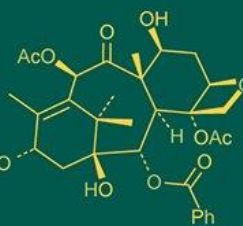
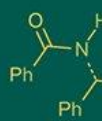


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Interactive effects of maltodextrin concentration, inlet air temperature and storage period on the sensory quality of spray-dried noni (*Morinda citrifolia* L.) juice nutraceutical powder

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Abstract

The optimization of nutraceutical encapsulated spray dried powder from underutilized fruits has gained increasing attention due to their potential health benefits and functional properties. Noni is recognized for its bioactive compounds; however, its strong inherent odor and bitter taste limit the consumer acceptability. The experiment was conducted by using twelve treatment combinations comprised of four levels of maltodextrin (6, 8, 10 and 12%) and three levels of inlet air temperature (155, 160 and 165 °C) were laid out in CRD with Factorial concept. Organoleptic evaluation with respect to colour, flavor, taste, texture and overall acceptability were carried out periodically during 0, 3 and 6 months of storage.

The Findings from the experiment revealed that spray-dried noni juice powder produced the highest taste score (8.11), texture score (8.39) and maximum overall acceptability score (7.77) was observed in noni spray dried powder prepared with maltodextrin 10 per cent at an inlet air temperature of 155 °C (M₃T₁). Although sensory scores declined progressively across all treatments during storage, the encapsulated spray-dried noni juice powder maintained acceptable sensory quality for up to six months.

Keywords: Noni, spray drying, maltodextrin, sensory quality, storage stability, nutraceutical powder

1. Introduction

Noni-Indian mulberry, *Morinda citrifolia* L.: The botanical name for the genus was derived from the two Latin words morus, mulberry, and indicus, Indian, in reference to the similarity of the fruit of Noni to that of true mulberry (*Morus alba*) (Singh *et al.*, 2011) [13]. This is based on the comparative richness of the Indian subcontinent in floristic and crop diversity, higher levels of plant species endemism, prominent occurrence of the family Rubiaceae and the genus *Morinda* (Singh, 2016) [14].

Morinda citrifolia L. (Noni-Indian mulberry) has gained considerable scientific attention owing to its rich nutritional profile and diverse phytochemicals. Noni fruit exhibits strong antioxidant activity and has been associated with DNA protection, blood lipid normalization, enhanced bone mobility, improved physical endurance, and immune system activation. A key volatile compound, 3-methyl-2/3-butenyl ester, present particularly in ripened and fermented juice, demonstrates antioxidant and antitumor properties (Wall *et al.*, 2017) [15]. The plant shows a wide range of therapeutic activities including antimicrobial, analgesic, anti-inflammatory, anticancer, antihelminthic, hypotensive, and hypolipidemic effects (Wang *et al.*, 2002; Shoeb *et al.*, 2016). [16, 12]. Traditionally, noni is used for managing CNS disorders and improving memory function (Pachauri *et al.*, 2012) [9]. Beyond medicinal uses, various parts of the plant have practical applications: leaves are consumed as herbal remedies and used in poultices; roots and bark provide natural dyes; seeds yield cosmetic-grade oil; while fruits are processed into noni juice, vinegar, wine, candies, gummies, herbal teas, capsules, and functional beverages (Chan-Blanco *et al.*, 2006; Nelson and Elevitch, 2006) [2, 8]. These diverse applications highlight the plant's value in traditional medicine, modern nutraceutical industries, and functional food development. Due to the strong pungent flavour and acrid taste, consumption and acceptance of fresh fruit and juice is limited; therefore,

It is necessary to mask the present flavour and taste by processing. Among the various drying methods, spray drying encapsulation technology is one of the most efficient and widely used methods for encapsulating bioactive compounds especially for the conversion of juice into encapsulated powders (Garofulic *et al.*, 2016 Nelson and Elevitch, 2006) [5, 8]. Encapsulation has been widely used in the chemical, pharmaceutical and food industries to protect bioactive compounds from environmental conditions such as temperature, pH 4 and light (Mousavi *et al.*, 2022) [7]. Encapsulation can also improve the characteristics of bioactive compounds, such as increased solubility in water. The present research focuses on developing and optimizing a spray-dried powder with enhanced nutraceutical properties for applications in the pharmaceutical, dietary supplement, and functional food industries, emphasizing improved bioavailability, stability, and scalability.

