Physical and Sensory Characteristics of Cascara Water Kefir with the Addition of Butterfly Pea (*Clitoria ternatea*) Flowers

Murna Muzaifa[1,3*], *Yusya* Abubakar[1,3], *Cut* Nilda[1], *Yuliani* Aisyah[1], *Faidha* Rahmi[2], *Juanda* Juanda[1], and *Alya* Fithriyyah[1]

[1]Agricultural Product Technology, Universitas Syiah Kuala, 23116 Banda Aceh, Indonesia
[2]Agricultural Faculty, University of Gajah Putih, 24560 Blang Bebangka Aceh Tengah, Indonesia
[3]Research Center for Aceh Coffee and Cacao, Universitas Syiah Kuala, 23116 Banda Aceh, Indonesia

Abstract. One of the byproducts of coffee processing is the fruit skin, which, after drying, is called cascara. This study aims to study the production of water kefir from cascara with addition of butterfly pea flower extract. The factors studied were the type of cascara (pulp and husk) and the concentration of butterfly pea flower extract added (0; 2 and 4%). The parameters analyzed included physical (color L*, a*, b*) and sensory (hedonic and descriptive) characteristics. The results showed that increasing the concentration of butterfly pea flowers decreased the brightness value L* (34.12–21.45), redness a* (14.46–3.27), and yellowness b* (18.35–6.14). The hedonic test showed that the panelists' preference level for color ranged from 3.05–3.80 (neutral–like), aroma 2.95–3.60 (slightly dislike–neutral), and taste 2.90–3.70 (slightly dislike–like), with a decrease in scores as the concentration of butterfly pea flowers increased. The best formulation was obtained in the combination of cascara husk with 2% butterfly pea flowers (K2B2), which had a balanced color (L* 28.74; a* 8.92; b* 12.08) and relatively good panelists' acceptance in the attributes of color (3.80), aroma (3.60), and taste (3.70).

1 Introduction

Coffee is one of the most popular beverages in the world, including in Indonesia, which ranks fifth as the country with the highest coffee consumption globally [1]. The coffee processing process generates waste in the form of non-bean parts, such as pulp and husk, that have not been optimally utilized [2]. Coffee skin is organic waste containing water content of 2.25%, ash content of 0.73%, volatile components of 74.20%, and solid carbon of 25.07% [3]. These parts contain carbohydrates, proteins, minerals, tannins, polyphenols, and caffeine that have the potential to be processed into value-added products [4].

One way to utilize coffee waste is through fermentation into functional beverages such as water kefir. Kefir is a fermented product typically made from milk, but it has evolved into water kefir, which utilizes non-animal ingredients [5]. Water kefir is fermented using kefir

* Corresponding author: murnamuzaifa@usk.ac.id

grains containing lactic acid bacteria, acetic acid bacteria, and yeast [6]. This fermentation process produces compounds that are beneficial to health, such as organic acids and other bioactive compounds.

The improvement of water kefir can be enhanced by adding natural ingredients such as butterfly pea flowers *(Clitoria ternatea)*. Butterfly pea flowers contain anthocyanin compounds that act as natural dyes and have good antioxidant properties [7]. In addition to functioning as a safe natural dye, anthocyanins from butterfly pea flowers also have good color stability in food products [8]. Therefore, adding butterfly pea flowers to water kefir not only enhances the visual appearance but also the functional potential of the drink.

Several studies have explored the use of cascara and butterfly pea flowers separately, such as the production of cascara kefir [9] and butterfly pea kefir [10]. Additionally, fermentation is also known to influence the color and flavor characteristics of cascara beverages [11, 12]. However, to date, there has been no study specifically combining cascara pulp and cascara husk with the addition of butterfly pea flowers in the production of water kefir. Therefore, this study aims to investigate the physical and sensory properties of cascara water kefir supplemented with butterfly pea flower extract, exploring it as an innovative functional beverage alternative.

2 Materials and Method

2.1 Research stages

This research was conducted in several stages, beginning with the brewing of cascara, the production of butterfly pea flower extract, and subsequently the creation of water kefir. To clarify the research process, the flowchart in Figure 1 illustrates the sequence of activities undertaken.

