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FULL PAPER

Nutritional, functional properties, glycemic index and glycemic load of indigenous rice from North and East Borneo

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Abstract

Rice is a staple food for Indonesians. Therefore, awareness of the nutritive value and the health benefit of rice is of vital importance. This study was conducted with the objective to evaluate the nutritional value, functional properties of rice, blood glucose response and glycemic index of the North and East Borneo native rice, such as the Red Mayas (RM), white Mayas (WM), red Adan (RA), white Adan (WA), and black Adan (BA). Proximate levels (proteins, fats, carbohydrates, ash, and water) in BA, WA, RM, WM, and RA are generally different from the highest levels of protein, fat, calories in BA rice. The highest insoluble dietary fiber in BA was 0.91g/100 g and the lowest is RA. The iron content in WA is 3-5 times higher than other local rice 14.48 mmg/100 g. The highest content of vitamin B1 (thiamine) indicated by RA is 0.38 mg/100 g, while the lowest is WA, which is 0.17 mg/100 g. Thus, the highest amylopectin and amylose content is RA, which is 69.09 g/100 g. Longer glucose is stored in the blood, namely BA and the five types of local rice in East and North Borneo, which show a high glycemic index.

1. Introduction

Rice (*Oryza sativa* L.) is highly consumed in Indonesia. It is one of the exotic riches and the native plants of North and East Borneo that must be developed. Rice Mayas and Adan are a kind of native mountain rice plant in Borneo that has long been planted by farmers hundreds of years ago. Paddy Mayas received special attention from the Provincial Food and Horticultural Crops Office along with Adan Krayan Rice due to its high economic value and are considered the main income of farmers since in time memorial years. Rice Adan is one of the best quality rice among other local rice varieties that are still cultivated in Krayan and other highland areas. There are three different varieties: white, red and black. Commercially, about two thousand varieties of rice are grown all over the world. Based on energy needs, over 2 billion people in Asia get 80% of their energy needs from rice, which contains 80% carbohydrates, 7-8% protein crude, 3% crude fat, and 3% crude fiber (Raghuvanshi *et al*., 2017). In an Asian country like Indonesia, rice is considered as a main source of energy in the diet (Hu *et al*., 2004). Most of the people in Indonesia assumed that if rice is not consumed as part of the diet, it is equivalent to not eating at all. This is based on the assumption that rice is a source of carbohydrates with a high glycemic index that if consumed will quickly raise blood sugar levels (Sun *et al*., 2010). In the body, carbohydrates will be broken down into smaller components such as disaccharides and monosaccharides that can contribute to increased blood glucose levels (Robert and Ismail 2012; Septianingrum *et al*., 2016). Whereas the glycemic response of rice varies greatly with processing, the type of varieties and the chemical composition (Foster-Powell *et al*.,1992; Saragih *et al*, 2013). In addition to carbohydrates, other carbohydrate components that may affect the glycemic response are sugars, as well as resistant food and starch (Widowati *et al*., 2006; Alsaffar, 2011; Syahariza *et al*., 2013; Mir *et al*., 2013; Umar *et al*., 2018). Red rice was found to have a lower glycemic index compared with white rice (Anitha *et al.*, 2017). In addition, intake of white and brown rice was both associated with higher total urinary arsenic concentrations, and the inorganic arsenic concentrations were not different between participants who primarily ate white rice versus those who ate brown rice (Wu *et al*., 2015).

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Black rice possessed a thicker bran layer than red rice. Non-milled red rice showed higher antioxidant activity than non-milled black rice (Paiva *et al*., 2014; Shao *et al*., 2017) Phytic acid was found to be negatively correlated to the antioxidant activity (Kaur *et al*., 2017). Dietary management based on carbohydrates is also very important. Diet and variation of carbohydrate sources consumed are primarily regulated by rice sources that do not respond quickly to the rise in blood glucose (Saragih, 2010; Saragih *et al*., 2017). Cho *et al*. (2014) showed prospective studies that consistently showed a reduced risk of diabetes with high intakes of cereal fiber or mixtures of whole grains and bran. Information on the nutritional value, functional properties and response of blood glucose after consuming rice from certain rice is important, especially in the development of healthy food sources and preserving the food source. Rice is generally considered a high glycemic index (GI) food. Therefore, there is a need to evaluate the nutritional value, functional properties of rice and blood glucose response derived from North and East Borneo rice, such as the RM, WM, BA, WA, and RA rice.

