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Optimizing papaya-guava pulp blends for superior fruit bar quality: A focus on nutritional, sensory and microbial stability

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Abstract

The fruit pulps of papaya and guava were blended in different ratios for the preparation of fruit bars. The fruit bars were evaluated for physico-chemical characteristics, microbial load and sensory attributes at 0, 30 and 60 days of storage. Among the different blending ratios, the fruit bar prepared with 60% papaya pulp and 40% guava pulp (T₃) recorded the highest sensory score for overall acceptability (8.75) and was identified as the best formulation. The microbial load in T₃ 60% papaya pulp and 40% guava pulp treatment also remained at a minimum and within the safe limits of consumption even after 60 days of storage. During storage, total soluble solids, reducing sugars and pH increased, whereas moisture content, titratable acidity, total sugars, ascorbic acid, total carotenoids, protein content and all sensory attributes decreased progressively with the advancement of storage period.

Keywords: Fruit bar, papaya, guava, physico-chemical characteristics, storage

Introduction

Papaya (*Carica papaya* L.) and Guava (*Psidium guajava* L.) are important tropical fruit crops valued for their high nutritional and commercial significance. Papaya is often regarded as the “wonder fruit” of the tropics and subtropics due to its nutritional richness and industrial importance. Owing to the increasing demand for fresh fruits and papain, the area and production of papaya have expanded rapidly during the past few decades.

Papaya is an excellent source of vitamin A (2020 IU/100 g) and also contains appreciable amounts of thiamine, riboflavin and nicotinic acid (Jain *et al.*, 2011). India is the largest producer of papaya in the world, with an annual production of about 5508 lakh tonnes from an area of 126 lakh hectares (NHB, 2014-15). In Andhra Pradesh, papaya is cultivated over 18.40 lakh hectares with an annual production of 1471.68 tonnes (NHB, 2014-15).

Guava, commonly known as the “poor man’s apple,” is one of the most widely cultivated fruits in tropical and subtropical regions of the world. It originated in tropical America, extending from Mexico to Peru, and has gained commercial importance due to its hardy nature, prolific bearing, high vitamin C content, mineral composition and high economic returns with comparatively low maintenance. The high vitamin C (ascorbic acid) content of guava plays a vital role in combating oxidative stress and free radical formation, thereby reducing the risk of degenerative diseases (Kadam *et al.*, 2012) [8]. In recent years, guava cultivation has gained momentum due to increasing international trade and its potential for value addition.

Processing of fruits into value-added products such as fruit leathers provides an effective method for utilizing surplus and overripe fruits while extending their shelf life. Fruit leathers are dehydrated, flexible sheets prepared from pureed fruit pulp structured as sugar-acid-pectin gels, possessing an attractive colour, soft texture and sweet taste (Natalia *et al.*, 2011) [15]. Dehydrated fruit products are gaining importance due to their long shelf-life, lower storage and transport costs and consumer preference for convenient and nutritious foods.

Fresh papaya and guava fruits are highly perishable and therefore require timely processing to reduce post-harvest losses, stabilize market supply and ensure better returns to growers. Despite its nutritional qualities, papaya has limited consumer acceptance due to its characteristic odour,

which restricts its wider commercial utilization. However, papaya deep red pulp, pleasant taste and low acidity make it suitable for blending with other fruits to produce nutritionally enriched products (Attri *et al.*, 2014) [2]. Guava, on the other hand, has a pleasant aroma, acidic flavor and high pectin content, making it ideal for preparation of blended products such as jams, jellies, candies and leathers. Blending these two fruits offers an economic and technological advantage by improving sensory appeal and product stability while enhancing utilization efficiency (Jain *et al.*, 2011) [7].

Therefore, the present investigation entitled papaya cv. Red Lady and Guava cv. Allahabad Safeda fruit pulp for preparation of fruit bar was undertaken to develop a value-added fruit bar with improved nutritional and sensory quality.

Materials and Methods

The current study was conducted in 2015-16 at the College of Horticulture, Anantharajupeta. The following headings in this chapter provide an explanation of the particulars of the materials and techniques employed throughout the study.

