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Development of coconut milk-based palmyrah fruit pulp drink for ready to serve beverage market

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ABSTRACT

Plant-based or non-dairy milk alternatives are a growing trend in new product development. The palmyrah (*Borassus flabellifer* L) fruits have excellent nutritional and functional properties with unique organoleptic characteristics. Unfortunately, they are often wasted during their peak season due to limited industrial utilization. The present study was focused on the ready-to-serve beverage market. Coconut milk (*Cocos nucifera* L.) based Palmyrah fruits pulp drink was developed with four product formulations by changing the pulp percentage (T1=0 %, T2=20 %, T3=40 %, and T4=60 %). Pulp was treated with acid and heat treatment to reduce and mask its bitterness. The proximate composition, physicochemical, functional, and microbial properties were determined for all product formulations. Results were analyzed using the parametric one-way ANOVA turkey test method at a 5 % significance level. Sensory properties were evaluated by performing nine point hedonic scale test using 30 semi-trained panelists and data were analyzed using the Friedman test. With compared to other formulations, T2 was selected with better physicochemical and sensory properties. The pH (5.2), TSS (12° Brix), titratable acidity (0.04), specific gravity (1.04), and viscosity (124 mm^2/s) were not significantly varied during storage at room temperature. Moisture, fat, protein, carbohydrate, crude fiber and ash contents are 83.29 %, 3.4 %, 1.63 %, 23.49 %, 0.21 % and 1.55 % respectively. Functional properties were determined by DPPH (112 mg/ml) and Total phenolic content (GAE 35.31 mg/100 g). According to evaluation, the shelf-life of the product can be predicted as more than 12 weeks. Overall the study findings highlight that the newly developed coconut milk based palmyrah pulp drink is a marketable product boasting significant nutritional and functional properties. With its favorable sensory attributes, stability during storage and extended shelf life, this beverage holds great potential in the market as a desirable and healthful alternative for consumers seeking plant based and lactose free options.

Introduction

Plant based drink is a food product obtained from plant sources that have a similar appearance to milk. It can be used as a substitute for animal milk due to its nutritive, functional, and sensory characteristics. Plant materials such as soy, nut, and rice are extracted in water to prepare non-dairy beverages (Singh et al., 2017). Coconut milk is a natural oil-in-water emulsion derived from the endosperm of mature coconuts (*Cocos nucifera* L), and it is used in many Asian and Pacific traditional dishes. Coconut milk is obtained with the addition of water into the aqueous extract of coconut flesh. Coconut milk products made with sterilized coconut milk or pasteurized coconut milk are available in the market. Because the protein concentration in coconut milk is insufficient to stabilize the product, it is unstable and susceptible to phase separation. Stabilizers, emulsifiers and thickening agents are added during the production of coconut milk to improve its stability (Thanatrungrueang, N. and Harnsilawat, T., 2019).

Palmyrah (*Borassus flabellifer* L) is a palm tree widespread in many countries including South America, southeast Asia, Africa, India, and Sri Lanka (Saidi et al., 2021). Palmyrah pulp and tuber contains some compounds such as bioactive components (Tannin, Saponin, and Phenol), dietary fibers, and anti-oxidant properties (Mishra et al., 2012). These are the nutrient-rich compounds that are used as food ingredients. In addition, palmyrah pulp has anti-inflammatory properties that help curing skin irritations and can provide therapy for nausea, vomiting as well as worm infestation (Vengaiah et al., 2021).

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Nowadays people desire plant-based milk products due to the increasing cost and intolerant characteristics of milk from animal origin. Coconut milk and palmyrah fruit pulp consist of high nutrition. These are seasonal fruits and are available at a low cost. Therefore, pulp-incorporated coconut milk was formulated to prepare nutritious rich beverage by reducing the bitterness of palmyrah pulp by evaluating the physicochemical, sensory and nutritional characteristics.

Materials and methodology

Raw materials

Raw materials such as palmyrah fruit and 8-month-old coconut were obtained from Mullaitivu district which is located in the Northern Province of Sri Lanka. Other food-grade ingredients were purchased from the local market. Analytical grade chemicals and equipment which were available at Palmyrah Research Institute and Sabragamuwa University of Sri Lanka was used for this study. Analytical balance (Radwag, Polland), Homogenizer (Velp Scientifica-OV5), Oven, K-Type Thermometer (TECPEL DTM-305, Taiwan), magnetic stirrer (C-MAG HS7), muffle furnace (HD- 230), pH meter (Sension+ pH 31, Spain), refractometer (HSR500, Japan) were used for the experiments.

