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Development of the supplementation of aloe vera juice incorporated with lime juice, guava juice, and pineapple juice beverage products

*Wirivutthikorn, W.

Department of Agro Industrial Technology, Faculty of Agricultural Technology, Rajamangala University of Technology Thanyaburi (RMUTT), Thanyaburi, Pathum Thani, 12130, Thailand

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Abstract

Thailand has an abundance of perishable fruits and vegetables. One of their many benefits is that they contain bioactive and nutritious ingredients. The purpose of this work was to investigate and establish the most appropriate ratios of aloe vera juice, lime juice, guava juice and pineapple juice. This research consisted of five experiments involving the analysis of aloe vera drinks: lime juice: guava juice: pineapple juice of 1.00: 0.00: 0.00: 0.00 and blended aloe vera juice, lime juice, guava juice and pineapple juice at ratios of 0.85: 0.15: 0.15: 0.15, 0.70: 0.30: 0.75: 0.75, 0.55: 0.45: 1.80: 1.80 and 0.40: 0.60: 3.30: 3.30, respectively. Physical properties such as brightness, colour, and viscosity as well as chemical properties including total acidity percentage, pH, vitamin C, total soluble solid, and antioxidant inhibition percentage (as DPPH assay) were analysed, while microbiological properties including bacteria were also examined. In addition, a sensory evaluation of each product's colour, odour, sweetness, sourness, texture and overall acceptability was carried out by 30 untrained panelists using a nine-point hedonic scale. The lightness, redness, yellowness and viscosity exhibited a pale yellow to dark yellow colour and were in the range of 20.78-51.23, -1.09-(-7.23), 7.25-24.98 and 1.14-1.29 cPs, respectively. The chemical properties showed that they were significantly different, except for the total soluble solids. The total soluble solid, pH, antioxidant inhibition percentage and total acidity percentage were in the range of 13.66-13.93°Bx, 3.48-5.39, 8.23-22.12% and 0.13-0.31%, respectively. The sensory evaluation divulged that the overall acceptability of blended aloe vera juice, lime juice, guava juice and pineapple juice at ratios of 0.70: 0.30: 0.75: 0.75 received the highest value of 7.57. Regarding the findings from the analysis of all properties, it was revealed that the quality of items was impacted when increasing the amounts of blended pineapple, guava, and lime juice. In this study, the beverage formulated was revealed to possess lower energy values. Thus, those who are concerned about their health can consume it regularly to meet their functional dietary demands.

1. Introduction

Guava is derived from numerous trees and shrubs native to the tropical regions of the world. Guava is well known for its sour, sweet taste, flavour, odour and various applications. Numerous people consider it a "magical" fruit because of its array of beneficial nutrients and medicinal applications (Uzzaman *et al.,* 2018).

Pineapple (Scientific name: *Ananas comosus*) manufacturing countries include Thailand. Pineapple is widely consumed around the world in the form of canned pineapple chunks, diced and sliced, fruit salads, pineapple juice, alcohol, sugar syrup, citric acid, pineapple puree and pineapple chips. It generally comprises water, sugars, carbohydrates, vitamin C, vitamin A, carotenoid balance of refreshing sugar-acid and an abundant source of organic acids and vitamin C (Chaudhary *et al.,* 2019).

Lime (*Citrus aurantifolia)* is a citrus fruit type that is customarily planted in Asian countries. It is an interesting composition applied to flavour Thai foods and beverages (Olaniran *et al*., 2020). There was some evidence about some species of limes containing phenolic compounds and vitamin C, which are all original forms of natural antioxidants (Addi *et al.,* 2022).

*Corresponding author.
Email: *wattana@rmutt.ac.th*

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Aloe vera is one of more than 400 kinds that originated in South Africa. A study of the structural components of aloe vera plant leaf parts found that the peel was mentioned to be about 20–30% and the flesh 70 –80% of the total leaf weight (dry weight basis); the peel and pulp percentages showed proteins (6.3% and 7.3%) and lipids (2.7% and 4.2%) as well (Sánchez *et al.,* 2020).

Nowadays, there is a tendency to choose foods that are good and beneficial for health. As a result, healthy products in the form of beverages have become more popular than in the past because they have good taste, are not expensive, and are easy to consume. They are convenient to consume since they are made in product formats such as ready-to-drink and powder (Wirivutthikorn, 2020).

