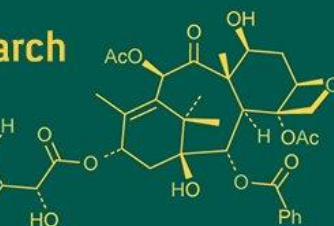
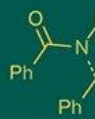


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Assessment of physico-chemical and sensory characteristics of jackfruit bar prepared from firm and soft flesh types

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Abstract

The present investigation entitled “Assessment of Physico-Chemical and Sensory Characteristics of Jackfruit Bar Prepared from Firm and Soft Flesh Types” was carried out at the Department of Postharvest Management, College of Horticulture, Mudigere, during 2025-2026. The experiment was laid out in a Completely Randomized Design (CRD) with ten treatments and three replications. The treatments consisted of jackfruit firm and soft flesh combined with varying proportions of jaggery. Among the treatments, T₁ (Jackfruit firm flesh 70% + Jaggery 30%) recorded superior physical properties with the highest fruit bar recovery (68.72%), *L** value (49.53), lower moisture content (14.18%) and water activity (0.62), along with the highest *b** value (13.84). T₆ (Jackfruit soft flesh 70% + Jaggery 30%) recorded the highest leather recovery (68.18%) and the highest TSS (73.08°Brix). In sensory evaluation, T₁ recorded the highest scores for colour (8.91), flavour (8.80), texture (8.72), taste (8.91) and overall acceptability (8.82). Overall, the results indicated that the proportion of jackfruit flesh and jaggery significantly influenced the physico-chemical, and sensory characteristics of jackfruit bar. Among the treatments, T₁ and T₆ exhibited superior overall performance and were followed by the remaining treatments across the evaluated quality parameters. Based on the overall quality and sensory acceptability, T₁ (Jackfruit firm flesh 70% + Jaggery 30%) was identified as the most suitable treatment for the preparation of jackfruit bar.

Keywords: Jackfruit, fruit bar, firm flesh, soft flesh, jaggery, fruit bar recovery, water activity, sensory evaluation

Introduction

Jackfruit (*Artocarpus heterophyllus* Lam.) belongs to the family Moraceae and it is one of the most significant and widely cultivated fruit trees in subtropical region. Jackfruit is rich in nutritive values and they can be utilized for therapeutic purposes such as anti-inflammatory, anti-oxidant, anti-bacterial and anti-diabetic (Prakash *et al.*, 2009) [13]. Innumerable types or forms with different fruit characters of jackfruit exists due to cross pollination and they are mainly grouped into two textural forms. One with soft flesh, pulpy perianth with high fiber and less shelf life and the other one is firm fleshed with thick and firm carpels which are used for table purpose and value addition (Rahman *et al.*, 1999) [14]. In the firm type, the perianth remains firm even at full ripeness, while in the soft type the perianths become soft and fleshy on ripening. The soft type has fruits with small, fibrous, soft and spongy flakes with very sweet carpels, whereas the firm type is crunchy with crisp carpels and not sweet as the soft type (Ranasinghe *et al.*, 2019) [15]. Nowadays, jackfruit bulb is being commercially stored in the frozen form for the year-round availability. But it requires more space and energy and also requires same conditions for longer shelf life and quality. Dehydration is one of the most feasible methods of preservation and such products can be used throughout the year. Fruit bars are Intermediate Moisture Foods (IMF), known for their intermediate moisture content and water activity ranges, which are not affected by microbial growth. It is shelf-stable and retains much of the fruit's natural flavour and nutrients. Fruit bars have concentrated flavour and sugars, making it a tasty and healthier alternative to candy or other processed snacks.

Materials and Methods

The present investigation was carried out at the Department of Postharvest Management, College of Horticulture,

Mudigere. The experiment was laid out in a Completely Randomized Design (CRD) with ten treatments and three replications.

