Original Research Article

Formulation and quality analysis of Palmyra tender fruit endosperm (PTFE) - lime based functional nectar

ABSTRACT

Aims: Functional nectars are gaining popularity as a healthy beverage option due to their nutritional and sensory benefits. Palmyra tender fruit endosperm (PTFE) is not commercially explored for the production of value-added products. Considering the nutritional aspects, PTFE is suitable for the preparation of beverages, especially nectars. The market holds substantial opportunities for creating innovative functional beverages because of the considerable health advantages and expanding consumer desire for these drinks. Natural ingredients with strong antioxidant activities could be used to formulate these novel functional beverages. In this context, the present study aims to develop functional nectar using PTFE pulp and lime juice enriched with functional ingredients like mint, ginger, and cardamom and to evaluate its chemical, nutritional, and sensory quality parameters.

Study design: Completely Randomized Design by using GRAPES (General R-based Analysis Platform Empowered by Statistics)

Place and Duration of Study: Department of Postharvest Management, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala Agricultural University between February 2022 and July 2024.

Methodology The study involved blending of PTFE pulp and lime juice in different ratios *viz.*, (T_1) 90P:10L, (T_2) 80P:20L, (T_3) 70P:30L, (T_4) 60P:40L and (T_5) 50P:50L for the development of blended nectars as per the FSSAI specifications. The developed blended nectars were compared with pure PTFE nectar (100P) for various chemical, nutritional and organoleptic quality parameters to explore the possibility of efficient blending and for the selection of a superior blending ratio. The best-blended nectar was further incorporated with mint, ginger, and cardamom extracts at varying concentrations (C_1 - 1% ginger extract, C_2 - 2% ginger extract, C_3 - 3% ginger extract, C_4 - 1% mint extract, C_5 - 2% mint extract, C_6 - 3% mint extract, C_7 - 1% cardamom extract, C_8 - 2% cardamom extract, C_9 - 3% cardamom extract, C_{10} - without addition (control)) to develop functional nectar with superior sensory parameters.

Results: The blended nectar with 90% PTFE pulp and 10% lime juice (90P:10L) recorded 21.76^{o}Brix TSS, 0.26% acidity, 1.33% reducing sugar, 35.47% total sugar, 41.77 mg 100g^{-1} ascorbic acid and 74.75% antioxidant activity with superior sensory scores. The selected best-blended nectar is incorporated with functional ingredients such as ginger, mint and cardamom extracts in different concentrations independently for the production of functional nectars. The functional nectar (90P:10L) incorporated with 1% mint extract recorded superior sensory parameters.

Conclusion: The study concludes that blending PTFE pulp with lime juice in a 90:10 ratio and incorporating 1% mint extract results in the development of a quality functional nectar with superior nutritional and sensory properties, making it a promising healthy beverage option.

1. INTRODUCTION

Palmyra palm (*Borassus flabellifer* L.), belonging to *Arecacea*e, has several uses as food, drink, fibre, medicine, timber etc. The palmyra palm fruit is a large, fibrous fruit with a black husk that grows in clusters inside which 3-4 sweet, jelly-like, translucent, pale-white endosperms can be seen. Palmyra tender fruit endosperm (PTFE) is a summer delicacy consumed in the southern and eastern parts of India and it acts as a coolant during hot summer. It contains 43 kcal of energy, 87.6 g water, 0.8 g protein, 0.1 g fat and 10.9 g carbohydrates per 100 g fresh weight (Piyush, 2016) and is rich in vitamin B, iron, calcium, niacin and riboflavin. It is used to cure ulcers, urinary infections and heat rashes which mainly occur during summer months. The endosperm possesses medicinal properties, including stomachic, sedative, laxative, and aphrodisiac effects, and is used in folk medicine to treat various ailments (Mathanghi *et al*., 2020). It also has anti-inflammatory, antibacterial, analgesic, and antioxidant properties (Behera, 2022).

Fresh PTFE has a short shelf life of 2-3 days and is very susceptible to post-harvest losses due to oxidation and fermentation. Adoption of proper processing, packaging, preservation and storage is necessary to extend shelf life and reduce postharvest losses. As an under-exploited crop, palmyra palm has received less attention from researchers for the development of value-added products (Ambrose, 2018).

