

The effect of adding pineapple honey fruit extract (*Ananas comosus* (L) Merr.) concentration on the characteristics of butterfly pea flower kombucha tea

Heny Munawaroh*, Sharfina Mutia Syarifah, Nosa Septiana Anindita

Biotechnology Study Program, Faculty of Science and Technology, Universitas 'Aisyiyah Yogyakarta, Indonesia.

*Email: Heny190602@gmail.com

Abstract

Kombucha Kombucha is a fermented beverage containing bioactive compounds with various health benefits. Honey pineapple was chosen because it contains vitamin C and bromelain, which function as antioxidants and anti-inflammatories, while butterfly pea flower was chosen because it is rich in anthocyanins, which are natural antioxidants. This study aims to determine the effect of variations in the formulation of butterfly pea flower (*Clitoria ternatea* L.) and honey pineapple (*Ananas comosus* L.) on the chemical parameters, microbiological parameters, and organoleptic parameters of kombucha. The study used a completely randomized design with three treatments and three replications, namely Purblu kombucha, Sunblu kombucha, and Goldblu kombucha. The parameters observed included chemical parameters (pH, alcohol content, total acetic acid content, vitamin C content, antioxidant activity (DPPH)), microbiological parameters (total lactic acid bacteria, antibacterial activity against *Escherichia coli* bacteria), and organoleptic parameters (taste, aroma, color, and level of preference). The data were analyzed using ANOVA at a confidence level ($\alpha \leq 5\%$) and followed by Tukey's test. The Goldblu kombucha formulation provided the best results based on chemical and microbiological parameters. Goldblu kombucha with 30% honey pineapple extract had a significant effect on chemical and microbiological parameters but did not have a significant effect on organoleptic parameters. Goldblu kombucha produced the highest levels of acid (1.26%), vitamin C (88.23 mg/100 mL), antioxidant activity (82.93%), and antibacterial activity (17.65 mm), with an alcohol content below the MUI safety limit (0.48%). The combination of butterfly pea flowers and honey pineapple with a formulation of 70% butterfly pea flowers and 30% honey pineapple extract was able to increase bioactive compounds that have the potential to ward off free radicals and inhibit pathogenic bacteria. Therefore, Kombucha Goldblu has the potential as a functional drink in the prevention of degenerative diseases.

Keywords: Antibacterial; Antioxidant; Butterfly pea Flowers; Kombucha; Honey Pineapple.

1. Introduction

The prevalence of degenerative diseases such as diabetes mellitus, hypertension, heart disease, and atherosclerosis continues to increase in line with changes in modern lifestyles. High-calorie and high-fat diets, low fiber intake, minimal antioxidants, and lack of physical activity contribute to this trend. These conditions trigger oxidative stress and chronic inflammation, which cause cell damage and metabolic disorders. This reduces quality of life and increases mortality rates and economic burdens. According to Putri and Sabrina (2024), one effective preventive measure is the consumption of functional foods and beverages rich in antioxidants that can neutralize free radicals and support metabolic health. One functional beverage that has been extensively studied for its antioxidant content and health benefits is kombucha.

Kombucha is a fermented beverage made from sweet tea using a symbiotic culture of bacteria and yeast (SCOBY). Kombucha fermentation takes 7-14 days. The microorganisms in kombucha break down the tea solution into bioactive compounds, including various types of organic acids (acetate, citrate, malate, glucuronate, etc.), amino acids, B vitamins (B1, B2, B3, B6, B12, B15), vitamin C, polyphenols, and natural probiotics that support gut microbiota balance (Evangelina, 2025; Putri & Sabrina, 2024). According to Evangelina (2025), kombucha has antioxidant activity to counteract free radicals, antibacterial properties, supports digestive health, and aids detoxification through glucuronic acid. This potential makes kombucha one of the functional beverages that can be beneficial for the prevention of degenerative diseases. In the current development of kombucha, the addition of local natural ingredients rich in bioactive compounds has become the main focus to enhance functional value and create a more appealing taste. Butterfly pea flower (*Clitoria ternatea* L.) was selected as a substitute for tea due to its high content of anthocyanins, flavonoids, and polyphenols with antioxidant, anti-inflammatory, and antimicrobial activities, as well as its potential as a cardiovascular protector (Pujiyanti & Ilmi, 2025). Furthermore, the anthocyanins in butterfly pea flowers are relatively stable at

acidic pH levels, making them suitable for fermentation, and the natural blue-purple color of butterfly pea flowers adds visual appeal to the product (Putri & Baharza, 2023).

In addition, honey pineapple (*Ananas comosus* L. Merr) was chosen as an additional ingredient due to its abundant bioactive content. Honey pineapple is rich in bromelain enzymes that aid protein digestion, have anti-inflammatory properties, and accelerate tissue healing (Astuti & Pade, 2020). The addition of honey pineapple extract to kombucha increases antioxidant activity, health benefits, and fresh taste and aroma. Bromelain in honey pineapple accelerates the fermentation process and increases the availability of nutrients in kombucha (Hujjatusnaini et al., 2022). The anti-inflammatory activity of bromelain also contributes to reducing the risk of chronic diseases associated with systemic inflammation. Additionally, honey pineapple contains vitamin C and polyphenols, which are powerful antioxidants that help strengthen the immune system and protect cells from oxidative damage, support collagen synthesis, while polyphenols and flavonoids function as antioxidants that protect the body from oxidative stress (Astuti & Pade, 2020; Rezaldi et al., 2022).

Butterfly pea flowers have been extensively studied due to their high content of anthocyanins, flavonoids, and polyphenols (Pujiyanti & Ilmi, 2025). On the other hand, honey pineapple fruit has been widely used in kombucha production due to its vitamin C, bromelain, polyphenol, and saponin content, (Destiana, 2022; Shofiyanti et al., 2023). Research related to kombucha generally evaluates ingredients separately, while the combination of butterfly pea flower and honey pineapple has not been widely studied. There are no studies that examine the combined effects of these two ingredients on the antioxidant activity, chemical properties, and organoleptic properties of kombucha. Therefore, this study aims to evaluate the effect of honey pineapple extract on butterfly pea flower tea kombucha on its physicochemical characteristics, antioxidant activity, and microbiological quality, in order to support the development of healthy and innovative functional beverages based on local ingredients.

2. Research Methods

2.1. Materials and Methods

The main ingredients consist of dried butterfly pea flowers (blue sail variety), honey pineapple fruit (queen variety) obtained from Beringharjo Market, granulated sugar, mineral water, and a seven-day-old kombucha culture (SCOBY) as a fermentation starter. Chemicals include 0.1 N NaOH, 0.01 N iodine, phenolphthalein, 1% starch, 97% ethanol, DPPH reagent, as well as MRS agar and Muller Hinton Agar microbiological media. The equipment used included a UV-Vis spectrophotometer, pH meter, alcohol meter, titration apparatus, autoclave, and general laboratory equipment such as Erlenmeyer flasks, measuring cups, measuring flasks, pipettes, micropipettes, blenders, filter cloths, glass jars, and Petri dishes.

2.2. Research Design

This study used a simple completely randomized design (CRD) with one treatment factor, namely the addition of honey pineapple extract to butterfly pea flower kombucha tea. The treatments consisted of Purblu (100% butterfly pea flower tea), Sunblu (85% butterfly pea flower tea with 15% honey pineapple fruit extract), and Goldblu (70% butterfly pea flower tea with 30% honey pineapple fruit extract). Each treatment was replicated three times, resulting in nine experimental units. Data were analyzed using one-way ANOVA ($\alpha = 5\%$) and Tukey HSD post-hoc test using SPSS.

