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Research Paper

Effect of Cassava Fermentation on Reducing Sugar and Sucrose Levels: A Preliminary Study of Healthy Snack Development

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Abstract

One of the causes of obesity in Indonesia is poor consumption patterns, especially those high in sugars such as reducing sugar and sucrose. Indonesia's food diversity has the potential to be developed as a solution to obesity problems. The fermentation process is able to change the nutritional value composition, especially in reducing sugar and sucrose as healthy food. This research functioned as a preliminary study in the development of healthy snacks, especially for obesity, in terms of the presence and amount of reducing sugars and sucrose in cassava tape, gathot, and growol. This was carried out in two stages. The first stage was a qualitative analysis to examine the presence of carbohydrates through the Molisch test, Benedict's test, and Iodine test. Reducing sugar and sucrose levels were determined through quantitative testing using Nelson Somogyi with three replications for each sample. The research was conducted for seven months (January-July 2019) located at Universitas Respati Yogyakarta and Chem-mix Pratama Laboratory. Differences in reducing sugar and sucrose levels were tested with One Way ANOVA and continued with the Tukey test. Cassava, cassava tape, gathot, and growol contain monosaccharides and polysaccharides. Growol's reducing sugar content was only 0.32% (the lowest compared to other products, $p<0.001$) in line with the qualitative test results on Benedict's test. Sucrose levels from lowest to highest were gathot (0.78%), cassava tape (1.47%), growol (2.36%), and cassava (4.77%) ($p<0.001$). Growol has the potential to be developed as a healthy snack for obesity in terms of reducing sugar and sucrose levels.

Keywords *cassava; fermentation; healthy snack; reducing sugar; sucrose*

INTRODUCTION

Obesity and overweight, accumulation of body fat mass, is an emergency health problem that is closely related to an increased risk of hypertension, dyslipidemia, cardiovascular disease, diabetes, cancer, and so on (Hruby and Hu, 2015; Faruque et al., 2019; Obesity Action Scotland, 2019; Rulkiewicz et al., 2022; The World Obesity Federation, 2022; WHO Regional Office for Europe, 2022). Globally, the prevalence of obesity and overweight is 13% and 39%. In 2030 it is predicted that 1 in 5 adult women and 1 in 7 adult men will live with obesity with a predicted prevalence of 10.8%. The increase in the incidence of obesity ranges from 3.9% in adults and 6.5% in children (Obesity Action Scotland, 2019; The World Obesity Federation, 2022).

Indonesia, one of the developing countries, has a high prevalence of obesity and overweight. The age group of 18 years and over is a group with a high prevalence of obesity and overweight (obese

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30.1% and overweight 46.3%) followed by a group of children aged 5-12 years (obesity 15% and overweight 30.3%) (Oktaviani et al., 2022). The incidence of obesity and overweight in Indonesia has increased sharply in recent years (1.5 times in 2018 compared to 2013) (UNICEF, 2022).

One of the causes of obesity in Indonesia is the poor consumption patterns of the people which are characterized by high fat, high sugar, high salt, and low fiber (Stanhope, 2016; Faruque et al., 2019; Zhang and Chen, 2020; Holmes, 2021; UNICEF, 2022). Excessive consumption of reducing sugars including glucose, fructose, maltose, and lactose increases the risk of obesity (Zhang and Chen, 2020). In addition, a preclinical study showed that sucrose intake is related to obesity and overweight. Sucrose intake rapidly promotes weight gain and a greater increase in fat mass (Burke et al., 2018).

Indonesia's food diversity has the potential to be developed as a solution to health problems, one of which is as a healthy snack to prevent and treat obesity. Cassava is one of the most easily found food ingredients in Indonesia. One of the potential processed cassava to be studied is fermented cassava products such as cassava tape, gathot, and growol (Surono, 2016; Wijaya, 2019; Cempaka, 2021; Hutajulu, Kulla and Retnaningrum, 2021).

Lactobacillus plantarum, Lactobacillus rhamnosus, Lactobacillus fermentum, Saccharomyces cerevisiae, Actinobacteria, Coryneform, Pediococcus, and Yeast is a microbial involved in the process of making cassava tape, gathot, and growol (Rahayu, 2003; Putri, Haryadi and Marseno, 2012; Nuraida, 2015; Surono, 2016). Cassava fermentation process can cause changes in nutritional value, one of which is a change in reducing sugar and sucrose (Aryanta, 2000; Purnomo, Lindayani and Hartayanie, 2013; Surono, 2016). The decline of reducing sugar and sucrose levels can provide benefits, especially as an alternative to healthy food in the prevention and treatment of obesity, considering that excessive consumption of sugar can increase hunger and energy consumption (Aller et al., 2011; Sari, Puspaningtyas and Kusuma, 2017). The limited studies related to changes in carbohydrates in the cassava fermentation process and the large potential of cassava as a local functional health food are the main points of this study, especially regarding changes in reducing sugar and sucrose levels in cassava tape, gathot, and growol.

