

Phenolic Content and Functional Groups of Green Tea Kombucha, Telang Flower Kombucha, Rosella Flower Kombucha, Chamomile Flower Kombucha and Lavender Flower Kombucha

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Abstract: Kombucha is a fermentation product between green tea and microorganisms. The basic ingredients for kombucha can be obtained from plants that contain high antioxidants, such as green tea, butterfly pea flowers, rosella flowers, chamomile flowers and lavender flowers. The aim of this research was to determine the phenolic content and functional groups in green tea kombucha, telang flower kombucha, rosella flower kombucha, chamomile flower kombucha and lavender flower kombucha. This research uses experimental research by testing phenolic content using a UV-Vis Spectrophotometer instrument and functional group analysis using Fourier Transform Infrared (FTIR). The results showed that the phenolic content of green tea kombucha was 162.35 mg/L GAE, butterfly pea flower kombucha was 124.46 mg/L GAE, rosella flower kombucha was 101.30 mg/L GAE, chamomile flower kombucha was 35.41 mg/L GAE and lavender flower kombucha was 136.43 mg/L GAE. The highest phenolic content is found in green tea kombucha. The spectra resulting from the identification of telang flower kombucha tea samples contain alcohol functional groups, amines, nitro compounds, and the broad peaks indicate the stretching vibration of OH monometric alcohol. In green tea kombucha, alkenes, alkynes and monometric alcohol groups are found. In rosella flower kombucha, the functional groups alcohol, alkene, alkyne, nitrile and phenol are found. In chamomile flower kombucha, the functional groups ether, amine, alkene, alkyne, ester and alcohol are found. In lavender flower kombucha, the functional groups alcohol, alkene, alkyne and alkane are found. It can be concluded that kombucha contains secondary metabolite compounds including flavonoids, phenolics, saponins, tannins, steroids and triterpenoids.

1 INTRODUCTION

Green tea (*Camellia sinensis*) is a drink that is often consumed by the wider community. Green tea has many beneficial ingredients such as water, minerals, vitamins, polyphenols and antioxidants (Hassmy, 2017). Green tea has a high polyphenol content with the main compound being catechin which really supports its antioxidant activity to capture free radicals so that it can reduce cell damage (Evasari and Susanti, 2021). Based on research by Nugraheni et al., (2022), green tea has a total content of phenolic compounds in both sample sizes (fine and coarse) showing optimum results at a temperature variation of 80 °C and a stirring time of 10 minutes

respectively, namely 44.487 ± 0.483 µg. AGE/g dry green tea leaves (fine samples) and 22.676 ± 0.483 µg AGE/g dry green tea leaves (coarse samples). One form of innovative green tea drink is kombucha.

Kombucha is a refreshing and beneficial drink for health, with a slightly sweet and sour taste produced through the fermentation process. The fermentation process for kombucha tea lasts 4-12 days (Falahuddin et al., 2017). Fermentation occurs in a solution of tea and sugar using various types of bacterial cultures (such as *Acetobacter xylinum*, *A. xylinoides*, *Bacterium gluconicum*) and fungi (such as *Saccharomyces cerevisiae*, *S. ludwigii*,

Zygosaccharomyces bailii, *Z. rouxii*, *Schizosaccharomyces pombe*, *Torulopsis delbrueckii*, *Brettanomyces bruxellensis*, *B. lambicus*, *B. custersii*, *Candida* sp., or *Pichia membranaefaciens*) which is known as SCOBY (Symbiotic Culture of Bacteria and Yeast) (Kaewkod *et al.*, 2019; Priyono and Riswanto, 2021). Kombucha is made through a fermentation process involving a symbiosis of microorganisms from a group of acetic acid bacteria and yeast (Majidah *et al.*, 2022).

