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Amritha SS
 PG Scholar, Department of
 Community Science, College of
 Agriculture, Vellayani, Kerala,
 India

Suma Divakar
 Professor, Department of
 Community Science, College of
 Agriculture, Vellayani, Kerala,
 India

Corresponding Author:
Amritha SS
 PG Scholar, Department of
 Community Science, College of
 Agriculture, Vellayani, Kerala,
 India

Development of food products made from chayamansa leaves (*Cnidoscolus aconitifolius*)

Amritha SS and Suma Divakar

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Abstract

Chayamansa (*Cnidoscolus aconitifolius*) is a plant that is vastly underutilized. It can tolerate a variety of weather conditions. If Chaya leaf is appropriately promoted, it will undoubtedly become a popular leafy vegetable for treating a variety of health conditions such as anemia, diabetes, kidney stones, and many more.

Consumer acceptable traditional and convenience food products were standardized and subjected to shelf life studies. The processed leaf powder and RTC products were discreetly packed in laminated zip lock pouches, ensuring optimal preservation under ambient conditions. The microbial profiles of the stored leaf powder samples were carefully monitored at three-month intervals. A diverse range of traditional foods and RTE products, including 'Idli', 'steamed kozhukatta', 'garlic chutney', 'Soup mix', 'ragi weaning mix', and 'dry coconut chutney', were standardized by varying the amounts and proportion of ingredients across four distinct treatments. A panel of 30 sensory evaluators assessed the various formulations, focusing on five key parameters: appearance, colour, flavour, taste, and overall acceptability. The evaluation was conducted using a nine-point hedonic scale, thus ensuring a thorough and nuanced appraisal of each sample's sensory appeal. From the sensory evaluation the outstanding treatments were selected. In traditional foods, Idli CI₁ with the least quantity of leaves was the best treatment and for Steamed kozhukatta SK₂ with 10 gm of chaya leaves outperformed other formulations, in garlic chutney GC₁ and GC₃ were on par with 5gm and 15 gm of chaya leaves respectively. The ready to cook products namely weaning mix, soup mix and chutney mix revealed better acceptance with 10 gm of chayamansa leaves. In the RTC products remarkably, no pathogens were detected throughout the entire three-month observation period, of the soup mix and chutney mix, highlighting the exceptional quality and safety of the products.

Keywords: Ready to cook food, *Cnidoscolus aconitifolius*, traditional food, anemia, Chaya leaf

1. Introduction

Leafy green veggies includes nutrients, phytochemicals, and other health-promoting components. *Cnidoscolus aconitifolius*, often known as Chaya plant is a green leafy vegetable with great health benefits. This leafy vegetable native to Mexico's Yucatán Peninsula is widely grown in tropical Central and South America, as well as areas of Africa and Asia. This plant is in the euphorbiaceae family and is commonly referred to as "tree spinach" because of its spinach-like leaves, but its nutritional profile and growth patterns are distinct. This genus includes 50 species, 20 of which are native to Mexico. They are found in tropical and subtropical climates, primarily in low deciduous forests and xerophilous scrubs in Mexico. *Cnidoscolus* are of interest for their nutritional potential, particularly the most often utilized for in traditional applications such as medicinal and ornamental plants, (Kuri and Guzman, 2017) [8]. Chaya leaves are valued for their nutritional characteristics, particularly their protein content and bioactive substances, primarily polyphenols. Chaya polyphenols are gaining popularity due to their antioxidant capacity and ability to prevent diseases through bioactivities such as hepatoprotective, anti-inflammatory, and biological activity against cancer and liver disorders (Ramírez, *et al.*, 2021) [11]. The vernacular names of *Cnidoscolus aconitifolius* are cabbage star, chaya, spinach tree, mayan chaya, chaya col, kikilchay, and chaykeken and awshadha cheera (Jose and Prasad, 2023) [5].

The Mayan civilization and other mesoamerican societies primarily cultivated this crop for food and medicinal purposes. Its use throughout southeastern México and Central America for food preparation has been documented, particularly in Yucatán, Chiapas, Belize, and

Guatemala, where chaya is considered a staple food. The chaya plant is a domesticated shrub that is widely appreciated in rural communities throughout central and southern Mexico as a food, medicinal plant, and ornamental. Chaya has been used as a food source since pre-Columbian times and is still consumed on a daily basis in some communities (Kuri and Guzman, 2017) [8].

Cnidoscolus aconitifolius is easy to grow and is rarely damaged by insects. It can tolerate both severe rain and mild droughts. Due to the scarcity of seed production, woody stem cuttings measuring 6 to 12 inches in length are commonly employed for propagation. Cuttings take time to establish, resulting in slow early development and delayed leaf collection until the second year. To guarantee healthy new plant growth, *Cnidoscolus aconitifolius* leaves can be harvested continuously as long as no more than 50% of the leaves are removed from the plant (Jose and Prasad, 2023) [5]. Ramirez *et al.*, (2021), proved that chaya leaves can be valorized for a sequential production of ingredients for developing high nutritional quality food products for human consumption. The protein concentrates could be used for partial replacement of animal-protein due to its amino acid composition (no limiting amino acids) and digestibility being a more affordable source of protein for low incomes population regions. The shoots and leaves have traditionally been used as laxatives, diuretics, circulation stimulants, digestion improver, lactation stimulators, and fingernail hardeners. Diabetes, obesity, kidney stones, hemorrhoids, acne, and eye issues have all been treated using an aqueous extract (in folkloric medicine) of the stem, leaves, and roots (Jimoh *et al.*, 2009) [4].

