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Effect of Drying Technique and Rice Variety to the Content of Antioxidant, Fiber, and Nutrient Composition of Rice Bran

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Abstact
Rice bran is a natural healthy food, as a source of antioxidants, and dietary fiber. The nutrient components of rice bran is depending upon the rice variety that influence the chemical composition of rice bran. To extend the storage period of rice bran, further processing into flour is one of the alternative products. Differences in rice varieties and drying technique may affect the chemical composition of rice bran. The objective of this research is to evaluate the effect of drying technique to bran flour from several different rice varieties on the capacity of antioxidants, dietary fiber and nutrient composition of rice bran flour. This research exercises two drying techniques such as ordinary oven, and microwave oven to three rice varieties namely, Ciherang, Cigeulis, and Inpari-13. The output showed that using oven microwave for Cigeulis rice variety produced the best quality of rice bran flour with characteristics as follow: antioxidant capacity of 92.13 ppm, the IC 50 at 7.02 mg/mL, the IDF was 30.51%, the SDF was 6.31%, TDF amounting to 36.82%, vitamin E at 2.05 mg/100g, moisture content at 10.54%, ash of 10,19%, protein content of 10.51%, fat content of 16:22% and carbohydrate content of 52.54%. This nutritional characteristics indicate that rice bran flour is one of the best quality and nutritious flour and good for human health.
Keywords: rice bran, flour, drying technique, rice variety.

1. Introduction

Rice is the main staple food for people of Indonesia with consumption per capita about 130 kg per year. Indonesia is also one of the rice producing country or number three in the world after China and India. Data from Indonesia Center Bureau of Statistics (CBS) 2013 showed that dried paddy production in 2013 is about 71,29 million tons or equivalent to 44.91 million tons milled rice or increased about 0.21 million ton (0.31%) compared with production in 2012. Rice bran is one of the byproduct of rice milling activities which is accounted at 8-12% or 10% in average from dried paddy (Widowati, 2001). The production volume of rice bran is positively correlated with milled rice production, if the average 10% is used, then the rice bran production is about 7.13 million tons per year.

Rice bran is mostly utilized for animal feed, while rice bran is one of source of natural healthy food as source of antioxidant (Ramezanzadeh *et al*., 1999 and Iqbal *et al*., 2005). In addition, rice bran as one of rice milling by product is consisted of pericarp, aleuron, embryo, and endosperm (FAO, 1996). Other important nutrient exist in rice bran is food fiber as the main source of calcium (Ca) that accounted at 500-700 mg/100g and magnesium (Mg) between 600-700 mg/100g. Rice bran also contains vitamin B complex, vitamin E, essential fatty acid, and amino acid (Astawan, 2009; Damayanthi *et al*., 2010; and Pasha *et al*., 2002). Nutrient composition in rice bran is vary widely that depend on rice variety, agronomic characteristics, and processing or milling technique (Iqbal *et al*., 2005; Anwar *et al*., 2005; Sampong *et al*., 2010, and Chatha *et al*., 2011).

Rice bran is a source of antioxidants that has important benefits for human health. Several studies in vivo expressed a decline in total cholesterol in rats (Oureshi *et al*., 1991) that were given rice bran as the dietary feed (Most *et al*., 2005). It can also lower blood sugar levels in diabetics people and useful for patients with hepatic impairment (Premakumani et al., 2013, and Sayre *et al*., 2007), as food additives, pharmaceuticals, and cosmetics (Lloyd *et al*., 2000). The results of the research that has been conducted on the dietary fiber content of rice bran showed that this by-product is helpful in reducing the risk of cardiovascular disease, lower blood sugar levels for people with type 2 diabetes, while the benefits of the SDF (*soluble dietary fiber*) is able to reduce the risk of liver cancer (Turner, 2008).

Rice bran that obtained from rice milling process is easily damaged in storage period, thus requiring further treatment to obtain durable rice bran. The research that has been carried out on most of the rice bran is aimed to maintain the quality of bran is mainly by inactivation of lipase enzyme as a cause of rancidity through stabilization of heat for 30 minutes (Thanonkaew *et al*., 2012 and Lloyd *et al*., 2000).

