Tuijin Jishu/Journal of Propulsion Technology
ISSN: 1001-4055
Vol. 46 No. 04 (2025)

Fortification Of Vitamin C In Synbiotic Drink Using Dragon Fruit

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Abstract:- In today's health-conscious era, consumers are increasingly drawn to traditional and functional foods that offer improved nutrition and well-being. Functional foods, at their core, revolve around the integration of probiotics, which play a pivotal role in enhancing immune function, cognitive well-being, and overall health. This study delves into the exciting realm of crafting synbiotic beverages using a blend of ragi and dragon fruit. It embarks on a comprehensive exploration of the nutritional, physicochemical, and microbiological attributes of these synbiotic concoctions, employing a diverse array of analytical techniques. Intriguingly, the sensory evaluation conducted unveiled a remarkable consumer preference, earning a commendable 7 on a 9-point hedonic scale. The principal component analysis showed significant variations in the synbiotic drink based on the sensory properties. A standardized technique study illuminated that the zenith of microbial growth materialized within 72 hours, with the onset of organism disintegration taking place after 96 hours. Collectively, the holistic analysis firmly substantiates the suitability of the recommended synbiotic beverage featuring ragi and dragon fruit for fostering gut health, marking a promising development in the realm of functional foods.

Keywords: *Dragon fruit, ragi, L. casei, synbiotic drink, vitamin C, dietary fibre.*

1. Introduction

The mounting body of evidence continues to bolster the assertions regarding the health advantages of probiotics, ranging from enhanced gut health and fortified immune defences to reduced serum cholesterol levels and potential cancer prevention. It's important to note that these health-promoting attributes are intricately linked to the specific strains used and can be influenced by a variety of factors. Some of these benefits enjoy well-established recognition, while others await further substantiation through ongoing research efforts. Notably, probiotics have garnered substantial support as an efficacious remedy for managing acute diarrheal illnesses, as a preventive measure against antibiotic-induced diarrhoea, and as a means to enhance lactose metabolism. It's essential to acknowledge that the corpus of evidence may not yet be robust enough to advocate for the widespread utilization of probiotics in various clinical scenarios beyond those specifically mentioned. Further investigation is still required to fully elucidate their potential impact in such contexts [1].

In recent years, there has been a surge in interest surrounding probiotic-infused fruit-based beverages. Nonetheless, integrating probiotic cultures into fruit-based drinks and their environments remains a challenging endeavor [2,3]. This challenge has spurred the curiosity of juice and beverage manufacturers who are keen to diversify their product offerings and expand the functional drinks market. In an intriguing study of the incorporation of Lb. helveticus MTCC 5463 into a mango beverage [4], envisioning the creation of a probiotic-infused mango delight. Notably, during the fermentation process, the pH levels dropped to 3.2, indicating the transformation of the beverage. Another noteworthy development demonstrates that apple juice served as an ideal medium for the probiotic Lb. plantarum PCS 26 to thrive and ferment [5]. This innovative approach resulted in the production of a healthful drink with an extended shelf life and delightful taste.

Another study investigating the efficacy of Lb. plantarum NCIMB 8826 in fermenting non-alcoholic apple juice stored at 4 °C for a duration of 15 days [6]. Remarkably, even under these storage conditions that simulated the harsh environment of the stomach and intestines, the bacteria demonstrated resilience, maintaining a colony-forming unit (CFU) count of over 107 per milliliter. In another notable exploration, Vivek et al., (2019) ventured into the realm of sohiong juice, harnessing the power of to craft a probiotic elixir over a 72-hour period at 37 °C. Impressively, even after a substantial four-week storage stint at 41.1 °C, the probiotic microorganism count remained significantly high, standing at log CFU mL-1 [7]. Hashemi et al., (2018) delved into the intriguing synergy between leaf extract from Moringa oleifera, a resilient and fast-growing tree native to the Indian subcontinent, and sweet orange juice. Their findings revealed that this combination not only extended the shelf life of the juice but also elevated its overall quality [8]. In a different vein, Chaiyasut et al., (2016) explored how Lb. paracasei HII01 facilitated the fermentation of amla fruit (Phyllanthus emblica), examining aspects like carbon sources, polyphenols, and antioxidant properties through FRAP and ABTS assays. The study unveiled that the fermentation mediated by Lb. paracasei HII01 resulted in the creation of a nutritionally rich beverage, boasting a high polyphenolic content and remarkable antioxidant properties [9].

