Lipid Composition of Rice (*Oryza sativa* L.) Bran

J. Hemavathy and **J.V. Prabhakar***
Discipline of Confectionery and Convenience Foods, Central Food Technological Research Institute, Mysore-570013, India

The composition of lipids of bran from three varieties of rice is reported. Lipids extracted amounted to 21.9-23.0% of the bran dry weight and consisted of 88.1-89.2% neutral lipids, 6.3-7.0% glycolipids and 4.5-4.9% phospholipids. Neutral lipids consisted mostly of triacylglycerols (83.0-85.5%), monoacylglycerols (5.9-6.8%) and small amounts of diacylglycerols, sterols and free fatty acids. Three glycolipids and eight phospholipids were separated and characterized. Acylated steryl glucoside and digalactosyldiacylglycerol were the main glycolipids, while monogalactosylmonoacylglycerol was present in small amounts. The major phospholipids were phosphatidylcholine, phosphatidylethanolamine, phosphatidylinositol and phosphatidic acid. Phosphatidylglycerol, lysophosphatidylcholine, lysophosphatidylethanolamine and acyl-phosphatidylethanolamine were present in small quantities.

In recent years, rice (*Oryza sativa* L.) bran has been reckoned as a potential source of edible oil. In India the paddy crop exceeds 90 million tons annually (1), which can yield about 0.66 million tons of oil. The problems associated with production of edible oil from rice bran are being studied (2). Some of the physicochemical characteristics of rice bran lipids and few components of phospholipids and glycolipids (3-10) have been reported. However, systematic study of the contents and composition of individual lipid components, particularly of Indian commercial rice cultivars, has not been reported. In this paper the composition of bran lipids of three varieties of rice has been reported.

EXPERIMENTAL

Materials. Bran from three varieties of rice, Rathnachoodi, Jaya and Madhu, was procured from a local rice mill. Glycolipids, phospholipids and fatty acid methyl esters were purchased from Sigma Chemical Co., St. Louis, Missouri, for use as standards. Solvents used were of analytical grade and distilled before use.

Methods: Lipid classes and fatty acid analysis. Total lipids of bran were extracted (11,12) and purified (13) by established procedures. A measured portion of individual extract was used for estimating total lipids gravimetrically.

The total lipids were fractionated into neutral lipids (NL), glycolipids (GL) and phospholipids (PL) on a silicic acid column (14) with chloroform, acetone and methanol, successively. NL were estimated gravimetrically. GL and PL were quantitated by total sugar estimation (15) and phosphorus estimation (16), respectively. NL were separated by thin layer chromatography (TLC) with hexane/diethyl ether/acetic acid (80:20:1, v/v/v) as the solvent system. Individual components of NL were identified by comparison with the standards and quantified by photodensitometry (17). GL and PL were separated on TLC with chloroform/methanol/acetic acid/water (60:40:10:4, v/v/v/v) as the solvent system. Individual components of GL and PL were identified by comparison with authentic standards and by specific spray reagents (18,19). Quantitation of different components of GL and PL on preparative TLC was effected by estimation of sugar (15) and phosphorus (16), respectively.

Fatty acid methyl esters (FAME) were prepared by acid-catalyzed transmethylation (20) of the lipids. The

TABLE 1

Major Lipid Classes of Rice Bran and Their Fatty acid Composition[a]

Variety	Lipid class[b]	Wt. %	Fatty acid composition (%)								
			12:0	14:0	16:0	16:1	18:0	18:1	18:2	18:3	20:0
Rathnachoodi	TL	22.8	0.4	0.4	21.2	0.3	3.0	41.9	31.1	1.1	0.6
	NL	88.1	0.4	0.4	22.8	-	2.6	40.6	31.9	1.0	0.7
	GL	7.0	0.1	0.1	27.8	2.8	0.2	38.3	30.6	0.1	-
	PL	4.9	0.4	0.1	21.9	1.0	0.2	40.5	35.8	0.1	-
Jaya	TL	21.9	0.1	0.6	25.5	0.2	0.3	37.4	33.2	2.7	-
	NL	89.2	0.2	0.5	26.2	-	0.3	36.1	34.3	2.4	-
	GL	6.3	-	0.1	29.5	1.3	-	35.9	33.0	0.2	-
	PL	4.5	-	0.2	23.0	0.8	-	36.8	39.0	0.2	-
Madhu	TL	23.0	0.4	0.4	22.2	0.3	2.0	39.2	32.9	2.2	0.4
	NL	88.5	0.4	0.4	23.5	-	1.8	37.8	33.7	1.9	0.5
	GL	6.9	0.1	0.1	28.4	2.8	0.1	35.8	32.5	0.2	-
	PL	4.6	0.4	0.1	22.0	1.0	0.1	37.8	38.5	0.1	-

[a]All values are means of three replicate analyses.
[b]TL, Total lipids; NL, neutral lipids; GL, glycolipids; PL, phospholipids.

