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# EFFECT OF ADDING BELIMBING WULUH (*Averrhoa bilimbi*), PINEAPPLE (*Ananas comosus*) AND LIME (*Citrus aurantiifolia*) EXTRACT ON THE PHYSICOCHEMICAL, MICROBIOLOGICAL, AND SENSORY CHARACTERISTIC OF SNAKE FRUIT *(Salacca zalacca)* JUICE DRINK

Pengaruh Penambahan Belimbing Wuluh (*Averrhoa bilimbi*), Nanas (*Ananas comosus*) dan Jeruk Nipis (*Citrus aurantiifolia*) pada Sifat Fisikokimia, Mikrobiologi, dan Karakteristik Sensori Minuman Sari Salak (*Salacca zalacca*)

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**ABSTRACT**

**Snake fruit is a fruit commodity native to Indonesia that can be made into fruit juice drinks. However, after drinking fruit juice, there was a significant decrease in vitamin C, so it did not meet the daily vitamin C requirement in the body. This study aim to evaluate effects of adding *belimbing wuluh* (*Averrhoa bilimbi*), pineapple (*Ananas comosus*) and lime (*Citrus aurantiifolia*) extract on physicochemical, microbial and sensory characteristic of snake fruit juice drink. This research used a Completely Randomized Design (CRD) consisting of four treatment levels such as without adding extract (F0), *belimbing wuluh* (F1), pineapple (F2), and lime (F3) 0.5 percent of w/w. Salak fruit juice is produced by boiling and grinding the fruit. Additionally, pH, viscosity, color, vitamin C content, total dissolved solids, total plate count (TPC), and sensory attributes were investigated. This research was analyzed using the *one-way Analysis of Variance* (ANOVA) method. If there is a significant difference then proceed with the *Duncan Multiple Range Test* (DMRT) with a significance level of 0.05. This study's results demonstrate that incorporating natural vitamin C extract into snake fruit juice significantly influences (p<0,05) its physical and chemical qualities, while exerting no notable impact on its microbiological properties. The incorporation of the extract considerably influences the color, aroma, flavor, aftertaste, and overall quality of snake fruit juice.**

**Keywords: *belimbing wuluh*, lime, pineapple, snakefruit, vitamin C**

**ABSTRAK**

**Salak merupakan komoditas buah asli Indonesia yang bisa dibuat menjadi minuman sari buah. Namun, setelah menjadi minuman sari buah, terjadi penurunan vitamin C secara signifikan, sehingga belum memenuhi angka kecukupan vitamin C harian dalam tubuh. Penelitian ini dilakukan dengan tujuan untuk mengetahui sifat fisik, kimia, mikrobiologi dan karakteristik sensori sari buah salak dengan penambahan ekstrak belimbing wuluh (Averrhoa bilimbi), nanas (Ananas comosus) dan jeruk nipis (Citrus aurantiifolia). Penelitian ini menggunakan Rancangan Acak Lengkap (RAL) yang terdiri dari empat taraf perlakuan yaitu control (F0), belimbing wuluh (F1), nanas (F2), dan jeruk nipis (F3) sebanyak 0,5 persen b/b. Pembuatan sari buah salak dilakukan dengan cara merebus dan menghaluskannya buahnya. Selanjutnya dilakukan analisis pH, viskositas, warna, vitamin C, total padatan terlarut, total plate count (TPC), dan karakteristik sensori. Penelitian ini dianalisis dengan metode one way Analysis of Variance (ANOVA). Jika terdapat perbedaan signifikan maka dilanjutkan dengan uji Duncan Multiple Range Test (DMRT) dengan taraf signifikan 0,05. Hasil penelitian ini menunjukkan bahwa penambahan ekstrak vitamin C alami pada sari buah salak berpengaruh nyata terhadap sifat fisik dan kimia, namun pada sifat mikrobiologi tidak berpengaruh signifikan. Sedangkan pada karakteristik sensori, penambahan ekstrak tersebut memiliki pengaruh signifikan terhadap warna, aroma, rasa, aftertaste, dan keseluruhan sari buah salak.**

**Keywords: belimbing wuluh, jeruk nipis, nanas, salak, vitamin C**

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## INTRODUCTION

Fuit juice beverages consist of fruit juice, water, and may include sugar or other allowable additives. Fruit juice may exhibit either a clear or hazy hue, derived from crushed fruit.[1,2] Fruit juice products may be manufactured using a single fruit variety or a blend of multiple fruits. Filtered and extracted fruit yields will produce fruit juice. Snake fruit is an indigenous Indonesian fruit that may be processed into juice. However, during conversion to a fruit juice beverage, there is a notable reduction in vitamin C content. The fruit juice is cooked to a temperature of 60-70°C for approximately 15 minutes.[3]

