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Analysis of nutritional quality and assessment of microbial safety during the storage of karonda sweet sauce

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Abstract
Standardization and examination of the karonda sweet sauce were performed to assess changes in its nutritional value through out storage. Research at ambient temperature indicated a TSS of 42.50 °Brix, titratable acidity of 1.30%, pH of 3.48, total sugars at 34.91%, and reducing sugars at 14.08% after a six-month storage duration. Throughout the six months of storage, there was an absence of bacterial and mould growth. While the sensory ratings for colour, flavour, texture, taste, and overall acceptability diminished over time, the overall acceptability at the end of this period was still rated at 7.60, which falls within the 'Like moderately' range. The nutritional value and overall acceptability demonstrated the feasibility of using karonda fruits for the preparation of karonda sweet sauce.

Keywords: Karonda, value addition, sweet sauce, nutritional value, storage studies, processing

Introduction
Karonda is a resilient, drought-resistant crop that originates from the Indian subcontinent. This evergreen shrub thrives even in marginal and subpar soil conditions, where many other fruit varieties either struggle to grow or yield unsatisfactory results (Tripathi *et al*., 2014) [14]. Karonda helps in tackling various health concerns like intestinal worms, diarrhea, and skin conditions. It demonstrates properties that are anti-inflammatory, antipyretic, antiviral, and anti-convulsant, among others (Kumar *et al*., 2013) [7]. Karonda fruit serves as a rich source of essential minerals, especially iron and calcium. It is also high in pectin. However, in spite of its nutritional advantages, Karonda is not commonly regarded as a dessert fruit, and its cultivation is mainly limited to bio fencing because the fruits possess a slightly sour and astringent taste (Bajpai *et al*., 2015) [2]. Karonda is used as bio fence owing to its spiny nature. Fresh karonda fruits cannot be consumed in significant amounts because of their highly acidic characteristics and astringency. Furthermore, the storage duration of karonda is very brief due to its soft flesh and elevated moisture content. Unripe fruits that are harvested at maturity can be stored for 5 to 7 days at room temperature, but once they reach ripeness, they can only be kept for up to two days (Srivastava *et al*., 2017) [13]. Converting karonda into a range of shelf-stable products improves the fruit's desirability and marketability. This also caters to the shifting preferences of consumers towards natural health supplements and functional foods. The current research aims to analyze nutritional changes and microbial safety over the storage period of karonda sweet sauce.

Materials and Methods
The research on the integration of karonda for the preparation of sweet sauce was carried out at the Department of Fruit Science laboratory, College of Horticulture, Rajendranagar, Hyderabad, SKLTGHU and the Central Instrumentation Cell, PJTAU in the year 2018. Ripe karonda fruits were sourced from the Fruit Research Station in Sangareddy, SKLTGHU for the research, while other ingredients required for preparation were acquired from the local market.

pH: 10 g sample was macerated in 100 ml of distilled water. The supernatant was then employed to ascertain the pH with pH meter.

TSS (^{0}Brix): Digital refractometer was used to analyse the total soluble solids and expressed as ^{0}Brix

Total and Reducing sugars (%): The quantification of total and reducing sugars was carried out using the titrimetric procedure described by Ranganna (1986) [17], employing Fehling's solutions A and B.

Calculations

$$\text{Reducing sugar (\%)} = \frac{\text{mg of invert sugar} \times \text{dilution} \times 100}{\text{weight of the sample x Titre value} \times 100}$$

$$\text{Total sugars as invert sugars (\%)} = \frac{\text{Factor x Volume made up x Dilution x 1000}}{\text{Weight of sample taken x Titre}}$$

Titrable Acidity (%): The measurement of titrable acidity in the sample was conducted by titrimetric method using phenolphthalein indicator (AOAC, 2000) [2]. 10 g of homogenized sample was made to 100ml using distilled water in a volumetric flask. 10ml of aliquot was titrated against 0.1 N NaOH sodium hydroxide with phenolphthalein indicator. The acidity was quantified in terms of percent citric acid equivalents.