2. Materials and methods

2.1 Material (rice)

BA rice, RA rice and WA rice were obtained from Nunukan District North Borneo while the WM and RM rice have been collected from West Kutai Regency East Borneo, Indonesia. Adan rice is a type of rice grown in rice fields produced by farmers in Krayan, Nunukan Regency, North Borneo, Indonesia which borders Sarawak Malaysia, with an altitude above 1000 m above sea level. While mayas rice is upland rice grown in West Kutai Regency, East Borneo. Planting rice by local people starting June and harvested at the end of each year in December. The five types of rice are local varieties of rice. BA, RA and WA, WM and RM rice harvest age is 6 months and harvested using ani-ani and dried in the sun for 2-3 days. The rice mill is carried out using a rice grinding machine. Sampling is done in January 2017.

2.2 Determination of proximate composition

The proximate composition of rice samples was determined by the standard method used for water content, ash content, fat content, and protein (AOAC, 2006) and carbohydrate by the difference method.

2.3 Determination of food energy

Calorific value is an important property indicating the useful energy content of foods (Verma and Srivastav, 2017). The gross food energy was estimated using the equation: Food energy (kCal/g) = (CPx 4) + (Fx9) + (CHOx4), where CP means crude protein (%); F means fat(%); and CHO means carbohydrate content (%).

2.4 Determination of fiber

Determination of soluble dietary fiber, insoluble dietary fiber, and total dietary fiber was carried out using enzymatic methods (Asp *et al.,* 1983), as follows: homogeneous dry samples with ratio 1: 2 were extracted with fat using petroleum benzene at room temperature for 15 mins if the sample fat content exceeded 6-8%. Fat extraction aims to maximize starch degradation. One gram of sample is inserted into Erlenmeyer. Then 25 mL of Sodium Phosphate buffer was added and made into a suspension. The addition of the buffer is intended to stabilize the thermal enzyme. Termamyl (100 µL) was added, sealed and incubated at 100°C for 15 mins, with occasional stirring. The purpose of thermal treatments to break the starch. The mixture was then raised and cooled. Further, 20 mL of distilled water was added and ipH was adjusted set to 1.5 by adding 4 M HCl. Then, 100 mg pepsin was added. A pH of 1.5 is intended to condition the maximum enzyme activity of pepsin incubated at 40°C and agitated for 60 mins with 225 rpm. Distilled water (20 mL) was added and the pH was adjusted to 6.8 with NaOH 0.1 N. Then, 100 mL of the pancreatic enzyme was added, and the mixture was incubated at 40°C for 60 mins with agitation. The pH was then adjusted with HCl 0.1 N to 4.5, filtered through a weighted weighing sintered crucible containing 0.5 g dried celite and washed twice with 10 mL distilled water. Insoluble dietary fiber (IDF) in the residue was washed twice with 10 mL 95% ethanol and 10 mL acetone. Then, dried for about 12 hrs, at a temperature of 105°C, to a fixed weight and weighed after cooling in a desiccator (D1). Furthermore, blanch in the 500°C furnace for at least 5 hrs, then weigh it after being cooled in the desiccator (I1). Then, the volume of the filtrate which contains the Soluble dietary fiber (SDF) was adjusted with water to 100 mL, and 400 mL of 95% warm ethanol at 60°C to precipitate for 1 hr. Thus, filtered with dry crucible (porosity 2) containing 0.5 dried celite and washed with 2 x 10 mL of 78% ethanol, and 2 x 10 mL of acetone. After cold, centrifuge the mixture at 822 x *g* for 10 mins. The absorbance of the supernatant was measured at 532 nm. As a standard solution, TEP is used (tetra ethoxy propane).

2.5 Determination of amylose and amylopectin

Determination of amylose and amylopectin was carried out using Spectrophotometric method (Apriyantono *et al.,* 1989). A 0.1 g sample was placed into a test tube, it was then added with1 mL of 95% ethanol and 1N NaOH, then heated to 100°C for 10 minutes until a gel formed. The mixture was then transferred into a 100 mL volumetric flask, mix, then made to volume with distilled water. Then, 5 mL aliquot was mineralized with 1 mL 1N acetic acid and 2 mL of Iodine solution (0.2 g Iodine and 2 g KI in 100 mL of the volumetric flask). The absorbance of the solution was measured by using a spectrophotometer at 625 nm wavelength. A standard solution of 40 mg of purified amylose was similarly prepared like the sample.

