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# Nutritional value and glycemic index of Bario rice varieties

(Nilai pemakanan dan indeks glisemia varieti beras Bario)

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Keywords: Bario rice varieties, nutritional value, glycemic index

**Abstract**

Many indigenous crops of Malaysia have great potential to become important in the future, which are essential for attainment of both food security and health. Among the potential crops are the Bario rice varieties which are famous for their soft texture, pleasant aroma and exquisite taste. There are four Bario rice varieties, namely *Adan Halus*, *Bario Tuan*, *Bario Merah* and *Bario Celum*. Analysis of nutritional values shows that these rice varieties can be labelled as main sources of protein (5.85 – 7.30 g/100 g), high in thiamine (0.46 – 0.63 g/100 g) and low in fat (0.5 – 1.05 g/100 g). These attributes showed that all Bario rice varieties have great potential to be promoted as ingredient for health foods. Analysis of glycemic index (GI) by human subject's glucose tolerance test method on the rice varieties shows that *Bario Celum* and *Bario Tuan* are classified as moderate GI rice with index of 60.9 and 62.2 respectively. Foods with low and moderate GI are reported to be good for controlling human blood glucose.

## Introduction

Bario rice has earned a name for itself because of its eating quality and the place of its origin, Bario highland in Sarawak (Teo 2006). Bario rice is cultivated by traditional method and grown with no chemicals used (Teo et al. 2008). There are four Bario rice varieties, namely *Adan Halus*, *Bario Tuan*, *Bario Merah* and *Bario Celum*. *Adan Halus* and *Bario Tuan* are categorised as white rice, while *Bario Merah* and Bario *Celum* are coloured rice with red and black bran layers respectively. *Adan Halus* variety is widely grown for commercialization. This variety has long been regarded for its sticky texture, fine elongated grains, mild pleasant aroma and exquisite taste (Wong et al. 2009). *Bario Tuan* and *Bario Merah* are amongst the favourite for the local people of Bario and Miri division of Sarawak. *Bario Celum* is mostly planted by farmers for own consumption. High market demand for Bario rice encourages farmers to sell their rice or paddy directly after harvesting.

Rice is a good source of insoluble fibre, which is also found in whole wheat, bran and nuts. Rice is rich in carbohydrate, low in fat, contains some protein and plenty of B vitamins. Those looking to reduce their fat and cholesterol intakes can turn to rice because it contains only a trace of fat and no cholesterol. Rice is also gluten free, so it is

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suitable for celiac, and it is easily digested, and therefore a wonderful food for the very young and elderly (Rosniyana et al. 2010).

Foods with a low glycemic index (GI) score contain slowly digested carbohydrate, which produces a gradual, relatively low rise in the level of blood glucose (Brand-Miller et al. 1996). Boiled white rice, mainly from India and Thailand, have moderate GI values ranging between 58 and 69, while brown rice has low GI value (50) (Foster-Powell et al. 2002). The glycemic index (GI) concept classified dietary carbohydrate according to their physiological effects, specifically their ability to raise human blood glucose, because the blood glucose response varies substantially among different carbohydrate-containing foods and cannot be predicted by their chemical composition (Wolever 1990; Augustine et al. 2002). The GI is therefore defined as the incremental area under the blood glucose response curve (AUC) after a portion of food containing 50 g available carbohydrate, expressed as a percentage of the response after 50 g of glucose taken by the same subject (Wolever et al. 1991).

The main objective of the study was to analyse the characteristics of four Bario rice varieties to provide data on their nutritional values and glycemic index which can be used as references for future food product development.

## Materials and methods

### *Sample preparation*

Freshly cleaned and dried (±13% moisture content) Bario paddies, *Adan Halus*, *Bario Tuan*, *Bario Merah* and *Bario Celum,* were used in this study. The paddies were collected from rice fields in the highland of Bario, Sarawak. The paddy samples were dehusked using the Mini Testing Husker (Takayama, Taiwan) and polished using the Mini Testing Mill/Polisher (Takayama TM-05). The milled rice samples were used for analysis. For comparison, MR 219 was used as the control variety.

