

*Original Research Article*

## Rice Bran of Different Rice Varieties in Malaysia: Analysis of Proximate Compositions, Antioxidative Properties and Fatty Acid Profile for Data Compilation

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**Abstract:** The research aims to investigate the difference in rice bran compositions of three major paddy varieties in Malaysia, which are MR 220 CL2, MR 219 and MR 297. The proximate compositions, antioxidative properties and fatty acid profile of the rice bran were compared. Stabilization of rice bran of all varieties was conducted in prior to the extraction of rice bran oil (RBO) by using the Soxhlet extraction. Fatty acid compositions consisted in RBO of each variety were analysed by using gas chromatography-mass spectrometry (GC-MS). Results on proximate compositions showed that MR 297 was the highest in the content of moisture ( $3.90 \pm 0.29$  %), fat ( $22.52 \pm 0.09$  %), protein ( $12.70 \pm 0.53$  %) and crude fiber ( $3.65 \pm 0.26$  %). MR 297 variety also exhibited the highest antioxidant activity, which indicated by the highest amount of total phenolic content (TPC) and ferric reducing antioxidant power (FRAP) compared to the other two varieties. Three components of fatty acids: palmitic acid; oleic acid; linoleic acid have made up around 90% of the total fatty acids of the RBO for all varieties. The RBO also contains ideal fatty acid compositions with more unsaturated compared to saturated fatty acid, which makes it suitable to be used as a healthy edible oil. Results of this study can provide significant nutritional information for future investigations on the conversion of this agro-waste into valuable products for animals and human benefits.

**Keywords:** rice bran; proximate compositions; antioxidant; fatty acid; rice; rice bran oil

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## 1. Introduction

The increasing interest in the relationship between health and food, results in the increment of formulation studies about functional products. Among the emerging source that is being explored is rice bran, which is produced from the milling process of brown rice. This process removes the outer brown layer in white rice processing (Eyarkai Nambi *et al.*, 2017). Rice bran is an indispensable, abundantly available and less expensive which exist in a soft and fluffy off-white powdery material. Around 2.7 million metric tons (MT) of paddy were averagely produced in Malaysia from the year 2014 to 2017 (Ministry of Agriculture, 2018). From this amount, rice bran constitutes around 8–10% of total rice production (Sereewatthanawut *et al.*, 2008; Salehi & Sardarodiyani, 2016), which signifies its abundance in Malaysia. However, it is currently underutilized, since it is either being disposed or used as an animal feed (Iqbal, *et al.*, 2005; Bhosale & Vijayalakshmi, 2015).

Despite its abundance, rice bran has been considered as an excellent source of nutrients (65% of beneficial nutrients) among other rice by-products. It is reported that rice bran was rich in protein (11–17%), carbohydrate (34–62%), fat (11–18%), crude fiber (10%), ash (9%), vitamins and trace minerals (Kumari *et al.*, 2018). It is also an important source of antioxidants due to the presence of  $\gamma$ -oryzanol, tocopherols, and tocotrienols, which can help in disease prevention and promoting good health (Alauddin *et al.*, 2017; Chakraborty & Budhwar, 2018). Rice bran and rice bran oil have profound health benefits contributed by its antioxidant's compounds, which are also important in improving the storage stability of food. Antioxidant properties were also responsible in lowering the cholesterol besides the contribution of fatty acid compositions. One of the rice bran components, identified as defatted rice bran, has a notable potential in the food industry, especially in the development of functional foods such as fermented cereals (Aktaş & Akin, 2020; Murai *et al.*, 2020), functional bakery products (Hu *et al.*, 2009; Saccotelli *et al.*, 2017) and low-fat meatballs (Hu & Yu, 2015). Rice bran oil (RBO), another portion of rice bran is also potential sources of edible oil, which can be extracted around 12–18.5% from the crude rice bran (Saikia & Deka, 2011). RBO encompasses of an ideal amount of unsaturated and saturated fatty acids, which contributes to the shifting towards the utilization of RBO as an edible oil in several countries like Bangladesh, Taiwan, Japan and a few Western countries (Ahmad Nayik *et al.*, 2015; Lai *et al.*, 2019). Besides its potential health benefits, RBO is highly preferred, since it is an excellent cooking medium contributed by its nutritional superiority, longer shelf life, abundant micronutrients, high stability at higher temperature, appealing flavour and alternative to bakery shortening (Liang *et al.*, 2014).