Collection of Raw Materials

The Red Lady cultivar of papaya is early, strong, and produces a lot of fruit with good quality. Fruits are short, oblong, red-fleshed, fragrant, and quite sweet. A highly well-liked commercial guava variety is Allahabad Safeda. The fruits are medium-sized, spherical, smooth fruits with yellow skin when mature, white pulp, a few medium-soft seeds, and good storage quality. The ripe papaya and guava fruits collected from farmer fields in and around Anantharajupeta.

Procedure for Extraction of Papaya and Guava Pulp

Papaya (cv. Red Lady) and guava (cv. Allahabad Safeda) fruits were used for extraction of pulp for fruit bar preparation. The fruits were thoroughly washed in clean tap water to remove surface contaminants and then cut into small pieces. The pulp was extracted using a mechanical pulp extractor. In the case of guava, seeds were separated from the pulp using an in-built sieve assembly in the extractor. The pulp recovery was higher in papaya (78.0%) compared to guava (54.5%).

Papaya-guava fruit bars were prepared by mixing 1 kg of pulp in different proportions as per the treatment, along with 250 g of sugar. The mixture was heated with continuous stirring until the total soluble solids (TSS) reached 50°Brix. The cooked mass was then allowed to cool slightly and potassium metabisulphite (KMS) was added at the rate of 500 ppm.

Drying and Preparation of Fruit bar Sheets

The concentrated pulp mixture was spread uniformly on stainless steel trays previously greased with ghee to prevent sticking. The pulp was leveled to a thickness of about 0.5 cm and dried in a cabinet dryer at 60 °C. After five hours of drying, a second layer of pulp (0.5 cm thickness) was spread over the partially dried first layer and drying was continued for a further eight hours at the same temperature. Drying was continued until the desired leathery texture was obtained. The dried sheets were then cooled to room temperature prior to cutting and packing.

Product Storage and Packaging

After drying, the fruit leather sheets from each blend were cooled to room temperature and cut into rectangular pieces of approximately 3 × 0.5 cm. The pieces were individually wrapped in butter paper, labelled with treatment and replication details, and stored at 25±3 °C until further analysis.

The fruit pulps of papaya and guava were blended in different proportions as per the treatments, and fruit bars were prepared following the method of Attri *et al.* (2014) [2] with slight modifications. The study comprised five treatments involving different blending ratios of papaya (cv. Red Lady) and guava (cv. Allahabad Safeda) pulp. The control (T₁) consisted of 100% papaya pulp without guava. In T₂, the pulp blend contained 80% papaya and 20% guava, whereas in T₃ the proportions were 60% papaya and 40% guava. Treatment T₄ consisted of an equal proportion of papaya and guava pulp (50:50), while in T₅ the blend ratio was 40% papaya and 60% guava.

Physico-Chemical and Sensory Evaluation

The physico-chemical characteristics and sensory quality of the papaya-guava fruit bars were assessed at 0, 30 and 60 days of storage. For each treatment, four samples were taken for laboratory analysis. Total soluble solids (TSS), pH, titratable acidity, total sugars, reducing sugars, ascorbic acid and overall acceptability were determined following the standard procedures outlined by Ranganna (2000) [20]. Moisture content was recorded on a fresh-weight basis as described by Saini (2001) [23]. Protein concentration and total carotenoid content in the fruit bar samples were estimated using the Lowry *et al.* (1951) [13] method and the protocol given by Srivastava and Kumar (2009) [28], respectively. Microbial load in the samples was evaluated according to the method proposed by Harrigan and McCance (1976) [5].

Statistical Analysis

The observations recorded for physico-chemical parameters and sensory scores were analysed using a Completely Randomized Design (CRD). Statistical procedures were followed as per the methodology suggested by Panse and Sukhatme (1985) [18].

Results and Discussion

Moisture Content (%)

The moisture content of papaya-guava fruit bars prepared with different pulp blends at various storage intervals is presented in Fig.1. At the initial stage (0 days), moisture content ranged from 14.95% in T₅ (40% papaya + 60% guava) to 15.04% in T₁ (100% papaya). The highest moisture level was observed in T₁, followed by T₂ (80% papaya + 20% guava), while T₅ recorded the lowest value. No significant differences were observed among the treatments at this stage.

After 30 days of storage, T₁ continued to exhibit the highest moisture content (15.03%), followed by T₂ (15.01%), whereas T₅ maintained the lowest value (14.97%). At 60 days, the trend persisted, with T₁ retaining the maximum moisture content (15.01%) and T₅ the minimum (14.95%).

