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 valueadded products. Considering the nutritional aspects, PTFE is suitable for the preparation of beverages especially nectars. The present study aims to develop a 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 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 extract at varying concentrations (1%, 2%, 3%) for developing 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 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 nectar. Functional ingredients such as the functional nectar incorporated with 1% mint extract recorded enhanced sensory properties.

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

1. INTRODUCTION

Palmyra palm (*Borassus flabellifer* L.), belonging to Arecaceae, 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 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) and 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 (Ambrose, 2018). Adoption of proper processing, packaging, preservation and storage are 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 valueadded products.

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 prominent part of the food industry, that are growing popularly around the world due to its appealing flavor, 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 is proposed to develop a 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 market during 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 nectar 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 (Parekha et al. 2014), reducing sugar (Parekha et al. 2014), 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, flavor, texture, taste and overall acceptability of blended nectars were evaluated by conducting sensory evaluation with a semi-trained panel of 30 members (Sadashivam & 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 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 nectar. The developed functional nectars were evaluated for sensory quality parameters like colour, appearance, flavor, texture, taste and overall acceptability by conducting sensory evaluation with a semi-trained panel of 30 members (Sadashivam & Manikam 1992).

3. RESULTS AND DISCUSSION

3.1 DEVELOPMENT OF PTFE-LIME BLENDED NECTAR

3.1.1 CHEMICAL PARAMETERS

The data with respect to 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°Brix), whereas the least TSS content (19.77°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 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.1).

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. 2). The increased acidity may be due to the inherent acidity of lime juice. 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) reported the similar findings in pawpaw-red ginger food drink.

The total and reducing sugar contents were decreased with 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 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). Similar results were observed by (Gupta et al., 2022) where incorporation of mint and basil juice in the bottle gourd based herbal nectar showed reduction in reducing sugar. The reduction in reducing sugar may be due to the lower concentration of reducing 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. 4). 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 Kesharwani et al. (2015) in blended jamun RTS, Tiwari and Deen (2015) in bael-aloe vera RTS beverage and in mulberry-aloe vera blended nectar by Rahman (2021).