Utilization of rice bran for food products is by further processing bran into flour. Good quality bran flour has a high nutrient content that can be obtained by selecting the appropriate drying technique. According to Sharma (2001) and Figiel (2009), using the oven drying technique has been widely used for drying food products, but to minimize the loss of nutrients and shorten drying time, it's been tried to dry some by product by using a microwave oven on banana (Maskan, 2000), kiwifruit (Maskan, 2001), spinach and radish slices (Orikasa *et al*., 2008).

Correlation of drying technique with rice varieties to produce good quality rice bran flour has not been widely studied. The purpose of this study is to observe the effect of drying technique of rice bran flour from different rice varieties on the capacity of antioxidants, dietary fiber and nutrient composition of rice bran flour. This study uses two techniques of drying that include ordinary oven and microwave oven for rice bran from 3 varieties, namely Ciherang, Cigeulis, and Inpari-13.

2. Materials and Methods

2.1 Materials

Rice bran used is this study is bran of Ciherang, Cigeulis and Inpari-13 rice varieties that were collected from farmers in Tabanan and Jembrana Districts, Bali Province, Indonesia. These three varieties are widely cultivated and favored by farmers as well as rice consumers.

Chemicals used consists of Sulfate acid (H_2SO_4), boric acid (H_3BO_3), HCL 0.02 N, Hexane, Na-phosphate 0.1M, 0.1 ml of the enzyme amylase, enzyme pepsin, enzyme pancreatic, HCL 4M, NaOH, 1.1-diphenyl-2-2 picrylhydrazyl (DPPH), petroleum ether, ascorbic acid, ethanol, alcohol, methanol, potassium hydroxide, α-tocopherol, methyl alcohol, and nitrium. All chemicals used for the analysis was obtained from Merk (Darmstadt, Germany).

The equipment used was oven (Shel Lab-USA brand, type: 1370 FX), Kris microwaves brands with specification: 230V-50Hz, 1400W with a frequency of 2450MHz, and a spectrophotometer Genesys 10S UV-VIS.

2.2 Methods

2.2.1 Sample Preparation

Rice bran was sifted using a 40 mesh sifter to separate dirt carried during milling activities. Bran stabilization was carried out by using steam with a weight of 400 g rice bran per stabilization process. Stabilization carried out for 30 minutes, then cooled at room temperature to eliminate hot steam. Bran which has been cooled that packaged using vacuum packaging and used as a stock sample.

Treatment on bran consisted of two factors such as drying technique and differences in rice varieties. The varieties used are Ciherang, Cigeulis and Inpari-13 by using two technique of drying namely: ordinary ovens and microwaves oven. Weight stabilized rice bran used per treatment was 250 g. Drying by an ordinary oven is performed at temperature of 105^{o}C for about 1 hour, while the microwave oven drying technique were using 20% power of 200 watt for 15 minutes. Dried rice bran is then crushed using a blender and then sifted using a 60 mesh sifter in order to obtain a smooth bran, hereinafter referred to as rice bran flour.

2.2.2 Chemical Analysis

Proximate analysis

Proximate analysis is conducted for moisture content measurement, ash content is measured using oven, protein content using Micro Kjeldahl method, fat content using Soxhlet method, and carbohydrate content is measurement by using *carbohydrate by difference* (Apriyanto , 1989).

Analysis of food fiber

Analysis of the fiber content is using multi enzyme (Asp *et al*, 1983). Analyses were performed using 3 types of enzyme namely: enzyme amylase, enzyme pepsin, and enzyme pancreatin.

Analysis of vitamin E

Analysis of levels of vitamin E is carried out by using HPLC method, 2 g samples were weighed and then saponified with KOH and ethanol and extracted with petroleum ether. The result in the form of concentrated sample is then vaporized in the evaporator, the remaining concentrates were dissolved in 2 ml of methanol. Chromatography using a mobile phase of methanol: water (97: 3) at a flow rate of 1.2 ml/min. Quantitative determination of vitamin E was carried out using a UV spectrophotometer at a wavelength of 295 nm, the column at a temperature of 24^{o}C.