Bathala et al., (2017) conducted a study exploring the quality of fermented/probioticated white and red grape juices using the bacterium P. pentosaceus. After 72 hours of fermentation, red grape juice, with a pH of 3.1 and containing viable bacteria at 6.5 log CFU mL-1, was compared to white grape juice, which had a pH of 3.2 and viable bacteria at 6.2 log CFU mL-1. Notably, fermented red grape juice exhibited a titrate capacity of 0.34%, while fermented white grape juice displayed a higher titrate capacity at 0.72% [10]. Sivudu et al., (2014) explored the potential of watermelon juice and tomato juice as key ingredients for crafting probiotic mixed juices, incorporating Lb. fermentum and Lb. casei [11]. Zandi et al., (2016) focused on the utilization of Lb. casei to create fermented functional beverages by blending carrot, beet, and apple juices [12]. Nagpal et al., (2012) delved into the realm of probiotic-enriched fruit juices, including tomato, orange, and grape. In their fermentation process, they employed two Lactobacillus isolates, Lb. plantarum and Lb. acidophilus [13]. Khatoon and Gupta. (2015) investigated the suitability of sugarcane and sweet lime juices as exclusive food sources for cultivating Lb. acidophilus. This study demonstrated that Lb. acidophilus thrived and produced lactic acid after 24 hours of growth, with live cell counts reaching 108 CFU mL-1. Sugarcane and sweet lime juices emerged as favourable environments for probiotic growth [14]. Shukla et al., (2013) harnessed Lb. acidophilus as the probiotic organism in their exploration of probiotic drinks crafted from a blend of whey and pineapple juice. The results indicated that these probiotic drinks not only exhibited high quality but also contributed to health benefits. The mixture of whey and pineapple juice, with a 65:35 ratio, and the addition of 1% (v/v) Lb. acidophilus allowed for a shelf life of 24 days at 5 °C ± 1 °C and 48 hours at 30 °C ± 1 °C [15].

Dragon fruit, often referred to as the "Honolulu queen," originates from Central America and Mexico and has garnered widespread popularity in recent times. It goes by various regional names, including strawberry pears and pitahayas, with the pink-skinned variety featuring white pulp and black seeds being the most common [16]. This low-calorie fruit is a rich source of fiber, iron, magnesium, and several vitamins. Notably, it boasts cell-protecting antioxidants like vitamin C, betalains, hydroxycinnamates, and flavonoids. Vitamin C, a potent antioxidant, plays a crucial role in guarding against chronic illnesses such as diabetes, Alzheimer's, Parkinson's, and cancer. Dragon fruit is particularly beneficial for expectant mothers, as it contains iron, folate, and vitamin B. Moreover, its magnesium content supports postmenopausal women in preventing health issues [17]. Le et al., (2021) have delved into the health benefits, nutritional value, and long-term sustainability of dragon fruit in the context of climate change [18]. Shrikant et al., (2021) conducted an examination of the fruit's nutritional and medicinal advantages, including its potential in colon cancer prevention, bone and renal health enhancement, visual acuity improvement, and even its utilization as a cosmetic ingredient [19]. Susilo et al., (2021) investigated the enhancement of dragon fruit (Hylocereus costaricensis) syrup quality through a double jacket vacuum evaporator process [20]. Ruzainah et al., (2009) conducted a proximate analysis of dragon fruit, examining its analytical qualities and shelf life. Their findings revealed that dragon fruit stems contained over 96% moisture, 0.270 g of protein, 0.552 g of glucose, and 132.95 mg of L-1 ascorbic acid, with premature stems exhibiting higher values than mature stems, potentially contributing to reducing the risk of certain diseases [21].

2. Objectives

Shobana et al., (2013) comprehensively addressed the ancient grain's utilization, nutrient content, processing, and potential health benefits. Among all grains and millets, finger millet stands out with the highest concentrations of calcium (344 mg) and potassium (408 mg) [23]. It also boasts a higher nutritional fiber content, more minerals, and sulfur-containing amino acids compared to white rice, which is the predominant grain in many countries. Despite its nutritional advantages, recent research has revealed that urban Indians tend to consume less millets, despite finger millet's robust nutritional profile [24]. Verma et al., (2014) conducted research on the diversity and phylogeny of plant growth-promoting bacteria associated with wheat (Triticum aestivum) in the central zone of India. Their findings highlighted that finger millet surpasses rice and wheat in terms of mineral and micronutrient content while being comparable to rice in terms of protein (6–8%) and fat (1-2%). For a significant portion of the population, it serves as a primary source of dietary carbohydrates, in addition to offering various health benefits and being a rich source of essential micronutrients alongside its primary macronutrients [25]. The latest survey underscores the growing importance of enhancing nutritional value for the overall well-being of society. In this context, efforts have been made to create a synbiotic beverage using ragi and dragon fruit, aiming to provide a range of health benefits, including immune system support, digestive health improvement, and weight management.