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

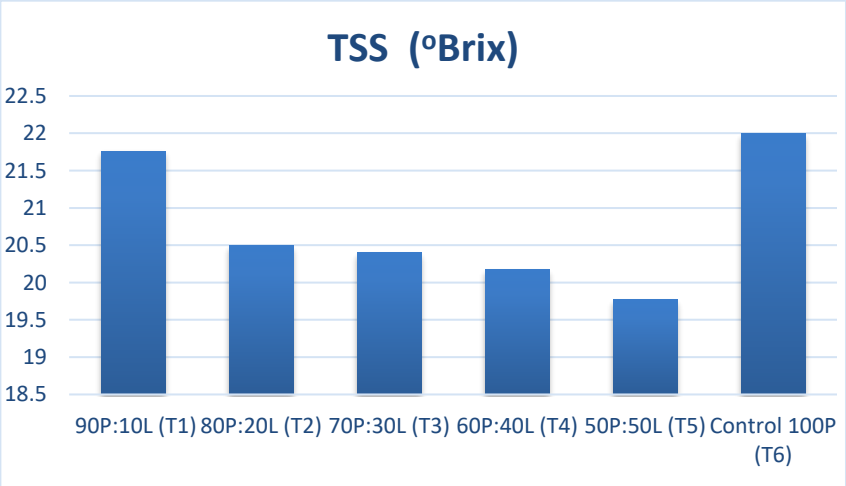

Fig. 1. TSS content of PTFE-Lime blended nectars

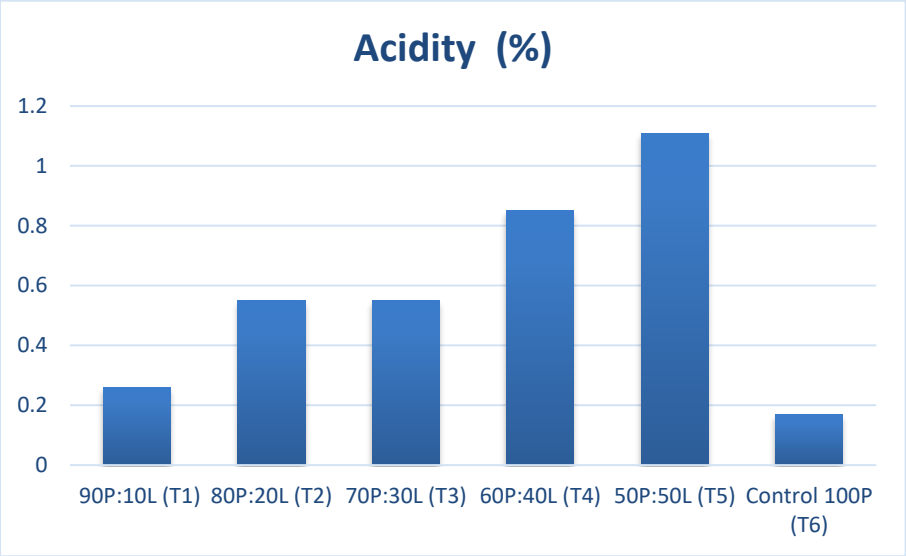

Fig. 2. Acidity content of PTFE Lime blended nectars

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 (31.58 mg $100g^{-1}$) (T_3) 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 $mg100g^{-1}$ was recorded in blended nectar prepared with 50% PTFE pulp and 50% lime juice (T_5) (Fig. 5). The results are in line with the findings of Verma et al. (2014) in aonla-lime carbonated soft drinks, where the vit 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 nectar prepared with 90% PTFE pulp and 10% lime juice (74.75%) (T_1) and the blended nectar prepared with 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. 6). 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 contributing to its high antioxidant properties.

