Activity of Porang Flour and Moringa Extract to Blood Glucose and Lipid Levels in Alloxan Induced Diabetic Mice

Dian Ratih Laksmitawati, Siti Fatimah, Risti Fathul Jannah, Yati Sumiyati, Umi Marwati

Faculty of Pharmacy, University of Pancasila
Srengseng Sawah, Jagakarsa, South Jakarta, 12640
Email*: dian.ratih@univpancasila.ac.id

ABSTRACT

Aim: to determine the effect of Porang (*Amorphophallus muelleri* Blume) tuber flour and Kelor (*Moringa oleifera* L) leaf extract to blood glucose, triglyceride and cholesterol levels in Alloxan-induced diabetic mice.

Methods: Thirty male DDY mice, aged 2-3 months and body weight ranging between 20-30 grams, were divided into 6 groups: normal healthy group (N), diabetic without treatment as negative control group (DM0) and diabetic with treatment groups which categorize as diabetic with acarbose (6.5 mg/kg)/fenofibrate (26 mg/kg) (DMCA/F) as positive control group, diabetic with porang feed (DMP), diabetic with moringa extract (DME) and diabetic with porang feed-moringa extract (DMPE). Porang feed was given as pellet form, 5 grams/day while kelor extract (420 mg/kg) was administered orally. Treatment was carried out for 14 days after hyperglycemia state. Glucose was measured by easy touch® while cholesterol and triglyceride level were measured by using the enzymatic method.

Results: all treatment groups had a significant decrease in blood glucose, triglyceride, and cholesterol level. The DMP group had the largest decrease in blood glucose levels of 67.6% compared to other groups. The DMP group showed the largest decrease in triglycerides (59.98%) and cholesterol (33.39%) for 14 days of porang feeding whereas the difference number in decreasing triglycerides and cholesterol are the same as DMC fenofibrate group.

Conclusion: Porang feeding group showed the highest reduction effect on all parameters. Thus, the porang tuber is a potential carbohydrate that has a beneficial effect for diabetes.

Keywords: *Amorphophallus muelleri*, *Moringa oleifera*, Diabetes, glucose, triglycerides, cholesterol.

INTRODUCTION

Diabetes prevalence continues to rise where a significant increasing case for 25 years is estimated at 57.4%. In 2040 around 642 million people in the age range of 20-79 years have diabetes [1]. Diabetes is a metabolic disease characterized by hyperglycemia due to a defect of insulin secretion, insulin action or both. Chronic consequences of diabetes including heart attack, stroke, kidney failure, amputation, loss of vision and nerve damage [2].

Diet, physical activity and treatment with metformin, sulfonylurea and or insulin were recommended by World Health Organization (WHO) to control glycaemia for type 2 diabetes mellitus (T2DM) patients [2]. Diet or nutritional therapy is very challenging, mainly when the

social media serve 'delicious' information with promotions. The main objectives to be achieved in dietary treatment include promoting and supporting a healthy diet for ideal body weight, blood glucose, blood pressure, and blood lipid levels to delay and prevent complications of diabetes mellitus, however, can maintain the pleasure of eating [3].

The composition of healthy nutrients to prevent the development of T2DM are those which can reduce oxidative burden and increase insulin sensitivity. The nutrients include vegetables, fruits, legumes, nuts, fish, cereals and unsaturated fatty acids. Reducing the intake of trans-fatty acids and eating more high-fiber, antioxidants and polyphenols-containing food also can prevent T2DM and weight gain [4].

Rice is a carbohydrate that is consumed frequently by the world community, especially Indonesia. Wheat flour is also in high demand and used as raw materials for bread and noodles. Both types of carbohydrates have a high glycemic index (GI), contributing to increased blood glucose levels. Therefore consumption of those carbohydrates needs to be limited. Low GI foods are recommended to reduce excess mucosal burden due to slow digestion process which impacts to slow the rate of gastric emptying. Thus the food suspension (chyme) will reach small intestine slowly so that the absorption of glucose run slower resulting in a relatively small fluctuation in blood glucose levels [5]. In general, high fiber-containing food has a low GI value [6].

Iles-iles or known as porang tuber (*Amorphophallus muelleri* Blume) is a carbohydrate source which has high glucomannan content (41.3%). Glucomannan is a low digestible carbohydrate that widely used in the food and beverage industry. Glucomannan as a dietary fiber can reduce blood cholesterol and sugar levels, improve digestive and immune system functions, and reduce body weight [7].

