Advances in Agricultural Technology & Plant Sciences
ISSN: 2640-6586

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Research Article

Volume 7 Issue 2

Optimizing Preservation of Kokum Rind Juice: Influence of Sodium Benzoate Treatment and Storage Conditions on Microbial Count and Quality Maintenance

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Received Date: July 03, 2024; **Published Date:** August 23, 2024

Abstract

This study investigated the storage conditions and preservation process for kokum rind juice to determine the influence of different treatments on microorganism count. Juice samples were chemically treated with sodium benzoate at concentrations of 500 ppm, 750 ppm, 1000 ppm, 1250 ppm, and 1500 ppm. These samples were stored at ambient temperatures of 28°C and low temperatures of 5°C for three months. The results indicated that juice treated with 750 ppm of sodium benzoate and stored at 5°C maintained the highest quality and was safe for consumption for up to three months. The Total Plate Count (TPC) was the primary microbiological parameter used to assess juice quality, ensuring it remained safe and of high quality throughout its shelf life. The findings suggest that a combination of 750 ppm sodium benzoate and cold storage at 5°C is optimal for preserving kokum rind juice, balancing microbial inhibition, sensory quality, and nutritional retention. This study provides valuable insights for producers aiming to extend the shelf life of kokum rind juice while maintaining its desirable properties.

Keywords: Sensory Evaluation; Kokum Rind Juice

Introduction

Fruits are regarded as one of mankind's most essential sources of antioxidants because they partially satisfy quantitative needs while also supplying vitamins and other nutrients, including minerals. Because of this, it's essential to provide them in fresh or processed form for consumption all year round. Garcinia indica (Kokum), commonly referred to as the "cool king" of Indian dishes, is a member of the Clusiaceae plant family. The fruits typically have a globular or spherical shape, are green when raw, turn scarlet to dark purple when completely mature, and have a distinctive aroma. They weigh between 15-20 grams and contain 5 to 8 big seeds [1]. Processing kokum fruits is a crucial task since mature, unprocessed fruits must be prepared before use. According to Dushyantha, et al. [2], the seed section of the entire fruit accounts for 20 to 23% of the fruit weight and is extremely rich in stearic, oleic, and stearic triglycerides. Three significant chemical components—garcinol, hydroxycitric acid, and the anthocyanin pigment—are found in kokum rind. Garcinol, a fat-soluble yellow color, is noted for its antioxidant properties, while hydroxycitric acid is utilized as an acidulant and has been found to drastically reduce body weight by inhibiting fat synthesis. The anthocyanin pigment

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contributes to the vibrant color of kokum and also possesses antioxidant properties [2]. In Ayurvedic medicine, kokum has a long history of use as a remedy for heart problems, tumors, dermatitis, diarrhea, dysentery, ear infections, and digestive issues. Additionally, kokum juice is employed as a home treatment for liver and stomach issues [3-6]. Beyond its medicinal uses, kokum is also valued for its culinary applications, particularly in coastal Indian cuisine, where it is used to add flavor and acidity to dishes. Its cooling properties make it a popular ingredient in beverages, especially during the hot summer months, providing both refreshment and health benefits. The versatility and health-promoting properties of kokum make it an invaluable fruit in both traditional and modern applications.The aim of this research paper is to investigate the preservation methods and storage conditions of kokum rind juice to determine their impact on microbiological stability and quality. Specifically, the study aims to evaluate the efficacy of different concentrations of sodium benzoate and storage temperatures in maintaining the juice's microbiological quality over three months. The research seeks to identify the optimal conditions that ensure the best quality and safety of kokum rind juice for consumption.

Materials and Methods

The experimental setup for the preservation of kokum rind juice involved the following details: The crop under investigation was kokum (Garcinia indica) of the local variety, with a design structured as F.C.R. D. In total, there were 24 treatment combinations, resulting from six different levels of sodium benzoate as the main treatments and four storage periods as sub-treatments. The sodium benzoate levels were set as follows: T1: 500 ppm, T2: 750 ppm, T3: 1000 ppm, T4: 1250 ppm, and T5: 1500 ppm. The sub-treatments were based on the storage period in days: S1: 0 days, S2: 30 days, S3: 60 days, and S4: 90 days. Each treatment combination was replicated three times to ensure the reliability and accuracy of the experimental results.