LITERATURE REVIEW

This study is a preliminary study in the development of healthy snacks, especially for the prevention and treatment of obesity in terms of the presence and amount of reducing sugars and sucrose in a fermented food, in this case cassava tape, gathot, and growol. The difference in the process of making cassava tape, gathot, and growol is thought to give a different change in nutritional value. The process of fermenting cassava tape occurs intentionally by sprinkling yeast on boiled cassava. Furthermore, cassava is fermented using leaves for 2 to 3 days by facultative anaerobic organism (Surono, 2016; Cempaka, 2021). Gathot and growol are cassava fermented products with spontaneous fermentation. The gathot fermentation process occurs in a sack for one to two weeks. This fermentation process is preceded by drying cassava in the sun (Puspaningtyas, Sari and Kusuma, 2018). Meanwhile, growol is fermented through a soaking process for about four days (Surono, 2016).

Changes in nutritional value during the fermentation process are divided into two main stages. In the early stages, the amylase enzyme-producing microbes will break down complex carbohydrate bonds into simple carbohydrates. In the second stage, the microbes will break down simple carbohydrates into various acidic and alcoholic compounds. The different fermentation processes between cassava tape, gathot, and growol allow for changes in reducing sugar and sucrose levels (Purnomo, Lindayani and Hartayanie, 2013; Surono, 2016; Frediansyah, 2018).

The fermentation process not only has the potential to change reducing sugar and sucrose levels, but is able to increase the potential for indigestible food compounds such as resistant starch which plays an important role in dietary therapy for obesity and also for various other degenerative diseases such as diabetes mellitus (Puspaningtyas, Sari and Kusuma, 2018). Previous studies have proven that changes in the levels and types of carbohydrates, to be precise, increases in dietary fiber content, also occur during the fermentation process (Sari, Puspaningtyas and Kusuma, 2017). Another study stated that the fermentation process can increase the capacity of antioxidants and anti-inflammatory compounds in a food product so that the food can be used in the prevention and treatment of obesity and also diabetes (Sivamaruthi et al., 2018; Cabello-Olmo et al., 2019; Jalili, Nazari and Magkos, 2023). Preclinical studies related to the development of tempeh products using lactic acid bacteria from cassava have been shown to be able to improve the balance of the gastrointestinal microflora (Kusuma et al., 2021).

Differences in nutritional components in a food due to the fermentation process are thought to have different health effects. Various studies have proven the effect of fermentation on changes in nutritional value in general (total energy, levels of protein, fat, water, ash, and carbohydrates by difference), changes in levels of dietary fiber and resistant starch, and also several studies about the effects of fermentation on health. However, studies related to changes in reducing sugar and sucrose levels, especially in various cassava preparations, have not been found much. It is necessary to study the differences in reducing sugar and sucrose levels in various cassava fermented products (cassava tape, gathot, and growol).

RESEARCH METHOD

A. Research Design

This was a laboratory observational study conducted through qualitative and quantitative observations. Qualitative studies were carried out using the Molisch, Benedict, and Iodine tests which were initiated by preparing an extraction solution. Qualitative testing was used to examine the presence of monosaccharides, disaccharides, oligosaccharides and polysaccharides in cassava, cassava tape, gathot and growol. Meanwhile, the levels of reducing sugar and sucrose in the product were tested quantitatively using the Nelson Somogyi method.

The research was carried out for seven months from January to July 2019. The Dietetic and Culinary Laboratory at Universitas Respati Yogyakarta was used as the location for making cassava tape, gathot and growol. Biomedical Laboratory of Universitas Respati Yogyakarta is a location for qualitative testing related to the type of carbohydrates in cassava, cassava tape, gathot, and growol. Meanwhile, testing for reducing sugar and sucrose levels was carried out at the Chem-mix Pratama Laboratory, Banguntapan, Bantul.

B. Tools and Materials

The main ingredient of this study was Klentengan Cassava (Darul Hidayah Cassava) aged 8-11 months which was obtained from the local farmer Ngudi Makmur in Gunung Kidul, Yogyakarta. The materials used in the qualitative and quantitative tests included distilled water, HCl solution, alpha-naphthol solution, 98% concentrated sulfuric acid, Benedict's solution, 10% NaOH solution, iodine solution, Nelson's reagent, and arseno molybdate solution.

