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The Immediate Effects of *Porang*-Processed Rice (*Amorphophallus oncophyllus*) on Blood Glucose Levels in Patients with Type 2 Diabetes Mellitus

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ABSTRACT

Background: Diabetes mellitus (DM) is a metabolic disorder characterized by hyperglycemia and associated with several risk factors, such as an unhealthy and unbalanced diet. *Porang* tubers, known as healthy diet resources, contain glucomannan, a substance that has many positive effects, such as ameliorating blood glucose. *Porang* tubers are processed as many food products, one of which is *porang*-processed rice (PR). This study investigated the immediate effects of PR on the blood glucose levels compared to white rice (WR) in patients with diabetes mellitus (DM).

Methods: This was a pilot study of a non-randomized clinical study with a pre-and post-test design held from July to August 2021 in Diponegoro National Hospital, Semarang, Indonesia, among 40 DM patients. Subjects who met the inclusion criteria were divided into two groups: subjects that consumed *Porang*-processed rice (PR group, n=20) for two days and those that consumed white rice (WR group, n=20). They were measured for fasting blood glucose (FBG) and 2 hours post-prandial glucose (2hPPG) at baseline (T0) and at day-3 after observation (T1). Data were analyzed using SPSS version 20 for Windows.

Results: There were no significant differences in FBG and 2hPPG between the PR group and WR group at T0 and T1 ($p>0.05$). However, there were slightly larger decreases in FBG and 2hPPG in the PR group compared to the WR group, although they were insignificant ($p>0.05$).

Conclusion: The immediate consumption of PR for only two days in patients with DM could not reduce FPG and 2hPPG. It is needed to be confirmed by further studies whether PR may have the role as adjunctive in inhibiting the dramatic rise of FBG or 2hPPG or stabilizing blood glucose in patients with DM in a more extended time of consumption.

Keywords: *Porang*-processed rice, *Amorphophallus oncophyllus*, blood glucose, diabetes mellitus.
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INTRODUCTION

Diabetes mellitus (DM) is one metabolic disease that occurs due to disruption in secretion and/or in function or action of insulin hormone characterized by hyperglycemia.[1,2] Chronic hyperglycemia may lead to various microvascular and macrovascular complications.[3-6] Because of those complications, DM is high in morbidity and mortality.[3,5,6] The cases significantly rose in these two decades.[1-6] In 2021, International Diabetes Federation (IDF) estimated that 537 million adults aged 20-79 were living with diabetes.[6] This number was predicted to rise to 643 million by 2030 and 783 million by 2045.[6]

Southeast Asia was the third-highest prevalence of diabetes.[6] Indonesia was one of the Southeast Asia countries listed as having the 10th highest number of diabetes mellitus patients. This represented that Indonesia should take several contributions to the prevalence of DM in Southeast Asian.[5-7]

DM is affected by various risk factors that can either be modified or cannot be modified. One of them is the unhealthy and unbalanced diet which is high in calories.[1,4–6] In the early stage of the disease, pancreatic β cells compensate for insulin resistance by increasing insulin secretion. But when insulin resistance develops, pancreatic Langerhans islands cannot resist the hyperinsulinemia state. In addition, there is skeletal muscle inability in glucose clearance which may lead to an increment of post-prandial blood glucose.[4] The diagnosis of DM is confirmed by the evaluation of fasting blood glucose (FBG) and 2-hour post-prandial glucose (2hPPG).[1-3]

Several studies have been done on patients with DM, including their medical treatments and adjunctive interventions.[6,8,9] Indonesia has many potential food resources that might be beneficial for maintaining a healthy diet for human beings. One of them is *porang* (*Amorphophallus oncophyllus*), a nutraceutical plant.[10] Nutraceutical means food or its part with health advantages, including prevention or treatment of a disease.[11,12] This plant consists of leaves, stems, and tubers, which have the

important content of glucomannan, a high carbohydrate substance. Glucomannan is a hemicellulose polysaccharide that has glucose, galactose, and mannose-binding chain.[13-20]

The glucomannan in *porang* tubers acts as water-soluble and can absorb water as much as 200 times its weight, giving a feeling of fullness. Moreover, it may also have positive physiological effects on the human body, such as: decreasing blood glucose; inhibiting cholesterol and glucose absorption; reducing obesity; and treating constipation.[14-20] As a gel-making substance, digestion viscosity increases so that the absorption rate in the intestines tends to slow down. Thus, post-prandial blood glucose and insulin surge decrease while the sensitivity of insulin increases.[14-20]