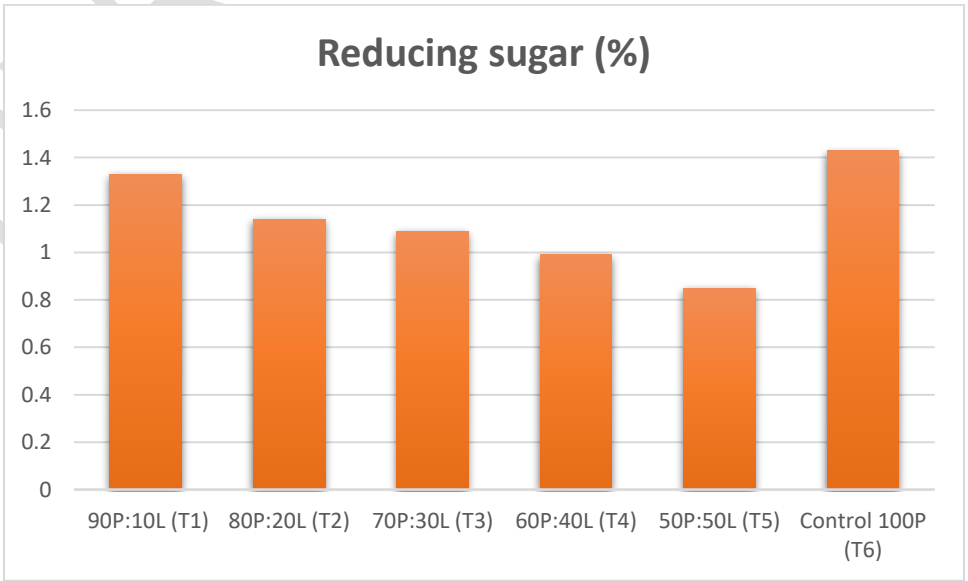

Fig. 3. Reducing sugar content of PTFE Lime blended nectars

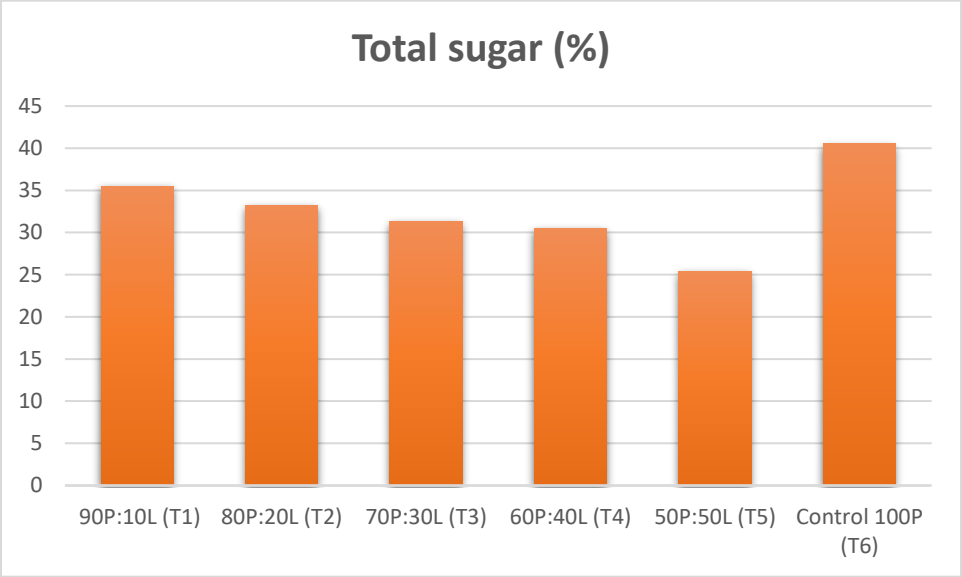

Fig. 4. Total sugar content of PTFE Lime blended nectars

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

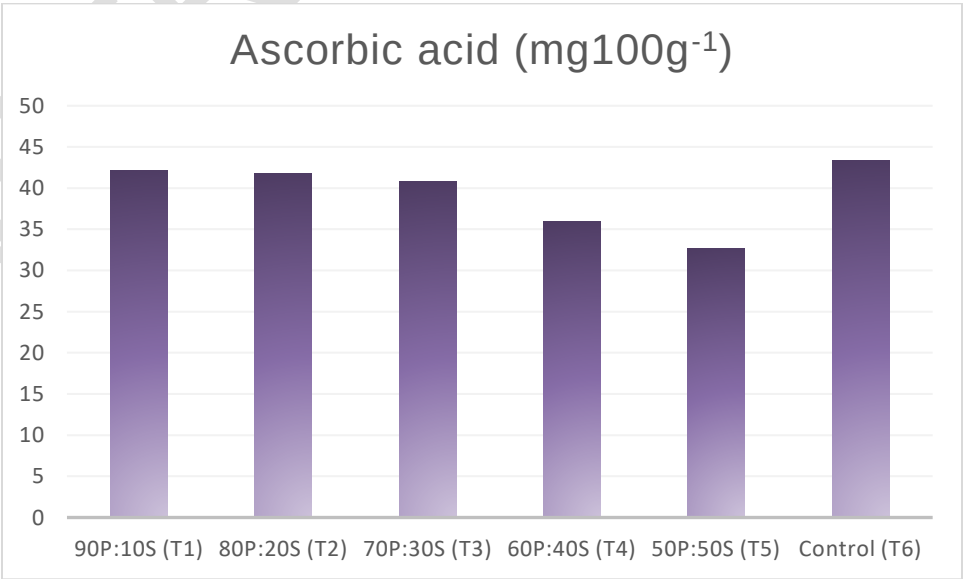

Fig. 5. Ascorbic acid content of PTFE Lime blended nectars

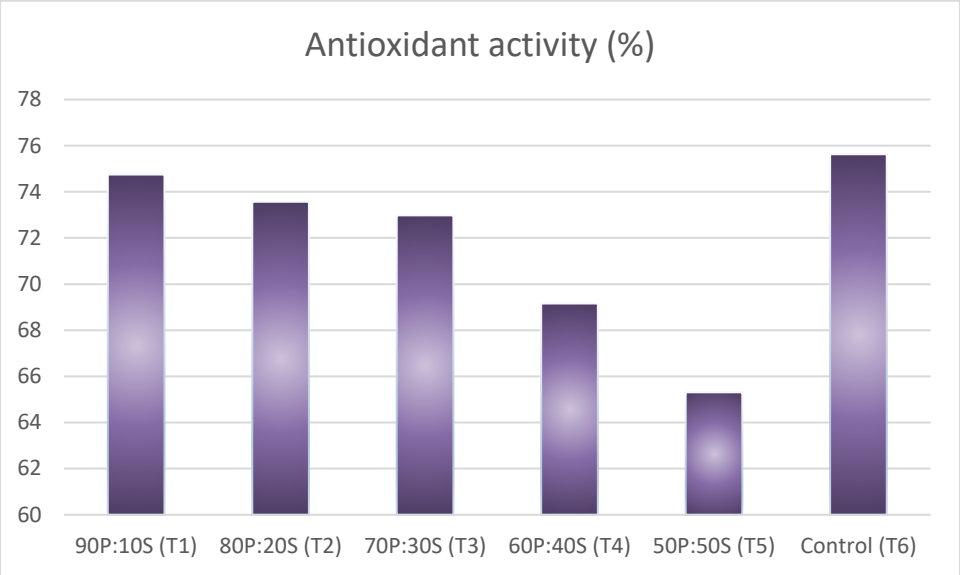

Fig. 6. Antioxidant activity of PTFE Lime blended nectars

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 hadn't made any difference in colour and apperence, 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 sensory properties. Blending fruit juices can enhance the sensory acceptability of nectars. Studies have shown that combining different fruits can create appealing flavor 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 an 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 Acceptibility
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 chosen optimal blended nectar (90P:10S (T_1)) was made by incorporating various functional ingredients, including extracts of ginger, mint, and cardamom at different levels (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 any additions) for the purpose of producing functional nectar.

When the prepared blended nectars were subjected to sensory evaluation (Table 4), the blended 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). Researches has shown that adding functional ingredients to fruit nectars can enhance their sensory and nutritional qualities. Incorporating 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 total phenolic content and antioxidant activity, enhancing its nutritional profile (Mokhtar & Ibrahim, 2020). 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. 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), 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 functional nectars

Blending ratios	Appearance	Colour	Flavour	Texture	Taste	Overall Acceptibility
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 (T_1) was selected as the best blended nectar due to its superior chemical, nutritional and organoleptic quality parameters. The blended nectar T_1 showed TSS of 21.76 ° Brix, acidity of 0.26%, reducing sugar content of 1.33% and total sugar content of 35.47%. Based on nutritional parameters the blended nectar T_1 showed ascorbic acid content of 42.17 $mg100g^{-1}$ and antioxidant activity of 74.75%. T_1 also recoded superior sensory scores for flavor (8.08), texture (8.75), taste (8.83) and overall acceptability (8.44), hence it is selected as the best blending ratio for the addition of functional ingredients. The blended 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)

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