2.3. Research Stages

2.3.1. Selection of Honey Pineapple and Butterfly Pea Flowers

Honey pineapple (*Ananas comosus* L. Merr) of the queen variety is used at 70%. According to Condro and Stefani (2024), pineapples at this stage of ripeness have higher vitamin C, bromelain, and antioxidant content, as well as lower sugar content (10%) compared to fully ripe pineapples. The flowers used are blue sail butterfly pea flower with blue-purple because they contain bioactive compounds such as anthocyanins, flavonoids, and phenols that provide the highest antioxidant and antibacterial activity. Harvested at full bloom for optimal bioactive content (Handito et al., 2022; Yurisna et al., 2022).

2.3.2. Preparation of Butterfly Pea Flowers (*Clitoria ternatea*)

The preparation process for butterfly pea flowers begins with drying in an oven at 40°C for 2

days. This drying process aims to prevent contamination and maintain the stability of bioactive compounds, as well as extend the shelf life of butterfly pea flowers. This is supported by Rezaldi et al. (2022), who state that drying is carried out to avoid contamination and maintain the stability of bioactive compounds. This method ensures that the raw materials remain safe, high-quality, and rich in benefits for kombucha fermentation.

2.3.3. Preparation of Honey Pineapple Fruit Extract

The process is carried out with fresh fruit that has been sorted, then separated from the skin and core. A total of 600g of pineapple flesh is washed thoroughly, cut into small pieces, and homogenized with the addition of 200 mL of mineral water (ratio of 3:1) using a blender. Next, the pineapple extract obtained through the homogenization process is boiled for 10 minutes, then filtered twice, then cooled to a room temperature of $\pm 25^{\circ}\text{C}$ before being used for fermentation (Budiandari et al., 2023; Rezaldi et al., 2022).

2.3.4. Preparation of Butterfly Pea Flower Kombucha Starter

The kombucha starter is made by weighing 200 g of dried butterfly pea flowers and 400 g of sugar in 1 liter of water for 10 minutes, then straining and cooled to room temperature ($\pm 25^{\circ}\text{C}$). The inoculation process is carried out by adding the SCOBY starter along with 10% (100 ml) of kombucha liquid (Zulfa et al., 2019) to the butterfly pea flower tea solution. Fermentation was carried out three times in a row using butterfly pea flower tea so that the SCOBY fully adapted to the medium (Rezaldi et al., 2022), so that the resulting starter was more stable and optimal for further fermentation.

2.3.5. Kombucha Production

The production of kombucha begins by boiling 200g of dried butterfly pea flowers and 400g of sugar in 1 liter of water for 10 minutes, then letting it cool. The butterfly pea flower tea is then mixed with pineapple honey extract, then adding the SCOBY starter along with 10% (100 ml) of seven-day-old kombucha liquid from the total volume of the solution (Zulfa et al., 2019). The mixture is stirred until homogeneous, then the container is covered with a sterile cloth and tied with a rubber band. Fermented at room temperature of $\pm 25^{\circ}\text{C}$ for 10 days in a room that supports the growth of bacteria and yeast (Rezaldi et al., 2022; Yanti et al., 2020).

2.4. Chemical Parameters

2.4.1. pH Level Testing

The pH value of kombucha was measured using a calibrated pH meter. The pH meter was dipped into the kombucha sample until it showed a stable value, indicating that the pH reading was correct and accurate (Pawestriningtyas et al., 2024). The measurement was taken on the 10th day of fermentation.

2.4.2. Alcohol Content Testing

The alcohol content was measured using an alcohol meter by dipping the device into the kombucha sample until the percentage scale (% v/v) on the device stabilized (Gustishio et al., 2023). Measurements were taken on the 10th day of fermentation.

2.4.3. Total Acid Testing of Kombucha

A total of 10 mL of kombucha sample was diluted in a 100 mL volumetric flask, then 10 mL of the filtrate was taken into an Erlenmeyer flask and 2 drops of phenolphthalein (PP) indicator were added. The sample was titrated using 0.1 N NaOH until the solution changed from clear to pink (Shofiyya et al., 2023):

$$\text{Total Acid (\%)} = \frac{V_{\text{NaOH}} \times N_{\text{NaOH}} \times \text{BM} \times 100\%}{V_{\text{Sampel}} \times 1000}$$

Description :

V_{NaOH} : Volume of NaOH for titration
 N_{NaOH} : Standard concentration of NaOH
 V_{sampel} : Sample Volume for titration
 BM : Molecular Weight of acetic acid

2.4.4. Vitamin C Content Test

A total of 25 ml of kombucha sample was diluted with 100 ml of distilled water. Then, 10 ml of the solution was placed in a 250 ml Erlenmeyer flask, and 2 ml of 1% starch indicator was added. Titration was carried out with 0.01 N iodine solution until the color changed to blue. Each 1 ml of 0.01 N iodine is equivalent to 0.88 mg of vitamin C (ascorbic acid). The vitamin C content was calculated based on the volume of iodine used (Puspitasari *et al.*, 2017).

$$\text{Vitamin C mg/100 mL} = \frac{A \times 0,88 \times FP}{W} \times 100$$

Description

A = ml of iodine used for titration
FP = Dilution Factor
W = weight of sample

2.4.5. Antioxidant Activity Testing

A total of 1 mL of sample was mixed with 1 mL of DPPH solution and left to stand for 20 minutes. Then, 97% ethanol was added to a total volume of 5 mL, homogenized using a vortex, and the absorbance was measured at a wavelength of 517 nm using a UV-Vis spectrophotometer. Measurements were also taken on a blank solution (DPPH without sample) as a control. (Puspaningrum *et al.*, 2022):

$$\% \text{ inhibisi} = \frac{A \text{ kontrol} - A \text{ sampel}}{A \text{ Kontrol}} \times 100\%$$

Description:

A = Absorbance value

2.5. Microbiological Parameters

2.5.1. Total LAB (lactic Acid Bacteria) Testing

A total of 1 mL of kombucha sample was diluted in 9 mL of sterile distilled water (10^{-1}) and continued until the desired dilution was achieved. From this dilution, 0.2 mL of the sample was inoculated into a sterile Petri dish containing ± 10 mL of MRS agar medium, then incubated for 48 hours at 37°C. The colonies that grew were counted and expressed as CFU/mL using the formula (Harahap, 2023):

$$\text{Numbers of Colonies} \left(\frac{cfu}{mL} \right) = \frac{\text{Number of bacterial colonies} \times \text{Sample Volume (mL)}}{\text{Sample Factor}}$$

2.5.2. Antibacterial Testing

Antibacterial activity was tested using the well diffusion method with *Escherichia coli* test bacteria grown on 24-hour-old MHA medium. A 7 mm diameter well was made in the MHA medium in a Petri dish, then filled with 50 μ L of kombucha sample (Purblu, Sunblu, Goldblu). The positive control used chloramphenicol 10 mg/mL. The dishes were incubated at room temperature for ± 3 days, then the diameter of the inhibition zone was measured with a caliper (Yanti *et al.*, 2020):

$$Z = \frac{(D1 - DS) + (D2 - DS) + (D3 - DS)}{3}$$

Description:

Z = Clear zone
D1 = Vertical Diameter
D2 = Horizontal Diameter
D3 = Diagonal Diameter
DS = well Diameter

2.6. Organoleptic Testing

The organoleptic test of kombucha was conducted using a hedonic test by 20 semi-trained panelists to assess color, aroma, flavor, and liking level using a 1–5 scale (1 = dislike to 5 = like very much). This method was used to assess sensory preferences in a systematic and standardized manner. (Wahyuningtyas *et al.*, 2023).