The acetic acid bacteria that is generally used is *Acetobacter xylinum*, while the yeast used is *Saccharomyces cerevisiae* (Majidah *et al.*, 2022). *Acetobacter xylinum* bacteria are known to have a liquid surface that can produce a cellulose layer. This layer is on the surface of the tea like a thin sheet which can form a mass of bacterial and yeast cells. This layer can be called "kombu mushroom" or SCOBY (Symbiotic Culture of Bacteria Yeast). SCOBYs will be arranged in layers following the breeding site and can grow successively (Ardheniati *et al.*, 2009). The metabolic activities of yeast and bacteria influence differences in substrate use. The invertase enzyme content in yeast can hydrolyze sucrose into glucose and fructose. The fructose substrate in the yeast glycolysis pathway can produce ethanol. Acetic acid bacteria such as *Acetobacter xylinum* can produce gluconic acid from glucose and acetic acid from ethanol (Karyantina dan Sumarmi, 2019).

Apart from green tea, the basic ingredients for making kombucha can also come from plants that are rich in antioxidants, such as rosella flowers, telang flowers, lavender flowers and chamomile. Rosella contains flavonoid anthocyanins as antioxidants, vitamin C, vitamin D and vitamin A which can help restore damaged or dead skin cells, as well as vitamins B1 and B2 to prevent dry skin, resulting in beautiful and healthy skin (Tungadi *et al.*, 2022). Based on research conducted by Formagio *et al.*, (2015), it shows that rosella has a phenolic content in its petals of 382.04 ± 4.22 . Butterfly pea flowers (*Clitoria ternatea* L.) are known to contain anthocyanins, flavonoids, flavonol glycosides such as routine, delphinidin, kaempferol, quercetin, malvidin, polyphenols contributing to antidiabetic qualities (Andriani dan Murtisiwi, 2020). Based on research conducted by Siregar *et al.*, (2023), telang flowers have a phenol content of 515.48 mg/100g, this value is in the high category.

Lavender contains the main ingredients linalyl-acetate and linalool which can have a relaxing effect so that currently in Indonesia, lavender aroma is widely used as a mixture of herbal tea, kombucha tea, bath soap, beauty products and even

aromatherapy oil. Lavender also has anti-inflammatory properties to reduce inflammation (Salsabila *et al.*, 2022). Based on research conducted by Dobros *et al.*, (2022), it shows that lavender flowers have phenolic compound levels varying from 14.88 to 32.82 mg/L GAE. Chamomile contains a flavonoid compound, namely apigenin, which binds to benzodiazepine receptors in the brain so that it can treat anxiety disorders, depression and sleep quality disorders (Suciwati *et al.*, 2023). Based on research conducted by Putrid and Astuti, (2023), it shows that chamomile has a phenolic content of 67.4 mg/GAE dry extract.

Phenolic compounds are secondary metabolite compounds originating from plants. Phenolic compounds are aromatic compounds with a structure derived from benzene so they have an aromatic ring and the presence of one or more hydroxyl (OH) groups (Mahardani dan Yuanita, 2021). Phenolic compounds have many benefits for human health, such as antioxidants, antidiabetic, antifilarial, anticancer, cardioprotective and anti-inflammatory which are good for health. Functional groups are groups that determine the properties of organic compounds because they are able to show distinctive properties when the compound content of the sample is detected (Setiawan, 2022). The instruments used to determine the levels of phenolic compounds are a UV Vis and FTIR spectrophotometer. Based on this explanation, research was conducted to determine the phenolic content and functional groups in green tea kombucha, telang flower kombucha, rosella flower kombucha, chamomile flower kombucha and lavender flower kombucha.

2 METHODS

Tools and Materials

Tools

The tools used in this research are measuring cups, beakers, measuring flasks, Erlenmeyer flasks, glass jars, stirrers, dropper pipettes, volume pipettes, spoons, analytical scales, stoves, ovens, vortexes, aluminum foil, pH meters, spectrophotometer UV-VIS, Fourier Transform Infrared (FTIR).

Materials

The ingredients used in this research were green tea, telang flowers, rosella flowers, chamomile flowers,

lavender flowers, water, kombucha starter culture, distilled water, granulated sugar, methanol p.a, Na₂CO₃, gallic acid, Folin-ciocalteu.

Kombucha Starter Preparation

Boil 1000 ml of water until it boils and add 100 grams of sugar (10% w/v) from the amount of water used and add 5 grams of 0.5% (w/v) tea. Then filter and cover the filtrate with aluminum foil and let sit until the tea has room temperature. After that, add 100 ml of kombucha starter culture (10% w/v) to the brewed tea and then close the container tightly. Propagation of the kombucha starter culture was left for 14 days.