In Malaysia, new paddy varieties are developed to fulfil certain requirements other than ensuring the improvement of paddy quality time to time. The innovation needs to be implemented and adopted to increase the country's rice production, meet the consumers' demand and to produce paddy with high resistance against diseases, which then contributed to a good environmental well-being (Hussain *et al.*, 2012). Various types of local and imported paddy in Malaysia have been studied by previous research, which are emphasized

on their nutritional compounds (Nori *et al.*, 2009; Thomas *et al.*, 2015; Hashmi & Tianlin, 2016), physico-chemical properties (Sam Lum, 2017), agronomic and soil's physico-chemical characteristics (Hanafi *et al.*, 2009) and morphological features (Ruslan *et al.*, 2018). However, to date, only few researchers have published their work focusing on the utilization of rice bran as a by-product from rice production in Malaysia. The effect of milling degree towards the nutritional compositions of rice bran (MR 220) has been reported by Rosniyana *et al.* (2007; 2009). Oryzanol content of several types of rice bran from different paddy varieties in Malaysia has been investigated by Azrina *et al.* (2008). Besides, the effect of extraction conditions towards the yield and properties of rice bran oil from different varieties have been studied in the previous report compiled by Daud *et al.* (2018).

Therefore, this study has attempted to further investigate the nutritional compositions of rice bran and its oil component extracted from paddy varieties in Malaysia. Additionally, this project is in line with Malaysia's Paddy and Rice Strategy 2011-2020, which intensifies the use of rice by-products. Information regarding beneficial compound in the rice bran extracted from this research paves a good way for the particular industries like food and agricultural to further plan suitable processing steps and products to be produced. Hence, this study aims to identify the chemical compositions of stabilized rice bran from three major paddy varieties in Malaysia, in term of its proximate compositions and antioxidative properties. Besides that, fatty acid profiles of the oil portions extracted from each rice bran variety were also analysed. Differences in the nutritional and fatty acid compositions among the paddy varieties were also discussed in this study.

## 2. Materials and Methods

### 2.1 Sample and Reagents

In total, three types of paddy varieties were used; MR 220 CL2, MR 219 and MR 297, as the samples of this study. All paddy varieties were obtained from local seed company in Tanah Merah, Pendang, Kedah. All chemicals used were procured from Merck or Sigma–Aldrich (Darmstadt, Germany) unless stated otherwise and were of analytical grades.

### 2.2 Sample Preparation

Rice bran was processed by milling 40 kg of paddy by using a 50 kg-capacity rice mill at the Malaysian Agricultural Research and Development Institute (MARDI) station, Bukit Raya, Kedah. Upon production, samples of rice bran were collected and stored in the dry ice in cold box containers. The samples were immediately processed by screening through 500 µm sieve to obtain uniform particle size. Each variety was processed separately. The initial moisture content was determined using a method by AOAC (2012).

### 2.3 Stabilization of Rice Bran

The stabilization of rice bran was done by using Autoclave Sterilizzazione Usata, 100L (Guangdong, China) at 120°C for 20 min according to the method described by Rosniyana *et al.* (2009). Stabilization step was done to increase the sustainability of the rice bran for long-term storage as well as to improve the availability of bioactive components. The stabilization process was done immediately after the sieving step. Then, the sample was dried at 60°C to reduce the moisture content to less than 5%.