2. Materials and Methods

2.1 Raw materials

Fully ripe noni fruits were collected from Navsari Agricultural University, Navsari campus. All chemicals used in this investigation were of analytical grade.

2.2 Noni juice extraction

Fully ripe noni fruits free from any infection were selected, washed thoroughly with potable water, and air-dried. Enzymatic treatment was given to crushed fruits with 0.1% pectinase for 3 hours to obtain higher juice recovery. The noni juice was extracted by hydraulic juice extractor then juice was filtered and pasteurized at 96 °C, packed in glass bottles and further processed at 96 ± 1 °C for 30 minutes.

2.3 Methodology for noni juice spray dried powder

Noni juice was first blended with maltodextrin at varying concentrations ranging from 6 to 12% (w/w). Maltodextrin

was incorporated as a carrier agent to improve drying efficiency, reduce stickiness during spray drying and enhance the overall powder stability. The resulting mixture, referred to as the feeding solution, was homogenized using a magnetic stirrer operated at a speed of 1500 rpm for a duration of 15 minutes. Following homogenization, the solution was filtered through a muslin cloth to remove coarse particles and insoluble matter. The clarified filtrate thus obtained was used as the feeding solution for the spray drying operation. Spray drying of the filtrate was performed using a laboratory scale spray dryer (model SPD-P-111, Techno search Instruments, Thane). The inlet air temperature of the spray dryer was regulated between 155 and 165 °C according to the experimental treatments. Simultaneously, the outlet air temperature was maintained at 100 °C. The feeding solution was continuously delivered into the spray dryer at a fixed feed rate of 1 mL/min., where it was atomized through a nozzle into fine droplets. The collected powder was immediately transferred into clean, dry glass bottles of 25 cc capacity, properly labelled and stored at ambient temperature.

2.4 Statistical analysis

The experimental data were statistically analysed using the analysis of variance (ANOVA) technique under Completely Randomized Design (CRD) with factorial concept as described by Panse and Sukhatme (1985) [10]. The significance of treatment differences was tested by the 'F' test based on the null hypothesis. Standard Error of Mean (SEm±) was calculated for each character, and treatment means were compared using Duncan's New Multiple Range Test (DNMRT) at 5% level of significance whenever the treatment effects were found significant. The coefficient of variation (CV%) was also calculated to assess the extent of variability among the experimental units.

Table 1: Treatment combinations used for the quality of spray dried noni juice powder

Sr. No.	Treatment combinations	Treatment details
1.	M ₁ T ₁	Maltodextrin 6% + Inlet air temperature 155 °C
2.	M ₁ T ₂	Maltodextrin 6% + Inlet air temperature 160 °C
3.	M ₁ T ₃	Maltodextrin 6% + Inlet air temperature 165 °C
4.	M ₂ T ₁	Maltodextrin 8% + Inlet air temperature 155 °C
5.	M ₂ T ₂	Maltodextrin 8% + Inlet air temperature 160 °C
6.	M ₂ T ₃	Maltodextrin 8% + Inlet air temperature 165 °C
7.	M ₃ T ₁	Maltodextrin 10% + Inlet air temperature 155 °C
8.	M ₃ T ₂	Maltodextrin 10% + Inlet air temperature 160 °C
9.	M ₃ T ₃	Maltodextrin 10% + Inlet air temperature 165 °C
10.	M ₄ T ₁	Maltodextrin 12% + Inlet air temperature 155 °C
11.	M ₄ T ₂	Maltodextrin 12% + Inlet air temperature 160 °C
12.	M ₄ T ₃	Maltodextrin 12% + Inlet air temperature 165 °C

