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PROTOCOL FOR DEVELOPMENT OF NUTRITIONALLY ENRICHED FRUIT BAR FROM KAMALAPUR RED BANANA

Chaitra[1*], Manjula Karadiguddi[2], Kirankumar Gorabal[3], Kantharaju V.[4] and Nataraja K. H.[5]

[1]Department of Postharvest Management, KRC College of Horticulture, Arabhavi- 591218, University of Horticultural Sciences, Bagalkot, Karnataka, India.
[2]Department of Postharvest Management, College of Horticulture, Sirsi- 581402, University of Horticultural Sciences, Bagalkot, Karnataka, India.
[3]Department of Postharvest Management, College of Horticulture, Bagalkot- 587104, University of Horticultural Sciences, Bagalkot, Karnataka, India
[4]ICAR-AICRP on fruits, KRC College of Horticulture, Arabhavi- 591218, University of Horticultural Sciences, Bagalkot, Karnataka, India
[5]Department of Fruit Science, College of Horticulture, Kolar- 563103, University of Horticultural Sciences, Bagalkot, Karnataka, India
*Corresponding author Email: chaitracs.kst@gmail.com
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ABSTRACT

Kamalapur Red banana, known for its rich nutrient profile used to develop fruit bar using nine recipes which consists of three levels of sugar (20, 25 and 30 g) and three levels of milk powder (without milk powder, 2.5 and 5 g) with Kamalapur Red banana pulp (100g), citric acid (0.3%) and pectin (0.5%). Organoleptically most preferred Kamalapur Red banana fruit bar was prepared by using 100 g banana pulp, 25 g sugar, 2.5 g milk powder, 0.3 per cent citric acid and 0.5 per cent pectin (T_8). This formulation exhibited optimum physico-chemical properties *viz*., moisture content (15.11%) water activity (0.37%), titratable acidity (1.14%) and total sugars (37.40%) throughout the storage period.
Keywords **:** Kamalapur Red banana, Water activity, Milk powder, Physico-chemical, Organoleptic evaluation

Introduction

Banana (Musa sp.), the second most important fruit crop in India after mango is valued for its year-round availability, affordability and exceptional nutritional content. Originating in Southeast Asia, bananas thrive in tropical climates with India being a major centre of production. The modern edible varieties we enjoy today have evolved from two species *viz*., *Musa acuminata* and *Musa balbisiana*. In India, the estimated area, production and productivity of banana are 995.19 thousand hectares, 37474.18 thousand MT and 37.66 MT/ha, respectively. However, Tamil Nadu, Maharashtra, Gujarat, Andhra Pradesh and Karnataka have ideal conditions for its growth and production. Karnataka state alone has an area of 113.73 thousand hectares and production of 3121.97 thousand MT with the productivity of 27.45 MT/ha (Indiastatagri, 2024).

Red banana, known for its reddish-purple skin is a distinct variety grown in regions like Kerala and Tamil Nadu. With a creamy, light pink flesh and a mango-like flavour when ripe, red bananas are packed with potassium, vitamin C, β-carotene, phenolic compounds, tannins, anthocyanins and natural antioxidants (Thiruppathi *et al*., 2023). Kamalapur Red banana, a unique variety from the Kalburgi district of Karnataka holds Geographical Indication (GI) status and is prized for its vibrant colour, creamy texture and rich nutrient profile (NRCB, 2022). Kamalapur Red banana is nutritionally superior to other red banana varieties, serving as an excellent source of protein, β-carotene, vitamin C and antioxidants.

The rich nutrient profile of Kamalapur Red banana makes it ideal for developing healthier product such as fruit bars. With various types of fruit bars available in the market, there is an opportunity to

develop a highly nutritious fruit bar using Kamalapur Red banana, offering a novel and healthful product option. So, the present study was conducted with an objective to develop the protocol for preparation of fruit bar from Kamalapur Red banana and to analyze the stability of fruit bar during storage.