### 2.4 Production of Rice Bran Oil (RBO)

Rice bran oil (RBO) was extracted by using a Soxhlet method adapted from Abdul Khalil *et al.* (2016) with slight modifications, using n-hexane as the extraction solvent. 5 g of rice bran samples were placed in a thimble and inserted in a Soxhlet extraction unit, which was connected to a reaction flask containing 250 mL n-hexane. The extraction was then conducted at 75°C for 90 min (Ferreira-Dias *et al.*, 2003). The resulting oil (RBO) extracted from the samples were collected and kept in 4°C.

### 2.5 Chemical Analysis of Rice Bran

Stabilized rice bran was analysed for chemical properties such as moisture, protein, fat, crude fiber and ash following the procedures of AOAC (2012) and the total carbohydrate was calculated by the difference method.

$$\text{Total carbohydrate (\%)} = 100 - [\text{crude protein (\%)} + \text{crude fiber (\%)} + \text{crude fat (\%)} + \text{total ash (\%)}] \quad (1)$$

### 2.6 Estimation of Antioxidant Activity

#### 2.6.1 Extraction of total antioxidants

Extraction was carried out following the method suggested by Arab *et al.* (2011). 5g of stabilized rice bran was extracted using 20 mL of methanol at room temperature for 3 hours in an electrical shaker MaxQ 4000 Incubator, Thermo Fisher (Waltham, M.A. USA). The residue was re-extracted twice and was filtered through Whatman (No.1) filter paper. The extracts from each procedure were combined and dried using rotary evaporator at 50°C.

#### 2.6.2 Determination of total phenolic content (TPC)

Total phenolic content was determined colourimetrically according to a method described by Singleton and Rossi (1965) with slight modifications. 1 mg/mL of crude rice bran extract was prepared. 20 µL of the extract was mixed with 100 µL of Folin–Ciocalteu

reagent and subsequently, 1.58 mL of distilled water was added. The mixture was mixed vigorously and 300  $\mu$ L of (20% w/v) sodium carbonate was added and vortexed. The absorbance was measured at 765 nm by using UV-vis spectrophotometer Shimadzu UV-2600i (Kyoto, Japan) after leaving to stand at room temperature (dark environment) for 2 hours. The results were expressed as g of gallic acid equivalents (GAE) per 100 gram of rice bran using gallic acid (0.01–0.05 mg/ml) as the standard curve. The following formula was used to calculate the total phenolic content (TPC):

$$\text{TPC} = c \times V/m \quad (2)$$

c is sample concentration from the calibration curve (mg/mL), V is volume (mL) of the solvent use for extraction and m is weight (g) of dried sample

### 2.6.3 Scavenging effect on 2,2-Diphenyl-1-picrylhydrazyl (DPPH)

The antioxidant activity was determined following the method described by Heinonen *et al.* (1998) with slight modifications. 0.1 mL of extract was mixed with 3.9 mL of 60  $\mu$ M DPPH solution in methanol in the test tube and vortexed. The mixture was kept at room temperature in a dark environment for 30 min, prior to measurement of the absorbance at 517nm. Higher free radical scavenging activity was indicated by the lower absorbance of the reaction mixture. Scavenging effect can be calculated using the following formula:

$$\text{DPPH scavenging activity (\%)} = \frac{(A_c - A_s)}{A_c} \times 100 \quad (3)$$

where  $A_s$  and  $A_c$  is the absorbance (at 517 nm) of sample and control solution, respectively.

### 2.6.4 Reducing power using Ferric Reducing Antioxidant Power (FRAP) assay

Method of Luqman *et al.* (2009) was used to determine ferric reducing antioxidant power (FRAP). 3 mL of freshly prepared FRAP reagent (25 mL of acetate buffer: 300 mM, pH 3.6; 2.5 mL 2,4,6-Tri(2-pyridyl)-s-triazine (TPTZ) solution: 10 mM TPTZ in 40 mM HCl and 2.5 mL of  $\text{FeCl}_3$ : 20 mM in water solution) was added to 200  $\mu$ L extract to initiate the reaction. After 30 min of incubation in a 37°C water bath, the absorbance was observed at

593 nm. Standard curve (mg/mL) was prepared by using iron (II) sulphate,  $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$  and the results were expressed as mg  $\text{FeSO}_4$  per grams of rice bran.

