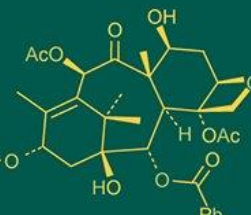
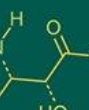
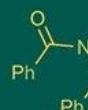


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Storage quality evaluation of phyto-extracts fortified chicken patties under aerobic packaging

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Abstract

This study assessed quality changes in chicken patties fortified with *Garcinia indica* extract (GID) and *Spirulina platensis* extract (SPL) under aerobic packaging at 4 ± 1 °C. Various levels of SPL (0.5%, 0.75%, and 1%) and GID (0.25%, 0.5%, and 0.75%) were tested. Results indicated that 0.75% SPL and 0.5% GID were optimal for incorporation. The storage study included a control (T₁) without extracts, BHT (T₂, 100 ppm), SPL (T₃, 0.75%), and GID (T₄, 0.5%). The patties were stored for 28 days, with evaluations of physicochemical, oxidative stability, instrumental color, texture, microbiological, and sensory properties every 7 days. Control samples (T₁) showed significant increases in pH, TBARS, FFA, peroxide value, and microbial counts compared to the treatment products, especially GID-treated (T₄), which exhibited the least growth. The study concluded that chicken patties with 0.5% GID offered better storage stability than those with 0.75% SPL and were comparable to the synthetic antioxidant BHT.

Keywords: Oxidative stability, chicken patties, BHT, aerobic packaging, natural antioxidants

Introduction

Chicken meat is widely accepted among Indian consumers for its distinct flavor and the absence of religious restrictions (Guleria *et al.*, 2015) [5]. It is nutritious, low in fat, and rich in healthy unsaturated fatty acids. While typically sold fresh, chicken is increasingly processed to meet demand, driven by limited cold chain infrastructure and the convenience of ready-to-eat products, which together make high-quality poultry more affordable. Fat oxidation in animal-derived products, particularly involving unsaturated fatty acids, leads to quality degradation and warmed-over flavor. Hydroperoxyl radicals and other reactive oxygen species (ROS) play a key role in initiating the free radical chain reactions that drive fat peroxidation. Consequently, there is a shift toward fortifying meat products with natural antioxidants from plant extracts rather than synthetic alternatives.

Spirulina platensis is rich in vitamins (especially vitamin B12), minerals, chlorophyll, carotenoids, glutamic acid, aspartic acid, sterols, and, most importantly, the pigments phycocyanin and allophycocyanin (Fu *et al.*, 2026) [3], which are primarily responsible for its antioxidant properties. The potential of *Spirulina platensis* extract as a functional bioactive component in the meat industry remains largely unexplored.

Garcinia indica is a member of the Clusiaceae family and is generally known as 'Kokum' in Maharashtra, notably found in the Konkan, Goa, and western regions of India. Garcinol, a polyisoprenyl benzophenone, exhibits potent antioxidant, free-radical-scavenging, anti-glycation, anti-cancer, and anti-inflammatory activities (Ajith *et al.*, 2025) [1]. Apart from hydroxy citric acid and garcinol, kokum includes other antioxidant-rich components comprising citric and malic acids, polyphenols, anthocyanin pigments, and ascorbic acid (Padhye *et al.*, 2009) [10].

In view of the above discussion, a study is planned to fortify chicken meat patties with different levels of *Spirulina platensis* and *Garcinia indica*, and to assess the effects on storage quality attributes, including various physicochemical, textural, color, and oxidative quality parameters. The microbiological evaluation will also be carried out.

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Materials and Methods

Source of meat

Spent hen chicken meat was sourced from the University Poultry Farm, Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana. Slaughter was conducted in accordance with ethical standards, and carcasses were chilled at 4 °C for 12-18 hours before manual deboning. The product is prepared using a defined and standardized formulation in the department.

Analytical techniques

pH and Oxidative stability value

pH was measured using a SAB 5000 digital pH meter equipped with a combination glass electrode, following the method described by Trout *et al.* (1992) [12]. The peroxide value and TBARS levels were calculated by modifying the methods of Koniecko (1979) [8] and Witte *et al.* (1970) [14], respectively.