Treatment Details

Treatments	Treatment Combinations
T ₁	Jackfruit firm flesh (70%) + Jaggery (30%)
T ₂	Jackfruit firm flesh (75%) + Jaggery (25%)
T ₃	Jackfruit firm flesh (80%) + Jaggery (20%)
T ₄	Jackfruit firm flesh (85%) + Jaggery (15%)
T ₅	Jackfruit firm flesh (90%) + Jaggery (10%)
T ₆	Jackfruit soft flesh (70%) + Jaggery (30%)
T ₇	Jackfruit soft flesh (75%) + Jaggery (25%)
T ₈	Jackfruit soft flesh (80%) + Jaggery (20%)
T ₉	Jackfruit soft flesh (85%) + Jaggery (15%)
T ₁₀	Jackfruit soft flesh (90%) + Jaggery (10%)

Procedure for preparation of jackfruit bar

Ripe jackfruits were selected and the bulbs were separated from the seeds and stored under refrigeration for further use. As per treatments concentration jackfruit bulbs and jaggery were blended together in a mixer to obtain a smooth and uniform pulp. The blended mixture was gently cooked over

low heat with continuous stirring until it reached a semi-solid consistency. The cooked mixture was then spread uniformly over trays to obtain a 3 to 5 mm thick layer. Drying was carried out in a dehydrator at 50 °C for 14-16 hours. The dried fruit Bar was cut into uniform pieces and packed in Low Density Polyethylene (LDPE) for storage.

Table 1: Effect of concentrations of firm and soft jackfruit flesh and jaggery on physical parameters of fruit bar

Treatment Combinations	Moisture content (%)	Water activity (a _w)	Leather recovery (%)	Colour		
				L*	a*	b*
T ₁ Jackfruit firm flesh (70%) + Jaggery (30%)	14.18	0.62	68.72 ^a	49.53 ^a	2.54 ^c	13.84 ^a
T ₂ Jackfruit firm flesh (75%) + Jaggery (25%)	14.20	0.63	67.40 ^b	48.74 ^c	3.08 ^d	13.45 ^c
T ₃ Jackfruit firm flesh (80%) + Jaggery (20%)	14.23	0.64	65.95 ^d	47.96 ^c	3.86 ^c	13.08 ^c
T ₄ Jackfruit firm flesh (85%) + Jaggery (15%)	14.26	0.65	64.08 ^f	47.12 ^g	4.38 ^b	12.65 ^g
T ₅ Jackfruit firm flesh (90%) + Jaggery (10%)	14.29	0.66	61.56 ^h	46.28 ^h	4.82 ^a	12.22 ⁱ
T ₆ Jackfruit soft flesh (70%) + Jaggery (30%)	14.19	0.61	68.18 ^a	49.18 ^b	2.42 ^c	13.63 ^b
T ₇ Jackfruit soft flesh (75%) + Jaggery (25%)	14.22	0.62	66.81 ^c	48.38 ^d	3.18 ^d	13.25 ^d
T ₈ Jackfruit soft flesh (80%) + Jaggery (20%)	14.25	0.63	65.11 ^e	47.58 ^f	3.72 ^c	12.84 ^f
T ₉ Jackfruit soft flesh (85%) + Jaggery (15%)	14.27	0.64	63.03 ^g	46.78 ^h	4.26 ^b	12.43 ^h
T ₁₀ Jackfruit soft flesh (90%) + Jaggery (10%)	14.30	0.65	60.88 ⁱ	46.00 ⁱ	4.76 ^a	12.02 ^j
S. Em±	0.02	0.02	0.14	0.02	0.05	0.02
CD @ 1%	NS	NS	0.58	0.07	0.19	0.07

Physico-chemical parameters of jackfruit bar

The data on Physical parameters were presented in the table 1. Fruit bars generally possess moisture content and water activity within the range of 12 to 25 percent which is required to maintain a soft texture while ensuring keeping quality, no significant variation was observed among the treatments with respect to moisture content and in all the treatments it was within the desirable range. The uniform moisture content among treatments may be attributed to drying under identical temperature and duration. Similar observations were reported by Khan *et al.* (2014) ^[6] in guava fruit leather, Dash *et al.* (2020) ^[3] in wild jackfruit leather and Kurniarianti *et al.* (2024) ^[9] in jackfruit leather.