Moringa oleifera is a famous plant that easily obtained and has been investigated for pharmacological effects such as antioxidant activities, immunomodulators, anti-inflammatory, liver and kidney protection and hypolipidemia. Moringa oleifera Lam. leaves has flavonoid compounds, namely quercetin which has hypoglycemic activity. Moringa leaf ethanol extract has two times of total phenol and three times of total flavonoids, higher compared to other plants that have been studied together such as spinach, broccoli, and cabbage. The scavenging activity to DPPH free radicals is more prominent than other plants [8,9].

This study aimed to determine the effect of feeding porang tuber flour and moringa leaf extract to blood glucose, cholesterol, and triglycerides level in alloxan-induced diabetic mice.

MATERIALS AND METHODS

Materials

Samples and Reagent

Porang tuber flour was obtained from Saradan plantation, Madiun, East Java meanwhile moringa leaves from BALITRO. The leaves were determined at the Botanical Research and Development Center "Herbarium Bogoriense", Center for Biological Research, LIPI, Bogor, Document number: 2469/IPH.1.01/If.07/XII/2016, determined by Dr. Joeni Setijo Rahajoe, NIP. 196706241993032004 as botanist. One touch® glucometer and glucose reagent strips (MHC Medical Products, LLC), triglyceride (REF 80019) and cholesterol (REF 80106) kits from Biolabo were the reagents that used to measure the parameter. BR2 (JAPFA) was used as standard food which contain rough protein (19-20%), water content (max 12%), fat (min 5%), rough fiber (max 5%), ash (max 7%), Ca (0,8-1,1%), P (min 0,45%) and ME (3050-3150 Kcal/kg). Other materials that used in this study were Alloxan tetrahydrate (Fluka Chemika) and ethanol 70%.

Porang feed and Moringa Extraction

Porang feed was made by mixing 60% porang tuber flour and 40% BR12 to be molded into pellets; meanwhile, ten kg of selected Moringa leaves was cleaned and dried for five days, then mashed to get 500 g of simplicia. The extraction process was performed by using kinetic macerator where 5 liters of 70% ethanol was used as the solvent (1:10). Remaceration was carried out five times. Extraction is at room temperature for 1x24 hours until liquid extract was formed. Evaporator was used to reach a concentrated extract of 144.79 grams. The extract was stored at 4° C until used.

Experimental animals

Thirty male, white mice with DDY strains, aged within 2-3 months and body weight ranging between 20-30 grams, were obtained from the Faculty of Animal Husbandry, Bogor Agricultural University (IPB). Mice were maintained for acclimatization in a cage with room temperature 22±3 °C, relative humidity of 30-70%, and lighting 12 hours bright 12 hours dark. A cage consist of 5 mice, according to the group. Mice were fed with standard food (BR2) ad libitum.

Alloxan-induced Diabetic Mice

Hyperglycemic state was induced by alloxan (dose of 180 mg/kg BW) intraperitoneally. Injections were performed three times on days 1, 2 and 3. Stable hyperglycemia state was reached after ten days from the first injection.

Treatment

Hyperglycemic mice were divided into five groups, each of which is five mice. Group 1 was made as a control (healthy mice). Mice were treated as follows:

- Normal healthy group (NDM): mice were not induced by alloxan and feed with standard food ad libitum.
- DM0 group: mice were induced by alloxan and had been fed with standard food, ad libitum.
- DMCA/DMCF group: mice were induced by alloxan, had been treated by acarbose (6.5 mg/kg BW/fenofibrate 26 mg/kg BW) and had been fed with standard, food ad libitum.
- DMP group: mice were induced by alloxan and had been fed with porang pellets, 5 gram/day.
- DME group: mice were induced by alloxan, had been treated with Moringa extract (420 mg/kg BW) and had been fed with standard food, ad libitum.
- DMPE group: mice were induced by alloxan, had been fed with porang pellets and had been treated with Moringa extract (420 mg/kg BW).

