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Satiety and glycemic control after giving glucomannan-modified growol cookies

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ABSTRAK

Latar Belakang: *Obesitas sudah menjadi epidemi di seluruh bagian dunia. Satu dari lima kematian berkaitan dengan predisposisi obesitas. Pemberian makanan tinggi serat dapat menjadi solusi dalam penanganan obesitas. Penambahan glukomanan ke dalam cookies growol dapat mengoptimalkan kandungan serat pangan yang akan berefek pada kontrol rasa kenyang dan kontrol glikemik.*
Tujuan: *Untuk mempelajari pengaruh pemberian cookies growol modifikasi glukomanan terhadap perubahan rasa kenyang dan kadar glukosa darah pada subjek berat badan berlebih dan subjek normal sebagai alternatif makanan sehat dalam rangka pencegahan obesitas.*
Metode: *: Penelitian quasi-eksperimental dengan rancangan pre-post without control group dilakukan kepada 30 subjek (15 subjek berat badan normal dan 15 subjek berat badan berlebih). Penelitian dilaksanakan di Universitas Respati Yogyakarta pada Juni-Juli 2023. Uji rasa kenyang dilakukan menggunakan metode SLIM (Satiety Labeled Intensity Magnitude). Pengukuran glukosa darah dengan metode Rapid Test menggunakan Easy Touch GCU dilakukan sebelum, segera setelah, dan 120 menit setelah pemberian cookies. Data pengujian rasa kenyang dan kadar glukosa darah secara berurutan dianalisis dengan Wilcoxon Signed Ranks Test dan Paired Sample Test (membandingkan sebelum dan sesudah intervensi) serta Mann Whitney U Test dan Independent SampleTest (membandingkan antar kelompok) dengan signifikansi 95%.*
Hasil: *Terdapat perbedaan rasa kenyang antara menit ke-0, menit ke-30, menit ke-60 hingga menit ke-90 dibandingkan dengan rasa kenyang awal (basal) pada keseluruhan kelompok ($p<0,05$). Tidak terdapat perbedaan kadar glukosa darah antara glukosa darah puasa, glukosa darah menit ke-0, dan glukosa darah menit ke-120. Pemberian cookies growol modifikasi glukomanan dapat menunda rasa lapar selama 1-1,5 jam sebelum waktu makan besar berikutnya. Pemberian cookies growol modifikasi glukomanan dapat menjaga stabilitas glukosa darah pada rentang 90 mg/dL.*
Kesimpulan: *Pemberian cookies growol modifikasi glukomanan dapat memberikan efek positif terhadap kontrol rasa kenyang dan kontrol glikemik.*

KATA KUNCI*: cookies growol; glukomanan; kontrol glikemik; obesitas; rasa kenyang*

ABSTRACT

Background: *Obesity has become an epidemic in all parts of the world. One in five deaths is related to obesity predisposition. Providing foods high in fiber can be a solution to treating obesity. The addition of glucomannan to growol cookies can optimize the fiber content of food which will have an effect in controlling satiety and glycemic control.*

Objectives: *To study the effect of glucomannan-modified growol cookies, as a healthy snack in the context of preventing obesity, on changes in satiety and blood glucose levels in excessive-weight subjects (ES) and normal-weight subjects (NS).*

Methods: *: A quasi-experimental study with a pre-post design without a control group was conducted on 30 subjects (15 NS and 15 ES). The research was carried out at Universitas Respati Yogyakarta in June-July 2023. The satiety test was carried out using the SLIM (Satiety Labeled Intensity Magnitude) method. Blood glucose levels were measured using the Rapid Test method using Easy Touch GCU before, immediately after, and 120 minutes after giving cookies. Data on satiety and blood glucose levels were sequentially analyzed using the Wilcoxon Signed Ranks Test and Paired Samples T Test (comparing before and after intervention) as well as the Mann-Whitney U Test and Independent Samples T Test (comparing between groups) with a significance of 95%.*

Results: *There was a difference in the feeling of fullness between the 0th minute, 30th minute, 60th minute, and 90th minute compared to the initial feeling of fullness (basal) in the entire group ($p<0.05$). There was no difference in blood glucose levels between fasting blood glucose, 0-minute blood glucose, and 120-minute blood glucose. Glucomannan-modified growol cookies can delay hunger for 1-1.5 hours before the next big meal. Glucomannan-modified growol cookies can also maintain blood glucose stability in the range of 90 mg/dL.*