The *C. aconitifolius* leaves contain macronutrients such as carbohydrates, proteins, fats, vitamins and minerals, so they have the potential to be developed into cheap and easily available foods. On the other hand, *C. aconitifolius* also contains anti-nutrients such as phytates and oxalates which can be degraded through processing methods (Silalahi, 2021) [12].

In addition to being a wholesome food, chaya has been utilized for its therapeutic qualities for a long time. Though chaya has many health benefits, it is reported that the poor preparation without enough heating might cause the release of anti nutrients. Chaya is a useful plant whose nutritional advantages are on par with or even greater than those of spinach. In the areas where it is grown, its high protein content, combined with vitamins and minerals, makes it a vital part of the diet (Temesgan *et al.*, 2022) [13].

This plant is a popular medicinal plant in Southeast Mexico, and it is highly prized for its multiple medical and nutritional benefits. However, there has been a shortage of pharmacological research that can provide light on the therapeutic processes and safety of medicinal plant ingestion. *Cnidoscolus chayamansa* clearly has strong anti-inflammatory and cardioprotective properties, which might be attributable to the presence of sterols, flavonoids (Garcia *et al.*, 2017) [6].

The rising use of tree spinach, especially in processed form, emphasized the health advantages of this vegetable. Tree spinach has a low moisture content that keeps it from spoiling, and it has crude fiber, and carbohydrate content in its nutritional profile. Chaya leaves have been selected, in the light of its nutritional value. According to the amount of intake, eating enough chaya leaves can help meet different

group's recommended daily allowances (RDAs) for carbs, such as adults, children, pregnant women, and nursing mothers. The presence of saponins and glycosides in these leaves protect against hypertension and have antibiotic and anti-inflammatory properties, cholesterol-lowering sterols, diuretics and moderately toxic coumarins have also been identified in chayamansa leaves (Ebel *et al.*, 2019) [1].

Furthermore, it has been observed that the high fiber and low-fat content of tree spinach, particularly chaya leaves, have therapeutic value in the treatment of digestive issues. It has been reported that the fiber content may help lower blood cholesterol, cause peristaltic movements, and inhibit hunger (Jimoh *et al.*, 2009) [4].

Despite its advantages, *Cnidoscolus aconitifolius* is underused, particularly in home cooking and large-scale foodservice enterprises. The primary reason for this is a lack of understanding about its culinary potential and health advantages. Many individuals are unfamiliar with the plant and seem to be ignorant of its use in a variety of meals. The availability and nutritional benefits of chayamansa and its widespread adoption in popular cookery has been hampered by a lack of awareness and expertise about its preparation and culinary applications.

Changes in lifestyle and eating habits have resulted in a significant demand for RTC meals. The popularity of handy meals, such as dried soups and dry salads, has increased significantly. Thus, there is a need to raise public awareness about the importance of developing appropriate technology for producing chayamansa based traditional and ready to cook Products that are convenient with longer shelf life.

To fully utilize the potential of *Cnidoscolus aconitifolius*, efforts should be made to increase knowledge of its advantages and to teach suitable preparation procedures. With its rapid growth potential, nutritional value, and low cost, it has the potential to become a household staple in both home kitchens and large-scale food service enterprises, particularly in areas where food security and nutrition are key problems. Chaya's popularisation might also assist small-scale farmers to improve their livelihoods, as the plant has minimum cost of production and has a ready market if its applications are promoted.

2. Materials and Methods

The Standardisation of food products was implemented in six phases namely:

- 2.1 Collection of leaves and raw materials.
- 2.2 Processing of leaf powder.
- 2.3 Packaging and storage of leaf powder.
- 2.4 Assessment of shelf life of leaf powder.
- 2.5 Standardization of traditional and ready-to-cook products.
- 2.6 Statistical analysis of data
- 2.7 Sensory analysis of standardized products
- 2.8 Assessment of shelf life of RTC products

2.1 Collection of leaves and raw materials

Chayamansa plants were planted in the premises of Department of Community science, in College of agriculture Vellayani. Fresh mature leaves of chayamansa were plucked and the other ingredients like dry chilli, roasted chana dal, salt, ragi, urad dal, rice, ginger, green gram, onion, coconut oil, curry leaves, garlic, cumin seed, tamarind were purchased from the local market.

2.2 Processing of leaf powder

The harvested Chayamansa leaves were properly cleaned in flowing tap water, to remove dust and other foreign contaminants. The leaves were drained using a drainer. Afterwards, the leaves were blanched. The leaves were blanched by immersing them in boiling water for 5 minutes before being immersed in cold water. The blanched leaves were dried in a cabinet dryer at 40-60 °C for 4-8 hours. It was powdered using an electric mixer in the laboratory followed by sieving in a 0.05 mm sieve. The powder was packed in laminated ziplock covers

2.3 Packaging and Storage of Chayamansa leaf powder

Proper packing and storage are essential for maintaining the quality, potency, and nutritional content of Chayamansa leaf powder throughout time. Laminated pouches are a highly effective means to keep foods fresh by shielding them from moisture, air, light, and pathogens. Chayamansa leaf powder were stored in laminated pouches to preserve its medicinal benefits, taste, and freshness for a longer time.