### *Proximate analysis*

Moisture, ash, crude fibre and energy were determined using standard AOAC methods (AOAC 1990; 1993). Protein and fat were determined according to in-house method 0506 and 0511 respectively, based on Pearson's Chemical Analysis of Food (Harold 1981). Ashing was done at 550 ºC to constant weight. Carbohydrate was calculated according to in-house method 0512 based on Method of Analysis for Nutritional Labelling (AOAC 1993) by subtracting the values of moisture, protein, crude fibre, fat and ash from 100. All analyses were done in duplicate on the milled rice samples. Energy was determined according to AOAC standard method (AOAC 1993).

### *Mineral and vitamin contents*

Minerals were analysed by an accredited company Chemical Laboratory (Malaysia) Sdn Bhd according to the method by AOAC (1993). Thiamine (B1) and niacin (B3) were determined according to AOAC (1993) and AAS standard method also by the same accredited company.

### *Glycemic index determination*

The glycemic index (GI) determination was carried out at Department of Nutrition and Dietetics, Universiti Kebangsaan Malaysia according to the method recommended by the Food and Agriculture Organization/ World Health Organization (FAO/WHO 1998). A total of 12 healthy adults with normal glucose tolerance and without medical history of diabetes mellitus were selected as subjects. On the day prior to the test, subjects were asked to restrict their activities and not to eat after 9.00 p.m. the night before the test, although plain water was allowed. Glucose tolerance test was performed as follows: After an overnight fasting, the blood samples were collected (0 min) and the subjects were asked to consume 50 g cooked Bario rice (as test food). Further blood samples were taken at 30, 60, 90 and 120 min for estimation of the

blood glucose by glucose oxidise method (Roche diagnostic) using an automated glucose analyser (model: Reflotron Plus, Germany).

On another occasion, after an overnight fasting, the same 12 subjects were given an equal-carbohydrate portion of 50 g glucose sugar (as reference food) and their 2-hour blood glucose response was also measured. The incremental area under the curve (IAUC), ignoring the area beneath the baseline, was calculated geometrically for each food and classified as glucose response by the subject (FAO/WHO 1998). GI value for the test food is then calculated for each subject by dividing their IAUC for the test food (IAUCt) by their IAUC for the reference food (IAUCr) (Chlup et al. 2004). The final GI value of the cooked Bario rice (test food) is the average GI value for the 12 subjects (Brand-Miller et al. 1996). Calculation of GI value is as below:

$$GI = \frac{IAUCt}{IAUCr} \times 100\%$$

IAUCt = Incremental area under the blood glucose response curve for the tested food (cooked Bario rice)

IAUCr = Incremental area under the blood glucose response curve for the reference food (glucose)

***Data analysis***

The experiment was conducted in completely randomised design and statistical analysis was performed using SPSS. The data was statistically analysed by analysis of variance. The Duncan Multiple Range Test was used to detect the significance differences between the samples.

## Results and discussion

***Proximate and nutritional values***

The ash contents in Bario rice varieties were in the range of 1.07 – 1.46% (*Table 1*). This showed that Bario rice contained some minerals which could be useful in improving health (Adzim et al. 2006).

Table 1. Proximate and nutritional composition of Bario rice varieties compared with MR 219 rice

| Varieties | Moisture (%) | Ash (%) | Protein (%) | Carbohydrate (%) | Fat (%) | Crude fibre (%) | Energy (kcal/100 g) |
|---|---|---|---|---|---|---|---|
| B. Adan Halus | 14.73 ± 0.02a | 1.46 ± 0.01ab | 7.30 ± 1.41a | 73.96 ± 1.04a | 1.05 ± 0.07a | 1.50 ± 0.42a | 239 ± 6.36a |
| B. Tuan | 13.59 ± 0.12b | 1.32 ± 0.17b | 6.45 ± 1.62a | 76.39 ± 1.64a | 0.85 ± 0.63a | 1.40 ± 0.56a | 289 ± 7.77a |
| B. Merah | 14.13 ± 0.05ab | 1.07 ± 0.16b | 6.95 ± 1.62a | 75.15 ± 1.73a | 0.65 ± 0.49a | 2.05 ± 0.49a | 297 ± 6.36a |
| B. Celum | 14.12 ± 0.53ab | 1.32 ± 0.16b | 5.85 ± 2.33a | 76.76 ± 2.74a | 0.50 ± 0.00a | 1.45 ± 0.07a | 285 ± 9.89a |
| MR 219 | 11.54 ± 0.09c | 2.20 ± 0.31a | 5.85 ± 1.20a | 78.45 ± 0.54a | 1.05 ± 0.07a | 0.90 ± 1.27a | 305 ± 21.21a |