Conclusions: *Glucomannan-modified growol cookies can have a positive effect on satiety control and glycemic control.*

KEYWORD***:*** *glucomannan; glycemic control; growol cookies; obesity; satiety*

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INTRODUCTION

Obesity has become an epidemic in all parts of the world. In 2017 globally there were one in five deaths related to obesity predisposition, such as high intake of salt and fat and low intake of fiber. Obesity accounts for 10-13% of deaths in various European regions. Data from the WHO European Childhood Obesity Surveillance Initiative (COSI) shows that almost 40% of boys aged 6 to 9 years are overweight and almost 20% are obese (1). Overweight and obesity rates have continued to increase over the years. In Indonesia, there has been an increase in the prevalence of overweight and obesity from 28.9% in 2013 to 35.4% in 2018. It is due to the increasing intake of unhealthy foods (2).

Obesity is related to the development of various diseases, such as cardiovascular disease, diabetes mellitus, chronic kidney disease, and others (3,4). Similar studies show that obesity contributes to the incidence of insulin resistance (5,6), and of course this will have an impact on increasing the incidence of diabetes 2-5 times higher than conditions with normal nutritional status (7,8).

In obesity, hormone metabolism disorders occur, one of which is leptin. Serum leptin levels were positively correlated with body mass index (BMI) (r=0.871), waist circumference (r=0.695), and waist-to-hip ratio (r=0.485). The disturbances in leptin metabolism can affect the ability to suppress appetite, so that obese individuals feel hungry more quickly. This appetite suppression disorder will have an effect on changes in insulin function which is characterized by non-optimal glycemic control (9,10).

Weight management or weight loss therapy provided 77.1% success in reducing the risk of disease progression (11). One arrangement that can be made is to reduce the consumption of simple sugars and increase the consumption of dietary fiber (7,8). One food product with good fiber content is growol (12–14). Growol has been developed in the form of cookies, and growol cookies have been modified using inulin to increase the effectiveness of the fiber in the cookies (15,16). However, the addition of inulin has a weakness in terms of the texture of the cookies produced, in which cookies tend to be more brittle and break easily (17). In the creation of growol cookies, glucomannan, a kind of water-soluble fiber, may be utilized in place of inulin. Glucomannan can be acted as a surfactant, thickener, binder, and emulsifier (18,19).

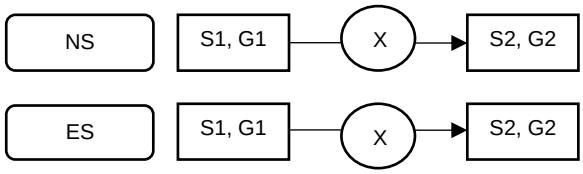
Furthermore, a study shows that glucomannan can be used as a solution in a weight loss program. Glucomannan is able to improve glycemic control (20,21). Studies in obese individuals show glucomannan has inhibitory effects on increase in glucose and insulin (22). This is because administration of glucomannan can provide a sensation or feeling of fullness and also increase stool output (20,21). Increased mastication due to the addition of glucomannan provides time for the digestive tract and brain to recognize the feeling of fullness. The slower absorption resulting from the use of glucomannan delays the release of insulin which will delay the sensation of hunger and prevent an increase in blood glucose levels (20,21,23,24).

To the best of our knowledge, studies on the addition of glucomannan to growol cookies on changes in satiety and blood glucose levels have never been carried out. The results of this study eventually will provide information regarding the role of glucomannan in growol cookies in controlling satiety and glycemic control, so that it can be used as a basis for developing healthy food products for obesity treatment.

MATERIALS AND METHODS

Research Design

This was a quasi-experimental research with a pre-post design without control group. The study examined the effect of glucomannan-modified growol cookies on satiety and blood glucose levels changes before and after the intervention in the normal-weight subjects (NS) and excessive-weight subjects (ES). The research design is as in **Figure 1**.