After hyperglycemia state, mice were treated according to their group for 14 days. Mice had been fed every 8 am and 3 pm, 25g per group. The remaining food was weighed. Moringa extract (420 mg/kg BW) was given in a suspense form orally. Blood from sinus orbital was collected to measure glucose, triglyceride and cholesterol levels. 300 □L blood sa
collected at baseline, before alloxan induction (day 0), hyperglycemia state (day 11), 7 days of treatments (day 18) and 14 days of treatment (day 25). Twelve hours before blood collection, mice have fasted. Blood glucose levels were measured by using an easy touch® glucometer meanwhile total cholesterol (REF 80106) and triglycerides (REF 80019) level was analyzed by an enzymatic colorimetric method, using commercial reagent from Biolabo and Microlab 300 instrument from Elitech Group.

RESULTS AND DISCUSSION

Profile of Blood Glucose, Total Cholesterol, and Triglycerides

Blood glucose profile dynamically changes, describing the condition or treatment. Table 1 showed that the range of blood glucose level at baseline between 86-105 mg/dL with an average of 97.8±6.7 mg/dL. Eleven days after injection of alloxan, blood glucose levels reached 164-195 mg/dL with an average of 182.5±16.9 mg/dL. The increase was statistically significant ($p<0.05$) with a percentage of 86.6% and demonstrated a hyperglycemic state.

Table 1. Blood Glucose Profile

Group	Glucose level (mg/dL) in average±SD, N=5			
	Baseline (Day-1)	Hyperglicemic state (Day-11)	7 days after treatment (Day-19)	14 days after treatment (Day-27)
NDM	98.2 ± 8.96	113.0 ± 7.81	117.2 ± 6.98	110.0 ± 6.89
DM0	96.0 ± 10.25	194.4 ± 9.84	181.2 ± 9.71	173.0 ± 7.71
DMCA	98.2 ± 10.25	163.2 ± 6.98	116.6 ± 21.34	87.8 ± 10.18
DMP	103.4 ± 7.54	194.8 ± 6.53	88.8 ± 5.49	62.8 ± 5.02
DME	86.0 ± 7.31	164.8 ± 5.76	130.4 ± 7.70	87.8 ± 7.46
DMPE	105.0 ± 7.97	195.4 ± 8.14	140.4 ± 13.45	82 ± 5.24

Note: NDM: Normal healthy group, mice were not induced by alloxan and had been fed with standard food; DM0 group: mice were induced by alloxan and had been fed with standard food; DMCA/DMCF group: mice were induced by alloxan, had been treated by acarbose (6.5 mg/kg BW/fenofibrate 26 mg/kg BW) and had been fed with standard food; DMP group: mice were induced by alloxan and had been fed with porang pellets; DME group: mice were induced by alloxan, had been treated with Moringa extract (420 mg/kg BW), and had been fed with standard food; DMPE group: mice were induced by alloxan, had been fed with porang pellets and had been treated with Moringa extract (420 mg/kg BW).

Alloxan induction can increase total cholesterol levels from an average of 85.25±5.28 mg/dL to 124.89±5.40 mg/dL with an increasing percentage of 46.50% ($p<0.05$). Likewise, triglyceride levels increased from 45.12±4.72 mg/dL to 100.94±7.23 mg/dL with an increased percentage of 123.7% ($p <0.05$). The data were shown in Table 2 and 3.