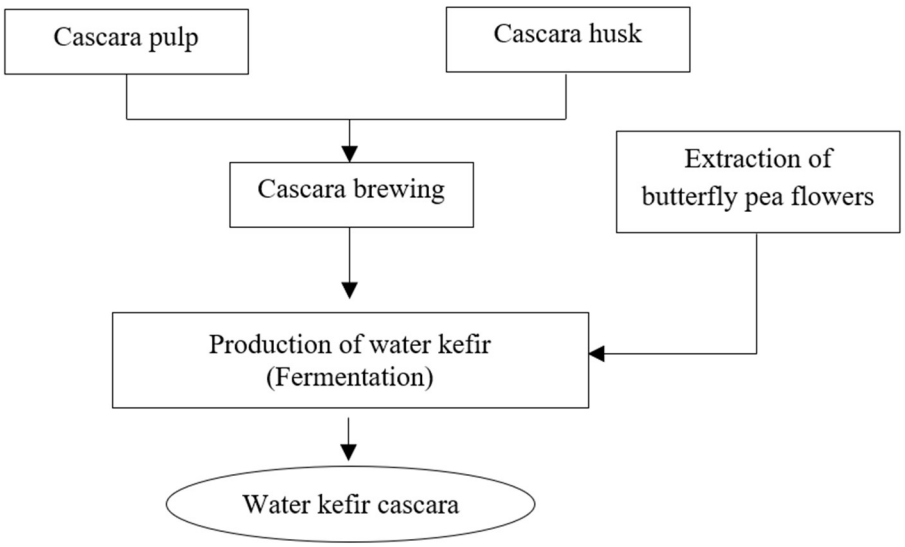

Fig. 1. Research stages.

2.2 Cascara infusion

This study utilised two primary types of raw materials: cascara pulp and cascara husk, sourced from farmers in Central Aceh Regency. The cascara brewing process was carried out using the Darma method [13], where 50 g of each cascara pulp and cascara husk were weighed. The ingredients are then brewed with 1000 ml of hot water at a temperature of around 90 ºC for 6.5 minutes. After the brewing process is complete, the solution is filtered to separate the liquid from the cascara pulp.

2.3 Preparation of butterfly pea flower extract

This study used dried butterfly pea flowers obtained from an online store. The process of making butterfly pea flower extract was carried out based on the method used by Turang [14], which involved washing the butterfly pea flowers with running water to remove any dirt. Subsequently, the butterfly pea flowers were soaked in 100 ml of hot water for 2 hours, then filtered to separate the butterfly pea flower extract from the flower residue.

2.4 Production of cascara water kefir (fermentation) with the addition of butterfly pea flower extract

The water kefir production process refers to the method described by Darma [13], with modifications regarding the addition of butterfly pea flower extract. The procedure begins with preparing 300 ml of cascara pulp tea and cascara husk tea that has been brewed. Next, 9% sucrose by volume is added, and the mixture is heated to 80°C and cooled to room temperature (±25°C). Once the solution reaches room temperature, telang flower extract is added at concentrations of 0%, 2%, and 4%. The mixture is placed in a sterile glass container, and then 5% water kefir grains are added. The container is sealed tightly and fermented at room temperature (±25 ºC) for 24 hours. After fermentation is complete, the solution is filtered to separate the water kefir grains from the final product.

2.5 Product analysis

The product analysis for cascara butterfly pea flower water kefir includes physical and sensory evaluations. Physical analysis involves colour analysis using a colourimeter [15], which measures the L* value (lightness), a* value (red-green component), and b* value (yellow-blue component). Sensory analysis was conducted through hedonic and descriptive tests.. Thirty semi-trained panellists evaluated the level of preference for colour, aroma, and taste using a 1-5 scale, ranging from "imensely dislike" to "very like". In the descriptive test, the panelists evaluated the aroma of cascara, the aroma of water kefir, the taste of cascara, and the sour taste on a scale of 1-5, indicating the strength of perception from very weak to very strong.