NS : Normal-weight subjects
ES : Excessive-weight subjects
X : Intervention of glucomannan-modified growol cookies
S1 : Satiety test before giving glucomannan-modified growol cookies
S2 : Satiety test after giving glucomannan-modified growol cookies
G1 : Blood glucose level before giving glucomannan-modified growol cookies
G2 : Blood glucose level after giving glucomannan-modified growol cookies

Figure 1. Research design for satiety and glycemic control after giving glucomannan-modified growol cookies

The research was conducted at Universitas Respati Yogyakarta, specifically in the Dietetics and Culinary Laboratory. Data collection was carried out from June to July 2023. This research has been declared ethically by the Health Research Ethics Commission, Faculty of Health Sciences, Universitas Respati Yogyakarta with the issuance of a certificate of ethical suitability with number 056.3/FIKES/PL/V/2023. This research consisted of several stages, namely: 1) screening research subjects, 2) making glucomannan-modified growol cookies, and 3) testing satiety and blood glucose levels.

Research Subject

The population in this study were adults at Universitas Respati Yogyakarta. The subjects were adults taken from Universitas Respati Yogyakarta who met the inclusion and exclusion criteria. Inclusion criteria include age 19-30 years, willing to be a subject by signing informed consent, no history of infectious/metabolic diseases related to nutrition, not currently on a weight loss program in the last six months, not taking drugs that affect appetite, no smoking, not being pregnant and not

breastfeeding for female subjects, having a BMI of 18.5–25 (for the NS), and having a BMI >25 (for the ES). Meanwhile, the exclusion criteria for subjects were having an intolerance to the use of dietary fiber, having a current blood glucose level of >200 mg/dL, and having a blood pressure of >160/100 mmHg.

The size of the research subjects was determined using the experimental research formula with a significance level of 95% (1.96) and a test power of 80% (0.84). The average difference between groups was obtained from previous research, namely 15.39 for the difference in satiety (25) and 198.8 for the difference in blood glucose levels (26). The size of the research subjects was determined based on the largest calculation of the average difference between groups so that the number of subjects was 10 people in each group. The estimated dropout is 10%, so the minimum number of subjects needed in this study is 11 people in each group.

Subject Screening

At the screening stage, interviews were conducted with the subjects regarding date of birth, history of illness, history of diet and food allergies, history of drug consumption, smoking habits, pregnancy and/or breastfeeding status. In addition, body weight, height, blood pressure, and blood glucose were measured at that time. The instruments used at the screening stage include a screening form, a digital scale with an accuracy of 0.1 kg, a microtoa with an accuracy of 0.1 cm, an Omron digital blood pressure monitor, and an Easy Touch GCU blood glucose checker.

Preparation of glucomannan-modified growol cookies

Making process of glucomannan-modified growol cookies is carried out in several stages, starting from preparing the growol and glucomannan raw materials. Growol is obtained from local farmers in Kulon Progo Yogyakarta. Next, the growol is processed into flour referring to the previous study (12), with the following steps: 1) the growol is sliced into thin pieces, 2) the growol is dried in a cabinet dryer at a temperature of 80 degrees Celsius for six hours, 3) the growol is ground using a grinder, and 4) the growol is sifted using a 60 mesh sieve. Meanwhile, the glucomannan used is porang glucomannan obtained from the Department of Food and Agriculture Products Technology, Faculty of Agricultural Technology, Universitas Gadjah Mada.

After the growol flour is ready, the ingredients for making cookies are prepared, including wheat flour, skim milk, butter, egg yolks, baking powder, non-calorie sugar, and cornstarch. The process of making growol cookies refers to previous studies (15,16). However, inulin was replaced with 4% glucomannan. The percentage of glucomannan use refers to the effective limit of glucomannan consumption of 1-4 grams per day (20). The instruments used at this stage include digital food scales, knives, cutting boards, ovens, grinders, sieves, bowls, spoons, mixers, cake molds, baking sheets, and microwave ovens.

Satiety and glycemic control measurement

One day before the measurement, subjects were asked to fast for 9-10 hours from 21.00 to 07.00 the next day. On the day of measurement, subjects were first measured for morning satiety (basal) and fasting blood glucose levels. Next, the subjects were asked to consume glucomannan-modified growol cookies. Then, satiety and glycemic control (measured as blood glucose) were measured until the 120th minute.