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Making Green Tea Kombucha

5 grams of green tea is brewed using 200 ml of boiling water. Then add sugar with a concentration of 50 grams and stir. Cover the brewed green tea tightly with a cloth and let it sit until room temperature. 20 ml of liquid kombucha starter is added and fermented for approximately 12 days in a closed container

Making Flower Kombucha

5 grams of telang flower, rosella, lavender and chamomile each are brewed using 200 ml of boiling water. Then add sugar with a concentration of 50 grams and stir. Cover the steeping flower tea with a cloth and let it sit until room temperature. 20 ml of liquid kombucha starter is added and fermented for approximately 12 days in a closed container.

Test pH Levels

pH measurements are measured using a pH meter. Green tea kombucha, telang flower kombucha, rosella flower kombucha, lavender flower kombucha and chamomile flower kombucha were put into a glass beaker and then dipped into a pH meter.

Phenolic Content Test

Standard Curve of Gallic Acid Standard Solution

The standard gallic acid solution was made in varying concentrations of 10, 20, 30, 40, 50 ppm. Take 1 ml of the standard solution of gallic acid of each concentration and put it into a test tube and add 0.5 ml of Folin-ciocalteu then let it sit for 8 minutes while shaking. To the solution was added 4 ml of 7% Na₂CO₃ solution and vortexed for 1 minute. Measurements were carried out at a wavelength of 760 nm.

Sample Absorption Measurement

Take 1 ml of kombucha from each sample and add 0.5 ml of Folin-ciocalteu, let stand for 8 minutes while shaking. 4 ml of 7% Na₂CO₃ solution was added and vortexed for 1 minute. Absorbance was calculated with a wavelength of 760 nm. Measurements were carried out at a wavelength of 760 nm. The total phenol content can be calculated using the following formula:

$$TPC = c \cdot v \cdot fp$$

Information:

TPC: total phenolic content (mg/L GAE)

c : concentration (x value) (ppm)

v : sample volume (ml)

fp : dilution factor

FTIR Test

In the FTIR test the sample is analyzed by wetting the instrument in the sample holder with alcohol and cleaning with a tissue. Then, each kombucha sample was taken using a dropper pipette and dropped alternately one by one onto a sample buffer that had been cleaned with alcohol. After that, the wave spectrum results were compared with literature frequency data to determine the functional groups in the sample.

3 RESULTS and DISCUSSIONS

Kombucha is a fermented drink that originated in Manchuria in the Tsin Dynasty around 220 SM, used as a detox and energy drink. In 414 M, it was brought

to Japan to treat Emperor Inkyo's digestive problems. Along with the development of trade routes, kombucha spread to Russia (known as *Cainiigrib*, *Cainii kvass*, *Japonskigrib*, *Kambucha*, *Jsakvasska*), then to Germany (known as *Heldenpilz*, *Kombuchaschwamm*) until the 20th century (Jayabalan *et al.*, 2014; Priyono and Riswanto, 2021). From an organoleptic perspective, kombucha has a sour taste. The sour taste is caused by the increase in organic acid compounds, such as acetic acid and so on during the fermentation process. Acetic acid bacteria in the kombucha fermentation process will convert glucose into various types of acids, vitamins and alcohol which are beneficial for the body's health. These types of acids include organic acids such as acetic acid, citric acid, malic acid, glucuronic acid, lactic acid, caprylic acid, carbonic acid, folic acid, gluconic acid, chondroitin sulfate acid, hyaluronic acid, usnic acid, and there are also amino acids. (Nasution and Nasution, 2022). The pH value of kombucha for each sample can be seen in table 1.