2.6 Data analysis

The data obtained were analysed statistically using Analysis of Variance (ANOVA). If significant differences were found between treatments, they were followed up with the Duncan Multiple Range Test (DMRT) method. The hedonic test scores and descriptions were presented in tabular form and analyzed descriptively.

3 Results and Discussion

3.1 Color analysis

3.1.1 L color analysis*

Color analysis was performed using a colorimeter to determine changes in L* (lightness), a* (redness), and b* (yellowness) values in cascara butterfly pea flower water kefir. The L* value describes lightness on a scale of 0 (black) to 100 (white). The L* values of cascara butterfly pea flower water kefir ranged from 16.40 to 27.50, with an average of 20.49. The effect of the interaction between cascara type and butterfly pea flower concentration can be seen in Figure 2.

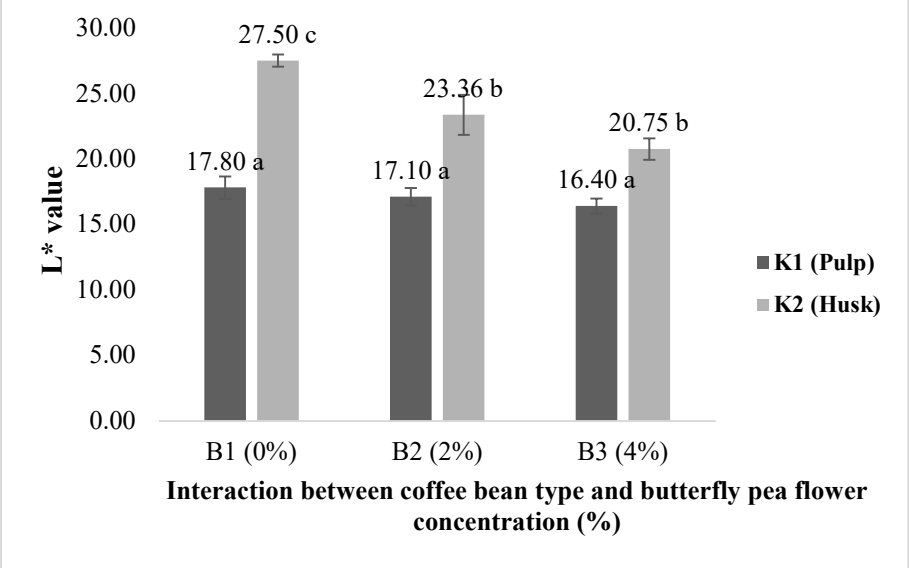

Fig. 2. The effect of cascara type and butterfly pea flower concentration on the L* value of cascara butterfly pea flower water kefir ($DMRT_{0.01}$, P2=2.70, P3=2.81, P4=2.89, P5=2.94, P6=2.98 values not followed by the same letter indicate a significant difference).

Based on Figure 1, the L* value of cascara husk without the addition of butterfly pea flower (K2B1) had the highest L* value of 27.50, while the lowest value of 16.40 was found in the pulp treatment with 4% butterfly pea flower (K1B3). The L* value tends to decrease with increasing butterfly pea flower concentration, particularly in the pulp-type cascara, indicating that the beverage color becomes darker due to increased anthocyanin pigment content. The increasing the concentration of butterfly pea flowers causes a significant reduction in the L* value due to the high intensity of the blue colour from anthocyanins.

3.1.2 a color analysis*

The a* value describes the red-green colour mixture, with a* (positive) ranging from 0 to +80 for red and a* (negative) ranging from 0 to -80 for green. The a* values for cascara butterfly pea flower water kefir range from 3.16 to 12.69, with an average of 8.75. The effect of the interaction between cascara type and butterfly pea flower concentration can be viewed in Figure 3.

