

Effect of konjac concentration on physicochemical and sensory properties of snake fruit jelly drink

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Abstract

Snake fruit has a short shelf life, necessitating efforts to extend its storage period. Snake fruit can be processed into fruit juice or transformed into jelly drinks. The characteristics of jelly drinks are largely influenced by the type of gelling agent used. This study utilizes konjac as a gelling agent. This research aimed to determine the effect of konjac concentration on the physicochemical and sensory characteristics of snake fruit jelly drinks and to identify the konjac concentration that yields snake fruit jelly drinks with the best sensory evaluation. The study utilized a randomized block design (RBD) focusing on five levels of konjac concentrations of 0.15%, 0.20%, 0.25%, 0.30%, and 0.35%. The resulting snake fruit jelly drinks underwent physicochemical testing, including pH, total soluble solids, suction force, and syneresis, with three replications. The sensory evaluation included a preference for suction force, mouthfeel, and taste. The results showed a significant effect of konjac concentration on suction force, syneresis, and sensory characteristics but no significant effect on pH and total soluble solids. The higher konjac concentration, pH and total soluble solids increased while suction force and syneresis decreased. The spider web test results indicated that snake fruit jelly drinks with 0.35% konjac addition was the best treatment, with preference scores of 6.00 (liked) for suction force, 6.30 (liked) for mouthfeel, and 6.04 (liked) for taste.

1. Introduction

Modern trends have led to an increased preference for food and beverages made from natural ingredients, which are beneficial for health and convenient. One such product is a jelly drink made from fruit juice. The jelly drink also offers the advantage of being consumable as a hunger-delaying beverage due to its relatively high carbohydrate content (Fitri *et al.*, 2024). The desired characteristics of a good jelly drink are transparency, a distinctive fruit aroma, and flavor. The ideal texture is soft, easily broken, and consumed using a straw with the gel felt in the mouth (Jariyah *et al.*, 2022).

Jelly drinks are generally made from fruit juice with high acidity and attractive colors. Several examples of fruits commonly used in jelly drink production include mango, strawberry, orange, and pineapple. One type of fruit that can be used for making jelly drinks is snake fruit. Central Bureau of Statistics Indonesia 2022 reported that snake fruit production in Indonesia is high, with production centers in Central Java, Yogyakarta Special Region, East Java, and North Sumatra. In 2022, snake fruit production in Central Java reached 482.097 tons, Yogyakarta Special Region 54.498 tons, East Java

199.625 tons, and North Sumatra 265.180 tons. One type of snake fruit produced in large quantities is Pondoh snake fruit. Snake fruit is chosen due to its abundant production, making it suitable for processing into innovative and appealing beverage products.

Snake fruit has a sweet and non-astringent taste but thin fruit flesh. It has a distinctive flavor and rich in antioxidants, polyphenols, organic acids and vitamin C (Ilmiah *et al.*, 2021). Antioxidant activity consists of various mechanisms, such as free radical scavenging and its capacity as a reducing agent. Gelling agents are needed to produce good jelly drink characteristics. Gelling agents commonly used in jelly drink production are agar, gelatin, carrageenan, and jelly powder (Nugiharti and Haryadi, 2021). Each gelling agent has different gelling abilities and gel characteristics. Konjac is one of the potential hydrocolloids for jelly drink formulation.

Konjac is a hydrocolloid polysaccharide derived from the *Amorphophallus* plant. The main component of konjac is glucomannan, a compound consisting of mannose and glucose linked by β -1,4 glycosidic bonds. Konjac can delay hunger when consumed as a food

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source, as it causes gradual absorption of dietary sugar and reduces high blood sugar levels. Konjac can also be used as a substitute for agar, gelatin, and other thickening agents. According to the Sun *et al.* (2023), konjac exhibits a high fiber content, high viscosity, solubility, and swelling property, a good film-forming property, and a good gel property in aqueous solutions. Adding konjac to gels is chosen to increase the strength and elasticity of the formed gel and make it more stable against syneresis. Preliminary research results indicate that jelly drinks with less than 0.15% konjac additions produce very fragile gels, while konjac concentrations exceeding 0.35% will result in overly firm gels. It is hypothesized that varying concentrations of konjac will affect the physicochemical and sensory evaluation of snake fruit jelly drinks. Consequently, the effects of various konjac concentrations will be further explored to determine the optimal level for producing jelly drinks.

