The Effect of Processed Tempeh Gembus Administration on Blood Glucose in Obese Women

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Abstract. Tempeh gembus is a local functional food from Indonesia which made from fermented tofu residues from Rhizopus oligosporus and containing high fibre. The fibre content in tempeh gembus are three times higher than soybean tempeh. Dietary fibre is thought to reduce blood glucose levels. The aim this study is to analyze the effect of giving variations of processed tempeh gembus on fasting blood glucose level. This study was an experimental study with a pre-post randomized control group design. The number of control and treatment group subjects was 20 people each who met the inclusion criteria. The control and treatment groups received 1500 kcal isocaloric diet. In addition, treatment group received additional variations of processed tempeh gembus 150 grams for 28 days. The average intake of processed tempeh gembus treatment group during the study was 58.9%. The average fibre intake of the treatment group was twice higher than the control group. There was no statistically significant difference in fasting blood glucose levels between the control and treatment groups after the intervention. There was no statistically significant difference on fasting blood glucose levels in both the control group and the treatment group (p> 0.05) but clinically it was able to reduce fasting blood glucose levels 4.5 mg / dl in the treatment group. Changes in blood glucose levels showed no significant differences between the control and treatment groups (p> 0.05). Processed tempeh gembus administration for 28 days increase fibre intake but could not been able to reduce fasting blood glucose levels.

Keyword: Blood glucose, dietary fibre, obese women, tempeh gembus

1 Introduction

Obesity is a state of excessive fat accumulation in the body and is one of the risk factors for the emergence of non-communicable diseases ¹, such as diabetes mellitus, hypertension and coronary heart disease ². Some factors that are thought to cause obesity are related to lifestyle such as changes in diet and decreased physical activity, and stress ¹, ³. The results of Basic Health Research showed, the prevalence of obesity in adult women (> 18 years) had increased from 13.9% (in 2007) to 32.9% (in 2013) and decreased to 29.3% in 2018. Despite a decline in prevalence obesity in adult women in 2018, but still needs to be a concern because the figure is still above the national prevalence of obesity of 21.8% ⁴. The prevalence of obesity in the adult population in Central Java Province is 20.4% ⁴. The prevalence of obesity in adult women is higher than adult men in Central Java by 27.5% compared to 13.1% ⁴. The prevalence of obesity tends to increase with increasing age and peak in adulthood ². Study cross sectional of Indonesia Health Survey results also show that the prevalence of obesity in
adult women occurs in the productive age group that is 35-54 years \(^4\). The incidence of obesity causing hyperglycemia is estimated to double over 30 years (the number 171 million in 2000 to 366 million in 2030) \(^5\). Obesity is a risk factor for the progression from normal glucose to high blood glucose or diabetes \(^6\). Study cross sectional in Southern Cone of Latin America in 2011 showed obesity and central obesity were also associated with an increased diabetes (OR 3,01 and 4,45) \(^7\).

Prevention of diabetes can be adjusted to eating patterns as part of healthy lifestyle changes. Eating arrangements can be done one way by regulating energy intake and increasing fibre intake \(^6\). Consuming high fibre food can reduced post-prandial blood glucose level \(^8\). Dietary fibre has hypoglycemic effect through several mechanisms which are increasing the growth and function of the upper gastrointestinal tract as well as the intestinotrophic factor, glucagons-like peptide 2 \(^9\), decreasing the response of insulin \(^10\), reducing the speed of glucose absorption by lowering gastric emptying and/or entrapment of materials in the viscous digesta \(^11\). One of food fermented product that is high contents of dietary fibre and antioxidants is tempeh gembus. Tempeh gembus is obtained from the process of tofu pulp fermentation with Rhizopus spp. The nutritional content of tempeh gembus includes fatty acids, amino acids with lower levels than soybean tempeh, but the fibre content in tempeh gembus is 3 times more than soybean tempeh, which is 3.93 grams / 100 grams of wet tempeh gembus \(^12\). Cooking processed that involved heating could affect fibres content, as well as antioxidant. Deep frying method increases fibre content of tempeh gembus by two fold and antioxidant 1,3 times higher than those in raw tempeh gembus \(^13\). Commonly, tempeh gembus is consumed after it has been processed as fried, boiled or stir-fry \(^14\). Therefore, it is important to examine the effect of processed tempeh gembus on fasting blood glucose levels of obese women.