2.4 Sensory evaluation

Noni juice spray dried powder was evaluated for colour, taste, flavour, texture and overall acceptability, using a 9-point Hedonic scale, where 9 = like extremely and 1 = dislike extremely, as described by Ranganna (2018) [11]. Eight sensory panel members, comprising faculty members and PG students from the Department of Post-Harvest Technology, NAU, Navsari, Gujarat, were involved in the sensory evaluation. Coded samples of the products were served, and plain potable water was provided to the panelists for mouth rinsing and as a taste breaker between evaluations.

3. Results and Discussion

3.1 Colour

The interaction effect between maltodextrin and inlet air

temperature (M×T) on colour score was statistically nonsignificant (Fig. 1). The highest colour score (7.95) was recorded in treatment M₁T₁. Whereas, the lowest colour score (6.81) was observed in M₄T₃. The data revealed that among different storage periods (Fig. 2), the significantly highest colour score (7.88) was recorded during the initial month of storage, followed by three months of storage (7.53). In contrast, the lowest colour score (6.83) was observed after six months of storage. It was evident from the results that the colour score decreased progressively with an increase in storage period. Results are aligned with (Barooah *et al.* 2018) [1] storage studies on spray dried ripe banana powder.

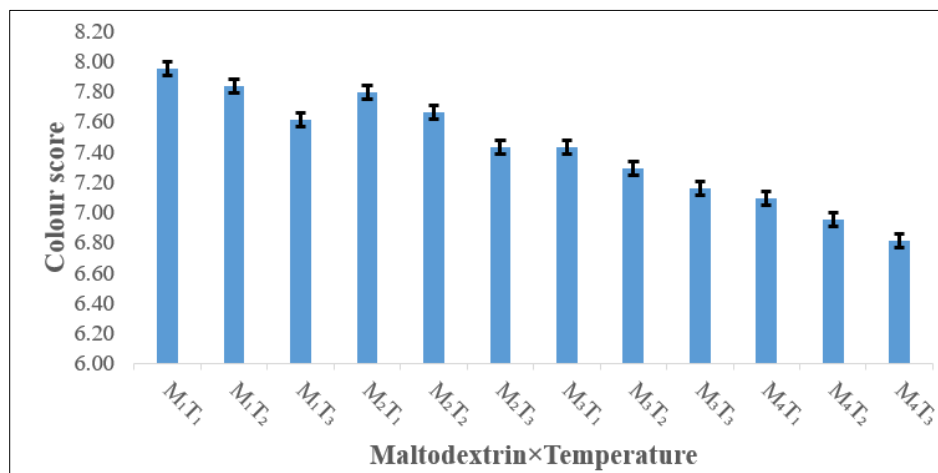


Fig 1: Effect of maltodextrin and temperature on colour score of noni juice spray dried powder