2. Materials and methods

2.1 Materials

The materials used in the jelly drink formulation were snake fruit juice (var. Pondoh), citric acid, konjac, water, and sugar. All ingredients were purchased from a local market. The snake fruit juice was prepared from high-quality snake fruit. The fruit was peeled, the seeds removed and then blanched at 80°C for 10 minutes. Following blanching, the fruit was dried and subsequently crushed for 3 minutes with a snake fruit-to-water ratio of 1:5. The mixture was then strained to extract the juice.

2.2 Preparation of jelly drink

The fruit juice obtained was mixed with 12.5% sugar and 0.15% citric acid and added with konjac at different concentrations (0.15%, 0.2%, 0.25%, 0.3%, and 0.35%). The resulting mixture was heated at 85°C for 5 minutes and then cooled at room temperature for 10 minutes. After cooling, the fruit juice was packaged in plastic cups and stored in a refrigerator at 6-9°C for 24 hours. The jelly drink was then analyzed for physicochemical properties such as pH, total soluble solids analysis, suction force, and syneresis over 1, 4, and 7 days, as well as sensory evaluations for preference in suction force, mouthfeel, and taste.

2.3 pH

The jelly drink was placed into a beaker and weighed to determine its mass, then diluted with distilled water at a ratio of 1:2 and homogenized using a blender. The electrode was rinsed with distilled water prior to measuring the sample. Subsequently, the electrode was dried using a tissue by gently blotting. Before use, the pH meter was calibrated using two pH buffer solutions of pH 4 and pH 7. The electrode was then immersed into the sample to measure the pH valued. The reading

displayed by the pH meter represented the pH value the tested sample. Each treatment was measured three times.

2.4 Total soluble solids

The jelly drink was placed into a beaker and weighed to determine its mass, then diluted with distilled water at a ratio of 1:2 and homogenized using a blender. The refractometer prism was rinsed with distilled water and wiped gently with a soft cloth. The sample was then dropped onto the refractometer prism using a dropper pipette. The Brix degree was measured. Each treatment was measured three times

2.5 Suction force test

The suction force was measured using a syringe (suction diameter = 1.5 cm). The test was conducted by pulling the top of the syringe upwards to draw the jelly drink into it. The time taken for the jelly drink to be suctioned or drawn up was recorded using a stopwatch over 20 seconds. The volume of the jelly drink drawn up after 20 seconds was recorded, with units of volume (mL)/20 seconds.

2.6 Syneresis test

Syneresis testing on the jelly drink was conducted after storage for 1, 4, and 7 days in a refrigerator at a temperature of 6-9°C. The jelly drink was weighed in plastic cups before storage. The oven-dried filter paper was weighed prior to use. Syneresis was quantified by measuring the water absorbed onto oven-dried filter paper in contact with the jelly drink. The filter paper's weight gain, representing the released water, was then recorded. The remaining jelly drink was also weighed. The syneresis percentage was calculated using the following formula:

$$\text{Syneresis} = \frac{(\text{Initial Weight (g)} - \text{Final Weight (g)})}{\text{Initial Weight (g)}} \times 100\%$$

Initial Weight = weight of filter paper before being used to absorb water.

Final Weight = weight of filter paper after absorbing water.

