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Research Article

The Effect of Consumption Rice Analogue of Banggai Yam (*Dioscorea Alata*) on Blood Sugar Levels of Pre-Diabetic Patients in the District of Banggai Archipelago

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ABSTRACT

Rice analogue of banggai yam (dioscorea alata) is made with the formula of banggai yam flour, mocaf flour and cornstarch in a ratio of 55:30:15. Furthermore, Banggai Yam's Analog rice (Dioscorea Alata) was given to respondents with prediabetes. The purpose of this study was to determine the effect of consumption of rice analogues of yam banggai on glucose levels of prediabetics. The research location is in Banggai Islands Regency. The number of respondents was 120 people and the intervention time was 2 weeks. The results showed that fasting blood sugar levels on pre and day 7 in both groups had differences or there was a decrease in fasting blood sugar levels with p values of <0.001 each. The greatest change was shown in the intervention/rice analog group with a difference of 24.55. While in the control group only amounted to 8,483. Reduction in Fasting Blood Sugar Levels on pre and day 14 p values of <0.001 each. The greatest change was shown in the intervention/rice analog group with a difference of 29.817. While the decrease in fasting blood sugar levels in the control group was 17,167. Comparison of day 7 and day 14, the two groups had differences or there was a decrease in fasting blood sugar levels with a p value of <0.001 each. Greater changes were shown in the control/brown rice group with a difference of 8.683. While the decrease in fasting blood sugar levels in the intervention group was 5,267. Thus, rice analogue of Banggai yam (dioscorea alata) as local food has a significant influence on reducing blood sugar levels of prediabetes mellitus sufferers in Banggai Islands district. The use of rice analogues of Banggai Yams (Dioscorea Alata) can be developed as functional foods.

Keywords: Analog Rice, Banggai Yams, Prediabetes Mellitus, Blood Sugar.

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BACKGROUND

American Diabetes Association (ADA) defines diabetes mellitus as a group of metabolic diseases characterized by high levels of glucose in the blood (hyperglycemia) that occur due to impaired insulin secretion, decreased insulin action, or as a result of both. Based on its etiology, diabetes mellitus can be divided into type 1 diabetes mellitus, type 2 diabetes mellitus (DMTP2), gestational diabetes and diabetes with other specific types. [1]

Diabetes mellitus (DM) is one of the public health problems in the world. Current global estimates that people with Diabetes mellitus are 415 million people and will increase to 642 million by 2040 [2]. People with diabetes mellitus have quadrupled in the past three decades, and diabetes mellitus is the ninth leading cause of death. About 1 in 11 adults worldwide currently has diabetes mellitus, 90% of whom have type 2 diabetes mellitus (DMT2). A further 193 million people with diabetes remain undiagnosed due to the often mild or asymptomatic nature of the condition, especially in type 2 diabetes (T2DM)[3]. About 387 million people live with DM worldwide, and type 2 diabetes mellitus (DMTP2) is 90% of them [4]. The prevalence of Diabetes Mellitus (DM) in Indonesia based on a doctor's diagnosis in the population aged ≥ 15 years increased from 1.5% in 2013 to 2.0% in 2018. While based on blood sugar checks by Perkeni 2015 which is 10.9%. The prevalence of Diabetes mellitus in Central Sulawesi Province is 2.1%, the number of Diabetes sufferers in Banggai Islands Regency in 2022 is 3.6% higher than the national prevalence of 2% in 2018 with the highest sufferers at the Salakan Health Center of 598 patients (13.36%) [5,6].

The lifestyle and pattern of food consumption of modern society that tends to be unhealthy has caused an increase in the number of people with diabetes mellitus (DM). An unbalanced lifestyle, lack of physical activity, excessive food consumption, can cause hyperglycemia, hyperlipidemia/ hypercholesterolemia, and hypertriglycerides.

In the process of eating, food will be digested in the gastrointestinal tract (intestines) and then converted into a form of sugar called glucose. Furthermore, this sugar is absorbed by the intestinal wall and then circulates in the bloodstream, after eating there will be an increase in blood sugar in the body. Blood sugar will be distributed into the body. Insulin as the key to enter blood sugar into the body. Insulin production in the pancreas is affected by blood sugar levels. As long as insulin is sufficient in quantity and function, then after eating, sugar in the blood will smoothly enter the cells until blood sugar levels will drop back to normal levels. In conditions of insulin resistance, the body refuses / does not respond to insulin, especially in its function to maintain blood sugar levels in the body remain normal. In this

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condition, glucose accumulates in the blood along with the amount of food intake that enters.