3. Methods

The development of probiotic drinks hinges on three key ingredients: dragon fruit, ragi (finger millet), and L. casei culture. Dragon fruit, a tropical fruit, is not only low in calories but also packed with fiber and an array of vitamins. Ragi, often referred to as finger millet, stands out as one of the healthiest and most nutritious grains available. Both fresh dragon fruits and carefully selected ragi were sourced from the local market in Eachanari, Tamil Nadu, India. These ingredients were chosen meticulously to adhere to stringent processing standards, and the fruits were stored under refrigeration to prevent premature ripening. The L. casei culture was obtained from a suitable medium, setting the stage for the creation of these synbiotic beverages.

The Probiotic drink, comprising dragon fruit and ragi, was meticulously prepared using a specific ratio of ingredients: 1 part ragi, 3 parts dragon fruit, 2 parts sugar, and 6 parts water, following the methodology outlined by [26]. The fruit is first peeled and diced into small pieces to extract the pulp. These fruit pieces are then crushed in a mixer jar to create a pulp, which is subsequently filtered. The ragi is initially cleaned, washed, and dried to eliminate any dust particles. Following this, the dried ragi is ground into a fine powder. To prepare a SYNBIOTIC drink, a mixture was created by combining 50 grams of ragi powder, 150 grams of dragon fruit pulp, 100 grams of sugar, and 300 milliliters of water. The quantities of each ingredient are detailed in Table 1.

Sl.No.	Name	Units	Quantity
1.	Ragi	Gm	50
2.	Dragon fruit	Gm	150
3.	Sugar	Gm	100
4.	Water	ml	300

5.	*L.*Casei	µL	2

Table 1: Quantity of each Ingredients for the development of symbiotic drink.

To initiate microbial fermentation, 2 µL of L. Casei culture were introduced into the mixture at a temperature of 35 °C. The samples were then maintained at this temperature for a period of up to 48 hours to allow the fermented drink to develop.

After fermentation, the fermented drink is carefully filtered and then stored under refrigeration conditions. This step is crucial to prevent further microbial growth, as over-fermentation could occur otherwise. Such over-fermentation may result in sensory properties that could lead to consumer rejection of the product. The stored samples are subsequently utilized for both physicochemical and sensory analyses.

Physiochemical analysis of samples:

In the course of physicochemical analysis, a comprehensive evaluation of both the specific chemical and physical properties was conducted. This encompassed an examination of various attributes of the probiotic beverage, such as pH, titrable acidity, total soluble solids, and flowability.

pH:

pH represents the hydrogen ion potential within a liquid, signifying both the concentration and activity of hydrogen ions. It serves as a critical parameter for assessing the acidic or alkaline nature of a product, a determination that can be made through the application of either pH paper or a pH meter. In the context of this research, the pH of the probiotic drink was assessed utilizing pH paper. A 1 ml sample of the drink was briefly immersed in a beaker, causing a color change in the pH paper. This color alteration was then compared to a standard reference value [28] to confirm the pH paper's accuracy.

Titratable acidity:

Titratable acidity represents the quantification of the overall acid content within a food sample, exerting a notable influence on its sensory characteristics. The determination of titratable acidity involves the titration of the sample with 0.1N NaOH, with phenolphthalein employed as the indicator to signal the endpoint. In this study, the titrable acidity of the samples was established, and the endpoint was discerned by the intensity of the pink color [29].

(%) Titrable acidity = (Titrate*N. of alkali*Volume made*Eq. wt of acid*100) / (Volume of sample taken*weight of sample taken*1000)

Total soluble solids:

Total soluble solids (TSS) represent the quantity of solid substances that can dissolve in a liquid, encompassing elements such as the complete sugar content alongside minor quantities of soluble proteins, amino acids, and other biological constituents. In line with the methodology [30], TSS of the samples was assessed utilizing a handheld refractometer.

Flowability:

Flowability pertains to the ability of liquids to flow through a conduit or pipe over a specific duration. In assessing flowability, the static angle of repose technique was employed. In this procedure, a 30cc sample was dispensed through a funnel, affixed to a stand, from a height of 25 cm. The resulting conical pile's radius was determined [31]. The angle of repose values were then calculated using a specific formula.

tan á = H/R

Where; á - angle of repose in degrees (°)

H - Height at which the powder is thrown

R - Radius of the conical pile.

Nutritional profiles:

To evaluate the nutritional quality of the developed beverage after processing, an analysis was conducted to assess the retention of key raw material attributes. Specifically, the nutritional properties of the developed drink were scrutinized with a focus on vitamin C, total protein, dietary fiber, and total carbohydrates.