Preparation of raw materials

Palmyrah fruit pulp: The black-skinned palmyrah fruit was selected for the pulp drink preparation. Immediately fallen, well-ripen, pest attack-free fruits were collected, washed in running tap water, and dipped in warm water intermittently to remove the pathogenic microbial load. Then the fruits were peeled off by adding 100 ml of water per seed. The pulp was extracted by squeezing manually and strained through a sieve to separate it from the fiber parts. The strained pulp was heated to 60 °C for 20 min and foams were removed while heating to reduce the bitterness. Pulp was treated with citric acid until pH comes to 4.

Coconut milk: 8–10 months old matured coconuts (*Cocos nucifera* L) were collected and scraped to get coconut scrapes. Then, 150 g of coconut scrapes was measured using an electrical balance. Then was firstly extraction of milk blended with 200 ml distilled water for 5 min and 18,000 rpm speed and strained. For the second extraction, the obtained solid residue was blended with 150 ml distilled water in 5 min and 18,000 rpm and strained. Then the third extraction was done similar to the second extraction. Therefore, totally 500 ml coconut milk was obtained from 150 g of scraped coconut. Finally, it was heated at 72°C for 20 min in the water bath. The total soluble solids content, acidity and pH of raw materials were measured using an automatic refractometer, titration and pH meter.

Formulation and development of coconut milk-based palmyrah pulp drink

Coconut milk-based palmyrah drink preparation: Coconut milk and pulp were mixed according to the treatments mentioned below. Then sugar and the stabilizer of 0.3 % CMC (carboxymethyl cellulose) were added and mixed well. The referred amount of SMS was added and homogenized the mixture at 15,000 rpm for 5 min. Finally, it was bottled in a transparent glass bottle and sterilized at 121°C for 20 min in the autoclave. These were stored at room temperature. The following 4 treatments were formulated by changing pulp percentage in 3 levels 20 %, 40 %, and 60 %. Table 1

The sweetener percentage was determined by sensory evaluation and the stabilizer was determined by considering the pH levels within which their stabilizing activity is optimum and by referring to previous research in which the optimum level has been selected for the best-stabilizing activity and texture development.

Table 1
Formulation of coconut milk-based palmyrah fruit drink.

Treatment	Pulp	Coconut milk	CMC	SMS	Sugar
T1	0 %	93.70 %	0.3 %	0.004 %	6 %
T2	20 %	73.70 %	0.3 %	0.004 %	6 %
T3	40 %	53.70 %	0.3 %	0.004 %	6 %
T4	60 %	33.70 %	0.3 %	0.004 %	6 %

Sensory analysis

The best formulation for the coconut milk-based palmyrah pulp drink was selected separately among four treatments using a nine-point hedonic test with 30 semi-trained panelists according to the characteristics such as color, flavor, appearance, taste, aftertaste, oiliness, overall acceptability and best pulp samples for each category was obtained. The data were statistically analyzed using the Turkey statistical test at a 5 % significant level in Minitab 19 software.

Nutritional compositional analysis

The finalized drink sample which was heat-treated at 121 °C for 20 min, sterilized milk sample and flavored milk available in the market were done to compare the nutritional composition. Moisture (oven drying method, AOAC, 2019), ash by incineration method, fat (soxhlet method), protein (AOAC 930.29; 2019), crude fiber (AOAC, 2019), total sugar (AOAC 925.36; 2019), salt (Korkmaz, 2001), minerals such as sodium, potassium (flame photometric method), calcium, magnesium (Vogel's Textbook, 1989), total phenolic content and DPPH (Mishra et al., 2012) were determined for all treatment of samples. All analyses were carried out in triplicates. Total carbohydrates of pulp drink samples were determined by a different method and energy was determined by a bomb calorimeter.

Total phenolic content (TPC)

A 110 μl of folin-ciocalteu phenol reagent was added to microplate wells and then 20 μl of each sample was put into them. After 70 μl of 10 %, $NaHCO_3$ was added for all, and mixtures were incubated at room temperature for 30 min. Then absorbance was measured at 765 nm by using a microplate reader. The water was used as blank. The gallic acid standard curve was made quantitatively. The TPC of coconut milk-based Palmyra pulp drink was expressed as milligram of Gallic acid equivalents per milliliters of the sample (GAE mg/ml) of the sample.

Quality evaluation

pH, total soluble solids, titrable acidity, specific gravity, viscosity (Fungilab Alpha Viscometers), and color (chromameter) were measured periodically for 3 months. The results were expressed in terms of Hunter color values of L, a, and b, where L denotes lightness and darkness, –a‖ redness and greenness, and –b‖ yellowness and blueness. Three measurements were taken from each replicate at 3 different positions to increase the effectiveness of the results obtained.