Water activity (a_w) is an important quality attribute that influences the microbial stability and shelf life of fruit bars. It ranges from 0 to 1, with fresh foods generally having a_w values close to 1, whereas dehydrated foods typically have values below 0.60. Water activity in the range of 0.60-0.65 is considered desirable for dehydrated fruit products, as it limits microbial growth, enhances product stability and extends shelf life. Concha-Meyer *et al.* (2016) ^[22] reported that foods with a_w values above 0.85 are more susceptible to microbial growth. In the present study, there was no significant difference in water activity among the treatments and all values remained within the desirable range. The lower water activity may be attributed to the hygroscopic nature of jaggery, which binds free water and reduces its

availability for microbial growth. Similar observations have been reported by Kushner *et al.* (1979) ^[10] in jamun leather, Dash *et al.* (2020) ^[3] in wild jackfruit leather and Kurniarianti *et al.* (2024) ^[9] in jackfruit leather.

Fruit bar recovery represents the percentage of yield obtained after dehydration and is an important parameter for assessing processing efficiency. Significant differences were observed among the treatments with respect to leather recovery. The highest leather recovery was recorded in T₁ (68.72%), which was statistically on par with T₆ (68.18%). The lowest leather recovery was recorded in T₁₀ (60.88%), fruit bars prepared with 70 percent jackfruit pulp and 30 percent jaggery recorded higher leather recovery than the other treatments. The higher recovery may be attributed to the optimum pulp-to-jaggery ratio, which increased the total solids of the pulp and minimized shrinkage during dehydration. In addition, jaggery acts as a humectant by binding water and increasing pulp viscosity, thereby reducing stickiness and improving recovery after drying. The lower recovery observed at higher pulp concentrations could be due to the comparatively lower soluble solids available in the mixture. Similar findings were reported by Kumar *et al.* (2017) ^[8] in papaya-guava fruit leather, Kaur (2017) ^[4] in fruit bars prepared from fruit processing waste, Dash *et al.* (2020) ^[3] in wild jackfruit leather and Kurniarianti *et al.* (2024) ^[9] in jackfruit leather.

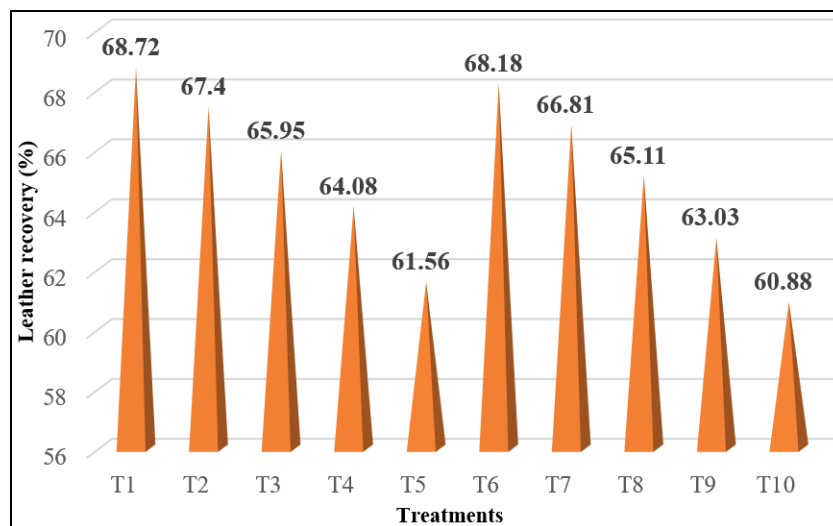


Fig 1: Effect of concentrations of firm and soft jackfruit flesh and jaggery on leather recovery (%) of fruit bar

Colour is one of the most important quality attributes governing the appearance and consumer acceptability of fruit bars. The L^* , a^* and b^* values provide an objective assessment of the colour characteristics of the product. The lightness (L^*) values differed significantly among the treatments. The highest L^* value was recorded in T₁ (49.53), which was followed by T₆ (49.18) and the lowest L^* value was recorded in T₁₀ (46.00), may be attributed to the optimum pulp-to-jaggery ratio, which minimized excessive non-enzymatic browning during drying and promoted better retention of the natural yellow colour of jackfruit. In contrast, increasing the proportion of jackfruit pulp with a corresponding reduction in jaggery resulted in comparatively lower L^* values, probably due to the concentration of natural pigments and browning reactions during dehydration. Similar findings were reported by Ahmad *et al.* (2005) ^[1] in papaya and tomato leather, Kurniarianti *et al.* (2024) ^[9] in jackfruit leather and Kumar *et al.* (2017) ^[8] while studying the effect of sugar-acid ratio on the stability of papaya and guava fruit leather.