Vitamin C:

The quantification of total vitamin C or ascorbic acid content within the sample was achieved through a systematic procedure. Initially, a 50 mL aliquot of the sample was carefully pipetted into a 100 mL volumetric flask, followed by the addition of 25 mL of a 20% metaphosphoric acid solution, serving as a stabilizing agent. The solution was then diluted to its final volume. Simultaneously, a 10 mL portion of the sample was pipetted into a smaller flask, and 2.5 mL of acetone was added. The subsequent titration process involved the incremental addition of an indophenol solution until a faint pink color persisted for precisely 15 seconds, indicating the endpoint and allowing for the determination of the vitamin C content in the sample.

Total protein:

The determination of total protein content is a fundamental biochemical analysis conducted to assess the concentration of proteins in the sample. The protein concentration is quantified using the UV absorbance method at 280 nm. To determine the protein concentration accurately, a calibration curve is established using known standards with known protein concentrations. The data obtained from the assay, along with the calibration curve, is used to calculate the total protein content in the sample. It is essential to ensure the accuracy and reproducibility of the results by triplicates of the sample and standards and monitoring the assay's linearity and sensitivity.

Dietary fibre:

The gravimetric method for determining dietary fiber entails a multi-step procedure. Initially, a representative sample of the food product is weighed; the sample size typically ranges between 1 to 5 grams, depending on the specific analysis and laboratory protocols. Subsequently, the sample undergoes treatment with a 1.25% sulfuric acid (H2SO4) solution. This step serves to hydrolyze and eliminate the non-fibrous carbohydrates present. Controlled heating, often employing reflux conditions, is employed for a specified duration during this hydrolysis process. Following hydrolysis, the mixture is subjected to filtration to segregate the insoluble dietary fiber residue from the soluble components. A suitable filter paper or filter crucible is used for this purpose. The residue is then meticulously washed with hot water to ensure the removal of any remaining soluble components. This washing process continues until the filtrate is no longer acidic. Subsequently, the washed residue is dried in an oven at a specified temperature until a constant weight is attained. This final weight corresponds to the isolated dietary fiber fraction. To determine the dietary fiber content as a percentage of the original sample weight, a formula is applied. This formula is as follows:

Dietary Fiber (%) = (Weight of Residue / Weight of Sample) x 100

Total carbohydrates:

To determine the total carbohydrates through a gravimetric approach, the procedure involves several key steps. Firstly, it is essential to prepare a representative sample of the food or substance containing carbohydrates. In case of complex carbohydrates hydrolysis is required to break down complex carbohydrates into simpler forms that are more amenable to analysis. Upon successful hydrolysis, the carbohydrates are then precipitated into a specific compound. Following precipitation, the residues were removed by filtration process. To ensure the purity of the precipitate, it is vital to thoroughly wash it with a suitable solvent or buffer, effectively removing any impurities or excess reagents that may be present. Subsequently, the washed precipitate undergoes a careful drying process in an oven or desiccator, to ensure that the precipitate reaches a state of constant weight. Once dried, the precipitate is weighed with precision using an analytical balance. The mass obtained in this step corresponds to the quantity of carbohydrates present in the original sample. The final calculation involves determining the concentration of carbohydrates within the sample.

Microbial analysis:

The total plate count (TPC) is a widely employed method for estimating the bacterial population present in food samples. TPC serves as a valuable tool for quantifying the abundance of microorganisms, including bacteria, yeast, and mold, within a given food sample. To commence the analysis, the food sample is subjected to a dilution process, ultimately reaching a 10-5 dilution factor. This dilution step is crucial to ensure that the microbial population within the sample can be accurately quantified on agar plates. By diluting the sample, reduces the likelihood of overcrowding on the plates, allowing for the formation of distinct colonies that can be counted. Subsequently, the total plate count of a fermented probiotic drink was determined according to the guidelines outlined in the IS1622:1981 standardized method, as described in the research conducted by Jannah et al., 2022 [22]. This method provides a systematic and recognized approach for assessing the microbial load in the synbiotic drink, thus contributing to the overall understanding of its microbiological quality and safety.

Sensory evaluation:

Sensory evaluation of food represents an empirical approach to assessing food products through the human senses. A panel of 30 naive assessors (students and faculties between 20-40 years) participated in the systematic assessment of food items, scrutinizing attributes such as appearance, aroma, and flavor to gauge both product quality and its potential for consumer acceptance. In the context of this research, the 9-point hedonic scale has been adopted as a pivotal tool for ascertaining the sensory attributes of the newly formulated beverage.