2.4 Assessment of shelf life of leaf powder

The powder was packed in laminated zip lock covers and were stored under ambient conditions.

To assess the shelf life of the chayamansa leaf powder for a period of three months, quality of the leaf powder was noted initially and at the end of the month, the moisture and microbial contamination of samples were assessed. This procedure required repeated dilution and pour plating at

regular intervals to count and identify the microorganisms in the leaf powder. This approach revealed important cues about the product's stability and microbial load, which could impact its safety, nutritional value, and overall quality.

2.5 Standardization of Traditional and RTC products

Despite its excellent nutritional content, chayamansa is an underappreciated green vegetable. To popularize chayamansa among the general public, six food products were standardized using chayamansa leaves which included three traditional foods and three processed foods. Different traditional foods namely Idli, steamed kozhukatta and garlic chutney were standardized with fresh leaves. Processed foods namely Soup mix, ragi weaning mix and dry coconut chutney were standardized using dry powder of the leaves, by varying amounts and proportions of ingredients used. For the Ready-to-cook products all of other ingredients were roasted over medium heat and blended in a mixer. The produced mixture was then transferred to a polypropylene storage bag and stored at room temperature.

2.5.1 Standardisation of Traditional food products

2.5.1.1 Formulations of chayamansa based idli (CI)

The ingredients namely chayamansa leaves, rice and black gram were used in different proportions as four treatments and their proportion are presented in Table 1. The cooked idli was evaluated by the sensory panel members. The products were made using standard protocols and subjected to sensory evaluation

Table 1: Formulations of chayamansa based Idli

Sl. No	Treatments	Ingredients	Proportions (In 100 gm)
1	CI ₁	Chayamansa leaves + rice + black gram	5:65:35
2	CI ₂	Chayamansa leaves + rice + black gram	10:25:65
3	CI ₃	Chayamansa leaves + rice + black gram	15:35:50
4	CI ₄	Chayamansa leaves + rice + black gram	20:35:45

2.5.1.2 Formulations of chayamansa based steamed Kozhukatta (SK)

The ingredients namely chayamansa leaves, rice and grated

coconut were used in different proportions as four treatments and their proportion are presented in Table 2. These treatments were then subjected to sensory evaluation.

Table 2: Formulations of chayamansa based steamed kozhukatta

Sl. No	Treatments	Ingredients	Proportions (In 100 gm)
1	SCK ₁	Chayamansa leaves + rice + grated coconut	5:35:60
2	SCK ₂	Chayamansa leaves + rice + grated coconut	10:25:65
3	SCK ₃	Chayamansa leaves + rice + grated coconut	15:35:50
4	SCK ₄	Chayamansa leaves + rice + grated coconut	20:35:45

2.5.1.3 Formulations of chayamansa based garlic chutney (GC)

The ingredients namely chayamansa leaves, grated coconut, urad dal, garlic, dried chilli, cumin seed and tamarind were

used in different proportions as four treatments and their proportion are presented in Table 3. The prepared chutney was then evaluated for the sensory parameters.

Table 3: Formulations of chayamansa based garlic chutney

Sl. No	Treatments	Ingredients	Proportions (In 100 gm)
1	GC ₁	Chayamansa leaves + grated coconut + urad dal + garlic + dried chilli + cumin seed + tamarind	5:60:15:10:2:3:5
2	GC ₂	Chayamansa leaves + grated coconut + urad dal + garlic + dried chilli + cumin seed + tamarind	10:60:10:10:2:3:5
3	GC ₃	Chayamansa leaves + grated coconut + urad dal + garlic + dried chilli + cumin seed + tamarind	15:60:15:10:2:3:5
4	GC ₄	Chayamansa leaves + grated coconut + urad dal + garlic + dried chilli + cumin seed + tamarind	20:55:5:10:2:3:5

2.5.2 Standardisation of Convenience foods

2.5.2.1 Formulations of chayamansa based Soup mix(SM)

The ingredients namely chayamansa leaf powder, corn starch, onion powder, pepper, ginger powder, garlic powder were used in different proportions as four treatments and

their proportions are presented in Table 4. All the adjuncts were dehydrated and powdered and blended thoroughly to form instant soup mix. Later the prepared mixture were transferred into a Polypropylene storage pouch at ambient temperature. Soup was cooked using 50 ml of water and was subjected to sensory evaluation.