Thailand is an agricultural nation with an abundance of agricultural products such as vegetables, fruits, and herbs. Therefore, the use of blended types of many raw materials from fruits and vegetables would enable the launch of a new type of beverage product that contains essential nutrients and bioactive substances that are beneficial to the body, which could cause a boost in the trend of consumer demand for such beverages. Researchers have studied various examples. Sharma *et al.* (2022) noted that the right quantity of apricot was combined with aloe vera, based on a low-calorie beverage functionally augmented with aonla juice (3, 5, 7 and 10%) employing steviol glycoside. According to an earlier experiment, adding 40% aloe vera to 60:40 apricot juice resulted in a tolerable flavour. However, the integration of 7% aonla juice with 40°Bx total soluble solid was chosen for the functional enrichment of squash based on colour, consistency, taste, and overall acceptance scores. Higher levels of ascorbic acid (26.83 mg/100 g), antioxidant activity (36.50%) and total phenols (68.77 mg/100 g) were observed in the developed squash. Moreover, the replacement of sweetness with up to 50% stevioside resulted in a semi-sweetness level without a bitter aftertaste and a significant drop in energy content from 142 kcal/100 g to 85.26 kcal/100 g. Aloe vera was found in different amounts (ranging from 30% to 99.8%) according to Comas-Serra *et al.* (2023).

Based on the above-stated reasons, the researcher came up with the concept to launch a drink product that would combine aloe vera with lemon, guava, and pineapple, thereby adding nutritional and health-promoting ingredients to the final product. Due to the reason mentioned above, the appropriate proportions of the formula for blended aloe vera juice, lime juice, guava juice and pineapple juice products have not been mentioned in previous studies. As a result, there is significant interest in research into developing novel Thai juice products from blended aloe vera juice, lime juice, guava juice and pineapple juice (Sidlagatta *et al.,* 2020; Huynh *et al*., 2023). Based on the results of the research, the concept of blending with other types of Thai fruits and vegetables could be used to further expand the small and medium enterprises (SMEs) in Thailand. It would also help cultivators earn more income from agricultural products and serve as an alternative for entrepreneurs to further expand commercially (Wirivutthikorn, 2022a, 2022b, 2022c). The main aim of this research was to determine the appropriate quantities of blended aloe vera juice, lime juice, guava juice and pineapple juice. Physicochemical qualities were assessed in terms of appearance and colour, viscosity, pH, total acidity percentage, total soluble solids, vitamin C, antioxidant inhibition percentage (as DPPH assay), microbiological properties and sensory evaluation.

2. Materials and methods

2.1 Raw materials

Raw materials (four) investigated in this research are guava, pineapple, lime and aloe vera, which were bought from Talad See Mum Muang in Pathum Thani Province, Thailand and transferred to the laboratory for experiments.

The ripened guava samples were thoroughly washed with tap water to remove dirt contaminants, normal flora and blemishes, after which they were cut in half. Seeds and central seed pulp were removed, and the remaining unpeeled flesh was cut into small pieces, then blanched at 70°C for 5 min and placed into a juice extractor with the help of an aliquot. The extracted guava juice was packed in a sterilised plastic bottle for further studies in the next steps (Nasef *et al*., 2020).

The selected maturing pineapple was removed from the crown, and then the leaves were thoroughly washed with sterilised water. Peeled flesh was cut into small pieces, blanched at 70°C for 5 min, and placed into a juice extractor with the help of an aliquot. The extracted pineapple juice was packed in a sterilised plastic bottle for further studies in the next steps (Wu *et al*., 2021).

The lime samples were washed thoroughly with tap water and separated to conduct samples independently from unknown raw materials, as well as dirt contaminants and microbiology. Fruit juice was extracted with the help of a juice extractor or squeezer. The aliquot was packed in a sterilised plastic bottle at 70°C for 5 min for further studies in the next steps (Nasef *et al*., 2020; Wu *et al*., 2021; Chailap and Nuanyai, 2022).

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The aloe vera sample was thoroughly washed with clean water and then peeled to remove green peels and cut into dice. The leaf was cut into small pieces, after which the rind was removed 2-3 times by washing using clean water and then blanching at 80°C for 15 min. The aliquot was immediately cooled down and stirred homogeneously in an electric blender for 5 s. The aliquot was poured into a beaker and settled for 5 min, followed by filtering through cheesecloth 3 times until the aliquot was clear. It was then packed in a sterilised plastic bottle (Nasef *et al*., 2020; Wu *et al*., 2021).

2.2 Preparation of raw materials

This research conducted five experiments as follows.

Experiment 1: A sample of 100 mL of aloe vera aloe vera drink: lime juice: guava juice: pineapple juice of 1.00: 0.00: 0.00: 0.00 (control formula). The juice was mixed with sucrose by Pearson square adjustment of the 14°Bx of total soluble solid (15.12 g of sucrose and aloe vera juice) and then pasteurised at 80°C for 20 min.

Experiment 2: A mixture of 85% aloe vera juice and 15% lime juice, guava juice and pineapple juice at ratios of 0.85: 0.15: 0.15: 0.15 was generated. The juice was mixed with sucrose by Pearson square adjustment the 14°Bx of total soluble solid (13.95 g of sucrose and aloe vera juice) and then pasteurised at 80°C for 20 min.