Material and Methods

An experiment was carried out during 2023-24 in the Department of Postharvest Management, KRC College of Horticulture, Arabhavi (UHS, Bagalkot), Karnataka. The design of the experiment was CRD with nine treatments and three replications. Treatments were: T_1 = 100g pulp + 20g sugar, T_2 = 100g pulp + 20g sugar + 2.5g milk powder, T_3 = 100g pulp + 20g sugar + 5g milk powder, T_4 = 100g pulp + 25g sugar, T_5 = 100g pulp + 25g sugar + 2.5g milk powder, T_6 = 100g pulp + 25g sugar + 5g milk powder, T_7 = 100g pulp + 30g sugar, T_8 = 100g pulp + 30g sugar + 2.5g milk powder, T_9 = 100g pulp + 30g sugar + 5g milk powder and constant amount of citric acid (0.3%) and pectin (0.5%) was added to all the treatments. Ripe fruits were separated, washed, blanched and cooled before peeling. The peeled fruit pulp was blended into a smooth paste and boiled to this, sugar and milk powder were added according to the treatment combinations. Potassium metabisulphite (KMS) at 350 ppm was incorporated uniformly. The pulp mixture was thoroughly blended, poured into trays and dried in a EZI dryer at 70°C for 10-12 hours. The dried sheet was flipped for uniform drying, cut into 3×2×1.5 cm pieces, wrapped in aluminium foil with butter paper and stored at room temperature.

Nutritional composition of Kamalapur Red banana used for the preparation of fruit bar was analysed on dry weight basis (Table 1).

The moisture content of Kamalapur Red banana fruit bars was measured using a moisture analyzer (Model: P1019319, A & D Company Limited, Japan). The water activity was measured using a digital water activity meter (Model: Novasia AG, Switzerland). Titratable acidity (%) and ascorbic acid (mg/100g) were estimated as per the modified procedure of AOAC (Anon., 1984). The total sugar content in the samples was determined using the Dinitro-salicylic acid (DNSA) method as described by Miller (1972). The β-carotene and crude fibre content were determined as outlined by Ranganna (2010). The organoleptic characters were evaluated by panel of semi-trained judges consisting of teachers and postgraduate students of KRC College of Horticulture, Arabhavi, on a nine-point hedonic scale as per the method of Meilgaard *et al*. (2006). Data interpretation was done in accordance with Panse and Sukhatme (1985).

Table 1 : Nutritional compositional of Kamalapur Red banana flour

Nutrients	Composition
Carbohydrate	81.73%
Protein	6.02%
Fat	1.24%
β-carotene	930.94 µg/100g
Antioxidant activity	87.13%
Titratable acidity	1.76%
Ascorbic acid	12.51%
Vitamin A	1551.57 IU
Vitamin B_6	59.12 ng/g
Vitamin B_{12}	0.33 ng/g
Phosphorous	0.72%
Potassium	1.30%
Calcium	5.57%
Magnesium	9.82%
Iron	0.21%

Results and Discussion

Moisture content and water activity

The results indicate a decrease in both moisture content and water activity with higher sugar and milk powder concentrations in the banana fruit bars (Fig. 1). Treatment T_9 had the lowest moisture and water activity (14.90% and 0.35 a_w, respectively), while T_1 had the highest (17.70% and 0.51 a_w, respectively) after three months of storage. The reduction might be due to hygroscopic and water binding nature of sugar and moisture absorbing property of milk powder. A steady decline in moisture and water activity across all treatments observed during storage was likely due to natural dehydration and storage temperature changes (Fig. 2). These results align with similar studies on fruit bars by Vu *et al*. (2023) in mango fruit bar, Awati *et al*. (2022) in sapota-based mixed fruit bars, Gorabal (2020) in wood apple fruit bar and Kumar *et al*. (2017) in papaya-guava fruit bars.

Titratable acidity and total sugars

Increased sugar and milk powder concentrations in Kamalapur Red banana fruit bars reduced titratable acidity and increased total sugars (Fig. 3). After three months, T_1 had the highest titratable acidity (1.43%) and lowest total sugars (31.75%), while T_9 showed the lowest titratable acidity (1.11%) and highest total sugars (37.49%). The decreased titratable acidity in T_9 was likely due to dilution, while the total sugar rise reflects added and inherent sugars. These findings are consistent with prior studies by Nimgade *et al*. (2019) in guava fruit bar, Biswas *et al*. (2019) in pineapple fruit bar. Over 90 days, titratable acidity dropped from

1.46 to 1.25 per cent, while total sugars increased from 34.58 to 34.77 per cent which might be due to acid-sugar conversion and polysaccharide breakdown (Fig. 4) consistent with trends observed in wood apple and guava bars (Choudhary *et al*., 2023 and Raut *et al*., 2021, respectively).

