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Comparing the Effect of Steamed and Boiled Okra (*Abelmoschus esculentus*) on Fasting Blood Glucose among Type 2 Diabetes Mellitus Patients with Hypercholesterolemia

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ABSTRACT

Background: Okra (*Abelmoschus esculentus*) is a vegetable with fiber, vitamin C and flavonoids that can delay emptying of the stomach and cause longer satiety based on the fiber contents so that calorie intake is reduced. The presence of vitamin C and flavonoids in okra acts as an antioxidant that can fight free radicals and detain oxidative stress caused by hyperglycemia. This study aimed to compare the effect of steamed and boiled okra on fasting blood glucose levels in patients of type 2 diabetes mellitus with hypercholesterolemia.

Methods: In this clinical trial study, the independent variables consisted of steamed and boiled okra and the dependent variable was fasting blood glucose level. Forty patients who suffered from type 2 diabetes mellitus and with hypercholesterolemia were enrolled and divided into three groups including the control group (G1), treatment group of G2 (boiled okra intervention as much as 40 g for 14 days) and G3 (steamed okra intervention as much as 40 g for 14 days).

Results: A greater decrease in fasting blood glucose level was noted for boiled okra group when compared with steamed okra group among patients suffering from type 2 diabetes mellitus and with hypercholesterolemia.

Conclusion: Administration of boiled and steamed okra as much as 40 g for 14 days was shown to reduce fasting blood glucose level among patients suffering from type 2 diabetes mellitus and with hypercholesterolemia.

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Introduction

Diabetes mellitus type 2 (T2DM) is a metabolic disease characterized by hyperglycemia that occurs due to abnormal insulin secretion or action (1). The usual symptoms are polyuria, polydipsia, and polyphagia (2). A wrong life style or diet can cause failure in β cell function and insulin resistance in patients with T2DM (3). Insulin resistance can increase the release of free fatty acids and cause an increase in total cholesterol levels, so that patients with T2DM often experience complications such as hypercholesterolemia (4)section 2.2, 3rd paragraph, second bullet: or radiopharmaceuticals (Iohexol.

According to the data of International Diabetes Federation (2017), the prevalence of diabetes mellitus (DM) in the world was estimated 10.3 million (5) which is dominated by T2DM as much as 95% (6). East Java has the incidence of DM of 2.1% that is greater than the national rate of 1.5%. According to the data from the Situbondo Health Office in 2018, there were two health centers with the highest patient number with T2DM and with complications of hypercholesterolemia counting to 103 patients (7).

The diet of people who frequently consume instant, high glucose, and high-fat food is one of the causes of T2DM and with hypercholesterolemia (8). The occurrence of T2DM associated with hypercholesterolemia can decline by an increase in physical activity and frequently consuming fruits and vegetables having high fibers, vitamins, and antioxidants (9). A relationship between T2DM and consuming fruit and vegetable was noted, where T2DM occurred 2.91 times more among subjects who consumed less fruit and vegetables (10).

Fruits and vegetables are good sources of fibers, vitamins, and antioxidants to be used for T2DM patients with hypercholesterolemia (11, 12). One type of vegetable that contains fiber, vitamins, and antioxidants is okra. Okra (*Abelmoschus esculentus*) was first discovered in South Africa and the Mediterranean countries (13). Okra is being widely cultivated in Indonesia, especially green okra, because it is one of the plants that has many benefits including a reduction in blood glucose level (14) and GLP-1 receptor (GLP-1R).

The content of fiber in okra can delay emptying of the stomach, thereby reducing the absorption of carbohydrates in the small intestine which can cause longer satiety (15). Okra also contains vitamin C and flavonoids which act as antioxidants that can counteract free radicals and prevent oxidative stress (16). Processed okra commonly eaten by Indonesian is provided by boiling, and steaming. Although it is processed by steaming and boiling, the nutrient contents in okra such as fiber, vitamin C and flavonoids are still present and not declined (17). The method of processing by steaming and boiling is a healthy process and is recommended for T2DM patients with hypercholesterolemia (18).

The research on pre-diabetic subjects who received okra as much as 40 g revealed an increase in insulin sensitivity (19). Also in rats given okra extract for anti-diabetic effects, a reduction in blood glucose level was noticed (20). Processing okra by boiling or steaming methods has been recommended for patients with T2DM and hypercholesterolemia, because it does not contain ingredients such as sugar, salt and oil that can increase the blood glucose level, even there are differences in the nutritional content for boiled and steamed okra (21).