Pondoh snake fruit is a horticultural commodity and is a climacteric fruit that is easily damaged.[4] In Indonesia, snake fruit can produce fruit continuously throughout the year without being restricted to a specific harvest season, as it grows fruit nearly perpetually. During the peak harvest, the price of snake fruit declines due to a significant surge in supply, making it essential to prepare the fruit to enhance its economic value.[5] Snake fruit is rich in nutrients, including carbs, calcium, phenolic compounds, and vitamins A and C. Nonetheless, snake fruit is characterized by its low fat content.[6] Nevertheless, the vitamin C concentration in snake fruit is inferior to that found in other fruits, like pineapple, starfruit, and lime. The intake of snake fruit fails to fulfill the daily vitamin C requirement for the body. Humans require varying quantities of vitamin C daily, depending upon their age. Infants under one year require 30 mg/day of Vitamin C, those aged 1 to 3 years need 35 mg/day, children aged 4 to 6 years require 50 mg/day, and children aged 7 to 12 years necessitate 60 mg/day. Pregnant women require 100 mg of Vitamin C per day, while lactating mothers need 150 mg per day.[7,8] Snake fruit, despite its lower vitamin C concentration relative to other fruits, possesses numerous advantages that render it interesting for the production of salak juice beverages. Snake fruit possesses a unique sweet and sour flavor, offering an alternative taste experience as a beverage. Moreover, the bioactive components present in snake fruit may render it a functional beverage. Snake fruit is regarded as a distinctive local fruit, hence salak juice products may appeal to people seeking novel experiences.

Vitamin C, or L-ascorbic acid, is a vital nutrient and the most delicate and vulnerable of the vitamins. Prolonged heating, oxygen exposure, and light exposure can diminish vitamin C levels in food. Fruits and vegetables are sources of natural vitamin C. Lemons, limes, guavas, apples, and pineapples are examples of fruits rich in vitamin C.[9] The vitamin C level in snake fruit juice is 4.73 mg/100g.[3] This shows that snake fruit juice does not meet the daily requirement of vitamin C for humans, which is around 60-90 mg per day. So, it is necessary to process and add high levels of vitamin C from other natural fruit raw materials such as *belimbing wuluh*, pineapple, and lime.

*Belimbing wuluh* (*Averrhoa bilimbi*) is a plant from Indonesia that is found on mainland Malaya.[10] This plant, which is one of the easy-to-grow plant varieties, is widely spread in home gardens. Starfruit comprises sugar, phenolic compounds, calcium ions, amino acids, citric acid, and vitamins. Starfruit contains flavonoids and triterpenoids, both of which possess antimicrobial properties. Furthermore, starfruit contains organic acids that may function as antibiotics. Starfruit can eliminate Salmonella sp. and stabilize the microbiota in the gastrointestinal tract. Citric acid (92.6-133.8 mg/100 g) is the predominant organic acid in starfruit.[11]

Pineapple (*Ananas comosus*) is one of the fruits that is rich in water and fiber. Every 100 g of pineapple contains 1.4 g of fiber and 86.37 g of water.[12] Pineapple has nutritional content including vitamins B6, B1, C and folic acid. Vitamin C has the ability as an antibacterial and antioxidant to ward off free radicals.[13] The vitamin C content in pineapple is 24 mg/100 g. The vitamin C content of pineapple is also higher than that of salak fruit. Pineapple contains many benefits and nutrients, namely high protein, lipid, carbohydrate, and mineral content. Pineapple also contains 90 percent water and is a good source of potassium, calcium, iodine, sulfur, chlorine, biotin, vitamin B12, and vitamin E. In addition, it also has the same amount of beneficial minerals and vitamin C as one orange in 150 g.[14–16]

Lime (*Citrus aurantifolia*) is utilized by individuals for culinary seasonings and medicinal purposes. The bacteria *Escherichia*

*coli, Streptococcus haemolyticus*, and *Staphylococcus aureus* can all be inhibited from proliferating by the antibacterial properties of lime juice. Alkaloids, flavonoids, tannins, phenols, and saponins are chemical constituents of lime that possess antibacterial characteristics. Alongside the fruit, the roots, stems, leaves, and skin of the fruit also possess same chemical components. Lime is utilized in medicine as an antidiarrheal, antipyretic, anti-inflammatory, and antibacterial agent.[17–19] Lime has a vitamin C content of 27 mg/100 g. The vitamin C content in lime is higher than that of sweet orange.[19,20]

The vitamin C concentration in snake fruit juice diminishes after heating; therefore, it is essential to incorporate a substance rich in vitamin C to enhance its vitamin C content. This study involves the preparation of a snake fruit juice beverage by including various fruit extracts that are high in vitamin C to improve the vitamin C concentration in the snake fruit juice. Additionally, an evaluation of the physicochemical, microbiological, and sensory attributes will be conducted.