Antioxidant capacity

Test of antioxidant capacity is conducted using DPPH (Blois, 1985). Samples were pipetted using a micropipette as much as 100 mL. Then inserted into the test tube which already contained 3 ml of methanol and divortex. Added 1 ml of DPPH and placed in a dark place at room temperature for 15 minutes. Decrease in absorbance of DPPH was measured using a spectrophotometer at a wavelength of 517 nm. Garllic acid has used as a standard with a concentration equal to the concentration of the sample solution. Value of IC 50 (inhibition concentration) was defined as the concentration of test sample that required to capture 50% of DPPH radicals. IC 50 values were determined by varying the concentration of the sample. IC 50 values calculated from the percentage inhibition of the uptake of various concentrations of the extract using linear regression equation Y = ax + b.

2.2.3 Statistical analysis

Average data observations obtained from 3 replication of each treatment. The data were analyzed by exercising the analysis of variance (ANOVA) using SPSS 16.0. Results of ANOVA were significantly different (p <0.05), followed by Duncan's multiple range test (DMRT).

3. Results and Discussion

3.1 Antioxidant Capacity and IC 50

Results of analysis of variance (ANOVA) showed that the treatment on technique of drying and bran of rice varieties and their interactions significantly affect (p <0.05) the antioxidant capacity of bran flour and IC 50 (Figure 1 and 2). Combination of treatment with microwave oven drying technique of Cigeulis rice bran varieties showed the highest antioxidant activity at 92.13 ppm, while the combination of oven drying technique using rice bran Ciherang had the lowest antioxidant capacity or about 73.38 ppm (Figure 1). Iqbal *et al.* (2005), states that the antioxidant capacity of the bran is strongly influenced by rice varieties, growth area environment, and the quality of the water used for rice farming. Statement of Lloyd *et al.* (2000), about the antioxidant capacity is that, rice grain milling process has a significant effect to the antioxidant content of rice bran, which with the shorter stages of the milling process, the bran antioxidant content will be higher.

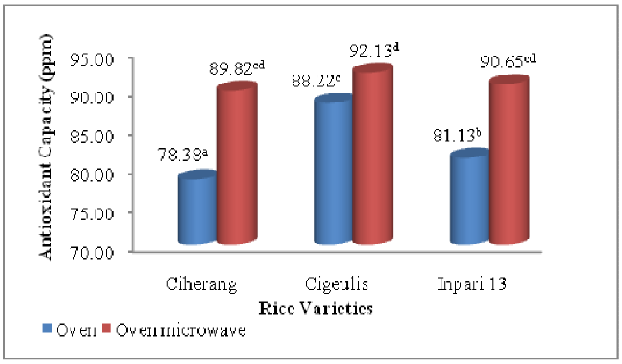


Figure 1. Effect of interaction between rice varieties and oven technique to the antioxidant (ppm). Note: same letter indicates no significant different between treatments (p>0,05)

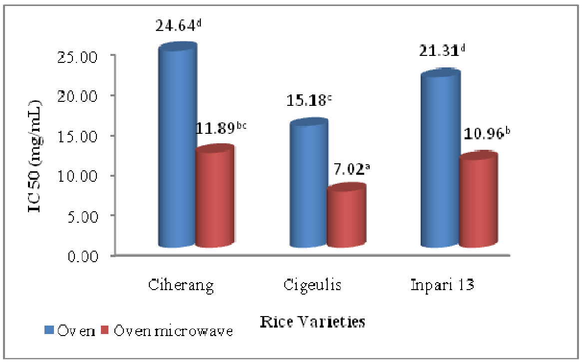


Figure 2. Effect of interaction between rice varieties and oven technique to the IC 50. Note: same letter indicates no significant different between treatments (p>0,05)

