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Comparison of Acidity, Reducing Sugars, Vitamin C, and Antioxidants of Several Types of Kombucha Tea: Review

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ABSTRACT

Kombucha tea is a beverage produced from sweet tea using symbiotic bacteria and yeast. This study aims to investigate and compare the pH, carbohydrate reduction, vitamin C content, and antioxidant content of different varieties of kombucha, analysing the effect of fermentation time on chemical characteristics which include organoleptic tests (pH value, vitamin C content and reducing sugar) and antioxidant tests. Literature study on existing research is about the pH contained, antioxidant activity, vitamin C, and reducing sugar in several types of kombucha tea. It is expected that the results of this research will provide significant benefits in the food, health and other sectors with the potential to be a good option for individuals who want to consume high nutritional drinks and have antioxidant activity, as well as provide a pleasant taste experience. The research is expected to help fulfil people's nutritional needs and support the strength of the immune system.

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1. INTRODUCTION

Along with the increasing understanding of the importance of maintaining health, people's views and behaviours have also changed. As a result of these behavioural changes, there is now more emphasis on preventive efforts, such as consuming foods and beverages that have additional health benefits. One product that may offer health benefits is kombucha.

Kombucha tea is becoming an increasingly popular beverage due to its beneficial properties that are thought to improve health in the body. The fermentation process by bacteria and yeast in kombucha not only ensures a unique flavour but also enriches the drink with various nutrients that have a positive impact on health.

One of the factors of interest in nutritional and health analyses of kombucha is pH, reducing sugars, vitamin C, and antioxidants. These ingredients play an important role in determining the quality and health benefits of this drink. Comparative study of pH, reducing sugar content, vitamin C, and antioxidant content of different types of kombucha. A comparative study of the pH, reducing sugar, vitamin C, and antioxidant content of different types of kombucha can help us better understand the nutritional differences between these beverages.

It is important to know whether differences in fermentation processes and types of tea ingredients ultimately impact the nutritional content of kombucha beverages. Therefore, this study investigated and compared the pH, carbohydrate reduction, Vitamin C content, and antioxidant content of different varieties of kombucha, thereby helping consumers and manufacturers make better product choices and it is intended to provide valuable insights as the times change.

2. METHOD

The research method used for this literature study uses two data sources, namely ScienceDirect and Google Scholar. Literature studies were used in the form of relevant national and international articles or journals where the keywords used are 'kombucha tea', 'functional beverage', 'antioxidant',

'vitamin C', and 'reducing sugar' with publication years ranging from 2014 to 2022. The tests used in the analysis of nutritional content include organoleptic tests and antioxidant tests, including:

2.1 Organoleptic test.

This organoleptic test includes measurement of pH, reducing sugar content and vitamin C content contained in various kinds of kombucha tea.

2.2 Antioxidant test.

Antioxidant activity was analysed using the DPPH method.

3. RESULT AND DISCUSSION

The test results in several studies on kombucha tea are pH value, reducing sugar, vitamin C and antioxidant activity contained. Making kombucha with various types of leaves or other ingredients has different characteristics and levels.

3.1 Organoleptic test

Asri S and Martina A, (2018) suggested that pH decreased significantly during fermentation. The longer the fermentation lasts, the lower the pH will be. The decrease in pH occurs gradually because the sucrose content is in the medium and microorganisms in the medium can continue their metabolism. This process will increase acidity due to the formation of organic acids that make the pH decrease. Pratama, et al. (2015) suggested that the length of fermentation affects the pH value. The length of fermentation time will make the pH value decrease. This is because more organic acids are produced by microorganisms such as bacteria and yeast and used as a starter.

Zahra, et al (2022) suggested that the pH of kombucha made from moringa leaves decreased as the fermentation time increased. The decrease in pH of moringa leaf-based kombucha tea during the fermentation process is influenced by the sugar substrate which is converted into products in the form of alcohol and organic acids. The higher the amount of organic acid, the lower the pH of the solution.

Simanjutak, et al (2016) suggested that as the acid content of a material increases, the pH value will decrease. The decrease in kombucha minimum pH is thought to be caused by an increase in the concentration of acidic substances during the fermentation process. Dissolved acidic substances in the solution will release protons which cause a decrease in pH. Puspitasari, et al (2017) suggested that the decrease in pH of kombucha tea occurs because, during the fermentation process, the yeast synthesises sugar into ethanol and by acetic bacteria it is broken down into organic acids, such as acetic acid and gluconic acid and some concentrations of organic acids result in a decrease in the pH of the fermentation medium.

Yuningtyas, et al (2021) stated that the decrease in pH in kombucha is caused by the fermentation process by SCOBY. The yeast cells in SCOBY will hydrolyse sucrose into glucose and fructose with the enzyme invertase. Handayani, et al (2022) suggested that the decrease in pH is due to the natural organic acids contained in the kersen itself and also the kombucha culture breaks down the carbon source of sugar in the kersen leaf concentration into organic acids, organic acids formed due to this fermentation process cause the acidity value to decrease.