β-carotene and crude fibre content

No significant difference was found between treatments for β-carotene and crude fibre content (Table 2) which might be due to the use of same concentration of Kamalapur Red banana pulp in all the treatments. β-carotene showed a slight decline from 98.07 to 97.75 µg/100g during storage, likely due to auto-oxidative degradation of carotenoids. Similar findings were reported by Singh *et al*. (2020) in guava-papaya leather and Ghimire and Ojha (2016) in papaya-soy leather.

Minerals

The data showed no significant variation in phosphorus and potassium levels which might be due to the presence of same concentration of pulp in all the treatments but calcium content varied across treatments (Fig. 5). Treatments with 5 g of milk powder (T_3, T_6 and T_9) had the highest calcium with T_9 reaching 0.67 per cent, while treatments without milk powder (T_1, T_4 and T_7) had the lowest (0.24–0.29%). This indicates a clear link between milk powder quantity and calcium content. Previous studies including Raut *et al*. (2021) in wood apple bar and Attri *et al*. (2014) in papaya leather have similarly noted minimal changes in mineral composition during storage.

Organoleptic evaluation

Among all treatments (Fig. 6), T_8 achieved the highest scores for colour and appearance (8.39), flavour (8.39) and overall acceptability (8.24), while T_9 received the highest score for texture (8.22). Irrespective of the treatment combination there was a gradual decline in overall acceptability from initial to three months of storage as observed in fig. 7 which might be attributed to temperature fluctuation which is known to accelerate undesirable biochemical reactions, as reported in similar studies by Raut *et al*. (2021), Gorabal (2020) in wood apple fruit bar, Kumar *et al*. (2017) in papaya-guava fruit bar and Vagadia *et al*. (2016) in papaya-banana fruit bar.

Conclusion

The Kamalapur Red banana fruit bar formulated with 100 g pulp, 30 g sugar, 2.5 g milk powder, 0.3 per cent citric acid and 0.5 per cent pectin (T_8) demonstrated superior acceptability across all sensory parameters throughout the study. While marginal changes in chemical composition, such as an increase in total sugars and decrease in moisture, β-carotene and crude fibre, were observed during the three-month storage period, this formulation consistently maintained higher organoleptic scores. These findings suggest that this specific recipe is optimal for producing high-quality, consumer-preferred fruit bars with stable physico-chemical properties over time.

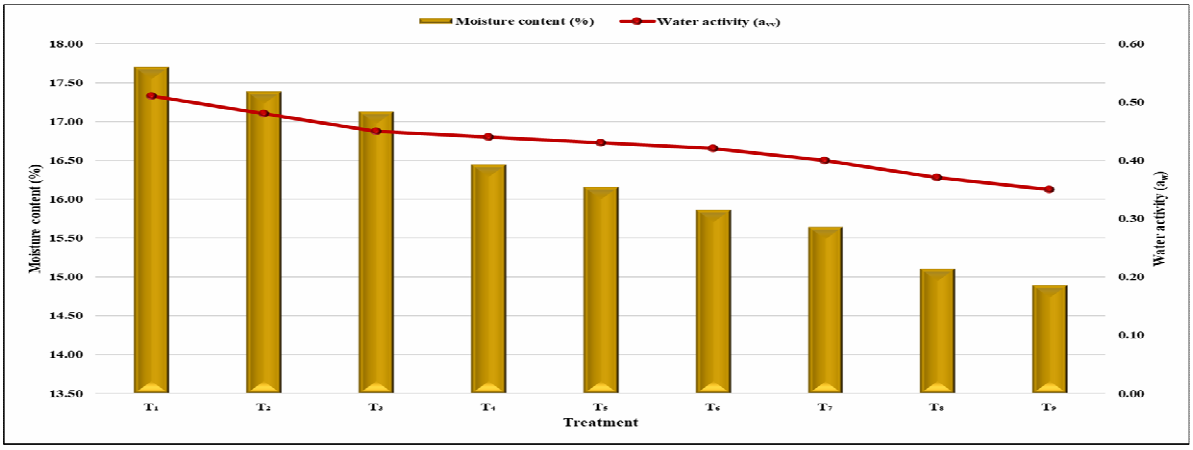

Fig. 1 : Effect of different treatment combinations on moisture content and water activity of Kamalapur Red banana fruit bar