Banggai yam (Dioscorea alata) has a low Glycemic Index [7,8,9] and also contains saponin compounds, Water soluble polysaccharides, Water insoluble polysaccharides[10-13]. Water Soluble Polysaccharides (PLA) as hypoglycemic, The mechanism of lowering blood glucose levels by PLA is caused by three factors: PLA is able to slow gastric emptying and inhibit glucose absorption, PLA also produces fermented dietary fiber and produces short-chain fatty acids and lowers the endoplasmic reticulum thereby reducing blood glucose levels.

One alternative breakthrough to support food diversification programs that have a fairly good chance of success is the development of analog rice processing technology, namely rice made from non-rice carbolocales. This product is expected to be used as "*product vehicle*"Food diversification program in reducing dependence on rice and flour [14.]

Analog rice is rice made from non-rice raw materials and has a shape similar to rice rice. How to consume analog rice is like consuming rice rice. The advantages possessed by analog rice are that the nutritional content can be designed to have the same nutrients or even exceed rice rice, and can have functional properties according to the raw materials used [15.] Analog rice is made from raw materials, including 50-98% ingredients containing starch or derivatives, 2-45% ingredients that can enrich analog rice, and 0.1-10% hydrocolloids [16].

Banggai Yams *(Dioscorea alata) is a* local food ingredient of Banggai Islands regency that can be used as an ingredient to make rice analogue to the above contents. The purpose of this study was to see the effect of giving rice analogues of Banggai Yams (*Dioscorea Alata)* on changes in blood sugar levels of people with Prediabetes Mellitus in Banggai Islands district.

RESEARCH METHODS

A. Types of Research

This type of research is an experiment with The design used is *Pretest-Posttest Control Group design*. In this design there are two groups that are randomly selected, then given a pretest to find out the initial state, is there a difference between the experimental group and the control group.

B. Time and Location of Research

1. Research Time

This research will be conducted in 2023, the time for the implementation of the research will be carried out within 1 month. This research was conducted in Banggai Islands Regency, Central Sulawesi.

C. Population and Research Sample

1. Populasi

The research population is the entire population in the Banggai Islands Regency in 2022 aged ≥15 years, which is **89,933** people.

2. Sample Size

Calculation of sample size using Lemeshow formula

$$n = \frac{Z^2_{1-\partial/2} p(1-p)N}{d^2(N-1) + Z^2_{1-\partial/2} p(1-p)}$$

$$n = \frac{1{,}65^2 \times 0{,}263 \times (1-26{,}3) \times 89.933}{0{,}1^2(89.933-1) + 1{,}65^2 \times 57{,}1(1-57{,}1)}$$

$$n = \frac{2{,}72 \times 0{,}263 \times 0{,}737 \times 89933}{(0{,}01 \times 89932) + (2{,}72 \times 0{,}263 \times 0{,}737)}$$

$$n = \frac{47.414{,}50}{899{,}32 + 0{,}52}$$

$$n = \frac{47.414{,}50}{899{,}99}$$

n = 52.65

n = 53 (rounded)

Information:

□	=	Number of samples
N	=	Total population (89,933)
P	=	estimated proportion (26.3%) (refers to the total proportion of GDPT in the population ≥ of 15 years (Riskesdas 2018)
	=	Z score at confidence level (90%)
D	=	precision (0.1)

Table 1. Pretest-Posttest Control Design.

Group	Pretest	Treatment	Posttest
AR	O1	X1	O2
BR	03	X2	04

Table 2. Characteristics of Respondents.