Experiment 3: A mixture of 70% aloe vera juice and 30% lime juice, guava juice and pineapple juice at ratios of 0.70: 0.30: 0.75: 0.75 was made. The juice was mixed with sucrose by Pearson square adjustment, the 14°Bx of total soluble solid (12.79 g of sucrose and aloe vera juice) and then pasteurised at 80°C for 20 min.

Experiment 4: A mixture of 55% aloe vera juice and 45% lime juice, guava juice and pineapple juice at ratios of 0.55: 0.45: 1.80: 1.80 was made. The juice was mixed with sucrose by Pearson square adjustment, the 14°Bx of total soluble solid (12.79 g of sucrose and aloe vera juice) and then pasteurised at 80°C for 20 min.

Experiment 5: A mixture of 60% aloe vera juice and 40% lime juice, guava juice and pineapple juice at ratios of 0.40: 0.60: 3.30: 3.30 was made. The juice was mixed with sucrose by Pearson square adjustment, the 14°Bx of total soluble solid (10.46 g of sucrose and aloe vera juice) and then pasteurised at 80°C for 20 min and then cooled at 4°C, as adapted from (Nasef *et al*., 2020; Wu *et al*., 2021; Chailap and Nuanyai, 2022).

Whole chemical reagents for chemical analysis performed in this work were food reagent grade and analytical reagent grade (Wirivutthikorn, 2022b, 2022c).

2.3 Physicochemical quality of blended aloe vera juice and lime juice, guava juice, pineapple juice beverage product

2.3.1 Colour (L, +a* and +b*)*

The colour and lightness values were analysed using a Hunter Laboratory Associates, Reston, VA (Mini Scan XE) (in terms of *L**, +*a** and +*b** values. *L** means lightness (0 -100), when +*a** (redness), -*a** (greenness), +*b** (yellowness) and -*b** blueness. The lightness and colour of the tests were also analysed using a colourimeter (Hunter Associates, Reston, VA) (Muhammad *et al*., 2018).

2.3.2 Total soluble solids

The total soluble solid was analysed using a hand refractometer (0-32°Bx) at room temperature (20-25°C). Approximately 1-2 pipette drops of the sample were placed on a hand refractometer, and the prism was immediately adjusted. Suitable illumination was used for the viewing field. The line dividing the light and dark sections of the surface was adjusted to view the crossing of the threads and to record the received value (AOAC Official Method 932.12).

2.3.3 pH value

The pH values were measured using a pH meter (Hanna, model HI98103, United States of America). Firstly, around 35-45 mL each of pH 4.00 and 7.00 buffers was poured into 50 mL beakers. The pH electrode was rinsed with water (deionised) and then placed into the beaker (pH 7.00 and 4.00 buffers). The pH electrode was placed in the measured sample to record the data (AOAC Official Method 973.41).

2.3.4 Vitamin C (ascorbic acid)

Vitamin C was measured by using the 2,6-dichloroindophenol (DCIP) reagent as the standard solution (titration method). A titration method approach was developed to test vitamin C (ascorbic acid). The reaction's endpoint fluctuation changes until a pale pink appears that lasts longer than 30 s. When at least two or three times are within 5% of one another, at least two or three titrations can be analysed (Raman *et al*., 2023).

2.3.5 Percentage of total acidity

The total acidity percentage, (calculated as the type of citric acid) was measured by the direct titration method. Pipette 10 mL of aliquot, and dilute to 100 mL with boiled water and cool. The aliquot was titrated with NaOH (0.1N) using phenolphthalein as an indicator, and the final colour change to pale pink at the endpoint persisted for 30 s (AOAC Official Method 942.15).

$$Total\ acidity\ (\%) = \frac{N\ (NaOH) \times V(NaOH) \times citric\ acid\ equivalent \times 100}{1000 \times V(sample)}$$

Where N is the NaOH concentration and V os the NaOH titrant volume (mL) and the citric acid equivalent is 70.

