EFFECT OF ADDING SORGHUM FLOUR TO CHOCO DRINK ON ADOLESCENTS' BLOOD SUGAR

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ABSTRACT

One way to prevent diabetes mellitus can be done by utilizing local foods such as chocolate and sorghum, which are rich in polyphenols that can reduce blood sugar levels. The purpose of this study was to analyze various choco drink formulations on blood sugar levels in adolescents. This research is a quasi-experimental with pre-post test control group design. The research subjects were 45 17-18 year old adolescents who met the inclusion and exclusion criteria. Measurement of blood sugar levels was carried out on days 0 and 15, subjects fasted 8-10 hours before blood collection. Subjects were given choco drink as much as 200 ml for 14 days. Data were analyzed using the Paired Sample T-test to determine differences in blood sugar levels pre-post intervention. Differences in blood sugar levels between groups were carried out using the One-way ANOVA test if the data were normally distributed and the Kruskal Wallis test if the data were not normally distributed. The results of measuring blood sugar levels in each group showed differences pre-post being given the intervention for 14 days. delta mean blood sugar levels after being given the intervention group P1: -5±-1.672 (ρ=0.002) and P2 group: -5±-1,899 (ρ=0,027). The Mann-Whitney test results showed that significant differences were located in the P1-K and P2-K groups (ρ≤0.05). This study concluded that the provision of intervention for 14 days showed that there were differences in reducing adolescent blood sugar in groups P1 and P2.

Keywords: *Choco drink; sorghum; polyphenol; blood sugar*

INTRODUCTION

Increased blood sugar is related to abnormalities in carbohydrate metabolism caused by insulin resistance (Dwianita, Tandi and Dermiati, 2017). This can be prevented by the daily nutritional intake recommended by WHO for sugar intake which is < 10% of total energy or ≤ 25 grams/day. Nationally, > 13% of the Indonesian population consumes sugar > 50 grams/day (Tangkilisan, Handayani and Suarayasa, 2022). Currently, teenagers prefer to consume food and drinks by following popular trends. One of them is a sugar-sweetened beverage such as boba milk tea, brown sugar latte, chocolate latte, and other types of beverages that are attractive to teenagers because these beverages have unique flavors and characteristics with more calories, sugar, and fat, so that intake such as antioxidants, fiber, vitamins, and minerals are consumed less (Yanti, Suryana and Fitri, 2020). Calories of sugar-sweetened beverages in 16 oz containers in boba milk tea 352 kcal, coffee frappe 493 kcal, soft drinks 205 kcal, energy drinks 226 kcal, packaged sweet tea 178 kcal, and packaged fruit juice 226 kcal (Safitri, Sunarti and Herliyanti, 2021). Therefore, it is necessary to regulate eating and drinking which can be an alternative way to maintain health towards controlling blood sugar levels.

Dietary management through beverage selection is an early alternative to prevent hyperglycemia that leads to type 2 diabetes mellitus. Previous research explains that chocolate has benefits such as anti-hyperglycemia. Research conducted by Oliveira et al (2022), giving dark chocolate to subjects who have type 1 and 2 diabetes with a period of 3 - 7 days shows the results of the incremental area under the curve (iAUC) lower blood sugar after consuming sugar-free dark chocolate (Oliveira, Falkenhain and Little, 2022). Another study conducted by Jafararid et al (2018), showed that giving dark chocolate for 8 weeks in subjects with type 2 diabetes showed a significant decrease in fasting blood sugar levels after consuming dark chocolate (Jafarirad *et al.*, 2018). In Indonesia, Sudrajat's research (2020), showed the results of chocolate drink intervention for 14 days in Wistar rat animal subjects and significantly reduced blood sugar levels (Sudrajat *et al.*, 2020).

Another local food that has the potential to reduce blood sugar levels is sorghum, sorghum can also help reduce blood sugar levels. Research conducted by Olawole et al (2018), on the administration of a fermented sorghum diet for 8 weeks in alloxan-induced rats after administration of sorghum diet, showed a significant decrease in blood sugar levels and relative expression of superoxide dismutase (Olawole *et al.*, 2018). Previous research by Dewi et al (2020), through the administration of sorghum flour for 28 days in rats induced by streptozotocin and nicotinamide, showed a significant decrease in fasting blood sugar levels in diabetic rats (Dewi, Widyastuti and Probosari, 2020).