### 2.7 Fatty Acid Profile

Transesterification was carried out to produce fatty acid methyl esters (FAME) based on the method of Ichihara and Fukubayashi (2010) with minor modifications. Approximately 0.1 g of rice bran oil (RBO) from each variety was dissolved in 0.2 mL of chloroform. This was followed by the addition of 2 mL methanol and 0.1 mL of concentrated HCl (35%, w/w) to the lipid solution which resulted in the final volume of 2.3 mL. The sample was tightly closed and after vortexed, the sample was heated in a water bath at 100°C for 1 hour. Following the procedure, the sample was left to cool to room temperature before 2 mL of hexane and 2 mL of distilled water was added for extraction of FAMEs. After the phase separation, the hexane phase was evaporated under nitrogen stream and the residue was dissolved again using 0.1 mL of hexane and 1  $\mu\text{L}$  of this solution was injected for GC-MS analysis. To separate and quantify the esterified fatty acid mixture, GC-MS QP 2010 by Shimadzu (Kyoto, Japan) equipped with split injector and capillary column of BPX70 (30 m  $\times$  0.25 mm  $\times$  0.25  $\mu\text{m}$ ) was used. Helium was utilized as the carrier gas at a flow rate of 1.03 mL/min. The injector and detector temperatures were set to 230°C. The chromatographic conditions for separation were 50°C, as the initial column temperature, raising to 170°C at a flow rate of 4°C/min and holding during 5 min. The second step involved the increment at a heating rate of 2°C/min to 220°C and held for 10 min. The peaks were identified and compared by relating them to the recognized standards.

### 2.8 Statistical Analysis

Statistical analysis of the results obtained in this study were subjected to a One-way analysis of variance (ANOVA) by using SPSS software (SPSS version 17.0 SPSS Inc., Wacker Drive, Chicago, IL, USA). The level of significance was determined at  $p < 0.05$ .

## 3. Results

### 3.1 Proximate Compositions

The proximate compositions of rice bran from three rice varieties, which are locally grown in Malaysia are shown in **Table 1**. Analysis of variance (ANOVA) showed that there were significant differences ( $p < 0.05$ ) in several proximate compositions of all rice varieties. Moisture content was recorded to vary within the range of 3.18-3.90%. It is also observed that there were no significant differences recorded for crude fibre content between all types

of bran. In Table 1, it is shown that MR 297 contains the highest amount of fat (22.52 %), protein (12.70 %), fiber (3.65 %) and moisture content (3.90 %) compared to other varieties, while the ash and carbohydrate contents were ranged between 8.97% to 10.08 %, and 50.71 to 51.99 %, in all varieties, respectively. Overall, in this study, MR 297 demonstrated the highest amount of chemical compositions compared to MR 219 and MR220 CL2.

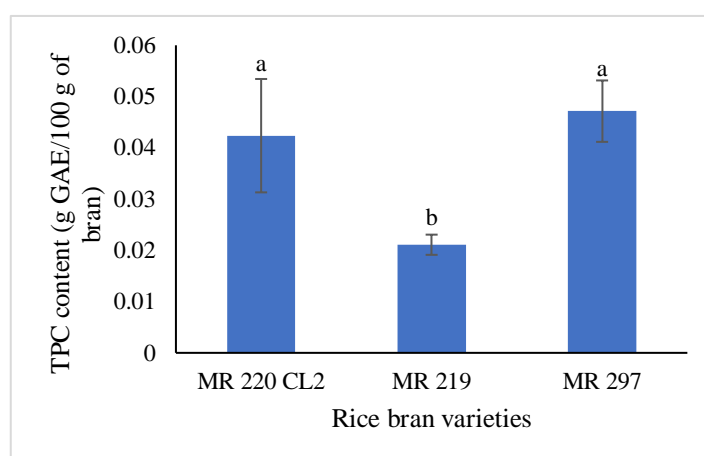
**Table 1.** Variations in proximate conditions for different types of varieties