The redness (a^*) values varied significantly among the treatments. The highest a^* value was recorded in T₅ (4.82), followed by T₁₀ (4.76), whereas the lowest value was observed in T₆ (2.42), which was statistically on par with T₁ (2.54). The gradual increase in a^* values with increasing jackfruit pulp concentration could be attributed to the greater retention and concentration of natural carotenoid

pigments in the pulp, along with the formation of reddish-brown pigments during the drying process. On the other hand, treatments containing lower pulp levels and higher jaggery concentrations exhibited comparatively lower a^* values, indicating less redness. These findings are in agreement with those reported by Ahmad *et al.* (2005) ^[1] in papaya and tomato leather, Kurniarianti *et al.* (2024) ^[9] in jackfruit leather and Kumar *et al.* (2017) ^[8] in papaya and guava fruit leather.

The b^* value also varied significantly among the treatments. The highest b^* value was recorded in T₁ (13.84), followed by T₆ (13.63). The lowest b^* value was recorded in T₁₀ (12.02). fruit bars prepared with 70 percent jackfruit pulp and 30 percent jaggery recorded higher b^* values, indicating better retention of the characteristic yellow colour of ripe jackfruit. The reduction in b^* values with increasing pulp concentration may be attributed to pigment degradation and the formation of brown coloured compounds during drying, which masked the natural yellow pigments. Nevertheless, the reduction in b^* values remained within the acceptable range and did not adversely influence the visual quality of the fruit bars. Similar findings were reported by Kumar *et al.* (2017) ^[8] in papaya and guava fruit leather, Arinzechukwu and Nkama (2019) ^[2] in banana and cashew fruit leather and Kurniarianti *et al.* (2024) ^[9] in jackfruit leather.

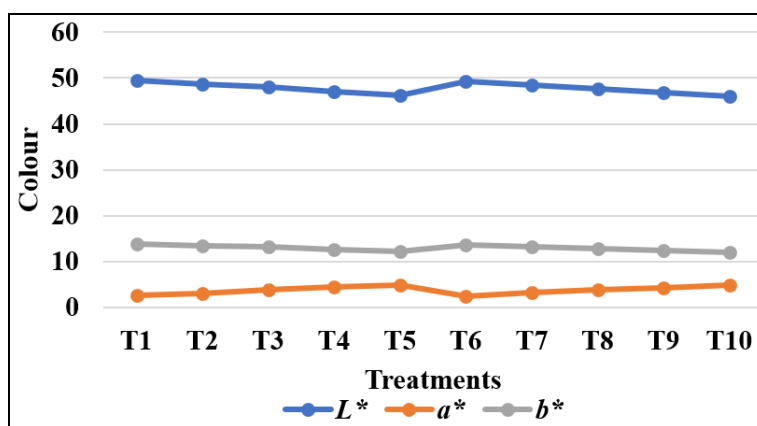


Fig 2: Effect of concentrations of firm and soft jackfruit flesh and jaggery on colour values of fruit bar