Table 1: pH value

No	Sample	pH Value
1	Green Tea Kombucha	3.32
2	Telang Flower Kombucha	2.86
3	Rosella Flower Kombucha	2.62
4	Lavender Flower Kombucha	2.9
5	Chamomile Flower Kombucha	2.78

The longer the fermentation time, the greater the total acid (Wistiana and Zubaidah, 2015). The degree of acidity (pH) is one of the parameters resulting from processed fermented food or drinks. The low pH value in the two kombucha samples is caused by the metabolic process of yeast and bacteria towards sucrose which produces a number of organic acids such as acetic acid, gluconic acid and glucuronic acid (Wistiana and Zubaidah, 2015). The decrease in the pH of kombucha tea also occurs because during the fermentation process, yeast will synthesize sugar into ethanol and by bacteria the acetate is broken down into organic acids, such as acetic acid and gluconic acid and several concentrations of organic acids. This results in a decrease in the pH of the fermentation medium (Puspitasari *et al.*, 2017).

The activity of lactic acid bacteria is to break down carbohydrates into lactic acid. The lactic acid that is formed will be secreted out of the cells and accumulate in the fermentation medium so that the longer the fermentation time, the total amount of accumulated acid will increase and reduce the pH. The pH value will decrease if there is enough acidification due to the activity of lactic acid bacteria

(Kinteki *et al.*, 2019). Glucose in acetic acid bacteria is obtained from yeast through a sucrose inversion process. In the process of making ethanol by the yeast *Saccharomyces cerevisiae* and cellulose by the acetic acid bacteria *Acetobacter xylinum*, the acetic acid bacteria will convert glucose into gluconic acid via the pentose phosphate pathway. Most of the fructose is metabolized into acetic acid and a small amount of gluconic acid (Ardheniati *et al.*, 2009).

In this process, glucose functions as a substrate for cell growth and the formation of a product in the form of acetic acid (Ardheniati *et al.*, 2009). The glucose in the fermentation medium is converted into lactic acid with the help of enzymes produced by lactic acid bacteria. Production of lactic acid for heterofermentation is produced from glucose via the pentose-phosphate pathway. Apart from producing lactic acid, ethanol and carbon dioxide are also produced as by-products of fermentation (Ferdaus *et al.*, 2008).

Table 2: Data for Determining the Standard Standard Curve for Gallic Acid

Concentration (ppm)	Absorbance
10	0.331
20	0.52
30	0.804
40	1.159
50	1.315

Solutions of varying concentrations (10 ppm, 20 ppm, 30 ppm, 40 ppm, 50 ppm) were searched for absorbance using a UV-Visible spectrophotometer instrument. The absorbance of each concentration can be seen in table 1. After obtaining the absorbance of each concentration, the next step is to create a standard standard curve for gallic acid which is used to find equations and linear regression. The standard standard curve for gallic acid can be seen in Figure 1.

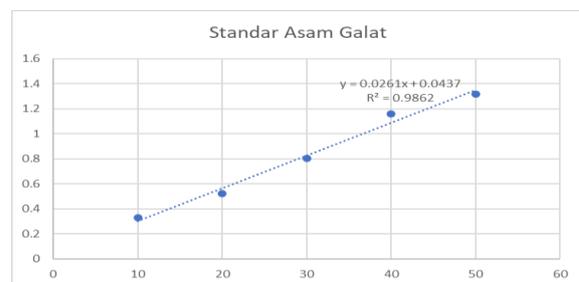


Figure 1: Gallic Acid Standard Calibration Curve

The standard standard curve for gallic acid has a regression equation y (absorbance) = 0.0261x (concentration) + 0.0437 with a coefficient of

determination $R^2 = 0.9862$. The curve can be said to be linear because the coefficient of determination (R^2) is 0.9862 or close to one. The phenolic concentration can be determined by substituting the absorbance of the sample into Y in the equation. The size of the X indicates the concentration of phenolics in the sample.

After knowing the phenolic concentration, then calculate the TPC. Determination of TPC is part of the analysis which is related to phenolic content and

antioxidant activity. Samples that have a relatively high content of phenolic secondary metabolite compounds usually have high antioxidant activity (Handayani *et al.*, 2022). The total phenolic content in each kombucha sample was expressed as gallic acid equivalent (GAE). GAE is a general reference for measuring the number of phenolic compounds contained in a material. Based on the existing phenolic concentration, the TPC value of kombucha for each sample was obtained. The TPC value of each sample can be seen in table 3.