Principal component analysis:

Principal component analysis (PCA) is a statistical tool for reducing the case by variables to its principal components. The main objective of PCA to examine a set of components with less information loss. The correlation of sensory properties of the synbiotic drink can be analyzed with eigen values [24].

Synbiotic drinks are typically liquid-based; however, in the current study, efforts were directed towards creating a synbiotic drink using a blend of dragon fruit and ragi, fermented with L. Casei bacteria. The fermentation process extended for approximately 48 hours at ambient temperature, resulting in a product characterized by both appealing visual attributes and a pleasing taste. Ipsum dolor sit amet consectetur adipiscing. Arcu felis bibendum ut tristique. Lectus sit amet est placerat in egestas. In massa tempor nec feugiat nisl pretium. Vel pharetra vel turpis nunc eget lorem dolor. Ornare aenean euismod elementum nisi quis eleifend quam. Tellus id interdum velit laoreet id donec. Eget arcu dictum varius duis at consectetur lorem donec massa. Amet facilisis magna etiam tempor orci eu lobortis. Consectetur adipiscing elit duis tristique sollicitudin. Pellentesque dignissim enim sit amet venenatis urna cursus eget.

3. Results

Physicochemical analysis:

The results of the physicochemical analyses conducted during the fermentation evaluation are presented in Table 2. These analyses yielded the following outcomes after 48 hours of fermentation: a pH value of 6.0, a TSS (ºBrix) reading of 23, a flowability measure of 1.01, and a titrable acidity of 0.30%. Jalgaonkar et al., (2018) conducted a study on dragon fruit and grape juice, revealing variations in pH, TA, and TSS based on the dragon fruit concentration [13]. Specifically, their study reported pH values of 0.26 and 0.19, along with a TA of 0.26 and 0.19, when using 60% and 80% dragon fruit concentrations in combination with 5% grape juice, respectively. In another relevant study, Islam et al., (2021) investigated the pH and titrable acidity changes in a whey-pineapple probiotic drink over an 8-week period, spanning from 0 to 56 days, under chilled storage conditions. Their findings indicated a fluctuation in the pH of the drink, ranging from 4.30 on the initial day to 3.50 on the 56th day of storage [25]. Additionally, the titrable acidity of the drink exhibited an increment from 0.65 to 0.95 over the same storage duration, from the 0th day to the 56th day.

Table 2: Results for physicochemical analysis of the symbiotic drink after 48 hrs of fermentation.

Sample	pH	TSS(°brix)	Flowability	Titratable Acidity (%)
Probiotic Drink	6.0	23	1.01	0.30

Nutritional properties:

A comparison between the commercially available probiotic drink and the developed drink reveals notable differences in their nutritional content, as illustrated in Figure 1. The commercially available probiotic drink is characterized by the following components per 100g: Vitamin C: 0g, total carbohydrates: 15g, total protein: 1.25g, dietary fiber: 0g. In contrast, the developed probiotic drink exhibits different nutritional values per 100g: Vitamin C: 5.45 ± 1.2g, total protein: 7.01 ± 0.8g, dietary fiber: 14.96 ± 1.6g, and total carbohydrates: 14.13 ± 1.0g. These findings demonstrate that the developed probiotic drink contains significantly higher levels of vitamin C, total protein, dietary fiber, and comparable total carbohydrates when compared to the commercially available probiotic drink. This distinction in nutritional composition may have important implications for the potential health benefits and consumer preferences associated with these products.