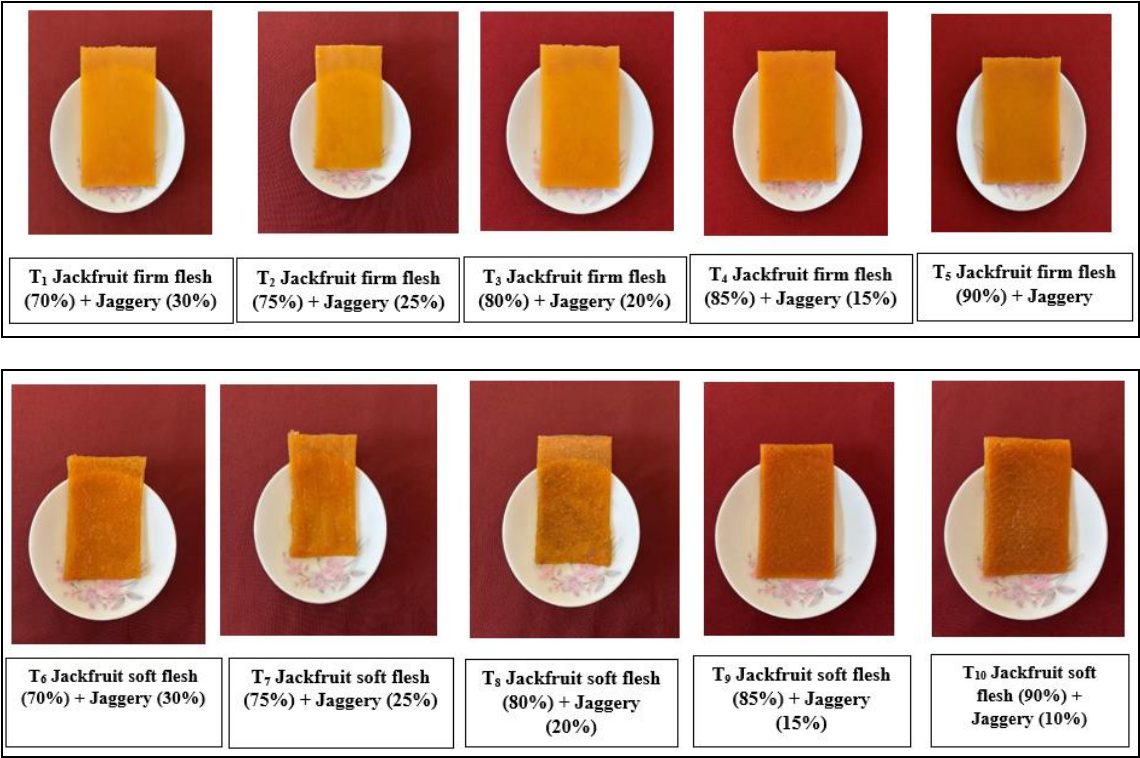


Table 2: Effect of concentrations of firm and soft jackfruit flesh and jaggery on Total Soluble Solids (⁰Brix), titratable acidity (%) and ascorbic acid (mg 100g⁻¹) content of fruit bar

Treatment Combinations	Total Soluble Solids (⁰ Brix)	Titratable Acidity (%)	Ascorbic acid (mg 100g ⁻¹)
T ₁ Jackfruit firm flesh (70%) + Jaggery (30%)	72.43 ^b	0.78 ^{gh}	14.93 ^h
T ₂ Jackfruit firm flesh (75%) + Jaggery (25%)	71.58 ^c	0.80 ^{def}	15.73 ^f
T ₃ Jackfruit firm flesh (80%) + Jaggery (20%)	70.84 ^d	0.82 ^{bcd}	16.53 ^c
T ₄ Jackfruit firm flesh (85%) + Jaggery (15%)	70.06 ^{ef}	0.84 ^{ab}	17.43 ^c
T ₅ Jackfruit firm flesh (90%) + Jaggery (10%)	69.24 ^g	0.86 ^a	18.63 ^a
T ₆ Jackfruit soft flesh (70%) + Jaggery (30%)	73.08 ^a	0.76 ^h	13.73 ^j
T ₇ Jackfruit soft flesh (75%) + Jaggery (25%)	72.26 ^b	0.77 ^{gh}	14.63 ⁱ
T ₈ Jackfruit soft flesh (80%) + Jaggery (20%)	71.46 ^c	0.79 ^{efg}	15.53 ^g
T ₉ Jackfruit soft flesh (85%) + Jaggery (15%)	70.63 ^{de}	0.81 ^{cde}	16.73 ^d
T ₁₀ Jackfruit soft flesh (90%) + Jaggery (10%)	69.86 ^f	0.83 ^{bc}	17.93 ^b
S. Em±	0.14	0.006	0.03
CD @ 1%	0.58	0.023	0.12

Total Soluble Solids (TSS) influence the sweetness, consistency and overall quality of fruit bars. Significant differences were observed among the treatments with respect to TSS. The highest was recorded in T₆ (73.08⁰Brix), this was followed by T₁ (72.43⁰Brix). The lowest was recorded in T₅ (69.24⁰Brix), may be attributed to the higher concentration of jaggery, which contributes not only sucrose but also minerals, reducing sugars and other

soluble constituents, thereby increasing the total soluble solids of the product. On the other hand, increasing the proportion of jackfruit pulp with a corresponding reduction in jaggery resulted in comparatively lower TSS values. Similar findings were reported by Singh (2012) ^[17] in guava and papaya leather prepared with jaggery, Dash *et al.* (2020) ^[3] in wild jackfruit leather and Kurniarianti *et al.* (2024) ^[9] in jackfruit leather.