Table 4: Formulations of chayamansa based soup mix

Sl. No	Treatments	Ingredients	Proportions (In 100 gm)
1	SM ₁	Chayamansa leaf powder + corn starch + onion powder + pepper + ginger powder + garlic powder	5:40:45:3:2:5
2	SM ₂	Chayamansa leaf powder + corn starch + onion powder + pepper + ginger powder + garlic powder	10:40:40:3:2:5
3	SM ₃	Chayamansa leaf powder + corn starch + onion powder + pepper + ginger powder + garlic powder	15:35:45:3:2:5
4	SM ₄	Chayamansa leaf powder + corn starch + onion powder + pepper + ginger powder + garlic powder	20:50:20:3:2:5

2.5.2.2 Formulations of chayamansa based ragi weaning mix (RWM)

The ingredients namely chayamansa leaf powder, ragi, green gram powder and ground nuts were used in different proportions as four treatments and their proportions are presented in Table 5. All the adjuncts were dehydrated and

powdered and blended thoroughly to form instant weaning mix. Later the prepared mixture were transferred into a Polypropylene storage pouches at ambient temperature. Weaning mix was be prepared using 50 ml of water followed by serving for sensory evaluation.

Table 5: Formulations of chayamansa based ragi weaning mix

Sl. No	Treatments	Ingredients	Proportions (In 100 gm)
1	RWM ₁	Chayamansa leaf powder + ragi + green gram powder + roasted ground nuts	5:55:25:20
2	RWM ₂	Chayamansa leaf powder + ragi + green gram powder + roasted ground nuts	10:50:20:20
3	RWM ₃	Chayamansa leaf powder + ragi + green gram powder + roasted ground nuts	15:45:25:15
4	RWM ₄	Chayamansa leaf powder + ragi + green gram powder + roasted ground nuts	20:15:20:10

2.5.2.3 Formulations of chayamansa based dry coconut chutney (DCC)

The ingredients namely chayamansa leaf powder, coconut powder, chana dal, tamarind, dried chilli, cumin seed, garlic, curry leaves were used in different proportions as four treatments and their proportions are presented in Table 6. All the adjuncts were dehydrated and powdered and mixed

thoroughly to form instant chutney powder. Later the prepared mixture were transferred into polypropylene storage pouches at ambient temperature. Dry chutney powder were cooked using 50 ml of water as observed after trial and error mixing. The treatments were evaluated by the sensory panel members

Table 6: Formulations of chayamansa based dry coconut chutney

Sl. No	Treatments	Ingredients	Proportions (In 100 gm)
1	DCC ₁	Chayamansa leaf powder + coconut powder + roasted chana dal dried red chilli + cumin seed + garlic + curry leaves + tamarind	5:10:60:5:5:2:5:2:3:3
2	DCC ₂	Chayamansa leaf powder + coconut powder + roasted chana dal dried red chilli + cumin seed + garlic + curry leaves + tamarind	10:20:55:3:3:5:2:2
3	DCC ₃	Chayamansa leaf powder + coconut powder + roasted chana dal dried red chilli + cumin seed + garlic + curry leaves + tamarind	15:25:45:4:2:4:2:3
4	DCC ₄	Chayamansa leaf powder + coconut powder + roasted chana dal dried red chilli + cumin seed + garlic + curry leaves + tamarind	20:15:50:2:2:3:4:2:2

2.6 Statistical analysis of Data

The developed products were evaluated organoleptically by a sensory panel of 30 members. These panelists were chosen based on their abilities to evaluate the items' sensory characteristics, such as taste, texture, flavor, appearance, and overall acceptability. The evaluation sought subjective feedback on the quality of standardized items. The Kruskal-wallis test was used to analyze the mean ratings collected from the sensory panelists for statistical purposes. The Kruskal-wallis test ranks all of the goods based on the sensory ratings of all panelists and then compares the rankings between product groups. The null hypothesis in this case is that there is no significant difference in sensory ratings between the items, but the alternative hypothesis is that at least one product varies significantly from the others.

A p-value less than 0.05 normally indicates a statistically significant difference in sensory ratings, implying that the sensory panel experienced one or more goods differently. The Kruskal-wallis test establishes a clear statistical framework for analyzing subjective sensory data and making evidence-based choices on product quality and consumer approval.

2.7 Particulars of sensory analysis of standardized products

A nine point hedonic scale was used to evaluate particular samples. This sensory evaluation technique employs a 9-point scale ranging from 1 to 9. In the scale system, each point is assigned a descriptive name, such as a score 1

relates to 'dislike extremely' and a score of 9 refers to 'like extremely'.

2.8 Assessment of shelf life of RTC products

The shelf life of food products can be thoroughly evaluated using a wide range of scientific testing methodologies, including microbiological investigation, sensory evaluation, package integrity, and storage condition evaluations. A precise balance of parameters such as component composition, proper storage conditions, and modern packaging technologies all play an important part in determining the durability and quality of these items. Furthermore, ensuring microbiological stability is critical to maintaining both safety and freshness throughout the product's life cycle.

By adhering to various parameters, chayamansa can fully ensure that its RTC products not only meets the greatest standards of flavour, texture, and appearance, but also stay safe, nutritious, and delicious from manufacturing to

consumption. The microbiological analysis of the stored products were conducted by assessing their microbial profile throughout the storage period.