Variable	Analog Rice		Brown Rice		Total
	n	%	n	%	
Gender					
L	23	38,3	23	38,3	46
P	37	61,7	37	61,7	74
Number of Families					
1	3	5	4	6,7	7
2	3	5	7	11,7	10
3	24	40	8	13,3	32
4	19	31,7	16	26,7	35
5	11	18,3	12	20	23
6	0	0	13	21,7	13
Education Level					
No school	0	0	1	1,7	1
SD	0	0	17	28,3	17
SMP	0	0	20	33,3	20
SMA	0	0	15	25	15
D2	0	0	1	1,7	1
D3	7	11,7	0	0	7
S1	48	80	6	10	54
S2	5	8,3	0	0	5
Work					
ASN	29	48,3	3	5	32
Honor	30	50	2	3,3	32
IRT	0	0	17	28,3	17
Farmer	0	0	33	55	33
Does not work	1	1,7	3	5	4
Other	0	0	2	3,3	2
Marital Status					
Marry	43	71,7	54	90	97
Unmarried	17	28,3	2	3,3	19
Cerai	0	0	4	6,7	4
Smoking History					
No	44	73,3	41	68,3	85
The	16	26,7	19	31,7	35
Family DM History					
Exist	15	25	12	20	27
None	45	75	48	80	93
Total	60	100	60	100	120

Table 3. Test normality of fasting blood sugar level data (three measurements) in the intervention and control groups.

Group	GDP1	GDP2	GDP3
Analog Rice	0,2	0,2	0,2
Brown Rice	0,2	0,00	0,009

* Kolmogorov-Smirnov

Table 4. Results Of Statistical Test Changes In Fasting Blood Sugar (Fbs) Levels (Pre With Days 7 And 14) In The Intervention Group Of Banggai Yams Analog Rice And Control Group (Brown Rice).

Group	$\bar{x}$ (sd)				p
	Fasting 0		FBS (days 7)		
Analog Rice	113,550	(7,502)	89	(10,687)	<0,001a
Brown Rice	112,433	(7,084)	103,950	(35,141)	<0,001b
p	0,404c		0,013d		

Group	$\bar{x}$ (sd)				p
	Fasting 0		FBS(days 14)		
Analog Rice	113,550	(7,502)	83,733	(8,856)	<0,001a
Brown	112,433	(7,084)	95,267	(17,869)	<0,001b
p	0,404c		<0,001d		

Group	$\bar{x}$ (sd)				p
	FBS(days 7)		FBS (Days 14)		
Analog Rice	89	10,687	83,733	8,856	<0,001a
Brown Rice	103,950	35,141	95,267	17,869	<0,001b
p	0,013c		<0,001c		

[a] Two related sample Student's T test
[b] Wilcoxon Test
[c] Two independent sample Student's T test
[d] Mann–Whitney U test

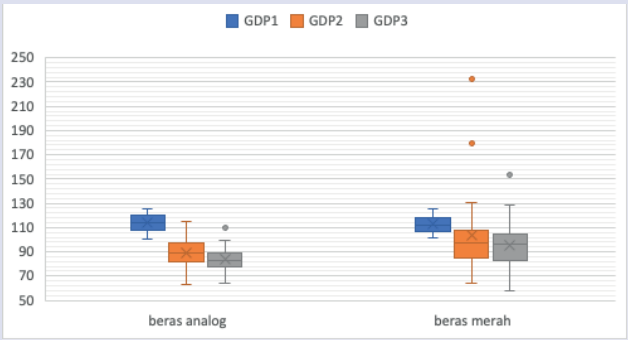

Figure 1: Comparison diagram of reduction in fasting blood sugar levels in the intervention and control groups, 2023.

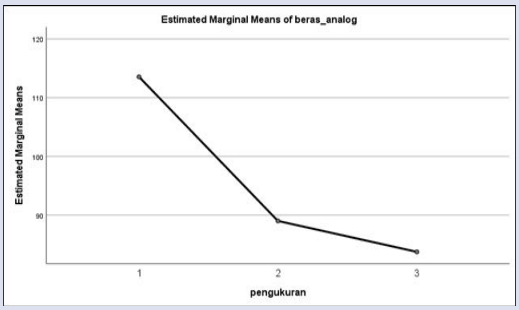

Figure 2: Sumber: Data Primer 2023 (1).
Source r: Data Primer 2023
1: Measurement of GDP before intervention
2: Day 7 GDP Measurement
3: Day 14 GDP measurement

