Indonesian Journal of Agricultural Science 2(1) 2001: 1-5

THE EFFECT OF HEATING ON THE PHYSICOCHEMICAL CHARACTERISTICS OF RICE BRAN OIL

S. Dewi Indrasari[a], Sutrisno Koswara[b], Deddy Muchtadi[b], and L. Mulyati Nagara[b]

[a]*Research Institute for Rice, Jalan Raya Sukamandi 9, Subang 41256, West Java*
[b]*Faculty of Agriculture, Bogor Agricultural University, Jalan Raya Darmaga 122, PO Box 220, Bogor 16002, West Java*

ABSTRACT

Rice bran oil has a potential in lowering blood cholesterol. The oil content extracted from rice bran is influenced by several factors such as raw material and processing methods. This research was conducted to study the effect of heating on the physicochemical characteristics of rice bran oil. The study was carried out at the Food Technology and Nutrition Laboratory and the Biological Science Laboratory of the Inter University Center, Bogor Agricultural University, from February to May 1997. Bran used was from IR64 rice variety obtained from a local milling rice in Tambak Dahan, Binong-Subang, West Java. Rice bran was subjected to different period of heating (0, 15 and 30 minutes) at 121°C by using an autoclave, then the oil was extracted by using hexane solvent followed by a standard processing at room temperature (28-30°C) and 40°C for two hours. The parameters observed were oil content and its quality such as saponification, iodine, acid, peroxide, tiobarbituric acid, and triglyceric acid values as well as oil color. The results showed that oil extracted from rice bran was high, ranging from 9.65 to 11.02%. Heating (sterilizing) of the rice bran for 15 and 30 minutes at 120°C prior to extraction increased the oil content. The quality of rice bran oil extracted met the standard of AOAC.

[*Keywords*: rice; bran; oils; heating; extraction; chemicophysical properties]

INTRODUCTION

Coronary heart disease was ranked first as a cause of death, i.e., about 16.5% of total death incidence in Indonesia (Sumantri, 1994). The disease was presumably associated with nutritional problems, especially consumption of high cholesterol food in daily meals.

Rice bran, account for about 10% of total milling, has not been optimally utilized, although it has a potential in lowering blood cholesterol. Its oil, accounting for 10-13% of rice bran (Lyn and Lawyer, 1966 *in* Ciptadi and Nasution, 1985), has an equal potential as that of the bran. The oil content extracted from rice bran was affected by several factors, such as quality of material (grain uniformity, moisture content, storage) and processing conditions (temperature solvent).

Many researches have reported the effect of rice bran and its oil to the level of cholesterol, both in animal and human. The high dietary fiber content of rice bran was able to reduce the transit time of food in the digestion system and lowering the probability of colon cancer (Slavin and Lampe, 1992). Rukmini and Raghuram (1991) reported that rice bran with full-fat content reduced blood cholesterol and also prevented an increase in blood sugar content. Plasma and liver cholesterol-lowering effects were also observed in hamsters fed diet containing 32 and 48 full-fat rice bran (Kahlon *et al.*, 1990).

In hypercholesterolemic rats, diet containing 5% of rice bran with neutral detergent fiber lowered cholesterol (Ayano *et al.*, 1980). Plasma cholesterol reduction due to rice bran consumption was also reported in monkeys (Nicolosi *et al.*, 1989) and human (Suzuki, 1982; Raghuram *et al.*, 1989; Hegsted *et al.*, 1990). Sharma and Rukmini (1986) reported that the polyunsaturated fatty acid in rice bran oil reduced the total cholesterol content, LDL and VLDL lipoproteins, liver cholesterol, and triglyceride in blood of rats. Polyunsaturated fatty acid content in rice bran oil was as high as 80% (Crust and West, 1933 *in* Ciptadi and Nasution, 1985).

This research was aimed to evaluate the effects of heating and extraction temperatures on the physicochemical characteristics of rice bran oil.

MATERIALS AND METHODS

Rice bran used in this study was that from IR64 rice variety, obtained from a local milling rice in Tambak Dahan, Binong-Subang, West Java. The equipment used for extracting rice bran oil consisted of a water bath with a stirrer, centrifuge, rotary evaporator, glass instrumentation, and a hexane solvent.

The experiment was arranged in factorial design with two factors and two replications. The first factor was heating (sterilization) period of 0, 15, and 30 minutes at 121°C. The second factor was extraction temperature, i.e., room temperature (28-30°C) and 40°C. The procedure of rice bran oil extraction is shown in Fig. 1.