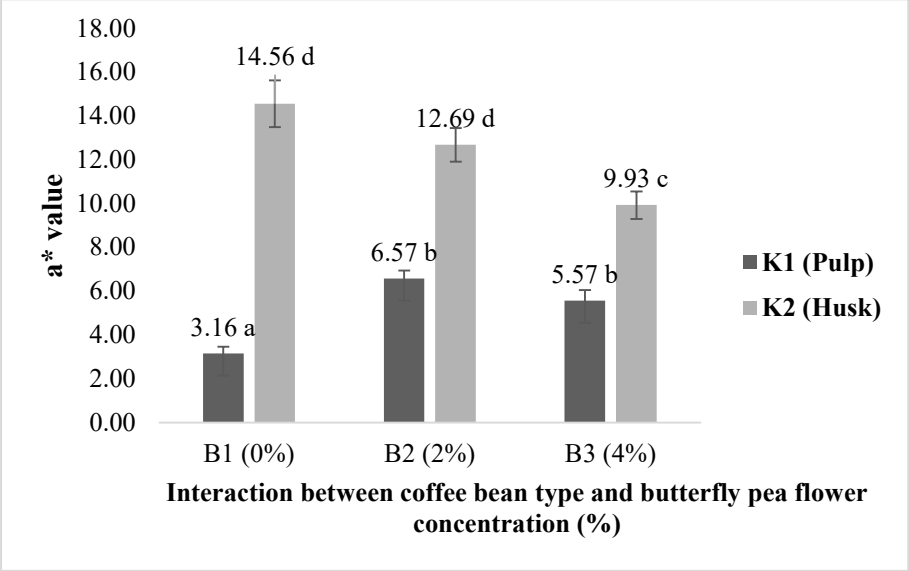

Fig. 3. The effect of cascara type and butterfly pea flower concentration on the a* value of cascara butterfly pea flower water kefir ($DMRT_{0.01}$, P2=2.01, P3=2.09, P4=2.15, P5=2.18, P6=2.21 values not followed by the same letter indicate a significant difference)

Based on Figure 3, all treatments have positive a* values, indicating that the colours tend toward red. The cascara husk treatment without the addition of butterfly pea flowers (K2B1) has the highest a* value of 14.46. Furthermore, the lowest value of 3.16 is obtained from pulp without butterfly pea flowers (K1B1). The addition of butterfly pea flowers generally reduces the a* value, indicating a decrease in red color intensity, which is likely due to the addition of blue anthocyanins from the butterfly pea flowers neutralizing the natural red hue of the cascara.

The reddish color of the high cascara content underlies the positive a* value in the treatment without butterfly pea. Cascara produces a reddish color that intensifies as the brewing ratio increases. The presence of the enzyme polyphenol oxidase is responsible for the red colour of cascara brew. Butterfly pea flowers contain ternatin anthocyanin compounds that change colour depending on the pH of the environment, turning red in acidic pH, blue in neutral pH, and yellowish-green in alkaline pH. Moreover, the addition of butterfly pea flower extract can lower the a* value due to the presence of blue pigments that neutralize the natural red hue of the base material.

3.1.3 b color analysis*

The b* value describes the blue-yellow colour mixture, with a positive b* value ranging from 0 to +70 indicating yellow, and a negative b* value ranging from 0 to -70 indicating blue. The b* values for cascara butterfly pea flower water kefir range from 4.44 to 19.26, with an average of 9.19. The effect of the interaction between cascara type and butterfly pea flower concentration can be viewed in Figure 4.