Overall, the fruit bars prepared entirely from papaya pulp consistently exhibited the highest moisture content throughout the storage period, reflecting the higher inherent water content of papaya pulp (Attri *et al.*, 2014) [2]. A slight decline in moisture content was observed across all treatments over time, likely due to surface evaporation during storage (Khan *et al.*, 2014). These results are consistent with previous findings reported for guava leather by Safdar *et al.* (2014) [22].

Total Soluble Solids (°Brix)

The total soluble solids (TSS) of papaya-guava fruit bars varied with blending ratios and storage duration, as presented in Fig.1. At the initial stage (0 days), T₅ (40% papaya + 60% guava) exhibited the highest TSS value of 79.15 °Brix, whereas the lowest TSS of 76.21 °Brix was recorded in T₁ (100% papaya).

No significant differences were observed among treatments at zero, 30, or 60 days of storage.

During storage, a gradual increase in TSS was observed in all treatments. At 30 days, T₅ recorded a TSS of 79.94 °Brix, while T₁ showed the lowest value of 77.34 °Brix. At 60 days, the maximum TSS (80.05 °Brix) was observed in T₅, and the minimum (78.15 °Brix) was recorded in T₂ (80% papaya + 20% guava).

The observed increase in TSS over the storage period may be attributed to the hydrolysis of residual polysaccharides into soluble sugars (Baramanray *et al.*, 1995) [3]. These findings are in agreement with previous studies on guava leather (Safdar *et al.*, 2014) [22] and peach-soy fruit leather (Anju *et al.*, 2014) [1].

Titration Acidity (%)

The titration acidity of papaya-guava fruit bars at different storage intervals (0, 30, and 60 days) is presented in Fig.1. Significant differences were observed among the treatments. At zero days of storage, T₁ (100% papaya) exhibited the highest acidity (1.02%), which was comparable to T₂ (80% papaya + 20% guava, 1.00%) and T₃ (60% papaya + 40% guava, 0.98%). The lowest acidity was recorded in T₅ (40% papaya + 60% guava), with a value of 0.91%.

At 30 days of storage, T₁ maintained the highest titration acidity (1.01%), closely followed by T₂ (0.99%) and T₃ (0.97%). The lowest value (0.89%) was observed in T₅. Similarly, at 60 days, T₁ continued to exhibit the maximum acidity (1.00%), with T₂ (0.98%) and T₃ (0.97%) showing slightly lower but comparable values. The minimum titration acidity (0.88%) was consistently recorded in T₅.

Overall, a gradual decrease in titration acidity was observed in all treatments over the 60-day storage period. This decline may be attributed to the formation of salts during storage (Kuchi *et al.*, 2014). The results are consistent with previous reports on apricot fruit bars (Sharma *et al.*, 2013) [25] and wood apple fruit bars (Vidhya & Narain, 2011) [31].

pH

The pH of papaya-guava fruit bars varied significantly among treatments at 0, 30, and 60 days of storage (Fig.2). At zero days, the highest pH was observed in T₁ (100% papaya) with a value of 3.52, followed by T₂ (80% papaya + 20% guava) at 3.45 and T₃ (60% papaya + 40% guava) at 3.38, with these three treatments being statistically comparable. The lowest pH (3.25) was recorded in T₅ (40% papaya + 60% guava).

After 30 days of storage, T₁ maintained the highest pH (3.52), closely followed by T₂ (3.46) and T₃ (3.38), while T₅ recorded the minimum value (3.26). At 60 days, T₁ again exhibited the highest pH (3.53), comparable to T₂ (3.46) and T₃ (3.39). The lowest pH at this stage was observed in T₅ (3.26).

A slight increase in pH was observed across all treatments during storage, which may be attributed to the formation of free acids and partial hydrolysis of pectin (Imran *et al.*, 2000) [6]. These observations are consistent with earlier findings on apple pulp reported by Durrani *et al.* (2010) [4].