Treatment details

T_1 - 100 g pulp + 20 g sugar + 0.3 per cent citric acid + 0.5 per cent pectin
T_2 - 100 g pulp + 20 g sugar + 2.5 g milk powder + 0.3 per cent citric acid + 0.5 per cent pectin
T_3 - 100 g pulp + 20 g sugar + 5 g milk powder + 0.3 per cent citric acid + 0.5 per cent pectin
T_4 - 100 g pulp + 25 g sugar + 0.3 per cent citric acid + 0.5 per cent pectin
T_5 - 100 g pulp + 25 g sugar + 2.5 g milk powder + 0.3 per cent citric acid + 0.5 per cent pectin
T_6 - 100 g pulp + 25 g sugar + 5 g milk powder + 0.3 per cent citric acid + 0.5 per cent pectin
T_7 - 100 g pulp + 30 g sugar+ 0.3 per cent citric acid + 0.5 per cent pectin
T_8 - 100 g pulp + 30 g sugar + 2.5 g milk powder + 0.3 per cent citric acid + 0.5 per cent pectin
T_9 - 100 g pulp + 30 g sugar + 5 g milk powder + 0.3 per cent citric acid + 0.5 per cent pectin

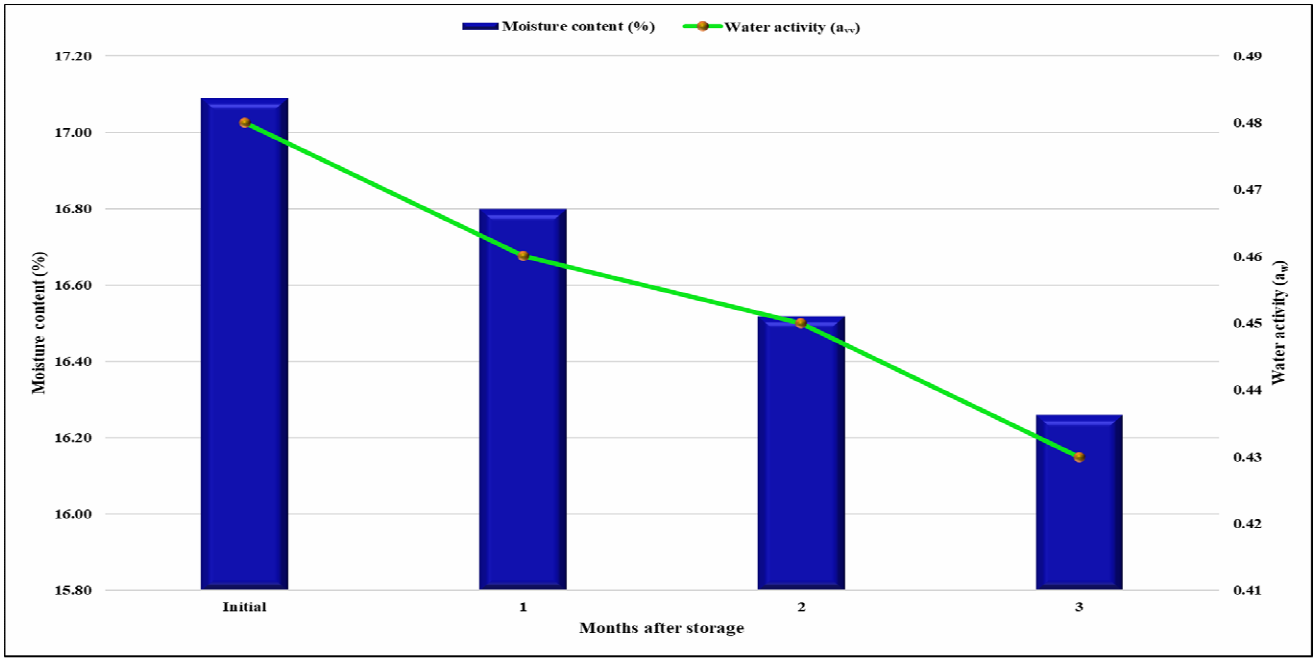

Fig 2 : Effect of storage period on moisture content and water activity of Kamalapur Red banana fruit bar