3. Results and Discussions

3.1 Microbial profile of the leaf powder

To examine the shelf life of the leaf powder, a thorough microbiological assessment was performed to determine the rate and extent of contamination with time. The study looked at the growth and development of bacterial colonies, fungal spores, and *E. coli* bacteria. The microbiological load was measured at various stages throughout the storage period to assess the way the quality and safety of the leaf powder were impacted. The findings of this extensive assessment, including the particular rates of bacterial, fungal, and *E. coli* contamination, are shown, providing insights into the product's shelf stability and microbiological safety throughout the storage term.

Table 6: Microbial load of the chayamansa leaf powder

Microbial Profile	Treatments	Period			
	Leaf powder	Initial	1 st Month	2 nd Month	3 rd Month
Bacteria	LP1	ND	ND	3×10 ⁴	4×10 ⁴
	LP2	ND	ND	ND	2×10 ⁴
	LP3	ND	ND	1×10 ⁴	3×10 ⁴
	LP4	ND	ND	ND	8×10 ⁴
Fungus	LP1	ND	ND	2×10 ⁴	11×10 ⁴
	LP2	ND	ND	ND	6×10 ⁴
	LP3	ND	ND	4×10 ⁴	3×10 ⁴
	LP4	ND	ND	ND	1×10 ⁴
E-Coli	LP1	ND	ND	ND	ND
	LP2	ND	ND	ND	ND
	LP3	ND	ND	ND	ND
	LP4	ND	ND	ND	ND

As demonstrated in Table 6, no growth of *E. coli* was detected during the three months of storage; nonetheless, both fungal and bacterial growths were detected only during the second and third month. This change was largely caused by an increase in moisture levels, which produced a more conducive environment for their development, allowing them to survive and reproduce as conditions improved.

Despite their existence, the bacterial and fungal colonies stayed far within FSSAI's permissible limits, suggesting that they complied with safety requirements.

3.2 Identification of the best treatments of Traditional foods and processed foods incorporated with chayamansa leaves

Table 7: Sensory evaluation of chayamansa incorporated Idli (CI)

Treatments	Appearance	Colour	Flavour	Taste	Overall acceptability
CI ₁	8.000 ^a	7.933 ^a	7.867 ^a	7.867 ^a	7.467 ^a
CI ₂	6.867 ^b	6.867 ^b	7 ^{ab}	6.6 ^b	6.333 ^{ab}
CI ₃	6.333 ^b	6.333 ^b	6.133 ^{bc}	6.267 ^b	5.765 ^b
CI ₄	6.200 ^b	6.267 ^b	5.4 ^c	6.000	5.800 ^b
X ²	21.886	20.114	24.689	14.76	11.778
P	0	0	0	0.002	0.008

Values are mean scores of panel

Appearance

The mean appearance scores for all four Idli formulations varied from 6.2 to 8.0. The maximum score was 8.0 for CI₁, while the lowest score was 6.2 for CI₄. However, there was no significant variation in appearance scores among the four formulations.

Colour

Among the four developed treatments, CI₁ had the greatest mean score of 7.9, while CI₄ had the lowest mean score of 6.2. However, the results showed that the differences were

not statistically significant.

Flavour

The flavors of the various compounded Idlis differed, with mean ratings ranging from 5.0 to 7.8. The greatest mean score of 7.9 was recorded by, CI₁ and the lowest mean score of 5.4 was found by CI₄. The balanced amount of Chayamansa leaves and other components is what gives CI₁ its excellent flavor.

Taste

The taste of the four Idli formulations differed, with mean ratings ranging from 6.0 to 7.8. CI₁ had the highest mean score of 7.9, while CI₄ had the lowest score of 5.4. CI₁'s exceptional taste may be ascribed to the balanced amount of Chayamansa leaves and other components, which results in a well-rounded taste profile.

Overall acceptability

In terms of overall acceptability, CI₁ had the greatest mean score of 7.4, while CI₄ had the lowest average score of 5.7. Based on these findings, CI₁ was chosen as the optimal formulation due to its minimum quantity of chayamansa fresh leaves.

Table 8: Sensory evaluation of Chayamansa incorporated Steamed Kozhukatta (SK)

Treatments	Appearance	Colour	Flavour	Taste	Overall acceptability
SK ₁	8.133 ^a	7.600 ^a	8.000 ^a	7.800 ^a	6.333 ^a
SK ₂	7.067 ^b	6.533 ^{ab}	7.067 ^b	7.067 ^{ab}	7.800 ^b
SK ₃	6.353 ^{bc}	6.412 ^b	6.529 ^b	6.824 ^b	7.267 ^{ab}
SK ₄	6.133 ^c	5.733 ^b	5.867 ^b	6.400 ^b	7.000 ^{ab}
X ²	23.413	11.49	15.552	11.331	9.264
P	0	0.009	0.001	0.01	0.026

*Values are mean scores of panel *

Appearance

The mean score for appearance of the steamed kozhukatta SK₁ was significantly higher, with a score of 8, compared to the other three formulations. On the other hand, SK₄ received the lowest mean score for appearance. However, analysis of the scores revealed no significant difference among them.

Colour

The mean color scores for the four steaming kozhukatta formulations varied from 6.1 to 8.133. SK₂ had the greatest score 8.133, while SK₄ had the lowest score of 6.1 for this criteria. There was no significant difference in treatment outcomes for this measure.