Table 3: TPC Value of Kombucha Green Tea, Telang, Rosella, Lavender and Chamomile

Sampel	Absorbansi	Konsentrasi Fenolik	TPC (mg/L GAE)
Green Tea Kombucha	4.281	162.348659	162.35
Telang Flower Kombucha	3.292	124.4559387	124.46
Rosella Kombucha	2.688	101.3141762	101.31
Lavender Kombucha	3.561	134.7624521	134.76
Chamomile Kombucha	0.968	35.4137931	35.41

The TPC value of green tea kombucha was 162.35 mg/L GAE, butterfly pea flower kombucha was 124.46 mg/L GAE, rosella flower kombucha was 101.31 mg/L GAE, lavender flower kombucha was 134.76 mg/L GAE, and chamomile flower kombucha

was 35.41 mg/L L GAE. Based on the data obtained, it can be seen that the TPC value in green tea kombucha is higher than the TPC value in other samples.

Table 4: Compound Content of Green Tea, Telang, Rosella, Lavender and Chamomile

No	Aspect	Green Tea	Telang Flower	Rosella	Lavender	Chamomile
1	Flavonoid	Catechin (-) epicatechin (EC) (-) epigallocatechin (EGC) (-) epicatechin gallate (ECG) (-) epigallocatechin gallate (EGCG) (Fadhlorrohman dan Susanto, 2024)	Kaempferol glycosides, quercetin glycosides, mirisetin (Andiarni dan Murtisiwi, 2018).	Kaempferol, Quercetin, Myricetin (Ramahani <i>et al.</i> , 2024)	Luteolin, Apigenin, quercetin (Stanciu <i>et al.</i> , 2014)	Luteolin, Apigenin, quercetin, patuletin (Putri dan Astuti, 2023)
2	Anthocyanin	-	Delphinidin-3,5-glucoside (Putri dan Baharza, 2023) Cyanidin-3-O-Glucoside, Cn-3-(6"-p-coumaroylglucoside) (Saputri <i>et al.</i> , 2023).	Cyanidin Peonidin Delfinidine Malvidin Petunidin (Gangulu, 2023)	-	-
3	Polyphenols	Epigallocatechin Gallate (EGCG), Epigallocatechin (EGC), Epicatechin Gallate (ECG), and Epicatechin (EC) (Fadhlorrohman dan Susanto, 2024)	Phenolic Acids and Flavonoids (Fadhlorrohman dan Susanto, 2024)	Citric Acid, Malic Acid, Ascorbic Acid (Nugroho <i>et al.</i> , 2018)	Linalool linalyl asetat (Sihite, 2022)	Apigenin, quersetin, patuletin, luteolin, coumarin, asam fenolat (Putri and Astuti, 2023)

4	Phenolic	Catechins, Epicatechin, Epigallocatechin, and Epigallocatechin Gallate (Galati, 2006)	Phenolic acids (gallic acid, chlorogenic acid) (Marpaung, 2020)	Citric Acid, Hydroxycitric Acid, Hibiscus Acid, Protocatechuic Acid (Boras-Linares, 2014)	Asam rosmarinic, linalool, luteolin, kemferol, quersetin (Sihite, 2022)	Apigenin, quersetin, patuletin, luteolin, coumarin, asam kafeat (Putri dan Astuti, 2023)
5	Steroid	Beta-sitosterol (Helilusiatiningsih, 2021)	Kaempferol glycosides, quercetin glycosides, mirisetin (Andiarni dan Murtisiwi, 2018).	-	-	-

Green tea contains more phenolic compounds or compounds with OH groups. This can be seen in table 4. Data on compound content in green tea samples is comparable to the TPC value obtained. The highest TPC value was the kombucha tea sample from green tea, namely 162.35.

The fermentation process is very important to change a molecule or compound and the effectiveness of the active compound. Biochemical transformation processes during fermentation not only adjust the balance between nutrients and antinutrients, but also influence product properties, such as increasing the levels of biologically active phenolic compounds and their antioxidant capacity. The fermentation process can also increase antioxidant properties by increasing free flavonoid levels. The fermentation process will promote cell wall damage, facilitating the release or even production of certain bioactive components. Through fermentation, microbial enzymes will also be released, so that active plant compounds can be released such as flavonoids, tannins and alkaloids (Rahmi *et al.*, 2016).