## METHODS

### Experimental design

This research was carried out using a simple Completely Randomized Design (CRD), which consisted of 4 levels, namely without adding extract or control (F0), *belimbing wuluh* (F1), pineapple (F2), and lime (F3) 0.5 percent of w/w. Each level of treatment was repeated three times, thus obtaining 12 formulation trials for adding natural vitamin C extract to the manufacture of snake fruit juice. This research includes the manufacturing of snake fruit juice with the addition of natural vitamin C extract, followed by analyzing the physical, chemical, microbiological properties and sensory characterization. The analytical methods used in this research are viscosity, pH and color tests, vitamin C, total dissolved solids, total plate counte (TPC), and sensory characterization.

### Preparation of Snake Fruit Juice

The preparation pf snake fruit juice follow the method from research by Arinda and Yunianta, (2015) with modifications.[21] The first step in making zalacca fruit juice is to sort the zalacca fruit, then peel the skin and separate the zalacca fruit seeds to take the flesh only. Subsequently, the fruit was rinsed under running water to eliminate any adhering dirt. Later on, the snake fruit was subjected to soaking and blanching at a temperature of 70°C for 7 minutes. The boiling fruit (200 g) was thereafter mashed and combined with an equal volume of water (1:1) using a blender. Upon completion of the crushing process, filtration was conducted thrice using a filter cloth till the filtrate is acquired. The fruit juice was partitioned into four samples: F0, F1, F2, and F3, each measuring 200 ml. Afterwards, 10 g of sugar was incorporated into each sample, along with 1 g of natural vitamin C extract (from starfruit, pineapple, and lime) added to F1, F2, and F3. After that, heating was conducted for 5 minutes on the four samples, following which boiling occurs, followed by removal and cooling.

The extraction of vitamin C from starfruit involves crushing the fruit, followed by juice extraction through filtration with filter paper. Pineapple is treated in the same manner as starfruit. The filtrate in lime is extracted by pressing and filtering via filter cloth.

### Physical, chemical, and microbial characteristics of snake fruit juice

The viscosity test was carried out used Brookfield Digital viscometer model DV-E.[22] The pH analysis was conducted based the research by Ramadhania et al., (2023). [22] The color test was carried out using Konica Minolta CR-400 Choromameter. Subsequently, a calculation was carried out to determine the amount of vitamin C content using equation (1).[18] To determine the dissolved solids content in fruit juice, the brix level was determined by referring to equation (2).[24] The total plate count (TPC) was conducted based on the research by Widhowati et al., (2021). [25]

$$\text{Vitamin C} = \frac{\text{ml iod} \times 0{,}88 \times \text{fp}}{\text{Ws (gram)}} \times 100 \qquad (1)$$

Descriptions:
ml iod = sample volume (ml)
fp = dilution factor
Ws = sample volume per replication (g)

$$\text{Product brix level} = \text{fruit brix level} \times \text{fruit content in the composition} \quad (2)$$

**Sensory Characteristic**

Sensory characteristics evaluation of color, aroma, taste, and overall assessment of fruit juice products is necessary to ensure their level of acceptability. Sensory characteristics test findings make it possible to identify alternative products that consumers like most. Every individual in every place has specific taste preferences, so the products to be marketed must be adjusted to the preferences of the local population. Sensory characteristics tests are closely related to taste. Apart from that, it is tailored to the target consumers, both children and adults. In the food sector and other agricultural product industries, sensory characteristics evaluation is often used to determine product quality. These evaluations can sometimes result in very detailed assessments.[26] The criteria for panelists were men or women aged between 18 and 25 years who were in good health, have no visual impairment, not hungry, and willing to take part in organoleptic tests. Panelists were asked to rate a test using a hedonic scale which has six values and five parameters, namely taste, aroma, color, *aftertaste* and overall product. In this sensory characteristic evaluation, there was 30 untrained panelist involved.[22]

**Statistic analysis**

This research was analyzed using the one-way Analysis of Variance (ANOVA) method. If there are differences or significant differences, then continue with the test using *the Duncan Multiple Range Test* (DMRT) with a significance level of 0.05.

## RESULTS

### Physical Properties of Snake Fruit Juice

**pH (Degree of Acidity)**

The pH of snake fruit juice with the addition of natural vitamin C extract was in the range of 3.83 ± 0.02 - 4.22 ± 0.04. The lowest pH value was snake fruit juice with lime fruit extract, while the highest was the control. Based on the *One-way ANOVA* analysis, the results obtained were significant, indicated by a significant value of $p < 0.05$.

**Viscosity**

The viscosity of snake fruit juice with the addition of natural vitamin C extract was in the range of 1.52 ± 0.02 mPa.s - 3.22 ± 0.19 mPa.s (Table 1). The lowest viscosity value was in the control formulation, while the highest viscosity value was in the addition of lime extract. Based on the *One-way ANOVA* analysis, the results obtained were significant, indicated by a significant value of $p < 0.05$. The addition of vitamin C extract has a significant effect on the viscosity value of snake fruit juice.