Table 2. Total Cholesterol Profile

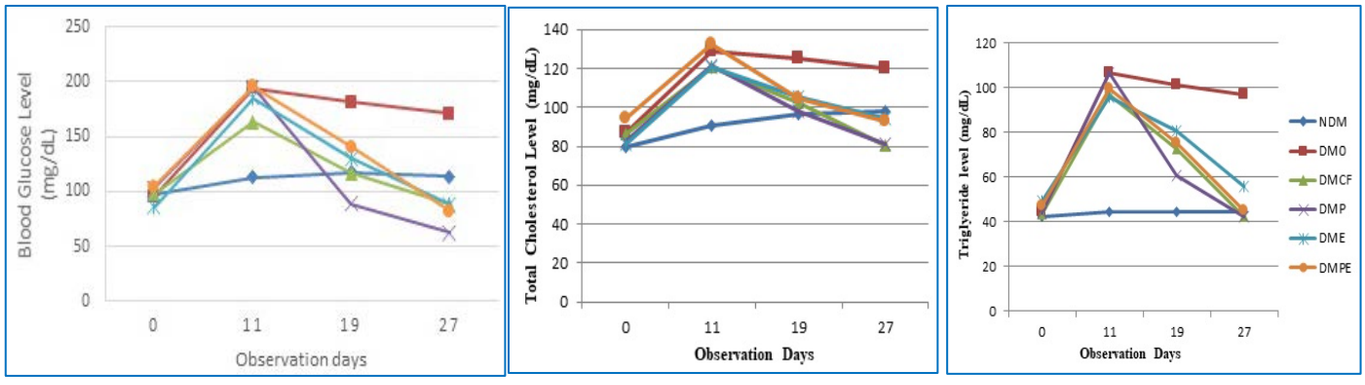
Group	Total cholesterol level (mg/dL) in average±SD, N=5			
	Baseline (Day-1)	Hyperglicemic state (Day-11)	7 days after treatment (Day-19)	14 days after treatment (Day-27)
NDM	79.94 ± 7.256	91.04 ± 12.531	96.62 ± 11.805	98.10 ± 8.833
DM0	86.92 ± 9.856	128.70 ± 4.183	125.40 ± 4.283	119.82 ± 8.503
DMCF	86.12 ± 9.856	120.70 ± 9.315	102.38 ± 12.00	80.56 ± 5.481
DMP	82.70 ± 7.863	121.46 ± 6.527	97.98 ± 2.755	80.90 ± 10.263
DME	81.32 ± 5.270	121.06 ± 10.043	105.54 ± 7.975	94.60 ± 8.312
DMPE	94.50 ± 7.300	132.52 ± 2.100	104.46 ± 1.488	92.98 ± 7.300

Note: NDM: Normal healthy group, mice were not induced by alloxan and had been fed with standard food; DM0 group: mice were induced by alloxan and had been fed with standard food; DMCA/DMCF group: mice were induced by alloxan, had been treated by acarbose (6.5 mg/kg BW/fenofibrate 26 mg/kg BW) and had been fed with standard food; DMP group: mice were induced by alloxan and had been fed with porang pellets; DME group: mice were induced by alloxan, had been treated with Moringa extract (420 mg/kg BW), and had been fed with standard food; DMPE group: mice were induced by alloxan, had been fed with porang pellets and had been treated with Moringa extract (420 mg/kg BW).

Table 3. Triglyceride Profile

Group	Triglyceride level (mg/dL) in average±SD, N=5			
	Baseline (Day-1)	Hyperglicemic state (Day-11)	7 days after treatment (Day-19)	14 days after treatment (Day-27)
NDM	42.44 ± 5.48	44.34 ± 4.12	44.46 ± 3.64	44.54 ± 6.16
DM0	44.50 ± 6.27	106.48 ± 5.38	101.22 ± 4.06	96.52 ± 2.68
DMCF	43.58 ± 3.35	96.96 ± 6.92	72.60 ± 5.53	42.07 ± 1.28
DMP	43.78 ± 3.41	106.3 ± 6.54	72.06 ± 8.55	42.54 ± 3.36
DME	49.30 ± 3.37	95.54 ± 5.96	80.58 ± 5.98	56.00 ± 2.98
DMPE	47.12 ± 4.05	99.4 ± 5.00	75.24 ± 10.10	45.10 ± 3.80

Note: NDM: Normal healthy group, mice were not induced by alloxan and had been fed with standard food; DM0 group: mice were induced by alloxan and had been fed with standard food; DMCA/DMCF group: mice were induced by alloxan, had been treated by acarbose (6.5 mg/kg BW/fenofibrate 26 mg/kg BW) and had been fed with standard food; DMP group: mice were induced by alloxan and had been fed with porang pellets; DME group: mice were induced by alloxan, had been treated with Moringa extract (420 mg/kg BW), and had been fed with standard food; DMPE group: mice were induced by alloxan, had been fed with porang pellets and had been treated with Moringa extract (420 mg/kg BW).



a. Blood Glucose Level (Glc) b. Total Cholesterol Level (TC) c. Triglyceride Level (TG)

Figure 1: Glucose and Lipid Profile

Figure 1 describes the profile of glucose, total cholesterol and triglyceride levels decreased in the treatment group of porang feed, moringa extract and the combination of porang feed and moringa extract. The difference in average levels of Glc, TC, and TG was calculated to find out the magnitude of the decrease. Table 4 showed the analysis of differences in glucose, total cholesterol and blood triglyceride levels of mice before and after administering the testing samples for 7 and 14 days. The treatment group has a higher decreasing number in all parameters compared to the control group (DM0). Porang feed for 7 days (DMP group) experienced the highest decrease in levels of Glc, TC, and TG compared to other groups,

respectively 106.0, 34.4 and 23.48 mg/dL. The differences were statistically significant ($p<0.05$). Treatment for 14 days showed higher in decreasing Glc, TC and TG level.