2.7 Sensory evaluation

Sensory evaluation was performed using a hedonic test or preference test. This test aimed to determine the panelists' preference level for suction force, mouthfeel, and taste of the snake fruit jelly drink product. Each sample used varying concentrations of konjac, and panelists evaluated them on a scale of 1 to 7. A score of 1 meant the panelists intensely disliked the product, while a score of 7 indicated that they strongly liked it. Sensory evaluation was carried out with a panel of 50 untrained participants. The sensory evaluation was performed by pouring jelly drinks with different konjac concentration additions into plastic cups (30 ml) and

storing them in a refrigerator at 6-9°C temperature for approximately 24 hours. After storage for approximately 24 hours, the panelists tested the samples. Panelists were given different random number codes for five samples simultaneously. The panelists explained how to conduct the test and fill out the questionnaire before the test started.

2.8 Statistical analysis

The experiment was conducted in triplicate. All statistical analyses were performed using SPSS Statistics 26 software (IBM Corporation, New York, USA). A significance level of $p < 0.05$ was established using a one-way ANOVA with a Duncan post hoc test. The results from the sensory test will be presented using a spider web graph. The expansion of the network toward the outer direction signifies the most favorable treatment. The formula for calculating the area is: $\text{Area} = \sin(120^\circ) \times 0.5 \times \text{base} \times \text{height}$. A 120° angle was used because only three test parameters were evaluated: taste, suction force, and mouthfeel.

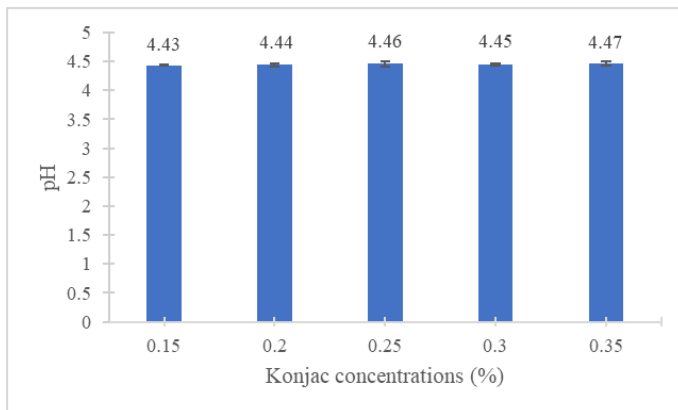


Figure 1. pH of snake fruit jelly drink with varying konjac concentrations.

3. Results and discussion

3.1 pH

pH, or the degree of acidity, is the concentration of different H^+ ions in a mixture or solution that expresses a solution's acidity or alkalinity level (Tasker, 1980). pH is crucial in jelly drinks as it can affect their characteristics, such as gel formation. The pH values of snake fruit jelly drinks with varying konjac concentrations ranged from 4.43 to 4.47. The ANOVA results at $\alpha=5\%$ showed that the differences in konjac concentration did not significantly affect the pH values of the snake fruit jelly drinks. The average pH values of the snake fruit jelly drinks are shown in Figure 1.

Figure 1 illustrates that the differences in konjac concentration did not significantly affect the pH of the snake fruit jelly drinks. The minimal impact on pH levels is likely attributable to adding konjac at low concentrations. Specifically, the small concentration differences of just 0.05% did not result in any significant change in pH. Konjac contains OH (hydroxyl) groups,

which are basic and can influence the acid-base balance in a solution (Atmaka et al., 2013). Although konjac did not significantly affect the pH values, it can form gels at specific pH ranges (pH 4-7). The pH of the snake fruit juice in this study ranged from 4.71, and snake fruit itself has a pH range of 4.02-4.12. The decrease in pH values can be attributed to the acid content in the snake fruit and the addition of citric acid, which further lowered the pH of the snake fruit jelly drinks due to the increased fruit usage. Snake fruit contains epicatechin, neochlorogenic acid, syringic acid, caffeic acid, ferulic and gallic acid, apigenin or 4,5,7-trihydroxyflavone and isoquercetin, which function as antioxidants (Widowati et al., 2023).