*To whom correspondence should be addressed.

TABLE 2

Neutral Lipids of Rice Bran and Their Fatty Acid Composition[a]

Variety	Neutral lipid[b]	Wt. %	Fatty acid composition (%) 12:0	14:0	16:0	18:0	18:1	18:2	18:3	20:0
Rathnachoodi	TG	83.0	0.6	0.6	27.2	2.8	50.9	16.0	1.1	0.8
	sn-1,3-DG	1.6	0.1	-	36.9	0.3	39.9	22.5	0.1	0.2
	sn-1,2(2,3)-DG	1.9	-	0.1	27.5	0.1	42.1	30.1	0.1	-
	MG	6.8	-	-	35.0	0.2	38.8	25.8	0.2	-
	FFA	3.7	-	-	33.1	0.1	38.6	28.0	0.2	-
	S,SE+H	3.0	-	-	-	-	-	-	-	-
Jaya	TG	85.5	0.3	0.8	29.9	0.3	48.6	17.3	2.8	-
	sn-1,3-DG	1.8	-	-	37.2	-	38.8	23.7	0.2	-
	sn-1,2(2,3)-DG	2.1	-	0.2	28.3	-	39.3	32.0	0.2	-
	MG	5.9	-	-	36.4	-	38.1	25.1	0.4	-
	FFA	2.4	-	-	34.3	-	34.6	31.0	0.1	-
	S,SE+H	2.3	-	-	-	-	-	-	-	-
Madhu	TG	84.3	0.6	0.6	28.8	2.2	49.1	17.5	2.4	0.7
	sn-1,3-DG	1.7	0.1	-	37.4	0.2	38.0	23.8	0.1	0.4
	sn-1,2(2,3)-DG	2.0	-	0.1	27.6	0.1	40.0	32.1	0.1	-
	MG	6.3	-	-	34.9	0.1	39.0	26.0	0.3	-
	FFA	2.1	-	-	33.9	0.1	35.9	30.0	0.2	-
	S,SE+H	3.1	-	-	-	-	-	-	-	-

[a]All values are means of three replicate analyses.

[b]TG, Triacylglycerols; DG, diacylglycerols; MG, monoacylglycerols; FFA, free fatty acids; S, sterols; SE, sterolesters; H, hydrocarbons.

FAME were analyzed on a Shimadzu GC 9A gas chromatograph equipped with flame ionization detector (FID); stainless steel column (152.4 cm x 3.17 mm) packed with 20% diethyleneglycol succinate on 80-100 mesh Chromsorb W support, at a column temperature of 180 C, the injection port and FID at 210 C, under a nitrogen flow rate of 40 ml/min. The peak area and relative percentage of FAME were obtained with a Shimadzu integrator. The component of each peak was identified on the basis of retention data with those of authentic standards.

RESULTS AND DISCUSSION

Total bran lipids of Rathnachoodi, Jaya and Madhu rice accounted for 21.9 to 23.0% of the bran (dry basis) and consisted of 88.1-89.2% neutral lipids, 6.3-7.0% glycolipids and 4.5-4.9% phospholipids (Table 1). Fatty acid analysis of the TL (Table 1) showed that oleic was the predominant fatty acid, followed by linoleic and palmitic acids in bran from all three varieties of rice. The TL from the Jaya variety contained only 0.3% stearic acid as against 3 and 2% in Rathnachoodi and

TABLE 3

Glycolipids of Rice Bran and Their Fatty Acid Composition[a]

Variety	Glyco-lipid[b]	Wt. %	Fatty acid composition (%) 12:0	14:0	16:0	16:1	18:0	18:1	18:2	18:3
Rathnachoodi	ASG	51.2	0.2	0.1	40.9	2.8	0.4	33.7	21.9	-
	DGDG	42.8	-	0.1	28.2	2.0	-	38.5	30.7	0.5
	MGMG	6.0	-	0.3	36.3	3.0	-	35.3	24.8	0.3
Jaya	ASG	49.1	-	0.1	40.8	1.4	-	34.1	23.6	-
	DGDG	43.9	-	0.1	29.6	1.0	-	34.8	33.5	1.0
	MGMG	7.0	-	0.3	36.0	1.6	-	32.8	28.7	0.6
Madhu	ASG	50.0	0.2	0.1	41.6	2.4	0.2	31.6	23.9	-
	DGDG	44.4	-	0.1	29.7	2.0	-	35.5	32.2	0.5
	MGMG	5.6	-	0.3	36.1	3.0	-	32.2	27.8	0.6

[a]All values are means of three replicate analyses.