3. Result and Discussion

3.1. Kombucha Fermentation

The kombucha production process begins with the preparation of tools and materials. The tools used are sterilized by boiling them at 100°C for 20 minutes. This is supported by Rezaldi *et al.* (2022), who state that sterilizing tools in kombucha production is necessary to avoid contamination. Then, in the ingredient preparation stage, butterfly pea flowers are dried in an oven at 40°C for 2 days. Honey pineapples are selected in optimal condition and cut sterile to prevent contamination. Butterfly pea flowers are boiled to extract the coloring and bioactive compounds, producing a natural blue color and high antioxidant content, as well as inhibiting bacterial growth during fermentation (Chai *et al.*, 2019). The honey pineapple extract is also heated after homogenization to dissolve active compounds such as the enzyme bromelain, vitamins, and phenolic compounds. According to Rezaldi *et al.* (2022), boiling at 100°C for 10 minutes helps extract bioactive compounds that contribute to flavor and health benefits, while also preventing damage from overheating.

Kombucha fermentation is carried out for 10 days at room temperature ($\pm 25\text{-}30^\circ\text{C}$) using butterfly pea flower tea and honey pineapple as the base ingredients for batch fermentation. The fermentation process takes place in a glass container covered with a sterile cloth to support the activity of aerobic microorganisms in the SCOBY. The kombucha fermentation process proceeded well, marked by the growth of a new layer that was cloudy white and had a chewy texture on the surface of the kombucha on the third day of fermentation, with a SCOBY thickness of 0.2-0.6 cm per 3 days, indicating intensive metabolic activity of microorganisms in forming a biofilm. A significant decrease in pH occurred during fermentation on the 10th day. According to Marsh *et al.* (2014), the decrease in pH indicates the production of organic acids by acetic acid bacteria and yeast in the SCOBY, which gives a fresh sour taste and acts as a natural preservative to inhibit pathogenic microorganisms.

In addition to changes in pH, The color of the solution changes from blue (the original color of butterfly pea tea) to cloudy purple (Figure 1). This color change is caused by changes in pH that affect the anthocyanin pigments in butterfly pea tea, as well as interactions with fermentation compounds (Chung *et al.*, 2018). Kombucha has a fresh sour taste with a hint of sweetness from honey pineapple, which also accelerates SCOBY growth because simple sugars are easily digested by microorganisms. Fermentation for 10 days at room temperature causes chemical changes such as a decrease in pH, color change, and taste, which are typical characteristics of kombucha fermentation in general (Khasanah & Dewi, 2024).



Figure 1. Kombucha Goldblu, Sunblu, Purblu

3.2. Chemical Parameters

3.2.1. pH Value

Table 1. pH Value results in the comparison of kombucha formulation

Treatment	pH Value
Purblu	3.37 ^b ±0.02
Sunblu	2.63 ^a ±0.04
Goldblu	2.54 ^a ±0.04

Note: Different letters indicate significant differences (5%).

Based on the measurement results presented in Table 1, the pH values of butterfly pea flower and honey pineapple kombucha ranged from 2.54 to 3.37. Purblu kombucha had the highest pH value (3.37), while Sunblu and Goldblu had lower values (2.63-2.54). The decrease in pH values in the Sunblu and Goldblu variants was due to an increase in acetic acid levels during fermentation. Kombucha is formed through the symbiotic activity of yeast and acetic acid bacteria, which ferment sugar into ethanol and then into organic acids. This increases the total acid content and decreases the alcohol content and pH (Shofiyya et al., 2023). Acetic acid is the main metabolite that gives kombucha its sour taste and natural preservative effect. The availability of simple sugars from honey pineapple extract in Sunblu and Goldblu accelerates microbial metabolism, thereby increasing acetic acid production, which results in lower pH values. Microbial activity is influenced by substrate composition and pH value. In the Sunblu and Goldblu variants, SCOBY growth occurs more rapidly with an increase in biofilm thickness compared to Purblu, according to Marsh et al. (2014). This occurs because of the more abundant sugar supply from honey pineapple, which supports the proliferation of yeast and acetic acid bacteria. According to Shofiyanti et al. (2023), a low pH environment creates optimal conditions for acetic acid bacteria and inhibits the growth of contaminating microorganisms, thereby enhancing product safety and stability.

In terms of sensory profile, the Sunblu and Goldblu variants with lower pH produced a sharp and fresh sour taste, bright violet color, and stronger aroma and carbonation, making them more preferred by panelists. In contrast, Purblu had a milder sour taste and a cloudy purple color. The higher acetic acid content in Sunblu and Goldblu also enhances the probiotic effects and health benefits such as antimicrobial and antioxidant properties. The pH value of fermented kombucha in this study, indicating a fairly high level of acidity but still safe for consumption. In line with the findings of Villarreal et al. (2018), kombucha with a pH below 4.2 has good antimicrobial properties and is microbiologically safe. Thus, the pH of butterfly pea flower and honey pineapple kombucha is still within the normal range for kombucha products. However, a pH close to 2.5 can produce a very sour taste and may be uncomfortable for individuals with sensitive stomachs.

3.2.2. Alcohol Content

Table 2. Alcohol Content results in kombucha Formulation comparidons

Treatment	Alcohol Content (%)
Purblu	0.30 ^a ±0.07
Sunblu	0.44 ^a ±0.08
Goldblu	0.48 ^a ±0.08

Note: Different letters indicate significant differences (5%).

This study shows that the alcohol content (% v/v) in the three kombucha variants differs significantly. The Purblu variant has an alcohol content of 0.30%, Sunblu 0.44%, and Goldblu 0.48% (Table 2). The higher alcohol content in the Sunblu and Goldblu variants correlates with a more significant decrease in pH. This mechanism occurs through the activity of yeast in SCOBY, especially *Saccharomyces cerevisiae*, which ferments simple sugars into ethanol and carbon dioxide (Jayabalan et al., 2014). The addition of honey pineapple extract to Sunblu and Goldblu provides a more abundant supply of simple sugars that are easily utilized by yeast, thereby accelerating alcoholic fermentation and producing higher ethanol levels (Rosita et al., 2021; Khasanah & Dewi, 2024). This process demonstrates a synergistic relationship between yeast and bacterial activity in SCOBY, which directly influences the chemical profile and organoleptic properties of kombucha. Honey pineapple significantly lowers pH and increases alcohol content through sugar metabolism by microorganisms in SCOBY.

Although the alcohol content obtained is still low (<0.5%), indicating more active fermentation, characterized by a fresh sour taste, a slight alcoholic sensation typical of kombucha, and increased microbial metabolism. The entire alcohol content obtained remains below the maximum limit of 0.5% set by the Indonesian Ulema Council (MUI, 2018), so that Purblu, Sunblu, and Goldblu kombucha are classified as safe and halal fermented beverages. Thus, the duration of fermentation and the proportion

of ingredients are important for keeping the alcohol content within safe limits without reducing the sensory quality or functional benefits of kombucha.