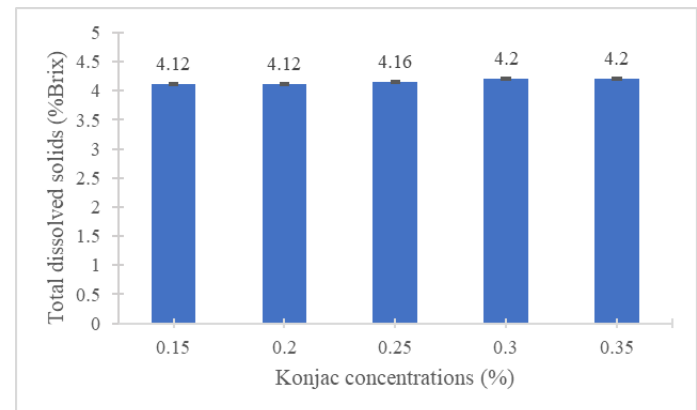


Figure 2. Average total dissolved solids graph of snake fruit jelly drink with varying konjac concentrations.

3.2 Total soluble solids

Total soluble solids represent the number of solids that can dissolve in a solution and are expressed in % Brix. TSS can affect the characteristics of the resulting jelly drink. The main components of total soluble solids are simple sugars, organic acids, nitrogen, and other chemical components. The total soluble solids values of snake fruit jelly drinks ranged from 4.12 to 4.20 %Brix. The ANOVA results at $\alpha=5\%$ showed that the differences in konjac concentration did not significantly affect the TSS of the snake fruit jelly drinks. The TSS of the snake fruit jelly drinks are shown in Figure 2. The konjac concentration did not significantly affect the TSS of the snake fruit jelly drinks, likely because the added konjac concentrations were small and the differences were minor, resulting in no significant differences. According to Stephen (2016), the total soluble solids in jelly originate from the thickening agents, Na Benzoate, and added sugar. Therefore, higher concentrations of added thickening agents will increase the dissolved solids values in jelly drinks.

3.3 Suction force

The suction force is an important parameter in determining jelly drinks' characteristics and gel strength. Suction force indicates the gel strength of jelly drinks. The suction force test was conducted using a syringe and expressed in mL/20 seconds. The suction force values

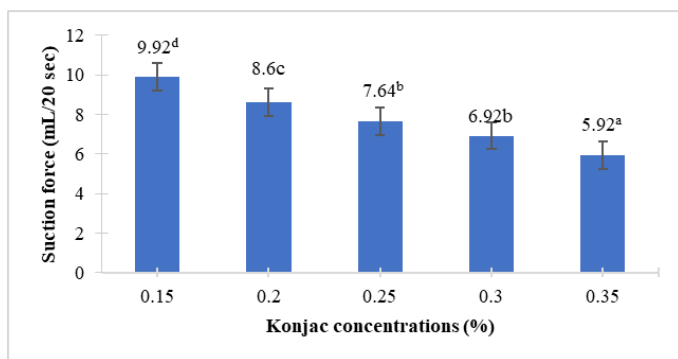


Figure 3. Suction force of snake fruit jelly drink with varying konjac concentration.

ranged from 9.92 mL/20 seconds to 5.92 mL/20 seconds. Based on the ANOVA results at $\alpha=5\%$, konjac concentration significantly affected the suction force of the snake fruit jelly drinks. The suction force of the snake fruit jelly drinks and the DMRT test results at $\alpha=5\%$ are shown in Figure 3. Figure 3 shows that higher konjac concentrations resulted in a lower suction force of the snake fruit jelly drinks. Lower konjac concentrations made the snake fruit jelly drinks easier to suck, as konjac has a high water-binding capacity. Higher konjac concentrations resulted in greater water-binding capacity. High konjac concentrations lead to more and stronger double helices, which can bind more water, making the gel firmer and harder to suck. Factors affecting konjac gel formation include hydrogen bonds and the availability of hydrophobic groups. Hydrogen bonds can form when konjac molecules lose acetyl groups, resulting in deacetylation. The deacetylation process leads to the formation of hydrogen bonds between konjac molecules (Srzednicki and Borompichaichartkul, 2020).