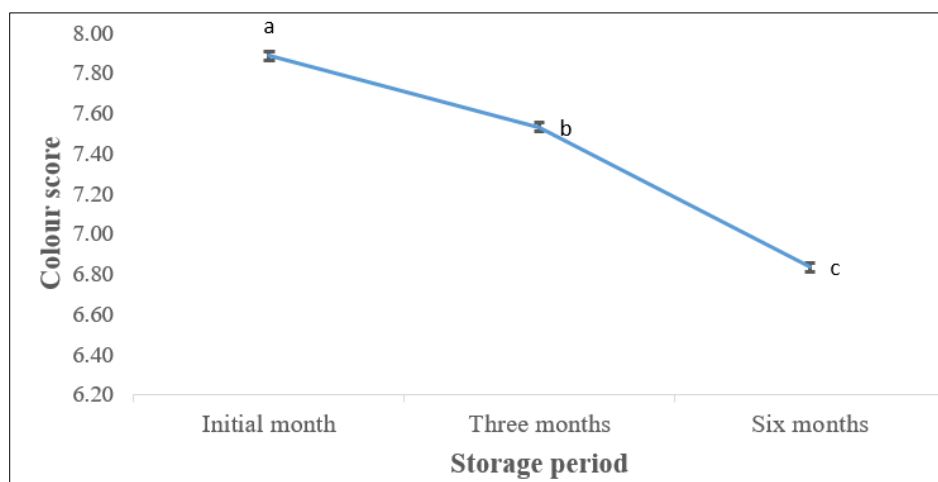


Fig 2: Effect of storage on colour score of noni juice spray dried powder

3.2 Flavour

The maximum flavour score (7.60) was recorded in treatment M₁T₁ (Fig. 3). While, the minimum flavour score (6.32) was observed in M₄T₃. This variation might be due to the combined effect of higher maltodextrin concentration causing dilution of characteristic noni flavour and elevated drying temperature leading to thermal degradation and loss of volatile flavour compounds. The observed trends are in line with the results reported by Jyothi (2022) [6] in spray dried jackfruit powder. The data revealed that among different storage periods (Fig. 4), the significantly superior

flavour score (7.38) was recorded during the initial month of storage, followed by three months of storage (7.04). In contrast, the lowest flavour score (6.56) was observed after six months of storage. It was evident from the results that the flavour score decreased progressively with an increase in storage period. Decreasing score may be due to the loss of volatile aroma compounds and oxidation of bioactive components over time. Similar results were reported by Chopade (2013) [3], who studied the preparation of spray dried pomegranate juice powder and observed a progressive decline in flavour scores during storage.

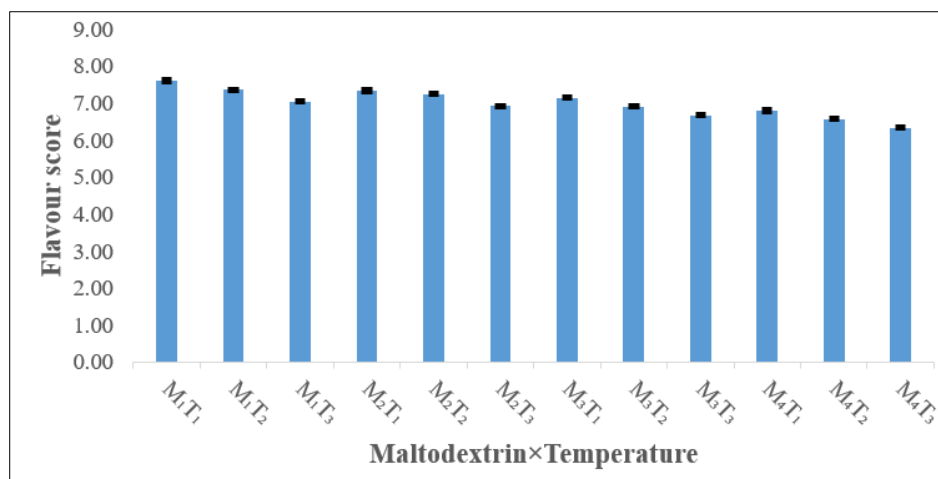


Fig 3: Effect of maltodextrin and temperature on flavour score of noni juice spray dried powder