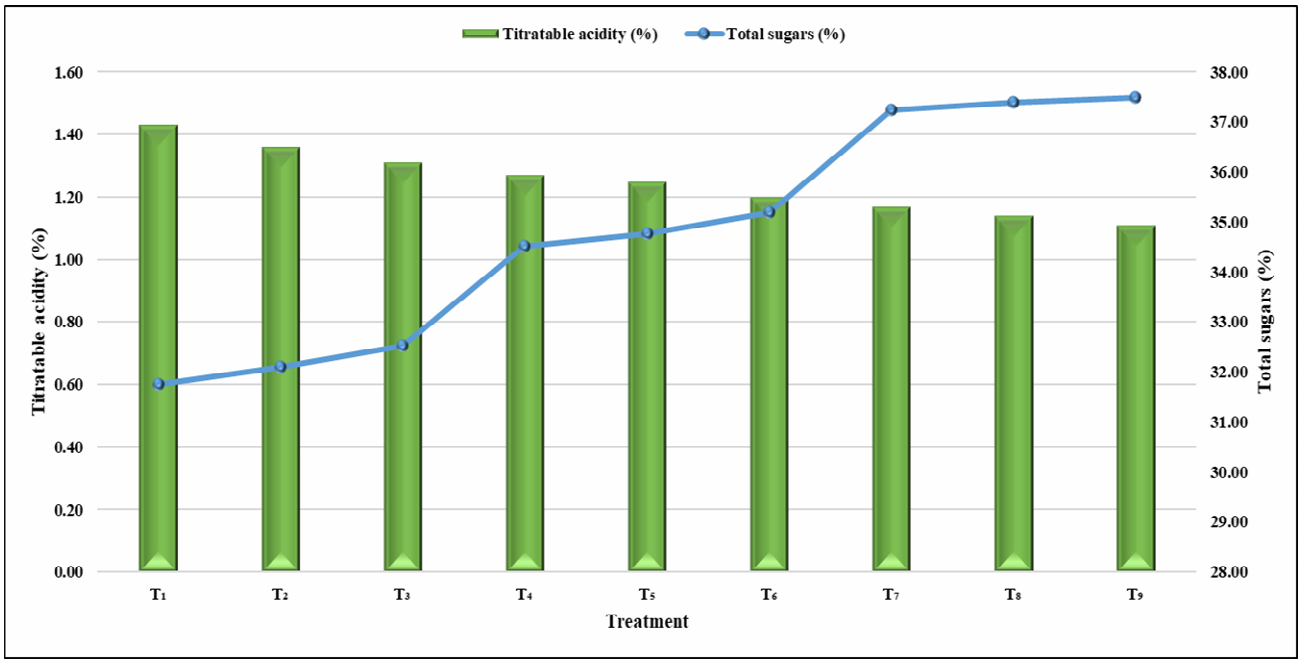

Fig. 3 : Effect of different treatment combinations on titratable acidity and total sugars of Kamalapur Red banana fruit bar

Treatment details

T_1 - 100 g pulp + 20 g sugar + 0.3 per cent citric acid + 0.5 per cent pectin
T_2 - 100 g pulp + 20 g sugar + 2.5 g milk powder + 0.3 per cent citric acid + 0.5 per cent pectin
T_3 - 100 g pulp + 20 g sugar + 5 g milk powder + 0.3 per cent citric acid + 0.5 per cent pectin
T_4 - 100 g pulp + 25 g sugar + 0.3 per cent citric acid + 0.5 per cent pectin
T_5 - 100 g pulp + 25 g sugar + 2.5 g milk powder + 0.3 per cent citric acid + 0.5 per cent pectin
T_6 - 100 g pulp + 25 g sugar + 5 g milk powder + 0.3 per cent citric acid + 0.5 per cent pectin
T_7 - 100 g pulp + 30 g sugar+ 0.3 per cent citric acid + 0.5 per cent pectin
T_8 - 100 g pulp + 30 g sugar + 2.5 g milk powder + 0.3 per cent citric acid + 0.5 per cent pectin
T_9 - 100 g pulp + 30 g sugar + 5 g milk powder + 0.3 per cent citric acid + 0.5 per cent pectin