Reducing Sugars (%)

The reducing sugar content of papaya-guava fruit bars varied significantly among treatments at 0, 30, and 60 days of storage (Fig.2). At zero days, the highest reducing sugars were recorded in T₅ (40% papaya + 60% guava) at 44.50%, followed by T₄ (50% papaya + 50% guava) at 41.40%, while the lowest value of 36.49% was observed in T₁ (100% papaya). A similar trend was noted at 30 days, with T₅ exhibiting the maximum reducing

sugars (45.20%) and T₁ the minimum (36.92%). At 60 days of storage, T₅ continued to show the highest reducing sugar content (47.56%), followed by T₄ (43.27%), whereas T₁ recorded the lowest value (38.16%). Overall, an increasing trend in reducing sugars was observed in all treatments over the storage period, which may be attributed to the inversion of non-reducing sugars and the hydrolysis of polysaccharides into monosaccharides (Sharma *et al.*, 2013) [25]. These results are in agreement with previous studies on mango leather (Rao & Roy, 1980) [21] and sapota-papaya fruit bars (Sreemathi *et al.*, 2008) [27].

Total Sugars (%)

The total sugar content of papaya-guava fruit bars prepared with different pulp blends at 0, 30, and 60 days of storage is presented in Fig.2. No significant differences were observed among treatments at any stage of storage. At zero days, T₅ (40% papaya + 60% guava) exhibited the highest total sugars (73.07%), followed by T₄ (50% papaya + 50% guava, 71.45%), whereas T₁ (100% papaya) recorded the lowest value (69.32%). At 30 days of storage, the maximum total sugar content was observed in T₅ (72.15%), with T₁ showing the minimum (68.15%). A similar trend was maintained at 60 days, where T₅ retained the highest total sugars (70.54%) and T₁ the lowest (67.05%). Overall, a slight decline in total sugar content was observed with increasing storage duration, which may be attributed to the acid hydrolysis of sugars into monosaccharides (Muralikrishna *et al.*, 1969) [14]. These findings are consistent with previous reports on papaya toffee and papaya leather (Attri *et al.*, 2014) [2] as well as apricot fruit bars (Sharma *et al.*, 2013) [25].

Ascorbic Acid (mg/100g)

The ascorbic acid content of papaya-guava fruit bars varied significantly with blending ratios and storage duration, as presented in fig 3. At zero days, the highest ascorbic acid was observed in T₅ (40% papaya + 60% guava) at 145.4 mg/100g, followed by T₄ (50% papaya + 50% guava) with 125.6 mg/100g, while T₁ (100% papaya) exhibited the lowest value of 45.34 mg/100g. After 30 days of storage, T₅ maintained the highest ascorbic acid content (137.6 mg/100g), with T₄ at 110.4 mg/100g and T₁ the lowest at 51.52 mg/100g. At 60 days, the trend remained consistent, with T₅ showing 124.5 mg/100g, T₄ 105.6 mg/100g, and T₁ 45.34 mg/100g.

The higher ascorbic acid content in fruit bars with greater guava pulp proportion is attributed to the naturally rich vitamin C content of guava, whereas 100% papaya bars contained significantly lower levels (Kumar *et al.*, 2010) [12]. A gradual decline in ascorbic acid was observed in all treatments over the storage period, likely due to oxidation to dehydroascorbic acid, subsequent conversion to 2,3-diketogluconic acid, and further degradation into furfural compounds, which also contribute to browning reactions (Sharma *et al.*, 2013) [25]. These results are in agreement with previous findings on guava nectar reported by Karanjalkar *et al.* (2013) [9].

Total Carotenoids (µg/100g) and Protein (%)

The total carotenoids content of papaya-guava fruit bars was significantly influenced by the blending ratio of papaya and guava pulp and storage duration (Fig.3). At zero days, the highest carotenoids were observed in T₁ (100% papaya) with 1593 µg/100g, followed by T₂ (80% papaya + 20% guava) at 1510 µg/100g. The lowest value was recorded in T₅ (40% papaya + 60% guava) at 968 µg/100g. At 30 days, T₁ maintained the highest carotenoids (1534 µg/100g), while T₅ showed the

lowest content (787 $\mu\text{g}/100\text{g}$). By 60 days, T₁ again exhibited the maximum carotenoids (1385 $\mu\text{g}/100\text{g}$), followed by T₂ (1271 $\mu\text{g}/100\text{g}$) and T₃ (1030 $\mu\text{g}/100\text{g}$), whereas T₅ had the minimum value of 635 $\mu\text{g}/100\text{g}$. The higher carotenoid content in fruit bars with greater proportions of papaya is attributed to the natural richness of papaya in carotenoids (Take *et al.*, 2012)^[29]. The observed decline in carotenoids during storage may be due to non-oxidative changes, such as cis-trans isomerization and thermal degradation, or oxidative reactions (Guarte *et al.*, 2005)^[33]. These findings are consistent with earlier reports on papaya toffee and papaya leather (Attri *et al.*, 2014)^[2].