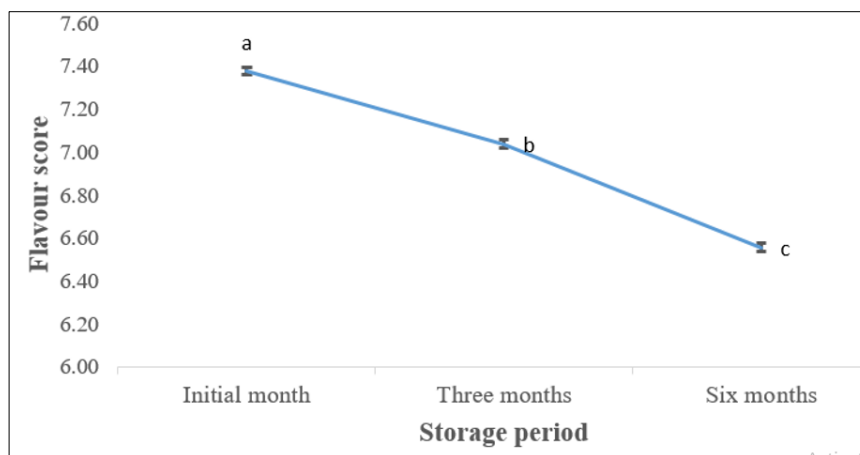


Fig 4: Effect of storage on flavour score of noni juice spray dried powder

3.3 Taste

The maximum taste score (8.11) was observed in treatment M_3T_1 (Fig. 5). While, the minimum taste score (5.49) was observed in M_1T_3 .

The data revealed that among different storage periods (Fig. 6), the significantly highest taste score (7.35) was observed during the initial month of storage, followed by three

months of storage (7.02). In contrast, the lowest taste score (6.58) was observed after six months of storage. It was evident from the results that the taste score decreased progressively with an increase in storage period. Similar results were reported by Dhana lakshmi (2024) ^[4] in spray drying of dragon fruit pulp.

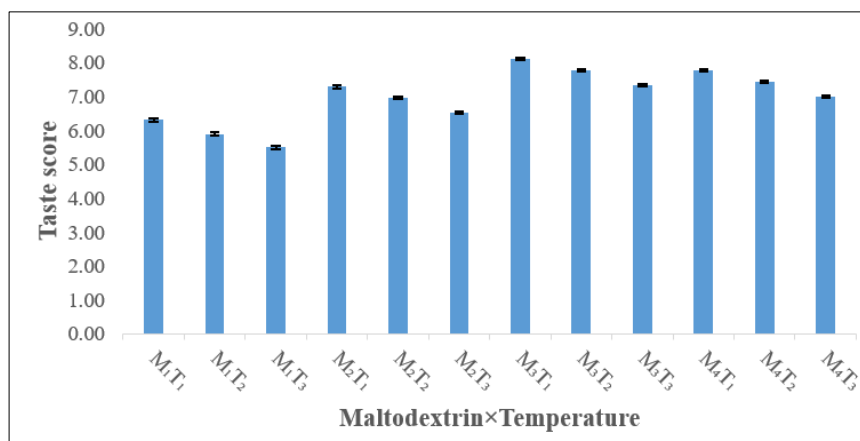


Fig 5: Effect of maltodextrin and temperature on taste score of noni juice spray dried powder