The tools used to make cassava tape, gathot and growol included basins, knives, cutting boards, pans, trays, scales, spoons, banana leaves and a gas stove. The tools used in qualitative and quantitative testing included mortar, pestle, test tube, measuring cup, filter paper, clamp, funnel, Bunsen, lighter, 3 feet, dropper pipette, wire gauze, volumetric flask, water bath, spectrophotometer, and digital scales.

C. Procedure for Making Cassava Tape, Gathot, dan Growol

Figure 1 – Figure 3 described the procedure for making cassava tape, gathot, and growol.

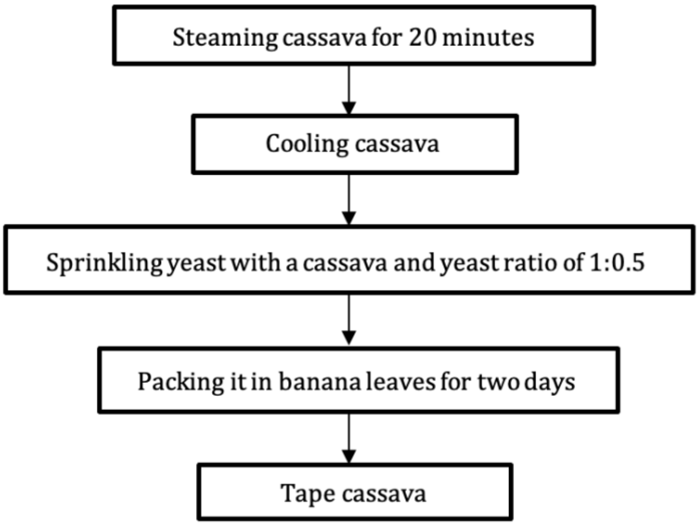

Figure 1. Cassava Tape Making Procedure

D. Qualitative Testing

Qualitative testing was started by preparing the extraction solution. Five grams each of cassava, cassava tape, gathot, and growol were crushed using a mortar and pestle. Furthermore, each sample was dissolved in 20 ml of distilled water, and mixed until homogeneous. The next step, filtered the solution with a funnel until a precipitate-free extract was obtained. Leaved the sediment-free extract for about five minutes and take the top phase (supernatant). Cassava supernatant, cassava tape, gathot, and growol were then used in qualitative testing.

The Molisch test was carried out by mixing 1 ml of the supernatant with distilled water. Next, added 3 ml of concentrated sulfuric acid and 1 ml of alpha-naphthol solution. Observed the changes that occur. Benedict's test begins by placing 5 ml of the supernatant into a test tube and adding 5 ml of Benedict's solution. Bring the solution mixture to a boil over low heat, then cooled it for 5 minutes. Observed the changes that occur. Iodine test was carried out by inserting 1 ml of supernatant into a tube and then adding five drops of iodine solution. Observed the changes that occur.