Ascorbic acid (mg/100 g): The estimation of ascorbic acid was conducted using the visual titration method involving 2, 6 dichlorophenol-indophenol dye (AOAC, 2000) [2]. A 5 ml sample of 3% metaphosphoric acid extract was placed in a conical flask and titrated with the standard dye. The endpoint of the titration was indicated by a pink color that persisted for a minimum of 15 seconds.
Calculation:

$$\text{Ascorbic acid (mg/100 g)} = \frac{\text{Dye factor x Titre value x Volume made x100}}{\text{ml of Aliquot for analysis x Volume of sample}}$$

Total Bacterial Count: For each sample, one gram was mixed with 9ml of sterilized distilled water. Following this, 1ml of the homogenized sample was serially diluted ten times (10-1 to 10-10). One ml of liquid from each dilution test tube was then spread onto a Nutrient Agar plate. The inoculated plates were inverted and incubated at 37 °C for a duration of 48 hours. The bacterial colonies were counted using a colony counter. Only plates with a colony count ranging from 30 to 300 were considered. The colony forming units (cfu), was computed as follows:

$$\text{cfu} = \frac{y}{dx}$$

*y refers to Number of colonies formed; d for dilution; x for Volume of sample

Total Mould Count: One gram of sample homogenized with 9ml of sterilized distilled water was serially diluted from 10^{-1}-10^{-10}. Inoculated Rose Bengal agar plates were inverted and incubated at 24 °C for 3-5 days. The numbers of colonies were computed under colony counter

Organoleptic evaluation: A panel consisting of 15 members conducted organoleptic scoring utilizing a scorecard designed for sensory acceptability based on a 9-point hedonic scale. This scale includes descriptive terms that range from 9, indicating 'like extremely', to 1, denoting 'dislike extremely'. Colour, flavour, taste, texture, and overall acceptability of the product were scored (Jones, 1955 and Marek *et al*., 2007) [8, 13].

Statistical analysis: The data's analysis of variance was executed through the application of a Completely Randomized Design (CRD) and was subsequently interpreted.

Results

Karonda sweet sauce was examined for alterations in nutritional quality, microbial safety, and sensory evaluation over a six-month storage period.

pH

The variation in pH during the six-month storage of karonda sweet sauce is detailed in Table 1. Initially, the pH of the karonda sweet sauce was measured at 3.41 right after preparation. A gradual rise in pH was observed when stored for six months, with a significant increase noted only after four months, reaching 3.48. This acidic range may be beneficial in positively contributing to the product's shelf life during storage.
Kumar *et al*. (2015) [8] reported a comparable upward trend in their storage studies involving dehydrated tomato powder-based ketchup, noting a gradual rise in pH over a storage period of 120 days. Likewise, Kumar and Ray (2016) [5] observed similar findings in their research on tomato-mushroom mixed ketchup, which was stored for twelve months at room temperature. In contrast, Jayashree *et al*. (2012) [3] examined five ginger-based sauces and found no significant changes in pH.

Total Soluble Solids (^{o}Brix)

The changes observed in TSS during the six-month storage of karonda sweet sauce are summarized in Table 1. Initially, total soluble solids were recorded at 40.23 ^{0}Brix. TSS significantly rose only noted after three months, with a continued significant rise until the end of the storage period, reaching 42.50 ^{0}Brix. Kumar *et al*. (2015) [8] documented a similar increase in TSS for dehydrated tomato powder-based ketchup over a 120-day storage period. Kumar and Ray (2016) [5] reported comparable results in tomato-mushroom mixed ketchup, whereas Jayashree *et al*. (2012) [3] studied five ginger-based sauces and found no significant variation in TSS.

Titrable acidity (%)

The titrable acidity observed during the six-month storage of karonda sweet sauce is documented in Table 1. The titrable acidity of the freshly prepared preserve was measured at 1.36%, which decreased to 1.30% after six months of storage. No significant changes in titrable acidity were noted up to four months; however, a significant reduction was observed in the later storage periods, resulting in a value of 1.30%. Comparable findings were reported by Jayashree *et al*. (2012) [3] in five ginger-based sauces, and by Kumar *et al*. (2015) [8] in ketchup made from dehydrated tomato powder. Additionally, Kumar and Ray (2016) [5] reported

similar outcomes in tomato-mushroom mixed ketchup during storage.

Total Sugars (%)
The total sugar level in karonda sweet sauce after being stored for six months was assessed and is presented in Table 1. The sugar content of the freshly prepared sweet sauce is recorded at 34.51%, which increased to 34.91% by the end of the storage period. There was no significant rise in total sugar content during the storage period. Similar results were documented by Jayashree *et al*. (2012) [3] in five ginger-based sauces.