References show that chocolate and sorghum can help prevent diabetes mellitus by lowering blood sugar levels. Chocolate is more popular among teenagers because of its sweet and distinctive taste, so many sweet drinks made from chocolate are high in calories, sugar, and fat. Chocolate also contains phenolic compounds. Phenolic compounds present in choco drink can help stabilize glucose homeostasis by inhibiting α-amylase and α-glucosidase by phenols which can slow down the process of carbohydrate breakdown in the gastrointestinal tract (Dewi, Widyastuti and Probosari, 2020). Therefore, there is a need for innovation in chocolate processing as a beverage product that is low in calories and sugar, and has antioxidants such as polyphenols.

The development of choco drink processing innovation with the addition of sorghum flour is expected to have a better effect on lowering blood sugar levels because the polyphenol content contained in choco drink can help inhibit fat absorption and slow the breakdown of carbohydrates. This study aims to prove whether the addition of sorghum flour to choco drink has an influence on blood sugar levels in adolescents. The purpose of this study was to analyze various choco drink formulations on blood sugar levels in adolescents.

MATERIALS AND METHOD

2.1 Subjects

This study was conducted in senior high school 3, Ketintang vocational high school, and Nusantara health vocational high school in Surabaya city, East Java. The sample size was determined using the sample size formula is n = $\frac{(Z_{1-\frac{a}{2}} + Z_{1-\beta})^2\ (S1^2 + S2^2)}{d^2}$ (Murti, 2016) and the standard deviation value used for formula calculation based on the mean value of previous research(Lee *et al.*, 2017). The results of the sample calculation found 12 subjects as the minimum sample limit then added a loss of follow-up of 20%, so that 15 subjects were obtained which would be divided into three research groups. The total number of subjects in this study was 45 adolescents who met the inclusion and exclusion criteria.

Inclusion criteria are like to consume sweet drinks, such as chocolate drinks, willing to have blood drawn 2x for 14 days, do not consume alcohol and supplements. Exclusion criteria are having a history of diabetes mellitus and food allergies. After that, randomization was carried out to be divided into three groups, K, P1, and P2. The confounding factor in this study was the subject's BMI, the researcher did not control the subject's food intake during the study. Then the subject was given an informed consent form before conducting the study.

2.2 Preparation of choco drink

Making choco drink uses 50 g pure cocoa powder, 30 g sorghum flour, 80 g sugar, and 800 ml water. The cocoa powder used comes from the city of Blitar, namely kampoeng coklat, the sorghum flour used comes from plantations in the city of Mojokerto, and the sugar used is conventional sugar.

Product preparation and processing were carried out by researchers. The processing of choco drink is by heating at 80-85^{o}C, then cooling at room temperature. When the product temperature becomes normal, it is packaged in 200 ml bottles. There were 2 products used as interventions in this study, choco drink without the addition of sorghum flour and choco drink with the addition of sorghum flour.

The intervention product was given once a day to the subject. Researchers were assisted by enumerators to ensure that the product was drunk until it ran out.

2.3 Study design

This study is a quasi-experimental with pre-post test control group design. This research was approved by the ethics commission of the Faculty of Medicine, Sebelas Maret University Surakarta with number 12/UN27.06.11/KEP/EC/2023. Measurement of blood sugar levels was carried out on day 0 and day 15. There were three groups of subjects, each consisting of 15 research subjects who had been randomly divided. The group that was not given choco drink (K), the group that was given choco drink without additional sorghum flour for 14 days (P1), and the group that was given choco drink with additional sorghum flour of 30 gr for 14 days (P2). Each subject was given 200 ml of choco drink for 14 days according to the reference in previous studies (Sudrajat *et al.*, 2020).

2.4 Measurements

This study takes anthropometric measurements and fasting blood sugar levels. Anthropometric measurements in the form of weight and height to see the nutritional status of the subject conducted before the study began. Blood sugar measurements were carried out by Surabaya city government laboratory professionals. Blood was drawn through a vein on day 0 and 15 to see changes in blood sugar before and after the intervention. Subjects fasted for 8-10 hours before blood sugar was taken.