2.6 Analysis of vitamin B1, Iron (Fe) and starch digestibility

Analysis of Vitamin B1 (Thiamin) using HPLC, Iron (Fe) analysis using AOAC Method 975.03 and AOAC method 965.09 (AAS) methods (AOAC, 2006). Starch digestibility was analyzed using spectrophotometric methods (Apriyantono *et al.,* 1989).

2.7 Organoleptic test

Organoleptic test was conducted using a hedonic scale to determine the level of consumer preference to instant rice produced. The hedonic scale used had a range of very dislike (numeric scale = 1) to very likable scale (numerical scale = 7). Each panelist is given a hedonic test questionnaire form to evaluate the resulting product. The quality attributes tested include color, flavor, aroma and texture. Instant rice yields from the fastest rehydration time and the best instantaneous organoleptic rice test of various herbal treatments are followed by starch digestibility test, soluble food fiber, insoluble food fiber, total dietary fiber and response to blood glucose.

2.8 Blood sampling and analysis

Capillary blood was taken from fingertips for blood glucose estimation using Glucometer (Autocheck). As many as ten normal individual volunteers who have undergone full fasting except water for around 20 hrs overnight, had their blood samples taken at fasting state (0 min) and at 30-, 60-, 90- and 120-mins interval after ingestion of the reference food as well as test food. Subjects were restricted from performing any physical activity during the 2 hrs of the study period (Miller and Leeds, 1998). The area under curve (AUC) of GI of rice was calculated for each subject. The Incremental Area Under Curve (IAUC) of both reference and test food was used to obtain the Glycemic Index (GI) by the following formula:

$$\text{GI food} = \frac{\text{IAUC in response to a relevant test food portion}}{\textit{IAUC in response to equal weight of reference food (glucose)}} \times \text{amount of food (100)}$$

2.9 Glycemic load

Glycemic load is obtained by multiplying the glycemic index by total carbohydrate of one serving of the test food divided by 100.

2.10 Statistical analysis

The data obtained by analysis of variance (ANOVA). If there is a significant difference, a further test with Least Significant Difference (LSD) with the level of significance is expressed in α = 5%, to determine the effect of the type of rice on nutritional value, sensory, functional properties, blood glucose response.

3. Results and discussion

3.1 Proximate composition

The proximate composition of five indigenous rice in North and East Borneo are shown in Table 1. The water content of rice determines the shelf life of rice. The dry grain milled water (DGM) is related to the water content of the rice. The water content of DGM is about 12-14%. The results of the analysis of water content of five types of rice showed a significant difference between RM water content with BA, RA, WA and WM, while BA with WM showed no significant difference. The high water content was found in RA were 14.30% and the lowest was WA was 11.50%.

The value of ash content was found significantly different among all rice varieties. WA had the highest ash content of 10.62%. The fat value was significantly different in all rice varieties except WA and WM rice. BA had the highest fat content at 1.4%. The protein content varied between 7.10-8.10%. The carbohydrate content of all the rice varieties ranges from 68.82-75.70%. The value of carbohydrate content was found to be significantly different among all rice varieties. Food energy value was also found to be significantly different, whereas the highest value energy was recorded in BA at

Table 1. Proximate composition of local rice North and East Borneo.

Proximate composition	Units (g/100 g)	BA rice	WA rice	RA rice	WM rice	RM rice
Moisture	%	12.60 ± 0.9^b	11.50 ± 0.6^a	14.30 ± 0.8^d	12.30 ± 0.6^b	13.20 ± 0.7^c
Ash	%	0.8 ± 0.2^a	10.62 ± 1.3^e	1.0 ± 0.2^b	9.20 ± 0.7^d	4.3 ± 0.5^c
Fat	%	1.4 ± 0.3^d	0.66 ± 0.2^a	0.9 ± 0.2^b	0.67 ± 0.1^a	0.95 ± 0.3^c
Protein	%	8.10 ± 0.8^b	7.10 ± 0.6^a	7.30 ± 0.7^a	7.20 ± 0.4^a	7.4 ± 0.5^a
Carbohydrate	%	74.47 ± 1.8^c	68.82 ± 1.3^a	75.70 ± 1.6^e	69.53 ± 1.5^b	75.30 ± 1.5^d
Food energy	Kcal	342.8 ± 2.1^e	309.6 ± 1.7^a	340.1 ± 1.9^d	312.9 ± 1.2^b	339.3 ± 1.4^c

Values are mean ± standard deviation. Values with different alphabet superscript are significantly different (p<0.05). Each value represents the average from three replication.