Microbial evaluation

The shelf life of the drink was determined by microbial count (Total plate count method – ISO 4833–1: 2013, and yeast and mold count method – ISO 21,527–2: 2013). Glasswares were sterilized at 180 °C for 1 h (SLS 516: part 1: 1991). 1 g of sample and 10 ml of sterilized water were added and mixed well using a stomach blender. Then dilution series were prepared as 10^{-1}, 10^{-2}, $10^{-3,}$ and $10^{-4.}$ Media was prepared using the standard method (ISO 4833: 2013).

Data analysis

The one-way ANOVA was performed to determine the difference between samples, and the Tukey paired-wise comparison method was used to identify the differences between sample means. Results were presented as mean values with standard deviation respectively.

Result and discussion

Determination of the levels of ingredients

In this study, a formulation for a coconut milk-based palmyrah fruit pulp drink was developed. The amount of palmyrah pulp was determined based on the previous research conducted by Nilugini and Mahendran (2010) where a ready-to-serve (RTS) drink was prepared using 12 % of palmyrah pulp with the most preferred treatment based on the physicochemical and organoleptic characteristics. According to the Sri Lankan Standard SLS 729:2010, a ready-to-serve drink should be constituted with a minimum of 5 % of fruit pulp sugar separately and an acidity of less than 1 %.

Palmyrah fruit pulp contains a bitter compound that can be removed through acid and heat treatment, thereby increasing its palatability. In this study, the fruit pulp percentage in the formulation of the drink started at 20 % and gradually increased up to 60 %. According to the Food Act, No. 26 of 1980 (Amended, 2019) in Sri Lanka, the sugar content in semi- solid food products is categorized as high if it exceeds 22 g, medium if it ranges from 5 to 22 g and low if it is below 5 g per 100 mL of drink. Coconut milk contains total sugar was 66.9 mg/mL in the first extract and the second extract contained 45.4 mg/mL recorded in the research by Ruwani (2015). The added sugar of 6 g indicated the sugar content was 6 g in this study.

The stabilizers have been selected by considering the pH range. The previous research by Kajan et al. (2018) indicated that pectin provides optimum stability in the pH range of 2 to 6, while CMC is effective in the pH range of 3.5–12.8 for matured coconut milk, preventing oil separation (Yakob et al.,2012). In this study, CMC was selected as the stabilizer based on the previous research findings where coconut milk is the natural oil-in-water emulsion (Raghavendra., 2010) and CMC is a surface-active molecule it adsorbs to the surface of freshly formed droplets during homogenization, forming protective layer it prevents aggregation of the droplets in the coconut milk (Thanatrungrueang & Harnsilawat, 2019).

Palmyrah fruit pulp has rich in nutrition and lower calories but palmyrah fruits have a bitter taste to its flabelliferin a steroidal saponin that consists of two rhamnoses and two glucose, and it is responsible for the bitterness compound (Jansz et al., 1994). Therefore it was reduced or eliminated by heating the pulp at 60 °C for 30 min and citric acid treatment until 4 pH of raw fruits pulp (Sangheetha et al., 2014).

Sensory evaluation

Sensory evaluation is used to determine the consumer acceptability of food products. A nine-point hedonic test was done using 30 semi-trained panelists for the evaluation of sensory properties to select the best formulation of coconut milk-based palmyrah fruit pulp drink.

T1 – Control; T2 – Coconut milk-based palmyrah fruit 20 % pulp drink; T3 - Coconut milk-based palmyrah fruit 40 % pulp drink; T4 – Coconut milk-based palmyrah fruit 60 % pulp drink

Fig. 1 shows the mean score value for the sensory evaluation which have done by changing the pulp percentage. The statistical analysis belongs to the nonparametric test. Friedman test was used to select the best drink formulation and Mann-whiteney was used to put the significance of different letters in the sample sensory attribute. According to the results, the sample with 20 % pulp (T2) was mostly preferred in the sensory evaluation. Based on the results, the sample with 20 % pulp (T2) was the most preferred in the sensory evaluation. This formulation exhibited superior sensory attributes including appearance, aroma, taste, after-taste, and overall acceptability when compared to other samples. Coconut milk-based palmyrah fruit 40 % pulp drink (T3) was most preferred overall. Also, the control (T1) was a higher oiliness attribute than other samples. There were significant differences in appearance and aroma and oiliness observed in samples (p <0.05).