Table 1. Results of pH test on several types of kombucha tea

Type of tea	Day 6-7	Day 8-9	Day 10-11	Name researcher
Black tea	2,4	2,3	2,2	Asri S and Martina A (2018)
Mangisteen peel tea	3,75	3,49	3,26	Pratama, et al (2015)
Moringa leaf tea	3,29	3,21	2,99	Zahra, et al (2022)
The wormwood plant	3,56	3,23	3,05	Simanjutak, et al (2016)
Green tea	5,12	4,84	4,06	Puspitasari, et al (2017)
Bay leaf	3,22	3,00	2,79	Yuningtyas, et al (2021)
Kersen leaves	3,69	3,62	3,56	Handayani, et al (2022)

Based on experiments that have been carried out by several researchers regarding pH levels in kombucha tea fermentation with black tea, mangosteen peel, and moringa leaves, there is a decrease in pH based on the length of fermentation time. During the fermentation process, sugar is broken down by yeast and converted into gas (CO_2) and various organic acids and other compounds. These organic acids will reduce the pH value. Based on testing several types of kombucha tea, there are differences in pH in

each sample, this is due to different chemical composition factors that can affect the final acidity level of kombucha. The difference in pH that occurs is also caused by additional microorganisms or certain chemicals that can affect the fermentation process and the final product of the fermentation results.

3.2 Reducing Sugar Content of different types of kombucha tea.

Simanjuntak, et al (2016) suggested that the results of research on reducing sugar levels in apu apu plant samples showed that as fermentation time increased, total sugar levels decreased. This is believed to be due to the ability of SCOBY cultures to break down sugar in each kombucha sample. Puspitasari, et al (2017) suggested that there was a decrease in reducing sugar levels in kombucha samples using green the. Reducing sugar explains that all microorganisms need sugar as a carbon source because sugar in the culture medium is used by microorganisms as nutrients and then converted into alcohol and CO .

Habibah, et al (2015) suggested that the more sugar content in a solution, the more the reduced sugar content increases, and the reduced sugar content decreases because the yeast (Saccharomyces cerevisiae) decomposes glucose into alcohol so that the alcohol content of kombucha tea increases. The use of sugar by yeast can be through the cell membrane directly or hydrolysed first, then the results of the hydrolysis enter the cell. Handayani, et al (2022) argued that based on the analysis of the variance of sugar types sugar decreased due to the depletion of sugar supply so that acetic acid bacteria oxidise acetic acid in obtaining energy for growth.

Endah (2016) suggests that reducing sugars, such as glucose and fructose, decreases with fermentation time because they are used as energy sources by microorganisms involved in the fermentation process, such as yeast or bacteria. Rosida, et al (2021) suggested that reducing sugar levels decreases over time because yeast breaks down glucose into alcohol, so the alcohol content in kombucha tea increases. Wijaya, et al (2017) suggested that the higher the sugar concentration, the higher the reduced sugar content in kombucha tea. The fermentation process can increase the degradation of disaccharide or oligosaccharide sugars which indirectly increases the formation of reducing sugars.

Table 2. Reducing sugar test results in several types of kombucha tea.

Type of tea	Lowest reducing sugar	Name researcher
Black tea	26,143 %	Habibah, et al (2015)
Mangisteen peel tea	0,6 %	Endah (2016)
Moringa leaf tea	12,7 %	Rosida, et al (2021)
The wormwood plant	5,2 %	Simanjutak, et al (2016)
Green tea	0,7 %	Puspitasari, et al (2017)
Bay leaf	10 %	Wijaya, et al (2017)
Kersen leaves	0,8145 %	Handayani, et al (2022)

Based on experiments that have been conducted by several researchers regarding reducing sugar levels in kombucha tea fermentation with various types of tea, there is a decrease in sugar levels based on the length of fermentation time. The reduction in sugar during fermentation indicates the level of microbial entry into the kombucha culture. The sugar in the culture medium is used for microbial growth and converted into various acids, thus reducing the total sugar content. The longer the fermentation lasts and the more inoculum is required, the more sugar is consumed by the microorganisms in the medium. This increase in total sugar consumption is due to the conversion of sugar into various organic acids, which are used as a carbon source (energy) for growth.

According to the literature, the higher the sugar concentration, the higher the reduced sugar content in kombucha. The fermentation process increases the breakdown of disaccharides or oligosaccharides and indirectly increases the production of reducing sugars.

3.3 Vitamin C levels of different types of kombucha tea.

Zahra, et al (2022) that the vitamin C content in kombucha made from moringa leaves decreases with the length of fermentation time. If the fermentation lasts long, the vitamin C content will decrease due to the activity of microorganisms that are important for survival. Puspitasari, et al (2017) stated that based on this data, the results of the analysis of the vitamin C content of kombucha tea increased with increasing fermentation time. The decrease in vitamin C content on days 9 and 11 is due to the destruction of vitamin C by bacterial activity that produces the enzyme L-gulonolactone oxidase which plays a role in converting L-gulonolactone oxidase into 2-keto-L-gulonolactone form and serves as the last step in vitamin C synthesis.

