Effect of Sugar and Tea Concentration on the Yield and Quality of Kombucha Tea Drinks with SCOBY Fermentation

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Abstract. Kombucha tea is a fermented beverage made from tea (black or green), sugar, and a symbiotic colony of bacteria and yeast (SCOBY). Kombucha has gained popularity as a health-promoting beverage due to several potential benefits, including the presence of probiotics produced during the fermentation process. Probiotics help improve the balance of the gut microbiota, which is essential for healthy digestion. This research aimed to determine the optimal combination of sugar and tea concentrations that supports SCOBY fermentation and produces a high-quality kombucha beverage. This research was conducted at the Agrotechnology Laboratory, Faculty of Agriculture, Islamic University of Malang, from February to November 2025. The research design employed a completely randomized design (CRD) with two factors: (I) sugar concentration (G), consisting of 5 levels, and (II) tea concentration, also consisting of 5 levels. There were 25 combinations of factors I and II, each repeated five times, resulting in a total of 125 experimental units. Because it uses destructive observation, 500 observation units are required. The research results of the combination of sugar concentration treatment (125 g/L) and tea (12.5 g/L), which was fermented 10 days after inoculation, indicate that it is ideal for supporting the taste, thickness of nata, weight of nata, and sugar content.

Keywords: Kombucha, fermentation, scoby, sugar, and tea

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1 Introduction

Kombucha tea is a fermented beverage made from tea (black or green), sugar, and a symbiotic colony of bacteria and yeast (SCOBY), also known as a "Dipho fungus." Kombucha has gained popularity as a health-promoting beverage due to several potential benefits, including the presence of probiotics produced during the fermentation process. Probiotics help improve the balance of gut microbiota, which is essential for healthy digestion. Organic acids, such as acetic acid, produced can help fight harmful bacteria in the digestive tract [1] [2].

The probiotics in Kombucha can support immune system function by maintaining gut health, a key factor in the body's defences. Antioxidants found in green or black tea (the base ingredient of Kombucha) help fight free radicals and reduce inflammation. Glucuronic acid, a fermentation product of Kombucha, is claimed to aid in detoxification by binding to toxins in the liver and facilitating their excretion through urine [3] [4].

The public can easily adopt Kombucha tea-making technology because the process is simple, does not require expensive equipment, and the ingredients are readily available. Many people may be unfamiliar with Kombucha or sceptical about the fermentation process. Educational programs, tutorials, or simple training can help them understand its benefits and how to make it. Emphasizing Kombucha's health benefits can increase public interest in trying to make it at home [5].

Kombucha may be more easily adopted in communities already familiar with fermentation methods, such as making tempeh or yoghurt. In areas where tea-drinking culture already exists, Kombucha can be seen as an innovation of a familiar tradition. Some remaining challenges include the need to carry out the fermentation process under sterile conditions to prevent contamination by harmful bacteria or fungi [6]. Kombucha has a distinctive sour taste. For some people, this may take some time to get used to. Although readily available, some communities may struggle to obtain a Scoby if there is no local supplier [7].

The quality of kombucha tea depends on the selection of appropriate tea, sugar, water, Scoby, and flavoring additives, as well as attention to the fermentation process. Using high-quality ingredients and maintaining good hygiene will produce delicious, healthy, and safe Kombucha. Research conducted to date has focused on analysing the origins of various tea ingredients, isolating acetic acid bacteria from Scoby, and using apple cider Scoby starter concentrations for organoleptic testing [8]. Research has not been conducted to combine sugar and tea concentrations to achieve a high-quality aroma and flavour. The goal of this research is to determine the optimal combination of sugar and tea concentrations that supports Scoby fermentation and produces a high-quality beverage.

2. Materials and Methods

2.1 Experimental Site and Design

This research was conducted at the Agrotechnology Laboratory, the Central Laboratory of Universitas Islam Malang, and the mushroom house (kombong) located at an altitude of 550 m above sea level. The air temperatures ranged from 25.7 °C to 31.1 °C, and the humidity ranged from 79% to 86%. The research was conducted from February to November 2025.

This research employed a factorial Completely Randomized Design (CRD) with two factors: (I) sugar concentration (G) and (II) tea concentration. Each factor consisted of: Factor I: Sugar Concentration (G), consisting of 5 levels: G1: Sugar Concentration 25 g/L; G2: Sugar Concentration 50 g/L; G3: Sugar Concentration 75 g/L; G4: Sugar Concentration 100 g/L; and G5: Sugar Concentration 125 g/L. Factor II: Tea Concentration (T), consisting of 5 levels: T1: Tea Concentration 2.5 g/L; T2: Tea Concentration 5.0 g/L; T3: Tea Concentration 7.5 g/L; T4: Tea Concentration 10.0 g/L; and T5: Tea Concentration 12.5 g/L. There were 25 combinations of factors I and II, each replicated five times, resulting in a total of 125 experimental units.