Porang tubers are processed for many products (e.g., noodles, tofu, jelly drinks), which are famous for the name "shirataki" or "konjac". One of the processed products is *porang*-processed rice (PR) which may be able to substitute for the original white rice (WR), which is high in calories.[16-20] Studies on the effects of immediate PR in patients with DM are still increasing. This study investigated the immediate effects of PR consumption compared to WR consumption on blood glucose levels in patients with DM.

METHODS

This was a non-randomized clinical study with an experimental pre-and post-test design held from July to August 2021 in Diponegoro National Hospital, Semarang, Indonesia. A total of 40 patients selected by consecutive sampling participated in this study. The inclusion criteria were (1) has been diagnosed with diabetes mellitus (DM) or has been consuming routine oral antidiabetic drugs; and (2) has signed the written informed consent. Meanwhile, the exclusion criteria were that (1) has been diagnosed with stroke or peripheral arterial disease; (2) malignancy or cancer; (3) acute infection; and (4) has been consuming corticosteroids.

All subjects were divided into two groups: the treatment group that consumed PR (n=20) and the control group that consumed WR (n=20). Either PR or WR was consumed ad libitum orally for 2 days, within 200 – 500 grams per day. All subjects were measured for fasting blood glucose (FBG) and 2 hours post prandial glucose (2hPPG) at baseline (T0) and on day 3 after observation (T1) with blood sampling from an antecubital vein. All subjects were still consuming routine medications during the study, such as oral anti-diabetic drugs, anti-hypertension, and/or anti-dyslipidemic drugs.

Study data included demography, physical examination, the information provided by questionnaires, and laboratory measurement consisting of blood glucose profiles. Blood pressure was measured using automated equipment (Sinocare Automatic Upper Arm Blood Pressure Monitor BA-801, Dongguan E-Test Technology Co., GuangDong, China). Blood glucose profiles taken from venous blood serum were measured using a laboratory analyzer (PROLINE R-910, Prodia Diagnostic Line, Indonesia).

Data were analyzed using computer software SPSS version 20 for Windows. Data were either presented as mean and standard deviation (SD) for continuous variables or as frequency and proportion (n, %) for categorical variables. The Shapiro-Wilk test determined the normality of data distribution. The independent *t*-test was performed to compare the data when normally distributed. The non-parametric Mann-Whitney Rank test was performed when the data were not normally distributed. Statistically, significance was considered as $p<0.05$.

RESULTS

The baseline demographic and clinical characteristics of participants are presented in Table 1 and Table 2. There was no difference in mean age between WR and PR groups (59.9 ± 7.77 vs. 60.2 ± 10.06, respectively, $p=0.917$). There were no differences in age distribution, body mass index (BMI), history of hypertension, and history of dyslipidemia between the two groups ($p>0.05$) (Table 1). There were no differences in baseline clinical characteristics, such as heart rate, respiratory rate, body temperature, systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) ($p>0.05$) between both groups (Table 2). There were no differences in all routine medications used in both groups (Table 3).

The blood pressure and blood glucose profiles in patients with PR consumption compared to those with WR consumption are presented in Tables 4 and 5. Neither group had any differences in SBP, DBP, and MAP in T1 (Table 4).

At baseline (T0), there was no difference on FBG in PR compared to WR group (130.3 ± 42.30 mg/dL vs 151.0 ± 58.77 mg/dL, respectively, $p=0.142$). At baseline (T0), there was also no difference in 2hPPG in PR compared to WR group (164.9 ± 74.37 vs 198.9 ± 78.41, respectively, $p=0.221$). There were also no significant differences between two groups after 2 days of treatment (T1) in FBG (128.8 ± 39.28 mg/dL vs 150.3 ± 59.03 mg/dL, $p=0.114$) and 2hPPG (162.0 ± 71.46 vs 192.2 ± 78.21, $p=0.242$) (Table 5, Figure 1 and 2).