Protein content of the fruit bars was also significantly affected by pulp blending ratios and storage period. At zero days, T₅ (40% papaya + 60% guava) exhibited the highest protein content (1.04%), which was comparable to T₄ (50% papaya + 50% guava, 1.00%) and T₃ (60% papaya + 40% guava, 0.96%). The lowest protein content was observed in T₁ (100% papaya, 0.85%). At 30 days, T₅ continued to have the highest protein (0.86%), closely followed by T₄ (0.85%) and T₃ (0.84%), while T₁ and T₂ (0.75% and 0.79%, respectively) recorded lower values. At 60 days of storage, a gradual decline in protein content was observed in all treatments, with T₅ retaining the highest level (0.75%), T₄ at 0.72%, and T₁ the lowest (0.62%). The increase in protein content with higher guava proportion is attributed to the relatively higher protein content in guava compared to papaya (Ashaye *et al.*, 2005)^[34]. The observed decrease in protein during storage may be due to participation in Maillard reactions, consistent with earlier reports on plum-soy and apricot-soy products (Sharma, 1997; Thakur & Neena, 1997; Anju *et al.*, 2014)^[24, 30, 2].

Overall Acceptability and Microbial Count (cfu/g)

The sensory evaluation of papaya-guava fruit bars indicated that the overall acceptability was influenced by the blending ratio of papaya and guava pulp (Table 1). At zero and 30 days of storage, no significant differences were observed among treatments, except at 60 days. The overall acceptability scores ranged from 7.78 (T₁, 100% papaya) to 8.75 (T₃, 60% papaya + 40% guava). T₃ consistently received the highest ratings, with scores of 8.75 and 8.60 at zero and 30 days, respectively, while the lowest scores were observed in T₅ (40% papaya + 60% guava) at 8.30 and 8.17. At 60 days, T₃ again recorded the highest overall acceptability (8.48), followed by T₂ (80% papaya + 20% guava, 7.99), and T₁ showed the lowest score (7.78). A gradual decline in sensory scores was observed over the storage period, likely due to changes in product composition, as well as loss of color and flavor (Parekh *et al.*, 2014)^[19]. These findings are in agreement with previous reports on the storage stability of aonla dehydrated products (Singh *et al.*, 2006)^[26].

Microbial analysis of the fruit bars revealed that all treatments were free from microbial contamination at the initial stage of storage, with no detectable growth of yeast or mould (Table 1). At 30 and 60 days of storage, the highest microbial counts were observed in T₁ (0.3×10^2 cfu/g), while other treatments exhibited lower counts. Importantly, yeast and mould counts in all treatments remained well below the safety threshold of 1×10^4 cfu/g as recommended by the World Health Organization (WHO, 1994)^[32]. These results indicate that papaya-guava fruit bars prepared with different blending ratios were microbiologically stable and safe for consumption throughout the storage period.

Table 1: Effect of varying blending ratios of papaya and guava pulp on the overall acceptability score and Microbial count (yeast and mould) (cfu/g) of fruit bars during storage at 0, 30, and 60 days of storage

Treatments	Overall acceptability score			Microbial count (yeast and mould) (cfu/g)		
	Days after storage			Days after storage		
	0	30	60	0	30	60
T ₁	8.42	8.30	7.78	0	0.3×10^2	0.5×10^2
T ₂	8.42	8.26	7.99	0	0.1×10^2	0.2×10^2
T ₃	8.75	8.60	8.48	0	0.01×10^1	0.1×10^1
T ₄	8.33	8.25	7.87	0	0.1×10^2	0.3×10^2
T ₅	8.30	8.17	7.93	0	0.2×10^1	0.4×10^1
SEM $\pm$	0.12	0.12	0.11	NA	NA	NA
CD @ 5 %	NS	NS	0.34	NA	NA	NA