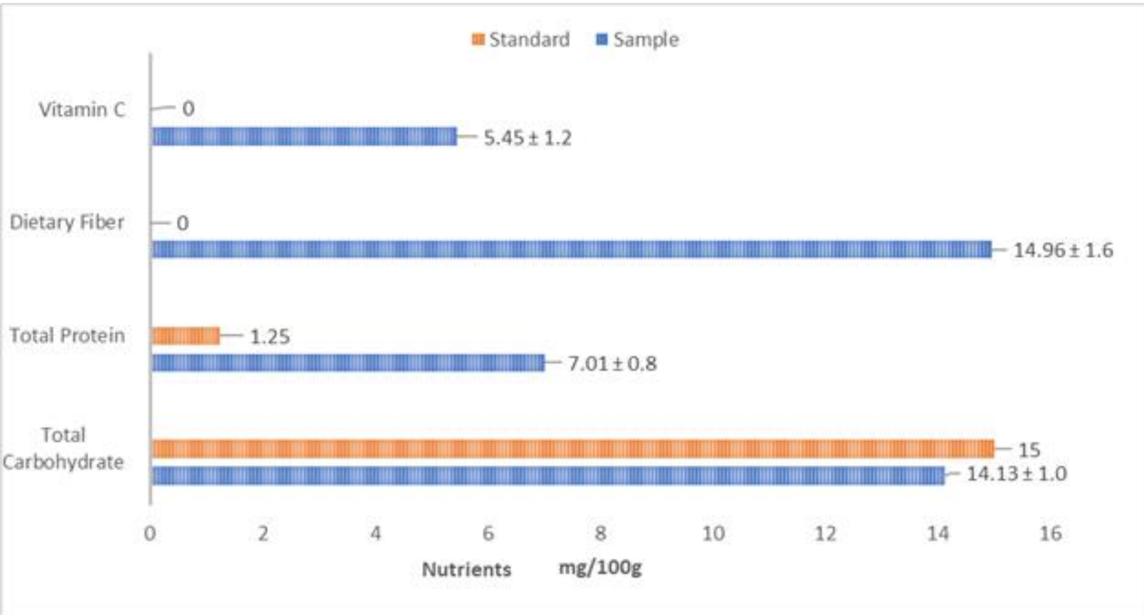

Fig. 1. Nutritional values of standard and SYNBIOTIC drink developed from dragon fruit and ragi.

Microbial analysis:

Total Plate Count (TPC) is a method commonly used to assess the growth of microorganisms in a given sample. In the context of your study, the probiotic drink was subjected to TPC analysis to determine the growth rate of L. Casei bacteria. The results obtained from this analysis revealed a substantial increase in the microbial load within a mere 2-day period. This information is critical for understanding how the L. Casei population evolves within the probiotic drink, which can have significant implications for product quality, shelf life, and potential health benefits associated with the consumption of these beneficial bacteria. Figure 4 illustrates the growth curve of L. Casei within the fermented drink over a span of four days. The growth pattern can be divided into distinct phases, each with its own characteristics. In the initial 24 hours, referred to as the Lag Phase, the L. Casei organisms exhibit a relatively modest growth, increasing to 120 CFU/ml. Following the Lag Phase, during the subsequent

24 hours in the Log Phase, there is a remarkable surge in growth, with the population reaching approximately 8500 CFU/ml. This phase represents a period of rapid multiplication.

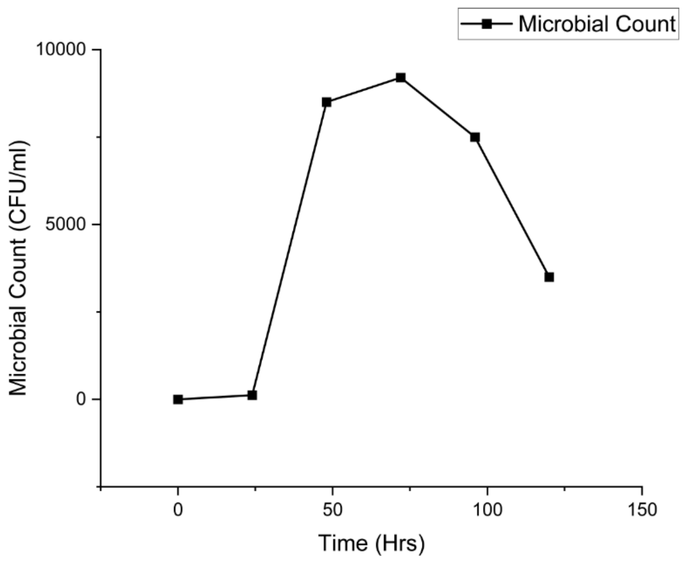

Fig. 2. Growth curve of *L.casei* for 0 to 120 hours of fermentation and storage.

After the Log Phase, the growth rate of L. Casei tends to slow down, entering the Stationary Phase. During this phase, there is a slight increase in the population, reaching around 9200 CFU/ml. This phase typically indicates a balance between microbial reproduction and decline. Upon reaching the 72-hour mark, a transition occurs, and a reduction in the L. Casei population is initiated, resulting in a decrease of approximately 1700 CFU/ml by the 96th hour. It's worth noting that the growth pattern observed in this study aligns with the findings [33] of who studied a probiotic drink developed from whey and pineapple juice. They reported a gradual microbial growth over 42 days of storage at 4 ºC, followed by a decline in growth. Their results suggest that the product remains safe for human consumption for up to 52 days under chilled storage conditions. This information is crucial for assessing the product's shelf life and safety for consumers.