Preparation of Fruit and Juice Extraction

The preparation of kokum rind juice involves several meticulous steps to ensure its quality and longevity. Firstly, ripe kokum fruits are carefully selected for processing. Then, to maintain hygiene standards, the fruits undergo thorough cleaning using sodium hypochlorite. The fruit stalk is removed, and the fruits are cut using a specialized kokum fruit cutter machine, separating the rind from the seeds. The juice is extracted from the rind using a basket press and then strained through a double-fold muslin cloth to remove any remaining solids. Sodium benzoate is added according to the treatment requirements to enhance preservation. Finally, the juice is packed into glass bottles and stored under ambient or refrigeration conditions as specified by the treatments. This meticulous process ensures the production of high-quality kokum rind juice with extended shelf life and optimal microbiological stability.

Microbiological analysis

according to the procedure outlined by Kiiyukia [7], the microbiological analysis of kokum rind juice was performed at initial and after 90 days of storage according to the procedure outlined by Kilyukia [7] the microbiological examination of the juice was performed at 0 and 90 days nutrient agar media was made by weighing the necessary quality of nutrient agar after 20 minutes of autoclaving at 121°C the media was cooled to 40°C and utilized for plating a 1 ml sample was used for plating in a sterile petri dish with laminar air flow each treatments sample was placed on its petri dish and then 20 ml liquid were added. of media (35 °C to 40 °C) on the sample and mixing was done by taking the plate properly the plate was sealed with parafilm and incubated at 37 °C for 24 hrs

Sensory Evaluation

The product was tested monthly for overall sensory acceptability by a committee of ten judges chosen from the staff and students using the method of [8] using a scale between 1 to 9, where 1 represented extremely dislike and 9 represented extremely like.

Results

Microbial Count of Kokum Rind Juice During Storage

The analysis of kokum rind juice showed significant effects of sodium benzoate concentrations and storage conditions on microbial counts over 90 days. Under ambient conditions (Table 1) microbial counts ranged from 3.34×10^3 cfu/ml to 1.76×10^3 cfu/ml, with a mean count of 2.61×10^3 cfu/ml. Under refrigeration (Table 2), counts ranged from 3.19×10^3 cfu/ml to 1.22×10^3 cfu/ml, with a mean count of 1.99×10^3 cfu/ml. Both storage conditions demonstrated a significant impact on microbial growth, with lower counts observed under refrigeration.

Microbial count (No. × 103 cfu/ml)		
Treatment	Storage period (Days)	
	0	90
T1	ND	3
T2	ND	3
T3	ND	3
T4	ND	2
T5	ND	2
Mean	ND	3
S.Em ±	0	0
CD at 5%	0	0

Table 1: Effect of sodium benzoate concentrations on microbial count (cfu/ml) of Kokum rind juice under ambient storage conditions.

Microbial count (No. × 103 cfu/ml)		
Treatment	Storage period (Days)	
	0	90
T1	ND	3.2
T2	ND	2.2
T3	ND	1.9
T4	ND	1.5
T5	ND	1.2
Mean	ND	2
S.Em ±	0	0
CD at 5%	0	0.1

Table 2: Effect of sodium benzoate concentrations on Microbial count (cfu/ml) of Kokum rind juice under refrigeration storage conditions.

Sensory Quality Parameters of *Kokum Rind Juice* During Different Storage Conditions

Colour: Throughout the 90-day storage period, the sensory evaluation for the color of kokum rind juice was significantly influenced by various sodium benzoate levels and storage circumstances. After 90 days of ambient storage, the sensory evaluation for the color of kokum rind juice was notably affected by different levels of sodium benzoate, as indicated in Table 3. Treatment T1 obtained the lowest score for color (5.99), followed by treatment T2 (6.15), while treatment T5 received the highest score of 6.50. The data shows that throughout the 90-day ambient storage period, storage time significantly affected the sensory evaluation of the color of kokum rind juice. The lowest sensory evaluation for color (5.52) was found after 90 days of storage, although the sensory evaluation for the storage condition began substantially higher (7.49). At 90 days of storage, it was discovered that there was no significant interaction between the various treatments and ambient storage length regarding the sensory evaluation of kokum rind juice.