Average antioxidant capacity by using microwave drying technique is 89.82 ppm (Ciherang), 92.13 ppm (Cigeulis), and 90.65 ppm (Inpari-13) respectively. Mean while, the antioxidant capacity of rice bran flour using the same technique of drying for Ciherang, Cigeulis, and Inpari-13 rice varieties are about 73.38 ppm, 88.22 ppm, and 81.13 ppm respectively (Figure 1). The difference in antioxidant capacity in two drying techniques is due to gradient temperature for ordinary oven, while the microwave oven heating occurs through a direct interaction between materials and microwave so that energy transfer takes place faster and the quality of the product better (Zhang and Hayward , 2006 and Das *et al*., 2009). The results of the study conducted by Pokorny *et al*. (2005), showed that the use of high heat treatment process can damage the antioxidant compounds. The same thing was reported by Purwanto *et al*. (2010), that the use of high temperature in a microwave oven produces lesser ginger oil extract, due to the evaporation of the substances that are volatile.

Treatment with a combination of rice bran varieties Cigeulis with oven microwave drying technique has the lowest value of IC 50 or about 7.02 mg/mL, while the highest value of IC 50 was 24.64 mg/mL that resulted from rice bran flour of Ciherang variety by using the oven drying technique (Figure 2). This suggested that rice bran flour of Cigeulis varieties that dried using a microwave drying technique has the potential for relatively larger antidote for free-radical. With an average concentration of 7.02 mg/mL have been able to remove free radicals by about 50%.

3.2 The Content of IDF, SDF, and TDF

The results of analysis of variance of rice bran flour with respect to the insoluble dietary fiber (IDF) under treatment of drying technique and rice varieties as well as their interactions is significantly affect the IDF (p <0.05) (see Figure 3). Average IDF starch content of rice bran flour from three rice varieties tested by using oven drying technique is lower than the microwave oven drying. The highest IDF content is obtained at rice bran flour of Cigeulis rice variety by using the oven microwave drying technique or at 30.51%, while the lowest IDF content was obtained at rice bran flour of Ciherang rice variety at about 11.92% by using the oven drying technique.

Results of analysis of variance also showed that the treatment of rice varieties and rice bran flour drying technique also significantly affect ($p < 0.05$) the content of soluble dietary fiber (SDF). The average value of SDF in rice bran flour levels is presented in Figure 4. Combine treatment between rice bran flour from Cigeulis varieties and using microwaves dried technique has the highest SDF content or at 6.31%, while the lowest SDF content of 4.91% was obtained in the combine treatment between Cigeulis rice variety and oven drying technique. This is because of pectin degradation due to the use of high temperatures in the oven drying technique. This statement is in accordance with the results reported by Nyman in 2003 for commodities such as: carrots, green beans, and mungbean that cooked by blanching technique has a lower content of SDF compared to cooking using a microwave oven and similar results in previous studies by Svanberg *et al*. (1997) for mungbean. Results of analysis of variance also showed that the interaction between rice varieties and drying technique significantly ($p < 0.05$) affect the content of dietary fiber (TDF) of rice bran flour. Average TDF content of rice bran flour from rice varieties and drying technique is presented in Figure 5. Combine treatment of Cigeulis variety and microwaves drying technique has the highest TDF content of rice bran flour or at 36.82%, while the combine treatment between Ciherang rice variety and ordinary oven drying technique showed the lowest TDF contains in rice bran flour or at about 17.19%.

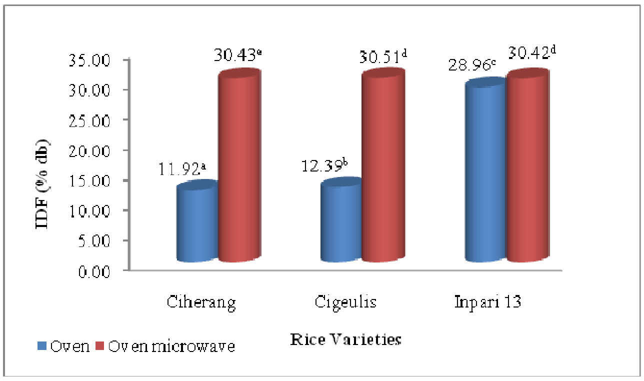


Figure 3. The effect of rice varieties and drying technique to the IDF (% db) content of rice bran flour. Note: same letter indicates no significant different between treatments (p>0,05)