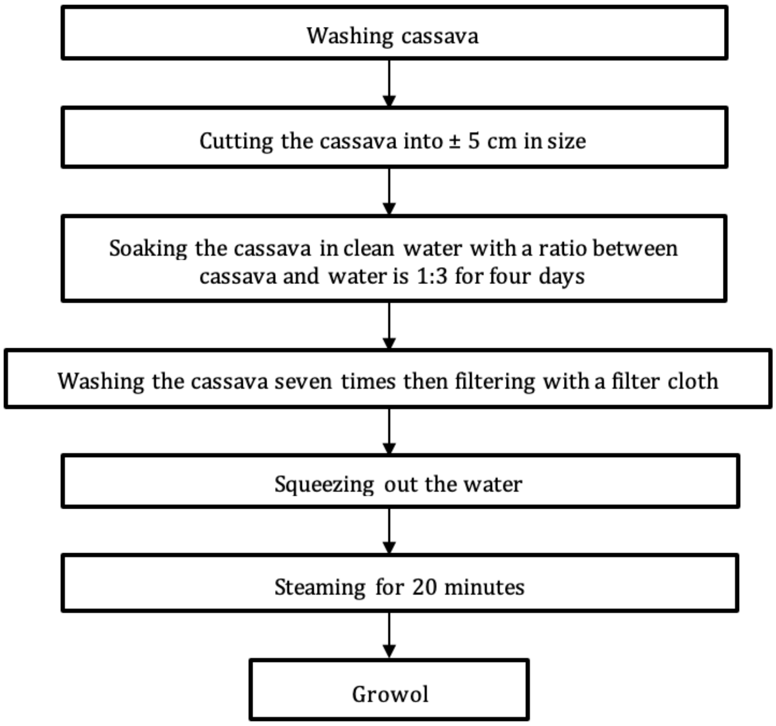

Figure 2. Gathotan Making Procedure

E. Quantitative Testing

Quantitative testing was carried out using the Nelson Somogyi method to determine the levels of reducing sugar and sucrose in each sample. Quantitative analysis was carried out using three replicates for each sample with absorbance readings using a spectrophotometer at a wavelength of 540nm.

F. Statistical Analysis

Qualitative test data were analyzed descriptively based on the results of observations. Meanwhile, quantitative test data were tested using One Way ANOVA at a significance level of 5%. If there is a difference between the groups, the test is continued with the Tukey test to find out the average difference in reducing sugar and sucrose levels in cassava, cassava tape, gathot, and growol.

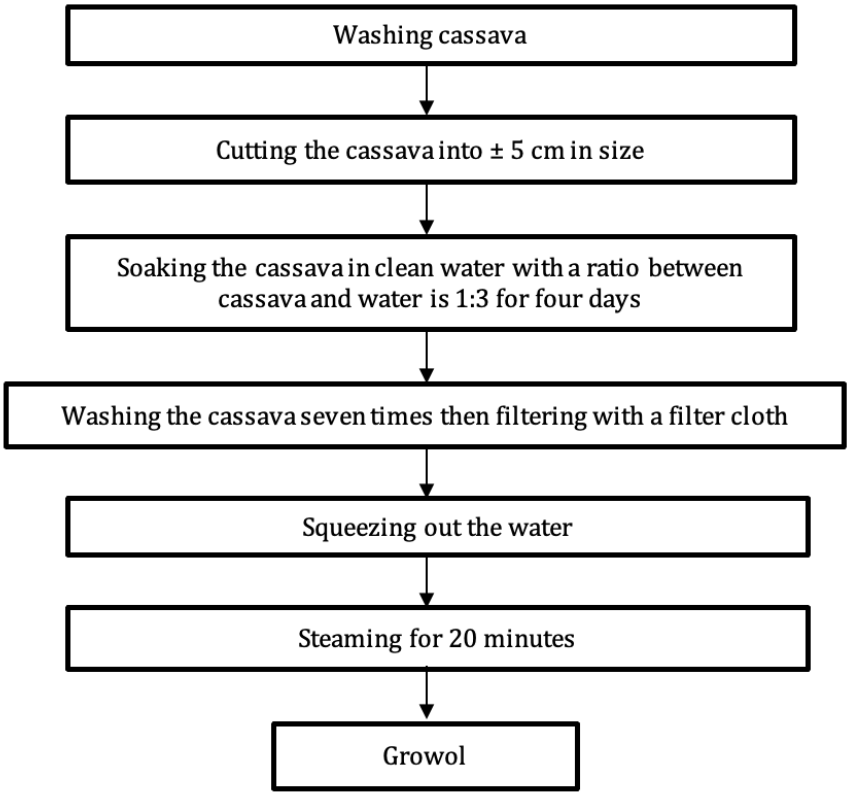

Figure 3. Growol Making Procedure

FINDINGS AND DISCUSSION

A. Finding

1. Final Characteristics of Cassava, Cassava Tape, Gathot, and Growol

Klentengan Cassava is cassava with specifications brownish green on the stem, dominantly red on the stalk followed by finger leaf segments. The outer skin of cassava is brown with a pale red inside. This white cassava tubers have a hard texture and a distinctive cassava smell. Cassava tape has a soft texture and crumbles easily with a yellowish-white final color accompanied by a residual white color from the *Yeast* used. The taste of tape is sweet and slightly sour with a distinctive aroma of alcohol. Gathot has a characteristic chewy texture, slightly sweet taste, blackish brown color, with a slightly sour aroma. Meanwhile, growol has a chewy texture like gathot with a dominant plain taste followed by a slightly sour taste, white color and slightly pungent aroma. The final products can be seen in **Figure 4**.

(a) (b) (c)

Figure 4 (a) Cassava Tape; (b) Gathot; (c) Growol

2. Qualitative Testing Results

The results of qualitative testing are used to describe the presence of carbohydrates based on their type. **Figure 5** is the result of the Molisch test. These results provide an overview regarding the presence of monosaccharides in cassava, cassava tape, gathot, and growol. All results show that all products contain monosaccharides with the appearance of a purple color or purple ring in the test sample.

