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RESEARCH PAPER

Glucomannan powder can be used as a food substitute for people with diabetes mellitus

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Abstract

Glucomannan contained in porang tuber (*Amorphophallus oncophyllus*) includes polysaccharide fiber which can be used as an alternative food replacement for diet, especially in treating diabetes. It contains calcium oxalate and long-term use can cause harmful effects. Six male mice in each dose group, aged 2-2.5 months, and bodyweight 20 -40 g were used in this study. Mice were induced by alloxan monohydrate to produce diabetic mice. The test group was mice given porang powder standardized by glucomannan with a dose of 85, 165 and 250 mg/kg BW mice for 21 days and glucose measurements were taken every three days. A toxicity study with a randomized post-control group design used six mice in the dose group. The number of deaths was calculated with three kinds of methods (Weil method, Line method and Probit method) to produce the LD_{50} of porang powder. The data were then analyzed using One Way Anova with a significant value of 5%. Porang powder based on glucomannan with a dose of 250 mg/kg BW mice reduced glucose levels significantly after 13 days of administration ($p<0.05$). The highest dose (5000 mg/kg BW mice) of porang powder standardized by glucomannan for 48 hrs did not show death in mice and was not toxic.

1. Introduction

Diabetes mellitus or blood sugar disease is a metabolic disorder usually characterized by hyperglycemia and metabolic disorders of carbohydrates, fats and proteins. It occurs due to a deficiency in the amount of insulin secretion and insulin works but is less sensitive and may also occur due to both. Diabetes mellitus type II (DM II) is the most common type that occurs and it is related to decreased insulin sensitivity (WHO, 1999; Inzucchi *et al*., 2012).

In diabetes prevention, drugs are the first line in controlling blood sugar levels, but the provision of nutrients can also be done to control blood sugar levels. The primary goal is to optimize glucose control in the blood as well as to prevent and treat acute hypoglycemic cases and various complications including nephropathy, hypertension, and other cardiovascular diseases (Harris, 1995).

Functional food contains active compounds that have nutritional value and can provide health benefits (Trowell, 1976; De Jong *et al*., 2003; Keithley and Swanson, 2005). In many types of functional foods, one of the most important is fiber because it cannot be digested by the digestive enzymes in the human small intestine (Topping, 1991). Fiber or polysaccharides will provide high viscosity. This trait can reduce glucose absorption. Thus, high consumption of dietary fiber can control blood sugar levels for patients who are already diagnosed with DM II (Chandalia *et al*., 2000; Marlett *et al*., 2002; Kumar *et al*., 2013). A polysaccharide that can be a substitute for food is glucomannan contained in porang plants (Ohtsuki, 1968; Chen *et al*., 2003), as prebiotics (Chen *et al*., 2005; Chen *et al*., 2006; Elamir *et al*., 2008; Conolly *et al*., 2010), and adds immune system (Onishi *et al*., 2005; Oomizu *et al*., 2006; Chua *et al*., 2010). Glucomannan is a polysaccharide polymer (Li *et al*., 2005; Alonso *et al.,* 2009). The bonds that make up the mannan polymer are β-1,4-glycosides and β-1,6-glycosides having a mannose ratio with glucose of about 1.6:1 (Takigami, 2000; McMurry, 2008). The glucomannan has a water-soluble character and forms a thick mass with considerable expansion ability (138-200%), as well as the β-1,4 bond on glucomannan cannot be hydrolyzed by the amylase enzyme found in saliva. So, it will feel full (Vuksan *et al*., 2000; Alonso *et al*., 2009; Keithley *et al*., 2013). One plant containing

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glucomannan is porang (*Amorphophallus oncophyllus*), where the tubers contain calcium oxalate which can cause itching (0-20 mg/100 g wet weight). It leads to kidney damage and death if used for a long period (Holloway *et al*., 1989). The development of glucomannan use in porang powder requires a series of research trials such as activity and toxicity tests to be an herbal medicine or use in functional food.

2. Materials and methods

2.1 Instrument

A glucometer (Easy Touch), strip test (Easy Touch), OHAUS Adventurer Analytical Balances, injection syringe (NIPRO), and oral Gavage Mice sonde.

2.2 Chemicals

Porang powder was purchased from Bogor Agricultural Research Agency, Indonesia. Glibenclamide tablets were purchased from one of the Pharmacies. Alloxan monohydrate p.a, CMC-Na p.a. and 96% ethanol were purchased from Sigma-Aldrich. The content of glucomannan in porang powder was determined beforehand by the Visible-Spectrophotometry method with phenol-sulfuric acid reagent, which was 52.33±0.74% (w/w) (Chua *et al*., 2012; Sudjarwo *et al*., 2019).