Texture and Instrumental Color Profile Analysis

Instrumental color analysis was conducted using a CR-400 Konica Chroma meter (Konica Minolta, Japan) to assess the sample's brightness, redness, and yellowness. Texture analysis was performed using instrumental texture profile analysis (TPA) (TMS-PRO, Food Technology Corporation, USA) to measure parameters such as hardness, chewiness, gumminess, springiness, resilience, and cohesiveness.

Sensory and Microbiological Quality

Microbiological quality was assessed using standard methods to determine plate, yeast, mold, and coliform counts, following the methods described by the American Public Health Association (APHA 1984) [2]. Sensory evaluation by a panel used an 8-point descriptive scale (Keeton, 1983) [7] for appearance, flavor, and overall acceptability.

Statistical analysis

Standard statistical analyses were conducted using IBM SPSS Statistics 20.0 software (USA packages). Data were analyzed using two-way ANOVA to evaluate the effects of treatments and storage times, with significant results assessed at $p < 0.05$ using Duncan's multiple range test. The findings were presented as Mean $\pm$ S.E.

Results and Discussion

pH

The developed chicken patties, including T₁ (Control), T₂ (BHT 100 ppm), T₃ (0.75% SPL), and T₄ (0.5% GID), were evaluated for storage stability at 4 $\pm$ 1 °C using various physicochemical, instrumental texture, color, microbiological, and sensory parameters on days 1, 7, 14, 21, and 28. The pH of the chicken patties increased significantly ($p < 0.05$) during refrigerated storage, indicating gradual protein degradation (Wagh *et al.*, 2015) [13]. The control (T₁) showed the highest pH values, increasing from 6.34 to 6.73 over 28 days, while T₄ (0.5% *Garcinia indica* extract) exhibited the lowest values (6.03 to 6.37), followed by T₃ (0.75% *Spirulina platensis* extract). BHT-treated patties (T₂) showed intermediate values (6.21 to 6.58). The lower pH values in phyto-extract-incorporated treatments, particularly T₄, may be due to the antioxidant and antimicrobial properties of *Garcinia indica*, which delayed microbial growth and deterioration.

Instrumental color profile

The instrumental color profile indicated that T₄ had higher lightness on day 1, but lightness decreased across all treatments as storage progressed. The instrumental color profile of chicken patties changed significantly ($p < 0.05$) during refrigerated storage. Lightness (L*) values decreased gradually in all treatments, with T₄ maintaining the highest values throughout storage (53.42 to 48.48), while the control (T₁) showed the lowest values by day 28 (46.59). Redness (a*) also declined due to lipid oxidation; however, T₄ retained the highest redness values at the end of storage (10.54), whereas the control showed the greatest decline (7.68). Yellowness (b*) increased progressively during storage, with T₃ recording the lowest initial b* value (15.60) and control patties exhibiting the highest value by day 28 (21.06). According to Patriani *et al.* (2021) [11], the organic acid characteristics of *Garcinia* could be responsible for the higher brightness/yellowness of the meat products. Overall, incorporating natural extracts effectively minimized color degradation in chicken patties during refrigerated storage.

Oxidative parameters

Thiobarbituric acid reactive substances (TBARS)

Fig. 1 shows that TBARS values, indicating lipid oxidation, increased significantly ($p < 0.05$) over 28 days of refrigerated storage (4 $\pm$ 1 °C) in both control and treated chicken patties. Initially, TBARS values were similar across all samples, but control patties showed a greater increase over time, highlighting the protective effects of *Spirulina platensis* extract (SPL), BHT, and *Garcinia indica* extract (GID) against lipid oxidation. Throughout storage, TBARS levels remained below the acceptable threshold of 2.0 mg malonaldehyde/kg. By day 21, patties treated with GID (T₄) exhibited the lowest TBARS values, indicating superior antioxidant capacity likely attributed to hydroxy citric acid and garcinol. These findings are consistent with Luo *et al.* (2017) [9], who reported that Chinese-style sausage samples treated with 0.1%, 0.25%, and 0.5% (wt/wt) *Spirulina platensis* polysaccharides (SPP) showed lower TBA values than the blank sample during refrigerated storage.