Table 4. Analysis of differences in glucose, total cholesterol, and blood triglyceride levels

Group	The difference in blood glucose, triglyceride, and total cholesterol level (mg/dL)					
	7 days after treatment			14 days after treatment		
	Glucose level	Triglyceride level	Cholesterol level	Glucose level	Triglyceride level	Cholesterol level
NDM	4.2 ± 1.8 [a]	2.32 ± 1.21 [a]	5.38 ± 2.39 [a]	4.6 ± 5.5 [a]	2.64 ± 1.63 [a]	7.38 ± 11.32 [a]
DM0	13.2 ±3.3 [b]	5.26 ± 2.69 [b]	4.1 ± 3.7 [b]	23.4 ± 3.8 [b]	9.96 ± 7.33 [b]	8.88 ± 7.04 [b]
DMCA/F	46.6 ± 19.7 [c]	24.36 ± 2.59 [c]	18.32 ± 2.71 [c]	75.4 ± 9.9 [c]	54.90 ± 7.02 [c]	40.14 ± 9.35 [c]
DMP	106.0 ± 11.0 [d]	34.24 ± 7.89 [d]	23.48 ± 4.41 [d]	132.0± 10.0 [d]	63.76 ± 5.53 [d]	40.56 ± 8.02 [ce]
DME	54.4 ± 7.9 [ce]	14.96 ± 1.85 [e]	15.52 ± 4.08 [c]	97.0 ± 4.9 [e]	39.54 ± 5.06 [e]	26.46 ± 6.59 [d]
DMPE	55.0 ± 11.5 [cf]	24.16 ± 5.49[c]	28.06 ± 1.21 [e]	113.4 ± 9.3 [e]	54.3 ± 7.19 [c]	39.54 ± 6.21 [e]

Note: NDM: Normal healthy group, mice were not induced by alloxan and had been fed with standard food; DM0 group: mice were induced by alloxan and had been fed with standard food; DMCA/DMCF group: mice were induced by alloxan, had been treated by acarbose (6.5 mg/kg BW/fenofibrate 26 mg/kg BW) and had been fed with standard food; DMP group: mice were induced by alloxan and had been fed with porang pellets; DME group: mice were induced by alloxan, had been treated with Moringa extract (420 mg/kg BW), and had been fed with standard food; DMPE group: mice were induced by alloxan, had been fed with porang pellets and had been treated with Moringa extract (420 mg/kg BW).
A superscript letter that is the same column showed s no significant difference

Administration of porang feed (DMP group) for 14 days can reduce levels of Glc, TC and TG for 67.6, 59.98 and 33.39 mg/dL, respectively. The difference in Glc levels during 7 days of porang feeding (DMP) showed the same values as the DME and DMPE groups, but administration for 14 days showed that the difference in Glc levels in the DMP group was higher and significantly different from other groups.

Table 5 showed the percentage in difference to emphasize the magnitude of decreased levels of all parameters.

Table 5. Percentage difference in glucose, triglyceride and total cholesterol level

Group	Percentage of difference (%)					
	Glucose level		Triglyceride level		Cholesterol level	
	7 days of treatment	14 days of treatment	7 days of treatment	14 days of treatment	7 days of treatment	14 days of treatment
NDM	3.7	2.6	0.27	0.45	6.13	7.75
DM0	6.8	11.0	4.94	9.35	2.56	6.90
DMCA/F	28.6	46.2	25.12	56.62	15.18	33.26
DMP	54.4	67.6	32.21	59.98	19.33	33.39
DME	20.8	46.7	15.66	41.39	12.82	21.86
DMPE	28.1	41.6	24.31	54.63	21.17	29.84

Note: NDM: Normal healthy group, mice were not induced by alloxan and had been fed with standard food; DM0 group: mice were induced by alloxan and had been fed with standard food; DMCA/DMCF group: mice were induced by alloxan, had been treated by acarbose (6.5 mg/kg BW/fenofibrate 26 mg/kg BW) and had been fed with standard food; DMP group: mice were induced by alloxan and had been fed with porang pellets; DME group: mice were induced by alloxan, had been treated with Moringa extract (420 mg/kg BW), and had been fed with standard food; DMPE group: mice were induced by alloxan, had been fed with porang pellets and had been treated with Moringa extract (420 mg/kg BW).