However, there were wider decreases of FBG (ΔFBG) (3.6 ± 2.56 mg/dL vs 2.9 ± 1.83 mg/dL) and of 2hPPG (Δ2hPPG) (3.4 ± 3.92 mg/dL vs 2.2 ± 4.44 mg/dL) in PR group compared to WR group, although they were not significantly different ($p>0.05$) (Table 5, Figure 1 and 2). No adverse effects were observed.

DISCUSSION

Several studies have been performed to investigate the effects of glucomannan administration, one of the main content in *porang* tubers, on the blood glucose level in patients with or without diabetes mellitus and the cholesterol levels.[13-20] Several studies showed that consuming *porang* tubers-processed products for several days could improve blood glucose levels.[13-16] Glucomannan showed a favorable effect in increasing positive physiological activity in the human body.[13-20] Administration of *porang*-based meals could gradually help glucose absorption and lower the increment of blood glucose.[13-20]

Our study showed no significant differences in FBG and 2hPPG between both groups consuming PR or WR. However, compared to the WR group, there was a better performance of blood glucose in the PR group, although those were not significant. This might be caused by inadequate time in PR consumption compared to the previous study, such as

in a study by Mardiah et al which was 15 days.[13]

Mardiah et al. showed that alloxan-induced hyperglycemic rats' blood glucose decreased from 492 mg/dL to 250 mg/dL after 15 days of feeding with glucomannan; however, the blood glucose of those without glucomannan was still high (470 mg/dL).[13] Sutriningsih A et al. also showed that *porang* tubers (*Amorphophallus oncophyllus*) in the processed form of Shirataki noodles within two weeks could decrease blood glucose levels from 281.75±87.94 mg/dL at baseline to 172.69±80.62 mg/dL at day-7.[14] Moreover, Ngatirah et al., showed that effervescent synbiotic tablets that contain glucomannan could reduce the blood sugar levels of white rats, but did not affect changes in the weight of white rats.[15]

Mardiah et al. also found that the improvement in blood glucose might be mediated by improvement in Langerhans Island and β-cells. Their study successfully showed a significantly increased number of Langerhans Island and β-cells after being treated by feeding glucomannan.[13]

Konjac glucomannan is a soluble dietary fiber that has been proven effective in lowering post-prandial glycemic response after intake as a food supplement.[16,17] Zhou Y et al. investigated whether konjac glucomannan in a noodles-based food matrix had a beneficial effect on digestion-related metabolism.[17] They showed that konjac glucomannan could inhibit in vitro enzymatic hydrolysis of wheat starch and wheat gluten nearly dose-dependently. Konjac glucomannan slowed the rise of post-prandial blood glucose and increased satiety by affecting the intestinal metabolism of rats.[17]

Table 1. Baseline Demographic Characteristics of Participants.

Parameter		Group (N=40)		p
		WR (N=20)	PR (N=20)	
Age (years old)		59.9 ± 7.77; 60.0 (42.0 – 72.0)	60.2 ± 10.06; 59.5 (43.0 – 78.0)	0.917[a]
Age, n (%)	40 to 49 years old	2 (5.0)	3 (7.5)	0.966[b]
	50 to 59 years old	8 (20.0)	7 (17.5)	
	60 to 69 years old	6 (15.0)	6 (15.0)	
	70 to 79 years old	4 (10.0)	4 (10.0)	
Gender, n (%)	Male	6 (15.0)	14 (35.0)	0.011[b]*
	Female	14 (35.0)	6 (15.0)	
Weight (kg)		69.5 ± 2.74; 68.5 (66.0 – 75.0)	71.0 ± 3.22; 72.0 (65.0 – 76.0)	0.121[c]
Height (cm)		167.1 ± 1.49; 167.0 (165.0 – 169.0)	170.6 ± 2.54; 170.5 (165.0 – 175.0)	0.001[c]*
BMI (kg/m^2)		24.8 ± 0.70; 24.6 (24.2 – 26.3)	24.3 ± 0.89; 24.2 (23.0 – 25.6)	0.063[c]
Hypertension, n (%)	Yes	12 (30.0)	11 (27.5)	0.749[b]
	No	8 (20.0)	9 (22.5)	
Dyslipidemia, n (%)	Yes	8 (20.0)	9 (22.5)	0.749[b]
	No	12 (30.0)	11 (27.5)	

Abbreviation: WR= white rice; PR= *porang*-processed rice; BMI = body mass index. Data are presented as frequency (proportion) or mean ± SD; median (minimum-maximum). Significant difference is considered if *p<0.05; [a]Independent *t*-test; [b]Chi-square test.; [c]Non-parametric Mann-Whitney test.