Rice bran variety	Proximate compositions (%)					
	Fat	Protein	Ash	Crude fibre	Moisture	Carbohydrate
MR 220 CL2	20.32±0.10 <sup>c</sup>	9.92±0.30 <sup>a</sup>	8.97±0.15 <sup>c</sup>	2.83± 0.73 <sup>a</sup>	3.18± 0.36 <sup>b</sup>	51.99±0.05 <sup>b</sup>
MR 219	21.84±0.54 <sup>b</sup>	10.64±0.60 <sup>b</sup>	10.08±0.12 <sup>a</sup>	3.13± 0.70 <sup>a</sup>	3.60± 0.21 <sup>ab</sup>	50.71±0.12 <sup>a</sup>
MR 297	22.52±0.09 <sup>a</sup>	12.70± 0.53 <sup>b</sup>	9.31±0.08 <sup>b</sup>	3.65± 0.26 <sup>a</sup>	3.90± 0.29 <sup>a</sup>	50.71±0.09 <sup>a</sup>

Mean ± standard deviation ( $n = 9$ ), means followed by the same superscript are not statistically significant at the 5% level.

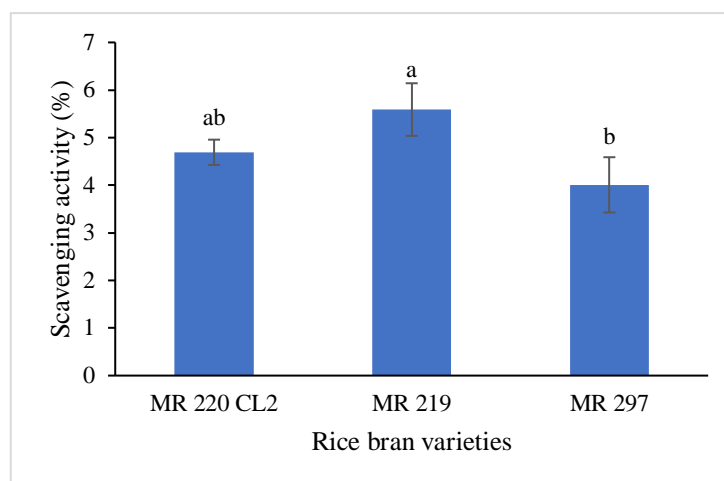
### 3.2 Antioxidant Activities

The total phenolic content (TPC) of the methanolic extracts of rice bran from all varieties is shown in Figure 1. From the figure, it can be depicted that MR 220 CL2 (0.042 g GAE/100 g bran) and MR 297 (0.047 g GAE/100 g bran) showed no significant difference ( $p < 0.05$ ) between the content of TPC in their methanolic extracts, while the lowest amount of TPC is shown by MR 219 (0.021 g GAE/100 g bran).



**Figure 1.** TPC contents (g GAE/100 g of bran). Mean ± standard deviation ( $n = 3$ ). TPC content with different letter between the rice bran varieties are significantly different ( $p < 0.05$ )