(a) (b) (c) (d) (e)

Figure 5 (a) Standard (Glucose); (b) Cassava; (c) Cassava Tape; (d) Gathot; (e) Growol

Figure 6 shows the results of Benedict's test. This test illustrated the presence of reducing sugar which is indicated by the appearance of a brick red color in the test sample. The results of cassava, cassava tape, and gathot showed the presence of reducing sugars in the samples. While, the test results on growol showed no brick red color appearing which indicated qualitatively that growol did not contain reducing sugars.

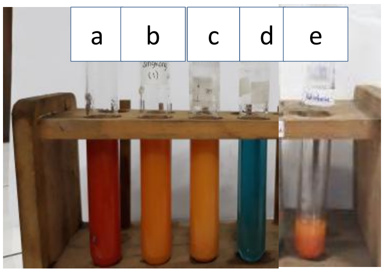

Figure 6 (a) Standard (Glucose); (b) Cassava; (c) Cassava Tape;

(d) Growol; (e) Gathot

Iodine test was only carried out on samples of cassava, cassava tape, gathot and growol (**Figure 7**). Appearance of blackish blue color in the sample indicated the presence of starch (cassava, growol, and gathot). While, the appearance of blackish brown color indicated the presence of glycogen (cassava tape).

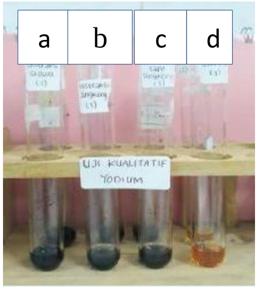

Figure 7 (a) Cassava; (b) Growol; (c) Gathot; (d) Cassava Tape

3. Quantitative Testing Results

The quantitative test results in **Table 1** showed that reducing sugars from lowest to highest levels were found in growol, cassava, gathot, and cassava tape respectively. Likewise, sucrose levels from lowest to highest were gathot, cassava tape, growol, and cassava. Based on statistical analysis, it is known that there are differences in reducing sugar and sucrose levels between cassava, cassava tape, gathot, and growol.

Table 1. Test Results for Reducing Sugar and Sucrose Levels

Sample	Reducing Sugar (%)		Sucrose (%)	
	Mean ± SD	p	Mean ± SD	p
Cassava	0.95 ± 0.01 [a]	<0.001*	4.77 ± 0.10 [a]	<0.001*
Cassava Tape	14.87 ± 0.06 [b]		1.47 ± 0.15 [b]	
Gathot	11.12 ± 0.03 [c]		0.78 ± 0.10 [c]	
Growol	0.32 ± 0.01 [d]		2.36 ± 0.01 [d]	

*One Way ANOVA (significant)
(a,b,c,d) in the same column shows a significant difference between groups (Tukey test)

B. Discussion

The difference in the final characteristics of cassava tape, gathot and growol is possible due to the fermentation processes differences between the products. Fermentation process of cassava tape occurs artificially (intentionally adding starter to cassava). While, gathot and growol fermentation processes occur spontaneously (without adding starter to cassava). In addition, differences in processing techniques for cassava tape, gathot, and growol also affect the differences in the microbial environment. Cassava tape runs into a steaming process first and is followed by a fermentation process by Saccharomyces cerevisiae. Gathot fermentation is carried out directly either openly under the sun or closed in sacks. After that, the gathot is steamed until cooked. Growol has a fermentation process that is almost similar to gathot, but growol fermentation is carried out openly during the cassava soaking process and then growol is steamed (Rahayu, 2003; Surono, 2016).

Fermentation of cassava into cassava tape, gathot and growol occurs in two stages. The first stage is the step in which amylolytic microbes break down complex carbohydrates (in this case starch) into simpler carbohydrates (such as simple sugars). In the next stage, simple sugars are broken down into acids and alcohols. The presence of a sour taste in cassava tape, gathot, and growol is possible due to the presence of an acidic compound (lactic acid) which is the final compound in the last stage of cassava fermentation (Purnomo, Lindayani and Hartayanie, 2013; Surono, 2016; Frediansyah, 2018). The white color in both cassava tape and growol is caused by the fermentation process carried out without direct contact with the air. Meanwhile, the fermentation process openly under the sun makes the cassava contact with the air so that the color of gathot is blackish brown. Furthermore, the making process difference also affects the difference in texture. During the fermentation process, cassava tissue is reshuffled which causes the texture of cassava tape to become softer (Frediansyah, 2018). For gathot and growol, the final process of making it, steaming, results in starch gelatinization so that the final texture of gathot and growol becomes chewier than the texture of cassava tape.