Considering the nutritional aspects, PTFE can be effectively utilized for product preparation. It is suitable for the preparation of beverages, especially nectars. Fruit-based beverages are a prominent part of the food industry, that are growing popular around the world due to their appealing flavour, taste and nutritional properties. The endosperm pulp can be mixed with fruit juices especially lime or with functional ingredients such as cardamom, ginger and mint in varying proportions for the development of blended and functional nectars with good sensory and quality attributes. In this context, the present study was conducted to develop functional nectar from palmyra tender fruit endosperm and to evaluate its chemical, nutritional and sensory quality parameters.

2. MATERIALS AND METHODS

Good quality, fresh and tender palmyra fruits were collected from the market during the season. The husk was removed, fresh endosperm was scooped out and pulp was extracted after removing the endocarp. The extracted pulp of PTFE was blended with lime juice in 6 different ratios *viz*., 90P:10L (T_1), 80P:20L (T_2), 70P:30L (T_3), 60P:40L (T_4), 50P:50L (T_5) and 100P (T_6) (control) for the production of blended nectars as per the FSSAI specifications. The blended nectars were compared with pure PTFE nectar (100P) for chemical, nutritional and organoleptic quality parameters. Chemical parameters such as TSS, acidity, reducing sugar, total sugar (Parekha *et al*., 2014) and nutritional parameters such as ascorbic acid (Parekha *et al*., 2014) and antioxidant activity (Sharma and Bhat, 2009) were evaluated. Sensory quality parameters like colour, appearance, flavour, texture, taste and overall acceptability of blended nectars were evaluated by conducting sensory evaluation with a semi-trained panel of 30 members (Sadashivam and Manikam, 1992). The present study was employed in Completely Randomized Design (CRD) with 6 treatments and 3 replications. Data recorded from the experiments were statistically analyzed using GRAPES (Gopinath *et al*., 2021) and significance was tested using analysis of variance (ANOVA). The General R-based Analysis Platform Empowered by Statistics (GRAPES) version 1.0.0 (Gopinath *et al*., 2021) was used to analyze the data. The scores obtained for sensory parameters were statistically analyzed using the Kruskall - Wallis Chi-square test (Reddy *et al*., 2024). Based on superior chemical, nutritional and organoleptic quality parameters, the best blending ratio of nectar was selected.

The selected best-blended nectar was incorporated with different functional ingredients such as ginger, mint and cardamom extracts in different concentrations (C_1 - 1% ginger extract, C_2 - 2% ginger extract, C_3 - 3% ginger extract, C_4 - 1% mint extract, C_5 - 2% mint extract, C_6 - 3% mint extract, C_7 - 1% cardamom extract, C_8 - 2% cardamom extract, C_9 - 3% cardamom extract, C_{10} - without addition (control)) independently for the production of functional nectars. The developed functional nectars were evaluated for sensory quality parameters like colour, appearance, flavour, texture, taste and overall acceptability by conducting sensory evaluation with a semi-trained panel of 30 members (Sadashivam and Manikam 1992). The flow chart for the development of 100 ml PTFE-lime-based best functional nectar is illustrated in Fig.1.