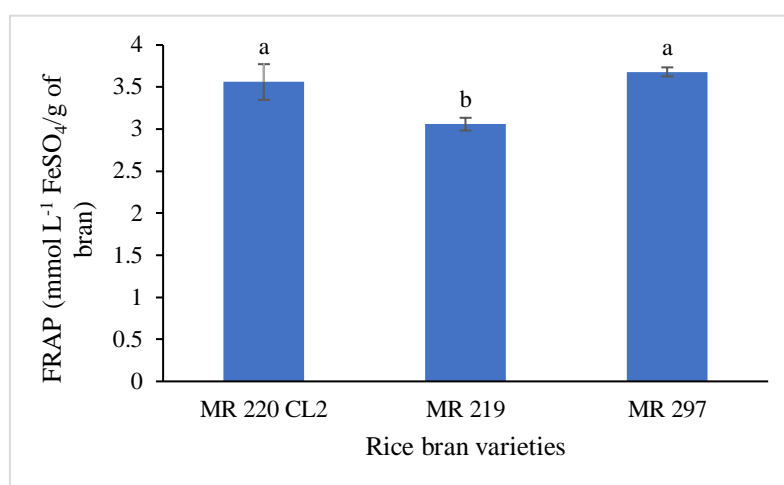
The scavenging activity of crude methanolic extracts from three varieties of rice bran is shown in Figure 2. From the figure, DPPH scavenging activity of MR 297 (4.0072%) was significantly different ( $p < 0.05$ ) from MR 219, but no significant difference from MR 220 CL2 (4.6915%) was observed.



**Figure 2.** Scavenging activities of rice bran of all varieties based on DPPH analysis. Mean  $\pm$  standard deviation ( $n = 3$ ). Scavenging activity with different letter between the rice bran varieties are significantly different ( $p < 0.05$ )

MR 219 has the highest DPPH scavenging activity (5.5893%). In comparison with TPC, MR219 contains the highest DPPH scavenging activity, but the lowest in TPC value. The third antioxidant analysis that was conducted in this study was the ferric reducing antioxidant power (FRAP) assay. The result was calculated from the  $\text{FeSO}_4$  calibration curve, with  $R^2 = 0.9991$ . The reducing capability of all rice bran extracts are represented by a graph in Figure 3. It is clearly shown that MR 297 (3.6803 mmol  $\text{L}^{-1}/\text{g}$  of bran) has the highest capability in reducing the  $\text{Fe}^{+++}$ /tripiryridyl-s-triazine (TPTZ) complex followed by MR 220 CL2 and MR 219. In this study, positive correlations between the amount of TPC and the ferric reducing capability of all rice bran varieties were observed.





**Figure 3.** FRAP assay of all varieties. Mean  $\pm$  standard deviation ( $n = 3$ ). FRAP content with different letter between the rice bran varieties are significantly different ( $p < 0.05$ )

### 3.3 Fatty Acid Profile

The fatty acid profiles obtained for the rice bran oil (RBO) that were extracted from three different rice varieties (MR 220 CL2, MR 297 and MR 219) are presented in **Table 2**. The results showed that the RBO from all varieties were dominated by the high percentage of monounsaturated fatty acid (MUFA) followed by polyunsaturated fatty acid (PUFA) and saturated fatty acid (SFA). It was also observed that all three varieties were consisted of three major fatty acids in RBO, which were palmitic acid (SFA), oleic acid (MUFA) and linoleic acid (PUFA). The results concluded that RBO from MR 219 is the best oil to be used, since it contains the highest MUFA and PUFA, while showing the least amount of SFA as compared to the other varieties.

**Table 2.** Fatty acids profiles of three varieties of rice bran oil.

Fatty acid	Lipid numbers	Group	Relative abundance (%)		
			MR 220 CL2	MR 219	MR 297
Myristic acid	C14:0	SFA	0.48	0.55	0.44
Palmitic acid	C16:0	SFA	23.92	19.20	23.81
Palmitoleic acid	C16:1	MUFA	ND	0.04	ND
Stearic acid	C18:0	SFA	3.76	3.23	3.08
Oleic acid	C18:1	MUFA	33.52	37.07	34.92
Linoleic acid	C18:2	PUFA	27.07	29.61	27.38
$\alpha$ -Linoleic acid	C18:3	PUFA	0.86	0.96	0.85
Arachidic acid	C20:0	SFA	0.57	0.74	0.54
Behenic acid	C22:0	SFA	0.26	0.25	0.26
Eruic acid	C22:1n	MUFA	ND	ND	0.23
Lignoceric acid	C24:0	SFA	0.41	0.43	0.34
Hexadecadienoic acid	C16:2n4	PUFA	ND	0.27	0.27
Others			9.15	7.46	7.88