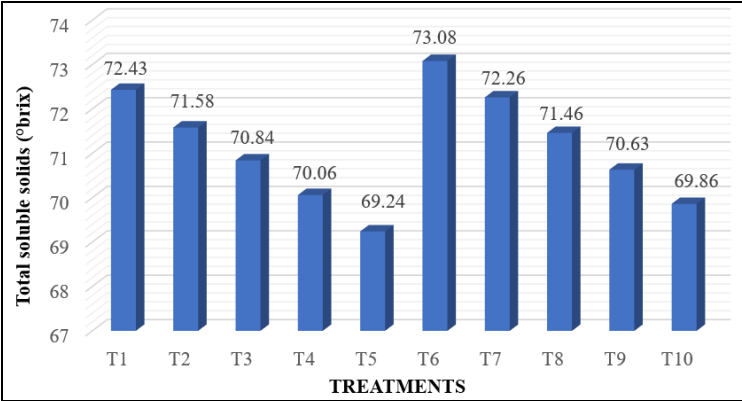


Fig 3: Effect of concentrations of firm and soft jackfruit flesh and jaggery on Total Soluble Solids (⁰Brix) of fruit bar

The titratable acidity imparts a pleasant flavour and helps maintain the quality of fruit bars. Significant variation was observed among the treatments. The highest titratable acidity was recorded in T₅ (0.86%), which was statistically on par with T₄ (0.84%). The lowest was recorded in T₆ (0.76%), may be attributed to the higher proportion of fruit pulp, which naturally contains organic acids, whereas treatments containing higher jaggery levels exhibited lower acidity because jaggery contributes minerals such as calcium, potassium and magnesium that act as natural buffering agents, thereby reducing the titratable acidity of the product. Similar observations were reported by Supritha *et al.* (2018) ^[19] in guava-papaya leather blended with sweet potato and soya slurry and Singh and Tiwari (2019) ^[16] in guava-papaya fruit leather.

Similarly, the ascorbic acid content also varied significantly among the treatments. The highest ascorbic acid content was recorded in T₅ (18.63 mg 100g⁻¹), followed by T₁₀ (17.93 mg 100g⁻¹) and the lowest was observed in T₆ (13.73 mg 100g⁻¹), may be attributed to the greater contribution of fruit pulp, which is the primary source of vitamin C in the formulation. The comparatively lower values observed in treatments containing higher proportions of jaggery could be due to dilution of fruit pulp and partial degradation of ascorbic acid during thermal processing. Similar findings were reported by Singh and Tiwari (2019) ^[16] in guava-papaya fruit leather, Narayana *et al.* (2007) ^[11] in banana fruit leather and Kurniarianti *et al.* (2024) ^[9] in jackfruit leather.