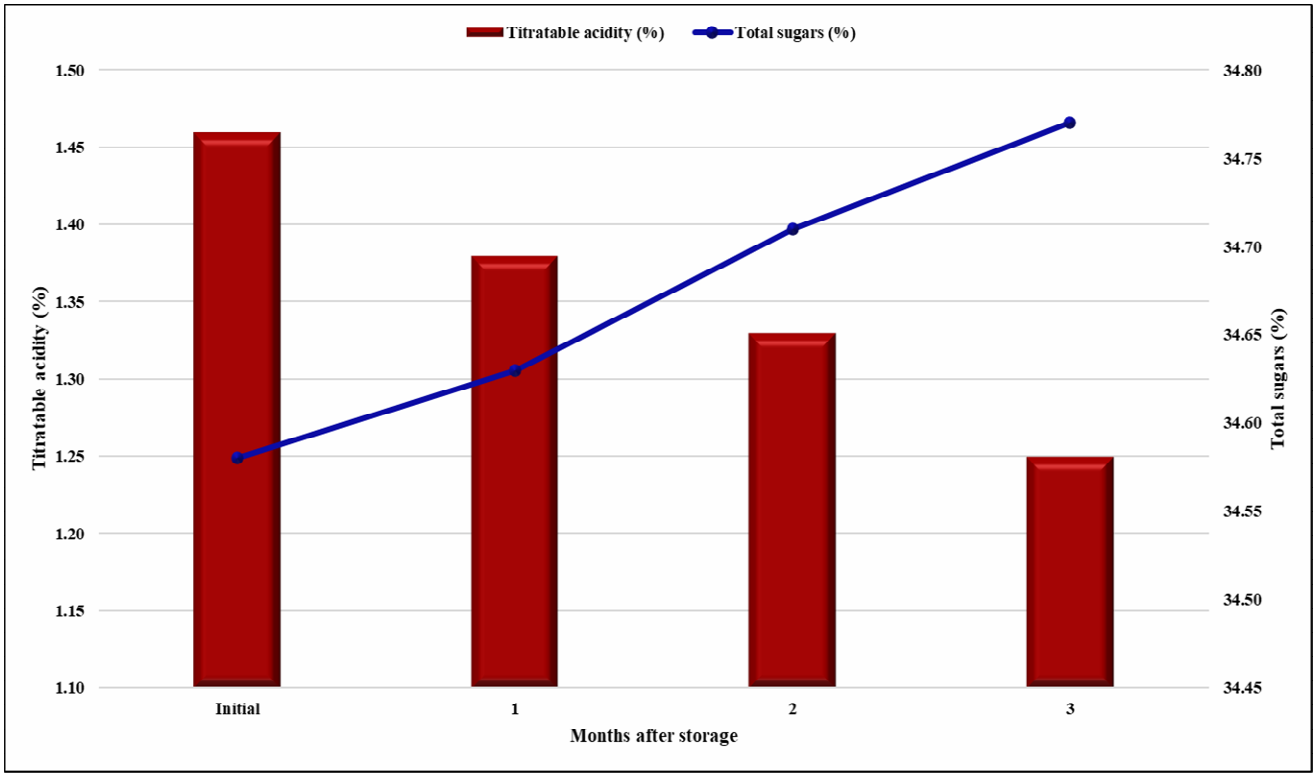

Fig. 4 : Effect of storage period on titratable acidity and total sugars of Kamalapur Red banana fruit bar