Free fatty acid (FFA)

FFA levels significantly increased ($p < 0.05$) during storage (Fig. 2), although patties treated with SPL, BHT, and GID showed lower levels compared to controls. *Spirulina's* antioxidant compounds effectively neutralize free radicals, thereby reducing fatty acid oxidation. Among the treatments, GID was the most efficient in lowering FFA levels. Supporting this, a study by Golmakani *et al.* (2018) [4] demonstrated that SP extract effectively decreased free fatty acid content in tilapia oil during storage, with BHT showing slightly superior antioxidant effects.

Peroxide value (PV)

PV followed a similar pattern, increasing during storage, but treated patties had significantly lower PV ($p < 0.05$) than controls, except on day 1. GID (0.5%) was particularly effective at delaying lipid oxidation (Fig. 3). This suggests that GID acts as a potent antioxidant, potentially due to its phenolic compounds, which can scavenge free radicals and inhibit the chain reactions involved in lipid oxidation, thereby enhancing the oxidative stability of the patties during storage.

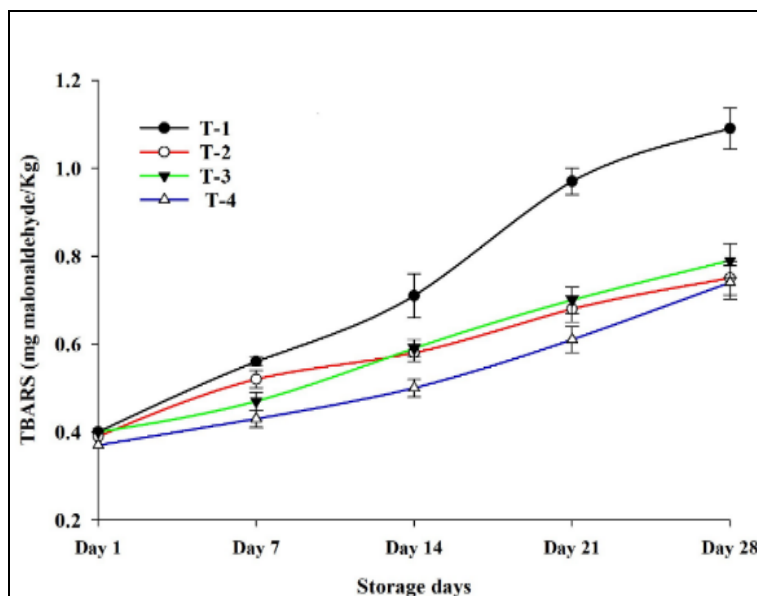


Fig 1: Change in the TBA reactive substances in chicken patties during storage period T₁: Control T₂: BHT T₃: SPL 0.75% T₄: GID 0.5%

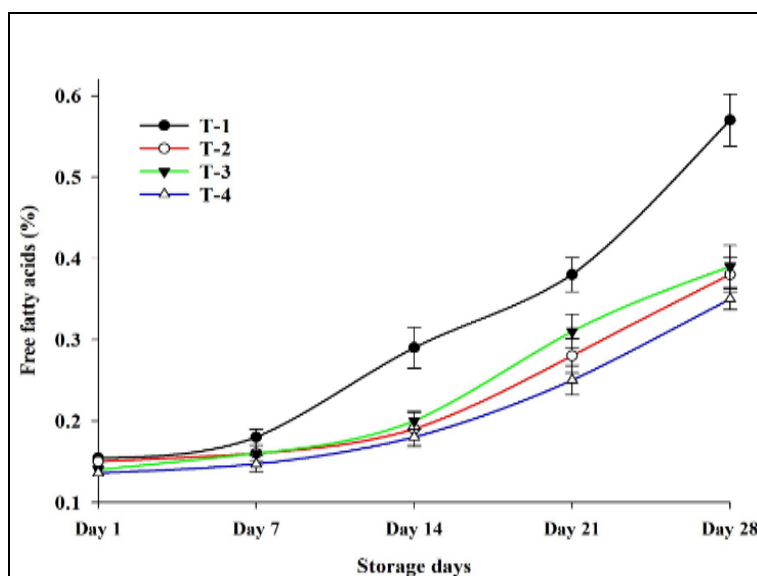


Fig 2: Change in the free fatty acids in chicken patties during storage period T₁: Control T₂: BHT T₃: SPL 0.75% T₄: GID 0.5%