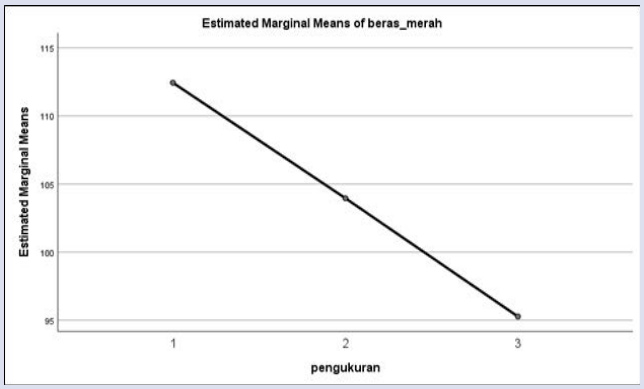

Figure 3: Data Primer 2023 (2).
source: Data Primer 2023
1: Measurement of GDP before intervention
2: Day 7 GDP Measurement
3: Day 14 GDP measurement

3. Inclusion Criteria

a. Have fasting blood glucose levels of 100-125 mg/dL

b. Age ≥15 years

c. Willing to consume rice analogue Banggai Yams (*Dioscorea Alata*) given for 14 days for the intervention group and brown rice for the control group

4. Exclusion Criteria

a. While Pregnant

b. Not willing to consume rice analogue Banggai Yams (*Dioscorea Alata*) given for 14 days for the intervention group and brown rice for the control group

5. How to take a blood sample

After at least 8 hours of fasting and blood is taken for fasting blood sugar checks, an examination is carried out by taking blood from the fingertips (middle finger or left ring finger with a simple tool *(autocheck).*

If a Fasting Blood Sugar level of 100-125 mg / dl is obtained, the research team explains about *the purpose and purpose* of the study, after the respondents understand and are willing to sign the informed consent, then the research can begin.

6. How to treat / intervene in research

The study respondents were divided into two groups, namely the intervention group and the control group and before the study (pretest) then carried out fasting blood sugar checks, abdominal circumference checks and took food intake data (recall 2 x 24 hours), physical activity (GPAC). Banggai yam Analog Rice *(Dioscorea Alata)* and brown rice were given to each group, giving was given every day morning and evening

The amount of Banggai Yams Analog Rice *(Dioscorea Alata)* is adjusted to the number of nutritional adequacy of the repondent which has previously been calculated using the Haris Benedict Formula

The consumption of Banggai Yam's analog rice (Dioscorea Alata) and brown rice will be supervised by the wife / husband or children / family as supervisors / companions. After 14 days then a re-examination (Post test) is carried out, namely checking fasting blood sugar and food intake. The 14-day intervention was based on several research results where there was a significant change in blood sugar on day 14 of the intervention [17,18, 19]

D. Data Collection

Primary data were obtained directly from the results of fasting blood sugar levels, abdominal circumference and food recall interviews for food intake and physical activity interviews using GPAQ (Global Physical Activity Questionaire) questionnaires. Secondary data were obtained by the Banggai Islands District Health Office, and from other reference sources that supported the research.

E. Data Processing and Presentation

Data processing using computer program SPSS 24,

F. Data Analysis

Univariate analysis to see data on respondent characteristics, by calculating the mean, maximum-minimum, and standard deviation, data is called normally distributed, if the meaning value (p) > 0.05, while the data is not normally distributed if the meaning value (p) <0.05. If the data is normally distributed, the hypothesis test is used *Paired sample t test.* However, if the data is not normally distributed, an alternative test is used*, namely the Wilcoxon signed rank test*, then the data that has been obtained will be presented in the form of tables and graphs accompanied by narratives.

G. Research Ethics

This research has received recommendations from the Ethics Commission of the Faculty of Public Health, Hasanuddin University. With Ethical Approval Recommendation Number: 6210/UN4.14.1/TP.01.02/2023

RESULTS

The results of the normality test in 6 data groups showed that there were 4 data groups that had a normal distribution. The data groups are all 3 data groups on analog rice, and 1 data group (GDP1) on brown rice. There are two (GDP2, GDP3) that have abnormal distributions. To compare GDP levels in the intervention group (analog rice), a *two-related sample Student's T test* was used. To assess the comparison of GDP levels in the control group (brown rice), the *Wilcoxon test* was used, because there was a data group with an abnormal distribution. In comparing GDP levels in the intervention and control groups in each measurement, the *Two independent sample Student's T test was used in the GDP1 measurement, and the* Mann–Whitney U test *to compare GDP2 and GDP3 levels in the intervention and control groups.*