2.3.6 DPPH as an antioxidant inhibition percentage assay

The volume of the sample was 2 mL and blended with 20 mL of 95 % ethanol. The sample was shaken with a shaking incubator under control conditions (2,000 rpm at 20-25°C) for 3 days. After that, it was centrifuged at a velocity of 4,000 rpm for 20 min. The apparent supernatant was stored in an amber glass bottle at chilled temperature (0-4°C) before analysis. A total of 1 mL of an aliquot and 10 mL of 50 % ethanol was pipetted and then blended in a tube (as centrifuged). Antioxidant capacity analysis of DPPH (2, 2-diphenyl-1-picryhydrazyl) was analysed by the described assay. The analysed test sample was pipetted for micro-volume (100 µL) and blended with 3 mL of 60 µM DPPH, after which it was placed in a black position for 10 min. The absorbance value (abs) of the analysed test was measured at 517 nm. The control sample used 100 µL of 95 % ethanol instead of the analysed test. The antioxidant capacity value was calculated as DPPH inhibition percentage type together (Burguieres *et al*., 2007).

$$DPPH\ Inhibition\ Percentage = \frac{(control\ absorbance - sample\ absorbance)}{control\ absorbance} \times 100$$

2.3.7 viscosity

Viscosity was determined by using the Brookfield viscosimeter apparatus (AOAC Official Method 920.15).

2.4 Microbiological quality of blended aloe vera juice and lime juice, guava juice, pineapple juice beverage product

All samples of blended aloe vera juice, lime juice, guava juice and pineapple juice were examined to count the organisms using the pour plate technique. With the addition of 10 mL of the dilution to 90 mL of sterile phosphate-buffered saline (PBS) tubes as a diluent, serial dilutions (as ten-fold) of 10^{-1}, 10^{-2} and other dilutions were made as essential homogeneous aliquots using sterile pipettes. The agar was allowed to set immediately flipped over hardened petri dishes and then incubated at 35-37°C for 48±2 h (AOAC Official Method 972.44).

2.5 Sensory evaluation

The samples of blended aloe vera juice, lime juice, guava juice and pineapple juice products were evaluated with thirty untrained panelists from the official staff and bachelor's degree students at the Department of Agro-Industrial Technology, Faculty of Agricultural Technology, Rajamangala University of Technology Thanyaburi (RMUTT) Muang Eak Rangsit campus. A nine-point hedonic scale was used to determine favourability scores by panelists ranging from 1-9 (1 means extremely disliked, 5 means neither liked nor disliked, and 9 means extremely liked). Untrained panelists (thirty) evaluated the essential attributes, including colour, odour, sweetness, sourness, texture and overall acceptability. Blended beverages or juices were freshly prepared before the sensory evaluation and stored under chilled temperatures. All samples were serviced in a solution form of 35-40 mL in an apparent glass cup with a cover labelled using a random three-digit number. All samples were served to the untrained panelists randomly, ensuring a blinded investigation (Watts *et al*., 1989; Larmond, 1997; Wiriyajari, 2018; Sukkrajang, 2021).

2.6 Statistical analysis

Total controlled experiments were investigated (triplicate), and the control data showed the obtained values. The sensory experiment applied the Randomized Complete Block Design (RCBD). The CRD (completely randomized design) was computed for analysis of the physicochemical properties. Duncan's new multiple range tests (DMRT) and analysis of variance (ANOVA) were performed to calculate the obtained data with a level of confidence at 0.05. The PASW statistics version was used to compute the ANOVA and the mean differences of total experiments (Watts *et al*., 1989; Larmond, 1997; Wiriyajari, 2018).

3. Results and discussion

Regarding changes in the lightness (L^*) and colour ($+b^*$ and $-a^*$), the values are shown in Table 1. It was found that they were different in terms of lightness, greenness, yellowness and viscosity among aloe vera juice, lime juice, guava juice and pineapple juice (Sukkrajang, 2021). When the guava juice was left standing, it was found that the solid content caused a large amount of sediments, resulting in the lowest lightness value but the highest viscosity values (guava juice: water at 35: 65) as well as 25.29 lightness, -2.23 greenness and 15.47 yellowness. Pineapple juice had little sediment when taking it to measure the yellow colour, so the yellow value was the highest value.

Regarding the obtained data (Table 2), it was found that the pH, total soluble solids, total acidity percentage and antioxidant inhibition (%) (DPPH assay) of aloe vera juice, lime juice, guava juice and pineapple juice were significantly different. The mean pH result value of the lime juice sample was 2.37, and the highest value total acidity percentage of 2.00 was nearly similar to the

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Table 1. Lightness, greenness, yellowness values and viscosity values of blended aloe vera juice, lime juice, guava juice and pineapple juice.

Ratio of fruit juice: water	Values			
	*L**	*-a**	*+b**	viscosity* (cPs)
Guava juice: water 35: 65	25.29±0.23^{c}	-2.23±0.77^{b}	15.47±0.66^{b}	1.59±0.88^{a}
Pineapple juice 100: 0	80.23 ±0.55^{a}	-1.99 ±0.41^{c}	30.42±0.78^{a}	1.04±0.32^{b}
Lime juice 100: 0	48.16±0.32^{b}	-7.23±0.55^{a}	5.89±0.16^{c}	1.02±0.40^{b}
Aloe vera juice 45:55	26.13±0.11^{c}	-2.58±0.31^{b}	4.12±0.49^{d}	0.97±0.31^{b}

Values are presented as mean±SD. Values with different superscripts in the same column are statistically significantly different (p<0.05).