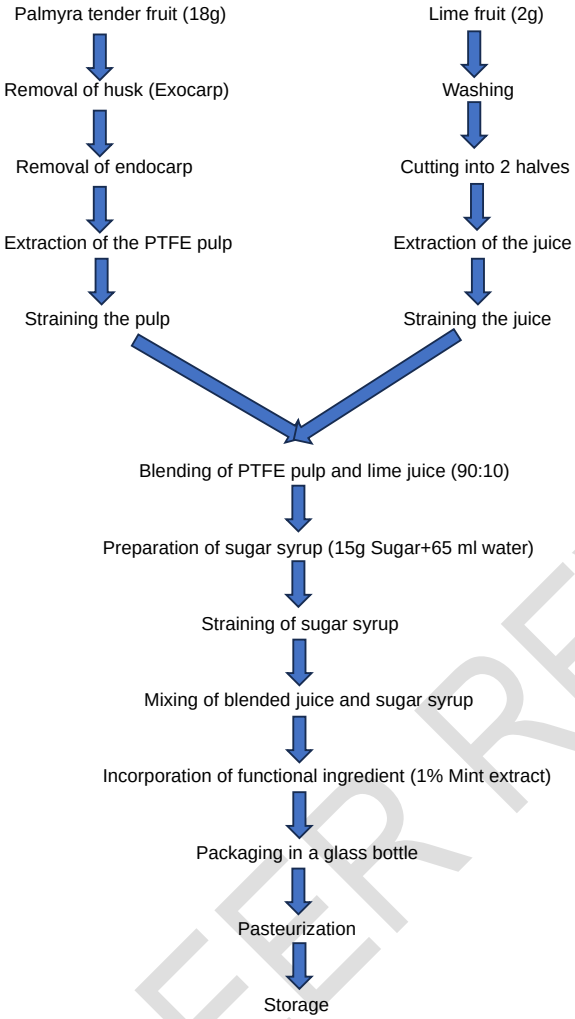

Fig 1. Development of Functional nectar

3. RESULTS AND DISCUSSION

3.1 DEVELOPMENT OF PTFE-LIME BLENDED NECTAR

3.1.1 CHEMICAL PARAMETERS

The data concerning the chemical quality parameters of blended nectars are presented in Table 1. The result revealed that the TSS content of blended nectars was significantly decreased with increased lime juice concentration. The pure PTFE nectar (T_6) recorded the highest TSS content (22.00^{o}Brix), whereas the least TSS content (19.77^{o}Brix) was observed in the blended nectar prepared with 50% PTFE pulp and 50% lime juice (T_5). This is due to the higher TSS content of PTFE pulp compared to the lime juice. The TSS of blended nectar prepared with 80% PTFE pulp and 20% lime juice (T_2) was 20.50 ^{o}Brix which was on par with the blended nectar 70% PTFE pulp and 30% lime juice (T_3) (20.40 ^{o}Brix) (Fig.2).

The acidity of blended nectars was significantly increased from 0.17% to 1.11% with the addition of lime juice. The highest acidity (1.11%) was found in the blended nectar prepared with 50% PTFE pulp and 50% lime juice (T_5) and the lowest was found in pure PTFE nectar (Control)(T_6) which was on par with the blended nectar prepared with 90% PTFE pulp and 10% lime juice (0.26%). The acidity of blended nectar prepared with 80% PTFE pulp and 20% lime juice (T_2) was 0.55% which was on par with the blended nectar 70% PTFE pulp and 30% lime juice (T_3) (0.64%) (Fig. 3). The increased acidity may be due to the inherent acidity of lime juice. A similar trend was reported by Inthuja *et al*. (2020) in cabbage-lime blended RTS beverage where the titrable acidity of blended RTS beverage increased gradually with the addition of lime juice. Daramola and Asunni, (2007) also reported similar findings in pawpaw-red ginger drink.

The total and reducing sugar contents were decreased with an increase in lime juice concentration. The highest reducing sugar content (1.43 %) was recorded in pure PTFE nectar (Control)(T_6) and the lowest (0.85%) was recorded in blended nectar developed by blending 50% PTFE pulp and 50% lime juice (T_5). The reducing sugar content of blended nectar prepared with 80% PTFE pulp and 20% lime juice (T_2) was 0.55% which was on par with the blended nectar 70%

PTFE pulp and 30% lime juice (T_3) (0.64%) (Fig. 4). Similar results were observed by (Gupta *et al*., 2022) where the incorporation of mint and basil juice in the bottle gourd based herbal nectar showed reduction in reducing sugar. The reduction in sugar may be due to the lower concentration of reduced sugar in the raw materials used for making nectar.

The highest total sugar content (40.51 %) was recorded in pure PTFE nectar (Control)(T_6) and the lowest (25.44%) was recorded in blended nectar developed by blending 50% PTFE pulp and 50% lime juice (T_5). The total sugar content of blended nectar prepared with 70% PTFE pulp and 30% lime juice (T_3) was 31.35% which was on par with the blended nectar 60% PTFE pulp and 40% lime juice (T_4) (30.53%) (Fig. 5). Similar results were reported by Gupta *et al*. (2022) where the total sugar content decreased with the addition of mint and basil juice. The results are in line with the findings of Kesharwani *et al*. (2015) in blended jamun RTS beverage, Tiwari and Deen (2015) in bael-aloe vera RTS beverage and Rahman (2021) in mulberry-aloe vera blended nectar.