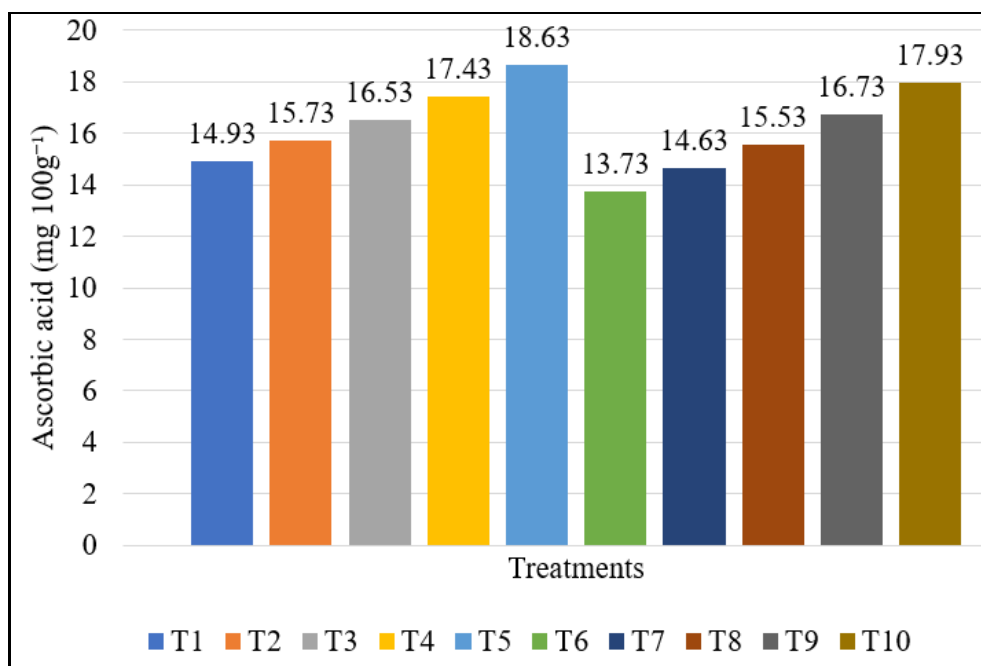


Fig 4: Effect of concentrations of firm and soft jackfruit flesh and jaggery on Ascorbic acid (mg 100g⁻¹) of fruit bar

Sensory evaluation provides an overall assessment of the quality and consumer acceptability of fruit bars based on attributes such as colour, flavour, texture, taste and overall

acceptability. In the present investigation, significant differences were observed among the treatments for all the sensory attributes.

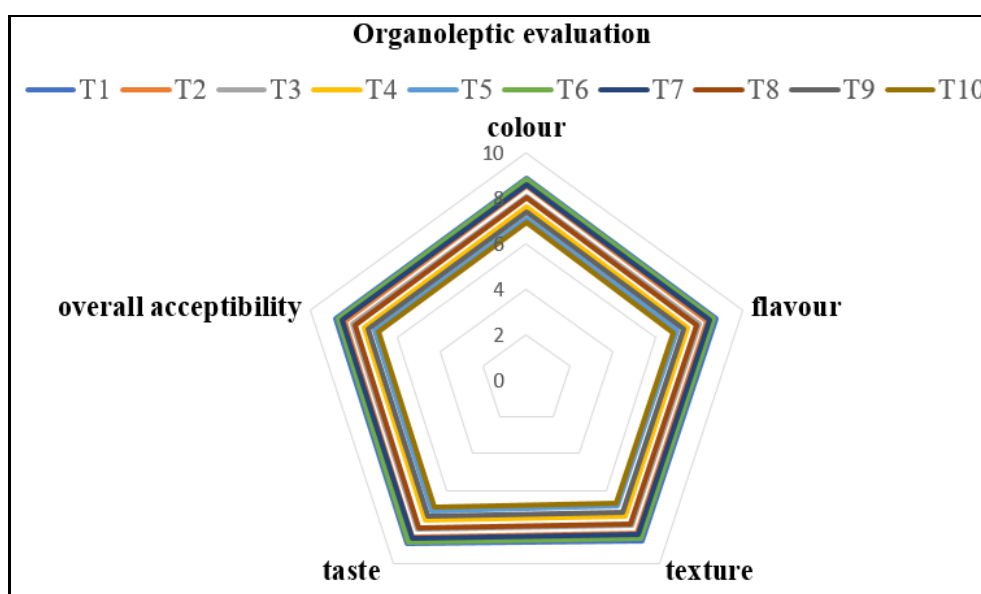


Fig 5: Effect of concentrations of firm and soft jackfruit flesh and jaggery on organoleptic evaluation of fruit bar

The highest colour score was recorded in T₁ (8.91), which was statistically on par with T₆ (8.82), whereas the lowest colour score was recorded in T₁₀ (6.92). In the present investigation, treatments containing 70 percent jackfruit pulp and 30 percent jaggery recorded superior colour scores, may be attributed to the optimum pulp-to-jaggery ratio that retained the characteristic golden-yellow colour of ripe jackfruit while minimizing excessive browning during dehydration. In contrast, increasing the proportion of jackfruit pulp with reduced jaggery resulted in comparatively lower colour scores due to darker appearance caused by non-enzymatic browning during drying. Similar findings were reported by Narayana *et al.* (2007)^[11] in banana fruit leather, Kurniarianti *et al.* (2024)^[9] in jackfruit leather and Kaushal *et al.* (2002)^[5] in apple pomace fruit leather.