DISCUSSION

Characteristics of Respondents

Prediabetes status describes the condition of blood glucose levels above normal but not enough to be diagnosed as diabetes. The prediabetes stage is a critical condition of blood glucose levels, but can return to normal if a healthy lifestyle is routinely carried out. In the U.S., one in three people is diagnosed with prediabetes. However, most people are unaware that they have a history of prediabetes.[20]. Risk factors for prediabetes are the same as risk factors for type 2 Diabetes mellitus. These risk factors can be classified into non-modifiable and modifiable risk factors. Risk factors that cannot be modified are genetic factors, age, and pregnancy, while modifiable risk factors are obesity, physical activity, diet and smoking habits.

Based on the results of this study when viewed based on gender, both groups were dominated by women (61.7%). The number of respondents' family members varied but most had 4 family members, both in the intervention group (31.7%) and the control group (26.7%). In the variable level of education, there is a pattern, namely, the tendency of the intervention group to have a high level of education. In the control group, the tendency of education level tends to be low.

Based on work, the intervention group was dominated by civil servants/honoraries, while the control group was dominated by farmers. The marital status of respondents has the same pattern, namely most respondents are in marital status.

Variables that contribute to the tendency to diabetes are smoking history and family DM history. On smoking history, the same pattern was seen in the intervention and control groups, with most respondents having no smoking history. In family DM history also tends to have the same pattern dominated by the absence of families who have a history of DM.

Changes in Fasting Blood Sugar Levels

Based on the results of the study, if a comparison is made between fasting blood sugar levels on pre and day 7, the two groups have differences or there is a decrease in fasting blood sugar levels with *p* values of <0.001 each. The greatest change was shown in the intervention/rice analog group with a difference of 24.55. While the decrease in fasting blood sugar levels in the control group was only 8,483.

When a comparison is made between fasting blood sugar levels on pre and day 14, the two groups have differences or there is a decrease in fasting blood sugar levels with *p* values of <0.001 each. The greatest change was shown in the intervention/rice analog group with a difference of 29.817. While the decrease in fasting blood sugar levels in the control group was 17,167.

When a comparison is made between GDP levels on day 7 and day 14, the two groups have differences or there is a decrease in fasting blood sugar levels with *p* values of <0.001 each. Greater changes were shown in the control/brown rice group with a difference of 8.683. While the decrease in fasting blood sugar levels in the intervention group was 5,267.

Significant changes in blood sugar in the group given the intervention of rice analogue yam banggai (Dioscorea alata) from the first, seventh and fourteenth day showed that rice analogue yam banggai (dioscorea alata) has benefits in preventing the occurrence of diabetes mellitus.

The lifestyle and pattern of food consumption of modern society that tends to be unhealthy has caused an increase in the number of people with diabetes mellitus (DM). Patients with diabetes or diabetes experience impaired glucose metabolism. Patients experience impaired glucose distribution metabolism so that the body cannot produce insulin in sufficient quantities, or is unable to use insulin effectively so that sugar in the blood is excessive [21], the speed of digestion of carbohydrates in the digestive tract, is not the same for every type of food. Foods that raise blood glucose levels quickly have high IG levels, whereas those that raise blood glucose levels slowly have a low glycemic index. (22) High IG foods cause the secretion of large amounts of insulin as a result of a rapid rise in blood glucose levels. This will cause increased hunger after eating and accumulation of fat in adipose tissue in the body. Blood glucose levels of DM sufferers can be controlled with a healthy lifestyle (right diet, enough physical activity, enough rest and not smoking). Controlled blood sugar levels will reduce the risk of acute complications and chronic complications (both micro and macroangiopathy) and improve the quality of life[23] Literature research by Miller et al, [22] found diabetic patients who consumed a low glycemic index diet had a decrease in HbA1c levels of 0.43% (CI 0.72-0.13) and a decrease in glycosylated protein levels of 7.4%, a diet with high fiber affected blood glucose levels. There was a decrease in post-prandial glucose levels of 21%. Diversification of food sources of carbohydrates that have a low glycemic index needs to be developed to prevent the prevalence of degenerative diseases, especially Diabetes mellitus, continues to increase.