Table 1. Chemical parameters of PTFE- Lime blended nectars

Blending ratios	TSS (° Brix)	Acidity (%)	Reducing sugar (%)	Total sugar (%)
90P:10L (T1)	21.76^{b}	0.26^{d}	1.33^{b}	35.47^{b}
80P:20L (T2)	20.50^{c}	0.55^{c}	1.14^{c}	33.25^{c}
70P:30L (T3)	20.40^{c}	0.55^{c}	1.09^{c}	31.35^{d}
60P:40L (T4)	20.17^{d}	0.85^{b}	0.99^{d}	30.53^{d}
50P:50L (T5)	19.77^{e}	1.11^{a}	0.85^{e}	25.44^{e}
Control 100P (T6)	22.00^{a}	0.17^{d}	1.43^{a}	40.51^{a}
SE(±m)	0.07	0.04	0.02	0.50
CD (0.05)	0.22	0.12	0.06	1.54

P: Palmyra tender fruit endosperm pulp, L: Lime juice

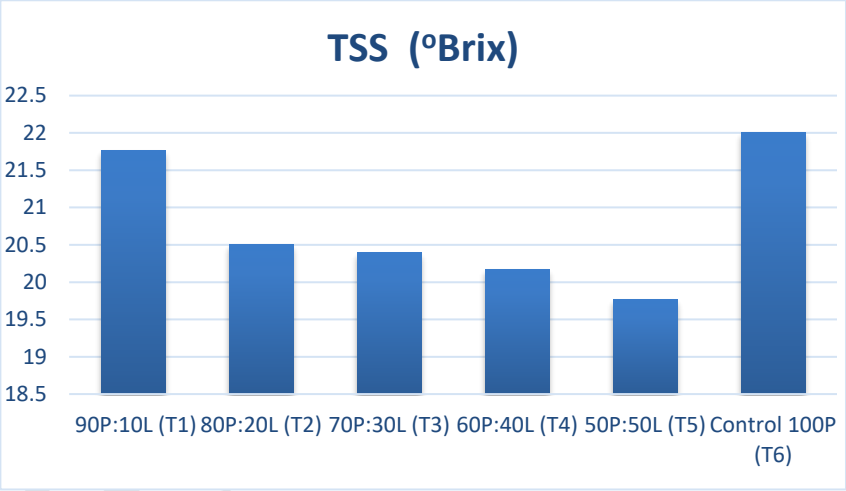

Fig. 2. TSS content of PTFE-Lime blended nectars

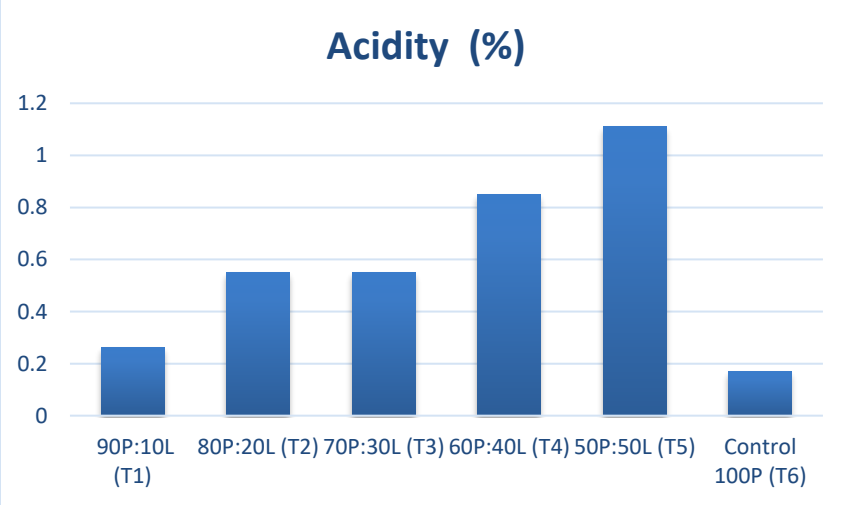

Fig. 3. Acidity content of PTFE Lime blended nectars

3.1.2 NUTRITIONAL PARAMETERS

The data with respect to the nutritional parameters of blended nectars are presented in Table 2. The ascorbic acid content of blended nectar decreased significantly with the addition of lime juice. The highest ascorbic acid content (43.20 mg $100g^{-1}$) was recorded in pure PTFE nectar (Control)(T_6), which was on par with the blended nectar prepared with 90% PTFE pulp and 10% lime juice (41.77 mg $100g^{-1}$) (T_1). The ascorbic acid content of blended nectar prepared with 70% PTFE pulp and 30% lime juice (T_3) was 31.58 mg $100g^{-1}$ which was on par with the blended nectar prepared with 60% PTFE