Likewise, the highest flavour score was recorded in T₁ (8.80), followed by T₆ (8.70). While the lowest was recorded in T₁₀ (6.80). The characteristic aroma and flavour of fruit bars are largely influenced by the balance between fruit pulp and sweetener. The superior flavour may be attributed to the caramel-like flavour compounds present in jaggery, which complemented the characteristic aroma of ripe jackfruit and produced a well-balanced flavour profile. However, increasing the proportion of jackfruit pulp resulted in comparatively lower flavour scores, probably due to the reduced sweetening effect and dominance of the natural flavour of the pulp. Similar observations were reported by Yamini *et al.* (2015)^[21] in wood apple fruit leather, Vinayaka (2019)^[20] in jamun fruit leather and Dash *et al.* (2020)^[3] in wild jackfruit leather.

Consumer acceptance of fruit bars is greatly influenced by their texture, which depends on moisture retention and binding characteristics of the ingredients. The maximum texture score was recorded in T₁ (8.72) followed by T₆ (8.63), whereas the minimum texture score was observed in T₁₀ (6.72), may be attributed to the humectant nature of jaggery, which retained moisture and produced a soft, pliable and chewy texture. Conversely, treatments containing lower levels of jaggery exhibited comparatively lower texture scores due to increased firmness after drying. Similar improvements in texture were reported by Patel and Kulkarni (2017)^[12] in banana-cactus mixed fruit leather, Vinayaka (2019)^[20] in jamun fruit leather and Kurniarianti *et al.* (2024)^[9] in jackfruit leather.

Taste is one of the most decisive sensory attributes governing consumer acceptability of fruit bars. The highest taste score was also recorded in T₁ (8.91), followed by T₆ (8.82) while the lowest was recorded in T₁₀ (6.93). The superior taste may be attributed to the balanced combination of jackfruit pulp and jaggery, which provided optimum sweetness while retaining the characteristic flavour of ripe jackfruit. Treatments containing lower levels of jaggery received comparatively lower taste scores due to reduced sweetness and less balanced flavour. Similar findings were reported by Kulshrestha *et al.* (2012)^[7] in papaya fruit leather and Vinayaka (2019)^[20] in jamun fruit leather.

Overall acceptability represents the combined perception of colour, flavour, texture and taste by consumers. With respect to overall acceptability, the highest score was recorded in T₁ (8.82), followed by followed by T₆ (8.72), while the lowest score was recorded in T₁₀ (6.83). The superior acceptability of these treatments may be attributed to the optimum pulp-to-jaggery ratio, which produced a

desirable balance of appearance, flavour, texture and taste. The comparatively lower scores recorded in treatments containing lower levels of jaggery may be due to less desirable sensory characteristics resulting from reduced sweetness and increased firmness. Similar observations were reported by Sood and Bandral (2015)^[18] in jamun fruit bars, Dash *et al.* (2020)^[3] in wild jackfruit leather and Kurniarianti *et al.* (2024)^[9] in jackfruit leather.

Conclusion

Among the treatments evaluated, T₁ (Jackfruit firm flesh 70% + Jaggery 30%) was identified as the best formulation based on its overall physico-chemical and sensory characteristics. T₁ recorded the highest leather recovery (68.72%), higher lightness (L*) value (49.53), lower moisture content (14.18%) and water activity (0.62), along with the highest b* value (13.84). It also recorded the highest sensory scores for colour (8.91), flavour (8.80), texture (8.72), taste (8.91) and overall acceptability (8.82). Among the soft flesh treatments, T₆ (Jackfruit soft flesh 70% + Jaggery 30%) emerged as the best treatment, recording the highest leather recovery (68.18%), highest TSS (73.08°Brix), desirable colour characteristics and superior sensory acceptability. Overall, the results indicated that increasing the proportion of jaggery up to 30 percent in combination with 70 percent jackfruit flesh resulted in better physico-chemical and sensory characteristics. Hence, T₁ (Jackfruit firm flesh 70% + Jaggery 30%) can be considered the optimum formulation for the preparation of jackfruit bar, followed by T₆ (Jackfruit soft flesh 70% + Jaggery 30%), thereby providing a suitable approach for value addition and utilization of both firm and soft jackfruit.

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