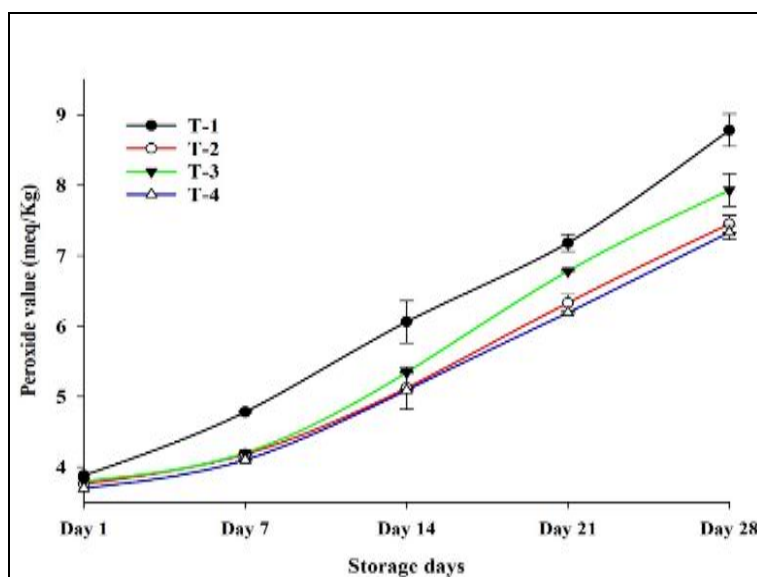


Fig 3: Change in the Peroxide values in chicken patties during storage period T₁: Control T₂: BHT T₃: SPL 0.75% T₄: GID 0.5% Texture profile analysis