NS: Non-significant; NA: Not applicable, T₁: (100 % Papaya pulp), T₂: (80 % Papaya pulp + 20 % Guava pulp), T₃: (60 % Papaya pulp + 40% Guava pulp), T₄: (50 % Papaya pulp + 50 % Guava pulp), T₅: (40 % Papaya pulp + 60 % Guava pulp + 50 % Guava pulp), T₅: (40 % Papaya pulp + 60 % Guava pulp)

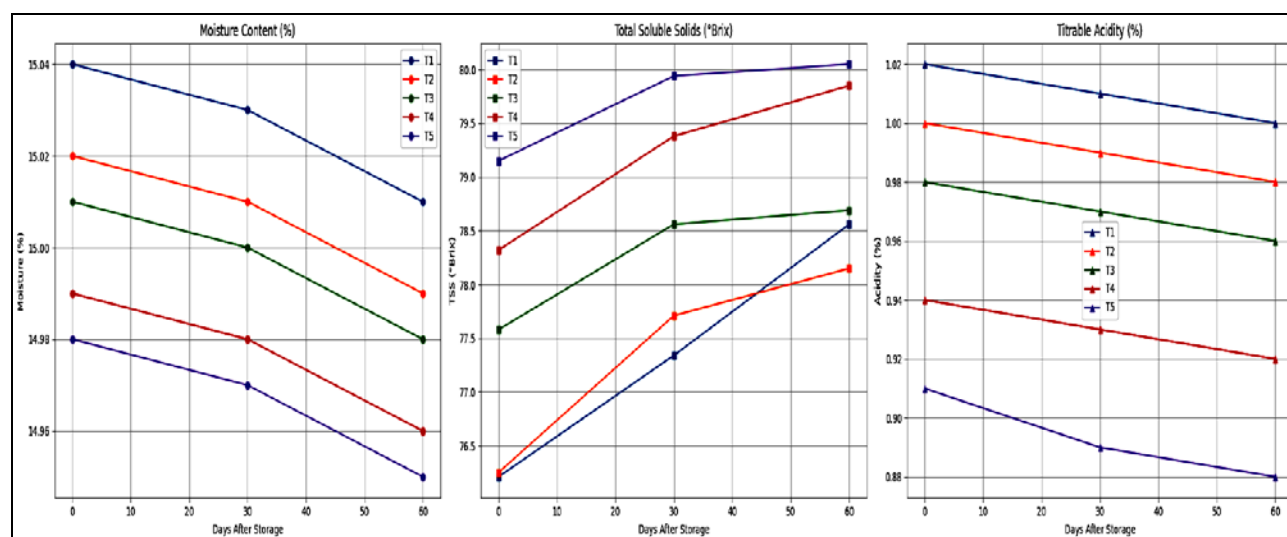


Fig 1: Effect of varying blending ratios of papaya and guava pulp on moisture content (%), total soluble solids (°Brix), and titratable acidity (%) of fruit bars during storage at 0, 30, and 60 day