Table 2. Baseline Clinical Characteristics of Participants.

Parameter	Group (N=40)		p
	WR (N=20)	PR (N=20)	
Heart rate (beats/min)	83.3 ± 16.15; 76.5 (63.0 – 125.0)	85.6 ± 12.30; 82.5 (70.0 – 118.0)	0.327[c]
Respiratory rate (breaths/min)	19.8 ± 3.88; 19.0 (14.0 – 26.0)	19.0 ± 3.45; 18.0 (14.0 – 26.0)	0.583[c]
Body temperature (Celsius)	36.0 ± 0.56; 36.2 (34.2 – 36.4)	36.3 ± 0.19; 36.3 (35.9 – 36.8)	0.108[c]
Systolic blood pressure (mmHg)	152.1 ± 21.09; 149.0 (118.0 – 195.0)	144.8 ± 22.05; 150.5 (92.0 – 171.0)	0.659[c]
Diastolic blood pressure (mmHg)	83.2 ± 9.40; 83.0 (69.0 – 105.0)	80.7 ± 11.83; 80.0 (56.0 – 108.0)	0.504[a]
Mean Arterial Pressure (mmHg)	106.3 ± 10.95; 107.0 (89.0 – 132.0)	102.0 ± 13.05; 103.5 (71.0 – 122.0)	0.730[a]

Abbreviation: WR= white rice; PR= *porang*-processed rice. Data are presented as mean ± SD; median (minimum-maximum). A significant difference is considered if *p<0.05. [a]Independent *t*-test; [c]Non-parametric Mann-Whitney test.

The glucomannan was hypothesized to improve metabolic control by forming glucomannan-gel, which might increase the viscosity of digested food, slow the food absorption rate in the small intestine, and thereby decrease post-prandial glucose and insulin surges.[13] These might result in a long-term improvement in peripheral insulin sensitivity.[13]

Arvill A and Bodin L also showed that glucomannan was an effective cholesterol-lowering dietary adjunct.[18] They showed that glucomannan fibers reduced total cholesterol (TC) concentrations, low-density-lipoprotein cholesterol (LDL-C) concentrations, triglycerides, and SBP. High-density-lipoprotein cholesterol (HDL-C) and the ratio of LDL-C to HDL-C did not change significantly. No change in DBP or body weight was observed.[16] However, our study did not observe their effects on cholesterol profiles.

The attenuated increased insulin sensitivity had been reported to reduce blood pressure by influencing sodium absorption in the distal tubule, increasing sympathetic nervous system activity and decreasing peripheral vascular resistance.[21-22] Such improvement in insulin sensitivity might have been mediated by sustained slowed absorption during the glucomannan treatment.[21-22] Meanwhile, our study could not show improvement in blood pressure due to the short duration of its consumption.

In our study, PR was given as a short-term treatment. We found a slightly better performance of FBG and 2hPPG in the PR group compared to the WR group, although they were not significant. PR seemed to have immediate effects on stabilizing blood glucose levels in patients with DM. However, our study had several limitations which should be considered. We did not elucidate its impact on the longer duration of PR administration and in various time post-prandial blood glucose measurements, such as 4-hour and 6-hour post-prandial blood glucose, to prove the significant effects of PR in decreasing blood glucose.

Further studies are needed to examine the effects of PR consumption with

Table 3. History of Medication Used in Both Groups.

Medications	Group (N=40)		P
	WR (N=20)	PR (N=20)	
Metformin, n (%)	15 (37.5)	12 (30.0)	0.311[b]
Sulfonylurea, n (%)	14 (35.0)	12 (30.0)	0.507[b]
Acarbose, n (%)	11 (27.5)	16 (40.0)	0.091[b]
Statin, n (%)	8 (20.0)	9 (22.5)	0.749[b]
CCBs, n (%)	11 (27.5)	8 (20.0)	0.342[b]
ACEi, n (%)	8 (20.0)	5 (12.5)	0.311[b]
ARBs, n (%)	4 (10.0)	5 (12.5)	0.705[b]

Abbreviation: WR= white rice; PR= *porang*-processed rice; CCB= calcium channel blockers; ACEi= angiotensin-converting enzyme inhibitor; ARB= angiotensin receptor blockers. Data are presented as frequency (proportion). A significant difference is considered if *p<0.05. [b]Chi-square test.