pulp and 40% lime juice (28.07 mg $100g^{-1}$) (T_4). The lowest ascorbic acid content of 22.81 mg$100g^{-1}$ was recorded in blended nectar prepared with 50% PTFE pulp and 50% lime juice (T_5) (Fig. 6). The results are in line with the findings of Verma *et al*. (2014) in aonla-lime carbonated soft drinks, where the vitamin c content showed a decreasing trend with the addition of lime juice. Similar findings were also recorded by Jumde *et al*. (2015) in watermelon-beetroot blended juice, where the addition of beetroot juice to watermelon juice reduced the vitamin C content.

The antioxidant activity of blended nectars was reduced with the addition of lime juice from 10% to 50%. The highest antioxidant activity (74.98 %) was recorded in pure PTFE nectar (Control)(T_6) which was on par with the blended nectars prepared with 90% PTFE pulp and 10% lime juice (74.75%) (T_1) and 80% PTFE pulp and 20% lime juice (71.30 %) (T_2). The lowest antioxidant activity of 67.01 % was recorded in blended nectar prepared with 50% PTFE pulp and 50% lime juice (T_5) which was on par with the blended nectar prepared with 60% PTFE pulp and 40% lime juice (70.90%) (T_4) (Fig. 7). The results confirmed with the findings of Tharmaratnam *et al*. (2020). They reported that the high phenolic and vitamin C content of palmyra tender fruit contributed to its high antioxidant properties.