Flavour

SK₂ had the greatest mean taste score (8.133), while SK₄ had

the lowest (5.8). However, there were no significant variations across the scores.

Taste

The mean score for taste across the four formulations of steamed kozhukatta ranged from a high of 7.0 for SK₂ to a low of 6.4 for SK₄. It was found that there were no significant differences between these scores.

Overall acceptability

The overall acceptability scores for the four formulations of steaming kozhukatta revealed that SK₂ had the highest mean score of 7.8, while SK₁ had the lowest. Based on these findings, SK₂ was chosen as the optimal therapy. However, there was no substantial difference between the scores.

Table 9: Sensory evaluation of Chayamansa incorporated Garlic Chutney (GC)

Treatments	Appearance	Colour	Flavour	Taste	Overall acceptability
GC ₁	6.267 ^a	6.467 ^d	6.800 ^a	6.200 ^a	7.133 ^a
GC ₂	8.133 ^a	8.000 ^a	8.067 ^b	8.000 ^b	6.133 ^a
GC ₃	7.267 ^{bc}	6.867 ^b	7.133 ^a	7.267 ^{bc}	7.067 ^a
GC ₄	6.733 ^{ac}	6.800 ^c	6.867 ^a	6.600 ^{ac}	4.467 ^b
X ²	18.247	11.648	12.511	16.158	24.969
P	0	0.009	0.006	0.01	0

*Values are mean scores of panel *

Appearance

The mean score for the visual appeal of the four formulations ranged from 6.2 to 8.13. The highest mean score of 8.13 was recorded for GC₂, which contains 10% chayamansa fresh leaves and different amounts of coconut powder, garlic, dried chile, cumin seed, tamarind, and curry leaves. The lowest mean score was obtained for GC₁. The statistical analysis found no significant differences between these formulations.

Colour

Chutney's color is typically an indicator of the balance of spices and other components, which influences its overall flavor. The mean color scores for the four garlic chutney formulations varied from 6.4 to 8.0. Among the combinations, GC₂ had the greatest mean score of 8.0, while GC₁ had the lowest mean score of 6.4. Statistical analysis found no significant differences across the formulations.

Flavour

The mean taste scores for the chutney formulations varied from 6.8 to 8.0. The greatest mean score was reported for GC₂, while the lowest mean score of 6.8 was found for GC₁. Statistical analysis indicated no significant differences between the scores.

Taste

The mean taste score for the four chutney compositions ranged from 6.2 to 8.0. The treatment with the highest mean score of 8.0 was GC₂, whereas GC₁ had the lowest mean score. The statistical analysis indicated no significant differences between the formulations.

Overall acceptability

The study indicated that GC₂, with a balanced combination of components, had the greatest mean score of 7.13, whereas GC₄ had the lowest score of 4.4 due to its increased chayamansa

leaf concentration. These findings highlight the significance of component balance in affecting the acceptance of chutney

recipes

Table 10: Sensory evaluation of Chayamansa incorporated Soup mix (SM)

Treatments	Appearance	Colour	Flavour	Taste	Overall acceptability
SM ₁	7.000 ^{ab}	7.400 ^a	7.200 ^{ab}	6.933 ^a	5.600 ^b
SM ₂	6.467 ^a	6.667 ^a	6.467 ^a	6.933 ^a	7.867 ^a
SM ₃	7.533 ^b	7.733 ^a	7.667 ^b	7.467 ^a	4.867 ^c
SM ₄	4.667 ^c	4.933 ^b	4.733 ^c	5.000 ^c	4.688 ^c
X ²	29.052	27.351	28.386	24.237	32.866
P	0	0	0	0	0

*Values are mean scores of panel *

Appearance

The mean appearance scores for the four Soup mix formulations varied from 7.5 to 4.6. SM₃ had the greatest score 7.53, while SM₄ had the lowest score of 4.6 for this criteria. There was no significant difference in treatment outcomes for these scores.

Colour

Among the four developed treatments, SM₃ had the greatest mean score of 7.73, while SM₄ had the lowest mean score of 4.93. However, the results showed that the differences were not statistically significant.

Flavour

SM₃ had the greatest mean taste score (7.66), while SM₄ had the lowest (4.73). However, there were no significant

variations across the scores.

Taste

The mean score for taste across the four formulations of Soup mix ranged from a highest score of 7.47 for SM₃ to a lowest score of 5.0 for SM₄. It was found that there were no significant differences between these scores.

Overall acceptability

In terms of overall acceptability, SM₃ obtained the greatest mean score of 7.8, while SM₄ had the lowest at 4.6. Based on these data, SM₃ was chosen as the best formulation due to its 15% concentration of chayamansa leaf powder and ideal quantities of additional additives such as onion powder, pepper, garlic powder, and corn starch.