The antioxidant contents of okra such as vitamin C were more in boiled okra than steamed form, demonstrated as 1.5 mg and 1.3 mg, respectively; while for the flavonoid content in steamed okra was more than in boiled okra, defined as 2.7 mg and 2.1 mg, respectively. The fiber content in steamed okra was demonstrated to be more than boiled okra, illustrated as 9.6 g and 4.9 g, respectively (22). This research was conducted to compare the effect of steamed and boiled okra on fasting blood glucose in patients with T2DM and with hypercholesterolemia.

Materials and Methods

This study was approved by the Health Research Ethics Commission of the Faculty of Medicine, Universitas Sebelas Maret (471/UN27.06/KEPK/EC/2019). All procedures were followed under the ethical standards of the Health Research Ethics Commission. Before the intervention was given, all subjects had signed informed consent. This study is categorized as a clinical trial with a pre- and post-test control group design. There were two variables in this study; the independent variable consisted of steamed and boiled okra (*A. esculentus*), and the dependent variable including fasting blood glucose level. The nutritional content of boiled and steamed okra was shown in Table 1.

The inclusion criteria of this study were not being pregnant, not smoking, absence of any history of hypertension, gastrointestinal, stroke, and heart

Table 1: Nutritional value of provided steamed and boiled okra (*Abelmoschus esculentus*)

Nutritional Value	Boiled form	Steamed form
Fat (g)	5.3	2.8
Carbohydrate (g)	57.7	61
Protein (g)	45.4	37.8
Cholesterol (g)	0	0
Crude fiber (g)	4.9	9.6
Vitamin C (mg)	1.5	1.3
Flavonoid (mg)	2.1	2.7

Source: Utami. RP, 2018

diseases, etc., not consuming alcohol and preferably people who consumed vegetables. The subjects of the study aged between 45 and 65 years and suffered from T2DM with hypercholesterolemia. The sample measurement method in this study was based on a sample size formula for hypothesis testing research in two average populations (23).

The calculation was done by multiplying the average blood glucose and total cholesterol level (δ^2) of 1225 with the addition of 95% confidence level ($Z_{1-\alpha}$) of 1.96 and with 80% test strength ($Z_{1-\beta}$) of 0.84, which then was divided by the mean difference between control and treatment groups ($\mu1$-$\mu2$) of 39.6^2. So a minimum number of 12 subjects were selected as research sample, and to anticipate the loss of subjects, a 30% follow-up loss was also added, so that the minimum number of subjects per group was 16 subjects with a total of 48 research participants.

In this study, by using serial numbers, the participants were randomly allocated between the groups. The subjects chosen in this study were patients with T2DM and hypercholesterolemia registered at 2 public health center in Situbondo, East Java, Indonesia inclding Banyuputih and Jangkar Public Health Center located in Asembagus District, Situbondo Regency. The subject recruitment was by laboratory results of fasting blood glucose level between 150 and 400 mg/dL.

This study also evaluated the data in relation to the subjects' characteristics regarding sex, drug consumption and the family history, occupation, income, physical activity, educational level, and body mass index (BMI). Also, the energy, carbohydrate, protein, fat, fiber, and vitamin C intake in foods were recorded using 2x24 hours recall after receiving okra vegetable intervention for 14 days. The nutritional content of boiled and steamed okra was shown in Table 1. The average energy intake of the subjects was included as less and enough, the average intake of protein and fat was presented as enough and more, the average carbohydrate intake of subjects was illustrated as enough and more and the intake of fiber and vitamin C was demonstrated as insufficient and sufficient (Table 2).

The processing of okra was done by boiling and steaming methods. In boiling process, 100 g of okra was transferred into 1 L distilled water, heated at 100^0C, and boiled for 3 minutes in a closed pot. Then okra was removed, put into a container filled with ice for 2 minutes to stop the cooking process. In the steaming procedure, 1 L of distilled water was heated at 100^0C in a steamed pan, and then 100 g of okra was added and steamed for 3 minutes. The okra was later removed and placed in a container filled with ice for 2 minutes to stop the cooking process (19). The steamed and boiled Okra were weighed as much as

Table 2: Information on subjects' dietary intake (n=40)