Table 2. Chemical properties of blended aloe vera juice, lime juice, guava juice and pineapple juice.

Chemical properties	Values			
	Guava juice	Pineapple juice	Lime juice	Aloe vera juice
Total soluble solid* (°Bx)	5.26±0.28^{c}	12.13±0.69^{a}	7.53±0.33^{b}	0.93±0.27^{d}
pH*	4.30±0.56^{b}	3.96±0.14^{c}	2.37±0.27^{d}	5.17±0.48^{a}
Total acidity percentage*	0.27±0.63^{b}	0.30±0.60^{b}	2.00±0.15^{a}	0.20±0.58^{b}
Vitamin C (mg/mL)	ND	57.48±0.47	264.90±0.18	ND
Antioxidant inhibition (%) (DPPH assay)*	57.58±0.25^{b}	60.12±0.67^{a}	0.54±0.55^{d}	20.34±0.66^{c}

Values are presented as mean±SD. Values with different superscripts in the same row are statistically significantly different (p<0.05). ND: not detected.

values of 2.43 and 2.48 for traditional lime beverage and industrial lime beverage values in Iran, respectively (Arian *et al*., 2019). According to Shojaee AliAbadi *et al*. (2022), Persian lime juices had concentrations of citric acid, iso-citric acid and malic acid ranging from 48.30 to 66.54 g/L, 0.24 to 0.61 g/L and 1.73 to 10.49 g/L, respectively. The average acidity value of the lime beverage sample, according to Arian *et al*. (2019), was 5.49 g (citric acid)/100 mL. Citrus fruit's overall acidity percentage is a crucial characteristic for both analyzing the overall beverage quality and determining the exact harvest time (Shojaee AliAbadi *et al*., 2022). Compared to other fruit juices, lime juice had a higher overall acidity percentage. The total acidity percentage of lime juice gave higher values than other fruit juices (Arian *et al*., 2019; Firouz *et al*., 2019; Amin *et al*., 2022; Shojaee AliAbadi *et al*., 2022). This research was related to Pinthong *et al*. (2019). The pH value of lime juice was lower than other juices. The total soluble solid readings were comparable. When compared to other juices, pineapple juice's total soluble solids had the highest value at 12.13°Bx. Amin *et al*. (2022) reported this value depending on κ-carrageenan concentrations. The vitamin C content of lime juice had the highest value (264.90 mg/mL) when compared with other juices, but it cannot be detected in either guava juice or aloe vera juice. The measured value of vitamin C was related to both pH and total acidity percentage. This value was adequate to inhibit the growth of microbes due to its high acidity (Sharma *et al.,* 2022). The antioxidant inhibition percentage was determined using DPPH for analysis. The recorded value of pineapple juice got the highest value of 60.12%. The results showed different values depending on different kinds of fruit (Olaniran *et al*., 2020).

The effects of different ratios of aloe vera juice, lime juice, guava juice and pineapple juice were observed for appearance (Table 3). From the experimental results, it was observed that when reducing aloe vera but increasing the ratio of lime juice, guava juice and pineapple juice, an increase in sediments. The colour and smell of the product became more yellow with the amount of lemon juice, guava juice and pineapple juice added. Increased sourness was proportional to the added juice. This may be due to the fact that each fruit juice added has a different pH, including the high total acid percentage (Olaniran *et al.,* 2020).

According to the values of lightness and colour (Table 4), it was found that the brightness, greenness and yellowness were significantly different. The results revealed that the green value measured in (Table 1) decreased when decreasing the aloe vera juice, but increased with lime juice, guava juice and pineapple juice. In contrast, the yellow values were increased depending on the ratios of aloe vera juice, lime juice, guava juice and pineapple juice. However, the heat processing can inhibit some enzymes in the blended aloe vera juice incorporated with lime juice, guava juice and pineapple juice. The decrease in the green values was correlated to the degradation of chlorophyll because of the residual enzymes and the light display during chemical reaction changes (Olaniran *et al.,* 2020).

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Table 3. Effect of ratios of blended aloe vera juice, lime juice, guava juice and pineapple juice on the physical properties of blended aloe vera juice, lime juice, guava juice and pineapple juice.