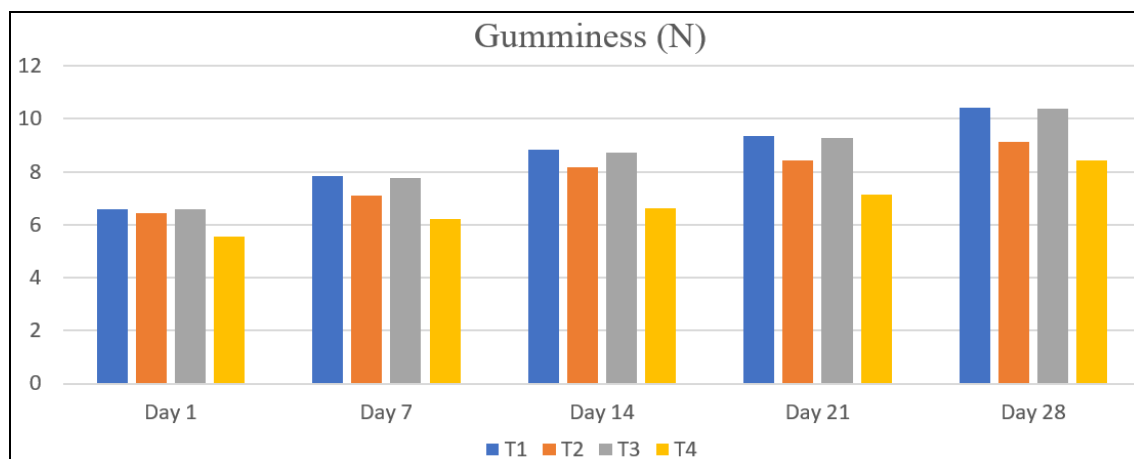
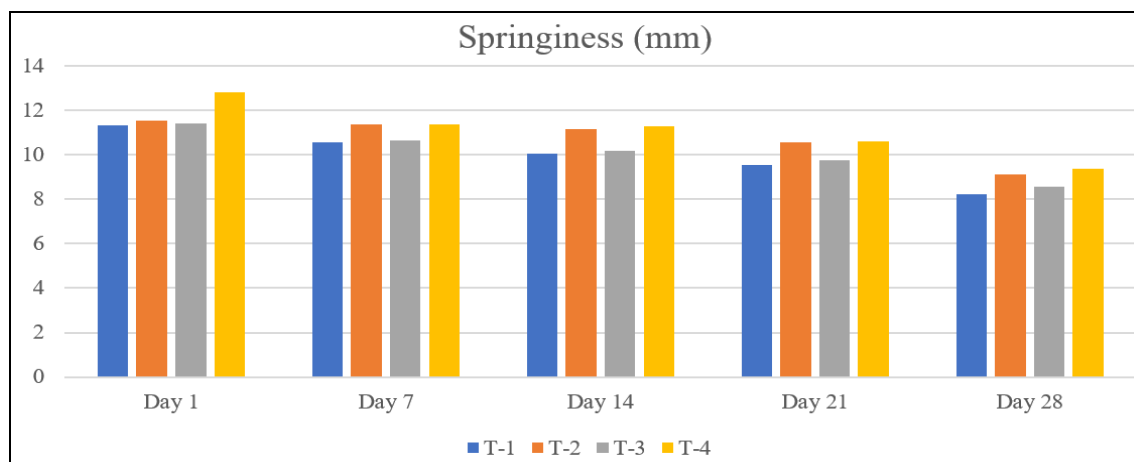
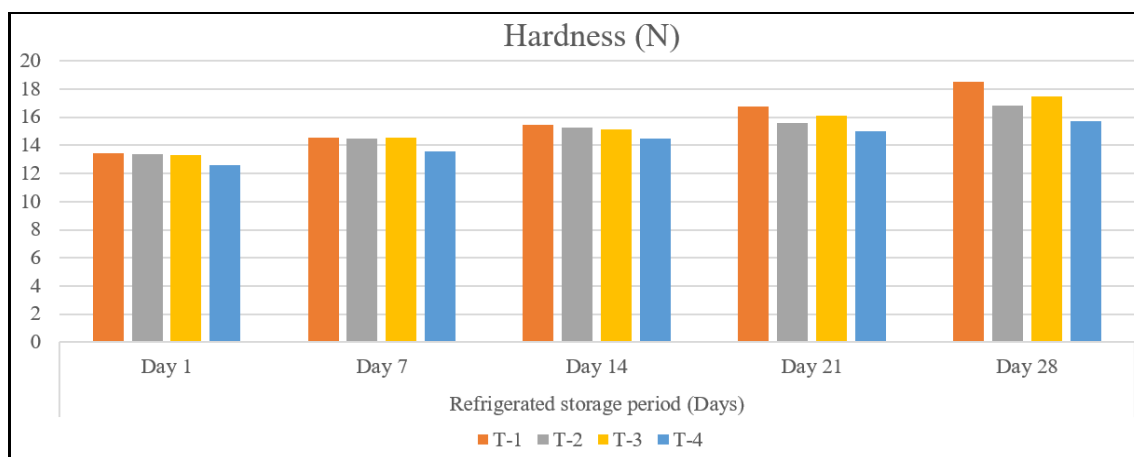
The texture profile analysis of chicken patties with 0.75% *Spirulina platensis*, 100 ppm BHT, and 0.5% *Garcinia indica* extract (GID) under refrigeration (4 ± 1 °C) as shown in Fig. 4. Hardness values were higher in the control (T_1) but not significantly different ($p>0.05$) on day 1. Over time, hardness increased due to water loss, with T_1 and T_2 showing comparable values by day 21. Springiness was generally similar except for day 20, where T_2 was higher. Gumminess and chewiness increased across all products, with gumminess following the pattern $T_1 > T_3 > T_2 > T_4$ on day 1. Adding natural antioxidants helped retain moisture, contributing to these texture changes. Organic acids, as noted by Hosseini and Esfahani Mehr (2015), reduce pH, solubilizing collagen and enhancing tenderness.

Microbiological quality

The microbiological analysis showed significant variations

($p<0.05$) in Standard Plate Count (SPC) among chicken patties with 0.75% *Spirulina platensis* (SPL), BHT (100 ppm), and 0.5% *Garcinia indica* extract (GID). T_4 exhibited the minimum SPC compared to T_3 and T_1 throughout storage. T_1 had the highest SPC during the 28-day period. However, T_4 's SPC remained well below the acceptable threshold (5.33 cfu/gm). No coliforms were detected in any samples during storage.