Table 4. Blood Pressure Profiles in Patients with *Porang*-processed Rice (PR) Consumption Compared to White Rice (WR).

Parameter Post WR or Post PR	Group (N=40)		p
	WR (N=20)	PR (N=20)	
Systolic Blood Pressure (mmHg)	147.0 ± 21.04; 149.0 (109.0 – 186.0)	134.2 ± 19.43; 130.0 (86.0 – 168.0)	0.633[a]
Diastolic Blood Pressure (mmHg)	78.4 ± 10.05; 79.0 (64.0 – 96.0)	75.0 ± 12.16; 75.0 (51.0 – 99.0)	0.650[a]
Mean Arterial Pressure (mmHg)	101.3 ± 9.72; 101.0 (80.0 – 116.0)	95.0 ± 12.10; 97.0 (68.0 – 117.0)	0.400[a]

Abbreviation: WR= white rice; PR= *porang*-processed rice. Data are presented as mean ± SD; median (minimum-maximum). Significant difference is considered if *p < 0.05. [a]Independent t-test.

Table 5. Blood glucose profile before and after *Porang*-processed Rice (PR) Consumption in Comparison with White Rice (WR).

Parameter	Group (N=40)				p
	WR (N=20)		PR (N=20)		
FBG Pre (mg/dL)	151.0 ± 58.77; 134.5 (93.0 – 340.0)		130.3 ± 42.30; 117.5 (84.0 – 235.0)		0.142[c]
FBG Post (mg/dL)	150.3 ± 59.03;	133.5 (94.0 – 341.0)	128.8 ± 39.28;	115.5 (88.0 – 231.0)	0.114[c]
2hPPG Pre (mg/dL)	198.9 ± 78.41; 202.5 (81.0 – 349.0)		164.9 ± 74.37; 149.0 (72.0 – 320.0)		0.221[c]
2hPPG Post (mg/dL)	192.2 ± 78.21;	179.5 (80.0 – 350.0)	162.0 ± 71.46;	146.5 (76.0 – 301.0)	0.242[c]
ΔFBG (mg/dL)	2.9 ± 1.83;	2.0 (1.0 – 9.0)	3.6 ± 2.56;	3.0 (1.0 – 10.0)	0.105[c]
Δ2hPPG (mg/dL)	2.2 ± 4.44;	1.0 (1.0 – 21.0)	3.4 ± 3.92;	2.5 (1.0 – 19.0)	0.054[c]

Abbreviation: FBG= fasting blood glucose; 2hPPG= 2 hours post prandial glucose. Δ = difference between pre and post-PR or WR consumption. Data are presented as mean ± SD; median (minimum-maximum). A significant difference is considered if *p<0.05. [c]Non-parametric Mann-Whitney test.