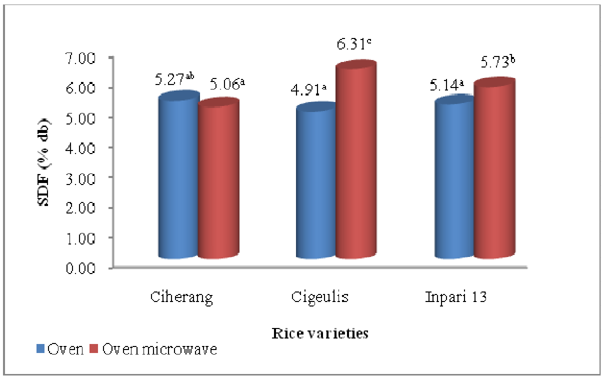


Figure 4. The effect of rice varieties and drying technique to the SDF (% db) content of rice bran flour. Note: same letter indicates no significant different between treatments (p>0,05)

Average content of IDF, SDF, and TDF in the rice bran flour of Cigeulis rice variety using microwave drying technique are 30.51%, 6.31%, and 36.82% respectively. Oven drying technique produces higher heat than the microwave drying technique, it can affect the content of TDF, because the degradation process occurs during the drying activities (Conteras and Gutierrez, 2011). In general, according to Carroll (1990) in Sharif *et al*, (2009), the TDF contains of stabilized rice bran is 25-40%.

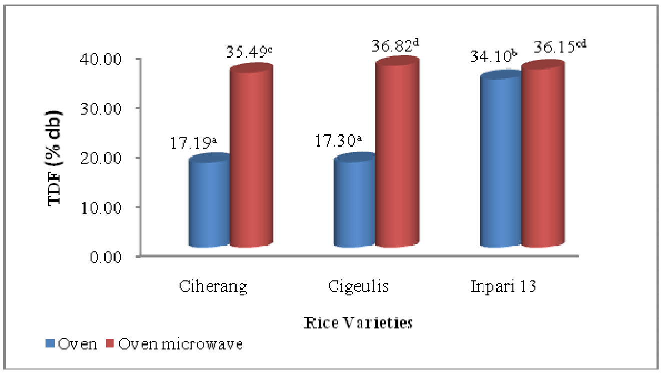


Figure 5. The effect of rice varieties and drying technique to the TDF (% db) content of rice bran flour. Note: same letter indicates no significant different between treatments (p>0,05)

TDF content of rice bran flour in Inpari-13 rice variety using the oven drying technique was 34.10%, higher than the TDF in Cigeulis variety of 17.30% and 17.19% for Ciherang variety (Figure 5). This results suggested that each rice variety has a nutrient content composition that is not the same, and strongly influenced by the growth area environment, the quantity of irrigation water, fertilizers, milling process and storage conditions (Iqbal *et al*., 2005; Anwar *et al*., 2005 ; Sampong *et al*., 2010; Houston, 2000, and Chatha *et al*., 2011). This is consistent with research conducted by Prosky *et al*. (1984), where differences in wheat varieties produce different content of SDF, IDF, and TDF respectively.

3.3 The Content of Vitamin E

Mean while, results of analysis of variance showed that vitamin E of rice bran flour is significantly different (p <0.05) based on drying technique, rice varieties, and their interaction (Figure 6). Drying of rice bran using microwave oven with a power of 20% (200 watt) for 15 minutes was able to maintain vitamin E bran flour content. The average content of vitamin E bran flour using the oven technique of Ciherang variety is about 0.24 mg/100g, Cigeulis varieties and Inpari-13 at about 0.79 mg/100g and 0.48 mg/100g respectively. While the content of vitamin E for using microwave oven drying technique for Ciherang is 0.74 mg/100g, Cigeulis 2.05 mg/100g, and Inpari-13 of about 0.69 mg/100g. The use of high temperature in the drying process has caused a decline in the amount of vitamin E, because vitamin E is very easily oxidized by heat (Morris *et al*., 2004). Similar results were also reported by Hassanein *et al*. (2003); Yoshida and Kajimoto (1989), that heating soybean oil using a microwave oven at high temperature at long time caused a decrease in tocopherol content of soybean oil.