An increase in total phenolic content after the fermentation process can occur due to the enzymatic activity of microorganisms in the substrate, causing a higher release of phenolic compounds (Laela *et al.*, 2023). The presence of microorganisms in the fermentation process is an important factor in increasing the phenolic content of kombucha tea. During the process, microorganisms play a role in damaging the cell wall structure so that plants (flowers) or green tea can release various bioactive compounds contained therein (Mahardani and Yuanita, 2021). Throughout the fermentation process,

these microorganisms can produce specific enzymes that promote the conversion of non-phenolic compounds into phenolic compounds (Ansory *et al.*, 2023).

Enzymes in the fermentation process play an important role in breaking down the structure of complex organic compounds into simple phenolic compounds, which are easier to obtain and measure. The metabolic activity of microorganisms results in the production of various secondary metabolites. Some of these secondary metabolites may exhibit phenolic characteristics or may be converted into phenolic compounds by these microorganisms. As a result, the overall phenolic content in kombucha will increase. The increase in phenolic compound levels during the fermentation process may be influenced by factors such as the type of microorganisms used, fermentation conditions, as well as the composition and chemical properties of the fermentation substrate (Ansory *et al.*, 2023).

Functional groups are groups that determine the properties of organic compounds because they are able to show distinctive properties when the compound content of the sample is detected (Setiawan, 2022). Fourier Transform Infrared (FTIR) analysis was carried out to identify the functional groups contained in green tea kombucha, telang, rosella, lavender and chamomile. The results of FTIR analysis provide information regarding the chemical structure and active components contained in each type of kombucha. FTIR data from various types of kombucha are presented in table 5 below:

Table 5. FTIR Data for Kombucha Green Tea, Telang, Rosella, Lavender and Chamomile

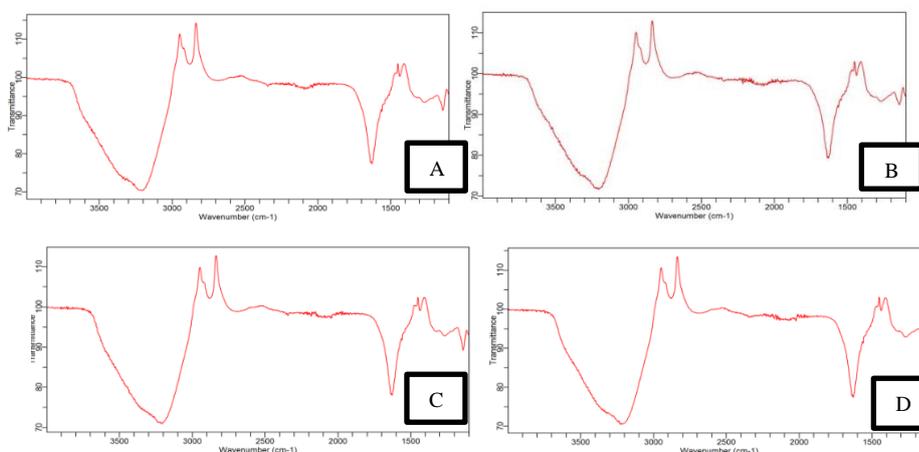
No	Sample	The Obtained Wavenumber Values (cm ⁻¹)	Type of Bond
1	Green Tea Kombucha	1136,84	C-O (Alcohol, ethers, carboxylic acids, esters)