Satiety data were carried out through interviews and filling out questionnaires using the 100 mm Satiety Labeled Intensity Magnitude (SLIM) bipolar scale questionnaire. Because of SLIM's ease of use, simplicity, and sensitivity in measuring perception in response to varying food intake composition, SLIM has been suggested. When compared to other outlined methods, the SLIM exhibits good accuracy and allows for better discriminating (27).

Measurement of satiety was carried out in the morning (basal), 0th, 30th, 60th, 90th, and 120th minutes after consuming glucomannan-modified growol cookies. Subjects are directed to put a mark on the line or number that indicates the satiety score. Satiety scoring includes: 1) neither hungry nor full (0); 2) slightly hungry (-18.6); 3) moderately hungry (-38.2); 4) very hungry (-56.2); 5) extremely hungry (-67.4); 6) greatest imaginable hunger (-100); 7) slightly full (31.9); 8) moderately full (46.7); 9) very full (74.3); 10)

extremely full (79.4); and 11) greatest imaginable fullness (100) (25,27).

Blood glucose levels were measured before giving cookies, immediately after (minute 0) giving cookies, and 120 minutes after giving cookies. Measurements are made using blood from the fingertip, in units of mg/dL. Tools for measuring blood glucose levels include alcohol swabs, lancets, lancet pens, glucose strips, glucose chips, GCU easy-touch tools, tissue, and medical waste plastic.

Data Analysis

Data on satiety and blood glucose levels were first analyzed for data distribution using the Shapiro-Wilk test. Normally distributed blood glucose data is indicated by $p>0.05$, and satiety data is not normally distributed ($p<0.05$). Differences in satiety between the NS and ES groups were tested using the Mann-Whitney U Test, while differences in satiety in each group were tested using the Wilcoxon Signed Ranks Test. Differences in blood glucose levels between the NS and ES groups were tested using the Independent Samples T Test, while differences in blood glucose levels in each group were tested using the Paired Samples T Test. The significance level used is 95%.

RESULTS AND DISCUSSIONS

Subject Screening

The screening was carried out on Monday, July 24, 2023. The screening was conducted on 35 potential subjects from the Nutrition Program, Nursing Program, and Public Health Program. Thirty-three subjects met the inclusion and exclusion criteria, one subject did not meet the inclusion criteria because he had a smoking habit, and one did not meet the criteria because her BMI was <18.5. However, only 30 subjects were involved in the research because three subjects were unwilling to participate. Table 1 presents the subject's age, weight, height, body mass index, random blood glucose, and blood pressure.

Excess body weight is a condition of excess body mass which is characterized by a body mass index (BMI) >25 kg/m2 for the overweight category and BMI >27 kg/m2 for obese category (28). In this study, the average of BMI score of the ES group was 31.62 kg/m2. The ES group had higher body weight, blood glucose levels, and blood pressure than the NS group.

Table 1. Characteristics of Subjects

Characteristics	Group	*Mean±SD*	*p*
Age (years)	NS	21.4±0.83	0.512**
	ES	22(20-23)*	
Body weight (kg)	NS	51.57±5.61	<0.001***,#
	ES	77.76±11.11	
Body height (cm)	NS	157.63±4.94	0.768***
	ES	157.06±5.60	
Body mass index (kg/m^2)	NS	20.73±1.80	<0.001***,#
	ES	31.62±5.00	
Random blood glucose (mg/dL)	NS	88.40±13.17	0.564***
	ES	91.13±12.49	
Systolic blood pressure	NS	110(99-136)*	0.116**
	ES	119.13±11.67	
Diastolic blood pressure	NS	77(71-95)*	0.041**,##
	ES	83.20±9.59	

NS: Normal-weight subjects
ES: Excessive-weight subjects
*Median(minimum-maximum)
**Mann-Whitney U Test
***Independent Samples T Test
#significant at p<0.001
##significant at p<0.05