2 Methods

An experimental study with a pre-post randomized control group design in Women's Penitentiary Class II in Semarang City. The study participants were 40 people divided into two groups: the control group and the treatment group. The inclusion criteria were women aged 35-50 years, not pregnant and not yet menopausal, BMI ≥ 25 kg / m2 or waist circumference ≥ 80 cm, blood glucose level were <200 mg / dl, and triglyceride levels <150 mg / dl. As for the inclusion criteria, namely having a history or being experiencing liver disease, kidney disease, thyroid disorders, cancer, coronary heart disease, stroke, diabetes mellitus and other diseases, smoking habits, taking nutritional supplements, taking hypoglycemia or insulin drugs, vegetarianism, did not completed blood glucose examination.

Subjects in treatment group were given processed tempeh gembus as much as 150 grams / day within 28 days to see the effect on fasting blood glucose levels. Processed tempeh gembus were given as bacem, balado, stir fry, satay, and pepes. The research instrument was a questionnaire to collect data on identity, history of illness, smoking habits, alcoholic drinks habits, food intake, and physical activity. Measurement of blood glucose levels for initial screening using glucose tools test. Meal intake were using 24-hour food recall forms. Assessment of compliance in consuming tempeh gembus with comstock and food consumption forms. Physical activity were measured by a backae form activity\(^15,16\). The instrument for anthropometric measurements used digital body weight scales, microtoise, and waist circumference bands. Stages of data processing began with descriptive analysis for variables of age, body weight, BMI, waist circumference, and fasting blood glucose levels for both groups. Characteristics of the study subjects (age, weight, BMI and waist circumference) were tested using Mann Whitney because the data were not normally distributed. Similarly, the data characteristics of the study subjects before and after the intervention (age, body weight, BMI, waist circumference, fasting blood glucose levels) in both groups used Mann Whitney because the data were not normally distributed. Data intake of protein, fat and carbohydrates before the study in both groups were tested using the Independent t-test because the data were normally distributed, while the energy intake was using Mann Whitney. Data on food intake during the study (protein, carbohydrate and fibre) in both groups were tested using the Independent t-test while data on energy and fat intake during the study
used the Mann Whitney test. Data on differences in changes in body weight, BMI and blood glucose levels were tested using the Wilcoxon test.

3 Results and Discussion

3.1 Subject Characteristic

| Table 1. Baseline characteristics | Control Group | Treatment Group | p     |
|----------------------------------|---------------|-----------------|-------|
| Variable                         | Mean±SD       | Median          | Min–Max| Mean±SD       | Median          | Min–Max |       |
| Age (year)                       | 35,1±8,54     | 34,00           | 21–50  | 39,00         | 21–48           | 0,65b   |
| Body Weight                      | 72,1±15,25    | 67,20           | 53,80–119,30 | 66,00         | 55,10–78,70  | 0,34b   |
| BMI (kg/m2)                      | 29,9±5,62     | 27,38           | 25,05–33,23 | 27,38         | 25,05–78,70  | 0,33b   |
| Waist Circumference              | 97,7±9,65     | 90,2±6,36       | 81,00–107,10 | 89,25         | 81,00–107,10 | 0,01*   |
| Blood Sugar (mg/dl)              | 77,8±11,69    | 77,00           | 61,00–85,1±      | 77,50         | 71,00–175,00 | 0,15b   |
| Physical activity                | 1,5±0,18      | 1,42            | 1,31–1,79       | 1,44          | 1,23–1,73   | 0,88b   |
| Energy Intake (kcal)             | 2082,5±310,59 | 2019,70         | 1669,70–2519,80 | 1879,50       | 1699,30–2561,00 | 0,22b |
| Protein Intake (gram)            | 89,6±23,68    | 87,60           | 52,00–125,90    | 75,40         | 47,90–139,30 | 0,21a   |
| Fat Intake (gram)                | 66,2±11,11    | 64,85           | 36,90–91,10     | 66,25         | 28,50–98,70 | 0,74a   |
| Carbohydrate intake (gram)       | 240,1±218,45  | 218,45          | 80,70–244,0±    | 225,25        | 177,00–346,30 | 0,85a   |