It was observed that S.P.C. exhibited a gradual increased as storage time progressed, which ranged from 2.13 to 3.13 log CFUg. However, T_4 showed the lowest microbial count among all the treatments on Day 1 (2.13 log CFUg). Yeast and Mould counts were reported in all treatments after 15th day of storage, while highest count was reported in T_1 followed by $T_3>T_2>T_4$ showing better antimicrobial activity of T_4 than T_2 and T_3 .



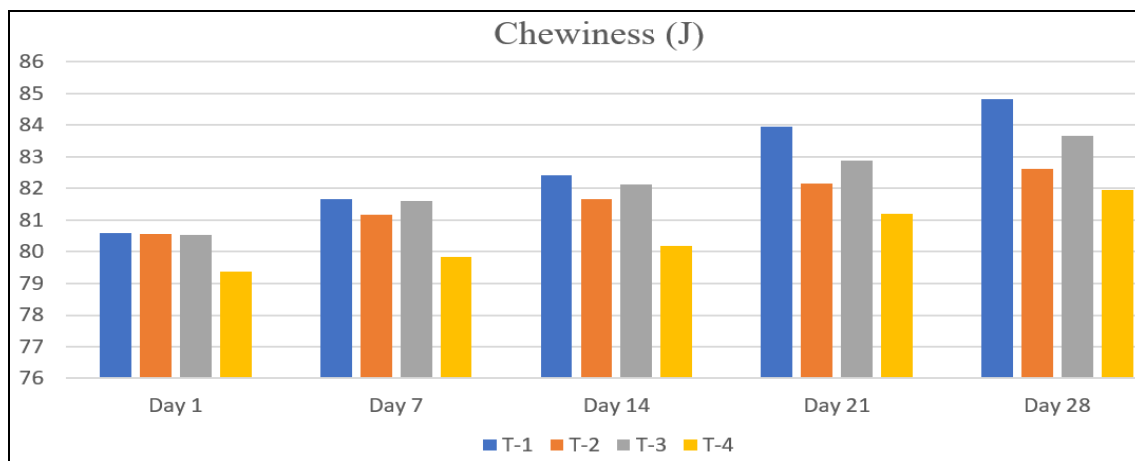


Fig 4: Effect of *Spirulina platensis* extract (SPL) and *Garcinia indica* extract (GID) on instrumental texture profile of chicken patties during refrigerated storage ($4\pm 1^\circ\text{C}$) under aerobic packaging

Sensory quality

Mean sensory scores of developed chicken patties during storage ($4\pm 1^\circ\text{C}$) are shown in figures below (Fig.5). The scores for appearance followed a declining trend with the advancement of storage time of 28 days. Appearance values found ($p<0.05$) lower in T_1 product during the storage time

On 28th day of storage time, scores for T_4 were significantly ($p<0.05$) higher than T_2 and T_3 products. The most probable cause of the decline in score might be attributed to the non-enzymatic browning inter-reaction between products prone to oxidation of fat and amino acids.