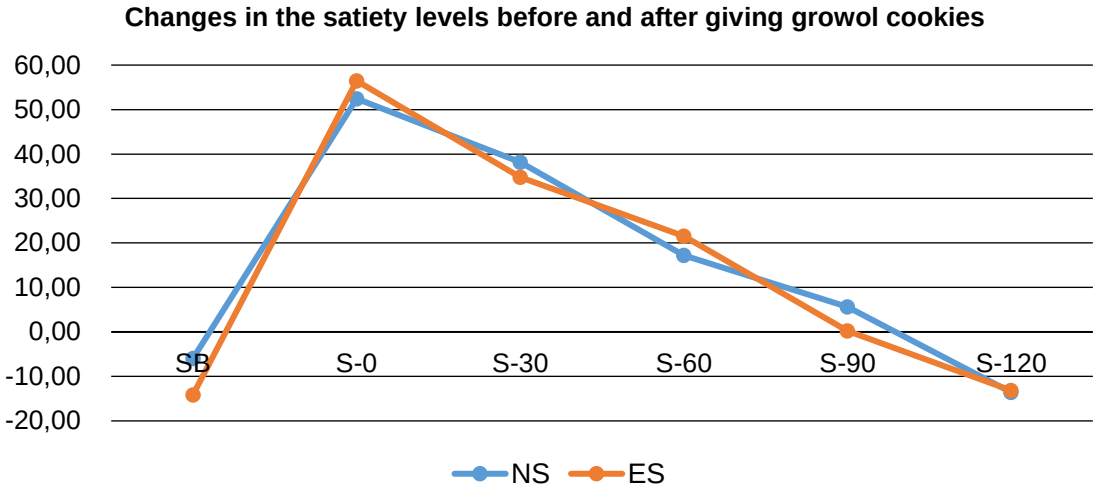
Preparation of glucomannan-modified growol cookies

The dose of glucomannan-modified growol cookies given to the subject ranges from 10-15% of the total energy consumed each time. The energy in 100 grams of glucomannan-modified growol cookies is 488.63 kcal (29). Regarding Indonesia's nutritional adequacy, the

recommended energy consumption for adults is 2,150 kcal. The recommended snack consumption at each meal is around 10-15% (30), so the range for snack consumption at one time is 215 kcal to 322.5 kcal. The size of one piece of growol cookies is around 8 grams, so to reach the minimum fulfillment range of 215 kcal, each subject will get and consume as many cookies as 6 pieces.

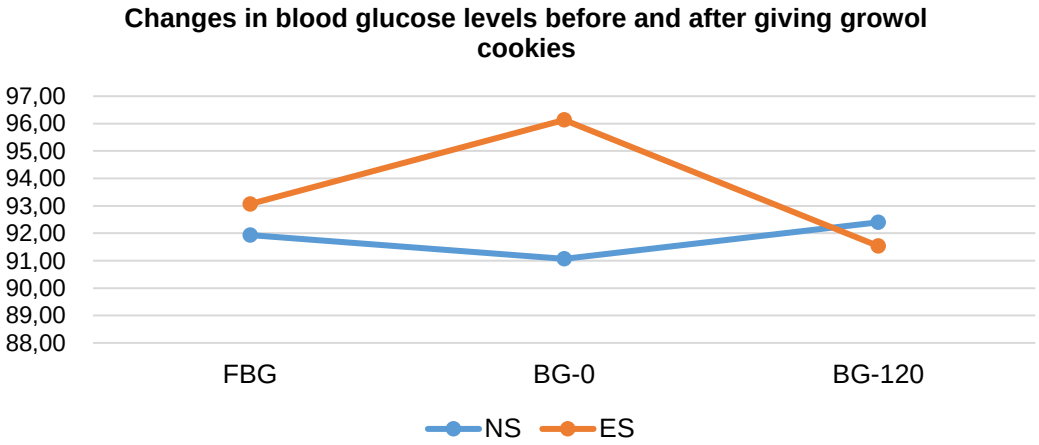
Satiety and glycemic control measurement

Satiety and glycemic control measurement were conducted on Friday, July 28 2023. On the day of measurement, the subject was first measured for initial satiety (basal) and fasting blood glucose levels, and then the subject was asked to consume glucomannan-modified growol cookies equivalent to the snack nutritional value content. After consuming glucomannan-modified growol cookies, subjects received measurements of satiety and blood glucose levels up to the 120th minute. **Figure 1** and **Figure 2** describe the changes of satiety levels and blood glucose levels before and after consuming growol cookies, consecutively.