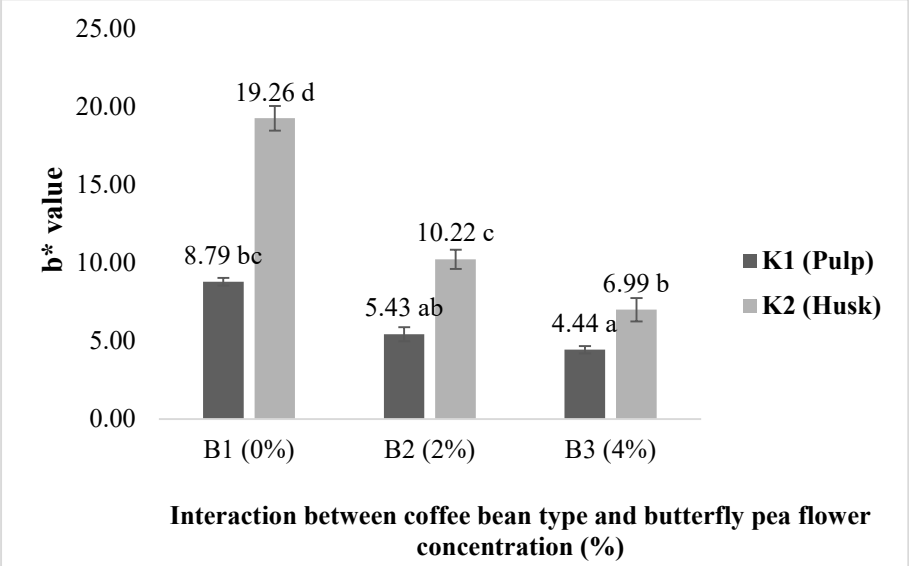

Fig. 4. The effect of cascara type and butterfly pea flower concentration on the b* value of cascara telang flower water kefir ($DMRT_{0.01}$, P2=1.71, P3=1.78, P4=1.83, P5=1.86, P6=1.89 values not followed by the same letter indicate a significant difference)

Figure 4 demonstrates that all treatments exhibit positive b* values, indicating a dominant yellow color in the water kefir beverage. The cascara husk treatment without the addition of butterfly pea flowers (K2B1) has the highest b* value of 19.26, indicating the most dominant yellow color. Conversely, the lowest b* value was found in the cascara pulp treatment with the addition of 4% butterfly pea flower extract (K1B3), which was 4.44, indicating a decrease in yellow color intensity. The decrease in b* value is strongly suspected to be due to the addition of butterfly pea flowers, which contain blue-purple anthocyanin compounds, thereby neutralizing the yellow hue of the cascara.

The pattern of decrease in b* value as the concentration of butterfly pea flowers increases indicates that anthocyanin pigments play a major role in the visual color change of the product. Anthocyanins from blue pea flowers exhibit a bright blue colour at pH levels ranging from 3.6 to 5.4 and show good colour stability at a storage temperature of 25°C, but are less stable when exposed to direct light. Cascara tea can vary from golden yellow to reddish, depending on the drying time and type of coffee, which influence the content of phenolic compounds and natural pigments in the coffee husks. Therefore, the interaction between the type of cascara and the concentration of butterfly pea flowers significantly determines the visual appearance of the beverage.

3.2 Sensory analysis

3.2.1 Hedonic test

Hedonic testing is a method used to determine the level of panellists' preferences for food products based on attributes such as colour, aroma, taste, and texture, utilising human senses as the primary instrument. Hedonic assessment in this study focused on three attributes, namely color, aroma, and taste of the produced butterfly pea flower water kefir. The assessment uses a scale of 1 to 5, where a score of 1 (very dislike), 2 (dislike), 3 (neutral), 4

(like), and 5 (very like). The results of the assessment for the three attributes are presented in Table 1.

Table 1. Hedonic characteristics of cascara butterfly pea flower water kefir.

Cascara butterfly pea flower water kefir	Color	Aroma	Flavor
K1B1	2.69 ± 0.14^{ab}	2.57 ± 0.03^{a}	2.66 ± 0.11^{a}
K1B2	2.53 ± 0.07^{a}	2.53 ± 0.12^{a}	2.56 ± 0.07^{a}
K1B3	2.76 ± 0.09^{ab}	2.93 ± 0.09^{b}	2.85 ± 0.20^{ab}
K2B1	2.65 ± 0.24^{ab}	2.59 ± 0.06^{a}	2.75 ± 0.05^{a}
K2B2	2.89 ± 0.21^{b}	3.00 ± 0.10^{b}	3.15 ± 0.12^{b}
K2B3	2.46 ± 0.11^{a}	2.75 ± 0.06^{ab}	2.76 ± 0.10^{ab}

Based on Table 1, the panellists' liking levels for the colour, aroma, and taste attributes of butterfly pea flower water kefir varied, with scores ranging from 2.46 to 3.15. These scores fall into the categories of dislike to neutral tend to like. This assessment indicates that the product is generally acceptable to the panellists, although it has not yet achieved a high level of liking. The differences between treatments also show the influence of formulation on the sensory preferences of the panelists.