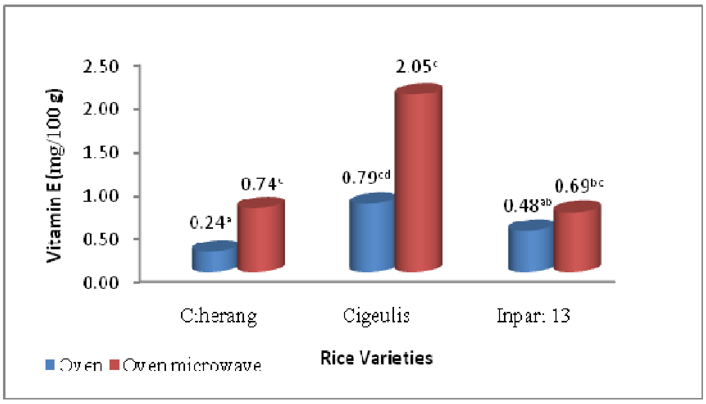


Figure 6. The effect of rice varieties and drying technique to the vitamin E (mg/100g) content of rice bran flour. Note: same letter indicates no significant different between treatments (p>0,05)

3.4 The content of Proximate

3.4.1 Moisture content

Results of analysis of variance showed that rice varieties and rice bran flour drying technique and their interactions is significantly (p <0.05) affect the moisture content of rice bran flour. Rice bran flour that processed by using oven drying resulted in lower moisture content compared to using a microwave oven. By oven drying technique on Ciherang variety rice bran flour has a moisture content of 7.78%, Cigeulis varieties and Inpari-13 at 7.68% and 7.01% respectively (Figure 7). In average, moisture content of Ciherang, Cigeulis, and Inpari-13 using microwave technque is about 9.95%, 10.54%, and 11.55% sequentially.

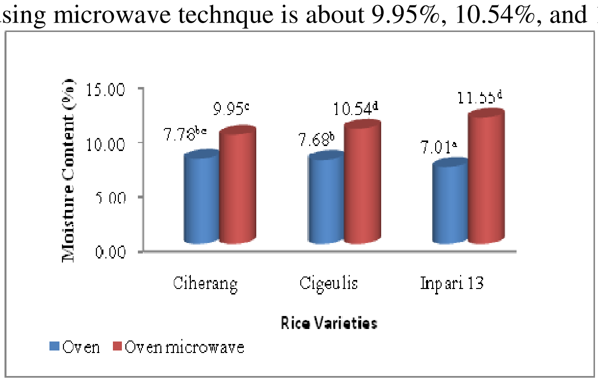


Figure 7. The effect of rice varieties and drying technique to moisture content (%) of rice bran flour. Note: same letter indicates no significant different between treatments (p>0,05)

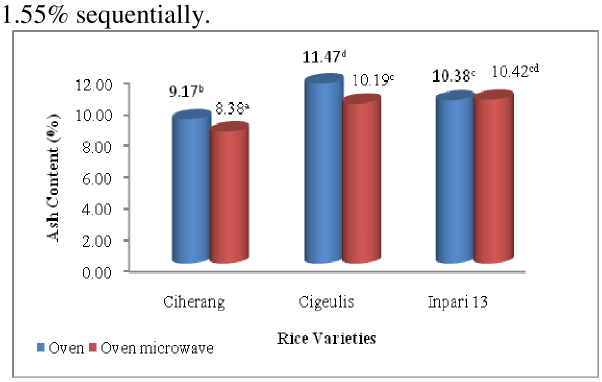


Figure 8. The effect of rice varieties and drying technique to the ash content (%) of rice bran flour. Note: same letter indicates no significant different between treatments (p>0,05)