Mean values in the same column with different letters are significantly different with $p < 0.05$

The protein content ranged from 5.85 – 7.30% which fulfilled the requirement to be stated as a good source of protein (>5 g/100 g according to Nutrient Reference Value in 18C Act, Table II Food Regulations of Malaysia). The protein contents were 7.30% in *Adan Halus*, 6.95% in *Bario Merah*, 6.45% in *Bario Tuan* and 5.85% in *Bario Celum*. The results also showed that all Bario rice varieties were low in fat (< 3 g/100 g according to 18C Act, Table II Food Regulations of Malaysia) with 0.5% in *Bario Celum*, 0.65% in *Bario Merah*, 0.85% in *Bario Tuan*, and 1.05% in *Adan Halus*. These results indicated that Bario rice varieties have great potential to be promoted as health food or as an ingredient for health food products.

The crude fibre content were in the range of 1.40 – 2.05% which were higher than MR 219, while the carbohydrate contents ranged from 73.96 – 76.76% which was lower than MR 219. According to Resurrection et al. (1979) and Rosniyana et al. (2010), rice is a good source of insoluble fibre which contains some protein, and a main source of carbohydrate. Energy contents were in the range of 239 – 297 kcal/100 g which was lower than MR 219 (305 kcal/100 g). Food with low energy level contributes to healthy diet.

***Mineral and vitamin contents***

The mineral contents of Bario rice varieties are shown in *Table 2*. The results showed that there were significant differences in the calcium, phosphorus, sodium, potassium and iron contents between the Bario rice varieties and MR 219.

Phosphorus content in *Bario Tuan* was 7.63 mg/100 g which was significantly higher compared to the other Bario rice varieties and MR 219 rice. However, *Bario Celum* has lower phosphorus content with 0.84 mg/100 g compared to the other three Bario rice varieties. The lower level of sodium content in Bario rice varieties compared to MR 219 rice was probably due to non or low-usage of fertilizer (Othman

Table 2. Mineral and vitamin composition of Bario rice varieties compared with MR 219 rice

| Varieties | Calcium (mg/100 g) | Phosphorus (mg/100 g) | Sodium (mg/100 g) | Potassium (mg/100 g) | Iron (mg/100 g) | Thiamine (mg/100 g) | Niacin (mg/100 g) |
|---|---|---|---|---|---|---|---|
| B. Adan Halus | 0.54 ± 0.04c | 4.67 ± 0.10b | 0.62 ± 0.00b | 19.55 ± 0.77c | 0.52 ± 0.05a | 0.52 ± 0.00b | 0.20 ± 0.00c |
| B. Tuan | 1.08 ± 0.09b | 7.63 ± 0.19a | 0.47 ± 0.00d | 16.55 ± 0.77cd | 0.45 ± 0.10a | 0.63 ± 0.01a | 0.22 ± 0.01b |
| B. Merah | 0.61 ± 0.02c | 3.20 ± 0.07d | 0.41 ± 0.00e | 40.05 ± 0.77a | 0.48 ± 0.01a | 0.46 ± 0.00c | 0.18 ± 0.00d |
| B. Celum | 1.01 ± 0.06b | 0.85 ± 0.14e | 0.58 ± 0.01c | 24.40 ± 0.98b | 0.59 ± 0.01a | 0.47 ± 0.00c | 0.28 ± 0.01a |
| MR 219 | 1.31 ± 0.01a | 3.95 ± 0.07c | 0.67 ± 0.00a | 15.85 ± 0.77d | 0.57 ± 0.06a | 0.34 ± 0.00d | 0.15 ± 0.00e |

Mean values in the same column with different letters are significantly different with $p < 0.05$

and Hadzim 1992). Low intake of sodium will reduce the potential of getting diseases such as hypertension and cardiovascular diseases (Adzim et al. 2006).