[b]ASG, Acylated steryl glucoside; DGDG, digalactosyldiacylglycerol; MGMG, monogalactosyl-monoacylglycerol.

Madhu, respectively. The TL of Rathnachoodi contained 1.1% linolenic acid as against 2.2 and 2.7% in Madhu and Jaya, respectively. Arachidic acid (≤0.6%) was present in Rathnachoodi and Madhu but not in Jaya. Distinct differences between the rice varieties in fatty acid composition were observed for NL, GL and PL. The fatty acid profile of NL reflected largely that of TL. GL and PL fractions had the highest content of palmitic and linoleic acids, respectively, compared to TL and NL. Palmitoleic acid was detected in both GL and PL. Lauric and stearic acids were not detected in GL or in PL of bran from Jaya.

In regard to the neutral lipid fraction, triacylglycerols (TG) were found to be the major component (Table 2). Monoacylglycerols (MG) were the second largest component regardless of the variety of rice, which is unusual for cereal lipids (21) or seed lipids (22,23). The amount of *sn*-1,2 (2,3)-diacylglycerols (DG) was slightly higher than *sn*-1,3-diacylglycerols and was similar to that observed in peanut oil (22). FFA of the lipids ranged from 2.1-3.7%. The fatty acid composition of different components of NL, except hydrocarbons, sterolesters and sterols, is presented in Table 2. Oleic, palmitic and linoleic acids were present in high amounts in different components of NL regardless of the variety. Myristic and arachidic acids were detected in TG and *sn*-1,3-DG. Lauric acid was present in TG and *sn*-1,2 (2,3)-DG. Stearic acid, which was present in all the components of NL Rathnachoodi and Madhu, was found only in TG of Jaya. Linolenic acid was present in the different components of NL regardless of the variety.

The glycolipid fraction was resolved into acylated steryl glucoside (ASG), digalactosyldiacylglycerol (DGDG) and monogalactosylmonoacylglycerol (MGMG) by TLC (Table 3). The major glycolipids were ASG and DGDG, while MGMG was present in small quantity. The fatty acid analysis of these GL (Table 3) showed that MGMG and DGDG contained high proportions of palmitic, oleic and linoleic acids. However, a high level of palmitic acid was present in ASG.

The phospholipid fraction was resolved into eight components by TLC (Table 4). The major phospholipids were phosphatidylcholine (PC), phosphatidylethanolamine (PE), phosphatidylinositol (PI) and phosphatidic acid (PA) in a decreasing order of concentration. Phosphatidylglycerol (PG), lysophosphatidylcholine (LPC) and lysophosphatidylethanolamine (LPE) were present in small quantities. Traces of acylphosphatidylethanolamine (APE) were detected in lipids of all three varieties of bran. Fatty acid composition of individual PL (Table 4) showed that high proportions of palmitic, oleic and linoleic acids were found in all the components of PL. Myristic, lauric, stearic and linolenic acid were present in PC, PE, PI and PA.

TABLE 4

Phospholipids of Rice Bran and Their Fatty Acid Composition[a]