3.4.2 Ash content

Similarly, results of analysis of variance on rice varieties and rice bran flour drying technique and its interaction is significant affect ($p < 0.05$) the ash content of rice bran flour (Figure 8). Average ash content of bran flour with oven drying technique is higher than the microwave oven technique. Different rice varieties have different ash content, this is due to the local climate, geographic, and environment of growth area (Krishnarao *et al.*, 1991). The lowest ash content is founded in the bran flour using oven drying technique or at about 11.47% (Cigeulis varieties), while Inpari-13 had the highest ash content or at 10.38% by using microwave oven drying technique (Figure 8). Oven drying technique with a high temperature (105°C) for 1 hour has caused a lot of ash components decomposed due to the high heat transfer process (Desrosier, 1988). Microwave drying technique using 20% power (200 watt) for 15 minutes can minimize the decomposition process of ash components due to lower temperature. This is in line with the statement of Kusumawati *et al.* (2012) about the jackfruit seed flour using a drying temperature of 60°C has a higher ash content compared with using 80°C temperature.

3.4.3 Fat content

Results of analysis of variance showed that rice varieties and rice bran flour drying technique significantly ($p < 0.05$) influence fat content of rice bran flour, but not significantly different ($p > 0.05$) on their interaction (Figure 9). Levels of fat bran flour of Ciherang, Cigeulis, and Inpari-13 varieties using oven drying technique are 9.68%, 14.56%, and 10.68% respectively. These fat content are lower than treatment using microwave drying technique with fat content of 11.26% for Ciherang, 16.22% for Cigeulis, and 11.25% for Inpari-13. This condition is due to the use of high temperature at longer time using oven drying technique has caused damage due to hot fat. The fat components split into volatile products, such as aldehydes , ketones, alcohols, acids, and hydrocarbons (Kusumawati *et al.*, 2012).

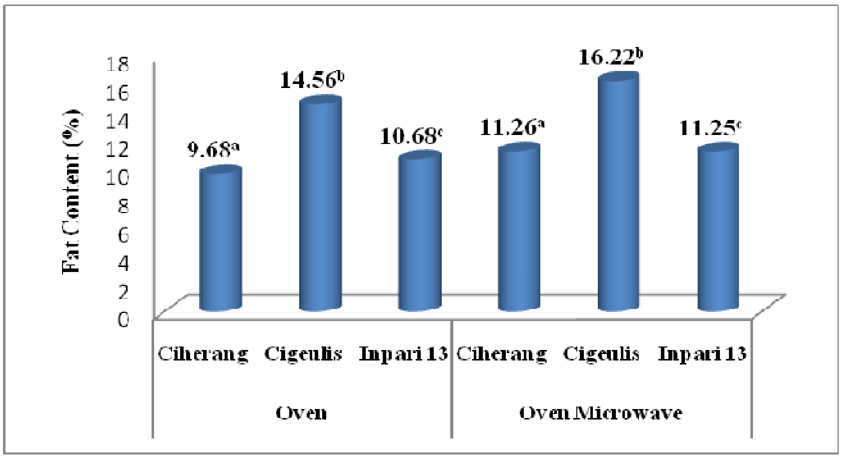
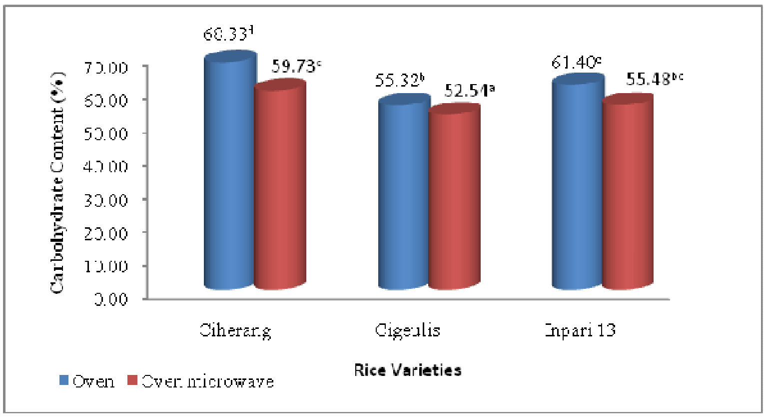


Figure 9. The effect of rice varieties and drying technique to fat content (%) of rice bran flour. Note: same letter indicates no significant different between treatments (p>0,05)

3.4.4 Carbohydrate content

Similarly, results of analysis of variance of rice varieties and rice bran flour drying technique is significantly ($p < 0.05$) affect the levels of carbohydrates content (Figure 10). Average carbohydrate content of rice bran flour using microwave oven drying technique is lower than using oven technique. This is because of the moisture content, ash, protein, and fat content of rice bran flour that dried using microwave technique is higher than using the oven technique. These differences than affect the nutritional composition of rice bran flour, so that each variety of rice bran flour does not has the same nutritional components (Houston, 2000).