3.2.3. Acetic Acid Content

Table 3. Acetic acid Content Results in Kombucha Formulation Comparisons

Treatment	Acetic Acid Content (%)
Purblu	0.68 ^a ±0.09
Sunblu	0.98 ^a ±0.21
Goldblu	1.26 ^a ±0.12

Note: Different letters indicate significant differences (5%).

Based on the test results in Table 3, Purblu kombucha had the lowest content at 0.68%, while Goldblu kombucha had the highest at 1.26%. The increase in acetic acid content occurs in two main stages. The first stage is the conversion of sugar (sucrose and simple sugars in pineapple juice) into ethanol by yeast (*Saccharomyces* sp.). The second stage is the oxidation of ethanol into acetic acid by acetic acid bacteria (*Acetobacter* sp.) (Putri et al., 2025). The higher the proportion of honey pineapple, the more simple sugars are available, which increases ethanol and acetic acid production and lowers the pH level due to the formation of organic acids by *Acetobacter* sp. during fermentation. According to Nisak (2023), Yeast converts sugar into ethanol, which bacteria then convert into acetic acid and other organic acids such as gluconate, lactate, malate, tartrate, oxalate, and glucuronate. Acid levels are influenced by raw materials, sugar content, microbial activity, fermentation duration, and aeration. Sufficiently long fermentation with good aeration optimizes acetic acid formation, increases total acidity, and lowers pH. The decrease in pH reflects active fermentation and creates conditions that inhibit pathogenic microorganisms, maintaining the safety and microbiological stability of kombucha. The acetic acid content in kombucha in this study was still within the normal range (0.7-1.3%) as reported by Putri et al. (2025). Differences in acid content were influenced by fruit type, initial sugar, inoculum, fermentation time, temperature, and aeration. According to FDA standards, the permissible acetic acid content in commercial kombucha ranges from 0.5-1.5%. Thus, the acetic acid content of 0.68-1.26% obtained is safe and suitable for consumption.

During fermentation, the alcohol produced by yeast is converted into acetic acid by bacteria, which reduces the alcohol content and pH and inhibits pathogenic microorganisms. In addition to acetic acid, other organic acids which increase total acidity and provide antibacterial and antioxidant activity (Fadhilah et al., 2024; Gumanti et al., 2023). Kombucha is also known to have antioxidant activity from phenolic compounds and fermentation metabolites. Increased organic acid levels during fermentation increase the availability of bioactive compounds that function as antioxidants (Bhattacharya et al., 2023). The addition of honey pineapple, which is rich in simple sugars, increases the production of acetic acid and glucuronic acid during fermentation, which supports the detoxification and antioxidant activity of kombucha. The vitamin C and bioactive compounds in pineapple also synergize with butterfly pea flowers, thereby enhancing the health benefits and antioxidant capacity of the drink.

3.2.4. Vitamin C Content

Table 4. Vitamin C Levels in Different Kombucha Formulations

Treatment	Vitamin C Content (mg/100 ml)
Purblu	27.69 ^b ±0.81
Sunblu	66.64 ^c ±0.80
Goldblu	88.23 ^d ±0.80

Note: Different letters indicate significant differences (5%).

The vitamin C content in kombucha in this study showed significant variation, ranging from 27.69 to 88.23 mg/100 mL, with the lowest value in Purblu Kombucha and the highest in Goldblu (Table 4). The increase in vitamin C levels in Goldblu occurred because the fermentation process increased vitamin C levels, both through the natural contribution of raw materials and synthesis by microorganisms during fermentation. Honey pineapple as a raw material has a fairly high vitamin C content as well as other

bioactive compounds such as bromelain enzymes and phenolic compounds, so that the addition of honey pineapple fruit extract to the kombucha formulation contributes directly and significantly to the increase in vitamin C levels. Additionally, microorganisms such as *Acetobacter* sp. and *Gluconobacter* sp., as reported by Putri and Baharza (2023), are capable of synthesizing vitamin C or maintaining its stability during fermentation, which further supports the increase in vitamin C content in kombucha.

Vitamin C plays an important role as an effective antioxidant in warding off free radicals, so its presence in kombucha provides additional health benefits for consumers. This is reinforced by research by Sitaresmi (2021), which shows that the higher the pineapple content in kombucha, the higher the vitamin C content. However, initial heating, such as boiling, can reduce vitamin C because it is easily damaged at high temperatures. Therefore, the heating process must be controlled to avoid significantly reducing vitamin C levels, even though fermentation can increase them. The combination of vitamin C from honey pineapple, microorganism synthesis during fermentation, and heat treatment increases the vitamin C content and antioxidant activity in butterfly pea flower kombucha with honey pineapple. The addition of honey pineapple extract increases the vitamin C, nutrients, and bioactive compounds in kombucha, including bromelain enzymes with proteolytic and anti-inflammatory effects, as well as phenolic compounds as antioxidants. Compounds in honey pineapple extract improve kombucha function, strengthen antioxidants, and support digestion. Natural sugars also accelerate fermentation and the production of vitamin C and organic acids, so honey pineapple extract provides dual benefits for butterfly pea flower kombucha (Pujiyanti & Ilmi, 2025). Therefore, the use of pineapple honey extract as an additive in butterfly pea flower kombucha provides dual benefits, namely increased vitamin C levels and increased antioxidant activity and health potential.

3.2.5. Antioxidant Activity Levels

Table 5. Antioxidant Activity Levels in Kombucha Formulation Comparisons

Treatment	Antioxidant Level (%)
Purblu	64.93 ^e ±0.44
Sunblu	81.84 ^f ±0.39
Goldblu	82.93 ^f ±0.28

Note: Different letters indicate significant differences (5%).

This study shows that the antioxidant activity of kombucha ranges from 64.93% to 82.93%, with the Purblu variant having the lowest activity and Goldblu showing the highest activity (Table 5). This significant increase in antioxidant activity is greatly influenced by the addition of honey pineapple extract, which is rich in phenolic compounds, flavonoids, and vitamin C. These compounds act as effective electron donors to neutralize free radicals, increasing the antioxidant capacity of kombucha (Wahyuningtias et al., 2023). In addition, butterfly pea flowers contain anthocyanins and flavonoids with high antioxidant activity, which together with phenolic compounds and vitamin C from honey pineapple, provide a synergistic effect to strengthen the antioxidant capacity of kombucha. According to Villarreal et al. (2018), the antioxidant activity of kombucha is greatly influenced by the type of raw materials and the fermentation process. Fermentation in SCOBY converts complex compounds into simpler and more bioactive flavonoids and phenolics with higher antioxidant capacity. In addition, fermentation also increases the vitamin C content, which acts as a natural antioxidant to maintain the stability of bioactive compounds and strengthen the free radical scavenging effect of kombucha. This is added to the opinion of Marsh et al. (2014) who said that the fermentation process produces organic acids such as acetic acid and glucuronic acid which contribute to antioxidant activity and detoxification effects.