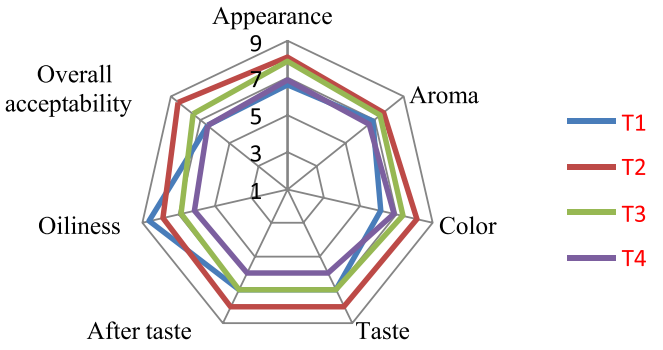

Fig. 1. Sensory evaluation test result for drink.

Nutritional composition analysis

The nutritional composition analysis is crucial in understanding the impact of food on health, influencing its physical, nutritional, and sensorial characteristics. Table 2 shows the obtained macro and micro nutritional contents of the samples.

The results indicate significant difference in moisture, ash, fat, protein, fiber, and carbohydrate among the samples. Reduced moisture content and fat followed with increased pulp percentage in drink samples. The moisture content of the samples ranged from 85.06 ± 0.00 % to 80.47 ± 0.02 % and fat ranged from 5.26 ± 0.00 % to 1.50 ± 0.02 % whereas high moisture content and fat content obtained in sample T1 and low in sample T4. In the CODEX standard, 240–2003 has light coconut milk moisture content of was maximum of 93.4 % and fat content was a minimum of 5.0 %. According to the research of Sivarajah (2018), moisture and fat percentages were 79.66 % and 3.27 % in the palmyrah fruit pulp-based cow milk drink. This coconut milk-based palmyrah pulp

Table 2
Nutritional composition of four different treatments of samples.

Parameters/ Sample	T1	T2	T3	T4
Moisture (g/100 g)	85.06 ± 0.00^{a}	83.29 ± 0.00^{b}	82.07 ± 0.05^{c}	80.47 ± 0.02^{d}
Ash (g/100 g)	0.26 ± 0.00^{d}	1.55 ± 0.00^{c}	2.45 ± 0.00^{b}	3.17 ± 0.00^{a}
Fat (g/100 g)	5.61 ± 0.00^{a}	3.40 ± 0.05^{b}	2.72 ± 0.02^{c}	1.50 ± 0.02^{d}
Protein (g/100 g)	1.27 ± 0.00^{d}	1.63 ± 0.00^{c}	2.47 ± 0.12^{b}	2.80 ± 0.02^{a}
Fiber (g/100 g)	0.11 ± 0.00^{d}	0.21 ± 0.00^{c}	0.51 ± 0.00^{b}	0.74 ± 0.00^{a}
Carbohydrate (g/ 100 g)	22.19 ± 0.02^{d}	23.49 ± 0.04^{c}	26.07 ± 0.05^{b}	27.73 ± 0.02^{a}
Total sugar (g/100 g)	6.04 ± 0.00^{d}	8.26 ± 0.00^{c}	10.33 ± 0.00^{b}	13.08 ± 0.00^{a}
Salt (g/100 g)	0.08 ± 0.00^{d}	0.15 ± 0.12^{c}	0.33 ± 0.8^{b}	0.39 ± 0.52^{a}
Na (mg/100 g)	1.17 ± 0.01^{d}	1.52 ± 0.00^{c}	25.22 ± 0.00^{b}	26.79 ± 0.01^{a}
K (mg/100 g)	13.57 ± 0.01^{d}	17.17 ± 0.01^{c}	118.44 ± 0.01^{b}	139.66 ± 0.01^{a}
Ca (mg/100 g)	3.94 ± 0.00^{d}	5.01 ± 0.00^{c}	6.00 ± 0.00^{b}	6.99 ± 0.00^{a}
Mg (mg/100 g)	9.66 ± 0.00^{d}	11.81 ± 0.00^{c}	13.21 ± 0.00^{b}	15.17 ± 0.00^{a}

Mean ± SD (n = 4); Tukey comparison of mean values indicates the means within Colum that contain different letters are significantly different (p <0.05).

drink has a low-fat plant-based drink.