Table 1

Physical Properties of Snake Fruit Juice

| Treatment | pH | Viscosity | Color | | |
|---|---|---|---|---|---|
| | | | *L** | *a** | *b** |
| **F0** | 4.22 ± 0.04 $^{c}$ | 1.52 ± 0.02 $^{a}$ | 35.08 ± 0.03 $^{a}$ | -102.66 ± 99.66 $^{a}$ | 4.24 ± 0.21 $^{b}$ |
| **F1** | 4.09 ± 0.0 2 $^{b}$ | 2.14 ± 0.15 $^{b}$ | 35.75 ± 0.02 $^{c}$ | -3.08 ± 0.01 $^{a}$ | 4.01 ± 0.03 $^{a}$ |
| **F2** | 4.19 ± 0.01 $^{c}$ | 3.07 ± 0.11 $^{c}$ | 35.50 ± 0.14 $^{b}$ | -3.15 ± 0.00 $^{a}$ | 4.03 ± 0.03 $^{ab}$ |
| **F3** | 3.83 ± 0.02 $^{a}$ | 3.22 ± 0.19 $^{c}$ | 35.62 ± 0.02 $^{bc}$ | -28.03 ± 86.27 $_{a}$ | 4.20 ± 0.14 $^{ab}$ |

Note: Data are presented as mean ± standard deviation (s.d). Numbers followed by different letter notations on the same row indicate a significant difference between treatments ($p<0.05$) based on Duncan's Multiple Comparision test. Snake fruit juice formulation: F0 (control), F1 (*Belimbing wuluh*), F2 (Pineapple), F3 (Lime).

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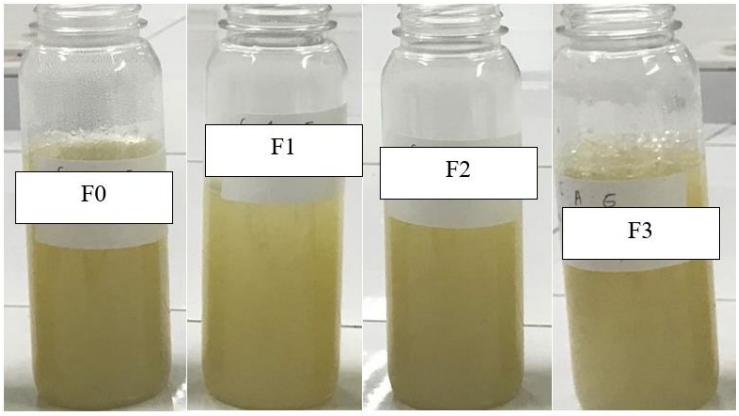


Figure 1

Snake fruit juice with the addition of various natural vitamin C.
F0 (control), F1 (*Belimbing wuluh*), F2 (pineapple), F3 (lime)

Table 2

Vitamin C and Total Dissolved Solid of Snake Fruit Juice

| Treatment | Vitamin C (mg/100g) | Total Dissolved Solids (°Brix) |
|---|---|---|
| F0 | 266 ± 0.04 [a] | 12.74 ± 0.01 [c] |
| F1 | 704 ± 0.00 [c] | 11.81 ± 0.01 [b] |
| F2 | 531 ± 0.05 [b] | 11.52 ± 0.02 [a] |
| F3 | 710 ± 0.05 [c] | 15.40 ± 0.00 [d] |

Note: Data are presented as mean ± standard deviation (s.d). Numbers followed by different letter notations on the same row indicate a significant difference between treatments ($p<0.05$) based on Duncan's Multiple Comparision test. Snake fruit juice formulation: F0 (control), F1 (*Belimbing wuluh*), F2 (Pineapple), F3 (Lime).

**Color**

The color test (Table 1) obtained was the L* value in the range 35.08 ± 0.03 - 35.75 ± 0.02 with the lowest value in the F0 and the highest value in the F1. The a* value is in the range -3.08 ± 0.01 to -102.66 ± 99.66 with the lowest value in the F0 and the highest value in the F1. The b* value is in the range 4.01 ± 0.03 - 4.24 ± 0.21 with the lowest value in the F1 and the highest value in the F0. The L* value indicates the brightness level of snake fruit juice. Snake fruit juice tends to have a yellow to bright yellow color. Based on the *One-way ANOVA* analysis, the results obtained are that the L* parameter shows that there is significant difference ($p < 0.05$) with a significance value of 0.00. The a* parameter shows significant different ($p > 0.05$) with a significance value of 0.44. The b* parameter shows that is not significant different ($p > 0.05$) with a significance value of 0.07. Snake fruit juice with the addition of starfruit and lime in the formulation tends to be bright yellow in color, while snake fruit juice in the control formulation and pineapple tends to be yellow in color (Figure 1).

Table 3

TPC of the Snake Fruit Juice

| Treatment | TPC (CFU/ml) |
|---|---|
| F0 | $1.022 \times 10^4$ |
| F1 | $2.367 \times 10^4$ |
| F2 | $1.67 \times 10^4$ |
| F3 | $5.067 \times 10^4$ |

Snake fruit juice formulation: F0 (control), F1 (*Belimbing wuluh*), F2 (Pineapple), F3 (Lime).