3.4 Syneresis

Syneresis is the phenomenon of liquid expulsion from a gel system. According to Winarno (1997), syneresis is the occurrence of liquid leaking or seeping out of a gel, such as jelly, jelly drink, and others, because the gel system loses its activation energy, causing water that was confined within the gel system to escape. Syneresis is associated with imperfect gel formation processes. Temperature changes affect the hydrodynamic permeability, which determines the air-sealing capacity and gel syneresis (Ako *et al.*, 2022). Water expulsion from the gel can reduce the organoleptic quality of snake fruit jelly drinks. Syneresis is calculated by measuring the liquid loss during storage and comparing it to the initial gel weight.

The ANOVA results at $\alpha=5\%$ showed that the differences in added konjac concentration significantly affected the syneresis of snake fruit jelly drinks. The DMRT test results at $\alpha=5\%$ indicated significant differences in each treatment. The average syneresis graph for storage days 1, 4, and 7 is shown in Figure 4.

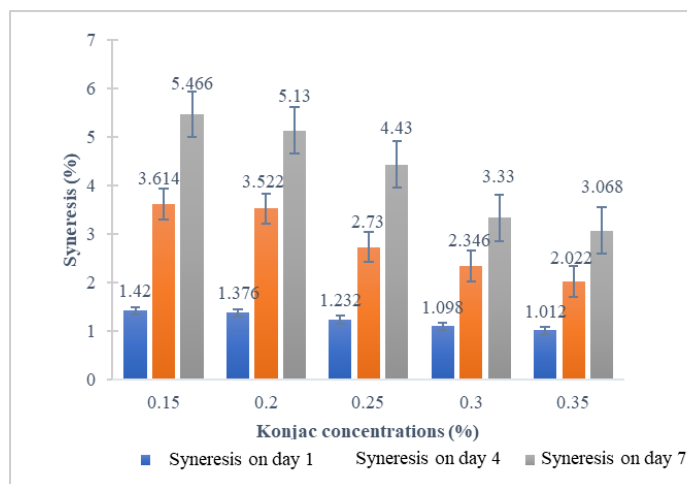


Figure 4. Syneresis of snake fruit jelly drink with varying konjac concentrations during 1, 4, and 7 days of storage.

Figure 4 demonstrates that increasing konjac concentration can reduce the syneresis of snake fruit jelly drinks. Konjac strong water-binding capacity reduces syneresis levels at higher concentrations (Bittante *et al.*, 2022). Higher konjac concentrations resulted in lower syneresis values. A higher concentration of gelling agents results in the formation of strong double helix structures. These structures effectively trap and bind water, which helps to retain moisture within the gel. Consequently, the movement of water molecules is restricted, reducing syneresis.

Figure 4 also shows that syneresis increased during storage. The snake fruit jelly drinks were stored for 1, 4, and 7 days. Higher syneresis values indicate lower product quality of the jelly drinks. Syneresis increased with longer storage times, likely due to continuous helix and aggregate formation, causing the gel bonds to shrink and release more free water (Prangdimurti *et al.*, 2014).

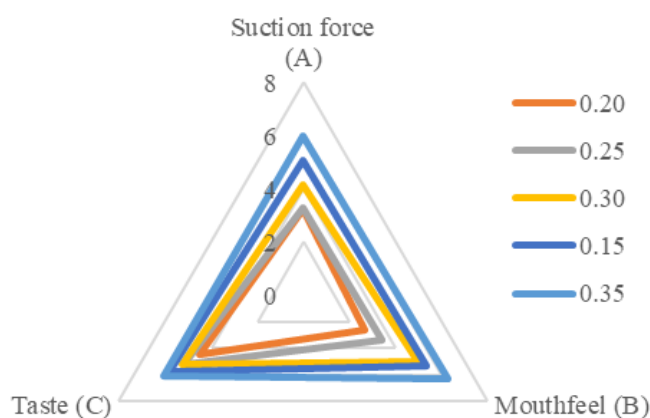


Figure 5. Spider web results for determining the best treatment of snake fruit jelly drink with varying konjac concentrations.