Sensory properties:

The sensory properties, also known as organoleptic properties, represent a highly effective means of gauging customer acceptance of a product. In this study, organoleptic analysis was conducted using the hedonic scale method to assess the sensory aspects of the synbiotic drink. The preference test focused on evaluating various attributes, including appearance, color, flavor, taste, and overall acceptance, utilizing a nine-point hedonic scale. The average values for all these sensory attributes were computed and are graphically represented in Figure 3. Additionally, these results are tabulated in Table 3. The analysis clearly indicates that the proposed probiotic drink achieved high ratings across all sensory attributes, signifying a strong preference among consumers. This suggests that the product excels in terms of appearance, color, flavor, taste, and overall acceptance, thus making it a favored choice among consumers [34]. In the study of Badilla et al., 2020 the consumer acceptance of coconut water-based synbiotic drink were analyzed and they found that there is a decrease in consumer acceptance after 15 days of storage at 1.5 ºC.

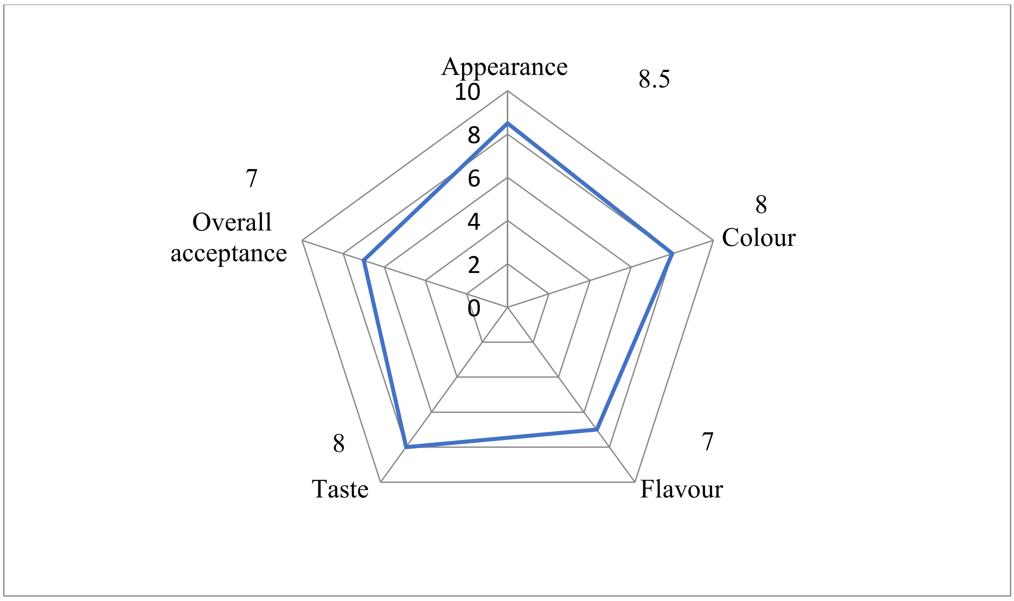

Fig.3. Spider chart for the sensory analysis of vitamin C fortified SYNBIOTIC drink.

Table 3: 9- point hedonic scale evaluation output for the developed product.

S.No	Factors	Response	Hedonic scale
1.	Appearance	8.5	Liked very much
2.	Color	8	Liked very much
3.	Flavor	7	Liked moderately
4.	Taste	8	Liked very much
5.	Overall acceptance	7	Liked moderately

Table 4: Principal compound score of the sensory properties of dragon fruit and ragi-based symbiotic drink.

Sensory Properties	PC1	PC2	PC3	PC4	PC5
Color	-0.039	-0.850	-0.324	-0.165	-0.379
Flavour	0.470	-0.342	0.520	-0.426	0.460
Appearance	0.424	0.368	-0.494	-0.743	-0.104
Taste	0.500	-0.097	-0.577	0.433	0.470
Overall acceptance	0.685	0.126	0.220	0.230	-0.643

Principal component analysis for sensory properties:

The principal component analysis (PCA) of sensory properties like color, flavor, appearance, taste, and overall acceptance for the synbiotic drink is explained on the basis of eigenvalues, proportions, and cumulative of the five eigen vectors. From Table 4, the first principal component has a positive association with all the parameters except color, the second component shows a positive association only for appearance and overall acceptance. Figure 4 represents the correlation of the first and second principal components of variables like color, flavor, appearance, taste, and overall acceptance. The loading plot for the first principal component (32.3%) shows a positive correlation with flavour (47.0%), appearance (24.2%), taste (50.0%) and overall acceptance (68.5%), only the color shows a negative deviation (Figure 5). The biplot of the first and second components is represented in Figure 8. It was observed that the sensory characterises like taste, texture, color, aroma, mouth feel, flavor, appearance and overall acceptability of legume milk chocolate with plant source. From this the first and second component is accounted for 59.9% and 18.7% respectively and all the sensory characterises shows a positive correlation with these principal compounds[35].