**Vitamin C**

The vitamin C value (Table 2) of snake fruit juice with the addition of natural vitamin C extract was in the range of 266 ± 0.0 4 mg/100g - 7 10 ± 0.0 5 mg/100g. Based on the results of the vitamin C test that was carried out, the lowest vitamin C value was in the control formulation, while the highest vitamin C value was in the addition of lime extract. Based on the *One-way* ANOVA analysis, the results obtained were significant, indicated by the vitamin C value $p < 0.05$. The significance value of vitamin C in snake fruit juice with the addition of variations in vitamin C is 0.00. The addition of vitamin C extract has a significant effect on the value of vitamin C in snake fruit juice.

**Total Dissolved Solids**

Total dissolved solids value (Table 2) of snake fruit juice with the addition of natural vitamin C extract was in the range of 11.52 ± 0.02 $^oBrix$ - 15.40 ± 0.00 $^oBrix$. Based on the results of the total dissolved solids test that has been carried out, the lowest total dissolved solids value is for pineapple, while the highest total dissolved solids value is for variations in the addition of lime extract. Based on the *One-way* ANOVA analysis, the results obtained were significant ($p < 0.05$). The significance value of the total dissolved solids of snake fruit juice with the addition of vitamin C extract is 0.00. The addition of vitamin C had a significant effect on the total soluble solids value of snake fruit juice.

**Total Plate Count (TPC)**

The TPC value (Table 3) of snake fruit juice with the addition of natural sources of vitamin C (*belimbing wuluh*, pineapple and lime) was higher than the standard ($1 \times 10^4$ CFU/ml).[27] The lowest TPC value was in the F0 formulation and the highest TPC value was in the F3 formulation.

**Hedonic Test**

The hedonic result (Table 4) of color attributes is in the range of 3.40 ± 1.13 - 3.90 ± 0.99. In terms of hedonic characteristics, the scale used is 1-5 with a rating of dislike to very like. The lowest value for the hedonic test for the color attribute was the control and lime variations, while the highest value was for the pineapple variation. Based on the *One-way ANOVA* analysis, the results obtained were not significant ($p > 0.05$). Variations in vitamin C did not have a significant effect on the color value of snake fruit juice.

The aroma attribute were in the range 3.53 ± 0.86 - 4.03 ± 0.92. The lowest value for the aroma attribute is the *belimbing wuluh* variation and the highest value is the control variation. Based on the *One-way ANOVA* analysis, the results obtained were not significant ($p > 0.05$). Variations in vitamin C did not have a significant effect on the aroma value of snake fruit juice.

The taste attribute was in the range of 3.60 ± 0.77 - 4.33 ± 0.92. The lowest value for the taste attribute is for the *belimbing wuluh* and lime variations, while the highest value for the pineapple variation. Based on the *One-way ANOVA* analysis, the results obtained were significant ($p < 0.05$). The significance value of the taste attribute of snake fruit juice with the addition of variations in vitamin C is 0.00. Variations in vitamin C have a significant effect on the taste value of snake fruit juice.

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Table 4

Hedonic Characteristic of Snake Fruit Juice

| Treatment | Color | Aroma | Flavor | *Aftertaste* | Overall |
|---|---|---|---|---|---|
| F0 | 3.40 ± 1.10 [a] | 4.03 ± 0.92 [a] | 3.73 ± 0.94 [a] | 3.50 ± 1.00 [a] | 3.36 ± 1.03 [a] |
| F1 | 3.46 ± 0.86 [a] | 3.53 ± 0.86 [a] | 3.60 ± 0.89 [a] | 3.40 ± 0.93 [a] | 3.10 ± 0.84 [a] |
| F2 | 3.90 ± 0.99 [a] | 3.63 ± 0.92 [a] | 4.33 ± 0.92 [b] | 4.73 ± 0.82 [b] | 4.70 ± 1.02 [b] |
| F3 | 3.40 ± 1.13 [a] | 3.70 ± 1.26 [a] | 3.60 ± 0.77 [a] | 3.36 ± 0.99 [a] | 3.63 ± 1.18 [a] |

Note: Data are presented as mean ± standard deviation (s.d). Numbers followed by different letter notations on the same row indicate a significant difference between treatments ($p<0.05$) based on Duncan's Multiple Comparision test. Snake fruit juice formulation: F0 (control), F1 (*Belimbing wuluh*), F2 (Pineapple), F3 (Lime).