3.5 Sensory evaluation

The sensory evaluation results of the jelly drink were evaluated using the spider web method to determine the best treatment for panelist preference for suction force,

mouthfeel, and taste in the snake fruit jelly drink product. The best treatment was determined by plotting the average results of all panelist preference tests. The best treatment was analyzed based on the largest area. The best treatment results based on the spider web method are shown in Figure 5. The calculation results showed that adding 0.35% konjac concentration had the best area across all sensory evaluation parameters, namely preference for suction force, mouthfeel, and taste in the snake fruit jelly drink product.

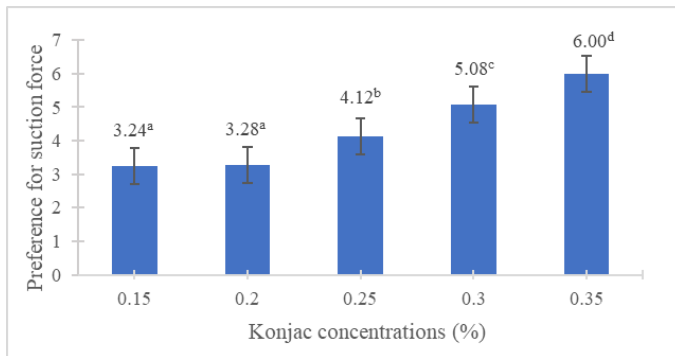


Figure 6. Preference for suction force of snake fruit jelly drink with varying konjac concentrations.

3.5.1 Preference for suction force

The preference values for the suction force of the snake fruit jelly drink ranged from 3.24 (slightly disliked) to 6.00 (liked). The ANOVA results at $\alpha=5\%$ showed a significant difference in the preference for the suction force of the snake fruit jelly drink due to variations in konjac concentration. The preference for the suction force of the snake fruit jelly drink and the DMRT test results are shown in Figure 6. Figure 6 illustrates that the concentration of 0.35% konjac received the highest preference rating from the panelists, scoring a value of 6.00, which indicates that it was the most liked concentration among those tested. This value stands out in comparison to the other konjac concentrations evaluated. Jelly drinks containing higher concentrations of konjac are more effective at creating gel formations. This quality enhances the unique texture associated with gel drinks, providing a satisfying suction sensation when consumed. The least preferred jelly drink by the panelists was the one with 0.15% konjac concentration, with a value of 3.24 (slightly disliked), due to its less firm or imperfect gel formation. The sensory suction force test results and the instrumental measurement were inversely proportional. The suction force measured instrumentally showed that higher konjac concentrations increased suction force, whereas panelists preferred increased suction force because it aligns with the typical characteristics of jelly drinks.

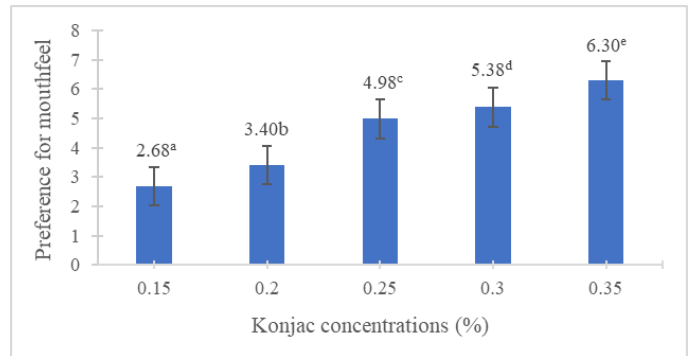


Figure 7. Preference graph for mouthfeel of snake fruit jelly drink with varying konjac concentrations.