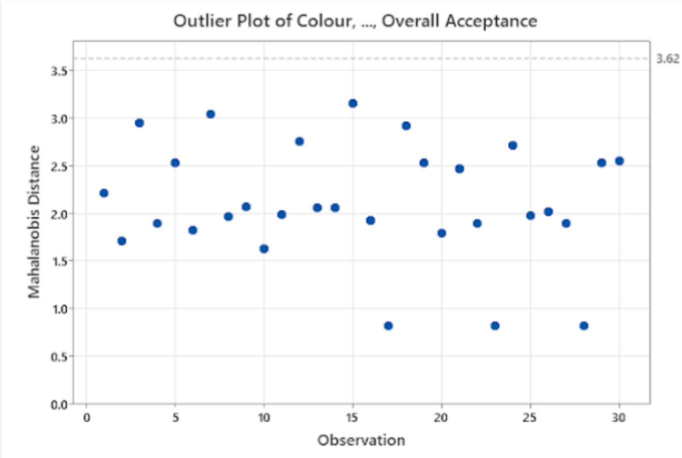

Fig. 4. The distribution and correlation of sensory parameters of the dragon fruit and ragi-based SYNBIOTIC drink with outlier plot.

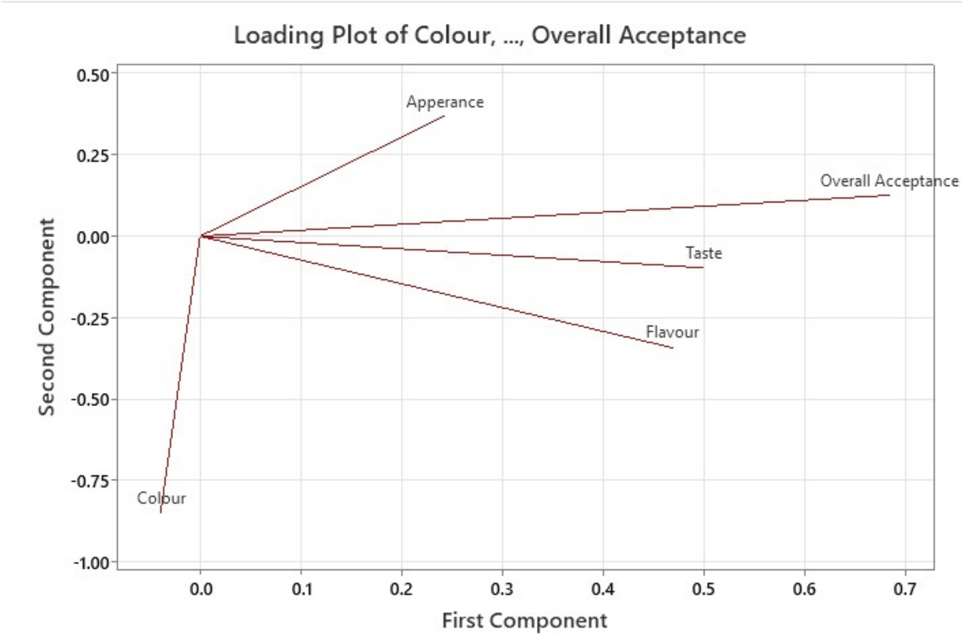

Fig. 5. The distribution and correlation of sensory properties of dragon fruit and ragi-based SYNBIOTIC drink represented with loading plot.

4. Discussion

The formulation of the vitamin C fortified synbiotic drink incorporating dragon fruit and ragi represents a significant achievement. Comprehensive analyses covering physicochemical, microbial, and organoleptic aspects have been conducted on the sample, revealing a notable consumer acceptance rate of 7 on a 9-point hedonic scale. This positive response underscores the product's appeal among consumers. The principal component analysis for the sensory properties of the drink showed that taste, appearance, and flavor highly contributed to the overall acceptance of the drink. Dragon fruit, renowned for its high vitamin C content and potential anti-cancer properties, combines synergistically with ragi, which boasts elevated levels of fiber and protein. This combination results in a nutrient-rich product with promising health benefits. In terms of microbial analysis, a standardized methodology was applied to assess microbial growth in the synbiotic drink. The analysis revealed that the peak of microbial growth occurs at the 72-hour mark, followed by a decline in microbial activity initiated after 96 hours. This information is valuable for understanding the product's microbiological characteristics and its potential shelf life. While the initial findings are promising, further research is needed to explore the product's shelf life under different atmospheric conditions. Extensive studies should be conducted to harness the full nutritional potential of dragon fruit, considering its rich nutrient profile, and its potential in reducing the risk of various cancers, particularly colon cancer in humans. This suggests an exciting avenue for future research and development in the field of functional foods and beverages.

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