Table 5

Scoring Test Value of Snake Fruit Juice

| Treatment | Color | Aroma | Flavor | Aftertaste | Whole |
|---|---|---|---|---|---|
| F0 | 3.00 ± 0.69 [a] | 3.16 ± 0.91 [a] | 4.03 ± 1.09 [b] | 4.60 ± 0.85 [b] | 3.43 ± 0.72 [b] |
| F1 | 3.03 ± 0.71 [a] | 3.13 ± 0.86 [a] | 3.53 ± 0.89 [a] | 3.33 ± 1.02 [a] | 2.90 ± 0.66 [a] |
| F2 | 3.03 ± 0.88 [a] | 3.50 ± 0.86 [ab] | 5.03 ± 0.71 [c] | 5.00 ± 0.69 [b] | 5.03 ± 0.80 [c] |
| F3 | 3.80 ± 0.96 [b] | 3.76 ± 0.89 [b] | 4.26 ± 0.69 [b] | 3.20 ± 0.71 [a] | 3.53 ± 0.81 [b] |

Note: Data are presented as mean ± standard deviation (s.d). Numbers followed by different letter notations on the same row indicate a significant difference between treatments ($p<0.05$) based on Duncan's Multiple Comparision test. Snake fruit juice formulation: F0 (control), F1 (*Belimbing wuluh*), F2 (Pineapple), F3 (Lime).

The aftertaste attribute was in the range 3.36 ± 0.99 - 4.73 ± 0.82. The lowest value for the aftertaste attribute is the lime variation, whereas the highest value is the pineapple variation. Based on the *One-way ANOVA* analysis, the results obtained were significant ($p < 0.05$). The significance value of the *aftertaste attribute* of snake fruit juice with the addition of variations in vitamin C is 0.00. Variations in vitamin C have a significant effect on the *aftertaste value* of snake fruit juice.

The overall attributes were in the range 3.10 ± 0.84 - 4.70 ± 1.02. The lowest value for the overall attribute is the *belimbing wuluh* variation, while the highest value is the pineapple variation. Based on the *One-way ANOVA* analysis, the results obtained were significant ($p < 0.05$). The significance value of the overall attributes of snake fruit juice with the addition of variations in vitamin C is 0.00. Variations in vitamin C have a significant effect on the overall value of snake fruit juice.

**Scoring Test**

The scoring value for snake fruit juice for color attributes was in the range of 3.00±0.69-3.80±0.96. In terms of hedonic characteristics, the scale used is 1-5 with a rating of dislike to very like. The lowest value for the color attribute is the control variation, while the highest value is the lime variation. Based on *One way ANOVA* analysis, the results obtained are significant ($p < 0.05$). The significance value of the color attribute of snake fruit juice with the addition of variations in vitamin C is 0.00. Variations in

vitamin C have a significant effect on the color value of snake fruit juice.

Scoring test for aroma attributes were in the range of 3.13 ± 0.86 - 3.76 ± 0.89. The lowest value for the aroma attribute is the *belimbing wuluh* variation, while the highest value is the lime variation. Based on the *One-way ANOVA* analysis, the results obtained were significant ($p < 0.05$). The significance value of the aroma attribute of snake fruit juice with the addition of variations in vitamin C is 0.01. Variations in vitamin C have a significant effect on the aroma value of snake fruit juice.

Scoring test for taste attributes were in the range of 3.53 ± 0.89 - 5.03 ± 0.71. The lowest value for the taste attribute is the *belimbing wuluh* variation and the highest value is the pineapple variation. Based on the *One-way ANOVA* analysis, the results obtained were significant ($p < 0.05$). The significance value of the taste attribute of snake fruit juice with the addition of variations in vitamin C is 0.00. Variations in vitamin C have a significant effect on the taste value of snake fruit juice.

Scoring test for the *aftertaste attribute* were in the range of 3.20 ± 0.71 - 5.00 ± 0.69. The lowest value for the aftertaste attribute is the lime variation and the highest value is the pineapple variation. Based on the *One-way ANOVA* analysis, the results obtained were significant ($p < 0.05$). The significance value of the *aftertaste attribute* snake fruit juice with the addition of a variety of vitamin C, namely 0.00. Variations in vitamin C have a significant effect on the *aftertaste value* of snake fruit juice.

Scoring test for the overall attributes were in the range of 32.90 ± 0.66 - 5.03 ± 0.80. The lowest value for the overall attribute is the *belimbing wuluh* variation, whereas the highest value is the pineapple variation. Based on the *One-way ANOVA* analysis, the results obtained were significant ($p < 0.05$). The significance value of the overall attributes of snake fruit juice with the addition of variations in vitamin C is 0.00. Variations in vitamin C have a significant effect on the overall value of snake fruit juice.