No	Sample	The Obtained Wavenumber Values (cm ⁻¹)	Type of Bond
2	Telang Flower Kombucha	1638,16	C-C aromatic or C=C (alkenes)
		3267,01	O-H (Hydrogen-bonded, alcohols, phenols)
		1261,7	C-N (amida, amina)
		1142,43	C-O
		3199,91	O-H
		1628,49	C-C aromatic or C=C (alkenes)
3	Rosella Flower Kombucha	3201,78	O-H
		1638,85	C-C aromatic or C=C (alkenes)
		1142,92	C-O
		1265,79	C-N (amida, amina)
		1628,84663	C-C aromatic or C=C (alkenes)
4	Lavender Flower Kombucha	2569,99944	O-H (Hydrogen-bonded, carboxylic acids)
		2689,27425	O-H (Hydrogen-bonded, carboxylic acids)
		2879,36848	C-H (Alkanes)
		3207,37421	O-H (Hydrogen-bonded, alcohols, phenols)
		1140,56538	C-O (Alcohols, ethers, carboxylic acids, esters)
5	Chamomile Flower Kombucha	1267,29486	C-O (Alcohols, ethers, carboxylic acids, esters)
		1628,84663	C-C aromatic or C=C (alkenes)
		3229,73824	O-H (Hydrogen-bonded, alcohols, phenols)

FTIR (Fourier Transform Infrared Spectroscopy) analysis is a spectroscopic technique used to identify functional groups in a compound based on the molecular vibrations produced when the compound absorbs infrared radiation (Dachriyanus, 2004). Each functional group has a characteristic vibrational frequency, so it can be used to identify the type of compound contained in the sample (Silverstein *et al.*, 2005). The wave number absorption results in the kombucha green tea sample were at wave numbers 3201.78 cm⁻¹ with wide intensity, 1638.85 cm⁻¹ with sharp intensity, 1142.92 cm⁻¹ and 1265.79 cm⁻¹ with medium intensity (Table 5). The wave absorption at 3201.78 cm⁻¹ with a wide intensity indicates the presence of the O-H functional group, while the wave absorption at 1638.85 cm⁻¹ with a sharp intensity indicates the presence of the aromatic C-C functional group. The results of FTIR analysis on kombucha tea,

telang, rosella, chamomile, and lavender contain almost the same functional groups as green tea.

Green tea kombucha with telang, rosella, lavender and chamomille kombucha tea both contain OH groups. However, the transmittance band stretch in telang, rosella, lavender, and chamomille kombucha teas was wider than that of green tea kombucha (Figure 2). Basically, tea samples contain aromatic OH and C=C groups which are characteristic of flavonoid compounds (catechins) in green tea leaves (Sukaesih, 2021). According to Abriyani *et al.*, (2023) the standard for flavonoids is OH (hydroxyl) wave absorption at 3372 cm⁻¹. In general, catechins are found in young tea leaves, and the concentration of catechins in tea leaves will decrease as the age of the tea leaves increases (Nugraheni *et al.*, 2022).



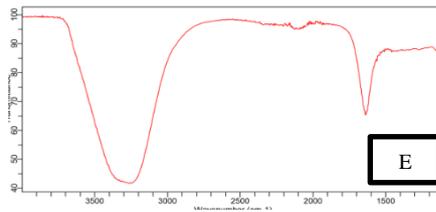


Figure 2: FTIR Spectra of Kombucha Tea Telang (A), Rosella (B), Lavender (C), Chamomille (D), and Green Tea (E)

The spectral stretch in the wave number range of 3000-3700 cm^{-1} is also influenced by the flavonoid and phenolic content in telang, rosella, lavender and chamomile flowers, as well as microbiological activity in the manufacturing process. The process of making kombucha tea uses a 7-21 day fermentation process with the help of microbes, one of which uses the yeast *Saccharomyces cerevisiae* (Priyono and Riswanto, 2021), which produces the alcohol content in kombucha tea from several sources (Table 3). Phenolic compounds are compounds in plants that have the most hydroxyl (OH) groups (Diniyah and Lee, 2020). According to Marpaung (2020), telang flowers contain relatively high levels of polyphenols, which can provide benefits for human health, including as antioxidants, antidiabetic, antiobesity, antihyperlipidemia, and cholesterol regulation. The content of phenolic compounds is widely known to destroy free radicals and in general the content of phenolic compounds is positively correlated with antioxidant activity (Febriana *et al.*, 2019). Polyphenol content is also found in lavender flowers (Dobros *et al.*, 2022) and chamomile leaves (Dai *et al.*, 2022). Derivatives of polyphenols are phenolics, which are polyphenolic compounds that dissolve in water (Arifin *et al.*, 2018). The flavonoid content in roselle is 0.23 mg/g (Mahadevan *et al.*, 2009; Nurnasari and Khuluq, 2017). The basic content of tea which contains OH groups (catechins) plus the alcohol content of polyphenols from each sample makes the FTIR spectrum stretch wider in the wave number range of 3000-3700 cm^{-1} .