NS: Normal-weight subjects; ES: Excessive-weight subjects; SB: initial satiety (basal); S-0: 0th minute satiety; S-30: 30th minute satiety; S-60: 60th minute satiety; S-90: 90th minute satiety; S-120: 120th minute satiety

Figure 1. Changes in the satiety levels before and after consuming growol cookies



NS: Normal-weight subjects; ES: Excessive-weight subjects; FBG: fasting blood glucose; BG-0: 0th-minute blood glucose; BG-120: 120th-minute blood glucose

Figure 2. Changes in the blood glucose levels before and after consuming growol cookies

Table 2 shows the differences of initial satiety (basal) with satiety after cookies consumption (starting from the 0th minute to the 120th minute) both in all subjects, the NS group, and the ES group. The Wilcoxon Signed Ranks Test result showed that there were differences in the feeling of fullness between the 0th minute, 30th minute, 60th minute, and 90th minute compared to the initial satiety (basal) in the entire group. Meanwhile, in both the NS group and ES group, there was a difference in the feeling of fullness between the 0th minute, 30th minute, and 60th minute compared to the initial satiety (basal). (34).

Table 2. Initial satiety and 0–120 minutes satiety after cookies consumption

Group	N	Satiety	*Median (Minimum–Maximum)*	*p*
Total	30	SB	-18.60 (-56.20 – 46.70)	<0.001*
		S-0	46.70 (0.00 – 100.00)	
		SB	-18.60 (-56.20 – 46.70)	<0.001*
		S-30	35.95 (-20.00 – 80.00)	
		SB	-18.60 (-56.20 – 46.70)	<0.001*
		S-60	15.95 (-38.20 – 74.30)	
		SB	-18.60 (-56.20 – 46.70)	0.041**
		S-90	-18.60 (-38.20 – 74.30)	
		SB	-18.60 (-56.20 – 46.70)	0.614
		S-120	-18.60 (-40.00 – 46.70)	
NS	15	SB	-18.60 (-38.20 – 46.70)	0.001**
		S-0	46.70 (0.00 – 79.40)	
		SB	-18.60 (-38.20 – 46.70)	0.002**
		S-30	40.00 (0.00 – 74.30)	
		SB	-18.60 (-38.20 – 46.70)	0.046**
		S-60	0.00 (-38.20 – 74.30)	
		SB	-18.60 (-38.20 – 46.70)	0.260
		S-90	0.00 (-38.20 – 46.70)	
		SB	-18.60 (-38.20 – 46.70)	0.406
		S-120	-18.60 (-40.00 – 31.90)	
ES	15	SB	0.00 (-56.20 – 0.00)	0.001**
		S-0	46.70 (31.90 – 100.00)	
		SB	0.00 (-56.20 – 0.00)	0.001**
		S-30	31.90 (-20.00 – 80.00)	
		SB	0.00 (-56.20 – 0.00)	0.003**
		S-60	31.90 (-20.00 – 74.30)	
		SB	0.00 (-56.20 – 0.00)	0.123
		S-90	-18.60 (-38.20 – 74.30)	
		SB	0.00 (-56.20 – 0.00)	0.969
		S-120	-18.60 (-40.00 – 46.70)	

NS: Normal-weight subjects
ES: Excessive-weight subjects
SB: initial satiety (basal)
S-0: 0th minute satiety
S-30: 30th minute satiety
S-60: 60th minute satiety
S-90: 90th minute satiety
S-120: 120th minute satiety
*significant at p<0.001
**significant at p<0.05

Table 3 presents the differences in satiety test results between the NS and ES groups. The results using the Mann-Whitney U Test showed no significant difference in the level of satiety between the groups. Furthermore, based on the result in **Table 2**; all subjects indicated slightly hungry. This is because the subject has fasted during the night to empty the stomach. This feeling of hunger arises due to the stimulus of empty stomach contractions (25). However, shortly after consuming cookies, overall, the subjects felt moderately full (score 46.7) compared to the initial satiety (basal) of being slightly hungry (score -18.6) or neither hungry nor full (score 0). This

feeling of fullness lasts until 60 minutes after consumption of cookies. At the 90th minute, the subjects began to feel hungry again, marked by a score of -18.60 in the overall group and the ES group. Meanwhile, in the NS group, the satiety was at a score of 0 (neither hungry nor full), and they started to feel slightly hungry (score -18.6) at the 120th minute. (36).