Ratios of blended aloe vera juice, lime juice, guava juice and pineapple juice	Appearance	Colour	Odour	Taste
1.00: 0.00: 0.00: 0.00	slime aloe vera sediment	clear no colour	off-flavour aloe vera	sweet
0.85: 0.15: 0.15: 0.15	few sediments	pale yellow	off-flavour aloe vera	A little sweet and sour
0.70: 0.30: 0.75:0.75	medium sediments	yellow	good flavour lime and pineapple	balanced sweet and sour
0.55: 0.45: 1.80: 1.80	many sediments	yellow	good flavour lime, guava and pineapple	medium sweet but very sour
0.40: 0.60: 3.30: 3.30	many sediments	yellow	very good flavour lime, guava and pineapple	medium sweet but very sour

Table 4. Physical properties of blended aloe vera juice, lime juice, guava juice and pineapple juice.

Ratios of blended aloe vera juice, lime juice, guava juice and pineapple juice	Values			
	*L**	*-a**	*+b**	viscosity* (cPs)
1.00: 0.00: 0.00: 0.00	27.86±0.22[c]	-7.23±0.24[a]	7.25±0.54[e]	1.20±0.39[b]
0.85: 0.15: 0.15: 0.15	51.23±0.19[a]	-5.99±0.65[b]	11.83±0.72[d]	1.28±0.28[a]
0.70: 0.30: 0.75: 0.75	38.21±0.63[b]	-4.18±0.18[c]	15.38±0.38[c]	1.14±0.17[c]
0.55: 0.45: 1.80: 1.80	24.23±0.41[c]	-2.36±0.29[d]	20.54±0.61[b]	1.15±0.12[c]
0.40: 0.60: 3.30: 3.30	20.78±0.28[d]	-1.09±0.51[e]	24.98±0.33[a]	1.29±0.35[a]

Values are presented as mean±SD. Values with different superscripts in the same column are statistically significantly different ($p<0.05$).

Therefore, when increasing the amount of lime juice, guava juice and pineapple juice, the value of the change from green to yellow of lemon juice incorporated with guava juice and pineapple juice increased (Olaniran *et al.,* 2020; Sidlagatta *et al.,* 2020; Sukkrajang, 2021; Huynh *et al.,* 2023). The other reasons for the lightness were different; it could be the non-enzymatic browning reactions occurring during pasteurisation. More yellow colour changes may also be a result of some non-enzymatic browning reactions, such as caramelisation and Maillard reactions occurring throughout pasteurisation. Non-enzymatic browning reactions could occur because of the levels of sugar in the finished products as well as the heat obtained from the aliquots (Sidlagatta *et al.,* 2020). The increase of +*b** and decrease of -*a** values may be the reason for the caramelisation reaction (non-enzymatic) and the enzymatic browning reaction. The phenolic compounds present in the lime result in oxidation when they are in contact with oxygen, which is catalysed by the enzyme polyphenol oxidase. Monophenol compound (no colour) is oxidised to diphenol compound (no colour), which in turn is oxidised to o-quinone compound. The o-quinone reaction with protein or an amino acid results in the formation of a great molecule named melanin or melanoidin, which is brownish (Olaniran *et al.,* 2020; Surin *et al*., 2022; Yan *et al*., 2023). The measured viscosity depends upon the content of total soluble solids, including fruit pulp, enzymes and dietary fibre. It was found that the viscosity of aloe vera juice: lime juice: guava juice: pineapple juice of 0.40: 0.60: 3.30: 3.30 had the highest viscosity value of 1.29 cPs and provided 20.78 lightness, -1.09 greenness and 24.98 yellowness, which was more viscous than the aloe vera juice in Table 1 according to the addition of sucrose at 15.12 g which affected the measured viscosity. Higher amounts of solids affect the elevated levels of solids in the sample, which contain the highest amount of 0.25% pectin (Sonawane *et al*., 2021; Sukkrajang, 2021).

Regarding the obtained pH, total soluble solid, total acidity percentage, vitamin C and antioxidant inhibition percentage (as DPPH assay) (Table 5), it showed that there were different values except for the total soluble solid (Surin *et al*., 2022). The total soluble solids revealed that there were no significant differences. This is due to the amount of dissolved soluble solids of raw materials and the ingredients that had similar values (Olaniran *et al.,* 2020). The pH of whole treatments was in a wide interval of 3.48-5.39. The results of lime juice content on pH in the sample were significantly different (Pinthong *et al.,* 2019; Comas-Serra *et al.,* 2023). The tendency of pH values was to decrease as the lime juice content increased. The possible argument might be that lime is a low pH fruit, usually with a pH in the range of 2.0-3.06 (Pinthong *et al.,* 2019; Comas-Serra *et al.,* 2023). The total acidity percentage of all experiments was in a wide range of 0.13-0.30, which tended to decrease as the pH value increased. This value had an inverse relationship with the pH value. The measured total acid percentage tends to be greater when the pH is

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Table 5. Chemical properties of blended aloe vera juice, lime juice, guava juice and pineapple juice.