The most preferred color was found in treatment K2B2 (cascara husk with 2% butterfly pea flower extract) with a score of 2.89. The colour in this treatment tended to be bright and attractive, making it a preferred choice among the panellists. Conversely, treatment K2B3 (cascara husk with 4% butterfly pea flower extract) received the lowest score of 2.46, indicating that the color was too dark and unattractive. Tthe concentration of butterfly pea flower extract influences the organoleptic properties of the syrup, particularly in terms of colour and taste. Notably, excessively high concentrations can reduce panellists' preference for the product's colour.

The average aroma of water kefir ranged from 2.53 to 3.00, indicating a rating between 'dislike' and 'neutral'. Treatments K2B2 (cascara husk with 2% butterfly pea flower added) and K1B3 (cascara pulp with 4% butterfly pea flower added) obtained the highest aroma scores and differed significantly from the other treatments. These results indicate that the addition of 2–4% butterfly pea flower positively contributes to the aroma of the product. However, no treatment reached a value above 3, so no aroma was considered particularly prominent. the addition of butterfly pea flower to kombucha beverages affects chemical and organoleptic properties, including aroma.

The most preferred flavor was found in treatment K2B2 (cascara husk with 2% butterfly pea flower extract) with a score of 3.15, which falls into the neutral category. This treatment differed significantly from most of the other treatments. The combination of cascara husk and 2% butterfly pea flower is believed to produce a balance of fermented flavour and the distinctive flavour of butterfly pea flower that best suits the panellists' preferences. The K1B3 treatment (cascara pulp with 4% butterfly pea flower) and K2B3 treatment (cascara husk with 4% butterfly pea flower) also showed fairly good flavor values, although they were not significantly different from some other treatments. The flavour of water kefir products is significantly influenced by the type of substrate used, as the substrate composition determines the type and ratio of organic acids formed during fermentation and affects the dominance of microorganisms, such as lactic acid bacteria and yeast, that play a role in the characteristic flavour of water kefir.

3.2.2 Descriptive test

Descriptive testing is one of the sensory methods used to evaluate food products, measured by specially trained human subjects. Analysis can be conducted based on all product parameters or limited to specific aspects, such as taste, aroma, texture, and color. Descriptive

analysis enables a detailed description of the product, which can identify variable ingredients and processes. Descriptive test parameters include cascara aroma, water kefir aroma, cascara taste, and sour taste, each rated on a 5-point scale: score 1 (very weak), score 2 (weak), score 3 (normal), score 4 (strong), and score 5 (fairly strong). The overall results of the descriptive testing can be seen in Figure 5.