2.2 Data Analysis

Observed variables included fermentation sugar content, thickness of nata (Cellulose Biofilm), and weight of nata. Observational data were analyzed using analysis of variance (ANOVA) with an α level of 0.05. If the calculated F value was greater than the F value, the test was continued with the Honestly Significant Difference (HSD) test with α = 0.05.

3. Results and Discussion

3.1 Sugar Content

The results of the analysis of variance showed that the combination of sugar and tea concentrations had a significant interaction on the sugar content variable (Fig. 1) at all observation ages (5, 10, 15, 20, 25, and 30 days) after inoculation.

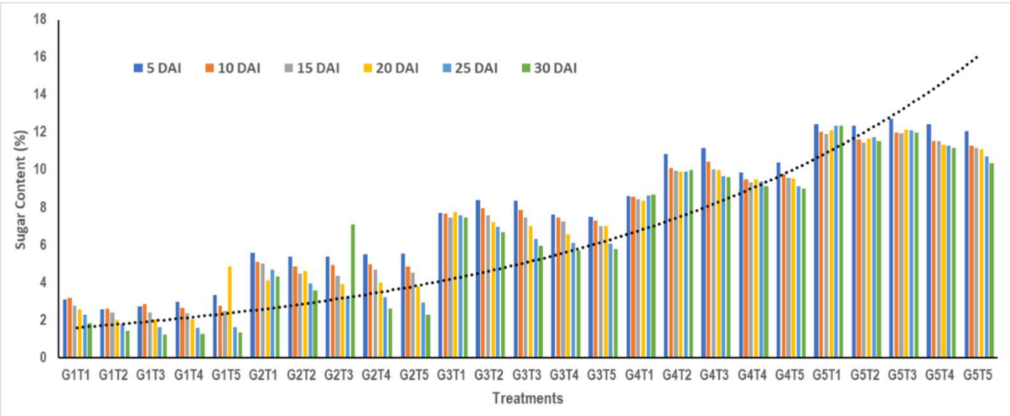

Fig.1. Sugar content of scoby fermentation results at various observation ages (DAI= days after inoculation)

The treatment of sugar concentration of 125 g/L with 2.5 g/L tea (G5T1) and sugar concentration of 125 g/L with 7.5 g/L tea (G5T3) had high sugar content at all fermentation observation ages (5, 10, 15, 20, 25 and 30) days after inoculation. The low sugar content was demonstrated by treating sugar concentrations of 25 g/L with the addition of 2.5 g/L tea (G5T1) and sugar concentrations of 125 g/L with 5.0 g/L, 7.5 g/L, 10.0 g/L, and 12.5 g/L tea. (G5T2, G5T3, G5T4 and G5T5). A high sugar content does not guarantee that the taste of kombucha tea drinks is liked; in fact, the results of organoleptic tests showed that 85% did not like it. SCOBY is only able to consume sugar according to its metabolic capacity. If the initial sugar concentration is too high, the amount of sugar exceeds the microbial consumption capacity, resulting in some of the sugar not being fermented. Consequently, the final sugar content remains high, even though the fermentation time is prolonged [9].

Low tea concentration results in fewer nutrients needed by the Scoby, as tea lacks nitrogen, vitamins, minerals, polyphenols, and components that balance the pH. If the tea concentration is low, the Scoby will lack nutrients, resulting in a slower fermentation rate, slower sugar consumption, and more sugar remaining at the end of fermentation [10] [11].

3.2 Thickness of Nata (Cellulose Bio Film)

The results of the Nata thickness variance analysis showed that the combination of sugar and tea concentrations significantly interacted across all observations. The averages for these variables are shown in Figure 2.

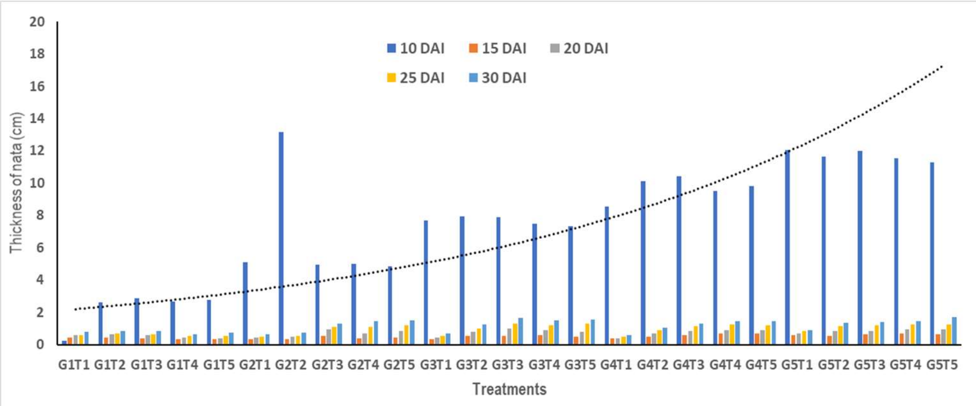

Fig.2. Average thickness of nata Scoby at various observation ages (DAI= days after inoculation)