Reducing Sugars (%)
The content of reducing sugars during the six-month storage of karonda sweet sauce was documented and is displayed in Table 1. Initially, a reducing sugar content of 11.98% was noted in the freshly prepared karonda sweet sauce, which increased to 14.08% after six months of storage. The significant rise in reducing sugars was observed only after three months of storage, likely due to the hydrolysis of polysaccharides and the conversion of non-reducing sugars into reducing sugars. This increase in reducing sugars may be attributed to the inversion of both total and non-reducing sugars into reducing sugars.
Comparable findings were reported by Kumar and Manimegalai (2001) [6] regarding strawberry sauces stored at room temperature, as well as by Jayashree *et al*. (2012) [3] in their study of five ginger-based sauces.

Ascorbic acid (mg/100 g)
The variations in ascorbic acid levels during the storage of karonda sweet sauce are illustrated in Table 1. The highest ascorbic acid content was observed in karonda sweet sauce right after preparation (35.08 mg/100 g), while the lowest was noted after a six-month storage duration (19.47 mg/100 g). Approximately 44% of ascorbic acid was lost in storage. The significant reduction in ascorbic acid may be attributed to its degradation into dehydroascorbic acid or leaching during storage.
Comparable findings were documented by Rahman *et al*. (2014) [10] in sweet guard ketchup, which was attributed to the oxidation of ascorbic acid. Kumar *et al*. (2015) [8] also reported similar findings in dehydrated tomato powder-based ketchup Kumar and Ray (2016) [5] in tomato-mushroom mixed ketchup, and Singh and Singh (2019) [12] in aonla sauce.

Moisture content (%)
The moisture level was measured at an interval of 30 days for six-months (Table 2). The moisture content of the karonda sweet sauce was determined to be 49.85%, remaining stable for the first four months of storage. A slight change was observed in the later storage period, where it increased to 50.64%. Comparable findings were documented by Jayashree *et al*. (2012) [3] in five ginger-based sauces over a storage duration of 135 days.

Total Bacterial Count
Bacterial growth was tested at monthly intervals over a period of six month (Table 2). The findings indicated that no bacterial growth occurred during the entire study duration. This absence of growth may be attributed to the antimicrobial properties of the spices and vinegar incorporated in the recipe. Proper hygienic handling, processing, and storage practices ensured that the product remained microbiologically safe for six months.

Total Mould Count
Karonda sweet sauce was tested for mould growth at monthly intervals for six months and presented in Table 2. The results revealed that the sauce is safe with out mould growth throughout the six months period. Antimicrobial action of spices and vinegar. hygienic handling might have been contributed for microbial safe shelf life of the product.

Sensory evaluation of Karonda Sweet Sauce
After testing for TMC and TBC karonda sweet sauce was kept for sensory evaluation at monthly intervals by a panel of 15 members, on a 9 point hedonic scale (Figure 1). The sensory scores recorded at the beginning of storage at room temperature were 8.33, 8.47, 8.40, 8.53, and 8.53 for colour, flavour, texture, taste, and overall acceptability, respectively. During the storage period, these sensory scores declined, and by the end of the six-month period, they fell within the "Like moderately" range on the Nine-point Hedonic scale. Notably, the sensory score for overall acceptability exhibited a significant decrease only after four months of storage. These results are consistent with the findings of Rahman *et al*. (2014) [10] regarding sweet gourd ketchup, as well as those of Kumar and Ray (2016) [5] concerning tomato-mushroom mixed ketchup.

Table 1: Variations in the nutritional value of Karonda Sweet Sauce during storage

Storage Period	Chemical properties of Karonda Sweet Sauce during storage					
	pH	TSS(° Brix)	Titrable acidity (%)	Total Sugars (%)	Reducing Sugars (%)	Ascorbic acid (mg/100 g)
0 Months	3.41	40.23	1.36	34.51	11.98	35.08
1 Month	3.41	40.23	1.35	34.51	11.98	33.05
2 Months	3.43	40.27	1.35	34.51	12.00	32.19
3 Months	3.44	40.37	1.33	34.52	12.08	28.00
4 Months	3.45	41.03	1.33	34.53	12.56	25.96
5 Months	3.47	41.77	1.31	34.87	13.11	22.32
6 Months	3.48	42.50	1.30	34.91	14.08	19.47
SEm ±	0.01	0.10	0.01	0.19	0.05	0.39
C.D. at (5%)	0.04	0.29	0.04	NS	0.16	1.18
C.V.	0.57	0.40	1.66	0.97	0.74	2.39