Gambar 10. The effect of rice varieties and drying technique to carbohydrate content (%) of rice bran flour. Note: same letter indicates no significant different between treatments (p>0,05)

3.4.5 Protein content

On the other hand, results of analysis of variance of rice varieties and rice bran flour drying technique was not significantly different (p> 0.05) with respect to the protein content of bran flour (Table 1). Treatment of drying technique had no effect on the protein content, because the use of two drying technique can cause damage to proteins (Yu *et al*., 2006).

Table 1. Average protein content (%) of rice bran flour of various rice varieties with different drying technique

Drying Technique	Rice Variety			Average
	Ciherang	Cigeulis	Inpari 13	
Oven	10.33 ± 0.43[a]	10.98 ± 0.61[a]	10.52 ± 0.62[a]	10.61
Oven microwave	10.67 ± 0.25[a]	10.51 ± 0.55[a]	11.31 ± 0.21[a]	10.83
Rata-rata	10.50	10.74	10.91	

Note: same letter indicates no significant different between treatments (p>0,05).

Three rice bran flour that have been tested have shown different nutritional composition. Treatment techniques of oven drying and microwaves drying may affect the nutritional components of rice bran flour, except the protein content. The difference in moisture content, fat, ash, and carbohydrates in each variety tested, strongly influenced by the differences in characteristics of bran, such as texture, color, and aroma (Tao *et al*., 1993).

3.5 Selection of the Best Technique

Decision to determine the best treatment can be exercised by using Effectiveness Index method. The principle of this method is to compare the measured parameters, namely: the antioxidant capacity, IC 50, dietary fiber, vitamin E, moisture content, protein, fat, ash, carbohydrates, and rendement. The best alternative is the one that has the highest total value of product (TNP) (Table 2).

Determination of the best treatment as presented in Table 2 which has the highest total product value (TPV) that is treated using a microwave oven drying technique for Cigeulis rice bran varieties or at 1,570. The results of this best treatment has antioxidant capacity of 92.13 ppm, the IC 50 of about 7.02 mg/mL, IDF of 30.51%, SDF 6.31%, TDF 36.82%, vitamin E 2.05 mg/100g, moisture content 10.54%, 10.19% ash content, protein content of 10.51%, 16:22% of the fat content and carbohydrate content of 52.54%.

Table 2. Determination of the best treatment based on Effectiveness Index indicator for bets quality rice bran flour from different rice varieties and drying technique

Technique	Rice Bran Variety	Total Product Value (TPV)
Oven	Ciherang	0.268
	Cigeulis	1.253
	Inpari 13	0.915
Oven microwave	Ciherang	1.379
	Cigeulis	1.570
	Inpari 13	1.491

4. Conclusion

Antioxidant capacity, content of dietary fiber, and nutrient composition of rice bran flour using microwave oven drying technique is higher than using the oven drying technique. Differences in rice bran varieties produce different antioxidant capacity, fiber content of food, and different nutritional composition. Cigeulis variety for example, has the highest antioxidant capacity, fiber content, and nutritional composition compared with Ciherang and Inpari-13. Proximate content of three rice bran varieties tested had different compositions in accordance to technique of drying such as ovens and microwaves. The results of this analysis showed that this best treatment has antioxidant capacity of 92.13 ppm, the IC 50 for 7.02 mg/mL, the IDF at 30.51%, the SDF 6:31%, TDF 36.82%, vitamin E at 2:05 mg/100 g, moisture content 10:54%, ash content 10,19%, protein content 10:51%, fat content 16:22% and carbohydrate content of 52.54%. The best treatment based on differences in bran variety and drying technique is the use of Cigeulis rice bran varieties with microwave drying technique with total product value (TPV) of 1,570.

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