Table 3. Differences in satiety levels between normal-weight subjects and excessive-weight subjects

Satiety	Group	*Median (Minimum–Maximum)*	*p*
initial satiety (basal)	Normal-Weight Subjects	-18.60(-38.20 – 46.70)	0.683
	Excessive-Weight Subjects	0.00 (-56.20 – 0.00)	
0th minute satiety	Normal-Weight Subjects	46.70 (0.00 – 79.40)	0.806
	Excessive-Weight Subjects	46.70 (31.90 – 100.00)	
30th minute satiety	Normal-Weight Subjects	40.00 (0.00 – 74.30)	0.838
	Excessive-Weight Subjects	31.90 (-20.00 – 80.00)	
60th minute satiety	Normal-Weight Subjects	0.00 (-38.20 – 74.30)	0.806
	Excessive-Weight Subjects	31.90 (-20.00 – 74.30)	
90th minute satiety	Normal-Weight Subjects	0.00 (-38.20 – 46.70)	0.461
	Excessive-Weight Subjects	-18.60 (-38.20 – 74.30)	
120th minute satiety	Normal-Weight Subjects	-18.60 (-40.00 – 31.90)	0.806
	Excessive-Weight Subjects	-18.60 (-40.00 – 46.70)	

Table 4 presents a comparison of blood glucose levels between fasting blood glucose, immediately after cookies consumption, and 120 minutes after cookies consumption in all subjects, the NS group, and the ES group. Paired Samples T Test result showed no difference in blood glucose levels between fasting, immediately, and 120-minute (postprandial), where the average blood glucose level in the entire group was 90 mg/dL.

Table 4. Comparison of blood glucose levels between fasting, immediately and 120 minutes after consuming cookies

Group	N	Blood Glucose	*Mean±SD*	*p*
Total	30	FBG	92.50±11.66	0.409
		BG-0	93.60±13.91	
		FBG	92.50±11.66	0.801
		BG-120	91.97±8.87	
		BG-0	93.60±13.91	0.485
		BG-120	91.97±8.87	
NS	15	FBG	91.93±11.86	0.571
		BG-0	91.07±12.27	
		FBG	91.93±11.86	0.892
		BG-120	92.40±7.82	
		BG-0	91.07±12.27	0.692
		BG-120	92.40±7.82	
ES	15	FBG	93.07±11.85	0.164
		BG-0	96.13±15.38	
		FBG	93.07±11.85	0.558
		BG-120	91.53±10.08	
		BG-0	96.13±15.38	0.168
		BG-120	91.53±10.08	

NS: Normal-weight subjects
ES: Excessive-weight subjects
BG-120: 120th-minute blood glucose
FBG: fasting blood glucose
BG-0: 0th-minute blood glucose

Table 5 shows the differences in blood glucose levels between the NS group and the ES group. Test results using the Independent Samples T Test showed no significant difference in blood glucose levels between the groups, even though fasting blood glucose levels and blood glucose levels immediately after consumption of cookies were higher in the ES group than in the NS group.

Table 5. Differences in blood glucose levels between normal-weight subjects and excessive-weight subjects

Glukosa Darah	Kelompok	*Mean±SD*	*p*
Fasting Blood Glucose	Normal-Weight Subjects	91.93±11.86	0.795
	Excessive-Weight Subjects	93.07±11.85	
0th-minute blood glucose	Normal-Weight Subjects	91.07±12.27	0.327
	Excessive-Weight Subjects	96.13±15.38	
120th-minute blood glucose	Normal-Weight Subjects	92.40±7.82	0.794
	Excessive-Weight Subjects	91.53±10.08	

In this study, it was seen that the addition of glucomannan in growol cookies is able to provide a feeling of fullness for up to 90 minutes. This is in accordance with the purpose of giving growol cookies. The glucomannan-modified growol cookies will be used as a snack in which the provision of snacks is around 10-15% of the total energy in each consumption. Apart from that, providing snacks is also expected to delay hunger for 1-2 hours before the next big meal.