The sterilization or thermal treatment was responsible for stabilizing the rice bran to avoid oil deterioration due to the activity of lipolytic enzyme. This thermal treatment also eliminated the fine problems by increasing the particle size and altering the physical characteristics of the particles with a "crisping" or "hardening" effect for better extractability and filtration (Luh, 1980).

Observations were carried out to determine the physicochemical characteristics of rice bran oil using the saponification value (Apriyantono *et al.*, 1989), acid value, iodine value by Hanus method (Apriyantono *et al.*, 1989), peroxide value, tiobarbituric acid (TBA) value, and fatty acid composition using gas chromatography (Apriyantono *et al.*, 1989). Two steps in analyzing fatty acids using gas chromatography were used namely esterification and sample injection.

Esterification is a method to separate triglyceride in fractions based on the degree of saturation with sodium or potassium methylate in methanol. With this method triglyceride becomes methyl ester and glycerol. During esterification, benzene was used as a sample solvent, because the solvent could dissolve the sample. Benzene is difficult to solve in methanol such as long chain fatty acids. Furthermore, benzene has a high boiling point (80°C) so there is little loose evaporation when esterification reactions occur. The esterification process could be carried out easily in a small capped bottle. The resulting esters usually will be condensed and extracted into carbon disulphides.

A microinjection tool was used to inject the ester methyl soluble in benzene solvent into gas chromatography. To get a better separation, a stabilizing sample that has an evaporate pressure of about 0.1 ton on operation temperature and interaction with the column filler material was needed. The interaction result was a distribution difference from the components of the sample between the two phases and resulted in a separation component becoming a ribbon which was printed in chromatogram form (Fardiaz, 1989).

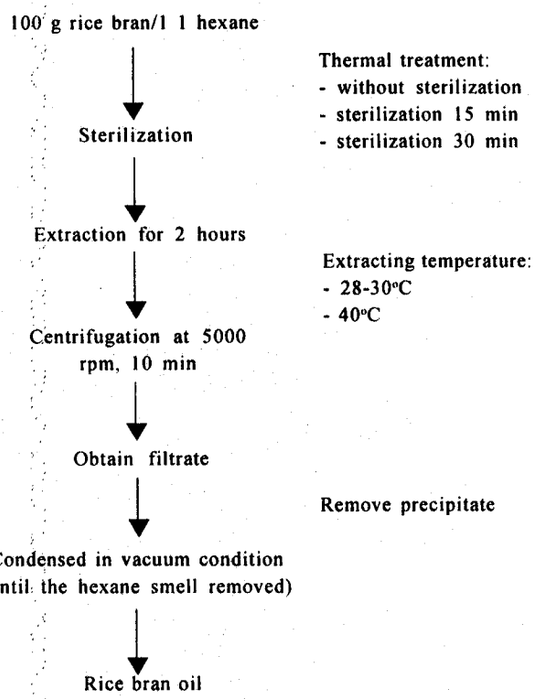

Fig. 1. The procedure of rice bran oil extraction.

RESULTS AND DISCUSSION

Rice Bran Oil Yield

The rice bran oil resulted was a crude oil and had not refined yet. The yield recovery of rice bran oil from extraction process was about 9.65-11.02% (Table 1), which were almost the same with that obtained by Lyn and Lawyer (1966) *in* Ciptadi and Nasution (1985), namely 10-13%. The crude fat content in rice bran was about 15.0-19.7% according to Juliano (1985) and about 12.8-22.6% according to Luh (1980).

The yield recovery of rice bran oil was not yet a maximum. According to Luh (1980), the rice milling condition influenced the yield recovery of rice bran oil. While Soemardi (1975) stated that yield recovery also influenced by rice variety, grain uniformity, moisture content, material mix (soil, purity, foreign matter), and time of material storage.

There was no interaction between extraction temperature and sterilization time. The sterilization treatment indicated that there was a significant difference between time of treatment (Table 1). Bran that was sterilized for 15 and 30 minutes resulted in higher rice bran oil (10.37 and 10.68%) compared to that directly extracted without sterilization (9.76%). The sterilization or thermal treatment eliminated the fine problems by increasing the particle size and altering the physical characteristics of the particles with a "crisping" or "hardening" effect for better extractability and filtration rates (Luh, 1980).

Table 1. The average percentage of rice bran oil yield recovery, 100 g l^{-1} hexane.