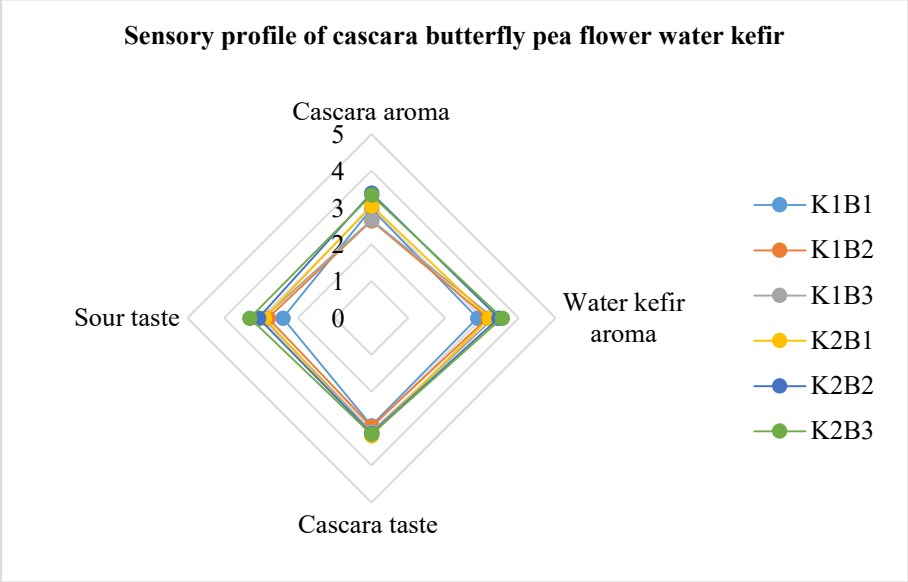

Fig. 5. Spider web graph of descriptive assessment of all attributes in all treatments with a description scale of 1-5 (1 = very weak, 2 = weak, 3 = normal, 4 = strong, 5 = very strong) (Note: K1B1 = cascara pulp without butterfly pea flower extract, K1B2 = cascara pulp with 2% butterfly pea flower extract, K1B3 = cascara pulp with 4% butterfly pea flower extract, K2B1 = cascara husk without butterfly pea flower extract, K2B2 = cascara husk with 2% butterfly pea flower extract, K2B3 = cascara husk with 4% butterfly pea flower extract).

Based on Figure 5, the descriptive values for the parameters of cascara aroma, water kefir aroma, cascara taste, and sour taste varied on a scale of 2 (dislike) to 4 (like). The aroma of cascara and water kefir tends to be stronger and more preferred in treatments K2B2 (cascara husk with 2% butterfly pea flower extract) and K2B3 (cascara husk with 4% butterfly pea flower extract). Additionally, butterfly pea flowers contain flavonoids and anthocyanins that contribute to the unique aroma and flavor of fermented products.

The highest acidity values were obtained in treatments K2B2 and K2B3, which were combinations of cascara husk with 2% and 4% butterfly pea flower concentrations. These results indicate that this combination was able to produce a stronger acidity intensity than the other treatments. This is thought to be due to the initial compounds in the husk that support the formation of organic acids during the fermentation process, such as simple sugars and phenolic compounds. These results are similar to those obtained by Muzaifa et al. [30], which states that cascara from husk has a higher content of bioactive compounds than pulp, resulting in more complex and stronger flavor characteristics in fermented beverages such as water kefir. Furthermore, the addition of butterfly pea flowers is believed to enhance the content of phenolic compounds, flavonoids, and organic acids that interact with microorganisms during fermentation, thereby increasing the production of organic acids. The addition of butterfly pea flowers to water kefir production enhances antioxidant activity, increases flavonoid content, and boosts anthocyanin levels, thereby contributing to the sensory characteristics of the final product.

4 Conclusion

The type of cascara and concentration of butterfly pea flowers affect all physical parameters (color values L*, a*, and b*), as well as sensory parameters (hedonic and descriptive). Increasing the concentration of butterfly pea flowers causes a decrease in the L*, a*, and b* color values, indicating a reduction in brightness, redness, and yellowness in the product due to the increased anthocyanin pigments from the butterfly pea flowers. Additionally, as the concentration of butterfly pea flowers added increases, the panelists' preference for the color and taste of the product decreases, indicating that the distinctive color and taste characteristics of butterfly pea flowers, when too intense, become less preferred by some panelists.
The best formulation was obtained by combining cascara husk with the addition of 2% butterfly pea flower (K2B2). This treatment produced an L* value of 23.6, an a* value of 12.39, and a b* value of 10.22. The hedonic aroma value was 3.00, the hedonic color value was 2.39, and the hedonic taste value was 3.40, all of which fall into the neutral category. Descriptive tests showed that the aroma value of cascara water kefir was 3.40, the aroma value was 3.46, the taste value was 3.13, and the acid taste value was 3.07, all of which fall into the normal category. It is necessary to add strong natural sources of flavor and aroma (certain fruits) to enhance the overall flavor, in addition to strengthening its functional properties to support health.

Acknowledgments

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