Based on qualitative testing, both cassava, cassava tape, gathot, and growol contain monosaccharides and polysaccharides. In addition, reducing sugar content was also detected in cassava, cassava tape, and gathot. Contrary to these results, it is proven that growol does not contain reducing sugars. The content of monosaccharides in a food can be tested using the Molisch test. This test is an initial test to detect the presence of carbohydrates in a food product. The reaction between 98% concentrated sulfuric acid and alpha naphthol causes the formation of a purple ring which indicates the presence of monosaccharides in the sample (Schreck and Loffredo, 2017; Pooja *et al.*, 2022). Reducing sugars including glucose, fructose, maltose and lactose are monosaccharides or disaccharides with free aldehydes, ketones, or hydroxyl hemiacetals (Zhang and Chen, 2020). Reducing sugar can be detected by Benedict's test. A change in the color of the solution to red or brick red is an indication of the reducing sugar presence in a sample. Reducing sugar will be converted into enediols through interaction with alkaline reagents (in this case Benedict's solution). The red color is formed due to the change of Cu (II) to Cu (I) in solution (Schreck and Loffredo, 2017; Pooja *et al.*, 2022). The presence of complex carbohydrates, polysaccharides, can be tested by the Iodine Test. This test is used to see the presence of starch which is indicated by the formation of a blue-black color in the test sample. The addition of this iodine solution will react with starch to form adsorption complex compounds that have a specific color, specifically for blue starch. Starch is composed of glucose units (monosaccharides) that form a helical chain due to the configuration of bonds in each glucose unit. In addition, this test is also used to prove the presence of glycogen which is indicated by the appearance of a dark brown color in the test (Schreck and Loffredo, 2017; Pooja *et al.*, 2022).

In line with the results of qualitative test, the quantitative test using the Nelson Somogyi method showed that the reducing sugar content of growol was only 0.32% (the lowest compared to other products). Then followed by the reducing sugar content of cassava, cassava tape, and gathot, namely 0.95%; 14.87%; and 11.12% respectively. The highest sucrose content was found in cassava (4.77%) and the lowest sucrose content was found in gathot (0.78%). Meanwhile, the difference in the levels of growol sucrose (2.36%) and cassava tape (1.47%) is not more than 1%. The results of the quantitative test showed that there were significant differences in the levels of reducing sugar and sucrose between cassava, cassava tape, gathot and growol ($p<0.001$).

Differences in the process of making cassava tape, gathot, and growol cause differences in the results of qualitative and quantitative tests on each product. The process of washing, steaming and fermenting in the making of cassava tape can affect the sucrose content of cassava tape. Fermentation using Saccharomyces cerevisiae increases the potential use of glucose as a substrate by converting glucose to alcohol and various other organic substances, while another microbe, Acetobacter, can break down alcohol into acid. In the cassava tape fermentation process, fermentation process is carried out for two days (48 hours). The cassava tape produced does not have a lot of alcohol content so it still tastes sweet which indicates that the sucrose level in cassava tape has not decreased much. This sweet taste determines that cassava tape has the highest sugar content compared to other fermented processed products.

When compared to its original form, namely cassava, gathot has a significantly lower sucrose content than cassava. This is influenced by the length of gathot fermentation, which is 10 days and the presence of treatments such as washing, drying, fermenting, soaking and steaming. The longer the fermentation is carried out, the sucrose will decrease because this sucrose is used as a substrate by microorganisms, namely lactic acid bacteria in spontaneous fermentation. Lactic acid bacteria from the Lactobacillus manihotivorans and Lactobacillus fermentum groups ferment saccharide substrates (sucrose and other simple sugars) for metabolism and growth.

In the growol making process, there are processes of washing, soaking, filtering, squeezing, pressing and steaming which can affect the sucrose content. Growol sucrose levels did not decrease much when compared to cassava and gathot. This is caused by the process of making growol is only carried out for four days, consist of soaking cassava followed by washing and squeezing using a cloth and then steaming until it becomes growol. The fermentation process will continue if the soaking of cassava is continued which can lead to reduced levels of sucrose in growol.