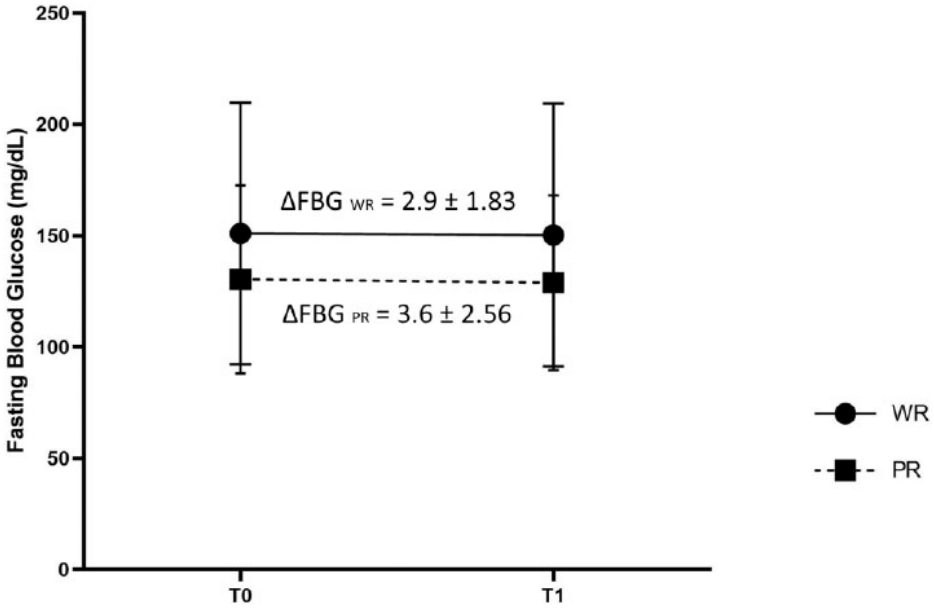

Figure 1. Fasting blood glucose (FBG) in both the white rice (WR) group and *Porang*-processed rice (PR) group in baseline (T0) and 2 days after their consumption (T1).

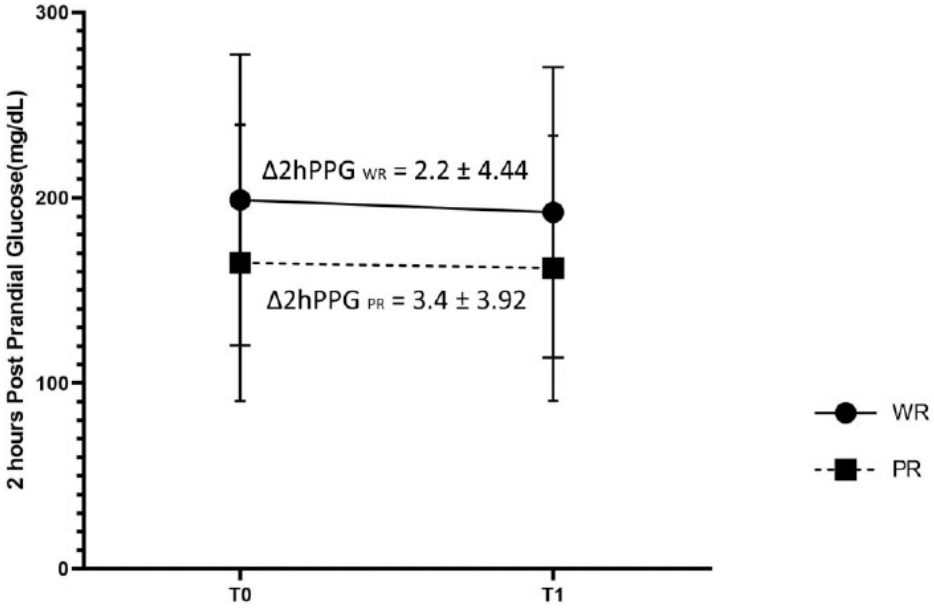

Figure 2. Two-hours post-prandial glucose (2hPPG) in both white rice (WR) group and *Porang*-processed rice (PR) group in baseline (T0) and 2 days after their consumption (T1).

a varying portion of rice that will be consumed and at various times of post-prandial blood glucose measurements. We also need to examine it in a longer duration of PR administration, such as within 1 week and/or 2 weeks, as there was no specific finding in the most effective period of PR consumption. It is also needed to study the effect of PR on the cholesterol profiles of those patients.

CONCLUSION

Immediate PR consumption for only two days in patients with DM could not reduce FPG and 2hPPG. It is needed to be confirmed by further studies whether PR may have the role as adjunctive in inhibiting the dramatic rise of FBG or 2hPPG or stabilizing blood glucose in patients with DM in a more extended time of consumption.

CONFLICT OF INTEREST

All authors declared no conflict of interest regarding this article's publication.

ETHICAL CONSIDERATION

Ethical clearance was obtained from the Ethics Committee in Health and Medical Research (KEPK) Faculty of Medicine, Universitas Diponegoro, Semarang (No. 203/EC/KEPK/FK-UNDIP/VI/2021). All subjects explained this study's purpose, advantage, and procedure. Subjects also had agreed by signing the written informed consent.

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AUTHOR CONTRIBUTION

GOL and SAW contributed equally to this study, including preparing the study until preparing the manuscript to be published. GOL and SAW conducted the study. SBU and SAW were involved in concepting, designing and supervising the manuscript. SAW, TEN, EK, and SGP analyzed the data. All authors agreed for this final version of manuscript to be submitted to this journal.

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