Variety	Phospho-lipid[b]	Wt. %	Fatty acid composition (%)							
			12:0	14:0	16:0	16:1	18:0	18:1	18:2	18:3
Rathnachoodi	PC	35.0	0.3	0.1	25.5	1.2	0.2	35.9	26.7	0.1
	PE	27.2	0.3	0.1	47.1	0.9	0.2	31.2	20.1	0.1
	PI	23.3	0.3	0.1	43.7	0.3	0.2	39.0	16.3	0.1
	PA	9.2	0.9	0.1	30.3	0.6	0.6	46.6	20.4	0.5
	PG	1.8	-	-	29.6	1.0	-	40.5	28.9	-
	LPC	1.5	-	-	38.2	0.1	-	37.2	23.5	-
	LPE	1.4	-	-	45.3	1.0	-	29.1	24.6	-
	APE	0.8	-	-	33.2	0.6	-	33.6	32.6	-
Jaya	PC	38.4	-	0.1	25.8	0.9	-	34.9	29.0	0.2
	PE	29.0	-	0.2	47.6	0.6	-	30.0	21.4	0.2
	PI	21.0	-	0.2	44.5	0.6	-	34.5	20.0	0.2
	PA	7.2	-	0.1	33.3	0.4	-	41.6	24.3	0.3
	PG	1.6	-	-	30.5	0.8	-	36.5	32.2	-
	LPC	1.0	-	-	39.1	0.1	-	33.0	27.0	-
	LPE	1.0	-	-	44.2	0.6	-	29.6	25.4	-
	APE	0.8	-	-	33.2	0.6	-	33.6	32.6	-
Madhu	PC	36.0	0.3	0.1	25.1	1.2	0.1	33.9	29.2	0.1
	PE	27.8	0.3	0.1	47.3	0.9	0.1	30.6	20.6	0.1
	PI	22.0	0.3	0.1	44.0	0.3	0.1	38.6	16.5	0.1
	PA	9.6	0.9	0.1	31.3	0.6	0.3	44.2	22.1	0.5
	PG	1.4	-	-	30.9	1.0	-	37.2	30.9	-
	LPC	1.3	-	-	39.4	0.1	-	33.7	25.8	-
	LPE	1.2	-	-	44.0	0.8	-	28.3	26.9	-
	APE	0.7	-	-	32.7	0.8	-	34.6	31.9	-

[a]All values are means of three replicate analyses.

[b]PC, Phosphatidylcholine; PG, phosphatidylglycerol; PE, phosphatidylethanolamine; LPC, lysophosphatidylcholine; PI, phosphatidylinositol; LPE, lysophosphatidylethanolamine; PA, phosphatidic acid; APE, acylphosphatidylethanolamine.

Palmitoleic acid was present in all the components of phospholipids regardless of the variety.

ACKNOWLEDGMENT

The authors thank Dr. B.L. Amla, director of the Institute, for his interest in this work.

REFERENCES

1. *FAO Production Year Book*, Food and Agricultural Organization of the United Nations, Rome, FAO Statistics No. 55, Vol. 37, 1983.
2. Prabhakar, J.V., and K.V.L. Venkatesh, *J.Am. Oil Chem. Soc. 63*:644 (1986).
3. Mehta, T.N., and P.M. Meshramkar, *Indian Oil Soap J. 26*:18 (1960).
4. Jugay, J.C., and B.O. Juliano, *J.Am. Oil Chem. Soc. 41*:273 (1964).
5. Gaydou, E.M., R. Raonizafinimanana and J.P. Bianchini, *Ibid. 57*:141 (1980).
6. Choudhury, N.H., and B.O. Juliano, *Phytochem. 19*:1385 (1980).
7. Juliano, B.O., *Riso 26*:3 (1977).
8. Fujino, Y., *Cereal Chem. 55*:559 (1978).
9. Fujino, Y., and M. Ohnishi, *Chem. Phys. Lipids 17*:275 (1976).
10. Miyazawa, T., Y. Yoshino and Y. Fujino, *J. Sci. Food Agric. 28*:889 (1977).
11. Nichols, B.W., *Biochem. Biophys. Acta. 70*:417 (1963).
12. Nichols, B.W., in *New Biochemical Separations*, edited by A.T. James and L.T. Morris, Van Nostrand Company Ltd., London, 1964, p. 321.
13. Folch, J., M. Lees and G.H.S. Stanley, *J. Biol. Chem. 226*:497 (1957).
14. Rouser, G., G. Kritchevsky and A. Yamamata, in *Lipid Chromatographic Analysis, Vol. 1.*, edited by G.V. Marinetti, Marcel Dekker Inc., New York, 1967, p. 99.
15. Dubois, M., K.A. Gilles, J.K. Hamilton, P.A. Rebers and F. Smith, *Anal. Chem. 28*:350 (1956).
16. Marinetti, G.V., *J. Lipid Res. 3*:1 (1962).
17. Blank, M.L., J.A. Schmit and O.S. Privett, *J. Am. Oil Chem. Soc. 41*:371 (1964).
18. Rosenberg, A., J. Gouanx and P. Milch, *J. Lipid Res. 7*:733 (1966).
19. Vaskovsky, V.E., and E.V. Kostetsky, *Ibid. 9*:396 (1968).
20. Christie, W.W., in *Lipid Analysis*, Second Edition, Pergamon Press, Oxford, 1982, p. 53.
21. Osagie, A.U., and M. Kates, *Lipids 19*:958 (1984).
22. Sanders, T.H., *J. Am. Oil Chem. Soc. 57*:8 (1980).
23. Wilson, R.F., R.W. Rinne and C.A. Brim, *Ibid. 53*:595 (1976).

[Received September 15, 1986]