The fermentation process not only changes the texture, aroma, and taste of food but is able to change the nutritional composition of it. Many previous studies have proven that there is a change in the type of carbohydrates during the fermentation process (Surono, 2016; Sari, Puspaningtyas and Kusuma, 2017; Puspaningtyas, Sari and Kusuma, 2018). Studies on various fermented foods in Indonesia showed that fermentation can increase the reducing sugar content by 8.1%. There was an increase in reducing sugar levels from 7.9% on the first day of fermentation to 16% on the fourth day of fermentation. However, several studies have also shown a decrease in reducing sugars during the fermentation process (Surono, 2016; Indasah and Muhith, 2020). Fermentation of cassava into growol can reduce the reducing sugar content of cassava from 1.88% to 0.21%. In addition, fermentation is also able to reduce sucrose levels from 1.18% to 0.02% (Puspaningtyas *et al.*, 2019). The longer the fermentation process, the lower the sucrose content in the product. During the fermentation process, the breakdown of sucrose into glucose and fructose will occur. Furthermore, the existing glucose will be broken down into alcohol. This condition contributes to changes in reducing sugar levels in the fermentation process (Aryanta, 2000; Purnomo, Lindayani and Hartayanie, 2013; Surono, 2016).

Cassava tape has the highest reducing sugar content. The long fermentation process in making cassava tape allows the starter, Saccharomyces cerevisiae, to continue breaking down cassava starch. The more cassava starch is hydrolyzed, the simpler sugars are produced. The presence of simple sugars goes hand in hand with the presence of reducing sugars. The fewer simple sugars are produced, the fewer reducing sugars are produced, and otherwise.

Cassava has the highest sucrose content when compared to cassava tape, gathot and growol. Sucrose in cassava acts as the main substrate in the survival of microorganisms. Amylolytic microorganisms require sucrose in the fermentation process and will break down sucrose into glucose and fructose. Therefore, the sucrose content in cassava is higher than the sucrose content in cassava tape, gathot, and growol.

Previous studies stated that the main microorganisms involved in the fermentation process will provide different characteristics to the nutritional value of a product. Differences in the levels of crude protein and fiber in cassava products can be seen from the different microorganisms involved in the fermentation process. Moreover, the fermentation process can improve the digestibility of a food product (Polyorach *et al.*, 2018). Saccharomyces cerevisiae, Lactobacillus fermentum, Lactobacillus plantarum is the main microorganism that plays a role in the process of fermenting cassava tape. Lactobacillus plantarum 250 Mut 7 FNCC and Saccharomyces sp. TR7 plays an important role in the gathot fermentation process. Lactobacillus, Bacillus, Actinobacteria, Coryneform, Streptococcus, and Yeast involved in the growol fermentation process (Nuraida, 2015; Surono, 2016).

Fermented food is a healthy food choice, especially in terms of probiotic and prebiotic potential. Fermented foods are not only capable of increasing the ability of the digestibility of nutrients but can have a beneficial effect on the balance of microflora. Regular consumption of fermented foods can improve digestive tract function, increase immunity, control weight, etc (Jalili, Nazari and Magkos, 2023). Testing for reducing sugar and sucrose levels has an important role in relation to the potential of cassava fermented products as a healthy snack, especially in the prevention and treatment of obesity. Growol is proven to have low reducing sugar and sucrose content. Therefore, growol has the potential to be used as a fermented product that can be consumed by obese people.

A study on the relationship between sugar intake and obesity in European adolescents (HELENA Study) showed that total energy intake in male adolescents was 2813.49 kcal with sugar intake reaching 102.6 grams (14.26% of total intake). Meanwhile, female adolescents consumed daily calories of 2156.17 kcal with sugar intake reaching 87.58 grams (16.03% of total intake). There is a correlation between free sugar consumption and fat mass index in female adolescents. The risk of obesity increased in the group with the consumption of fruit and vegetable juices with added sugar. Furthermore, both boys and girls consume high sugar with low fiber (Flieh *et al.*, 2020).

In addition to simple sugars, consumption of foods high in sucrose is closely related to the incidence of obesity, which can increase body weight, waist circumference, adipose tissue, and inflammation, considering that sucrose can provide energy of 4 kcal/gram (Kuhnle *et al.*, 2015; Lin *et al.*, 2016; Togo *et al.*, 2019; Magriplis *et al.*, 2021; Setyaningrum, Sutoyo and Atmaka, 2021). A study conducted on 25,639 healthy men and women in the EPIC-Norfolk study showed that sucrose intake is related to obesity biomarker (Kuhnle *et al.*, 2015). Sucrose consumption has been shown to cause or increase the risk of metabolic syndrome, such as increased triglycerides, decreased HDL, promoted insulin resistance and glucose intolerance, increased blood glucose, increased blood pressure and weight gain (DiNicolantonio and Berger, 2016). Other studies proved that consumption of foods high in sucrose and fructose can lead to weight gain and increase the risk of overweight and obesity. Diets high in sucrose and fructose also increase the risk of metabolic diseases in obese subjects through increased risk of NAFLD (Nonalcoholic Fatty Liver Disease), liver damage, decreased energy expenditure on the body, and oxidative reactions in the kidneys (Setyaningrum, Sutoyo and Atmaka, 2021). The addition of excess sugar (including sucrose) has an impact on changes in the sensation of fullness (in terms of changes in leptin levels and the incidence of insulin resistance in the body) (Magriplis *et al.*, 2021).