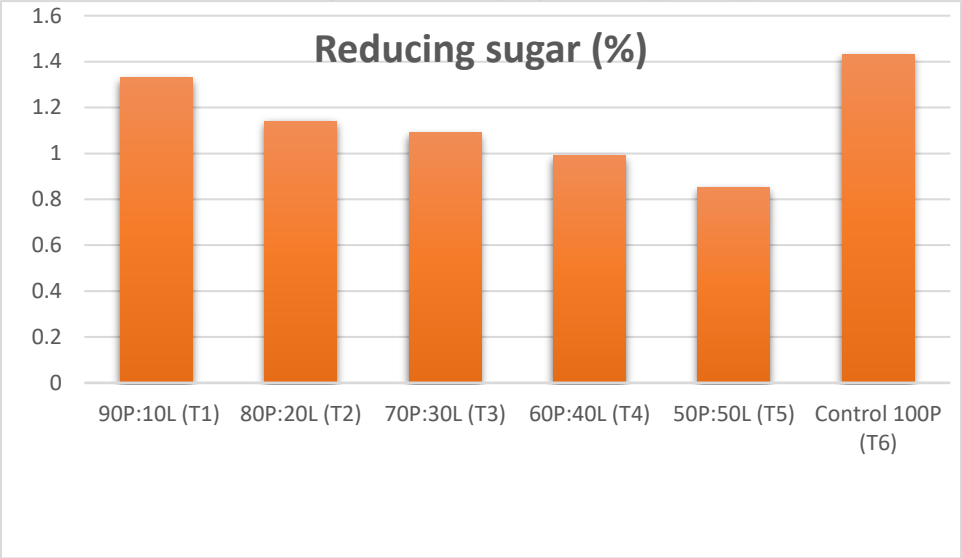

Fig. 4. Reducing sugar content of PTFE Lime blended nectars

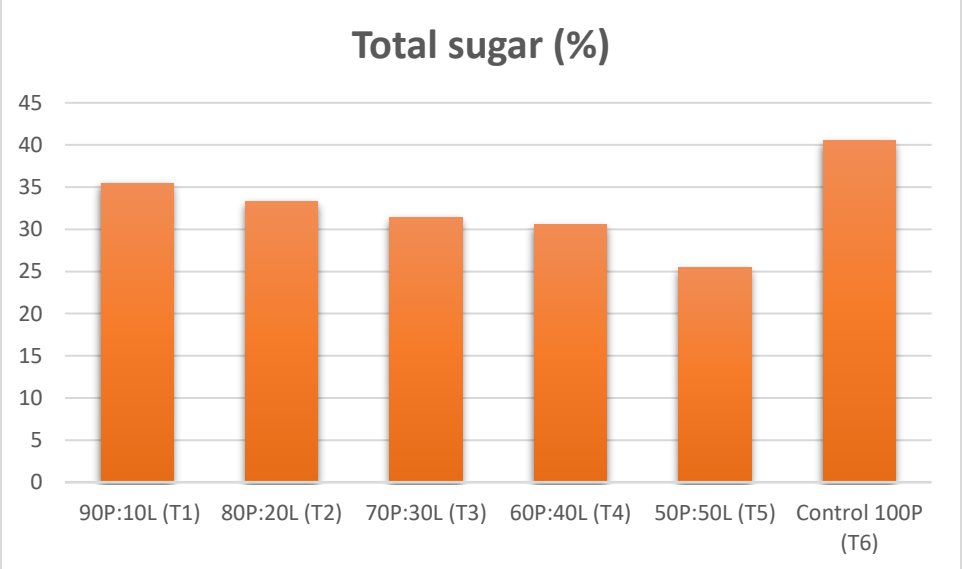

Fig. 5. Total sugar content of PTFE Lime blended nectars

Table 2. Nutritional parameters of PTFE-Lime blended nectars

Blending ratios	Ascorbic acid (mg 100g^{-1})	Antioxidant activity (%)
90P:10L (T1)	41.77^{a}	74.75^{a}
80P:20L (T2)	35.09^{b}	71.40^{ab}
70P:30L (T3)	31.58^{bc}	71.30^{bc}
60P:40L (T4)	28.07^{c}	70.90^{c}
50P:50L (T5)	22.81^{d}	67.01^{c}
Control (T6)	43.20^{a}	74.98^{a}
SE(±m)	1.25	1.23
CD(0.05)	3.85	3.78