Discussion

This research was conducted to find the supplements as well as food alternatives that have the effect of reducing blood glucose, total cholesterol, and or triglyceride levels in patients with diabetes. Diabetic mice model was designed by induction of alloxan whereas the substance can induce free radicals that potential to injure the pancreatic tissue, resulting in the impairment of insulin secretion and trigger the hyperglycemic state. Also well known that excessive hepatic glycogenolysis and gluconeogenesis combine with decreased utilization of glucose is the primary mechanism in hyperglycemia [10].

High cholesterol (TC) and triglycerides (TG) level often found in the diabetic patient. Insulin defects activate *Hormone Sensitive Lipase* (HSL) increase lipolysis in adipose tissue, results in excessive free fatty acids. In circulation, these free fatty acids are used as energy sources and some other as a precursor for triglycerides production in the liver. High level of free fatty acids in the liver stimulates VLDL secretion, a lipoprotein rich in triglycerides contribute to hypertriglyceridemia state [11].

The activity of cholesterol ester protein transfer (CETP) will increase in hypertriglyceridemia condition. CETP exchange triglycerides content from VLDL with cholesterol from LDL and HDL. The triglycerides contained in LDL being hydrolyzed by the Hepatic Lipase (HL) to form small dense LDL, a lipoprotein that is easily oxidized [11]. Hypercholesterolemia and hypertriglyceridemia are lipid metabolism disorder which observes in patients with diabetes. This condition occurred in this study.

Our study showed that Porang feed, Moringa extract and combination of Porang feed with Moringa extract could reduce blood glucose, total cholesterol and triglyceride level in alloxan-induced diabetic mice. Porang fluor contains glucomannan, a heteropolysaccharide consisting D-mannose and D-glucose in a 1.6: 1 ratio. Glucomannan is a water-soluble fiber which forms a gel in the stomach and contribute to slow the gastric emptying process. The fiber can be easily fermented by the microflora of the colon and was thought to stimulate the production of *Glucagon-Like Peptide* (GLP-1) [12].

Glucagon-like peptide 1 (GLP-1) is an incretin hormone, produced by the proglucagon gene in the L-cells of the small intestine. In response to nutrients, GLP-1 stimulates insulin release by the pancreatic beta cells and thought to slowing gastric emptying and improving satiety, a mechanism to exert antihyperglycemic. It has been reported that this hormone improves insulin sensitivity [13].

A decrease in blood glucose levels in Moringa extract allegedly caused by quercetin, a flavonoid content which interferes the intake of glucose in the small intestine mucosa by inhibiting α-glucosidase. This enzyme decrease the digestion rate of polysaccharide into monosaccharides and cause longer absorption process and give impact in lowering blood glucose levels [14].

Another study that have an in-line result with this research was carried out by Al-Malki et al. which states that treating the diabetic rats with 50 or 100mg Moringa seeds powder/kg BW ameliorated the levels of fasting blood sugar and HbA1c. Phenolic and flavonoid content have a

scavenging effect on the free radicals. Moringa oleifera contains glucosinolates i.e. glucomoringin, flavonoids i.e. quercetin and kaempferol, and phenolic acids i.e. chlorogenic acid which has the pharmacological effect such as antioxidant, hypoglycemic, hypotensive, antidyslipidemic, anticancer, anticancer, and anti-inflammatory [15].

A lower level of cholesterol and triglyceride in Moringa extract group may be due to quercetin content which can reduce LDL cholesterol and triglycerides, by increasing the activity of the lipoprotein lipase. This enzyme plays a role in hydrolysis triglycerides into fatty acids, a working mechanism to reduce LDL sensitivity to free radicals [16].