2.3 Animal ethics

The animal ethics test was conducted at the Faculty of Veterinary, Universitas Airlangga Surabaya 60115 with Number: 670-KE, Surabaya, on March 9, 2017.

2.4 Animal requirements

Male mice (aged 8-12 weeks) with a body weight of 20-40 g. The condition of the mice is healthy (active and not disabled). For activity and toxicity, 30 mice were used in each test and divided into five groups that consisted of six mice each. Experimental animals were adapted for one week, fed and watered regularly. Before the test, the animals were fasting for 3-4 hrs.

2.5 Dosage

Firstly, mice were induced by alloxan monohydrate with a dose of 200 mg/kg BW mice (Szkudelski, 2001) to become diabetic mice. The dose on the activity test was 85, 165, and 250 mg/kg BW mice that were calculated as glucomannan in porang powder. The negative control group was given 0.3% CMC Na suspension and a positive control group was given glibenclamide suspension of 0.013 mg/20g/BW mice. For the toxicity test of porang powder, glucomannan with a dose of 320, 800, 2000, and 5000 mg/kg BW was used.

3. Results

The results of determining blood sugar in mice (Table 1 and Figure 1) were tested for normality using the Kolmogorov Smirnov test indicating that all data are normally distributed ($p>0.05$). The homogeneity test carried out in each treatment group using the Levene Test showed that all data were homogeneous ($p> 0.05$).

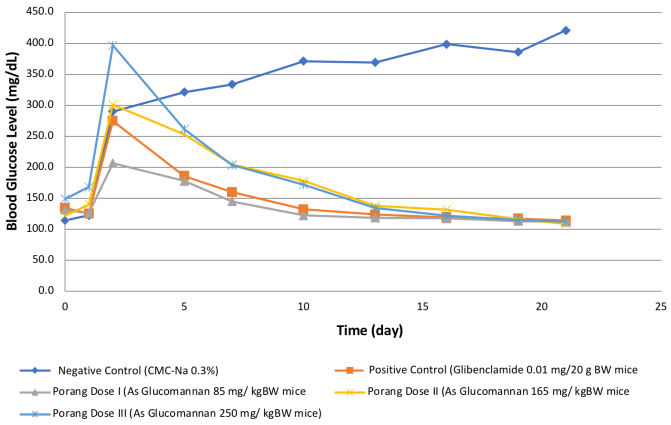

Figure 1. Blood sugar levels in mice.

Table 2. Statistical analysis of One Way ANOVA.

	Sum of squares	df	Mean square	F	p-Value
Between groups	442779.250	7	63254.179	3.350	0.007
Within groups	755226.667	40	18880.667		
Total	1198005.917	47			

The blood sugar levels analyzed using One Way Anova signified there are differences between groups (p: 0.007) (Table 2).

There was a significant difference ($p<0.05$) in blood sugar levels between positive controls, doses I, II, and III, and negative controls (LSD software). The positive

Table 1. Blood sugar level.

Group	Number of mice	Blood sugar level day to (mg/dL)									
		0	1	2	5	7	10	13	16	19	21
Negative	6	93.0	102.0	132.0	146.0	148.0	178.0	188.0	245.0	234.0	354.0
Glibenclamide	6	134.2	125.2	274.7	186.0	160.0	132.2	123.8	119.3	117.2	114.2
Porang 1	6	131.2	126.3	242.2	181.5	136.0	129.8	118.8	118.8	116.0	112.7
Porang II	6	121.7	140.3	272.5	177.0	161.0	137.8	126.8	125.0	117.2	110.8
Porang III	6	149.3	168.3	369.8	279.5	177.0	146.7	127.2	125.0	125.2	109.0

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Table 3. Statistical analysis paired t-test.

Days to	Difference significantly (p)				
	Negative control	Positive control	Porang 1	Porang 2	Porang 3
5 – 7	0.262	0.019*	0.016*	0.011*	0.014*
7 – 10	0.035*	0.026*	0.029*	0.025*	0.029*
10 – 13	0.782	0.046*	0.040*	0.047*	0.047*
13 – 16	0.018*	0.255	0.100	0.081	0.116
16 – 19	0.035*	0.369	0.103	0.098	0.123
19 – 21	0.114	0.165	0.188	0.180	0.148

* significant ($p<0.05$)

controls and doses I, II, and III groups can reduce blood sugar significantly for 21 days. The paired t-test (Table 3) showed that those two groups significantly reduced blood sugar levels from the first to the 13th day. Based on the calculation of the value of tan α (Figure 2), it signified that the dose III group could lower blood sugar levels the best with a tan α value of 11.736 (Table 4).