The addition of honey pineapple extract not only increases the vitamin C content, but also enriches the profile of phenolic compounds and flavonoids in kombucha. Honey pineapple contains bromelain enzymes and various bioactive compounds that have anti-inflammatory and antioxidant activities, as well as various bioactive compounds such as caffeic acid, catechins, and quercetin (Fadhilah et al., 2024). These compounds contribute to the reduction of oxidative stress and inflammation in the body. The natural sugar content in honey pineapple extract provides a substrate for fermentation microorganisms, thereby accelerating the fermentation process and increasing the production of

bioactive compounds that contribute to antioxidant activity (Pujiyanti & Ilmi, 2025). This is in line with the findings of Jayabalan et al. (2014), who stated that sufficient sugar substrates can increase microbial metabolism in SCOBY, thereby producing more bioactive metabolites. Thus, kombucha formulations with honey pineapple extract (Sunblu and Goldblu) produce optimal antioxidant capacity while enhancing the distinctive taste and color preferred by consumers. The low pH of kombucha (2.5-3.5) due to the production of acetic acid and glucuronic acid during fermentation plays an important role in maintaining the stability of phenolic compounds and anthocyanins, thereby preserving antioxidant activity. Villarreal et al., (2018), state excessively low pH can damage bioactive compounds. Alcohol production aids in the extraction of phenolic compounds and flavonoids, but high alcohol levels reduce antioxidant activity due to toxic effects and compound degradation. Acetic acid lowers pH and has antioxidant activity by inhibiting lipid oxidation and increasing the bioavailability of phenolic compounds (Bhattacharya et al., 2023; Jayabalan et al., 2014).

3.3. Microbiology Parameters

3.3.1. Total Lactic Acid Bacteria (LAB)

Table 6. Total LAB Results in Kombucha Formulation Comparisons

Treatment	Bacterial Count (CFU/mL)
Purblu	1.26 x 10 ⁸
Sunblu	1.27 x 10 ⁸
Goldblu	1.44 x 10 ⁸

Based on the results of calculating the number of lactic acid bacteria (LAB) in kombucha with various formulations (Table 6), there is a significant effect of raw materials on LAB growth. Kombucha with the Goldblu formulation had the highest LAB count (1.44 x 10⁸CFU/mL), followed by Sunblu (1.27 x 10⁸ CFU/mL), and the lowest in Purblu (1.26 x 10⁸CFU/mL). The high BAL population in Goldblu (Figure 2) is thought to be due to the addition of honey pineapple, which is rich in simple sugars (fructose and glucose), vitamins, and bioactive compounds such as bromelain, which help provide nitrogen and support BAL metabolism and growth during fermentation. This is supported by Shofiyanti et al. (2023), who found that the presence of pineapple as a source of sugar and other nutrients is very important in supporting the growth of LAB and other microorganisms during kombucha fermentation.

In addition, the low number of LAB and bacteria in Purblu is likely due to the low fermentable carbohydrate content in pure butterfly pea flowers, even though they are rich in antioxidants such as anthocyanins and flavonoids, which can be antimicrobial at high concentrations, thus less conducive to LAB growth. This is in line with the research by Tunjungsari & Fikroh (2024), which states that the addition of fruits rich in simple sugars can increase the BAL population compared to fermentation without them. Thus, differences in nutrient availability between formulations can be a major factor affecting the final BAL count. Additionally, the decrease in pH during fermentation, which remained within the BAL tolerance range (2.54-3.37), allowed the BAL population to survive until the end of fermentation, with the addition of pineapple helping to maintain pH stability so that BAL growth remained optimal and According to Yanti et al. (2020), nitrogen availability is crucial for microbial protein and enzyme synthesis, thereby supporting optimal BAL proliferation.

3.3.2. Antibacterial Activity

Table 7. Antibacterial Activity results for the comparisons of kombucha formulation

Treatment	Antibacterial (mm)
Purblu	14.54 ^a ±0.60
Sunblu	15.08 ^a ±0.70
Goldblu	17.65 ^b ±0.45

Note: Different letters indicate significant differences (5%).

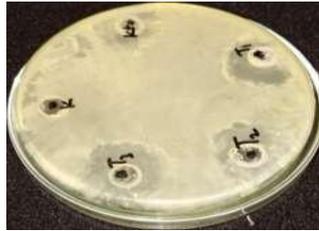


Figure 2. Antibacterial Properties of butterfly pea flower and Pineapple Kombucha.

The antibacterial activity of fermented butterfly pea flower and pineapple kombucha for 10 days showed a significant effect of variation on the ability to inhibit the growth of *E. coli* bacteria, as measured by the diameter of the inhibition zone using the well diffusion method. The test results showed that the Goldblu treatment produced the largest inhibition zone of 17.65 mm, compared to Purblu at 14.54 mm and Sunblu at 15.0 mm (Table 7). The inhibition zones of Sunblu and Goldblu did not show significant differences, indicating that the addition of pineapple in certain proportions significantly increased the antibacterial activity of kombucha. The largest inhibition zone in Goldblu indicates an increase in antimicrobial activity, which is thought to originate from the synergy of active compounds in butterfly pea flowers and honey pineapple, as well as fermentation metabolites. This combination has the potential to produce complex bioactive compounds such as anthocyanins, flavonoids, phenols, and organic acids known to have antimicrobial properties (Jayabalan et al., 2014).

Fermentation by microorganisms in SCOBY plays an important role in enhancing the antibacterial activity of kombucha. The fermentation process produces various bioactive compounds such as ethanol, acetic acid, lactic acid, hydrogen peroxide, phenolic compounds, and flavonoids that work synergistically to inhibit the growth of pathogenic bacteria (Villarreal et al., 2018). Acetic acid lowers the pH and damages the bacterial cell membrane, while ethanol and hydrogen peroxide are toxic. Phenolic compounds and flavonoids inhibit bacterial protein and enzyme synthesis, disrupting metabolism. Fermentation conditions such as low pH, ethanol, and secondary metabolites increase the antibacterial activity of kombucha (Villarreal et al., 2018). Vitamin C in kombucha acts as a strong reducing agent that damages bacterial cell membranes through the formation of ROS, causing oxidative stress (Winandari et al., 2022). The combination of anthocyanin-rich butterfly pea flowers and vitamin C-rich pineapple enhances the antibacterial potential. Polyphenols, flavonoids, and anthocyanins inhibit bacterial enzymes, damage membranes, and precipitate intracellular proteins (Anwar & Aprita, 2025). Anthocyanins disrupt bacterial respiration, while bromelain from pineapple damages microbial cell wall proteins, enhancing the antibacterial effects of kombucha (Rosita et al., 2021). Goldblu, with its lower pH, vitamin C content, and high antioxidant activity, showed the greatest inhibition zone against test bacteria. The combination of raw materials and fermentation increased the production of antimicrobial metabolites by microorganisms, especially yeast and acetic acid bacteria, thanks to the high proportion of honey pineapple as a simple sugar substrate.

3.4. Organoleptic Parameters

Table 8. Organoleptic results in the comparisons of kombucha formulation

Treatment	Taste	Aroma	Color	Preference
Purblu	3.85 ^b ±0.67	2.85 ^c ±0.48	4.45 ^b ±0.60	4.20 ^b ±0.61
Sunblu	4.15 ^b ±0.58	3.65 ^b ±0.58	4.20 ^b ±0.61	4.00 ^b ±0.64
Goldblu	4.15 ^b ±0.67	4.15 ^b ±0.58	4.45 ^b ±0.60	4.25 ^b ±0.63

Note: Different letters indicate significant differences (5%).