2.5 Statistical analysis

The data were analyzed statistically using the SPSS for windows 21 program. The data normality test used the Shapiro-Wilk test and showed normal distribution results so that it was continued with the Paired sample T-test to determine the difference in blood sugar levels before and after giving choco drink. Furthermore, One-way ANOVA test was conducted to determine differences in blood sugar levels between groups. But the Δ mean blood sugar was analyzed using the Kruskal Wallis test as a substitute for the one-way ANOVA test because the data was not normally distributed, then continued with the Mann-Whitney test as a substitute for the Post Hoc test to determine which group had the most significant difference.

RESULT AND DISCUSSION

Information related to subject characteristic data in this study includes age, gender, and body mass index (BMI) as listed in table 1.

Table 1. Subject Characteristics

Characteristics	Category	Group	Total

		K		P1		P2			
		n	%	n	%	n	%	n	%
Age	17 years	1	2.22	4	8.89	5	11.11	10	22.22
	18 years	14	31.11	11	24.44	10	22.22	35	77.78
Gender	Male	3	6.67	6	13.33	3	6.67	12	26.67
	Female	12	26.67	9	20	12	26.67	33	73.33
BMI	Underweight	1	2.22	2	4.44	1	2.22	4	8.89
	Normal	11	24.44	10	22.22	8	17.78	29	64.44
	Overweight	1	222	1	2.22	4	8.89	6	13.33
	Obesitas	2	4.44	2	4.44	2	4.44	6	13.33

Table 1 shows that the number of research subjects with the age of 18 years (77.78%) is more than the age of 17 years, and the gender is more female (73.33%) than male. In the characteristics of the nutritional status or BMI of the research subjects, the results showed that most of them had normal nutritional status (64.44%), but the BMI of some subjects was in the obese and obese categories.

Table 2. Blood sugar levels pre and post treatment

Group	n	Pre Mean ± SD (mg/dL)	Post Mean ± SD (mg/dL)	Δ mean ± SD (mg/dL)	ρ^a
K	15	92 ± 8.031	93 ± 8.618	1 ± 0.587	0.808
P1	15	98 ± 8.535	93 ± 6.863	-5 ± -1.672	0.002*
P2	15	94 ± 8.163	89 ± 6.264	-5 ± -1.899	0.027*
ρ		0.218^b	0.341^b	$0.049^{c,*}$	

K = Control group; P1 = Group given choco drink; P2 = Group given choco drink with the addition of sorghum flour; a = Paired Sample T Test; b = One Way Anova test; c = Kruskal-Wallis t; * = significant $\rho < 0.05$

Table 2 shows that there are differences in the effect pre-post giving choco drink and choco drink with the addition of sorghum flour on blood sugar levels in each group. The mean difference between the measurement results pre-post giving choco drink to blood sugar levels in group K is 1 ± 0.587, group P1 is -5 ± -1.672, and group P2 is -5 ± -1.899.

The results of normally distributed blood sugar level data were analyzed using the Paired sample T-test and showed that there was a difference in the effect before and after giving choco drink on blood sugar levels in group P1 (ρ = 0.002) and group P2 (ρ = 0.027), but there was no difference in blood sugar levels in group K. Further analysis to determine differences in blood sugar levels between groups using the One-Way ANOVA test showed that all data from the measurement of blood sugar levels pre-post intervention did not have a significant difference in influence in each group (ρ> 0.05).

The delta mean normality test showed the results of the data were not normally distributed so continued using the Kruskal wallis test as a substitute for the One way ANOVA test. The results of the analysis showed that the delta mean blood sugar of each group had a significant difference characterized by a significance value of 0.049 (ρ <0.05). The results were further tested using Mann-Whitney as a substitute for Post Hoc, so that the results of the analysis of delta mean blood sugar are listed in Table 3.

Table 3. Mann Withney test for blood sugar levels

Group	**ρ**
P1-P2	0.713
P1-K	0.026*
P2-K	0.050*

* = significant ρ < 0.05

The results of the Mann-Whitney test showed that significant differences in the delta mean blood sugar of the subjects were located in the P1-K and P2-K groups with a value of ρ ≤ 0.05, so there were differences in blood sugar between the intervention group and the control group. In the P1-P2 group (ρ>0.05) showed no significant difference, indicating that there was no difference in blood sugar between intervention groups.