On the other hand, contents of ash, protein, crude fiber, and carbohydrate were increased with increasing pulp percentage in the samples. The ash content of the samples ranged from 0.26 ± 0.00 % to 3.17 ± 0.00 %, the protein content ranged from 1.27 ± 0.00 % to 2.80 ± 0.02 %, the crude fiber content ranged from 0.11 ± 0.00 % to 0.74 ± 0.00 % and carbohydrate content ranged from 22.19 ± 0.02 % to 27.73 ± 0.02 %. Ash, protein, crude fiber, and carbohydrate were found high in the sample of T4 and these parameters were lower in sample T1. The palmyrah fruit pulp has protein, ash, fiber, and carbohydrates 2.8 %, 4.3 %,1.5 %, and 18.5 % respectively (Jansz et al., 2002), and the concentration of coconut milk has protein, ash, fiber, and carbohydrate was 3.10 %, 0.84 %, 9 %, and 15 % respectively (Alyaqoubi et al., 2015). The diluted coconut milk was used in the study. Due to that nutrition amount may be reduced in the prepared samples. The palmyrah pulp-based cow milk drink had ash was 0.75 % and protein of 3.21 % (Sivarajah et al., 2018). Nevertheless, the increased ash, protein, crude fiber and carbohydrate content in the present drink samples with higher pulp percentage indicate a good mineral profile, particularly with regards to protein content in this coconut milk based palmyrah pulp drink.

According to the results, Na, K, Ca, and Mg contents in the samples were significant differences between the treatments, and these were increased with increasing palmyrah pulp percentage. Sodium was found from1.17 ± 0.01 to 26.79 ± 0.01 mg/100 g, potassium ranged from 13.57 ± 0.01 to 139.66 ± 0.01 mg/100 g, calcium ranged from 3.94 ± 0.00 to 6.99 ± 0.00 mg/100 g and magnesium was ranged from 9.66 ± 0.00 to 15.17 ± 0.00 mg/100 g in samples. In the previous study by VijayaKumari and Kiranmayi (2014), calcium, magnesium, sodium and potassium were found at 8.76 mg/100 g, 10.2 mg/100 g, 20 mg/100 g and 21.5 mg/100 g respectively were in the palmyrah pulp powder.

Calorific values are the amount of heat energy present in food. The USDA recommends that consume up to 35 % of your calories from fat. In a 2500-calorie diet, this translates to up to 97 gs of fat per day. The optimal daily calorie intake varies with age, metabolism, and level of physical activity, among other factors. In general, women should consume 2000 calories per day and men should consume 2500 calories per day (Ismail, 2018). The caloric values of the prepared drinks of T1, T2, T3 and T4 contains energy of 66.28 ± 0.22^{d}, 73.97 ± 0.02^{c}, 75.53 ± 0.11^{b}, and 79.80 ± 0.91^{a} kcal/100 g respectively. According to the results, calorific value was a significant difference between samples, and the energy of the drink was increased with incorporated palmyrah pulp concentration. Energy in the samples ranged from 66.28 ± 0.22 kcal/100 g to 79.80 ± 0.91 kcal/100 g. According to the annual report of the Palmyrah Development Board in 2012, pulp calorie was 102.83 kcal/100 g, and also coconut milk has a calorie of 354 kcal/ 100 g (Matin et al., 2020). Therefore T4 was in higher calories than others. Low calories indicated that this is a good nutritious beverage while the Sri Lanka choco milk shake contained 127 kcal/100 g.

In the Food Act, No. 26 of 1980, sugar, salt, and fat content are selected in the traffic light system. High, medium, and low amounts of constituents were indicated in the colors red, amber, and green in the system respectively. Sugar content for ready-to-serve drink has more than 22 g is meant high sugar, 5 – 22 g is medium sugar and less than 5 g is low sugar in 100 ml of drink. As such more than 1.25 g/100 g is meant high salt, 0.25 to 1.25 g/100 g is medium salt and less than 0.25 g/100 g is low salt and fat more than 17.50 g/100 g is red, 3 to 17.5 g/100 g is amber and less than 3 g /100 g is green. Sugars are important to sweetness. This is a necessity for overall acceptability in RTS beverages. The minimum total sugar content (as sucrose) for RTS preparation is 5 % (SLS729:2010).

According to the result (Table 2), total sugar, salt, and fat were significant differences between samples indicated with means within a row that contain different letters. Total sugar content was increased with increasing palmyrah pulp percentage. The total sugar ranged from 6.04 ± 0.00 g/100 ml to13.08 ± 0.00 g/100 ml and salt ranged from 85.95 ± 0.00 mg/100 ml to 385.95 ± 0.52 mg/100 ml. In the previous study by Maathumai et al., 2018, total sugar was 5.7- 6.0 in palmyrah fruit pulp. Therefore increasing effect depends on palmyrah pulp total sugar was 10.11 % in the palmyrah pulp-based cow milk drink (Sivarajah et al., 2018) and, 11.97 % in the study of Hemalatha et al., 2018. These coconut milk-based palmyrah fruit drink samples are suitable for human consumption due to their low calories and low sugar.

Palmyrah pulp has a higher amount of Na content (Annual report, PDB, 2012). It reveals a higher amount of salt content in the pulp drink. According to the findings, the sample with 20 % Palmyrah pulp consist of medium sugar (amber), low salt (green) and medium fat (amber) whereas low fat observed in the 40 % pulp sample.