The potassium contents in *Bario Merah*, *Bario Celum*, *Adan Halus* and *Bario Tuan* were 40.05, 24.40, 19.55 and 16.55 mg/100 g respectively, were higher than MR 219. The amount of potassium in the two coloured varieties, *Bario Merah* and *Bario Celum,* were significantly higher than the two white varieties and MR 219, due to the concentration of minerals in the bran as mentioned by Saunder (1990). The coloured varieties are preferably consumed as brown rice which is also known as cargo rice or loonzain (Wahid et al. 2003). In brown rice, the husks have been removed but the other parts such as the pericarp, seed coat, testa, aleurone layer, germ or embryo and endosperm are still intact. Its nutritional quality is higher than milled/ polished rice as mentioned by Ajimilah and Rosniyana (1994).

In this study, the two coloured varieties (*Bario Merah* and *Bario Celum*) still contain some of the bran as a seed coat even after milling. Research indicates that the rice bran lowers blood cholesterols level (Hammond 1994). It offers an advantage over other brans that it can be tolerated by people who are gluten intolerant, or allergic to protein gluten, which is found in most cereal grains (Hammond 1994).

Bario varieties can be categorised as high in thiamine (vitamin B1) content (> 0.42 mg/100 g according to Nutrient Reference Value, Food Regulations of Malaysia, 2011) with *Bario Tuan* showed the highest (0.63 mg/100 g), followed by *Adan Halus* (0.52 mg/100 g), *Bario Celum* (0.47 mg/100 g) and *Bario Merah* (0.46 mg/100 g). *Bario Celum* had the highest niacin (vitamin B3) content (0.29 mg/100 g), followed by *Bario Tuan* (0.23 mg/100 g), *Adan Halus* (0.20 mg/100 g), and *Bario Merah* (0.15 mg/100 g). Thiamine content in Bario rice varieties were significantly higher compared to MR 219. The result shows that Bario rice varieties are more nutritious as thiamine is known to play a fundamental role in energy metabolism. Thiamine is a major factor in the metabolism of glucose; therefore it has long been known that ingestion of simple carbohydrates, processed in the body mainly to glucose, automatically increase the need for dietary thiamine (Lonsdale 2006).

***Glycemic index***

The glycemic index (GI) determination of *Adan Halus*, *Bario Tuan*, *Bario Merah* and *Bario Celum* were based on the post-prandial glycemic response of individuals after ingesting each of these food respectively. According to Brand-Miller et al. (1996) foods may be devided into three groups: food with low GI (55% or less), food with moderate GI (55 – 69%), and food with high GI (70% or more).

Determination of GI values for every Bario rice variety and MR 219 were done separately in different occasion. Results of mean glucose responce of subject upon supplementation of Bario rice samples (test food) and glucose (reference food) are shown in *Table 3*. A total of 17 data were treated as outliers in five different occasion due to incomplete number of glucose estimation or due to high glucose concentration at the start (≥ 7.0 mmol/litre) and had to be excluded from the statistical analysis. The number of outlier data excluded were 5, 2, 2, 4 and 4 (*Table 3*) in the test group of *Adan Halus*, *Bario Tuan*, *Bario Merah*, *Bario Celum* and MR 219 respectively.

The final GI value of each Bario rice variety and MR 219 was the average GI value for the 12 values excluding the outliers, except for *Bario Merah* with only 11 values due to unavailibility of one appointed subject during the occasion. GI values of Bario rice varieties are shown in *Table 3*. The results indicated that GI of *Adan Halus*, *Bario Celum*, *Bario Merah* and *Bario Tuan* rice were 72.1, 60.9, 78.3 and 62.2 respectively.