P: Palmyra tender fruit endosperm pulp, L: Lime juice

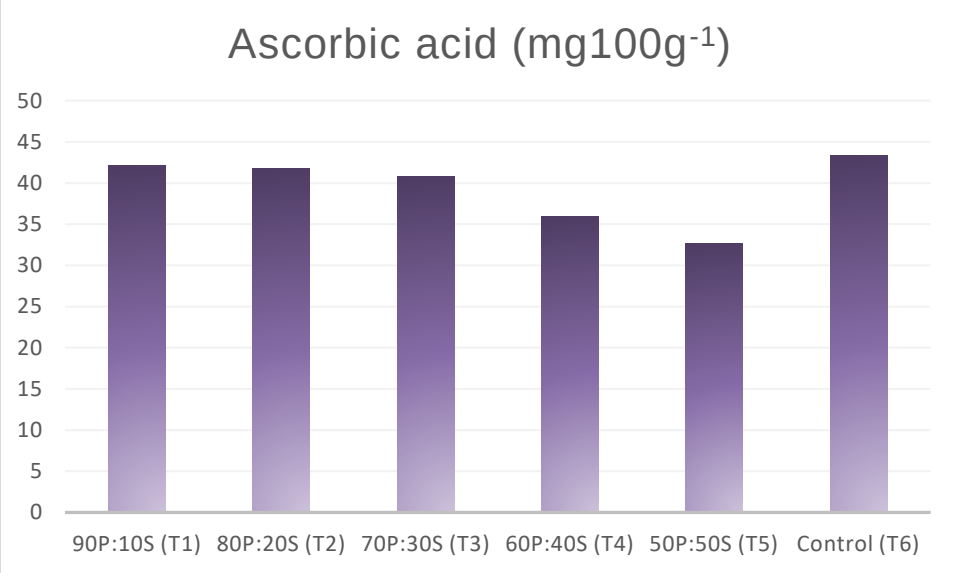

Fig. 6. Ascorbic acid content of PTFE Lime blended nectars

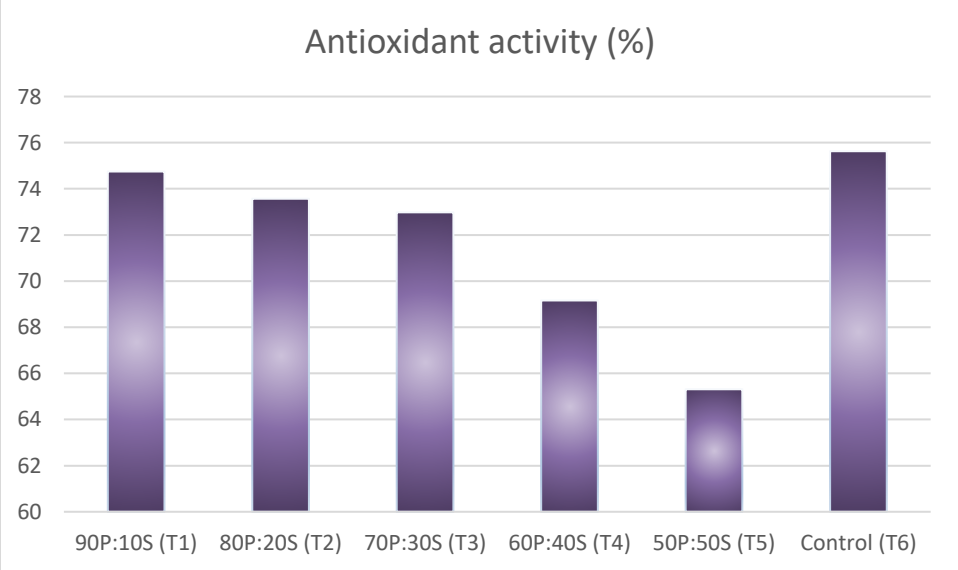

Fig. 7. Antioxidant activity of PTFE Lime blended nectars

3.1.3 SENSORY EVALUATION OF PTFE-LIME BLENDED NECTARS

When the prepared blended nectars were subjected to sensory evaluation (Table 3), the blended nectar prepared

with 90% PTFE pulp and 10% Lime juice (T_1) had superior sensory scores for flavour (8.08), texture (8.75), taste (8.83) and overall acceptability (8.44). As the addition of lime juice hadn't made any difference in colour and appearance, there was no significant difference in it. Blending of fruit pulps could improve the acceptability of products as reported by Take *et al*. (2012). Hence, it would be concluded that the blending of fruit pulps provides better compatibility for the preparation of quality blended nectars. A study conducted by Jain *et al*. (2011) reported that blending of two or more fruit pulps in different ratios had positively influenced the sensory properties of beverages. Blending of fruit juices can enhance the sensory acceptability of nectars. Studies have shown that combining different fruits can create appealing flavour profiles and improve nutritional content. For example, a nectar made from papaya, passion fruit, and acerola received positive consumer ratings (Matsuura *et al*., 2004). Similarly, according to Hayat *et al*. (2019), blending fruit juices, such as lemon with ginger, enhances sensory acceptability by reducing bitterness and improving sensory qualitative parameters. The study found that the 80% lemon and 20% ginger blend was particularly well-received, indicating its potential as a nutritional drink.

