±0.5*	12.85±0.03*
1%	19.3±0.1	20.13±0.11	13.53±0.25 *

Values are expressed as mean ± standard deviation (n = 3). An asterisk (*) indicates a statistically significant difference ($p \leq 0.05$) compared to the 0th day within the same sample group

The color index of the beverage exhibited notable change over storage where T0 showed a steady increase in the color index from 5.59 (Day 0) to 20.13 (day 7) indicating darkening over time due to oxidation/pigment degradation in the absence of the sample. In contrast,the T1 sample started with a high color index (22.3) but decreased to 12.85 by day 7 which might be due to settling of pigments or interaction between lemon juice and *Caralluma* bioactive components. Whereas the T2 sample remained stable but decreased to 13.53 on day 7 shows that the higher concentration of *Caralluma* may initially stabilize color but undergo degradation (Noor *et al.*, 2024).

3.10. Ascorbic Acid

Table 8: Ascorbic acid value of RTD beverage

Sample/ Variations/ Days	0^{th} day	3^{rd} day	7^{th} day
Control	72±0.00	162.6±0.01*	62.6±0.01*

0.5%	40±0.00	184±0.007*	101±0.02*
1%	48±0.05	200±0.00*	114.6±0.00*

Values are expressed as mean ± standard deviation (n = 3). An asterisk (*) indicates a statistically significant difference ($p \leq 0.05$) compared to the 0th day within the same sample group

The vitamin C content varied among the samples where the highest initial concentration was noted in T2 on the 3rd day (200mg/ml) while the lowest was in T0 on the 7th day (62.6mg/ml). This decline may be due to the natural breakdown of ascorbic acid during storage as vitamin C gets easily destroyed in acidic liquids, especially when exposed to heat, light, and oxygen. Similar results were reported by Burdulu *et al.,* (2006) who found that lemon and orange juice showed a decrease in vitamin during storage.

CONCLUSION

This study successfully demonstrated the potential of *Caralluma Fimbriata* as a functional ingredient in the development of RTD beverages. The incorporation of this plant not only contributed to the nutritional profile of the product but also added value in terms of health benefits, particularly in terms of appetite suppression and weight management. The addition of lemon juice complemented these effects by enhancing hydration and providing a refreshing taste. The findings provide a pathway for further research on sensory evaluation, consumer acceptance, shelf-life assessment, and clinical studies to substantiate the functional claims.

Therefore, this study contributes to the growing interest in plant-based, health-promoting beverages and encourages the commercial utilization of *Caralluma Fimbriata* in functional food product development. This research demonstrates the feasibility of creating a health-oriented beverage that can manage weight and metabolic health, while addressing the modern-day challenges of obesity and unhealthy appetite patterns.

CONFLICT

NIL

REFERENCE

1. Ali, A., Mashwani, Z. U. R., Raja, N. I., Mohammad, S., Ahmad, M. S., & Luna-Arias, J. P. (2024). Antioxidant and Hypoglycemic Potential of Phytogenic Selenium Nanoparticle-and Light Regime-Mediated In Vitro Caralluma tuberculata Callus Culture Extract. *ACS omega*, 9(18), 20101-20118.
2. Anwar, R., Rabail, R., Rakha, A., Bryla, M., Roszko, M., Aadil, R. M., & Kieliszek, M. (2022). Delving the role of Caralluma Fimbriata: An edible wild plant to mitigate the biomarkers of metabolic syndrome. Oxidative Medicine and Cellular Longevity, 2022(1), 5720372.
3. Astell, K. J. (2016). *Effects of Caralluma fimbriata extract on cardiovascular and metabolic disorders* (Doctoral dissertation, Victoria University).
4. Babu, P. A. S., Aafrin, B. V., Archana, G., Sabina, K., Sudharsan, K., Sivarajan, M., & Sukumar, M. (2017). Effects of polyphenols from Caralluma Fimbriata on acrylamide formation and lipid oxidation—An integrated approach of nutritional quality and degradation of fried food. International Journal of Food Properties, 20(6), 1378-1390.
5. Burdurlu, H. S., Koca, N., & Karadeniz, F. (2006). Degradation of vitamin C in citrus juice concentrates during storage. *Journal of food engineering*, *74*(2), 211-216.
6. Buttice, A. L. (2012). *Aggregation of Sediment and Bacteria with Mucilage from the Opuntia ficus-indica Cactus*. University of South Florida.
7. Chandrasekaran, M., Basheer, S. M., Chellappan, S., Krishna, J. G., & Beena, P. S. (2015). Enzymes in food and beverage production: an overview. *Enzym Food Beverage Process CRC Press*, *25*, 133-154.
8. Demircan, B., & Velioglu, Y. S. (2024). Control of browning, enzyme activity, and quality in stored fresh-cut fruit salads through chitosan coating enriched with bergamot juice powder. *Foods*, *13*(1), 147.
9. Gajanan, H. P. (2020). *Preparation of Herbal Flavoured Milk Blended with Aloe Vera (Aloe Barbadensis Miller) and Tulsi* (Doctoral Dissertation, Dr. Panjabrao Deshmukh Krishi Vidyapeeth).
10. Greenland, S., Nguyen, N., Hunt, W., Rogers, S., Stanley, R., & Juliano, P. (2023). NT Shelf-stable Food Products: Market Opportunity Analysis.
11. Griggs, J. L. (2016). *The effects of Caralluma Fimbriata on appetite behaviour and associated neural pathways in Prader-Willi syndrome* (Doctoral dissertation, Victoria University).