Table 3. Mean glucose (mmol/litre) upon supplementation of Bario rice samples (test food/IAUCt) and glucose (reference food/IAUCr)

| Subject | B. Adan Halus | | | B. Tuan | | | B. Merah | | | B. Celum | | | MR 219 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean IAUCt rice | Mean IAUCr glucose | GI | Mean IAUCt rice | Mean IAUCr glucose | GI | Mean IAUCt rice | Mean IAUCr glucose | GI | Mean IAUCt rice | Mean IAUCr glucose | GI | Mean IAUCt rice | Mean IAUCr glucose | GI |
| 1 | 141.3 | 146.2 | 96.65 | 177.3 | 146.2 | 121.27 | 204.8 | 146.2 | 140.08 | 60.6 | 146.2 | 41.45 | 133.9 | 146.2 | 91.6 |
| 2 | 71.6 | 104.9 | 68.28 | 78.5 | 104.9 | 74.86 | 82.4 | 104.9 | 78.58 | 46.4 | 104.9 | 44.25 | 42.9 | 104.9 | 40.9 |
| 3 | 82.2 | 146.0 | 56.31 | 81.2 | 146.0 | 55.63 | 91.5 | 146.0 | 62.69 | 96.2 | 146.0 | 65.91 | 124.0 | 146.0 | 85.0 |
| 4 | 145.6 | 132.6 | 109.80 | 69.2 | 132.6 | 52.19 | 127.0 | 132.6 | 95.78 | 101.4 | 132.6 | 76.47 | 77.2 | 132.6 | 58.2 |
| 5 | 89.9 | 229.0 | 39.26 | 27.9 | 229.0 | 12.18 | 103.3 | 229.0 | 45.11 | 66.9 | 229.0 | 29.21 | 59.6 | 229.0 | 26.0 |
| 6 | 82.1 | 142.9 | 57.47 | 75.8 | 142.9 | 53.06 | 95.1 | 142.9 | 66.57 | 35.3 | 142.9 | 24.71 | 58.3 | 142.9 | 40.8 |
| 7 | 82.2 | 99.9 | 82.25 | 60.8 | 99.9 | 60.84 | 61.6 | 99.9 | 61.64 | 69.9 | 99.9 | 69.95 | 96.0 | 99.9 | 96.1 |
| 8 | 72.6 | 160.2 | 45.33 | 83.3 | 160.2 | 52.01 | 92.9 | 160.2 | 58.00 | 122.2 | 160.2 | 76.30 | 100.6 | 160.2 | 62.8 |
| 9 | 104.1 | 146.5 | 71.06 | 124.1 | 146.5 | 84.71 | 127.1 | 146.5 | 86.76 | 95.6 | 146.5 | 65.26 | 129.5 | 146.5 | 88.4 |
| 10 | 66.6 | 96.3 | 69.16 | 56.3 | 96.3 | 58.46 | 54.1 | 96.3 | 56.18 | 85.1 | 96.3 | 88.37 | 66.6 | 96.3 | 69.2 |
| 11 | 55.8 | 122.9 | 45.39 | 91.7 | 122.9 | 74.59 | 121.5 | 122.9 | 98.83 | 99.7 | 122.9 | 81.10 | 107.2 | 122.9 | 87.2 |
| 12 | 95.9 | 122.2 | 78.48 | 61.0 | 122.2 | 49.92 | – | – | – | 47.0 | 122.2 | 38.46 | 42.3 | 122.2 | 34.6 |
| | | | 68.27 ± 21.30 (n = 12) | | | 62.48 ± 25.78 (n = 12) | | | 77.29 ± 26.96 (n = 11) | | | 58.45 ± 21.68 (n = 12) | | | 65.06 ± 24.84 (n = 12) |
| | Mean value after declination of outliers | | 72.1 ± 9.5 (n = 7) | Mean value after declination of outliers | | 62.2 ± 8.9 (n = 10) | Mean value after declination of outliers | | 78.3 ± 9.9 (n = 9) | Mean value after declination of outliers | | 60.9 ± 7.2 (n = 8) | Mean value after declination of outliers | | 66.6 ± 6.9 (n = 8) |

(Mean with ± SD)