3.5.2 Preference for mouthfeel

Mouthfeel is a parameter that indicates the texture of the jelly drink in the mouth. The preference values for mouthfeel ranged from 2.68 (disliked) to 6.30 (liked). The ANOVA results at $\alpha=5\%$ showed a significant difference in the mouthfeel preference of the snake fruit jelly drink due to variations in konjac concentration. The mouthfeel preference of the snake fruit jelly drink and the DMRT test results are shown in Figure 7. Figure 7 shows that higher konjac concentrations resulted in higher panelist preference. Panelists least preferred the mouthfeel of the snake fruit jelly drink with 0.15% concentration, with a value of 2.68 (disliked), due to the imperfect gel formation, making it easily breakable and fragile in the mouth, thus barely providing a gel sensation. Panelists preferred the snake fruit jelly drink with 0.35% konjac concentration, with a value of 6.30 (liked), because it had a well-formed gel that was not too fragile in the mouth, enhancing panelist preference.

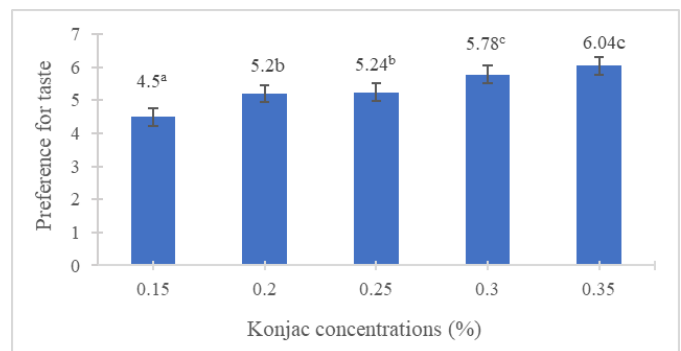


Figure 8. Preference for taste of snake fruit jelly drink with varying konjac concentrations.

3.5.3 Preference for taste

Taste plays a crucial role in food flavor, and flavor determines consumer acceptance of a product. The preference values for the taste of the snake fruit jelly drink ranged from 4.50 (neutral) to 6.04 (liked). The taste preference test was based on panelist preference for the taste of the snake fruit jelly drink upon consumption. Based on the ANOVA results at

$\alpha=5\%$, there was a significant difference in the taste preference of the snake fruit jelly drink due to variations in konjac concentration. The taste preference of the snake fruit jelly drink and the DMRT test results are shown in Figure 8. Figure 8 shows that the preferred konjac concentrations by the panelists were 0.30% and 0.35%, with values of 5.78 and 6.04, respectively, as they both had the notation "c," while the least preferred concentration was 0.15%, with a value of 4.50 (neutral). In the taste testing parameter, different konjac concentrations did not significantly affect the taste of the snake fruit jelly drink. At 0.35% konjac concentration, the formed gel was firmer and more pronounced in the mouth, leading panelists to perceive the taste of the snake fruit jelly drink as more acidic. Taste preference is subjective to each panelist. The test results concluded that panelists preferred snake fruit jelly drinks with a firm gel and a tangy and refreshing taste.

Conclusions

Variations in the added konjac concentration did not significantly affect pH and total soluble solids. However, konjac concentration significantly influenced suction force, syneresis, and sensory evaluation, including a preference for suction force, mouthfeel, and taste. Increasing konjac concentration resulted in a slight increase in pH and total soluble solids. Konjac possesses a strong water-binding capacity, leading to a decrease in suction force and syneresis values with higher konjac concentrations. The optimal treatment, based on spider web analysis, was the snake fruit jelly drink with 0.35% konjac concentration, which exhibited high preference scores: 6.00 (liked) for suction force, 6.3 (liked) for mouthfeel, and 6.04 (liked) for taste.

Conflict of interest

The authors declare no conflict of interest.

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