Similarly, according to the data in Table 4, the sensory evaluation for the color of kokum rind juice after 90 days of refrigeration storage was significantly impacted by the various sodium benzoate concentrations. Treatment T5 received the highest score (8.19), whereas treatments T1 and T2 received the lowest scores (7.00 each). Treatments T2, T3, and T4 were comparable to one another. From the data in Table 4, it can be concluded that during the 90 days of refrigeration storage, the storage situation had a substantial impact on the sensory evaluation of the hue of kokum rind juice. The sensory evaluation for the storage state started much higher (8.40) and dropped to its lowest point (7.20) after 90 days. At 90 days, it was discovered that the interaction impact between various treatments and the refrigerator storage length was non-significant about the sensory evaluation for the hue of kokum rind juice.

Comparing the data from Table 3 (ambient conditions) and Table 4 (refrigeration conditions), the refrigeration condition recorded significantly higher sensory scores for color (7.00, 7.63, 7.76, 7.61, and 8.19, respectively) than the ambient storage condition after 90 days of storage.

Treatment	Sensory score for colour				
	Storage period (Days)				
	0	30	60	90	Mean
T1	7.2	6	5.7	5.3	5.99
T2	7.3	6	5.8	5.3	6.15
T3	7.6	6	6.1	5.4	6.34
T4	7.6	6	5.9	5.7	6.33
T5	7.7	6	6.1	5.9	6.5
Mean	7.5	6	5.9	5.5	
		S.Em ±		CD at 5%	
Treatment(T)		0.06		0.16	
Storage(S)		0.05		0.14	
Interaction (TxS)		0.11		NS	

Table 3: Effect of sodium benzoate concentrations on sensory score for colour of kokum rindjuice stored in ambient conditions.

Treatment	Sensory score for colour				
	Storage period (Days)				
	0	30	60	90	Mean
T1	8	6.7	6.7	6.3	7
T2	8	7.5	7.5	7.1	7.63
T3	8	7.6	7.8	7.2	7.76
T4	8	7.1	7.2	7.7	7.61
T5	9	8.3	8.3	7.7	8.19
Mean	8	7.4	7.5	7.2	
	S.Em ±		CD at 5%		
Treatment(T)	0.12		0.34		
Storage(S)	0.11		0.31		
Interaction (TxS)	0.23		NS		

Table 4: Effect of sodium benzoate concentrations on sensory colour of Kokum rind juicestored in refrigeration conditions.

Flavour: Throughout the 90-day storage period, the sensory evaluation of flavor in kokum rind juice was significantly influenced by varying sodium benzoate concentrations and storage conditions. Table 5 illustrates that after 90 days of ambient storage, the sensory evaluation for flavor was notably impacted by different sodium benzoate concentrations. Treatment T5 achieved the highest flavor score (7.12), followed closely by treatments T4 (6.93) and T3 (6.94), while treatment T1 had the lowest score (6.47), comparable to treatment T2 (6.64). Throughout the 90-day ambient storage period, the sensory evaluation for flavor was significantly affected by storage time. The lowest score (6.15) was recorded at 90 days under ambient conditions, contrasting with the substantially higher score (7.58) observed initially. Notably, at 90 days of storage, there was no significant interaction between treatments and ambient storage duration regarding flavor sensitivity.

Similarly, according to Table 6, the sensory evaluation for flavor after 90 days of refrigeration storage was significantly influenced by various sodium benzoate concentrations. Treatment T5 attained the highest score (7.42), on par with treatment T4. Treatment T1 scored 6.76, comparable to treatment T2 with a score of 6.94. During the 90 days of refrigerated storage, the storage conditions had a substantial impact on flavor evaluation, with a significantly higher sensory score (8.07) on the first day compared to a lower score (6.50) on the 90th day. At 90 days of storage, the interaction effect between treatments and refrigerated storage duration had no significant impact on flavor evaluation.

Comparing the sensory evaluation for flavor under refrigeration conditions (Table 5) with ambient conditions (Table 6), it's notable that refrigeration generally resulted in higher sensory scores. After 90 days of storage, the refrigeration condition recorded higher sensory scores for flavor (ranging from 6.50 to 7.47) compared to ambient storage conditions.