The thickness of nata from Scoby fermentation increased from the 1st to the 6th observation. The treatments (G2T4, G2T5, G3T4, G5T4, G3T5, G3T3, and G5T5) had good thickness and were not significantly different from each other. Sugar is the main substrate for Acetobacter to produce nata cellulose, but the impact is not linear, meaning that the higher the sugar, the thicker the Scoby nata. Sugar concentrations that are too low cause nata to become thin because the Scoby lacks energy sources, ethanol production (by yeast) is low, and acetic acid bacteria only produce a small amount of cellulose. High sugar concentrations do not always affect the thickness of nata. The thickness is influenced by the following factors: high osmotic pressure inhibits Scoby growth, fermentation runs slower, and the ethanol and acetic acid required for cellulose synthesis become depleted, leading to less active cellulose bacteria [12][13].

3.3 Weight of Nata (Cellulose Bio Film)

Based on the results of the analysis of variance, the weight of Nata Scoby 30 days after inoculation showed a significant interaction between sugar and tea concentrations, as presented in Figure 3.

High Nata weight was found in treatments (G3T5, G3T3, and G5T5), while low weight was found in treatments (G4T1, G2T1, G3T4, G3T1, and G1T4). The balance of sugar and tea concentrations significantly affected the Nata weight of the Scoby. At 30 days, the advanced phase, only a stable and optimal microbial system from the start can maintain cellulose production. If the sugar or tea balance is not balanced at the start, microbial activity is disrupted during the expansion phase, resulting in a final weight (day 30) that is much lower than optimal. Furthermore, the sugar-tea balance determines the performance of the Scoby during the critical phase (days 1–10), which predominantly influences the final weight on day 30 [14] [15].

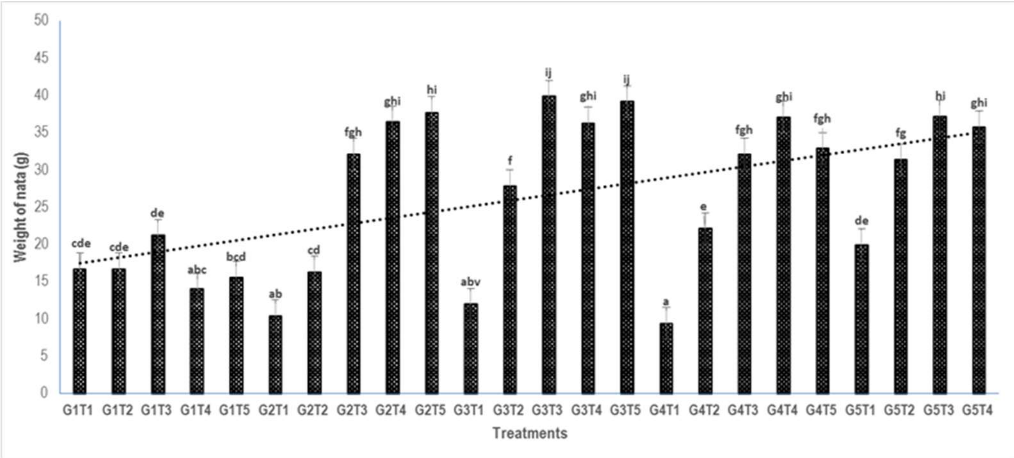

Fig.3. Weight of Nata (Cellulose Bio Film) from Fermented Scoby Observations 30 Days After Inoculation

4. Conclusion

The research results conclude that the combination of sugar concentration treatment at 125 g/L and tea at 12.5 g/L, fermented 10 days after inoculation, is ideal for supporting the taste, thickness of nata, weight of nata, and sugar content. Alternative formulas that are balanced and produce a taste that consumers prefer are combinations of 75 g/L sugar and 7.5 g/L tea concentrations, as well as 75 g/L sugar and 12.5 g/L tea concentrations, with a fermentation time of 10 to 15 days after inoculation. A quality kombucha tea drink has a balanced sweet and sour taste with Scoby fermentation not exceeding 14 days after inoculation.

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