Thermal sterilization treatment	Extraction temperature (°C)		Average
	28-30	40	
Without sterilization	9.88	9.65	9.76[b]
Sterilization 121°C, 15 min	10.39	10.35	10.37[a]
Sterilization 121°C, 30 min	11.02	10.34	10.68[a]
Average[1]	10.43	10.11	

[1]Average from two replications
Values followed by the same letter are not significantly different at P = 0.05

Table 3. The physicochemical charateristics of rice bran oil of AOAC standard.

Description	Minimum limit	AOAC
Frozen point (°C)	2	-
Saponification value (mg g^{-1})	179-195	183-194
Refraction index on 20°	61-68	61.7-66.4
Iodine value (g 100 g^{-1})	85-109	99-108
Thiocyanogen value	65-70	68-70
Specific gravity (15/150°C)	0.918-0.928	0.920-0.928
Free fatty acids as oleic (%)	5-80	-
Unsaponifiable matter	4-7	2-5

Source: Williams (1966)

Physicochemical Characteristics of Rice Bran Oil

Saponification value

There was no significant difference between treatments on saponification value of rice bran oil (Table 2). This was due to the low sterilization process and extraction temperature. These did not influence the oil triglyceride. Furthermore, the analysis indicated that the saponification values of rice bran oil, i.e., 160.42-167.86 mg g^{-1} oil, were lower than the quality standard of rice bran oil (Table 3), which was about 179-195 mg g^{-1} oil.

Iodine value

There was no significant difference between treatments on iodine value of rice bran oil, namely about 73.55-77.95 g 100 g^{-1} oil (Table 2). This was caused most probably by the sterilization process and that the bran extraction did not destroy the unsaturated fatty acids contained in the oil. This condition was also reflected by the chromatography gas data indicating that the levels of unsaturated fatty acids (oleic, linoleic, and linolenic) of rice bran oil in a whole room temperature extraction were about 75.24-80.89% . Those unsaturated fatty acid values in a whole were in the range of rice bran oil quality standard namely about 60-94%.

Based on the analysis, the iodine value was lower than that from rice bran oil standard (Table 3) which was about 85-109 g 100 g^{-1}. Therefore, the rice bran oil contained lower unsaturated fatty acid content than that from standard of the AOAC rice bran oil. This could be due to the different process or equipment used.

Acid value

The analysis indicated that the higher extraction temperature and the longer sterilization time of the bran, the higher acid value of rice bran oil (Table 2). Based on the ANOVA test, there was an interaction between extraction temperature and sterilization time (Table 4).

The above phenomena might be caused by the following reason. During the gradual warm (20-30°C) before achieving the expected activation temperature, high temperature may occur on the surface layer through to the inner layer of the rice bran. This resulted in the hydrolysis of oil into glycerol and free fatty acid (FFA). This further caused the sterilized oil

Table 2. The average value of physicochemical characteristics of rice bran oil extracted at 28-30°C and 40°C and sterilized for 0, 15, and 30 min.

Observation variable	28-30°C			40°C		
	0 min	15 min	30 min	0 min	15 min	30 min
Saponification value (mg g^{-1})	164.92 ± 1.57	164.06 ± 1.94	165.75 ± 1.19	163.23 ± 3.97	160.42 ± 4.77	167.86 ± 2.95
Acid value (mg g^{-1})	12.70 ± 0.09	30.67 ± 0.27	22.73 ± 0.12	14.51 ± 0.01	29.87 ± 0.19	23.28 ± 0.19
Iodine value (g 100 g^{-1})	75.20 ± 0.59	75.23 ± 0.56	77.95 ± 1.11	74.35 ± 3.71	73.55 ± 4.44	75.19 ± 0.87
Peroxide value (meq kg^{-1})	9.29 ± 0.01	9.35 ± 1.09	9.12 ± 0.67	9.42 ± 0.41	9.68 ± 0.36	8.83 ± 0.001
TBA value (mg kg^{-1})	0.21 ± 0.08	0.56 ± 0.07	0.69 ± 0.23	0.19 ± 0.03	0.55 ± 0.17	0.26 ± 0.17

The value is the average value ± standard deviation

Table 4. The influence of interaction between extraction temperature (ET) and time of sterilization (TS) on the physicochemical characteristics of rice bran oil.