Banggai yam plants including the Dioscoreaceae family are vines and have root tubers that are sometimes very large. Rahmatu,

Ramadhanil and Sangaji (24) found 11 species of plants belonging to the family Dioscoreaceae, namely: Babanal (Dioscorea warburgiana Uline), Ondot (Dioscorea hispida Dennst.), Siloto (Dioscorea cf. deltoidea Wall.), Bakutu (Dioscorea glabra Roxb.), Baku makuloloang (Dioscorea bulbifera var. celebica Burkill), Baku pusus (Dioscorea cf. alata), Dioscorea keduensis Burkill, Dioscorea numularia, Ndolungun (Dioscorea esculenta [Lour.] Burck.), Baku butun (Dioscorea alata L.). One of the distinguishing features of the banggai yam variety is the color of the tubers. Colored tubers indicate that banggai yam contains chemical components that function as natural antioxidants. The antioxidant content of Banggai Yams is 78.87% consisting of flavonoids and phenolics [25]. Banggai yam (Dioscorea) is one of the plant genera that cannot be separated from the life of the Banggai Islands (Bangkep) people. This is because Banggai Yams is one of the staple foods of the Bangkep community, which is found in Banggai and Liang Districts. With a yield of 8,933.9 tons of Banggai Yamses made a significant contribution in increasing regional income [25]. The identified color of Banggai yam consists of three major groups, namely purple, yellow and white. Many cultivars have purple tubers so in English it is known as purple yam. Purple tubers are caused by the presence of anthocyanin pigments, while yellow tubers are caused by the presence of beta-carotene [25]. The content of beta carotene and anthocyanins as well as tocopherol and phenolic compounds function as antioxidants [25]. In addition, some studies found other types that have the effect of lowering blood glucose levels, namely Dioscorea Bulrifera, Dioscorea Rotundata,[8] Dioscorea Hispida,[26]. Bioactive content in dioscorea that can reduce blood glucose levels is water-soluble dietary fiber, water-insoluble dietary fiber, water-soluble polysaccharides, diosgenin. In addition, Banggai Yams also contains antioxidants such as phenol and polyvenol.

Water-soluble polysaccharides are a type of hydrocolloid compound that can increase viscosity with their ability to form a gel formation so that it can reduce the ability to absorb glucose in the blood. In addition, its physique allows it not to be digested in the small intestine so that it is carried to the large intestine [25] While dietary fiber in general can reduce food transit time in the small intestine and increase fecal mass, it can be fermented by microflora in the large intestine, and is also able to lower postprandial blood glucose levels and insulin levels [27] so that the presence of dietary fiber will help PLA in lowering blood glucose levels.

PLA and dietary fiber together inhibit glucose in digestion so that increased blood glucose levels can be suppressed. Blood glucose levels are proportional to the amount of insulin needed so that there is an increase in blood glucose levels so that insulin production increases. Furthermore, hyperglycemia can be avoided by consuming PLA and dietary fiber in diabetics. Diosgenin also has a decrease in blood glucose by lowering the enzymes lactase, maltase, and transaminases [28].

Diosgenin is also able to reduce disaccharide activity so that the breakdown of carbohydrates into monosaccharides is inhibited. The increase in blood glucose levels will be smaller if there is no production of glucose in digestion. Based on research conducted by Ghoshet et al. diosgenin from tubers of the dioscorea family is able to inhibit α-glucosidase and α-amylase thus possible in the treatment of diabetes mellitus [29]. Both enzymes are agents that break down starch into simpler carbohydrates such as glucose. In the presence of diosgenin, it indirectly lowers endoplasmic blood glucose levels thereby reducing blood glucose levels [30-40].

In addition, Banggai Yams contains phenolics as much as 2.63% and high antioxidant activity (78.87%),[25] Where antioxidants play a role in repairing pancreatic beta cells, namely adding islets of langerhan cells so that they can increase and maintain insulin excretion [31, 42-45]

CONCLUSION

Rice analogue of Banggai yam (dioscorea alata) as local food has a significant influence on reducing blood sugar levels of prediabetes mellitus sufferers in Banggai Islands district. The use of rice analogues of Banggai Yams (Dioscorea Alata) can be developed as functional foods.

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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