Glucomannan is a type of water-soluble dietary fiber that is easily fermented. Glucomannan can be extracted from konjac and porang. Glucomannan consists of a polysaccharide with a chain of beta-D-glucose and beta-D-mannose linked to an acetyl group at a beta-1,4 bond. The structure of glucomannan is not easily changed by the body, allowing digestive tract bacteria to ferment it (31). This is why glucomannan has health benefits.

A similar study using high-fiber food ingredients made from modified cassava flour (mocaf) and banana blossoms proved that adding fiber to a food product can reduce hunger scores from 54.4 to 12.8. In addition, adding fiber can also increase feelings of fullness from a score of 6.9 to 49.0 (32).

As a source of fiber, glucomannan can be used as a solution in a weight loss program by controlling satiety. Previous studies have shown that a dose of glucomannan of 2-4 grams per day is a dose that is easily tolerated and produces significant weight loss in individuals with overweight and obesity (20,21). Preclinical studies using glucomannan from porang flour showed that the administration of glucomannan was able to reduce body weight and food intake in test groups induced by a high-fat diet (23). The recommended dose varies from 1 to 4 grams per day and can be given one hour before the main meal (20).

Glucomannan can increase the sensation of fullness through several mechanisms. Increased mastication due to the addition of glucomannan provides time for the digestive tract and brain to recognize the feeling of fullness (20,21). There is a significant relationship between mastication speed and an increase in body mass index. This is related to changes in an appetite due to the action of leptin, glucagon-like peptide-1 (GLP-1), peptide YY, cholecystokinin, and ghrelin (33). Previous studies have also proven that food intake after the hunger phase can increase the feeling of fullness because organic molecules derived from food can stimulate the secretion of cholecystokinin and GLP-1 to increase the sensation of fullness and slow gastric emptying (25).

In addition, delayed gastric emptying and slower bowel movements due to increased viscosity by glucomannan can make the stomach feel full and delay the sensation of hunger. Slower absorption due to the use of glucomannan delays insulin release, which also has an effect on delaying the sensation of hunger and controlling the blood glucose (20,21).

In terms of the change in blood glucose levels, glucomannan-modified growol cookies can maintain blood glucose levels within normal limits. The presence of food intake, in this case, the glucomannan-modified growol cookies, can increase the subject's carbohydrate intake, which

is able to prevent a decrease in blood glucose immediately after eating compared to fasting blood glucose. Meanwhile, the glucomannan content as dietary fiber plays a role in providing good glycemic control so that after consuming cookies, there is no drastic increase in glucose levels. Dietary fiber is thought to be able to increase the potential of prebiotics, which play a role in selectively stimulating gastrointestinal microbes and producing short-chain fatty acid (SCFA), which will play a role in overcoming metabolic disorders in obesity, one of which is glycemic control (34).

The addition of glucomannan to cookies can provide a sensation of fullness and have an impact on glycemic control, characterized by stable blood glucose levels. Another preclinical study using glucomannan showed an effect on blood glucose control and improvement of insulin resistance conditions in a test group with diabetes (26). Studies in obese individuals show glucomannan has inhibitory effects on glucose and insulin (22).

Glucomannan can increase gastric viscosity, which will regulate the sensation of fullness. This is what causes restrictions in food intake and a slowdown in the rate of glucose absorption (20,35). Previous studies show that consumption of foods high in dietary fiber can provide good glycemic control, characterized by a decrease in blood glucose levels (34,36).

CONCLUSIONS AND RECOMMENDATIONS

The consumption of glucomannan-modified growol cookies can have a positive effect on satiety control and glycemic control. Glucomannan-modified growol cookies can delay hunger for 1-1.5 hours before the next big meal if consumed as many as 6 pieces or the equivalent of 10% of the recommended snack consumption. Apart from that, administering glucomannan-modified growol cookies can maintain blood glucose stability in the range of 90 mg/dL. Therefore, the glucomannan-modified growol cookies have the potential to be used as a healthy snack for treating obesity.

This study is only limited to the short-term effects of administering glucomannan-modified growol cookies on satiety control and glycemic control. Further studies regarding administration are needed for glucomannan-modified growol cookies over a certain period of time to see the long-term effects of cookies on metabolic indicators in the obesity treatment.

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