Table 3. Sensory evaluation of PTFE-Lime blended nectars

Blending ratios	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability
90P:10L (T1)	7.92	8.33	8.08	8.75	8.83	8.44
80P:20L (T2)	7.67	7.50	7.08	7.25	6.67	7.15
70P:30L (T3)	7.42	7.33	6.58	6.92	6.75	6.94
60P:40L (T4)	7.33	7.08	6.08	6.75	6.17	6.56
50P:50L (T5)	7.42	7.33	5.58	5.75	5.42	6.18
Control (T6)	8.00	7.67	7.33	7.58	7.00	7.39
KW VALUE	4.32	8.13	23.10**	35.80**	29.70**	35.00**
X^2			11.07			

*P: Palmyra tender fruit endosperm pulp, L: Lime juice ** Significant*

3.2 DEVELOPMENT OF FUNCTIONAL NECTAR

The selected superior blended nectar (90P:10S) was incorporated with various functional ingredients such as extracts of ginger, mint, and cardamom at different concentrations (C_1 - 1% ginger extract, C_2 - 2% ginger extract, C_3 - 3% ginger extract, C_4 - 1% mint extract, C_5 - 2% mint extract, C_6 - 3% mint extract, C_7 - 1% cardamom extract, C_8 - 2% cardamom extract, C_9 - 3% cardamom extract, C_{10} - control without addition) for the production of functional nectars.

When the developed functional nectars were subjected to sensory evaluation (Table 4), the functional nectar prepared with 90% PTFE pulp and 10 % lime juice incorporated with 1% mint extract (T_4) had superior sensory scores for appearance (8.20), flavour (7.10), texture (8.00), taste (7.40) and overall acceptability (7.43). Various research has shown that adding functional ingredients to fruit nectars can enhance their sensory and nutritional qualities. According to El-Refai *et al*. (2017), medicinal extracts such as ginger, roselle, peppermint, and aloe vera have been shown to increase the antioxidant activity and bioactive compound content in fruit nectar blends. Aloe vera gel into mango nectar increased its total soluble solids, acidity, viscosity, and vitamin C content while acting as a natural preservative (Elbandy *et al*., 2014). Similarly, the addition of pomegranate peel and guava leaf extracts to guava nectar significantly increased its antioxidant activity, enhancing its nutritional profile (Mokhtar and Ibrahim, 2020). These extracts are rich in flavonoids and phenolic compounds, which contribute to the health benefits of the nectar. It was also in line with the findings of Gupta *et al*. (2024), who reported that the incorporation of functional ingredients such as mint and basil in nectar formulations has been shown to positively influence sensory qualities.

Table 4. Sensory evaluation of PTFE-Lime (90:10) functional nectars

Blending ratios	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptability
T1 (Ginger-1%)	6.40	6.90	6.60	6.80	7.10	6.73
T2 (Ginger-2%)	6.00	5.65	5.90	6.60	5.80	5.93
T3 (Ginger-3%)	5.80	5.70	6.30	6.60	6.10	6.03
T4 (Mint-1%)	8.20	7.10	7.10	8.00	7.40	7.43
T5 (Mint-2%)	6.30	6.80	6.10	6.60	6.10	6.30
T6 (Mint-3%)	6.20	5.60	6.30	6.00	5.70	5.98
T7 (Cardamom-1%)	7.50	7.10	7.10	7.50	7.30	7.31
T8 (Cardamom-2%)	7.00	6.60	6.30	6.70	6.30	6.55
T9 (Cardamom-3%)	6.30	6.10	6.80	6.70	6.90	6.55
T10(Control)	5.10	5.60	3.90	3.40	5.80	4.85
KW value	31.74**	15.60	24.88**	30.43**	17.10**	28.01**
X^2			16.91			

*** Significant*

4. CONCLUSION

In this study, the blended nectar prepared with 90% PTFE pulp and 10% lime juice was selected as the best-blended nectar due to its superior chemical, nutritional and sensory quality parameters. The selected blended nectar showed TSS of 21.76 ° Brix, acidity of 0.26%, reducing sugar content of 1.33% and total sugar content of 35.47%, ascorbic acid content of 42.17 $mg100g^{-1}$ and antioxidant activity of 74.75%. It also recorded superior sensory scores for flavour (8.08), texture (8.75), taste (8.83) and overall acceptability (8.44), hence selected for the addition of functional ingredients to produce quality functional nectar. The functional nectar prepared with 90% PTFE pulp and 10 % lime juice incorporated with 1% mint extract had superior sensory scores for appearance (8.20), flavour (7.10), texture (8.00), taste (7.40) and overall acceptability (7.43).

Disclaimer (Artificial intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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