*a Independent Sample test
b Mann Whitney test

Population of Women's Penitentiary Class II in Semarang City assisted residents as many as 340 people, only 88 people who met the initial screening criteria for the determination of research subjects. As many as 47 people who met the criteria for the advanced screening stage were randomized, obtained 22 people as the control group and 25 people as the treatment group. During the research, there were 2 people dropped out in the control group and 5 people dropped out in the treatment group so that 20 people each were obtained in the control and treatment group. Intervention of giving variations of processed tempeh gembus 150 gram / day, which is distributed at lunch, to be consumed at lunch and afternoon snacks for 28 days.

Subject characteristics included age, weight, BMI, waist circumference, GDP, and physical activity (Table 1). In the description of age, it can be seen that the subjects in this study are 21 - 50 years old. Statistical test results using Mann Whitney showed that there were no differences in age, body weight, BMI, Fasting Blood Glucose, and physical activity between the two groups. As for waist circumference, there was a statistically significant difference (p = 0.01). Energy intake in the control and treatment groups were 2019.70 kcal and 1879.50 kcal, respectively. The average energy intake in the control and treatment groups was normal when compared to the Nutrition Adequacy Rate (2019). The average energy intake of the two groups was able to meet 90% of the RDA. The average protein intake of the control and treatment groups was 89.60 grams and 80.00 grams. The proportion of protein intake in both groups was normal (16-17%). The average fat intake of the control and treatment groups was 64.85 grams and 66.25 grams. When calculated the proportion of fat intake to
energy intake obtained 28.6% for the control group and 29.5% in the treatment group. The proportion of fat intake in both groups are high so that the proportion of carbohydrate intake in both groups are relatively low. It can be concluded that the fat intake of the two groups tends to be high. Statistical analysis revealed that energy, protein, fat and carbohydrate intake did not differ between the two groups (p> 0.05). Characteristics of the study subjects based on food intake showed no difference between the two groups. This shows the research subjects are homogeneous in terms of energy and nutrient intake.

3.2 Differences in Characteristics of Subjects Before and After Intervention

Table 2 shows the characteristics of the study subjects before and after the intervention based on weight, BMI and waist circumference indicators. Mann Whitney test results showed no difference in body weight and BMI in the two groups after the intervention (p> 0.05). Although the statistical results showed no differences in body weight and BMI in the two groups after the intervention, they were clinically able to maintain body weight and BMI. The control group tended to increase body weight and BMI (difference in body weight 0.1 kg and BMI 0.2kg / m²) between before and after the intervention. Similar to the waist circumference of the two groups before the intervention, there were differences in the waist circumference of the two groups after the study (p = 0.02). Clinically there was a decrease in waist circumference in the control group before and after the intervention of 1.66 cm as well as in the 0.4 cm treatment group.

| Variabel                  | Control Before  | Treatment Before | p     | Control After | Treatment After | p     |
|---------------------------|------------------|-------------------|-------|---------------|-----------------|-------|
| Body Weight (kg)          | 72,1 ± 15,25     | 66,2 ± 6,97       | 0,34b | 72,3 ± 15,73  | 66,2 ± 6,74     | 0,32b |
| BMI (kg/m²)               | 29,9 ± 5,62      | 28,0 ± 2,60       | 0,33b | 30,1 ± 5,83   | 28,0 ± 2,44     | 0,43b |
| Waist Circumference (cm)  | 97,7 ± 10,13     | 90,2 ± 6,36       | 0,01b | 96,04 ± 10,08 | 89,8 ± 5,71     | 0,02b |

a Independent Sample test
b Mann Whitney test

3.3 Food Intake During Intervention

Food intake can affect blood glucose levels. Intake data includes energy, protein, fat, carbohydrate, cholesterol and fibre intake. The difference in intake of research subjects during the intervention in the control and treatment groups are presented in Table 3.