Table 2: Changes in Moisture content, Total Bacterial and Mould count of Karonda Sweet Sauce through out the storage period

Storage Period	Moisture content, Total Bacterial and Mould count of Karonda Sweet Sauce		
	Moisture Content (%)	Total Bacterial Count (Log CFU/g)	Total Mould Count (Log CFU/g)
0 Months	49.85	0.00	0.00
1 Month	49.85	0.00	0.00
2 Months	49.85	0.00	0.00
3 Months	49.87	0.00	0.00
4 Months	49.89	0.00	0.00
5 Months	50.16	0.00	0.00
6 Months	50.64	0.00	0.00
SEm ±	0.02	0.00	0.00
C.D. at (5%)	0.06	0.00	0.00
C.V.	0.07	0.00	0.00

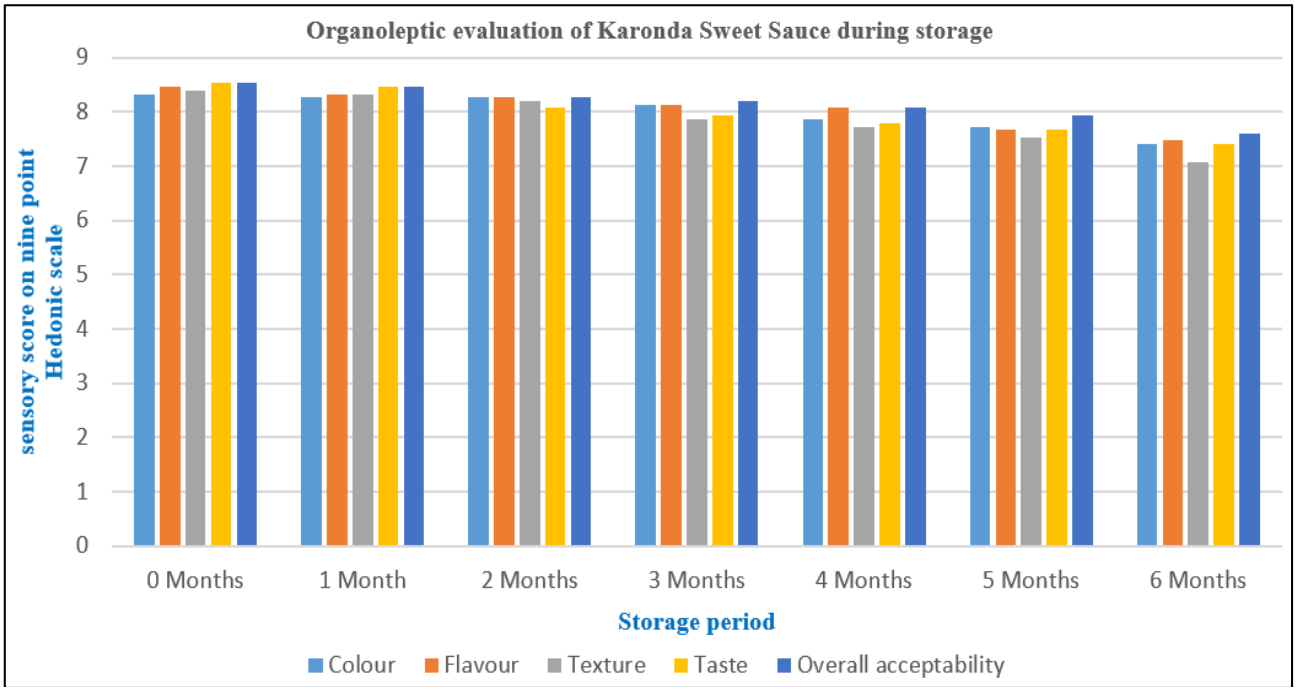

Fig 1: Organoleptic evaluation of Karonda Sweet Sauce during storage

Conclusion

The development of safe and acceptable products will provide promising opportunities for rural communities to secure sustainable livelihoods, thereby achieving both nutritional and economic security. The findings indicated that karonda fruits can be transformed into an acceptable sweet sauce, which can be safely stored for six months while maintaining satisfactory sensory evaluations.

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