Glucomannan as a fiber able to absorb water and be able to bind bile salts in the intestinal lumen. Commonly, more than 95% of bile salts will be recycled and returned to the liver. This fiber inhibits the recycling process so that bile salts will be secreted through the feces and only a small amount of bile salt is returned to the liver. This process will stimulate the liver to form new bile salts and will take cholesterol from circulation, a mechanism in reducing the cholesterol level in the blood [17]

CONCLUSION

Porang flour and Moringa extract play a role in reducing blood glucose, triglyceride and cholesterol levels in alloxan-induced diabetic mice. Porang feeding group showed the highest reduction effect on all parameters. Thus, the porang tuber is a potential carbohydrate that has a beneficial effect for diabetes.

ACKNOWLEDGEMENTS

This research was supported by a grant from Indonesian Directorate General of Higher Education (DIKTI) in 2018 (No. 2113/LPPM/UP/III/2018).

REFERENCES

[1] Ogurtsova, K. et al., 2017. IDF Diabetes Atlas: Global estimates for the prevalence of diabetes for 2015 and 2040. *Diabetes Research and Clinical Practice*, 2017, 128(March), 40–50.
[2] World Health Organization, *Global Report on Diabetes*, WHO Press, 2016.
[3] American Diabetes Association, Lifestyle management. In *Standards of Medical Care in Diabetes*, 2017. pp. S33–S43.
[4] Mohammad Asif, The prevention and control the type-2 diabetes by changing lifestyle and dietary pattern. *J Educ Health Promot*, 2014, 3(1).
[5] Fernandes G, Velangi A, W.T., Glycemic index of potatoes commonly consumed in North America. *J Am Diet Assoc*, 2005, 105(4), pp.557–5562.
[6] Trinidad, T.P. et al., Glycemic index of commonly consumed carbohydrate foods in the Philippines. *Journal of Functional Foods*, 2010, 2(4), pp.271–274.
[7] Rokhmah D.N., S.H., Prospek pengembangan iles-iles (*Amorphophallus muelleri* Blume) sebagai upaya diversifikasi pangan di Indonesia. *Sirinov*, 2015, 3 (1)(April), pp.1–10.
[8] Pakade, V., Cukrowska, E. & Chimuka, L., Comparison of antioxidant activity of Moringa oleifera and selected vegetables in South Africa. *South African Journal of Science*, 2013, 109(3–4), pp.1–6.
[9] Sahay, S., Yadav, U. and Srinivasamurthy, S., Potential of Moringa oleifera as a functional food ingredient: A review. *International Journal of Food Science and Nutrition*, 2017, 2(5), pp.31–37.
[10] Rohilla, A. & Ali, S., Alloxan Induced Diabetes: Mechanisms and Effects, *International Journal of Research in Pharmaceutical and Biomedical Science*, 2012, 3(2), pp.819–823.

[11] Rampengan, S.H, Meningkatkan Kolesterol HDL: Paradigma Baru dalam Pencegahan Penyakit Kardiovaskular, *JBM*, 2015; 7(2): 89-98.
[12] Keithley, J.K. et al., Safety and Efficacy of Glucomannan for Weight Loss in Overweight and Moderately Obese Adults. *Journal of Obesity*, 2013; Volume 2013.
[13] Dungan, K. & Buse, J.B., Glucagon-Like Peptide 1–Based Therapies for Type 2 Diabetes: A Focus on Exenatide, *Clinical Diabetes*, 2005; 23(2), pp.56–62.
[14] Murray RK, Granner DK, Rowdell VW. Biokimia Harper. 25th edition, EGC, Jakarta, 2003.
[15] Al-malki, A.L. & Rabey, H.A. El, The Antidiabetic Effect of Low Doses of Moringa oleifera Lam. Seeds on Streptozotocin Induced Diabetes and Diabetic Nephropathy in Male Rats, *BioMed Research International*, volume 2015.
[16] Prahastuti, Sijani, Potensi Kedelai Hitam (*Glycine max* L.Merr) dan Daun Jati Belanda (*Guazuma ulmifolia* Lamk) untuk Pengobatan Alternatif Dislipidemia In Vivo. *Journal of Medicine and Health*. 2016; 1(3): 200 – 213.
[17] Chen HL, Sheu WH, Tai TS, Liaw YP and Chen YC, Konjac supplement Alleviated hypercholesterolemia and hyperglycemia in type 2 diabetic subjects-A randomized double-blind trial. *J Am CollNutr*, 2003; 22: 36-42.