Table 11: Sensory evaluation of Chayamansa incorporated Ragi weaning mix (RWM)

Treatments	Appearance	Colour	Flavour	Taste	Overall acceptability
RWM ₁	5.733 ^b	5.600 ^b	5.733 ^b	5.800 ^b	5.733 ^b
RWM ₂	7.867 ^a	7.867 ^a	7.933 ^a	8.000 ^a	8.067 ^a
RWM ₃	5.600 ^c	4.867 ^c	5.800 ^c	5.467 ^c	5.733 ^c
RWM ₄	5.000 ^c	4.688 ^c	5.250 ^c	4.688 ^c	5.125 ^c
X ²	29.661	32.866	24.372	32.41	31.282
P	0	0	0	0	0

*Values are mean scores of panel *

Appearance

The mean appearance scores for all four weaning mix formulations varied from 5.0 to 7.8. The maximum score was 7.8 for RWM₂, while the lowest score was 5.0 for RWM₄. However, there was no significant variation in appearance scores among the four formulations

Colour

Among the four developed treatments, RWM₂ had the greatest mean score of 7.8, while RWM₄ had the lowest mean score of 4.6. However, the results showed that the differences were not statistically significant.

Flavour

The flavours of the various compounded weaning mix differed, with mean ratings ranging from 5.25 to 7.9. The greatest mean score of 7.9 was recorded by, RW₂ and the lowest mean score of 5.25 was found by RWM₄. The balanced amount of Chayamansa leaves and other components is what gives RWM₂ its excellent flavor.

Taste

The taste of the four weaning mix formulations differed, with mean ratings ranging from 4.6 to 8.0. RWM₂ had the

highest mean score of 8.0, while RWM₄ had the lowest score of 4.6. Ragi weaning mix's exceptional taste may be ascribed to the balanced amount of chayamansa leaves and other components, which results in a well-rounded taste profile.

Overall acceptability

In terms of overall acceptability, RWM₂ had the greatest mean score of 8.0, while RWM₄ had the lowest average score of 5.7. Based on these findings, RWM₂ was chosen as the best formulation considering to its 10 g of leaf powder and the addition of adjuncts such as ragi, green gram, and roasted peanuts.

Table 12: Sensory evaluation of Chayamansa incorporated Dry Coconut Chutney (DCCP)

Treatments	Appearance	Colour	Flavour	Taste	Overall acceptability
DCC ₁	6.867 ^b	6.267 ^b	6.600 ^b	6.80 ^b	6.533 ^b
DCC ₂	7.867 ^a	7.800 ^a	8.067 ^a	8.00 ^a	8.067 ^a
DCC ₃	5.200 ^c	4.533 ^c	5.333 ^c	5.00 ^c	5.133 ^c
DCC ₄	5.125 ^c	4.375 ^c	4.938 ^c	4.75 ^c	4.688 ^c
X ²	34.784	36.04	36.086	35.371	36.618
P	0	0	0	0	0

*Values are mean scores of panel *

Appearance

The mean score for the visual appeal of the four formulations of dry coconut chutney ranged from 5.1 to 7.8. The highest mean score of 7.8 was recorded for DCC₂, which contains 10% chayamansa fresh leaves and different amounts of coconut powder, garlic, dried chilli, cumin seed, tamarind, and curry leaves. The lowest mean score was obtained for DCC₄ of 5.1. The statistical analysis found no significant differences between these formulations.

Colour

The mean color scores for the four dry coconut chutney formulations varied from 4.3 to 7.8. Among the combinations, DCC₂ had the greatest mean score of 7.8, while DCC₄ had the lowest mean score of 4.3. Statistical analysis found no significant differences across the formulations.

Flavour

The mean taste scores for the chutney formulations varied from 4.9 to 8.0. The greatest mean score was reported for DCC₂, while the lowest mean score of 4.9 was found for DCC₄. Statistical analysis indicated no significant differences between the scores.

Taste

The mean taste score for the four chutney compositions ranged from 4.7 to 8.0. The treatment with the highest mean score of 8.0 was DCC₂, whereas DCC₄ had the lowest mean score. The statistical analysis indicated no significant differences between the formulations.

Overall acceptability

The study indicated that DCC₂, with a balanced combination of components, had the greatest mean score of 8.0, whereas DCC₄ had the lowest score of 4.6 due to its increased chaya leaf concentration. These findings highlight the significance of component balance in affecting the acceptance of chutney recipes.

3.3. Assessment of Shelf life of RTC Products

Microbial study of stored RTC products, namely soup mix, ragi weaning mix, and dry coconut chutney powder, was performed to assess the products' shelf life under ambient

environments for three months. Microbial tests were done at the beginning and at month intervals. Nutrient Agar (NA), Rose Bengal (RB) Agar, and Eosin Methylene Blue (EMB) Agar were used to determine the growth of bacteria, fungi, and *E. coli* respectively. The analysis was carried out using serial dilution followed by the pour plate method. The microbial load of RTC products was determined, and the outcomes are shown in Table 13, 14 and 15.