Fatty acid	Lipid numbers	Group	Relative abundance (%)		
			MR 220 CL2	MR 219	MR 297
SFA			29.4	24.4	28.47
MUFA			33.52	37.11	35.15
PUFA			27.93	30.84	28.50

Abbreviations: SFA-saturated fatty acid; MUFA-monounsaturated fatty acid; PUFA-polyunsaturated fatty acid; ND – not determined

#### 4. Discussion

Chemical analysis on the proximate compositions can provide useful information on the main components of certain food. Among the compositions analysed in proximate analysis were moisture, protein, fiber, fat, ash and carbohydrate (Satter *et al.*, 2014; Verma & Srivastav, 2017). The amount of moisture obtained in all rice bran varieties were in agreement with the studies reported by Bhosale and Vijayalakshmi (2015) (4.30%) and Chakraborty and Budhwar (2018) (4.18%). The moisture content of food should be considered by food manufacturers for several reasons. Moisture plays a significant role in measuring the quality, preservation and resistance of certain material to deterioration. It is also necessary to be measured so that the content of other constituents can be calculated on a uniform basis. It was suggested by Mercer (2008) that the lower moisture contents as observed in this study satisfies the minimum value of moisture (<10%) for long-term storage, which can prevent microbial growth as well as insect infestation.

Unlike other macronutrients such as lipid and carbohydrate, proteins are necessary in the formation of biomolecules rather than its function as a source of energy. The amount of ash content present in the food samples indicates the level of essential minerals. Carbohydrate contents were high (>50%) in all varieties, thus showing rice bran as a good source of carbohydrate. The data obtained for protein, carbohydrate and ash contents satisfied the range of basic chemical components of rice bran reported by Kumari *et al.* (2018). High amount of fat content in rice bran also found by Rosniyana *et al.* (2007) and Issara and Rawdkuen (2018), which lies between the range of 20% to 26%. High nutritional compositions observed in MR 297 had revealed its potential as a promising rice bran source of functional food. In Malaysia, MR 297 is a new paddy variety which were released in 2016. This variety can be easily obtained since it is the second largest variety cultivated in the main season of 2017/2018. The planted area is about 31.6% from the total cultivated paddy in that year (Hosnan, 2019; Omar *et al.*, 2019).

Phenolic content is one of the major group of compounds that plays an important role in antioxidative action especially as free radical terminators (Awika *et al.*, 2003; Oviasogie *et al.*, 2009). According to Du *et al.* (2013), phenolic compounds in rice comprises of several flavonoid components like kaempferol, myricetin, catechin and quercetin. Study done by

Iqbal *et al.* (2005) stated that the amount of TPC in 80% methanolic extract of different rice bran varieties originated from Pakistan were ranged from 0.250 to 0.397 g GAE/100 g. Chatha *et al.* (2006) had also revealed that TPC of four varieties of rice bran indigenous to Pakistan ranged from 0.251–0.359 g GAE/100 g bran. Comparable TPC contents were reported by Muntana and Prasong (2010) from the methanolic extracts of rice bran from Thai rice cultivars (red, white and black rice), which were ranging from 0.089–0.122 g GAE/100 g of bran.

In 2,2-Diphenyl-1-picrylhydrazyl (DPPH) assay, higher free radical-scavenging activity was indicated by lower absorbance of the reaction mixture. Radical-scavenging activity was expressed as the percentage of inhibition of free radical by the sample (Thirunavukkarasu *et al.*, 2011). Negative correlation observed between TPC and scavenging activity of MR 219 can be supported by Tawaha *et al.* (2007), which discovered that the amount of TPC was not a direct indicator of the total amount of antioxidants that might be present in the extract. Besides that, Prior *et al.* (2005) also emphasized the different role of Folin-Ciocalteu assay and free radical scavenging assay in which the former gives a crude estimation of the TPC present in an extract, whereas the latter is not only specific to polyphenols. The inverse correlation between TPC and DPPH was also reported in the study done by Ruslan *et al.* (2018) regarding the antioxidant potential of two varieties of sesame seed from Indonesia.