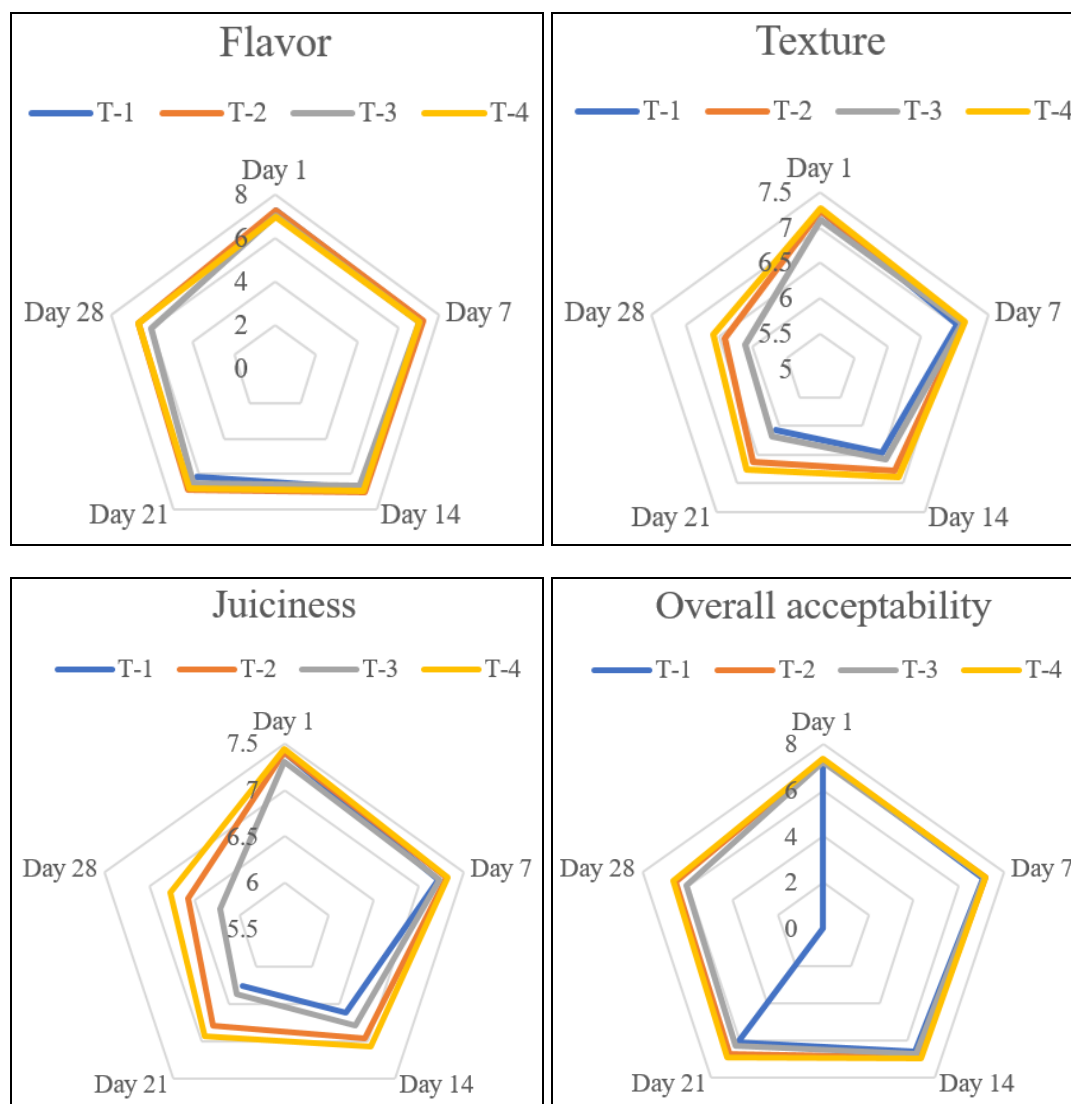


Fig 5: Effect of *Spirulina platensis* extract (SPL) and *Garcinia indica* extract (GID) on the sensory quality profile of chicken patties during refrigerated storage ($4\pm 1^\circ\text{C}$) under aerobic packaging

Sensory evaluations revealed a significant decrease in flavor ($p < 0.05$) during 28 days of storage due to lipid oxidation, which correlated with increased TBARS values. On day 1, flavor scores were comparable between control and treated patties, but treated patties (T_4 , T_2) maintained higher flavor scores owing to the antioxidant activity of 0.75% *Spirulina platensis* (SPL) and 0.5% *Garcinia indica* (GID). Texture scores also declined, with T_4 scoring significantly higher from day 7 onward, likely due to moisture retention. Juiciness followed a similar trend, with T_4 scoring highest, attributed to the succulent effect of SPL and GID. Sensory panelists rated T_4 highest for overall acceptability (OA), following the pattern $T_4 > T_2 > T_3 > T_1$. Results indicate that chicken patties containing SPL, GID, and BHT (100ppm) could be stored for 28 days with minimal loss in sensory, texture, microbiological, and physio-chemical qualities. GID was the most effective natural antioxidant among the plant extracts.

Conclusion

The incorporation of 0.75% *Spirulina platensis* (SPL) and 0.5% *Garcinia indica* (GID) extracts proved effective in developing chicken patties with improved storage stability. These patties, stored at 4 °C under aerobic packaging, maintained their physicochemical, color, texture, microbiological, and sensory attributes for 28 days. GID extract provided antioxidant effects comparable to the artificial antioxidant BHT (100 ppm), making it a suitable natural alternative for extending product shelf life.

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