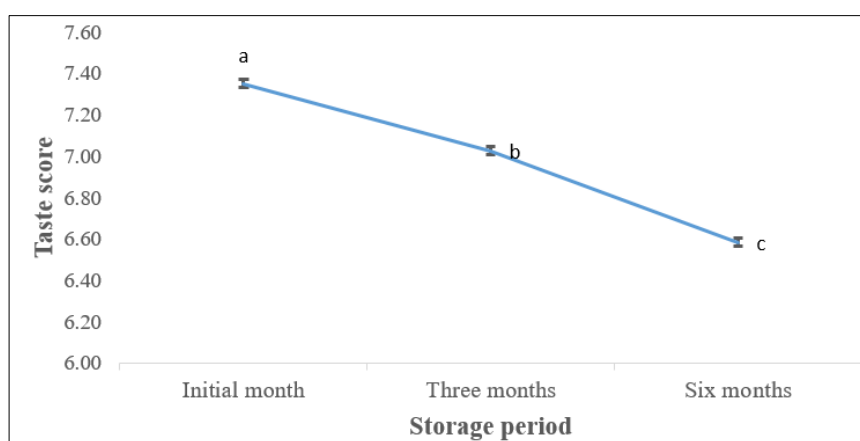


Fig 6: Effect of storage on taste score of noni juice spray dried powder

3.4 Texture Score

The maximum texture score (8.39) was observed in treatment M_3T_1 (Fig.7). Whereas, the minimum texture score (5.92) was observed in M_1T_3 . The data revealed that among different storage periods (Fig. 8), the highly significant texture score (7.62) was observed during the

initial month of storage, followed by three months of storage (7.35). In contrast, the lowest texture score (6.97) was observed after six months of storage. It was evident from the results that the texture score decreased progressively with an increase in storage may be due to gradual moisture

absorption, which promotes particle agglomeration and reduces flowability. Prolonged storage can also induce structural changes in powder particles, leading to deterioration in mouthfeel and textural uniformity. These

combined effects contribute to the overall decline in textural quality during storage. Similar results were reported by Jyothi (2022) ^[6] in spray dried jackfruit powder.

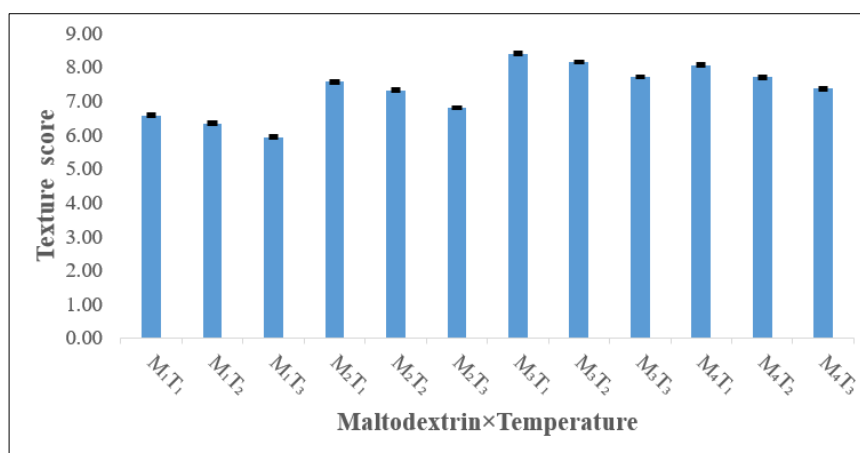


Fig 7: Effect of maltodextrin and temperature on texture score of noni juice spray dried powder

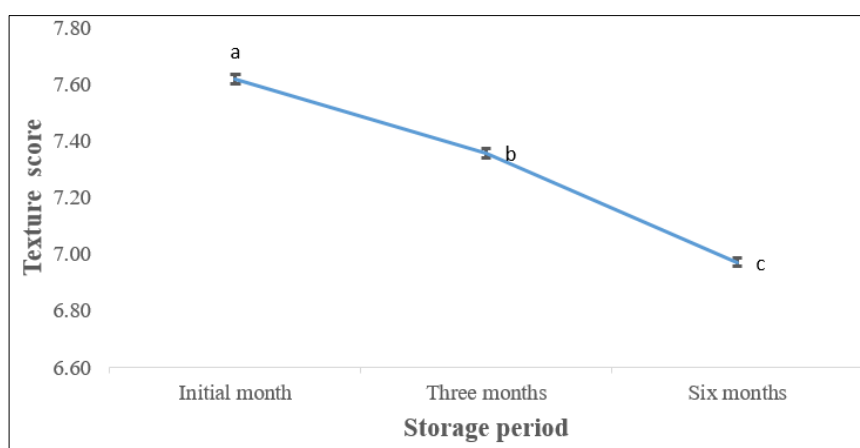


Fig 8: Effect of storage on texture score of noni juice spray dried powder

3.5 Overall acceptability

The maximum overall acceptability score (7.77) was observed in treatment M₃T₁ (Fig.9). Whereas, the minimum overall acceptability score (6.51) was observed in M₁T₃.