The mean blood sugar level of the research subjects before treatment in all groups was between 92-98 mg/dL which was in the normal category between 70-99 mg/dL according to the PERKENI guidelines in 2021 (Soelistijo, 2021). The results of measuring blood sugar levels in each group showed a difference after being treated with choco drink and choco drink with the addition of sorghum flour for 14 days, namely in groups P1 and P2 compared to group K. Choco drink uses pure cocoa powder which has a relatively high polyphenol content, under a study conducted by Halib et al (2020), explaining that eating dark chocolate containing high polyphenols can reduce blood sugar levels in adults (Halib *et al.*, 2020). In addition, the HELENA study conducted regarding the relationship between polyphenol intake and metabolic syndrome was conducted on adolescent respondents in Europe consuming foods with high polyphenol content, one of which is chocolate. The results showed that eating foods high in polyphenols was associated with lower BMI z-scores in the HELENA population, but certain classes of polyphenols were associated with preventing inflammation in adipose tissue and insulin resistance due to high polyphenol intake (Wisnuwardani *et al.*, 2020). Polyphenols can inhibit α-amylase and α-glucosidase to reduce glucose digestion, resulting in low intracellular ROS in insulin-responsive (Williamson and Sheedy, 2020).

Choco drink uses pure cocoa powder containing polyphenols and is given to group P1, the results show that there are differences in blood sugar levels before and after the intervention. This is in line with research conducted by Sudrajat (2020), giving chocolate drinks derived from cocoa powder for 14 days to male Wistar rats that have been induced by alloxan, showing significant results in reducing blood glucose levels in rats (Sudrajat *et al.*, 2020). Choco drink contains polyphenol compounds which are included in bioactive substances that can help control postprandial hyperglycemia. The ability of polyphenols can suppress hyperglycemia by becoming an inhibitor in the activity of enzymes that hydrolyze carbohydrates, inhibit glucose transport in the blood, affect the function of pancreatic β-cell performance, and affect tissues in the process of glucose uptake (Pawestri *et al.*, 2021).

Giving choco drink with the addition of sorghum flour in group P2 proved to show differences in blood sugar levels before and after intervention. This is in line with research conducted by Dewi et al (2020), showing that male Wistar rats who have been induced by streptozotocin (STZ) and nicotinamide (NA) are given sorghum flour intervention for 28 days, there are significant results in reducing fasting blood glucose levels in diabetic rats (Dewi, Widyastuti and Probosari, 2020). Sorghum contains phenolic compounds that function to inhibit α-glucosidase and α-amylase enzymes so that they can reduce glucose concentrations (Xiong *et al.*, 2019). Phenolic compounds can also modulate glucose metabolism to provide hypoglycemic effects (Kumari *et al.*, 2021). In addition, sorghum has a high fiber content that can bind glucose in the intestine and inhibit the absorption process so there is a decrease in glucose diffusion (Dewi, Widyastuti and Probosari, 2020).

There are several factors that can affect the increase or decrease in blood sugar levels such as food intake, physical activity, BMI, family history and other factors. This study did not measure the subject's food intake and physical activity, but only measured the subject's BMI. Table 1 shows that most of the subjects' BMI was normal, although there were a small number who were overweight and obese. IMT is one of the risk factors for triggering an increase in blood sugar levels that occurs due to a decrease in the hormone insulin in the pancreas (Lisnawati *et al.*, 2023), so people who are obese are 10.25 times more likely to experience an increase in blood sugar levels (Damayanti, 2023).

CONCLUSION

The results of the research conducted showed that the provision of choco drink and choco drink with sorghum flour as much as 200 ml for 14 days in groups P1 and P2 showed that there were differences in the effect pre and post the intervention on reducing blood sugar levels. Decreased blood sugar can be caused by other factors such as dietary intake, physical activity, and BMI. The weakness of this study is that the subject's food intake and physical activity were not measured, so in future studies it is necessary to measure physical activity and interview the subject's food intake.

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