ET X TS	Acid value (mg g^{-1})	TBA value (mg kg^{-1})
28-30°C, 0 min	12.70 ± 0.09^{f}	0.211 ± 0.08^{b}
28-30°C, 15 min	30.67 ± 0.27^{a}	0.558 ± 0.07^{ab}
28-30°C, 30 min	22.73 ± 0.12^{d}	0.698 ± 0.23^{a}
40°C, 0 min	14.51 ± 0.01^{e}	0.195 ± 0.03^{b}
40°C, 15 min	29.87 ± 0.19^{b}	0.554 ± 0.17^{ab}
40°C, 30 min	23.28 ± 0.19^{c}	0.256 ± 0.17^{b}

Values in the same column followed by the same letters are not significantly different at P = 0.05

to posses a higher acid value in comparison to that without the sterilization process.

The oil acidity could be stated as acid value or the percentage of FFA of the acid value from the oil which is calculated as dominant FFA contained in the acid oil, such as oleic, lauric and palmitic acids. The dominant FFA in the rice bran oil is oleic acid (C18:1) which is about 38.81-42.66 % (Table 5). The range of oleic acid contained is in agreement with the limit of AOAC standard (Table 3).

Peroxide value

Based on the results of ANOVA test, the peroxide value was not influenced by all treatments. The peroxide value ranged from 8.83 to 9.68 meq kg^{-1} oil (Table 2), which was in accordance with the iodine value. The iodine data indicated that the number of unsaturated fatty acids were double-bound and bind to oxygen to form peroxide. Analysis of the iodine value indicated that sterilization treatment did not affect the iodine value. In other words, the sterilization process did not destroy the rice bran oil quality.

TBA value

Based on the results of ANOVA, the longer sterilization time of bran, the higher TBA value (Table 4). The range of TBA was 0.195-0.698 mg kg^{-1} oil (Table 2). This was due to the oxidation of some parts of the oil being caused by heating and increased the malonaldialdehyde compound. Theoretically, malonaldialdehyde compound could occur by forming diperoxide in pentadiena group followed by cutting the molecule chain or by advanced oxydize from two enols resulted from monohydroperoxide disentangling (Ketaren, 1986).

Table 5. Rice bran oil fatty acid identified using gas chromatography, sterilized at 121°C with extraction time of 0, 15, and 30 min (room temperature).

Fatty acid	Component	% of fatty acid after sterilization time		
		0 min	15 min	30 min
Lauric	C12:0	-	0.05	-
Myristic	C14:0	1.58	0.53	0.57
Palmitic	C16:0	17.53	12.03	15.32
Palmitioleic	C16:1	-	0.18	-
Stearic	C18:0	1.83	1.73	1.74
Oleic	C18:1	38.81	42.66	40.87
Linoleic	C18:2	34.88	36.56	36.24
Linolenic	C18:3	1.55	1.67	1.58
Arachidonic	C20:0	0.63	0.65	0.60
Gadoleic	C20:1	0.44	0.75	0.45
Behenic	C22:0	-	0.11	-

- = undetected

Table 6. Rice bran oil fatty acid identified using gas chromatography, sterilized at 121°C with extraction time of 0, 15, and 30 min (40 °C).

Fatty acid	Component	% of fatty acid after sterilization time		
		0 min	15 min	30 min
Miristic	C14:0	0.38	0.50	0.60
Palmitic	C16:0	15.98	13.16	15.83
Palmitioleic	C16:1	0.18	-	-
Stearic	C18:0	1.80	1.72	1.78
Oleic	C18:1	40.88	42.04	39.62
Linoleic	C18:2	35.51	37.56	36.91
Linolenic	C18:3	1.59	1.69	1.57
Arachidonic	C120:0	0.62	0.60	0.60
Gadoleic	C20:1	0.46	0.50	0.43
Behenic	C22:0	0.19	-	-

- = undetected

Fatty acid analysis

The fatty acid composition of rice bran oil sterilized or not is shown in Tables 5 and 6. The major fatty acids of rice bran oil, sterilized or not were almost the same, namely oleic (C18:1) which ranged from 38.81 to 42.66% followed by linoleic (C18:2) at 34.88-37.56%, and palmitic (C16:0) at 12.03-17.53%. Compared with the rice bran oil standard (Table 7), these value were almost the same, namely oleic at about 40-50%, linoleic at 20-42%, and palmitic at 12-18%.

Oil color

The color of sterilized rice bran oil obtained was green, while that unsterilized was yellow brown. The

Table 7. Fatty acid composition of rice bran oil and X-M rice oil.