## DISCUSSION

The addition of lime to snake fruit juice causes its acidity level to decrease. This is due to the low pH of lime, around 3.5.[28] The reactivity of the water-soluble antioxidant ascorbic acid is contingent upon pH levels. The ascorbate monoanion, which predominates at neutral physiological pH, is widely acknowledged to function as a more potent antioxidant than its protonated counterpart, ascorbic acid. Numerous studies indicate that a lower pH correlates with elevated vitamin C levels.[29,30] Lime variations had a lower pH value than the control variations, *belimbing wuluh*, and pineapple. This is because the more lime extract added to the drink, the more acidic the drink will be and lower the pH of the drink. Change This is also because lime contains citric acid which affects acidity which can cause a decrease in the pH value of the drink. This is in accordance with research conducted by Waisnawi et al., 2022 which shows that increasing the addition of lime to telang flower drinks can lower the pH (pH 5.47).[32] The pH value is related to vitamin C, namely the lower the pH value, the more acidic a material is. So, the relationship between vitamin C and acidity is not only a similarity in taste, but also a chemical nature. Therefore, high vitamin C from functional drinks is thought to be one of the causes of low pH values in drinks. [33]

Based on Table 1, at low pH, the viscosity of snake fruit juice increases. At both low and high pH levels, viscosity decreased due to the degradation of polymer chains in acidic and alkaline environments.[34] As a radiation inhibitor, ascorbic acid can prevent the reduction in the viscosity of carrageenan induced by radiation and safeguard its rheological characteristics.[35] Consequently, it may be asserted that elevated vitamin C levels correlate with reduced pH, resulting in increased viscosity in acidic conditions. This investigation indicated that lime exhibited the lowest pH level. Snake fruit juice with the addition of lime variations had a lower viscosity value than the control, *belimbing wuluh,* and pineapple variations. This is due to the increasing acid content in lime juice so that during cooking in acidic conditions the solubility of sugar will increase and the viscosity of the solution will also increase. [36] The difference in viscosity values is due to differences in the total dissolved solids which are interconnected so that the viscosity increases due to the presence of solids that can bind water, sucrose and citric acid. Dissolved solid components include the addition of sugar and acid content to the

solution. The higher the total dissolved solids component in a solution, the resulting viscosity will increase. This is in accordance with research conducted by Farikha et al., 2013 where there was a decrease in viscosity due to a decrease in dissolved solid ions which caused the fruit juice to become thinner and the viscosity to decrease.[37]

Snake fruit juice with the addition of *belimbing wuluh* and lime in the formulation tends to be bright yellow in color, while snake fruit juice in the control formulation and pineapple tends to be yellow in color. Star fruit will produce a slightly bright color or brownish yellow to pale yellow (L*). The citric acid contained in starfruit is thought to cause the yellow color (b*). However, it will produce a color that tends to be dark without the addition of starfruit extract (brown).[38] The color of the final drink is also influenced by the addition of pineapple. Pineapples have a low pH, namely around 3.36, which is included in the acidic pH. In acidic conditions chlorophyll becomes unstable to heat, whereas in alkaline conditions chlorophyll can be very stable to heat, so this is what causes chlorophyll to form a brown color.[39] The color of lime extract is pale yellow, so the color combination of the two raw materials will be clear. The color will change to become slightly cloudy as more and more lime juice is added.[36] The results of the analysis show that the higher the acid content in the fruit juice, the b value of the fruit juice will decrease. This is related to the oxidation of ascorbic acid and the degradation of anthocyanins.[40] Ascorbic acid (vitamin C) served both as a nutritional addition and as a preservative for color and flavor in the food product. In addition to vitamin C, the color alterations in food are also affected by the temperatures employed during processing and cooking.[41–43]

The highest vitamin C value in this study was the variation of lime added to snake fruit juice which was higher compared to research conducted by Waisnawi et al., 2022 which reported that the addition of lime to the telang flower drink after it was added had a vitamin C content of 5 .47 mg/g, while snake fruit fruit juice with lime added has a higher vitamin C content, namely 7.10 mg/g or 710 mg/100g. [32] Snake fruit juice with pineapple variations has a lower vitamin C value compared to starfruit and lime variations. This is because the vitamin C content of fresh pineapple is lower than that of lime and *belimbing wuluh*. In accordance with research conducted by Halimah et al., 2021, fresh pineapple has a vitamin C content of 24 mg/100 g, in Fitriyana's research, 2017, lime has a vitamin C content of 27 mg/100 g and meanwhile according to Agustin & Putri, 2014 Starfruit contains vitamin C of 25 mg/100 g.[44–46] The greater the addition of fruit juice containing vitamin C will affect vitamin C levels and the quality of food products .[47]

In this study, the addition of natural sources of vitamin C from *belimbing wuluh*, pineapple and lime can meet the daily needs of vitamin C in humans. Meanwhile, the vitamin C content in fresh snake fruit is 2 mg in 100 g of snake fruit and the control formulation without additional sources of vitamin C, is still not enough to meet the daily vitamin C needs of adult humans, which is an average of 60 mg per day. [48]