The low levels of reducing sugar and sucrose in growol can be a healthy snack options for individuals who are obese and or overweight. Previous studies have described the growol potential as a healthy snack in terms of the decreased levels of total sugar, reducing sugar, and sucrose and also increased levels of total dietary fiber, water soluble dietary fiber, and water insoluble dietary fiber after the fermentation process. During the fermentation process, there was an increase in food fiber content by 25% in growol compared to cassava with an increase in water insoluble and water-soluble dietary fiber by 24.9% and 34.9%, respectively. Increased levels of dietary fiber in growol have the potential to become a source of prebiotics that can improve the gastrointestinal microbiota (Puspaningtyas *et al.*, 2019).

In addition, an increase in fiber content in growol has the potential to reduce the glycemic index of foodstuffs. Foods with a low glycemic index accompanied by high fiber can reduce fasting blood glucose levels by 9.97-15.3 mg/dL and reduce HbA1c levels by 0.26-0.55%. Furthermore, dietary fiber plays a role in selectively stimulating the digestive tract microbes in producing short chain fatty acids (SCFA) which will play an important role in the regulation of energy metabolism, provide satiety, increase insulin sensitivity and improve lipid profiles (Vinelli *et al.*, 2022). In other words, the balance of the digestive tract microbiota will maintain energy balance which will have an effect on weight regulation (Cerdó *et al.*, 2019; Megur *et al.*, 2022; Santos, Filho and Nunes, 2022).

An in vitro study also proves that the fiber content in growol can increase the potential of prebiotics in terms of the increasing number of good bacteria, Lactobacillus sp., in in vitro testing (Sari and Puspaningtyas, 2019). A study conducted on 86 participants showed that consumption of 20 grams of fiber per day was able to increase the number of Parabacteroides and Bifidobacterium and balance the gastrointestinal microbiota (Santos, Filho and Nunes, 2022). Similar studies also prove that giving prebiotics can increase the growth of Lactobacillus and Bifidobacterium in the digestive tract, and can reduce pathogenic bacteria such as Firmicutes and Bacteroidetes. This microbiota balance supports the achievement of body homeostasis and has an impact on body weight control, blood sugar, lipid profile, and inflammation (Cerdó *et al.*, 2019).

Growol's potential as a healthy snack has also been proven through the use of growol flour in a preclinical study. Implementation of growol flour in the diet can reduce fasting blood sugar levels and increase insulin sensitivity. There was a decrease in fasting blood glucose levels of 99 – 152 mg/dL and an increase in insulin levels of 32 -86 pg./mL (Nofia, Wasita and Susilawati, 2022).

The potential of growol and other cassava-based fermented foods as healthy foods can be studied in more detail through the study of amylose and amylopectin. Amylose is an unbranched polymer which together with amylopectin compile a component of starch. The levels of amylose and amylopectin in food determine the content of resistant starch in foodstuffs which will certainly be beneficial for obesity, especially in terms of improving glycemic control (Aini, Wijonarko and Sustriawan, 2016).

CONCLUSION

The results of qualitative and quantitative tests proved the presence of carbohydrates in cassava, cassava tape, gathot, and growol products. growol is a cassava-based fermented food that can be used as an alternative functional food, especially in the prevention and treatment of obesity, in terms of sucrose and reducing sugar levels.

LIMITATION & FURTHER RESEARCH

Of course, this study has weaknesses considering that qualitative tests are carried out subjectively and require accuracy and expertise in assessing changes in each test. Further studies related to the potential of growol in terms of levels of dietary fiber, resistant starch, amylose, amylopectin need to be carried out to further prove the role of growol as a healthy snack. Studies related to the clinical effects of consumption of cassava-based fermented foods can be carried out to further strengthen the evidence of the function of fermentation in treating health problems, especially in terms of changes or control of body weight, blood glucose levels, levels of lipid profile, insulin sensitivity, and others.

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