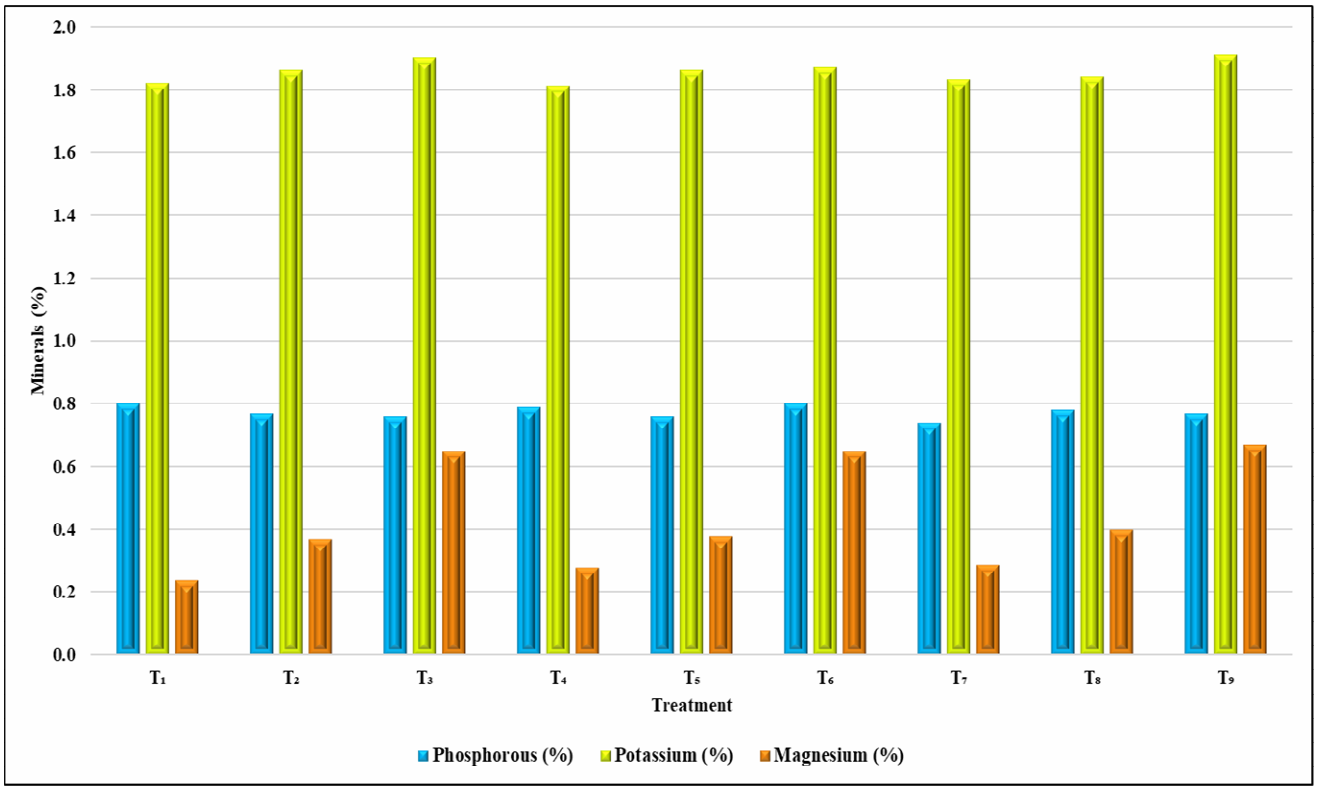

Fig. 5 : Effect of different treatment combinations on mineral content of Kamalapur Red banana fruit bar

Table 2 : Effect of different treatment combinations and storage period on β-carotene and crude fibre of Kamalapur Red banana fruit bar

Treatments	β-carotene (µg/100g)				Crude fibre (%)			
	Months after storage							
	Initial	1	2	3	Initial	1	2	3
T_1	98.45	98.32	98.19	98.07	1.50	1.48	1.47	1.45
T_2	98.21	98.16	98.04	97.93	1.47	1.46	1.43	1.42
T_3	98.20	98.08	97.96	97.89	1.46	1.45	1.43	1.41
T_4	98.15	97.99	97.91	97.84	1.45	1.43	1.41	1.40
T_5	98.09	97.87	97.81	97.74	1.41	1.40	1.39	1.37
T_6	97.92	97.85	97.75	97.69	1.40	1.38	1.36	1.35
T_7	97.89	97.78	97.69	97.61	1.38	1.37	1.36	1.34
T_8	97.75	97.68	97.61	97.54	1.38	1.36	1.34	1.33
T_9	97.71	97.63	97.56	97.47	1.37	1.35	1.33	1.31
Mean	**98.07**	**97.93**	**97.84**	**97.75**	**1.42**	**1.41**	**1.39**	**1.37**
S.Em±	2.03	2.02	1.98	1.93	0.06	0.03	0.05	0.04
C.D.@1%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