The result showed that the intake of energy, protein, fat, carbohydrate in control group was lower than the treatment group. The average energy intake of the control group was in accordance with the provision of 1500 kcal of energy and the treatment group received an additional intake of gembus worth an average of 200 kcal per day. Energy, protein, fat and carbohydrate intake in the treatment and control groups during the intervention showed no significant difference. The fibre intake of the control group had a minimum intake of 4.30 grams, the highest intake of 14.50 grams with an average intake of 10.4 ± 2.47 grams. Whereas the treatment group had a minimum fibre intake of 13.50 grams, the highest intake was 27.32 grams with an average intake of 20.8 ± 3.94 grams. The average fibre intake of the treatment group was twice that of the control group. The average fibre intake of the treatment group is able to meet 60% of the fibre needs based on the RDA. Fibre intake during the intervention in the treatment and control groups showed that there was a significant difference (p = 0.00). This result shows that tempeh gembus is one source of food fibre.
Table 3. Food Intake During Intervention

| Nutrients (days) | Group | p |
|------------------|-------|---|
|                  | Control | Treatment | |
|                  | Mean ± SD | Median | Mean – Max | Mean ± SD | Median | Mean – Max |
| Energy (kkal)    | 1598,1 ± 286,9 | 1571,70 | 1177,93 – 2598,90 | 1704,79 | 370,92 | 1310,48 – 2680,59 |
| protein (gram)   | 59,1 ± 13,47 | 58,15 | 36,60 – 98,63 | 66,47 | 66,9 ± 14,44 | 45,50 – 105,70 |
| Fat (gram)       | 54,1 ± 17,77 | 50,32 | 32,93 – 112,17 | 57,36 | 58,5 ± 13,45 | 41,11 – 92,24 |
| Carbohydrate (gram) | 221,4 ± 31,92 | 220,64 | 172,70 – 249,7 | 235,15 | 177,20 | 0,07 |
| Fibre (gram)     | 10,4 ± 10,30 | 9,04 | 4,30 – 14,50 | 21,12 | 20,8 ± 3,94 | 13,58 – 27,32 |

Independent Sample test, Mann Whitney test

3.4 Fasting Blood Glucose Level Before and After Intervention

Table 4. Fasting Blood Glucose Level Before and After Intervention

| Variable          | Control | Treatment | p |
|-------------------|---------|-----------|---|
| Fasting Blood Glucose (mg/dl) | Before | 77,8 ± 11,69 | 85,1 ± 22,96 | 0,15 |
|                   | After   | 83,9 ± 27,04 | 80,6 ± 13,43 | 0,63 |
| Δ                 | 6,1 ± 29,26 | -4,5 ± 13,71 | 0,79 |
| P                 | 0,88c   | 0,21c      |    |

Independent Sample test, Mann Whitney test, Wilcoxon test

Table 4 shows that there were no statistically significant differences in fasting blood glucose levels in both the control group (p = 0.88) and the treatment group (p = 0.21) but were clinically able to reduce fasting blood glucose levels 4.5 mg / dl in the treatment group. Changes in blood glucose levels showed no significant difference between the control and treatment groups (p = 0.79).

Fibre content in tempeh gembus are three times higher than soybean tempeh, which is 3.93 grams / 100 grams of fresh tempeh gembus. Fatty acids contained in tempeh gembus are unsaturated fatty acids namely linoleic acid (21.5%); linolenic (1.82%) and oleic (16.72%). Fibre plays a role in weight management through several mechanisms. Food sources of fibre usually contain low energy density, require a longer digestion process and inhibit gastric emptying faster. Fibre is also able to slow down the absorption of nutrients because of the enzymes and substrates contained in it so that it can regulate hormones related to food intake and pancreatic function. Sixteen cohort studies in seven countries showed that increased fibre intake was inversely related to body fat storage. The results of a systematic review study also showed that fibre intake of at least 12 grams per day was able to reduce 10% of energy intake and lose weight of 1.9 kg in 4 months. Sources of food fibre in vegetables, fruits, nuts and seeds also play an important role in regulating blood glucose levels and insulin response because of their effect in slowing gastric emptying and absorption of macro nutrients in the digestive tract. This mechanism is able to delay hunger because it can provide a feeling of fullness. In addition, tempeh gembus fibre has isoflavones. The isoflavone content in tempeh gembus is daidzein 33.1 μg / g and genistein 57.1 μg / g. Isoflavones from soy helps weight loss through increased levels of the hormone cholecystokinin (CCK) as a stimulator in decreasing appetite. Obesity is a condition of excess body fat accumulation that can be measured using BMI and waist circumference. BMI is an indicator commonly used to determine overweight in addition to waist circumference. BMI is an indicator of the accumulation of body fat as a whole because it is associated with a high percentage of body fat but BMI does not yet describe the distribution of body fat. While
waist circumference is an indicator for the distribution of abdominal fat so it is related to the form of obesity 19, 20.