Table 2. Vitamin B1 and Iron (Fe) of local rice varieties of North and East Borneo.

Nutrients	Units	BA rice	WA rice	RA rice	WM rice	RM rice
Fe	mg/1000 g	3.61± 0.4^{c}	14.48±1.3^{e}	0.21±0.1^{a}	1.33±0.2^{b}	5.53±0.5^{d}
Vit. B1	mg/100 g	0.23±0.1^{b}	0.20±0.1^{b}	0.30±0.1^{c}	0.17±0.03^{a}	0.38±0.1^{d}

Values are mean ± standard deviation. Values with different alphabet superscript are significantly different (p<0.05). Each value represents the average from three replication.

Table 3. Functional properties of North and East Borneo rice.

Functional Properties	Units	BA rice	WA rice	RA rice	WM rice	RM rice
Soluble dietary fiber	g/100 g	2.42±0.4^{d}	3.25±0.7^{e}	2.37±0.3^{c}	1.88±0.2^{a}	2.15±0.3^{b}
Insoluble dietary fiber	g/100 g	0.91±0.1^{e}	0.64±0.2^{c}	0.81±0.1^{d}	0.61±0.2^{b}	0.58±0.1^{a}
Total dietary fiber	g/100 g	3.33±0.8^{d}	3.89±0.7^{e}	3.18±0.5^{c}	2.49±0.5^{a}	2.73±0.3^{b}
Amylose	g/100 g	10.81±1.6^{c}	9.74±1.4^{b}	9.43±0.9^{a}	11.57±0.9^{d}	14.11±0.4^{e}
Total starch	g/100 g	76.28±2.5^{c}	71.75±1.4^{a}	78.49±1.2^{e}	74.01±1.3^{b}	75.98±.1.4^{d}
Amylopectin	g/100 g	65.47±2.3^{d}	62.01±1.4^{b}	69.06±1.2^{e}	62.44±1.0^{c}	61.87±0.8^{a}

Values are mean ± standard deviation. Values with different alphabet superscript are significantly different (p<0.05). Each value represents the average from three replication.

342.8 kCal/100 g. Types of varieties and processing methods had an effect on the carbohydrate, protein, fat and water content. Carbohydrate levels and characteristics of food had influenced on the glycemic index. While the caloric value was calculated based on carbohydrate, protein and fat. The value of calories in milled rice ranged from 309.62-342.88 kCal/100 g. The nutritional value of rice depends on many factors, and due to the abundant biodiversity of local varieties, one can surely not generalize on the 'nutritional value of landraces. Variation of nutrition value of rice in the study also found similar and within the study of Sompong *et al*. (2011) and Devi *et al*. (2015).

3.2 Fe (iron) and vitamin B1 levels

Iron content in the five rice samples showed significant differences between all types of rice with the highest iron content in white and 14.48 mg/1000 g and the lowest in red and 0.2 mg/1000 g (Table 2).

The value of vitamin B1 content was found significantly different among all rice varieties except in BA and WA rice. WM rice had the lowest vitamin B1 content of 0.17 mg/100 g. Iron (Fe) is a component of hemoglobin, myoglobin, cytochrome, as well as catalase and peroxidase enzymes (Asp *et al*., 1983). The role of iron, in general, is related to the process of respiration in cells. The absorption of iron in food by the intestines is very low and is affected by the form of iron in the diet, as well as the presence of substances that inhibit or increase absorption. (Verma and Srivastav, 2017). Iron levels in all five samples showed significant differences between all rice varieties with the highest iron content for WA rice at 14.48 mg/1000 g. The highest iron content of WA rice depending on the soil conditions in which the rice was grown. The main mineral elements are calcium, phosphorus, magnesium and iron. The genetic characteristics and environmental factors are responsible to affect mineral content (Zimmermann and Hurrell, 2002; Wang *et al*., 2011). Vitamin B1 (Thiamin) levels show the difference between RM with BA, WA, RA and WM rice. The highest levels of vitamin B1 were found in RM rice and lowest WM rice was 0.17 mg/100 g (Table 2). The complete grinding of rice and turning red rice into white rice destroys many vitamins (vitamins B, B3, B6 and folic acid), minerals, essential fatty acids and all the dietary fiber contained therein (Lyon *et al*., 1999; Haryadi, 2006; Paiva *et al*., 2014).