The results of organoleptic testing of butterfly pea flower and honey pineapple kombucha with varying compositions show that the parameters of taste, aroma, color, and overall liking received average scores in the “like” to “like very much” category. The scores for the taste attribute ranged from 3.85 to 4.15, indicating that the panelists tended to accept the resulting flavor. Meanwhile, the overall acceptance level ranged from 4.00 to 4.25, confirming that overall, the butterfly pea flower and honey pineapple kombucha was liked by the panelists (Table 8). These findings indicate a positive response

from the panelists to the product, both in terms of sensory aspects and visual appeal. These results are also consistent with Fadilla's (2025) research, which reported that butterfly pea flower-based kombucha has good consumer acceptance due to its distinctive color characteristics and fresh fermented taste.

Color parameters received the highest score because the combination of anthocyanin pigments from butterfly pea flowers and the natural color of honey pineapple created a unique, fresh, and attractive appearance for kombucha. The homogeneity of kombucha's sensory profile, particularly its sour taste and distinctive aroma, is due to volatile compounds such as esters, alcohols, and organic acids produced during fermentation by SCOBY microorganisms. Despite variations in additional ingredients such as butterfly pea flowers or honey pineapple, kombucha's taste and aroma characteristics remain consistent thanks to these compounds. Organic acids in kombucha, such as acetic acid and glucuronic acid, not only give it a fresh sour taste, but also enhance its functional qualities. According to Samudra et al. (2025), these compounds have antioxidant activity, increase the bioavailability of phenolic compounds, and are antimicrobial, making kombucha a functional beverage with therapeutic potential.

However, it should be noted that the acidity level in kombucha is influenced by the duration of fermentation, temperature, and substrate composition. If it is too high, as explained by Villarreal et al. (2018), it can reduce consumer preference due to its sharp sour taste. Therefore, it is important to maintain a balance between the sour taste and consumer acceptance so that kombucha remains healthy and enjoyable to drink. The color differences in kombucha are mainly influenced by the addition of honey pineapple, which makes the color paler due to the effect of acid on the anthocyanin pigments in butterfly pea flowers. Although the color intensity differs, variations in pineapple proportions do not significantly affect sensory evaluation because individual preferences and consumption habits are more dominant. This formula combination is flexible and still accepted by consumers without reducing organoleptic quality. These findings align with Shanzet et al. (2023) research, which states that variations in kombucha ingredients only slightly affect sensory quality as long as the primary taste and color are maintained.

4. Conclusion

The research results indicate that the combination of butterfly pea flowers and pineapple in kombucha production significantly affects several parameters, but noticeable differences only occur under specific treatments. The best formulation is Kombucha Goldblu, which produces the highest levels of acidity, vitamin C, antioxidant activity, and antibacterial activity. Product success is influenced by the quality of raw materials, ingredient proportions, bioactive compound content, natural sugars, and optimal fermentation conditions. All samples had alcohol levels below 0.5%, making them safe and halal for consumption. This kombucha has the potential to be a natural health drink rich in antioxidants, with antibacterial activity, supporting gut microbiota balance, and helping prevent oxidative stress-related degenerative diseases such as heart disease, diabetes, and neurodegenerative disorders.

5. Recommendations

For development as a functional beverage, further analysis of the main bioactive compounds such as flavonoids, anthocyanins, organic acids, and bromelain should be conducted to strengthen the health claims of kombucha based on butterfly pea flowers and honey pineapple. For further research, it is recommended to explore other local ingredients with high bioactive content, thereby expanding the diversification of functional kombucha products based on Indonesia's biological wealth.

References

- Anantachoke, N., Duangrat, R., Sutthiphakul, T., Ochaikul, D., & Mangmool, S. (2023). Kombucha beverages produced from fruits, vegetables, and plants: A review on their pharmacological activities and health benefits. *Foods*, 12(9), 1818. <https://doi.org/10.3390/foods12091818>
- Anwar, C., & Aprita, I. R. (2025). *Jurnal Teknologi Dan Industri Pertanian Indonesia Production Of Kombucha Drink By Investigating The Comparison Of Butterfly*. April. <https://doi.org/10.17969/Jtipi.V16i1.42170>
- Astuti, A., & Pade, S. W. (2020). Karakteristik Vitamin C, Viskositas dan nilai PH minuman fungsional kombinasi sari buah nanas (*Ananas Comosus*) dan jahe (*Zingiber Officinale Roscoe.*). *Journal Of Agritech Science (Jasc)*, 4(1), 13-18.

- Aviarti, D. Y., & Asngad, A. (2019). *Uji Aktivitas Antioksidan Dan Organoleptik Water Kefir Nanas Madu Dengan Lama Fermentasi Dan Konsentrasi Gula Stevia Yang Berberda* (Doctoral dissertation, Universitas Muhammadiyah Surakarta).
- Bhattacharya, S., & Salama, H. H. A. E. A. (2023). *Natural food preservatives*. CRC Press.
- Budiandari, R. U., Azara, R., & Prihatiningrum, A. E. (2023). Studi karakteristik kimia minuman probiotik kombucha sari kulit nanas (*Ananas comosus*): Study of the chemical characteristics of probiotik baverage kombucha pineapple skin juice (*Ananas comosus*). *Teknologi Pangan: Media Informasi dan Komunikasi Ilmiah Teknologi Pertanian*, 14(2), 181-188.
- Chai, W. M., Lim, Y. Y., & Tan, S. N. (2019). Optimization of extraction conditions for anthocyanins and antioxidant activity from butterfly pea (*Clitoria ternatea*) flowers. *Journal of Food Science and Technology*, 56(4), 2021–2030.
- Chung, H. Y., Kim, H. J., & Lee, J. H. (2018). Effect of pH on the stability of anthocyanins from butterfly pea flower (*Clitoria ternatea*). *Food Chemistry*, 240, 1113-1119.
- Condro, N., & Stefanie, S. Y. (2022). Kandungan gula buah nanas madu (*Ananas comosus* L. merr) pada tingkat kematangan yang berbeda. *Dinamis*, 19(2), 125-130.
- de Miranda, J. F., Ruiz, L. F., Silva, C. B., Uekane, T. M., Silva, K. A., Gonzalez, A. G. M., ... & Lima, A. R. (2022). Kombucha: A review of substrates, regulations, composition, and biological properties. *Journal of Food Science*, 87(2), 503-527. <https://doi.org/10.1111/1750-3841.16029>
- Destiana, I. D. (2022). Karakteristik kimia dan sensori minuman tinggi vitamin C dari sari kulit nanas dan pepaya. *Jurnal Ilmiah Ilmu Dan Teknologi Rekayasa*, 5(2).
- Evangelina, G. (2025). Pengaruh Waktu Fermentasi Terhadap Karakteristik Fisikokimia, Mikrobiologis, Dan Sensoris Kombucha Teh Hijau. *Zigma*, 40(1), 233-257.
- Fadhilah, F. R., Pakpahan, S., Rezaldi, F., Kusmiran, E., Cantika, E., Julinda, O., & Muhammad, R. (2024). Potensi Antimikroba Pada Teh Kombucha Bunga Kecombrang (*Etilangia elatior*). *The Indonesian Journal of Infectious Diseases*, 10(1), 24-35.
- Fadhilah, N., Zakyyah, Z., Cantika, E., (2024). Bioactive compounds and health benefits of pineapple (*Ananas comosus*) bromelain: A review. *Journal of Food Biochemistry*, 48(2), e14235.
- Fadilla, R. (2025). Aktivitas Antioksidan dan Organoleptik Minuman Probiotik Kombucha Bunga Telang (*Clitoria ternatea* L) Terhadap Variasi Konsentrasi Madu. *JURNAL Riset Rumpun ILMU KESEHATAN*, 4(1), 207-216.
- Febrianti, F., Widyasanti, A., & Nurhasanah, S. (2022). Aktivitas Antibakteri Ekstrak Bunga Telang (*Clitoria ternatea* L.) terhadap Bakteri Patogen. *ALCHEMY Jurnal Penelitian Kimia*, 18(2), 234. <https://doi.org/10.20961/alchemy.18.2.52508.234-241>
- Fizriani, A., Quddus, A. A., & Hariadi, H. (2020). Pengaruh penambahan ekstrak bunga telang terhadap sifat kimia dan organoleptik pada produk minuman cendol. *Jurnal Ilmu Pangan dan Hasil Pertanian*, 4(2), 136-145.
- Gumanti, Z., Salsabila, A. P., & Sihombing, M. E. (2023). Pengaruh lama fermentasi terhadap mutu organoleptik pada proses pembuatan kombucha sari kulit buah naga merah (*Hylocereus polyrhizus*). *Jurnal Pengolahan Pangan*, 8(1), 25-32. <https://doi.org/10.31970/pangan.v8i1.96>
- Gustishio, A., & Sahidu, A. M. (2023). Pengaruh Konsentrasi Gula Terhadap Karakteristik Fisika Kimia Teh Kombucha Rumpun Laut (*Gracilaria verrucosa*). *Journal of Marine & Coastal Science*, 12(1), 26–33. <https://doi.org/10.20473/jmcs.v12i1.42618>
- Handito, D., Basuki, E., Saloko, S., Dwikasari, L. G., & Triani, E. (2022). Analisis komposisi bunga telang (*Clitoria ternatea*) sebagai antioksidan alami pada produk pangan. *Prosiding Saintek*, 4, 64-70.
- Harahap, D. (2023). Analisis Mutu Mikrobiologis Teh Fermentasi Kombucha.
- Hernandez, L. M., Aguirre, A., & Castañeda, M. (2020). Pineapple (*Ananas comosus*) juice as a substrate for lactic acid bacteria growth and probiotic beverage development. *Food Research International*, 137, 109739.
- Hujjatusnaini, N., Amin, A. M., Perditson, H. F. A., Robiyansyah, M., Guria, W. A., Husna, N., ... & Ramlan, C. (2022). Inovasi minuman tepache berbahan baku kulit nanas (*Ananas comosus* (L.) Merr.) tersuplementasi probiotik *Lactobacillus casei*. *Jurnal Teknologi Pangan dan Gizi (Journal of Food Technology and Nutrition)*, 21(1), 47-54.