= Values were treated as outliers

The results showed that *Bario Celum* and *Bario Tuan* were classified as moderate GI rice (range 55 – 69), which can be considered capable in controlling human blood glucose (Kodanda Rami et al. 2009). As comparison, MR 219 rice was also classified as moderate GI rice with the value of 66.6 ± 6.9. Foods with a low GI contain slowly digested carbohydrate, which produce a gradual, relatively low rise in the level of blood glucose (Brand-Miller et al. 1996). In contrast, foods with high GI contain rapidly digested carbohydrate, which produce a rapid rise and fall of glucose level in the blood. According to Foster-Powell et al. (2002), consumption of a high-carbohydrate, low-GI food with bulk of carbohydrate being rich with nonstarch polysaccharide will contribute to good health.

Some food in the world market already show their GI rating on the nutritional information label. Term such as complex carbohydrate and sugar, which commonly appear on food labels, are now recognized as having little nutritional and physiological significance. The FAO/WHO recommended that these terms be replaced with the total carbohydrate content of the food and its GI value (Rudolf et al. 2004). Result from this study shows that *Bario Celum* and *Bario Tuan* have potential of carrying the 'moderate GI' symbol that may support good eating habit as rice is a staple food in most Asian countries.

## Conclusion

Bario rice varieties namely *Adan Halus*, *Bario Tuan*, *Bario Merah* and *Bario Celum* can be labelled as good sources of protein (>5 g/100 g), high in thiamine (>0.42 mg/100 g) and low in fat (<3 g/100 g) as referred to Food Regulations of Malaysia. These attributes showed that all Bario rice varieties have great potential to be promoted as ingredient for health foods. *Bario Celum* (60.9) and *Bario Tuan* (62.2) are classified as moderate glycemic index (GI) rice which is believed to be capable in maintaining or slightly lowering human blood glucose.

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## References

Adzim, M.K.R., Norhayati, A.H., Rokiah, M.Y., Admah, R., Mohd Nasir, M.T. and Siti Muskinah, M. (2006). Proximate composition and selected mineral determination in organically grown red pitaya (*Hylocereus* sp.). *J. Trop. Agric. and Fd. Sc.* 34(2): 269 – 275

Ajimilah, N.H. and Rosniyana, A. (1994). Brown rice consumption in Malaysia: A new trend? *Proc. of 5th Asean Food Conference,* Kuala Lumpur. Malaysia

AOAC (1990). *Official methods of analysis*. 15th edition. Washington, DC: Association of Official Analytical Chemists

—— (1993). *Official methods of analysis for nutritional labeling*. (Sullivan, D.M. and Carpenter, D.E., eds.). Washington, DC: AOAC International

Augustine, L.S., Franceschi, S., Jenkins, D.J.A., Kendall, C.W.C. and La Vecchia. C. (2002). Glycemic index in chronic disease – a review. *Euro J. of Clin Nutr.* 56: 1049 – 1071

Brand-Miller, J., Foster-Powell, K. and Colagiuri, S. (1996). *G.I. Factor: The Glycemic index solution*. Rydelmere: Hodder and Stoughton

Chlup, R., Bartek, J., Reznickova, M., Zapletalova, J., Doubravova, B., Chlupova, L., Secker, P., Dvorackova, S. and Simanek, V. (2004). Determination of glycemic index of selected foods (white bread and cereal bars) in healthy person. *Biomed Paper* 148(1): 17 – 25

FAO/WHO (1998). Carbohydrate in human nutrition: Report of a joint FAO/WHO expert consultation, Rome. *FAO Food Nutr Paper* 66: 1 – 140

Foster-Powell, K., Susanna, H.A.H. and Brand-Miller, J. (2002). International tables of glycemic index and glycemic load value. *American Journal of Clinical Nutrition* 62: 5 – 56

Hammond, N. (1994). Function and nutritional characteristics of rice bran extracts. *Cereal Food World* 39(10): 752 – 754

Harold, E. (1981). *Pearson's chemical analysis of food,* 8th Edition. New York: Churchill Livingstone