12. Gupta, A., Sanwal, N., Bareen, M. A., Barua, S., Sharma, N., Olatunji, O. J., ... & Sahu, J. K. (2023). Trends in functional beverages: Functional ingredients, processing technologies, stability, health benefits, and consumer perspective. *Food Research International*, *170*, 113046.
13. Hirdyani, H. (2015). Development and quality evaluation of RTS (ready to serve) beverages made from traditional Indian medicinal plants. Journal of Nutrition & Food Sciences, (S13), 1.
14. Junaedi, D. (2020). Penerapan model pembelajaran discovery untuk meningkatkan hasil belajar siswa pada pembelajaran pendidikan kewarganegaraan. *Jurnal Educatio Fkip Unma*, *6*(1), 55-60.
15. Kou, T., Faisal, M., Song, J., & Blennow, A. (2024). Polysaccharide-based nanosystems: a review. *Critical Reviews in Food Science and Nutrition*, *64*(1), 1-15.
16. Kumar, A., & Jnanesha, A. C. (2016). Conservation of rare and endangered plant species for medicinal use. *Int. J. Sci. Res*, *5*, 1370-1372.
17. Maheshu, V., Priyadarsini, D. T., & Sasikumar, J. M. (2014). Antioxidant capacity and amino acid analysis of Caralluma adscendens (Roxb.) Haw var. fimbriata (wall.) Grav. & Mayur. aerial parts. *Journal of food science and technology*, *51*, 2415-2424.
18. Noor, N., Din, G. M. U., Nadeem, M., Qureshi, T. M., Khalid, W., Nadeem, M. A., ... & Aqlan, F. (2024). Development and Nutritional Evaluation of Ready-to-Drink Beverage Using the Choongan (Caralluma tuberculata L.) Extract. *Journal of Food Biochemistry*, *2024*(1), 8831525.
19. Razzak, A., Mahjabin, T., Khan, M. R. M., Hossain, M., Sadia, U., & Zzaman, W. (2023). Effect of cooking methods on the nutritional quality of selected vegetables at Sylhet City. *Heliyon*, *9*(11).
20. Shehu, M. A., & Garba, U. M. (2025). Development of Nano Emulsion as an Edible Coating on Fresh Fruit and Vegetable for Postharvest Quality Evaluation. *Journal of Health, Wellness and Safety Research*.
21. Shehu, U. S. (2022). *Estimation of Reference Evapotranspiration in Selected Areas in Niger State, Nigeria* (Doctoral Dissertation).
22. Shekhar, S. (2024). Traditional Phytotherapy Practices Among Diverse Tribal Communities in India. In *Ethnomedicinal Plants for Drug Discovery: Current Developments* (pp. 97-124). Singapore: Springer Nature Singapore.
23. Shi, Y., Zhang, C., & Li, X. (2021). Traditional medicine in India. *Journal of Traditional Chinese Medical Sciences*, *8*, S51-S55.
24. Shuaib, M. J., Shailabi, T. I., Borwis, E. O., & Muhammed, A. S. (2021). Antimicrobial activity evaluation of citrus lemon against Streptococcus pyogenes and Escherichia coli. *IOSR J Pharm*, *11*(12), 11-6.
25. Thakur, C., Kaushal, M., Vaidya, D., Verma, A. K., Gupta, A., & Sharma, R. (2024). Optimization of the static brewing technique for ready-to-drink Kangra orthodox green tea, sweetened with selected sweeteners. *Journal of Food Measurement and Characterization*, *18*(5), 3681-3707.
26. Thamilselvi, C., Krishnakumar, T., &Amutha, S. (2015). Preparation and quality evaluation of lime based herbal blended RTS beverage. Asian journal of Dairy and Food research, 34(1), 54-58.
27. Tong, C. B. S., Hicks, K. B., Osman, S. F., Hotchkiss Jr, A. T., & Haines, R. M. (1995). Oxalic acid in commercial pectins inhibits browning of raw apple juice. *Journal of agricultural and food chemistry*, *43*(3), 592-597.
28. Vyshali, V. M., HS, R. P., Basavanna, M., Shivakumara, P., Sumalatha, K. R., Sushmitha, S., & Maruthi, K. R. (2023). A Comparative Study on Wet and Dry extracts of Caralluma fimbriata for Phytochemicals and Evaluation of Therapeutic activity. Biological Forum – An International Journal 15(8a): 1-14
29. Wang, H., Yuan, J., Chen, L., Ban, Z., Zheng, Y., Jiang, Y., ... & Li, X. (2022). Effects of fruit storage temperature and time on cloud stability of not from concentrated apple juice. *Foods*, *11*(17), 2568.
30. 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.