Characteristics	G1 (n=16) (%)	G2 (n=12) (%)	G3 (n=12) (%)
Energy intake*			
Less	9 (56.2)	4 (33.3)	7 (58.3)
Enough	6 (37.5)	6 (50)	5 (41.7)
More	1 (6.2)	2 (16.7)	0 (0)
Protein intake*			
Less	0 (0)	0 (0)	0 (0)
Enough	11 (68.7)	6 (50)	5 (41.7)
More	5 (31.2%)	6 (50)	7 (58.3)
Fat intake*			
Less	0 (0)	0 (0)	0 (0)
Enough	3 (18.7)	6 (50)	5 (41.7)
More	13 (81.2)	6 (50)	7 (58.3)
Carbohydrate intake*			
Less	2 (12.5)	2 (16.7)	2 (16.7)
Enough	8 (50)	2 (16.7)	2 (16.7)
More	6 (37.5)	8 (66.7)	8 (66.7)
Fiber intake*			
Less	5 (31.2)	7 (58.3)	0 (0)
Enough	12 (75)	5 (41.7)	12 (100)
More	0 (0)	0 (0)	0 (0)
Vitamin C intake*			
Less	3 (18.7)	1 (8.3)	0 (0)
Enough	13 (81.2)	11 (91.7)	12 (100)
More	0 (0)	0 (0)	0 (0)

*Ministry of Health Republic of Indonesia, 2018

40 g to be distributed later among the groups.

The subjects were divided into three groups called group control group (G1) that did not undergo steaming or boiling intervention, boiled okra group (G2) that received boiled okra as much as 40 g/day during breakfast between 07.00 and 09.00 AM for 14 days, and the steamed okra group (G3) that received steamed okra as much as 40 g/day at breakfast time between 07.00 and 09.00 AM for 14 days (20). In each group, a 24-hour recall was performed to determine the subjects' food intake before and during the study. In this study, blood sampling was carried out two times; before and after the intervention on the 1st and 14th day. Blood was drawn through veins for 2 mL in ethylene diamine tetraacetate (EDTA) containing tube. Blood glucose level was determined by using the enzymatic colorimetric method.

Univariate tests assessed the distribution of general characteristics of subjects such as sex, drug consumption, history of illness, occupation, income, physical activity, education, and food intake, as well as to see fasting blood glucose levels. Bivariate tests analyzed the effect of okra intervention on fasting blood glucose levels using a non-parametric test namely the Kruskal- Wallis test and the Mann-Whitney test A P≤0.05 was considered statistically significant.

Results

The characteristics of the study population were presented in Table 3. Before and after the treatment, it was found that receipt of boiled okra decreased fasting blood glucose (129.08 mg/dL) more than steamed okra (79.41 mg/dL), whereas the control

Table 3: Baseline characteristics of research subjects (n=40)

Characteristics	G1 (n=16) (%)	G2 (n=12) (%)	G3 (n=12) (%)
Gender			
Male	6 (37.5)	1 (8.3)	1 (8.3)
Women	10 (62.5)	11 (91.7)	11 (91.7)
Drug consumption			
No consumption	5 (31.2)	0 (0)	0 (0)
Glibenglamide	3 (17.7)	5 (41.7)	4 (33.3)
Simvastatin	4 (25)	4 (33.3)	3 (25)
Simvastatin & glibenglamide	4 (25)	3 (25)	5 (41.7)
Familial History			
Diabetes mellitus	15 (93.7)	8 (66.7)	6 (50)
Hypercholesterolemia	1 (6.2)	4 (33.3)	6 (50)
Profession			
Civil servants/Soldiers/Police/Teachers	1 (6.2)	0 (0)	2 (16.7)
Entrepreneur	0 (0)	0 (0)	1 (8.3)
Farmers/Workers	7 (43.7)	3 (25)	4 (33.3)
Selling at home	0 (0)	1 (8.3)	1 (8.3)
Does not work	8 (50)	8 (66.7)	4 (33.3)
Income			
500-800 thousand	16 (100)	11 (91.7)	9 (75)
1-3 million	0 (0)	1 (8.3)	1 (8.3)
4-5 million	0 (0)	0 (0)	2 (16.7)
Physical activity			
Light	9 (56.2)	9 (75)	7 (58.3)
Medium	7 (43.7)	3 (25)	5 (41.7)
Heavy	0 (0)	0 (0)	0 (0)
Education			
No school	13 (81.2)	4 (33.3)	0 (0)
Elementary school	3 (18.7)	7 (58.3)	7 (58.3)
Middle school	0 (0)	0 (0)	1 (8.3)
High school	0 (0)	1 (8.3)	2 (16.7)
S1	0 (0)	0 (0)	2 (16.7)
Body Mass Index (BMI)*			
17.0-18. 4 (Thin)	1 (6.2)	0 (0)	1 (8.3)
18.5-25.0 (Normal)	4 (25)	4 (33.3)	2 (16.7)
27.1-27.0 (Fat)	11 (68.7)	8 (66.7)	9 (75)