Antioxidant activity

DPPH radical scavenging assay is a method widely used to determine antioxidant activity. That scavenged all free radicals. IC50 value negatively correlated with antioxidant activity (Antolovich et al., 2002). The DPPH radical scavenging activity IC 50 of T1, T2, T3 and T4 was 156.91 ±0.0^{a}, 12±0.00, 12.21±0.00^{c} and 62.00 ± 0.00^{d} respectively. The standard ascorbic acid IC50 was 0.17. Fig. 2

In this research, there was a significant difference in the inhibition% of DPPH radical scavenging activity. The milk drink incorporating 60 % palmyrah fruit pulp exhibited the highest antioxidant activity with a value of 62.00 ± 0.00 mg/mL. In contrast, the control showed the lowest ability to scavenge free radicals; a concentration of 156.91 ± 0.00 mg/mL control wants to scavenge 50 % of free radicals. When comparing the samples with the ascorbic acid standard has more than 10 000. According to the results of the study, palmyrah fruit pulp had higher antioxidants than coconut milk, was 6553.33 AAE mg/ L which is proved in previous literature (Kajan et al., 2018). Moreover, the present study observed an increase in the percentage of palmyrah fruit pulp. It is worth noting that the first extracted coconut milk had an IC50 value is 35.55 mg/ml while the second extracted coconut milk had IC50 51.78 mg/ml (Ruwani et al., 2015).

Total phenolic content

Phenolic compounds are a class of antioxidant agents that act as free radical terminators and bioactivities may be related to their abilities to chelate metals, prevent lipoxygenase, and scavenge free radicals (Khoddami et al., 2013). Total phenolic content was measured using Gallic acid as a standard (Ho, 1992).

According to the results, TPC was raised with an increased pulp percentage. Sample T4 was high TPC than other samples at 36.40 ± 0.02 GAE mg/100 g. Sample T1 was a lower TPC was 0.06 ± 0.00 GAE mg/100 g. The selected drink formulation T2 had a TPC of 35.31± 0.00^{c} GAE mg/100 g. TPC in the previous study of palmyrah pulp-based cow milk drink, TPC values of 15.86 GAE mg/100 g (Sivarajah et al., 2018), and 13.8 GAE mg/100 g in palmyrah ready to serve drink (Kajan et al., 2018) were reported. Therefore coconut milk-based Palmyrah fruit drink relatively higher TPC compared with other drinks. Also in the

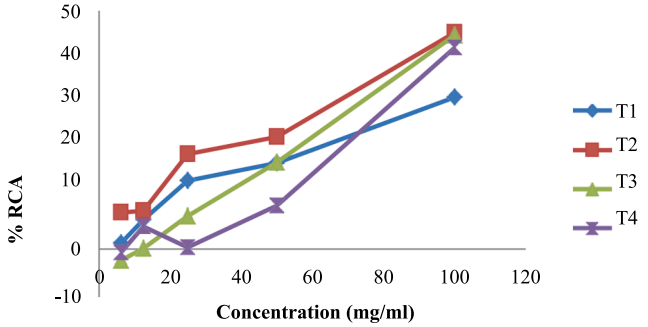

Fig. 2. DPPH radical scavenging activity IC50 values.

Alyaqoubi et al., 2015 study TPC of coconut milk was 575.15 (GAE mg /100 g).

Physicochemical properties of samples

The presence of free hydrogen ions and buffering capacity of the drink depends on the pH value of the beverage. The Table 3 shows the result of the pH of samples with storage time. According to the results, pH ranged from 6.43 pH to 4.72 pH in the samples. There are no significant differences in storing the time at room temperature in each sample. There was reduced pH with increased palmyrah pulp percentage because palmyrah fruit pulp was acid-treated until pH 4 by citric acid to reduced bitterness which was proved in the previous study by Hemalatha et al., 2018. Also, pH was not changed with storage time in the room temperature by Turkey comparison. SLS standard has a pH maximum of 5 to ready-to-serve fruit drink. T3 and sample T4 were selected by pH in this study. pH was 4.25 in the ready-to-serve pineapple juice with coconut milk (Kumara et al., 2019), and the pH was 3.89 in the ready-to-serve palmyrah fruit pulp drink (Hemalatha et al., 2018). Compared to these studies high pH was observed due to raw coconut milk 6.2.