Chemical properties	Ratios of blended aloe vera juice, lime juice, guava juice and pineapple juice				
	1.00: 0.00: 0.00: 0.00	0.85: 0.15: 0.15: 0.15	0.70: 0.30: 0.75:0.75	0.55: 0.45: 1.80: 1.80	0.40: 0.60: 3.30: 3.30
Total soluble solid[ns] (°Bx)	13.77±0.21	13.66±0.15	13.93±0.32	13.93±0.22	13.66±0.33
pH*	5.39±0.09[a]	3.48±0.18[c]	3.48±0.18[c]	3.65±0.20[b]	3.66±0.14[b]
Antioxidant inhibition (%) (DPPH assay)*	8.23±0.33[e]	12.96±0.52[d]	15.25±0.36[c]	20.85±0.47[b]	22.12±0.58[a]
Total acidity percentage* (calculated as citric acid) (g/100 mL)	0.13±0.23[c]	0.20±0.18[b]	0.20±0.18[b]	0.30±0.35[a]	0.31±0.29[a]
Vitamin C (mg/mL)	ND	ND	ND	22.00±1.14	52.34±0.95

Values are presented as mean±SD. Values with different superscripts in the same column are statistically significantly different ($p<0.05$). ND: not detected. [ns] non-significant.

low. Vitamin C (ascorbic acid) is probably the most essential water-soluble antioxidant as well as an efficient scavenger of reactive oxygen species; lime is a rich source of this nutrient (Arian *et al*., 2019). The content of vitamin C is an indicator of the quality of the juice and pasteurisation. Vitamin C has an important role in assessing the degree of protection by carrier reagents used (Sukkrajang, 2021; Saini *et al*., 2022; Surin *et al*., 2022; Huynh *et al*., 2023). The original ascorbic acid content in fresh lime juice (Table 2) was 34.89 mg/100 mL fresh lime juice and degraded around the percentage range of 11.58-37.35 (Table 5) depending upon the heat condition and lime juice content. Vitamin C (ascorbic acid) was decreased as it is a type of water-soluble vitamin with low stability; it can degrade simply when exposed to heat, light, metal ions and oxygen. Furthermore, the heat or pasteurisation process disrupts vitamin C, resulting in quicker degradation if it is in the L-ascorbic acid type. Moreover, according to the storage duration of this product, oxidation reactions may appear and may come from the residual oxygen in the packaging during the pouring process. Vitamin C is the major cause of significant decomposition. The cause, according to vitamin C degradation is combined with increased oxygen and time of storage significantly. Furthermore, decomposition occurs according to the vitamin C changes as well as oxidation reactions. Vitamin C loss depends upon the quantity of light and oxygen. Vitamin C decomposition can be left for a long period. It can be associated with the type of trans-isomer (Sukkrajang, 2021; Saini *et al*., 2022; Surin *et al*., 2022; Huynh *et al*., 2023). For the antioxidant inhibition percentage, this research used as DPPH assay for analysis. The blended aloe vera juice, lime juice, guava juice and pineapple juice at ratios of 0.40: 0.60: 3.30: 3.30 gave the highest values. The obtained values in each experiment were not different. The results showed that increasing the amount of lime juice had no effect on the antioxidant DPPH content. This might be because the production process through homogenization or the added lime juice, guava juice and pineapple juice may be significant, resulting in an increase in antioxidant DPPH. The DPPH assay is a stable free radical assay largely performed to evaluate the efficacy of these extracts as hydrogen donors or free radical scavengers to evaluate the activity of antioxidants in food complexes (Shyamala Gowri and Manjunathan, 2020; Saleem *et al*., 2023). According to Saleem *et al*. (2023), lemon peels had the highest free radical scavenging activity (93.1%) of DPPH, whereas mousami peels had the lowest activity (78.6%). Orange peel ethanolic extract showed greater reducing power with an absorption of 1.98, superior to that of methanolic (1.11) and acetone (0.81) extracts. According to Shyamala Gowri and Manjunathan (2020), a number of foods have substantial amounts of antioxidants that may be used therapeutically to support human health and wellbeing. The fresh leaves, stem and bark of *Psidium guajava* were processed using 70% acetone and 50% ethanol. The results revealed that a dosage ranging between 0.013 and 0.038 mg of acetone extracts for both leaf and bark offered increasing percentages of free radical scavenging activity (17.3 - 66.7%). The ethanol extracts of leaf and bark contained the lowest concentration of polyphenolics, which exhibited the weakest free radical scavenging activity.

From Table 6, there were no bacteria found in any experiments, relating to a study by Arian *et al*. (2019) that reported 106 samples that had no microorganisms (Shyamala Gowri and Manjunathan, 2020; Saleem *et al*., 2023). All products with low pH ranged from 3.48 - 5.39 (Table 5) and received high acidity percentage in the range of 0.13 to 0.31 as citric acid inhibited the growth of bacteria. The antimicrobial activity of lime juice was studied on both Gram-negative and positive bacteria. The conclusion for inhibition of the growth of spoilage

Table 6. Microbiological properties of blended aloe vera juice, lime juice, guava juice and pineapple juice.