In summary, both sodium benzoate concentrations and storage conditions significantly affected the sensory evaluation of flavor in kokum rind juice throughout the 90-day storage period, with refrigeration generally resulting in higher flavor scores

Treatment	Sensory evaluation for flavour				
	Storage period (Days)				
	0	30	60	90	Mean
T1	7.4	6.5	6.2	5.8	6.47
T2	7.4	6.9	6.5	5.8	6.64
T3	7.6	7.2	6.6	6.3	6.94
T4	7.7	7.1	6.6	6.3	6.93
T5	7.8	7.4	6.7	6.6	7.12
Mean	7.6	7	6.5	6.2	6.82
		S.Em ±		CD at 5%	
Treatment(T)		0.1		0.29	
Storage(S)		0.09		0.26	
Interaction (TxS)		0.19		NS	

Table 5: Effect of sodium benzoate concentrations on sensory evaluation for flavour of kokum rind juice under ambient storage conditions

Treatment	Sensory evaluation for flavour				
	Storage period (Days)				
	0	**30**	**60**	**90**	**Mean**
T1	8.1	6.6	6.3	6	6.76
T2	8.2	6.6	6.8	6.1	6.93
T3	8.1	7.4	6.9	6.4	7.19
T4	8.1	7.2	7.2	6.7	7.31
T5	7.8	7.4	7.3	7.3	7.47
Mean	8.1	7	6.9	6.5	
		S.Em ±		CD at 5%	
Treatment(T)		0.12		0.34	
Storage(S)		0.11		0.3	
Interaction (TxS)		0.22		NS	

Table 6: Effect of sodium benzoate concentrations on sensory evaluation for flavor of kokum rind juice under refrigerating storage conditions.

Overall acceptability

The variations in overall acceptability scores of kokum rind juice under both ambient and refrigeration storage conditions are detailed in Tables 7 (ambient condition) and 8 (refrigeration condition). These tables highlight the significant impact of different sodium benzoate concentrations on overall acceptability after 90 days of storage.

In Table 7 (ambient condition), treatment T5 garnered the highest mean sensory evaluation for overall acceptance (6.81), followed by treatments T4 and T3. Conversely, treatment T1 had the lowest mean score (6.19), closely followed by treatment T2. Throughout the 90-day ambient storage period, the storage duration notably influenced the sensory evaluation for overall acceptability, starting at a significantly higher score (7.46) and decreasing to 5.81 after 90 days. Importantly, the interaction effect between treatments and ambient storage duration on overall acceptability was statistically non-significant.

Table 8 (refrigeration condition) demonstrates that treatment T5 also displayed the highest mean score (7.69), comparable to treatment T4, while treatment T1 had the lowest mean score (6.79), followed by treatment T2. Refrigeration storage similarly had a substantial impact on overall acceptability sensory evaluation, with scores starting higher (8.16) and declining to 6.75 after 90 days. The interaction effect between treatments and refrigeration duration on overall acceptability was also found to be statistically non-significant.

In summary, both ambient and refrigeration storage conditions, along with varying sodium benzoate concentrations, significantly affected the overall acceptability of kokum rind juice over the 90-day storage period.

Treatment	Sensory evaluation for overall acceptability				
	Storage period (Days)				
	0	30	60	90	Mean
T1	7.1	6	6.1	5.6	6.19
T2	7.4	6.3	6.4	5.7	6.4
T3	7.5	6.3	6.4	5.6	6.42
T4	7.7	6.3	6.6	6	6.64
T5	7.7	6.5	6.8	6.3	6.81
Mean	7.5	6.3	6.4	5.8	
		S.Em ±		CD at 5%	
Treatment(T)		0.03		0.1	
Storage(S)		0.03		0.09	
Interaction (TxS)		0.07		NS	

Table 7: Effect of sodium benzoate concentrations on overall acceptability of kokum rind juice under ambient storage conditions

Treatment	Overall acceptability				
	Storage period (Days)				
	0	30	60	90	Mean
T1	7.9	6.9	6.3	6.1	6.79
T2	8.2	7.1	6.9	6.5	7.16
T3	8.1	7.2	7.2	6.8	7.31
T4	8.3	7.5	7.1	7.1	7.48
T5	8.4	7.5	7.5	7.4	7.69
Mean	8.2	7.2	7	6.8	
		S.Em ±		CD at 5%	
Treatment(T)		0.09		0.25	
Storage(S)		0.08		0.23	
Interaction (TxS)		0.17		NS	

Table 8: Effect of sodium benzoate concentrations on overall acceptability of kokum rind juice under refrigeration storage conditions.