Telang flowers contain phytochemical compounds including flavonoids, saponins, terpenoids and tannins (Cahyaningsih *et al.*, 2019). Rosella flowers have been confirmed to contain 0.23 mg/g flavonoids, 0.125 mg/g phenolics, 0.13 mg/g saponins, 0.12 mg/g alkaloids, and 0.17 mg/g tannins. Flavonoid content was also identified in lavender flowers (Mahadevan *et al.*, 2009). The alkaloid content in roselle can be seen at the absorption wave of 1142.92 cm^{-1} . The C-N group detected at the absorption wave of 1142.92 cm^{-1} is possibly an alkaloid compound with a piperidine base structure as in research conducted by

Fachriyah *et al.* (2018). Kareru *et al.*, (2008) stated that saponin has absorption of the infrared functional groups OH, CH, C=C, C=O, and C-O-C. It can be seen in Figure 2 that the OH group absorption of rosella kombucha tea is more stretched compared to green tea, this is also caused by the saponin content in rosella kombucha tea. Uptake of saponin oligosaccharides with saponin. Likewise, other samples contain the same phytochemical compounds so that the spectral absorption in each sample is almost the same. The wide peak that appears in the spectrum indicates the stretching vibration of the monometric OH group of alcohol. These groups are characteristic of secondary metabolite compounds in the flavonoid, phenolic and saponin groups (Harborne, 1987).

The results of FTIR analysis on the five kombucha tea samples showed that there were differences in the identified functional groups. In butterfly pea flower kombucha tea, functional groups of alcohol, amines and nitro compounds were detected. The wide peak that appears in the spectrum indicates the stretching vibration of the alcohol's monometric O-H group. These groups are characteristic of secondary metabolite compounds in the flavonoid, phenolic and saponin groups (Harborne, 1987). Green tea kombucha has alkene, alkyne and alcohol functional groups, which indicate the presence of flavonoid and phenolic compounds. These compounds are known to have high antioxidant activity and play a role in maintaining body health (Cabrera *et al.*, 2006). In rosella flower kombucha, the functional groups alcohol, alkene, alkyne, nitrile and phenol were identified. These groups are characteristic of flavonoid, phenolic, tannin and steroid compounds. These compounds have various bioactivities, such as antioxidant, antimicrobial and anti-inflammatory (Riaz and Chopra, 2018).

Chamomile flower kombucha contains ether, amine, alkene, alkyne, ester and alcohol functional groups, which indicate the presence of flavonoid, phenolic, saponin and triterpenoid compounds. These compounds are known to have calming, anti-

inflammatory and antimicrobial effects (Singh *et al.*, 2011). Meanwhile, in lavender flower kombucha, the functional groups alcohol, alkene, alkyne and alkane were detected. This indicates the presence of flavonoid, phenolic and steroid compounds in the sample. These compounds contribute to the relaxing, antioxidant and antimicrobial effects of lavender flowers (Cavanagh and Wilkinson, 2002).

4 CONCLUSIONS

Based on research that has been carried out, it can be seen that the TPC value of green tea kombucha is 162.35 mg/L GAE, telang kombucha is 124.46 mg/L GAE, rosella kombucha is 101.31 mg/L GAE, chamomile kombucha is 35, 41 mg/L GAE, lavender kombucha is 134.76 mg/L GAE, so it can be concluded that the highest phenolic content is found in green tea kombucha. Based on FTIR analysis, it can be concluded that each type of kombucha tea contains different secondary metabolite compounds. Telang flower kombucha tea contains flavonoids, phenolics, saponins and nitro compounds, while green tea contains flavonoids and phenolics. Rosella flower kombucha tea is rich in flavonoids, phenolics, tannins, steroids and alkaloids, meanwhile, chamomile flower kombucha tea contains flavonoids, phenolics, saponins, triterpenoids and lavender flower kombucha tea contains flavonoids, phenolics and steroids.

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