Source: Primary data, 2019. *Ministry of Health of Republic of Indonesia, 2018

Table 4: Fasting blood glucose levels before and after treatment

Group	No	Day 0 (Mean±SD) (mg/dL)	Day 14 (Mean±SD) (mg/dL)	Δ GDP (Mean±SD) (mg/dL)
G1	16	202.56±53.72	207.06±36.96	4.50±23.34
G2	12	281.50±108.85	152.42±41.81	-129.08±92.95
G3	12	220.00±74.90	140.58±36.21	-79.41±54.68
P value	40	0.139	0.001*	0.001*

Source: Primary Data, 2019. G1: Control group, G2: Boiled okra intervention group, G3: Steamed okra intervention group, ΔFasting blood glucose: Changes in fasting blood glucose, No: Number of samples, *P<0.05 (Kruskal-Wallis test)

Table 5: Comparative analysis of changes in fasting blood glucose level

Groups	ΔFasting blood glucose level (Mean±SD) (mg/dL)		P value
G1:G2	4.50±23.34	-129.08 ± 92.95	0.001*
G1:G3	4.50±23.34	-79.41 ± 54.68	0.001*
G2:G3	-129.08±92.95	-79.41 ± 54.68	0.128

Source: Primary Data, 2019. G1: Control group, G2: Boiled okra intervention group, G3: Steamed okra intervention group, ΔFasting blood glucose: Comparisons between groups regarding fasting blood glucose level, N: Number of samples, *P<0.05 (Mann-whitney test)

group who did not get okra experienced an increase in fasting blood glucose (4.50 mg/dL) (Table 4). There was a significant difference (P=0.01) between the control (G1) and the treatment groups (G2 and G3) denoting to a decrease in fasting blood glucose in the treatment groups, while an increase in fasting blood glucose was visible in the control group (Table 5).

Discussion

When comparing fasting blood glucose levels before and after treatment, there was a decrease in fasting blood glucose level by 45% after consuming boiled okra and a reduction in fasting blood glucose level by 35% when consuming steamed okra. In comparison between the control and the treatment groups, a significant increase in fasting blood glucose level by 2.2% was noted in the control group. Giving boiled okra was shown to be effective to decrease fasting blood glucose among patients with T2DM and hypercholesterolemia.

The decrease in fasting blood glucose level happened in the study can be due to the presence of fibers in okra that absorbs water and binds to glucose, so that it can reduce the availability of glucose. Our finding is in line with research undertaken on okra processed by boiling method and used for subjects with pre-diabetes resulting in an increased insulin sensitivity (24). Okra also contains vitamin C and flavonoids which act as antioxidants and can clean the chain of free radicals binding to metal ions (chelating), and blockade the polyol pathway by inhibiting the enzyme α-glucosidase through hydroxylation bonds and substitution in the β-pancreatic ring (25).

It can also inhibit the enzyme aldose reductase action which indirectly inhibits the release of oxidative stresses caused by hyperglycemia (26). These findings are the same as research conducted on rats weighing 200 g and were given okra at doses of 100 and 200 mg and demonstrated a decline in blood glucose level (27). In patients with T2DM, there are always complaints of not being able to control total cholesterol levels despite undergoing a good glucose control (28).

Increased insulin resistance in patients with T2DM resulted in an increased release of free fatty acids from adipose tissue and increased synthesis of fatty acids in the liver and increased production of very low-density lipoprotein (VLDL) causing an increase in low-density lipoprotein (LDL) and decreased high-density lipoprotein (HDL) levels (26). So patients with T2DM may often experience complications of hypercholesterolemia (29). Consuming okra was shown to reduce total cholesterol levels in patients with T2DM and hypercholesterolemia (30). The contents of nutrients in the form of fiber, vitamin C and flavonoids in okra have been useful in helping the hydroxylation reaction and to form bile salts. Increased bile salt formation can cause an increase in cholesterol excretion, so that it can reduce blood cholesterol levels too (31).

Conclusion

Consumption of boiled and steamed okra as much as 40 g for 14 days was illustrated to reduce fasting blood glucose among patients suffering from T2DM and hypercholesterolemia. Subjects who received boiled okra were demonstrated to experience a more decrease in fasting blood glucose when compared to intake of steamed okra. The greatest decrease in fasting blood glucose ws noted when boiled okra was administered.

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Conflict of interest

None declared.

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