3.3 Functional properties

Dietary fiber is foods that are chemically unchanged or resistant to the coloring digestion. Although natural fibrous foods contain no nutrients, their presence is indispensable in the digestive process in the human body. Dietary fiber can be both soluble and insoluble. The results of statistical analysis showed that there was a significant difference between soluble dietary fiber among the five types of rice, with the highest soluble dietary fiber in the WA rice and the lowest in WM rice. While insoluble dietary fiber also showed a marked difference between the five rice varieties tested, the highest insoluble dietary fiber recorded was in BA rice at 0.91 g/100 g (Table 3).

Total dietary fiber (TDF) also showed a significant difference between the five types of rice with the highest -to-lowest TDF, namely WA, BA, RA, RM and WM. Fiber can reduce the risk of bowel disorder and the ability to decrease blood cholesterol (Saragih, 2010). The result of statistical analysis with LSD (Least Significant Difference) test at 5% showed that there was a significant difference of amylose level between the five types of rice tested with the highest amylose were RM content of 14.11 g/100 g and the lowest amylose was RA at 9.43 g/100 g. The result of statistical test analysis showed that there was a significant difference of amylopectin level between the five types of rice, with the highest amylopectin content in RA rice and lowest in

RM rice at 61.87 g/100 g. The total starch content of the five samples of rice tested showed a significant difference between the RA rice with the four other types of rice, while the total amount of starch BA rice with RM rice showed no significant difference. The lowest total starch was WA rice at 71.75 g/100 g and the highest was RA rice at 78.49 g/100 g. Based on the amylose content, rice is classified as low-grade sticky rice (<10%), low-grade amylose rice (10-20%), moderate amylose rice (20 -24%), high-amylose rice (>25%) (Haryadi, 2006). Rice carbohydrate are mainly starch which is composed of amylose and amylopectin (Rohman *et al*., 2014). Based on the results of amylose analysis for five types of rice, rice BA, WM and RM were included in the low amylose rice group, while RA and WA were supplied with a very low rice group (<10%). Thus, the five types of local rice in the east and north Borneo do not show an increase in glucose levels in the blood if consumed at reasonable levels. Besides that, with the low amylose and amylopectin in rice, this facilitates the cooking process of these kinds of rice. Syahariza *et al.* (2013) showed the important structure of amylose and amylopectin for starch digestibility in cooked rice grains.

3.4 Sensory properties

The result of analysis with variance indicated that there was a very real difference (P <0.05) in rice color score from various local varieties of North and East Borneo, rice color after cooking is presented in Table 4.

The results of further test analysis with the least significant difference (LSD) at the 0.05% level indicate a significant difference with RM, RA and BA. RM rice was significantly different from RA and BA, while BA was not significantly different from the value of the sensory score of the resulting rice color. WM has the most preferred color with a score of 6 (like very much). Rice Adan dan Mayas are characterized by its small and fine grains, good taste, and fragrant aroma after cooking. It feels fine and tasty though it is devoured without side dishes and vegetables. The color of rice is influenced by the white power level, amylose content and changes during the storage of rice. According to Juliano (1994), the value of color and brightness of rice has a positive correlation with amylose levels. Rice with high amylose content tends to absorb more water when ground and expands larger so that the color is whiter. The results of further test analysis with the least significant difference (LSD) at the 0.05% level showed no significant difference in the flavor of RM, and BA whereas the white scores differed significantly from the other three types of local rice. WM has a more fragrant aroma of the three types of rice from the local rice. Medium amylose-containing rice has a higher value of rice aroma than rice with high amylose. This is due to the low amylose content having a soft consistency, having an affinity for lower aroma compounds than rice with high amylose. The older the rice, the formation of the aroma compounds is increasing (Juliano, 1994). Volatile compounds that characterize the taste and aroma of rice have been widely studied. Hundreds of compounds have been characterized by steam distillation of rice. The compounds include 13 hydrocarbons, 13 alcohols, 16 aldehydes, 14 ketones, 14 acids, 8 esters, 5 phenols, 3 pyridines, and 6 pyrazines (Yajima *et al*., 1977 cited in Juliano, 1994).