Discussion

Microbial Count of Kokum Rind Juice During Storage

The study revealed that microbial growth in kokum rind juice decreased with increasing sodium benzoate concentration. The microbiological count remained within the permitted safety levels in both storage conditions. However, refrigeration proved particularly effective in managing microbial development over 90 days. Similar findings were observed in studies on Nigerian fruit juice by Oladipo [9], apple and apricot combo juice by Hussain, et al. [10], spicy radish juice by Kumar, et al. [11], and kinnow juice by Bhardwaj, et al. [12].

Sensory Quality Parameters of Kokum Rind Juice during Different Storage Conditions

For ready-to-serve (RTS) kokum rind juice, a recipe consisting of 6% juice, 12.5% total soluble solids (TSS), and 0.28% acidity was used. A panel of six judges evaluated the organoleptic quality on a 9-point Hedonic scale at 30-day intervals, considering color, flavor, and general acceptability.

Color: Tables 3 and 4 present the findings for the color score of RTS kokum rind juice. Judges praised the color of kokum juice RTS across all treatments. However, significant disparities were noted across treatments, with varying doses of sodium benzoate showing a tendency for color diminishment. After 90 days of storage, the sensory evaluation for color significantly declined, possibly due to a decrease in anthocyanin content. Similar effects were observed in kinnow juice by Ranote, et al. [13], Perlette grape juice by Masoodi, et al. [14], and other juices, as reported by Hiremath, et al. [15]. These findings align with Zeb, et al. [16], who noticed a decline in the color of grape juice preserved with sodium benzoate and potassium sorbate after one month at room temperature.

Flavor: The sensory evaluation for flavor of kokum rind juice is shown in Tables 5 (ambient condition) and 6 (refrigeration condition). The various treatments and storage times had a substantial impact on the sensory scores. Initially, the sensory evaluation for flavor was significantly affected by storage conditions. From the beginning and every 30 days up to 90 days, the ambient storage condition resulted in a lower sensory evaluation for flavor compared to the refrigerated condition. These findings are consistent with earlier studies showing changes in grape juice flavor after a month of storage at ambient temperature with potassium sorbate and sodium benzoate. Ayub, et al. [17] observed a deterioration in the flavor of pomegranate syrup maintained at room temperature for four months under various lighting conditions and packing materials. Similarly, Nilugin, et al. [18] found that ready-to-drink beverages made from palmyrah fruit pulp lost some flavor after six months at room temperature.

Overall Acceptability: Tables 7 and 8 show that under both ambient and refrigerated storage conditions, the overall acceptability of kokum rind juice was significantly impacted by different sodium benzoate concentrations and storage times. There was also a statistically significant interaction between treatment effects and storage duration. Kokum RTS made from juice in treatment T5 outperformed treatments T3 and T4, having the highest mean score (6.81 under ambient and 7.69 under refrigeration) for overall acceptance. Overall acceptability scores showed a considerable drop at the end of both storage conditions, but kokum RTS from all treatments remained palatable for the full 90 days of refrigerated storage. It was established that kokum rind juice with 1500 ppm sodium benzoate stored under refrigeration is superior to kokum rind juice with 750, 1250, or 1000 ppm sodium benzoate stored under refrigeration. Similar findings were reported in studies on kinnow juices by Ranote, et al. [13], Masoodi, et al. [14], Panesar, et al. [19], and Hiremath, et al. [15]. Studies conducted by Sandhan, et al. [20], Kute, et al. [21] for sapota pulp, and Chauhan, et al. [22] for sugarcane juice discovered that ambient storage conditions caused pomegranate juice beverages to lose their overall acceptance score more quickly than cold storage conditions.

Conclusion

In conclusion, this study demonstrated that the optimal preservation method for kokum rind juice involves using 750 ppm sodium benzoate and storing it at 5°C. This combination effectively maintained the juice's microbial safety, sensory quality, and overall acceptability for up to three months. Both ambient and refrigerated conditions were evaluated, with refrigeration showing superior results in maintaining juice quality. The research highlights the importance of specific preservative concentrations and storage temperatures in extending the shelf life of kokum rind juice. These findings provide valuable insights for producers aiming to maintain the juice's desirable properties while ensuring consumer safety. This study contributes to the broader understanding of effective preservation techniques for fruit juices.

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