Fatty acid	Component	Rice bran oil (%)	X-M rice oil (%)
Miristic	C14:0	0.1-1	0.49
Palmitic	C16:0	12-18	13.80
Palmitioleic	C16:1	0.2-0.6	-
Stearic	C18:0	1-3	2.01
Oleic	C18:1	40-50	43.60
Linoleic	C18:2	20-42	36.60
Linolenic	C18:3	0-1	1.77
Arachidonic	C20:0	0-1	0.91

- = undetected

Source: Luh (1980)

green color was due to chlorophyll pigment which was extracted into the oil. Since carotenoid was not stable at high temperature, sterilization caused the yellow color to be destroyed or removed (Ketaren, 1986).

CONCLUSION

The yield recovery of rice bran oil extracted using hexane solvent ranged from 9.65 to 11.02%. Bran that was sterilized for 15 and 30 minutes resulted in higher yield recovery of rice bran oil (10.37 and 10.68%) compared to that without sterilization (9.76%). The sterilization process or thermal treatment did not influence the quality of rice bran oil. The fatty acid composition of rice bran oil was in accordance with the standard of AOAC. Therefore, rice bran oil could be developed further and promoted as an edible oil in Indonesia.

REFERENCES

Apriyantono, A., D. Fardiaz, N.L. Puspitasri, Sedarnawati, dan S. Budiyanto. 1989. Analisis pangan. PAU Pangan dan Gizi, Institut Pertanian Bogor, Bogor. 227 hlm.

Ayano, Y., F. Ohta, Y. Watanabe, and K. Mita. 1980. Dietary fiber fractions in defatted rice bran and their hypocholesterolemic effect in cholesterol-fed rats. J. Nutr. Food (Japanese) 33: 283-291.

Ciptadi, W. dan Z. Nasution. 1985. Dedak padi dan manfaatnya. Jurusan Teknologi Industri Pertanian, Fakultas Teknologi Pertanian, Institut Pertanian Bogor, Bogor. 47 hlm.

Fardiaz, D. 1989. Kromatografi gas dalam analisis pangan. Petunjuk laboratorium. PAU Pangan dan Gizi, Institut Pertanian Bogor, Bogor. 196 hlm.

Hegsted, M., M.M. Windhauser, and S.B. Lester. 1990. Stabilized rice bran and oat bran lower cholesterol in humans. FASEB J. 4: A368 (abs.590).

Juliano, B.O. 1985. Rice: Chemistry and technology. The American Association of Cereal Chemists, Inc. St. Paul, Minnesota. 774 pp.

Kahlon, T.S., R.M. Saunders, F.L. Chow, M.M. Chiu, and A.A. Betschart. 1990. Influence of rice bran, oat bran and wheat bran on cholesterol and triglycerides in hamsters. Cereal Chem. 67: 439-443.

Ketaren, S. 1986. Pengantar teknologi minyak dan lemak pangan. UI Press, Jakarta. 296 hlm.

Luh, B.S. 1980. Rice: Production and utilization. The AVI Publ., Co., Westport, Connecticut. 925 pp.

Nicolosi, R.J., L.M. Ausman, and D.M. Hegsted. 1989. Lipoprotein levels in monkeys fed a diet containing rice oil. Circulation 80: II-86 (abs.).

Raghuram, T.C., U.B. Rao, and C. Rukmini. 1989. Studies on hypolipidemic effects of dietary rice bran oil in human subjects. Nutr. Rep. Int. 39: 889-895.

Rukmini, C. and T.C. Raghuram. 1991. Nutritional and biochemical aspects of the hypolipidemic action of rice bran oil: A review. J. Am. Coll. Nutr. 10: 593.

Sharma, D. and C. Rukmini. 1986. Rice bran oil and hypocholesterolemia in rat. Lipid J. 21(2): 715-717.

Slavin, J.L. and J.W. Lampe. 1992. Health benefit of rice in human nutrition. Cereal Foods World 37(10): 760.

Soemardi. 1975. Pendayagunaan dedak. Prosiding Seminar Teknologi Pangan II. Balai Penelitian Kimia, Departemen Perindustrian, Bogor. hlm. 187-216.

Sumantri, S. 1994. Survai kesehatan rumah tangga 1992. Keragaman dan kecenderungan sebab kematian di Indonesia. *Dalam* M.A. Rifai, A. Nontji, Erwidodo, F. Jalal, D. Fardiaz, and T.S. Fallah (Ed). Risalah Widyakarya Pangan dan Gizi V. LIPI, Jakarta. hlm. 409-420.

Suzuki, M. 1982. Repressive effect of dietary fiber fractions in unpolished rice on the increase in cholesterol and triglyceride. J. Nutr. Food (Japanese) 35: 155-160.

Williams, K.A. 1966. Oil fats and fatty food. J&A Churchill Ltd., London. p. 488.