Kodanda Rami, R.K., Naga Raju, I., Giriprasad, B., Lakshminarayanan, G., Chandra Sekhar, R. and Damodar Reddy, C. (2009). Determination of glycemic index value of naturo fruits bars. *Journal of Association of Physicians India* 57: 748 – 750

Lonsdale, D. (2006). A review of biochemistry, metabolism and clinical benefits of thiamine and its derivatives. *eCAM*. 3(1): 49 – 59

Othman, O. and Hadzim, K. (1992). Beras Bario. *Teknol. Padi* 8: 33 – 38

Resurrection, A.P., Juliano, B.O. and Tanaka, Y. (1979). Nutrient content and distribution in milling fractions of rice grain. *J. Sci. Food. Agri*. 30: 473 – 481

Rosniyana, A., Khairunizah Hazila, K., Hashifah, M.A. and Shariffah Norin, S.A. (2010). Quality characteristics of organic and inorganic Maswangi rice variety. *J. Trop. Agric. and Fd. Sc*. 38(1): 71 – 79

Rudolf, C., Josef, B., Martina, R., Jana, Z., Blanka, D., Ludmila, C., Pavel, S., Svatava, D. and Vilim, S. (2004). Determination of the glycaemic index of selected foods (white bread and cereal bars) in healthy persons. *Biomed. Papers* 148(1): 17 – 25

Saunder, R.M. (1990). The properties of rice bran as foodstuff. *Cereal Food World* 35: 632 – 636

Teo, G.K. (2006). Bario rice certification scheme. Research Officers' Conference 2006 Proceedings of the Technical Sessions, p. 165 – 167. Department of Agriculture Sarawak

Teo, G.K., Megir, G. and Lily, E. (2008). *Guidebook for Bario rice production*. Kuching: Department of Agriculture Sarawak

Wahid, S., Rosniyana, A., Hashifah, M.A. and Shariffah Norin, S.A. (2003). Packaging techniques to prolong the shelf life of brown rice and partially milled rice at ambient storage. *J. Trop. Agric. and Fd. Sc*. 31(2): 225 – 233

Wolever, T.M.S. (1990). Glycemix index. *World Review of Nutrition and Dietatics* 62: 120 – 185

Wolever, T.M.S., Jenkins, D.J.A., Alexandra, L.J. and Robert, G.J. (1991).The glycemic index – methologogy and clinical implications. *American Jurnal of Clinical Nutrition* 54: 856 – 854

Wong, S.C., Yiu, P.H., Bong, S.T.W., Lee, H.H., Neoh, P.N.P. and Rajan, A. (2009). Analysis of Sarawak Bario rice diversity using microsatelite markers. *American Journal of Agric. and Biological Sc*. 4(4): 298 – 304

**Abstrak**

Malaysia mempunyai banyak sumber tanaman tradisional yang berpotensi untuk dijadikan sebagai sumber penting pada masa akan datang khususnya untuk keselamatan makanan dan kesihatan. Antara tanaman yang berpotensi ialah varieti padi Bario yang terkenal dengan tekstur nasi yang lembut, berbau wangi dan rasa yang sedap. Terdapat empat varieti beras Bario iaitu *Adan Halus*, *Bario Tuan*, *Bario Merah* dan *Bario Celum*. Analisis nilai pemakanan menunjukkan varieti beras ini boleh dilabelkan sebagai sumber utama protein (5.85 – 7.30 g/100 g), tinggi kandungan thiamin (0.46 – 0.63 g/100 g) dan rendah lemak (0.5 – 1.05 g/100 g). Ini menunjukkan bahawa semua varieti beras Bario berpotensi untuk dimajukan dan dijadikan sebagai bahan untuk makanan kesihatan. Analisis indeks glisemia (GI) melalui kaedah ujian tindak balas pengguna terhadap glukosa menunjukkan *Bario Celum* dan *Bario Tuan* dikelaskan sebagai beras dengan indeks glisemia sederhana (GI) masing-masing dengan indeks 60.9 dan 62.2. Makanan yang mempunyai nilai GI rendah dan sederhana dilaporkan sebagai baik untuk mengawal kandungan glukosa dalam darah manusia.

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