A total soluble solid (TSS) is the indication of the availability of dry matter content in the product. According to the present study, TSS ranged from 9 to 17 °Brix in the samples. This shows no significant difference with storing the time at room temperature, its indicated means within a row that contain different letters letter in Table 3. There was increased TSS with increased palmyrah pulp percentage due to the profile. TSS in the preserved palmyrah pulp was 16.5 °Brix. Therefore, sample T4 was a higher TSS and sample T1 was a lower TSS. In storing room temperature does not change it proved by no significantly different (p <0.05) in one-way ANOVA. The maximum of 16 °Brix for the ready-to-serve fruit beverage is mentioned in SLS 729: 2010 standard. Commonly RTS Brix is from 12 to 16, therefore samples T2 and T3 can be selected by TSS. In a previous research report by Kumara (2019), TSS was 13° Brix in ready-to-serve pineapple juice with coconut milk and, TSS was 15.12 °Brix in the palmyrah pulp-based cow milk drink (Sivarajah et al., 2018). TSS is medium in the coconut milk-based palmyrah pulp drink compared with previous studies.

The result of titrable acidity was not significantly different during the storage at room temperature in samples and titrable acidity ranged from 0.02 % to 0.07 % in the samples where a higher value was observed in sample T4. During storage, there were no changes observed in the samples. Titrable acidity has a maximum of 1 % for the ready-to-serve fruit beverage (SLS 729: 2010). Therefore this coconut milk-based Palmyra pulp drink was in an acceptable range. The recorded titrable acidity was 0.28 % in the palmyrah pulp-based cow milk drink (Sivarajah et al., 2018). The present coconut milk-based palmyrah pulp drinks are suitable where the titrable acidity of palmyrah pulp was 0.18 % and coconut milk was 0.05 % as raw material. Therefore increased trend was observed with adding more pulp.

The specific gravity of the sample ranged from 1.06. According to the results, there was no significant difference in storage time at room temperature in each sample. High Specific gravity was in sample T4 and lower specific gravity was in sample T4. Specific gravity of the fruit beverages ranged from 1.005 to 1.05 in Sri Lanka (Okoye and Ibeto, 2009). Therefore in this present study sample T1, T2, and T3 can be selected in the formulation. Viscosity is a major concern in the food and beverage industry since it has an impact on product processing and packaging, as well as customer acceptance. The resistance to flow is known as viscosity. According to the result, the viscosity increased indicating the rising amount of palmyrah pulp content. Viscosity was not changed during the storage room temperature.

Table 3
Physiochemical properties of the samples.

Treatments	pH	TSS (° Brix)	Viscosity (mm2/s)	Titrable acidity (%)	Specific gravity
T1	6.43–6.46 ± 0.01^{a}	9.00 ± 0.00^{a}	31.70 ± 0.87^{d}	0.02 ± 0.01^{a}	1.03± 0.01^{a}
T2	5.11–5.20 ± 0.01^{b}	12.00 ± 0.00^{b}	124.00 ± 0.16^{c}	0.04 ± 0.01^{b}	1.04± 0.01^{b}
T3	4.81–4.88 ± 0.01^{c}	14.00 ± 0.00^{c}	174.25 ± 0.19^{b}	0.06 ± 0.01^{c}	1.05± 0.01^{c}
T4	4.72- 4.64 ± 0.02^{d}	17.00 ± 0.00^{d}	537.60 ± 2.18^{a}	0.07 ± 0.00^{d}	1.06± 0.01^{d}

Mean ± SD (n = 4); Tukey comparison of mean values indicates the means within a row that contain different letters are significantly different (p <0.05).

Color measurement

Color is described using a variety of color scales or schemes. The Commission International de l'Eclariage (CIE) system, the Hunter L, a, b system, and the Munsell color solid are the most commonly used in the food industry. The color of the food is commonly measured in the L*a*b* color space, which is an international color standard. The lightness or luminance component of luminance is expressed by the L* value. The L* value ranges from 0 to 100 (0 indicates black and 100 indicates white), while the two chromatic components a* (from green to red) and b* (from blue to yellow) range from 120 to 120 (Pathare et al., 2013). Color values were determined using ANOVA, at the 95 % confidence level, p<0.05. According to the result, There was a significant difference between the L*, a*and b* values of the drink. Table 4 shows the L*, a*, and b results of the drink.

Sample T1 has the highest L* value with 76.84±0.01and the lowest both a* and b*value such as 1.76 ± 0.01 and 5.89 ± 0.02. Sample T4 has the highest a* and b * values 11.41 ± 0.0 and 40.85 ± 0.02. In this study, L* was significantly different from sample T1, and samples T2 and T3 were the same and also samples T3 and T4 were the same. Only sample T1 was significantly different in the a* and b* value others are same in Turkey test (Table 4).