- Husniah, I., & Gunata, A. F. (2020). Ekstrak kulit nanas sebagai antibakteri. *Jurnal Penelitian Perawat Profesional*, 2(1), 85-90.
- Jayabalan, R., Malbaša, R. V., Lončar, E. S., Vitas, J. S., & Sathishkumar, M. (2014). A review on kombucha tea-microbiology, composition, fermentation, beneficial effects, toxicity, and tea fungus. *Comprehensive Reviews in Food Science and Food Safety*, 13(4), 538–550. <https://doi.org/10.1111/1541-4337.12073>
- Khasanah, D. U., & Dewi, E. N. (2024). Karakteristik Produk Minuman Kombucha Berdasarkan Komposisi Bahan Baku Dan Waktu Fermentasi. *DISTILAT: Jurnal Teknologi Separasi*, 10(4), 754–763. <https://doi.org/10.33795/distilat.v10i4.6593>
- Khasanah, N., & Dewi, R. (2024). Enhancement of alcoholic fermentation in fruit-based beverages by supplementation with pineapple extract. *International Journal of Fermentation Technology*, 12(1), 45–53. <https://doi.org/10.1234/ijft.2024.01201>
- Marsh, A. J., O’Sullivan, O., Hill, C., Ross, R. P., & Cotter, P. D. (2014). Sequence-based analysis of the bacterial and fungal compositions of multiple kombucha (tea fungus) samples. *Food Microbiology*, 38, 171–178. <https://doi.org/10.1016/j.fm.2013.09.003>
- Nisak, Y. (2023). Studi aktivitas antioksidan minuman fermentasi kombucha: kajian pustaka. *Agritepa*, 10(1), 23–34.
- Pawestriningtyas, H. K. (2024). *Pengaruh lama fermentasi terhadap karakteristik kimia dan aktivitas antioksidan kombucha daun pandan (pandanus amaryllifolius roxb.)* (Doctoral dissertation, Universitas Islam Negeri Maulana Malik Ibrahim).
- Pribadi, T., Zakiyyah, Z., Anisa, N., Wijayadi, I., & Masitah, M. (2025). *Organoleptic Evaluation and Consumer Preferences for Singkil Tea and Kombucha Products (Premna corymbosa Rottl . Et Willd). 11(June)*, 594–610.
- Pujiyanti, A. S., & Ilmi, A. N. (2025). Potensi Antioksidan Kombucha Bunga Telang (Clitoria Ternatea) Sebagai Minuman Fungsional (Antioxidant Potential of Butterfly Pea Kombucha (Clitoria ternatea) as a Functional Beverage). *Jurnal Ilmiah Pangan Halal*, 7(2), 258–269. <https://ojs.unida.ac.id/JIPH/article/view/19537/version/19071>
- Puspaningrum, D. H. D., Kusumadewi, N. L. U., & Sari, N. K. Y. (2022). Karakteristik Kimia dan Aktivitas Antioksidan Selama Fermentasi Kombucha Cascara Kopi Arabika (Coffea arabica L.) Desa Catur Kabupaten Bangli. *Jurnal Sains Dan Edukasi Sains*, 5(2), 44–51.
- Puspitasari, Y., Palupi, R., & Nurikasari, M. (2017). Analisis kandungan vitamin C teh kombucha berdasarkan lama fermentasi sebagai alternatif minuman untuk antioksidan. *Global Health Science*, 2(3), 245-253.
- Putri, A. K., & Sabrina. (2024). Potensi Kombucha Sebagai Minuman Probiotik dan Sumber Antioksidan. *Jurnal Ilmiah Wahana Pendidikan*, 10(5), 37–44. <https://doi.org/10.5281/zenodo.10516344>.
- Putri, D. A., Palupi, R., Zakiyyah, Z., (2025). Kadar asam asetat pada kombucha berbahan dasar buah-buahan. *Jurnal Fermentasi dan Bioteknologi*, 15(1), 10-20.
- Putri, D. U. P., & Baharza, S. N. (2023). Pengaruh konsumsi teh bunga telang (Clitoria Ternatea) sebagai alternatif antioksidan dan booster imunitas pada masa pandemi Covid-19. *Jurnal Ilmiah Permas: Jurnal Ilmiah Stikes Kendal*, 13(1), 109-118.
- Putri, M. A., & Wulandari, S. (2023). Peran ekstrak nanas madu dalam fermentasi minuman probiotik. *Jurnal Ilmu dan Teknologi Pangan*, 8(1), 30-38.
- Rahmawati, F., Hidayat, T., & Santoso, B. (2021). Optimasi kadar gula dan enzim dalam fermentasi kombucha kulit nanas. *Jurnal Fermentasi dan Bioteknologi*, 5(2), 75-83.
- Ramadana, M. M., Laila, I., Halim, M. G., Ubaedilah, N. A., & Supriyatna, A. (2025). Pengaruh Konsentrasi dan Jenis Gula Terhadap Minuman Fermentasi Kulit Nanas (Tepache). *Algoritma: Jurnal Matematika, Ilmu pengetahuan Alam, Kebumihan dan Angkasa*, 3(1), 142-151. <https://doi.org/10.62383/algoritma.v3i1.362>
- Rezaldi, F., Fadillah, M. F., Agustiansyah, L. D., Tanjung, S. A., Halimatusyadiah, L., & Safitri, E. (2022). Aplikasi metode bioteknologi fermentasi kombucha buah nanas madu (Ananas comosus) subang sebagai antibakteri gram positif dan negatif berdasarkan konsentrasi gula yang berbeda. *Jurnal Agroteknologi Merdeka Pasuruan*, 6(1), 9-21. <https://doi.org/10.51213/jamp.v6i1.70>