Yuningtyas, et al (2021) suggested that the vitamin C content of bay leaf kombucha increased along with the increase in bay leaf concentration. During the fermentation of bay leaf kombucha, biotransformation of simple sugars into vitamin C occurs. This process increases the content of ascorbic acid (vitamin C) in bay leaf kombucha. Santoso and Rahadi (2021) suggested that the length of fermentation caused an increase in vitamin C content, both in green tea and black tea. The increase in vitamin C content in both types of tea occurred significantly, which is indicated by different notations.

Table 3 Vitamin C test results in several types of kombucha tea

Type of tea	Highest vitamin C content	Name researcher
Black tea	4,71	Santoso (2021)
Moringa leaf tea	14,08	Zahra, et al (2022)
Green tea	8,43	Puspitasari, et al (2017)
Bay leaf	30,506	Yuningtyas, et al (2021)

Judging from the results of research in several journals, the size of the value of vitamin C content in kombucha tea is related to fermentation time and sample concentration. The research of Fadillah Zahra et al. and Yenny Puspitasari et al. mentioned that vitamin C levels in moringa leaf kombucha and green tea decreased along with the length of fermentation time, while the results of Sitaresmi Yuningtyas et al. Mentioned that vitamin C levels in bay leaf kombucha will increase along with the increase in concentration. This can actually happen because, during fermentation, vitamin C levels in kombucha tea can decrease over time because the fermentation process can destroy or reduce the amount of vitamin C. However, when the concentration of the sample is increased, the concentration of the sample is increased. However, when the concentration of the sample is increased or increased even though the total amount of vitamin C remains the same, the relative levels may appear to increase because it is distributed in a smaller volume.

3.4 Antioxidant activity of different types of kombucha tea.

Yenny Puspitasari, Retno Palupi, and Maulina Nurikasari suggested that the increase in antioxidant activity in kombucha tea was due to the metabolism of microorganisms in the kombucha during the fermentation process. Antioxidant activity decreased after day 7 of fermentation. This is thought to be because the acidic atmosphere stabilises phenolic compounds making it difficult to release protons that bind to DPPH resulting in a decrease in antioxidant activity.

Table 4 Antioxidant test results on several types of kombucha tea

Type of tea	Highest antioxidant	Name researcher
Mangosteen Peel Tea	92,43	Pratama, et al (2015)
Moringa Leaf Tea	8,43	Zahra, et al (2022)
The wormwood plant	12,1	Simanjutak, et al (2016)
Green tea	93,21	Puspitasari, et al (2017)
Bay leaf	75,05	Yuningtyas, et al (2021)
Kersen leaves	7,66	Nintiasari, et al (2022)

Pratama, et al (2015) suggested that fermentation time has a significant influence on the IC_{50}. IC_{50} value is a number that indicates the ability to inhibit the oxidation process by 50%. The lower the IC_{50} value, the higher the antioxidant activity. The longer the fermentation process, the higher the IC_{50} value, meaning that the ability to produce antioxidant activity decreases. The decrease in antioxidant

activity due to the fermentation process is caused by changes in pH. The longer the fermentation process, the lower the pH of kombucha will be. This causes damage to phenols, which act as antioxidants.

Nintiasari, et al (2022) stated that the results of the antioxidant activity test showed that Kombucha had antioxidant activity, in the very strong category. Which is indicated by the IC_{50} of 7.66. Zahra, et al (2022) suggested that the longer the fermentation, the IC_{50} value increases which means that the ability of antioxidant activity decreases. The smaller the IC_{50} value, the greater the antioxidant activity.

Simanjutak, et al (2016) suggested that a material can be said to be a strong antioxidant if it has an IC_{50} value of less than 200 ppm. The results of the study obtained very low antioxidants and decreased allegedly due to heating in the process of processing the drink. Puspitasari, et al (2017) suggested that the increase in antioxidant activity in kombucha tea is caused by the metabolic results of microorganisms in kombucha during the fermentation process.

Yuningtyas, et al (2021) suggested an increase in antioxidant activity and total. Phenols in bay leaf kombucha are due to the metabolic process of microorganisms during the fermentation process. During kombucha fermentation, microorganisms can increase the formation of polyphenol compounds. Based on the explanation above regarding the level of antioxidant activity, where the level of antioxidant activity is influenced by fermentation time, concentration value and IC_{50}. Fermentation time, concentration, and IC_{50} kombucha are relevant for determining antioxidant activity. Generally, the longer the fermentation time and the higher the concentration, the higher the antioxidant activity. This is reflected by lower IC_{50} values, indicating the ability to neutralise free radicals more efficiently.

4. CONCLUSION

Based on this research, it can be concluded that the content contained in kombucha tea is influenced by the length of fermentation time, the concentration of ingredients in various teas and the amount of sugar used in the process of making this kombucha tea. Analysing the effect of fermentation time on chemical characteristics such as pH value, reducing sugar, and vitamin C can give a holistic understanding of the fermentation process and the benefits of the products it produces.

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