According to Pathare et al., Parameter a* measures the red coloration of fruits due to the presence of the carotenoid lycopene, while parameter b* measures the orange coloration of fruits due to the presence β -carotene the fresh pulp contains carotenoids (609.10 mg per kg of pulp). Therefore, a* and b* value were increased with the incorporated Palmyrah pulp percentage. Also, the L value reduces with increased pulp percentage due to browning, ripening palmyrah pulp has high sugar and protein therefore with increased temperature formed the Maillard reaction.

Microbial analysis

The shelf life, or "life of the product on the shelf," is the length of time that a product keeps its qualities. According to the microbial test (ISO 21,527–2: 2013) results, the total plate count is within safety margins for all samples there are not exceeding 10, In SLS 729:2010 the ready-to-serve fruit drink has 50 per ml is a limited total plate count. Also, the resulting yeast and mold count not exceed 10 for all samples until 12 weeks. In SLS 729: 2010 for the ready to serve fruit drink has to be absent per ml is limited.

Microbial growth was prevented by preheating treatment of coconut

Table 4
Color values for drink samples.

Sample	L*	a*	b*
T1	76.84 ± 0.02^{a}	1.76 ± 0.01^{b}	5.89 ± 0.02^{b}
T2	60.28 ± 0.02^{b}	7.16 ± 0.01^{a}	34.62 ± 0.02^{a}
T3	61.29 ± 0.02^{bc}	9.61 ± 0.01^{a}	39.82 ± 0.02^{a}
T4	52.48 ± 0.02^{c}	11.41 ± 0.0^{a}	40.85 ± 0.02^{a}

Mean ± SD (n = 4); Tukey comparison of mean values indicates the means within a row that contain different letters are significantly different (p <0.05).

milk and pulp, heat treatment to 121 °C for 20 min, and maintaining the sanitized condition during the entire preparation. Uzodinma and Ochulor (2020) reported pasteurized coconut milk smoothie kept in cold temperature. However, many products that could safely be maintained sterile. Sterilization is done at 121 °C for 20 min by using autoclave which kills life-threatening pathogens and their toxins such as low-acid foods, to eliminate all mesophilic microorganisms such as spores of *Clostridium botulinum*, (Saikhwan et al., 2015). Also in this coconut milk-based palmyrah pulp drink added Sodium metabisulfide (SMS) that inhibits yeasts, molds, and bacteria (Doughari and Elmahmood, 2007). The microbial count was not achieved until the 12th week in drink samples.

Conclusion

The newly developed coconut milk-based palmyrah fruit pulp drink is a highly nutritious and low-calorie beverage suitable for human consumption. It is beneficial for lactose-intolerant people. Among the four formulations of drinks (T1, T2, T3, and T4), sample T2 (20 % pulp drink) was selected as the most preferred sample by the semi-trained sensory panel. The quality parameters such as pH, TSS, viscosity, titrable acidity and specific gravity of the T2 sample were 5.11, 12.0 ºBrix, 124.0, 0.04 g/ 100 g and 1.04. Those were not significantly differed until 12th week of the sample preparation, indicating the stability of the product over time. The ash content of T2 was 1.55 g/ 100 g which was higher than the control T1 while the fat content was lower (3.40 %) than T1. The color value of the product is the same as expected in the T1 sample. In the nutritional analysis, all samples were significantly different ($p < 0.05$) in terms of ash, protein, crude fiber, and carbohydrate with increased pulp percentage of samples therefore which are higher in the 60 % pulp drink. The microbial count did not differ during storage time by the sterilization and samples were stable after 12 weeks. Therefore the expected shelf-life of the product is 12 weeks. Functional properties such as phenolic content and antioxidant activity which indicate that the drink offers additional health benefits beyond basic nutrition. The energy of sample T2 was 73.97 kcal/ 100 g which were lower than the Sri Lankan choco milkshake. This makes the palmyrah fruit pulp drink as ideal choice for health conscious consumers seeking a low calorie ready to serve beverage.

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Ethical statement

Sensory evaluation is the observational study where the trained panellists at Palmyrah Research Institute, Sri Lanka performed with hedonic scale assessment. The formal documentation or ethical process does not exist. Therefore, voluntary written consent for their participation. The evaluation was using appropriate protocols and all participants were aware of the research work.

CRediT authorship contribution statement

S. Thuraisingam: Conceptualization, Project administration, Data curation, Writing – original draft, Writing – review & editing. **S. Arjana:** Methodology, Investigation, Formal analysis. **J.W.A. Sajiwanie:** Resources. **M. Subajini:** Writing – review & editing. **V.S. Samsan Kapil:** Methodology, Investigation, Formal analysis.

Declaration of Competing Interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Data availability

Data will be made available on request.

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