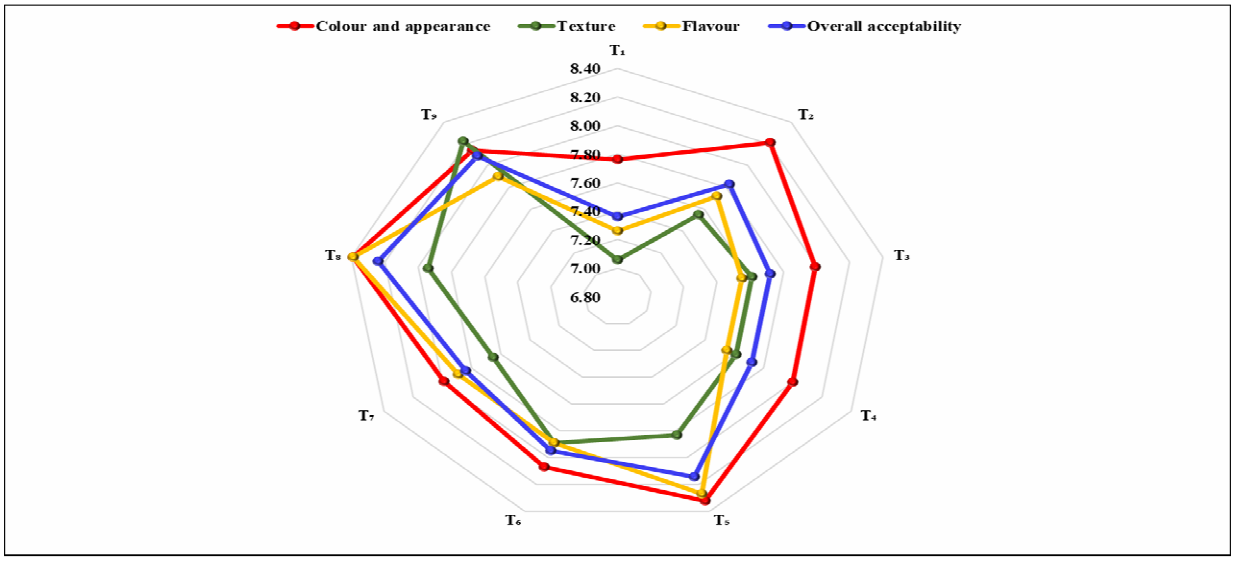

Fig. 6 : Effect of different treatment combinations on colour and appearance, texture, flavour and overall acceptability scores (9-point hedonic scale) of Kamalapur Red banana fruit bar

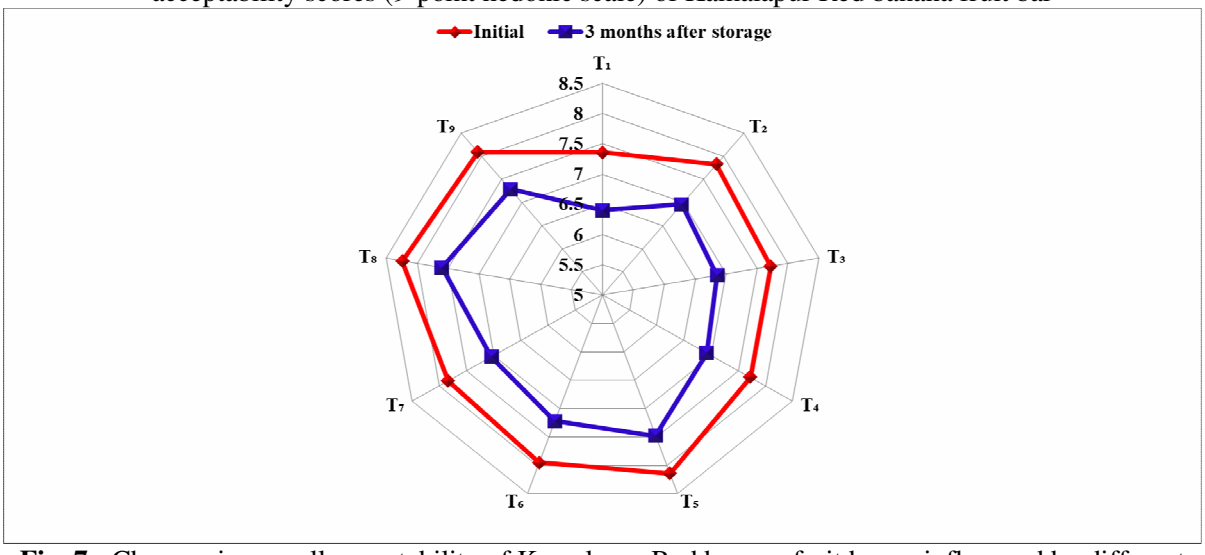

Fig. 7 : Changes in overall acceptability of Kamalapur Red banana fruit bar as influenced by different treatments during initial and three months after storage

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