Table 13: Microbial load of Soup mix during storage

Microbial Profile	Treatments	Period			
	Soup mix	Initial	1 ST Month	2 ND Month	3 RD Month
Bacteria	SM ₁	ND	ND	ND	ND
	SM ₂	ND	ND	ND	ND
	SM ₃	ND	ND	ND	ND
	SM ₄	ND	ND	ND	ND
Fungus	SM ₁	ND	ND	ND	ND
	SM ₂	ND	ND	ND	ND
	SM ₃	ND	ND	ND	ND
	SM ₄	ND	ND	ND	ND
<i>E. coli</i>	SM ₁	ND	ND	ND	ND
	SM ₂	ND	ND	ND	ND
	SM ₃	ND	ND	ND	ND
	SM ₄	ND	ND	ND	ND

Table 13 shows that no *E. coli*, fungus, or bacteria were discovered during the course of three months. This is a strong sign that the soup mix's safety and quality remained consistent throughout time. The elements in the combination, such as ginger powder, onion powder, and pepper powder, are ideal for long-term storage due to their dry nature and inherent preservative characteristics. These components not only served to restrict microbial development, but they also maintained a decreased moisture level, which considerably minimized the risk of contamination. As a consequence, the soup mix is found stable and safe to eat throughout its shelf life. Furthermore, the consistency of both flavour and taste points out the product's well-preserved quality, ensuring that it have a consistent and delightful experience even after long-term preservation. This combination of attributes makes it an ideal choice for long-term storage without compromising safety.

Table 14: Microbial load of Ragi weaning mix during storage

Microbial profile	Treatments	Period			
	Ragi weaning mix	initial	1 ST Month	2 ND Month	3 RD Month
Bacteria	RWM ₁	ND	ND	ND	ND
	RWM ₂	ND	ND	ND	ND
	RWM ₃	ND	ND	ND	2×10 ⁴
	RWM ₄	ND	ND	ND	3×10 ⁴
Fungus	RWM ₁	ND	ND	ND	ND
	RWM ₂	ND	ND	ND	1×10 ⁴
	RWM ₃	ND	ND	ND	4×10 ⁴
	RWM ₄	ND	ND	ND	2×10 ⁴
<i>E. coli</i>	RWM ₁	ND	ND	ND	ND
	RWM ₂	ND	ND	ND	ND
	RWM ₃	ND	ND	ND	ND
	RWM ₄	ND	ND	ND	ND

Table 14 shows that no *E. coli* growth was observed during the three months of storage; however, during the second and third month, both fungi and bacteria were observed to grow. This microbial growth was mainly caused by the addition of

roasted groundnut powder to the mix, which over time became rancid because of its natural oil content, it happens when the oils in the peanuts oxidize and create an environment that is more favourable for the growth of

specific microorganisms, including fungi and bacteria. Additionally, the fact that the taste remained consistent adds to the product's quality and attractiveness. The balance between safety and flavour is critical, and it appears that the combination retained its integrity over time in both respects, giving it a solid alternative for consumption. The amounts of bacteria and fungus, despite this microbial development, stayed well within the FSSAI-established permissible limits, meaning that mixture was still safe to eat and complied with all legal safety requirements.

Table 15: Microbial load of Dry coconut chutney powder during storage

Microbial Profile	Treatments	Period			
	Dry coconut chutney leaf powder	Initial	1 ST Month	2 ND Month	3 RD Month
Bacteria	DCP ₁	ND	ND	ND	ND
	DCP ₂	ND	ND	ND	ND
	DCP ₃	ND	ND	ND	ND
	DCP ₄	ND	ND	ND	ND
Fungus	DCP ₁	ND	ND	ND	ND
	DCP ₂	ND	ND	ND	ND
	DCP ₃	ND	ND	ND	ND
	DCP ₄	ND	ND	ND	ND
<i>E. coli</i>	DCP ₁	ND	ND	ND	ND
	DCP ₂	ND	ND	ND	ND
	DCP ₃	ND	ND	ND	ND
	DCP ₄	ND	ND	ND	ND

The findings in Table 15 show that the product remained free of bacteria and fungus throughout the first, second, and third months, with no *E. coli* growth. The addition of spices to the chutney powder sves as a natural preservative, which, paired with the low moisture level, considerably increased the product's shelf life and durability. Furthermore, the antibacterial qualities of several spices, such as garlic and cumin, may also be able to suppress microbial development, maintaining the product's long-term safety and freshness. This implies that the chutney powder was kept sound, and that its components—most likely helped to maintain its sensory attributes during its shelf life.

Conclusion

The study reveals that the products were highly acceptable, owing mostly to their simplicity of preparation and perceived as healthier alternatives to conventional food options. Chayamansa's nutritional advantages, paired with its adaptability in food processing, contributed to the panel's favorable response, emphasizing its potential as a beneficial component in the production of functional and nutritious food items. The sensory qualities, such as flavor, texture, and overall acceptance, showed that chayamansa-based meals are appealing and advantageous for those looking for better diet options. This shows that chayamansa not only lines up with the increased need for nutrient-dense meals, but also provides a long-term and conveniently accessible alternative for enhancing the general well-being. Chayamansa, is abundant in important vitamins, minerals, and dietary fiber, making it an excellent complement to a variety of culinary preparations. The ability to turn this leaf into functional meals such as soups, snacks, and flour-based items offers an opportunity to improve diets, particularly in food-insecure areas. With additional product development and consumer education, chayamansa has the potential to be incorporated into mainstream diets, especially at places

focused on enhancing intake of nutrients and supporting improved quality of life. The sensory panel's positive responses is an indicator toward establishing chayamansa as an important element in functional food items, opening up new opportunities for future food innovations.

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