The results of the analysis of the further test of the least significant difference (LSD) at the level of 0.05% showed a significant difference in the value of the aroma of RM, RA and BA rice. While the score of white flavor is significantly different from the other three types of local rice. The preference for taste is primarily determined by the level of tenderness, flowering, texture, the color of the rice, the flavor and the aroma of the rice. The flavor and aroma of rice are influenced by the varieties of rice (Srisawas and Jindal, 2007; Sompong *et al.,* 2011; Subudhi *et al*., 2013; Asaduzzaman *et al*., 2013; Verma and Srivastav, 2017). The length of rice storage does not affect the taste of rice, but it affects the smell.

The results of the analysis of the least significant difference (LSD) at the 0.05% level indicated that the texture score of RM with different RA was not a significant difference, while the BA, RM, RA and WM rice varieties were significantly different. The white texture score showed a marked difference to the other types of local rice. Differences in cultivars, storage

Table 4. Sensory evaluation of five local rice varieties of North and East Borneo.

Attributes		BA rice	WA rice	RA rice	WM rice	RM rice
Color	Average	4.14±1.34^{b}	5.24±1.04^{c}	4.00±0.57^{b}	5.86±0.89^{d}	3.14±0.89^{a}
	Mode	4	5	4	6	4
Aroma	Average	4.00±1.15^{a}	4.80±1.50^{a}	4.29±1.38^{a}	5.57±0.97^{b}	4.14±1.21^{a}
	Mode	4	4	4	5	4
Flavor	Average	4.4±1,06^{a}	5.14±1.24^{b}	4,00±0.81^{a}	5.71±0.76^{b}	4.57±1.2^{a}
	Mode	4	5	4	6	4
Texture	Average	4.71±0.49^{ab}	5.02±1.40^{bc}	4,00±0.30^{a}	6.14±0.69^{c}	4.14±0.38^{a}
	Mode	5	5	4	6	4

Values are mean ± standard deviation. Values with different alphabet superscript are significantly different (p<0.05). Each value represents the average from three replication.

Table 5. Blood glucose level (mg/dL) after consumption of five local rice varieties of North and East Borneo.

Sample	Time of taking blood (minutes)				
	0	30	60	90	120
Glucose	84.5±2.4^a	157.6±4.2^a	152.6±2.0^a	121.9±2.6^a	86.1±2.6^a
BA rice	84.0±2.0^a	100.5±6.4^c	87.4±2.2^d	88.1±4.2^c	86.3±2.8^a
WA rice	85.5±4.6^a	119.2±2.8^b	114.4±4.4^b	89.7±4.8^c	87.1±2.4^a
RA rice	82.4±4.2^a	109.3±2.4^c	95.2±1.8^c	89.3±2.2^c	87.8±2.2^a
WM rice	85.2±2.4^a	122.5±2.0^b	116.6±2.2^b	99.5±4.2^b	85.6±4.4^a
RM rice	86.1±2.6^a	108.3±4.2^c	99.2±4.8^c	92.5±2.8^c	89.2±2.6^a

Values are mean ± standard deviation. Values with different alphabet superscript are significantly different ($p<0.05$). Each value represents the average from three replication.

temperatures and length of storage affect the hardness and stickiness of the rice produced. The texture of the rice is also influenced by postharvest handlings such as drying conditions, final water content and degassing levels (Lyon *et al*., 1999). In general, the response of nutritional value and functional properties, then the best is black and black rice. Conservation efforts and local rice exploration of North and East Borneo that has not been done so BA rice most appropriate to be developed in further research, especially for food with special needs as food for diabetes.