Ferric reducing antioxidant power (FRAP) assay is a measurement of the ability of antioxidant capacity to reduce the Fe<sup>+++</sup>/tripiryridyl-s-triazine (TPTZ) complex, to the ferrous form under acidic conditions (pH 3.6) (Luqman *et al.*, 2009). Several studies reported the FRAP assay of bran from other sources such as wheat bran which ranged from 21.5 to 36.1 mmol L<sup>-1</sup> sulfate/g (Saad Smuda *et al.*, 2018) and 85.06–109.12 µmol/g dm in wheat grain (Durazzo *et al.*, 2015). In comparison with the previous studies mentioned, the antioxidative properties of rice bran resulted from the antioxidant analysis in this study were lowered by approximately 90%. The variation in the nutritional compositions of rice bran might be explained by the influenced of cultivation area, distribution of chemical composition, anatomy and geometry of grains, environmental variability, stabilization technique used and the milling process (Malekian *et al.*, 2000; Rosniyana *et al.*, 2007).

Fatty acid analysis of an oil is of primary importance to be determined by both manufacturers and consumers in order to evaluate the quality of the edible oil used. An ideal amount of monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA) and saturated fatty acids (SFA) are required as an indicator of the oil quality and appear to be critical to avoid any adverse effect in any level of fat intake (Hayes, 2002). The balanced proportions of MUFA, PUFA and SFA in all varieties observed in this study were in agreement with the research conducted by Bakota *et al.* (2014) and Orsavova *et al.* (2015).

The studies reported that a balanced amount of SFA, MUFA and PUFA of rice bran was ranging from 18.4–25.5 %, 38.4–42.3 % and 33.6–39.2 %, respectively. Gopala Krishna *et al.* (2006), Pal and Pratap (2017) and Mas'ud *et al.* (2017) also found that palmitic, oleic and linoleic acid were among the three main fatty acids compositions consisted in RBO. Higher proportion of palmitic acid (SFA) in palm oil (44%) (May & Nesaretnam, 2014) had pointed out the advantage of RBO over this commonly-used oil. Additionally, a higher relative percentage of oleic acid were observed in this study against the previous oil in research such as sunflower oil (28%), pumpkin seed oil (24.9%), wheatgerm oil (12.7%) and coconut oil (6.2%) (Orsavova *et al.*, 2015). This fatty acid profile of RBO has placed the oil at an advantage over other vegetable oils. According to FAO and WHO (1993), oleic, linoleic and linolenic acids are among the essential fatty acids required for physiological functions, growth and body maintenance. Unlike saturated fatty acids (SFA), unsaturated fatty acids (MUFA and PUFA), which are largely present in RBO for all three varieties are beneficial due to its nutritional and health benefits. Other than useful as an edible oil for frying and baking, consumption of RBO can reduce heart related diseases, which is associated with cholesterol (Law, 2000).

## 5. Conclusions

From the present work, it can be concluded that rice bran is a good source of proteins, carbohydrate, fibre and fatty acids. All these compositions indicate the capability of rice bran to be utilized in the development of nutraceuticals and functional food. Rice bran oil (RBO) extracted from all varieties showed an ideal composition of saturated, monosaturated and unsaturated fatty acids. MR 297 was found having the highest proximate compositions and antioxidative properties, while rice bran oil (RBO) from MR 219 variety showed the highest amount of unsaturated fatty acids compared to other varieties. Further detailed research into amino acids and antioxidant components of rice bran are recommended to create a strong nutritional database for rice bran and its oil derivatives of local varieties.

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