3.5 Differences in Blood Glucose Levels Before and After Intervention

Changes in blood glucose levels showed no significant difference between the control and treatment groups (p = 0.79). The basic ingredients of tempeh gembus are tofu waste, but tempeh gembus contains essential fatty acids, such as linoleic acid (21.51%), linolenic acid (1.82%) and oleic unsaturated fatty acids (16.72%). Analysis of the nutritional value of tempeh gembus (dry weight per 100 g edible portion) consists of 77.7 kcal energy, 4.07 g protein, 0.23 g fat, total carbohydrate 14.25 g, 4.69 g fibre, ash 0.84 g, calcium 159.98 mg, phosphorus 59.69 g iron 0.48 mg and water 6%. The level of fibre in tempeh gembus are three times higher than soybean tempeh. Fibre is a type of complex carbohydrates that cannot be digested by the body but it is beneficial for gastrointestinal health and plays a role in reducing cholesterol, blood glucose levels and related to body weight regulation. Decreased on fasting blood glucose levels are not solely influenced by fibres from tempeh gembus.

Research shows that high fibre intake for 4 weeks can increase insulin secretion in non diabetic overweight subjects. Fibre is able to activate the secretion of incretin because the production of short chain fatty acids (SCFA) is induced by fibre fermentation, although other studies say high fibre intake can increase the secretion of glucagon-like peptide-1 (GLP-1) in healthy subjects for 1 year. Another meta-analysis study showed a high fibre intake (an increase in fibre intake of at least 18.3 grams per day) was able to reduce HbA1c in DM type 2 subjects 21. The average of the intervention group's fibre intake of 20.8 grams (with adequate fibre intake category) which is equivalent to 50% tempeh gembus intake during the intervention has not been able to reduce fasting blood glucose levels statistically.

In contrast to the research of Dewi et al (2018) which states that the administration of 100 gram of tempeh gembus with the enzyme bromelain for 28 days as can reduce the risk of the inflammatory response in experimental animals. This study involving human subjects. Acceptability of processed tempeh gembus is influenced by the level of boredom and taste. The compliance of processed tempeh gembus during the study was only 60% on average. Therefore, it would also affect the amount of fibre consumed. Fibre plays an important role in regulating blood glucose levels and insulin response. Types of fibre, whether water soluble or insoluble fibre, has potential effect for the treatment of diabetes. Recent research shows that water soluble fibre does not correlate with diabetes risk. While water insoluble soluble fibre can help reduce blood glucose levels through a mechanism of decreasing serum free fatty acids in insulin sensitive tissue.

Carbohydrates is also related to insulin response, the type of carbohydrate (simple/refined carbohydrates and dietary fibre) is thought to be associated with an increased risk of blood glucose. Glycemic index is an index (level) of food according to its effect in increasing blood sugar levels. Foods that have a high glycemic index when consumed will increase blood sugar levels quickly and high. Conversely, when consuming low glycemic indexed foods, the increase in blood sugar levels is slow and the peak sugar content is low 23. Commonly, glycemic indeks of food, affected by fibre contained. Unfortunately, this research has not analyzed the glycemic index of variations of processed tempeh gembus.

4 Conclusion

Administration of 150 gram of processed tempeh gembus for 28 days reduced fasting blood glucose levels by 4.5 mg / dl.

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