Ratios of blended aloe vera juice, lime juice, guava juice and pineapple juice	Values (log CFU/mL)
1.00: 0.00: 0.00: 0.00	3
0.85: 0.15: 0.15: 0.15	4
0.70: 0.30: 0.75: 0.75	3
0.55: 0.45: 1.80: 1.80	4
0.40: 0.60: 3.30: 3.30	4

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bacteria in mixed juices could be attributed to the fact that the producers prepared and completed the fruit juice pasteurisation process with good hygiene as GMP specifications (Arian *et al*., 2019; Sukkrajang, 2021).

The sensory evaluation was based on the colour, odour, sweetness, sourness, texture and values of overall acceptability, as in Table 7. The sensory analysis results indicated that they were different in all attributes. The results indicated that the ratio of lime juice with different amounts of aloe vera juice, lime juice, guava juice and pineapple juice affected the acceptance scores for all attributes, including colour, odour, sweetness, sourness, texture and overall acceptability. When considering the overall acceptability scores, it can be seen that the ratios for aloe vera juice, lime juice, guava juice and pineapple juice at 0.70:0.30:0.75:0.75 received the highest acceptance from the panelists, likely because the aloe vera juice, lime juice, guava juice and pineapple juice additions were at appropriate ratios. The greatest perceived score for the mouthfeel attribute was observed from the use of 0.25% pectin (Ali *et al*., 2021; Sukkrajang, 2021). One possible guideline might be by reason of the appropriate lime juice, guava juice and pineapple juice in the flavour and mouthfeel; the mouthfeel was not too sour (Ali *et al*., 2021; Sukkrajang, 2021; Wirivutthikorn, 2022a, 2022b, 2022c). This may have been due to consumers preferring the optimum ratios of blended aloe vera juice, lime juice, guava juice and pineapple juice. The sourness of lime juice, guava juice and pineapple ratios was not too strong and provided a good taste. The flavour changes of all experiments were very minor (Sukkrajang, 2021).

4. Conclusion

The results revealed that the appropriate blend of aloe vera juice, lime juice, guava juice and pineapple juice included ratios of 0.70:0.30:0.75:0.75, respectively, which obtained the highest overall acceptability from the panelists. Due to some portions of the data about blended juice products in this research, other fruits may be substituted when making aloe vera juice mixed with fruit juice to allow the water to have more variety of flavours and more choices for consumers. Pineapple, lime and guava were used in this experiment.

Based on the aforementioned, further studies should be conducted in the field of water mixing. Other fruit juices could be added to provide more variety in terms of the colour, aroma and nutrients obtained, such as oranges and apples or herbs such as tea, etc. This study found that there were certain amounts of sediment that occurred when adding juice. The information obtained from this research used the concept of mixing pineapple juice. Studies of other types of herbal juice should research the number of substances that reduce the sedimentation of fruit juice, such as gum, etc., which could be used for the development of fruit juice products that continue to use herbal juice mixed with fruit in business.

Conflict of interest

The authors declare no conflict of interest.

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Table 7. Sensory evaluation of blended aloe vera juice, lime juice, guava juice and pineapple juice.

Ratios of blended aloe vera juice, lime juice, guava juice and pineapple juice	Liking scores					
	Colour*	Odour*	Sweetness*	Sourness*	Texture*	Overall acceptability*
1.00: 0.00: 0.00: 0.00	5.90±0.99[c]	5.20±0.98[c]	6.20±0.77[ab]	4.80±0.76[c]	5.90±0.76[b]	5.70±0.77[c]
0.85: 0.15: 0.15: 0.15	6.03±1.25[c]	6.53±0.49[b]	5.80±0.65[c]	6.73±0.77[b]	5.87±0.81[b]	6.30±0.54[bc]
0.70: 0.30: 0.75:0.75	6.83±0.88[b]	7.13±0.88[a]	6.57±0.88[a]	7.20±0.62[a]	6.13±0.93[a]	7.57±0.77[a]
0.55: 0.45: 1.80: 1.80	6.90±0.76[b]	6.73±0.91[b]	6.13±0.66[ab]	6.80±0.84[b]	6.17±0.75[a]	6.97±0.87[ab]
0.40: 0.60: 3.30: 3.30	7.20±0.54[a]	7.13±0.65[a]	6.63±0.88[a]	7.03±0.73[a]	6.23±0.44[a]	7.07±0.95[a]

Values are presented as mean±SD. Values with different superscripts in the same column are statistically significantly different ($p<0.05$).

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