The data revealed that among different storage periods (Fig.10), the highly significant overall acceptability score (7.56) was noted during the initial month of storage, followed by three months of storage (7.24). In contrast, the

lowest overall acceptability score (6.74) was observed after six months of storage. It was evident from the results that the overall acceptability score decreased progressively with an increase in storage period. This might be due to the degradation of colour, flavour, taste and texture over time, leading to a less desirable product. Dhana Lakshmi (2024) ^[4] also found same result in spray drying of dragon fruit pulp.

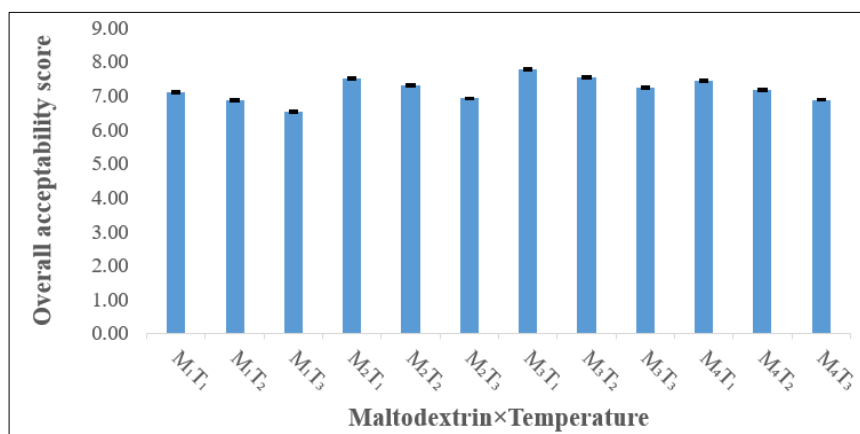


Fig 9: Effect of maltodextrin and temperature on overall acceptability score of noni juice spray dried powder

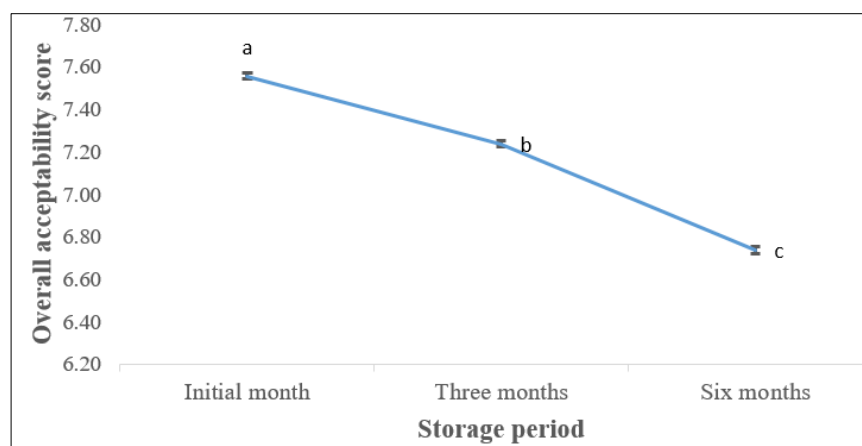


Fig 10: Effect of storage on overall acceptability score of noni juice spray dried powder

4. Conclusion

The study demonstrated that noni juice spray-dried powder prepared with 12% maltodextrin at an inlet air temperature of 155 °C (M₃T₁) achieved significantly higher scores for taste, texture, and overall acceptability compared to other treatments. Based solely on sensory evaluation parameters, M₃T₁ was identified as the most preferred formulation and the most suitable for commercial production from a consumer acceptability perspective.

5. Acknowledgment

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