The results of the analysis of total dissolved solids showed that the lowest value was in the formulation adding variations of pineapple, while the highest value of total dissolved solids was in the formulation adding variations of lime. The total dissolved solids value in the variation of adding lime in this research was 15.40 ± 0.00 °Brix , lower than research conducted by Sinica, 2016, which stated that lime had a total dissolved solids value of 30 °Brix.[49] This is in line with research by Assalam et al., 2023 which states that lime juice is a fruit that contains carbohydrates in the form of simple sugars which are a source of soluble solids.[50] The higher the content in the fruit used, the higher the total dissolved solids. Fruit content is also dissolved, such as carbohydrates, water and organic acids which will affect the total dissolved solids of a food product.[34] Total dissolved solids are related to vitamin C, where the total dissolved solids value will increase as the acid concentration in the fruit increases.[34]

An important criterion to ensure product quality is food safety. Therefore, calculations for this product provide information on the level of contamination in food ingredients. TPC can determine how many other microorganisms can contaminate a food product. [52] In principle, fresh fruit and vegetables that are suitable for consumption will have an TPC value of 6-7 log CFU/ml. However, the Indonesian standard for packaged fruit juice drinks, only allows a maximum of 1 × $10^4$ CFU/ml. The results of

microbial contamination in the F0 formulation can still meet the permitted standards. Meanwhile, the F1, F2, and F3 are classified as high with numbers exceeding the permitted standards. However, the TPC test results on this sample were lower than the fruit juice test results in research conducted by Astuti et al., 2020 , namely ranging from 6.07 ± 0.37 to 8.95 ± 0.04 log CFU/ml. This shows that *hygiene* and sanitation need to be improved in the manufacture and storage of this product.[33] The TPC value in juice containing vitamin C extract from bilimbi, pineapple, and lemon may surpass Indonesian national standards due to various circumstances. The fruits may possess elevated microbial burdens if inadequately washed or handled. Natural extracts may harbor bacteria and yeast, hence influencing the total plate count (TPC). The techniques employed to extract vitamin C from these fruits may introduce extraneous microbes if not performed under hygienic circumstances. The inherent sugars and acidity in the juice can foster an environment conducive to bacteria proliferation, particularly in the absence of preservatives. Inadequate storage temperatures or extended exposure to air can facilitate microbial proliferation, resulting in elevated TPC. To guarantee adherence to standards, it is essential to enforce rigorous cleanliness protocols throughout harvesting, processing, and storage.[2,53,54] Water activity will encourage optimal growth of microbes if extrinsic factors support their growth. Apart from that, the growth of bacteria in fruit juice is also influenced by contamination after heating such as sanitation of the packaging, when putting ingredients into the packaging and unhygienic storage. One of the critical control points in the fruit juice processing process is the water quality. The water used in the process should not only be free from microbiological contamination, but also free from chemical contamination, especially residual chlorine. [53,55]

The hedonic test is a test to determine the level of liking for a product. The hedonic test was carried out with the aim of knowing the response of the panelists to the quality characteristics of Snake fruit fruit juice in general (color, aroma, taste, *aftertaste*, and overall). Snake fruit juice in the hedonic test or preference test for color attributes showed a yellow to bright yellow color. Star fruit will produce a slightly bright color or brownish yellow to pale yellow (L*). The citric acid contained in starfruit is thought to cause the yellow color (b*). However, it will produce a color that tends to be dark without the addition of starfruit extract (brown).[38] In the aroma attribute of Snake fruit fruit juice, the addition of lime extract has a distinctive aroma so that it can form a taste and eliminate unpleasant odors in a food product.[49] In terms of taste attributes, panelists liked snake fruit juice in the F2 formulation, namely with the addition of lime extract. This is because lime extract has a distinctive aroma and taste so that the unpleasant odor it produces can be masked and can also affect the taste. Overall, the results of the average color, aroma, taste and *aftertaste* of snake fruit juice in the variation of added vitamin C that were most preferred by the panelists were formulations with variations of pineapple vitamin C.

The scoring test is a scale test in organoleptic testing by providing an assessment of a parameter listed on the available sample. The scoring test was carried out to determine the panelists' assessment of the appearance of snake fruit juice based on the intensity of the attributes being assessed. In the scoring test, the addition of natural vitamin C extract had a significant effect on the overall score of snake fruit juice. Overall, the results of the average color, aroma, taste and *aftertaste* of snake fruit juice when adding variations of vitamin C with the highest value scale are in the formulation of variations in adding vitamin C to pineapple fruit.

## CONCLUSION AND RECOMMENDATION

### Conclusion

The addition of natural vitamin C extract from *belimbing wuluh*, pineapple, and lime has a significant effect on the physical and chemical properties of snake fruit juice drinks, namely pH, viscosity, color, vitamin C, and total soluble solids. Meanwhile, the addition of natural vitamin C extract from *belimbing wuluh*, pineapple and lime had no effect on the microbiological properties of snake fruit juice drinks. The addition of natural vitamin C extract from star fruit, pineapple and lime has a

significant effect on the organoleptic properties of snake fruit juice drinks.

**Recommendation**

Overall, the best natural extract for snake fruit juice was lime because of highest result in vitamin C. However, the most likely was the addition of pineapple on the snake fruit juice.

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