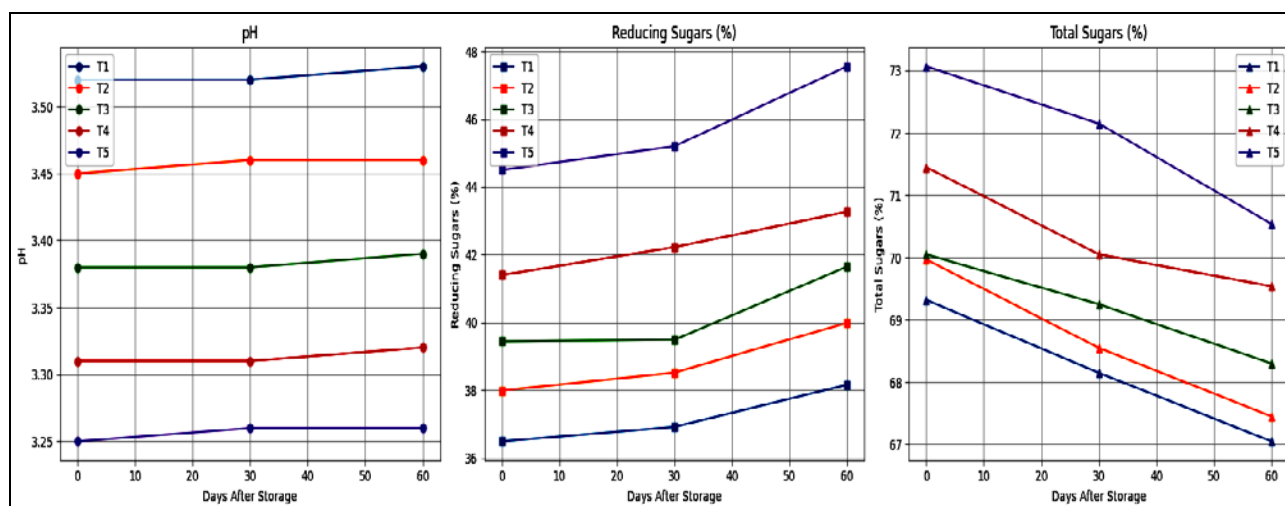
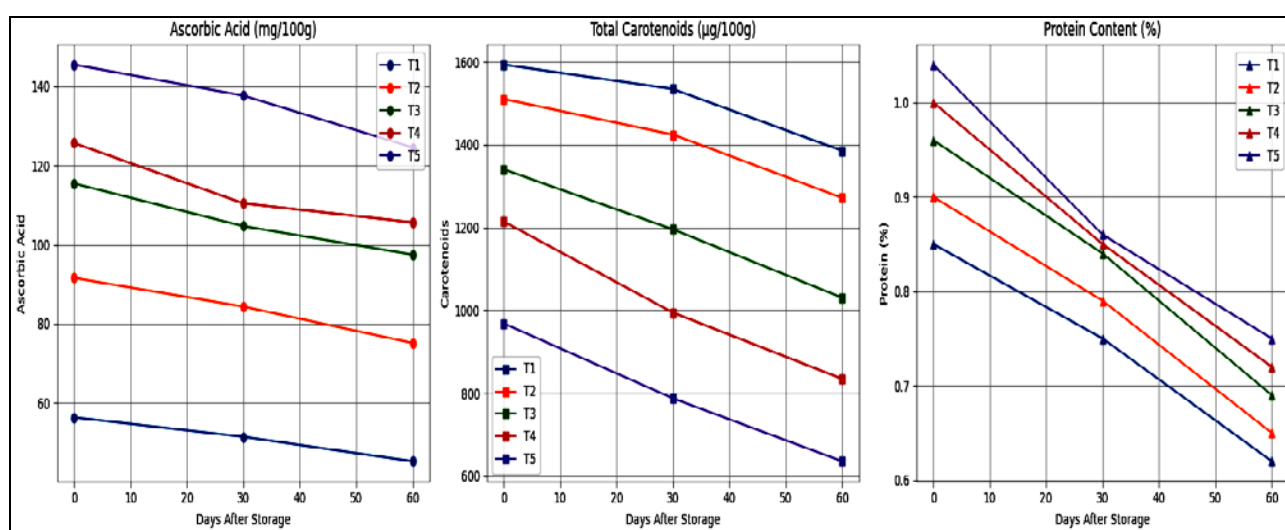


Fig 2: Effect of different blending ratios of papaya and guava pulp on pH, Reducing sugars (%) and Total sugars (%) of fruit bars during storage at 0, 30, and 60 days of storage



Note (common for Figures 1, 2, and 3):

T₁: 100% Papaya pulp

T₂: 80% Papaya pulp + 20% Guava pulp

T₃: 60% Papaya pulp + 40% Guava pulp

T₄: 50% Papaya pulp + 50% Guava pulp

T₅: 40% Papaya pulp + 60% Guava pulp

(Guava variety: Allahabad Safeda)

Fig 3: Effect of different blending ratios of papaya and guava pulp on ascorbic acid content (mg/100 g), total carotenoids (µg/100 g), and protein content (%) of fruit bars during storage at 0, 30, 60 days of storage

Conclusion

Among the different blending ratios of papaya and guava pulp, the fruit bar prepared with 60% papaya and 40% guava pulp (T₃) was found to be superior in terms of sensory attributes. This treatment also demonstrated favorable nutritional retention, with ascorbic acid content of 115.4 mg/100g, total carotenoids of 1340 µg/100g, and protein content of 0.96%. Importantly, T₃ maintained adequate levels of these nutrients even after 60 days of storage, indicating its suitability for producing nutritionally enriched and shelf-stable papaya-guava fruit bars.

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