3.5 Blood glucose response

The *glycemic index* (GI) is a rating system for foods containing carbohydrates. Its value is unpredictable from the chemical composition of the material alone. However, each food component contributes and interacts synergistically between material properties to produce a glycemic response. Blood glucose levels (Table 5, Figure 1) show that there are individual variations of ten volunteers both before and after consuming rice. At 30 and 60 mins after consumption of rice by volunteers the highest levels of glucose volunteers occur in WM and WA and the lowest occur in BA rice but still under control by using pure glucose.

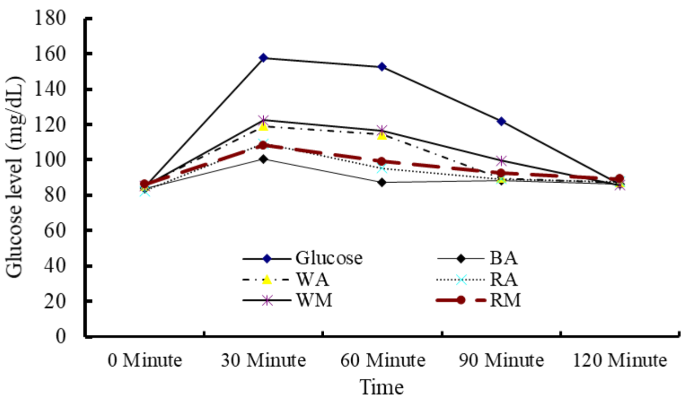

Figure 1. Comparison of blood glucose response due to consumption of five local rice varieties of North and East Borneo (n=10)

Glycemic index (IG) of food is measured according to its effect on the increase of blood glucose level. Foods that raise blood glucose levels quickly have high IG, whereas low IG foods will raise blood glucose levels slowly. The results of Gilbertson *et al*. (2001) showed that food with low IG can improve metabolic control in adult type 2 diabetes mellitus (DM). Consumption of rice is restricted, let alone avoided by Indonesian people suffering from DM. This is considering the culture of eating rice in Indonesia is very high. The assumption that rice is one of the foods that quickly raise blood glucose levels are not always true. Rice has a wide range of IG so that rice can be categorized as high and low IG foods as influenced by varieties, methods of processing and chemical composition of rice (Miller *et al*., 1992; Foster-Powell *et al*., 2002). Miller *et al*. (1992) further state that milled rice has a range of IG from 54 to 121 mg/dL.

3.6 Glycemic index and glycemic load

The glycemic index and glycemic load profile of five rice from North and East Borneo (Table 6). WA rice (74) had the highest of glycemic index and glycemic load at 74, 72 and 35, respectively. While the lowest of glycemic index and the glycemic load was observed in black adan (BA) rice. Results of another study by Xia *et al*. (2003) on the inhibition of atherosclerotic lesions of the black rice pigment fraction is due to increase cholesterol accumulation and decreased oxidative stress and inflammation. A diet composed of pigmented black rice had proposed functional food property (Saragih *et al*., 2013; Paiva *et al*., 2014; Rohman *et al*., 2014). Glycemic index (IG) and glycemic load are affected by factors processing (Astawan *et al*., 2011; Saragih *et al*., 2017), and starch content (Miller *et al*., 1992; Gilbertson *et al*., 2001; Hu *et al*., 2004; Robert *et al.*, 2012). Rice with pulses or cooking oils can be used to elicit a lower glycemic response (Kuma *et al*., 2017).

Table 6. Glycemic index of glucose across five local varieties of North and East Borneo rice.

Samples	Glycemic Index	Glycemic Load
Glucose (food reference)	100	50
BA rice	64	32
WA rice	72	34
RA rice	69	33
WM rice	74	35
RM rice	68	34

4. Conclusion

Protein, fat, carbohydrate, ash and water levels in BA, RA, WA, WM, and RM showed different values. BA shows the highest levels of protein, fat, calories. The highest insoluble dietary fiber in BA rice is 0.91 g/100 g and the lowest is RM rice. Iron content in WA is 3-5 times higher compared to other local varieties at 14.48 mg/1000 g. Higher levels of vitamin B1 (thiamine) in RM rice 0.38 mg/100 g and lowest in WM rice were 0.17 mg/100 g. The highest amylopectin content in mayas red 69.06 g/100 g. BA rice, WM and RM belong to the rice class with low amylose, while RA and WA are supplied with very low amylose rice (<10%). Functional BA rice provides the availability of longer blood glucose available in the blood (slow release).

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