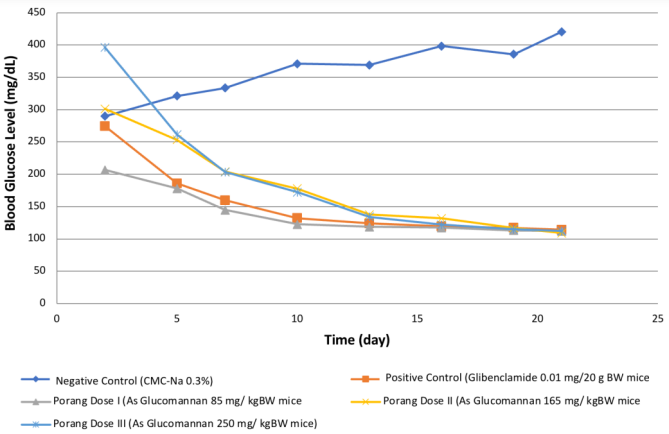

Figure 2. Tan α decreased blood sugar levels

Table 4. Tangent (tan) value of each treatment group.

Groups	Regression equation	tan α
Positive control	Y = -6.8049x + 232.53	6.8049
Porang 1	Y = -5.4909x + 208.31	5.4909
Porang 2	Y = -6.6064x + 230.31	6.6064
Porang 3	Y = -11.736x + 318.86	11.736

In this study, glucomannan with a dose of 85, 165, and 250 mg/kg BW was able to reduce blood sugar levels in mice within 13 days where the most significant decrease occurred on the fifth day when porang was given at a dose of 250 mg/kg BW in mice. For the in vivo toxicity test, the treatment of animals was carried out in accordance with the regulation of the Indonesian Food and Drug Supervisory Agency number 7/2014. After the administration of porang, mice were observed for 24 and 48 hrs and none of them died (Table 5).

4. Discussion

The content of glucomannan in porang is a water-soluble polysaccharide fiber that can be used as an alternative food substitute for diet, especially for diabetics (Yoshida *et al*., 2006; Singh and Shelley, 2007). A toxicity test is necessary because the porang tubers contain calcium oxalate which may be toxic and cause itching.

The results of lowering blood sugar at a dose of 250 mg/kg BW in mice were significant after 13 days of administration ($p<0.05$). Based on the toxicity test, there was no sign of mortality at the highest dose of 5000 mg/kg BW in mice for 48 hrs. The glucomannan in the stomach can form a thick gel that may inhibit gastric emptying as well as sugar and fat absorption. Thus, it is capable of lowering blood sugar levels. (Chearskul *et al*., 2007; Mardiah and Rahmawati, 2019).

In the OEDC toxicity test (OEDC, 2017) for acute toxicity, the minimum number of doses used is three dose levels. The results of the toxicity test, the lethal dose (LD_{50}), was calculated by the Weil method, Line method, and Probit method. However, the calculations using the three methods could not be explained because none of the experimental animals died. The Weil method could not determine the value of r (number of experimental animal deaths) and f (a constant in the weed table). In the Line and Probit method, a linear regression equation (y = a + bx) is necessary. However, it was impossible to explain the calculation because the

Table 5. Animal observation results of 24 hrs and 48 hrs test after administration.

Groups	Dose of Porang (mg/kgBW/day)	Long Dose	Number of Mice	Number of Dead Mice	% Dead Mice
1	Negative Control	-	6	0	0
2	320	2.505	6	0	0
3	800	2.903	6	0	0
4	2000	3.301	6	0	0
5	5000	3.699	6	0	0

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value of y (percentage of experimental animals' deaths) could not be obtained. Therefore, it can be concluded that porang powder is not toxic (Food and Drug Administration (FDA), 2000; Nishinari *et al*., 2007; OECD, 2022).

Another research has evaluated porang in male and female Wistar mice with 3 males and 3 females per group using a variable dose ratio of 320, 800, 2000, and 5000 mg/kg BW in mice. The study showed that no mice died. Therefore, the study argued that porang is non-toxic because the LD_{50} cannot be calculated (Natalia *et al*., 2014). According to the OECD (Chearskul *et al*., 2007), if the dose used in the test preparation is more than 2000 mg/kg BW and or equal to 5000 mg/kg BW showed no experimental animal dies, then it is said to be non-toxic.

4. Conclusion

The porang powder with a glucomannan content of 250 mg/kg BW can reduce blood sugar levels in mice most effectively and is not toxic so glucomannan powder can be used as a food substitute for people with Diabetes Mellitus.

Conflict of interest

The authors declare no conflict of interest.

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