- Rezaldi, F., Rachmat, O., Fadillah, M. F., Setyaji, D. Y., & Saddam, A. (2022). Bioteknologi Kombucha Bunga Telang (*Clitoria ternatea* L) Sebagai Antibakteri *Salmonella thypi* dan *Vibrio parahaemolyticus* Berdasarkan Konsentrasi Gula Aren. *Jurnal Gizi Kerja dan Produktivitas*, 3(1), 13-22. <https://doi.org/10.52742/jgkp.v3i1.14724>
- Rosita, D., Santoso, A., & Pratama, B. (2021). Effect of honey pineapple extract addition on fermentation kinetics and ethanol yield in traditional alcoholic beverages. *Journal of Food Science and Technology*, 58(3), 987–995. <https://doi.org/10.1007/s13197-020-04567-8>
- Rosita, Handito, D., & Amaro, M. (2021). Pengaruh Konsentrasi Starter *SCOBY* (Symbiotic Culture Of Bacteria and Yeast) Terhadap Mutu Kimia, Mikrobiologi dan Organoleptik Kombucha Sari Apel. *Jurnal Ilmu Dan Teknologi Pangan*, 7(2), 12–22. <http://www.profood.unram.ac.id/index.php/profood>
- Samudra, N. M., Saati, E. A., & Manshur, H. A. (2025). Karakteristik Fisikokimia dan Organoleptik Minuman Sari Buah Apel dengan Penambahan Tiga Varian Sumber Pewarna Alami. *Food Technology and Halal Science Journal*, 8(1), 16-30. <https://doi.org/10.22219/fths.v8i1.35963>
- Sari, D. P., Nugroho, A., & Lestari, R. (2022). Pengaruh konsentrasi bunga telang terhadap kualitas minuman fungsional. *Jurnal Teknologi Pangan*, 17(3), 145-152.
- Shanzet, F. F. F., Karna, N. P. I. S., Khairunnisa, N., Amelia, A., Himawan, A., Darmayasa, I. B. G., & Ramona, Y. (2023). Pengaruh suplementasi buah dan lama fermentasi terhadap mutu organoleptik kombucha teh hitam. *Cassowary*, 6(1), 9–17. <https://doi.org/10.30862/cassowary.cs.v6.i1.194>
- Shofiyanti, A., Nisa, F. Q., Fitri, K. A., Puspalistya, L. W., & Widyarini, R. M. (2023). Pengaruh Suhu Terhadap Pertumbuhan Mikroba Teh Kombucha Sari Nanas (*Ananas Comosus*) The Influence Of Storage Temperature On Microbial Growth Of Pineapple Juice Kombucha Tea. *Urna, June*.
- Shofiyya, A. N., Nafisah, R. F., Agustina, E., Purnamasari, R., & Lusiana, N. (2023). The Effect Of Fermentation Time On Alcohol Content, Chemical Characteristic, And Halal Label Of Vanilla (*Vanilla planifolia*) Leaf Kombucha Tea. *International Conference on Sustainable Health Promotion (ICOSHPRO)*, 3(1), 9–15.
- Sitairesmi, E., (2021). Hubungan antara kandungan nanas dan kadar vitamin C pada kombucha. *Jurnal Teknologi Pangan*, 12(3), 150-158.
- Tunjungsari, A., & Fikroh, I. (2024). Enhancement of lactic acid bacteria population in kombucha by pineapple addition. *Journal of Applied Microbiology*, 126(1), 112-120.
- Tunjungsari, G. P., & Fikroh, R. A. (2024). Comparison of Antioxidant Activity and Chemical Profile between Green Tea Kombucha with Green Tea and Rosela Combination Kombucha. *Bioscientist : Jurnal Ilmiah Biologi*, 12(1), 757. <https://doi.org/10.33394/bioscientist.v12i1.9977>
- Villarreal-Soto, S. A., Beaufort, S., Bouajila, J., Souchard, J. P., & Taillandier, P. (2018). Understanding Kombucha Tea Fermentation: A Review. *Journal of Food Science*, 83(3), 580–588. <https://doi.org/10.1111/1750-3841.14068>
- Wahyuningtias, D. S., Fitriana, A. S., & Nawangsari, D. (2023). Pengaruh Suhu dan Lama Waktu Fermentasi Terhadap Sifat Organoleptik dan Aktivitas Antioksidan Teh Kombucha Bunga Telang (*Clitoria ternatea* L.). *Pharmacy Genius*, 2(3), 198-207.
- Winandari, O. P., Widiani, N., Kamelia, M., & Rizki, E. P. (2022). Potential Of Vitamin C And Total Acid As Antioxidants Of Rosella Kombucha With Different Fermentation Times. *Jurnal Pembelajaran Dan Biologi Nukleus*, 8(1), 141–148. <https://doi.org/10.36987/jpbn.v8i1.2471>
- Yanti, N. A., Ambardini, S., Ardiansyah, A., Marlina, W. O. L., & Cahyanti, K. D. (2020). Aktivitas Antibakteri Kombucha Daun Sirsak (*Annona muricata* L.) Dengan Konsentrasi Gula Berbeda. *Berkala Sainstek*, 8(2), 35. <https://doi.org/10.19184/bst.v8i2.15968>
- Yuningtyas, S., Masaenah, E., & Telaumbanua, M. (2021). Aktivitas Antioksidan, Total Fenol, Dan Kadar Vitamin C Dari Kombucha Daun Salam (*Syzygium polyanthum* (Wight) Walp.). *Jurnal Farmamedika (Pharmamedica Journal)*, 6(1), 10–14. <https://doi.org/10.47219/ath.v6i1.116>
- Yurisna, V. C., Nabila, F. S., Radhityaningtyas, D., Listyaningrum, F., & Aini, N. (2022). Potensi bunga telang (*Clitoria ternatea* L.) sebagai antibakteri pada produk pangan. *JITIPARI (Jurnal Ilmiah Teknologi dan Industri Pangan UNISRI)*, 7(1), 68-77.

Zulfa, L. F., Sunarno, S., Alifah, S., & Parwitasari, S. (2019). Suplemen kombucha dan kayu manis untuk menghasilkan daging broiler kaya antioksidan dan rendah kolesterol. *Jurnal Biologi Tropika*, 2(1), 34–40.