Fatty Acid Composition of Indica- and Japonica-Types of Rice Bran and Milled Rice

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Fatty acid compositions of 10 cultivars each of Indica- and Japonica-types of rice bran and milled rice were investigated. The Indica-type, as compared with the Japonica-type, had significantly higher palmitic, stearic, linolenic, and arachidic acid contents and lower linoleic and eicosenoic acid contents in the bran and milled rice, and lower oleic acid content in the bran. The correlation coefficient between oleic and linoleic acid contents of bran and milled rice was negative in the Indica- and Japonica-types and was the highest between all fatty acids. The regression line in the scatter diagrams between oleic and linoleic acid contents of bran and milled rice divided the Indica and Japonica lines.

Until recently, rice bran has been used as livestock feed and fuel. High grade edible oil presently is extracted from fresh raw bran, followed by refining, bleaching, and deodorization. The fatty acids of the oil are the most important constituents from the standpoint of food processing and nutrition. Fatty acid compositions of rice bran oil have been reported by several investigators (1-6). In earlier work, it was shown that the fatty acid compositions of nonglutinous brown rice differed in Indica-type (*Oryza sativa* L. subsp. *indica* Kato) and Japonica-type (*O. sativa* L. subsp. *japonica* Kato) (7). This suggested that the bran also may differ in fatty acid composition, and investigations were undertaken.

EXPERIMENTAL

Rough rice of 10 nonglutinous cultivars each of Indica and Japonica types was collected from a field at the Chiay Agricultural Experiment Station, Taiwan. The seeding and transplanting times were December 13, 1979 and January 29, 1980, respectively. The heading dates are shown in Table 1. Amounts of fertilizer per hectare were as follows: N, 60 kg; P_2O_5, 80 kg; K_2O, 80 kg as basal dressing; N, 30 kg each as twice-top dressings. The rough rice samples were dehulled using conventional seed-cleaning equipment. The brown rice samples were milled with a grain testing mill into bran (true bran plus polish and germ) and milled rice. Table 1 shows the 1000-kernel weight of brown rice and the degree of milling.

ANALYTICAL PROCEDURE

The bran and milled rice samples were ground to pass a 0.5 mm diameter sieve. Oil was extracted from the ground samples with a Butt-type extractor using diethyl ether as the solvent. Fatty acids in the oil were determined by gas chromatography after transesterification to their methyl esters by the boron trifluoride method of the Association of Official Analytical Chemists (8). Esters were separated using a Shimadzu GC-6APF chromatograph equiped with a FID and 3 mm × 3 m glass column packed with Unisol 3000 Uniport C, 80-100 mesh (Gasukurokogyo Co., Ltd.). Column temperature was 240°C, and the carrier gas was

TABLE 1

Heading Date, 1000-Kernel Weight, and Degree of Milling of Indica- and Japonica-Types

Cultivar	Heading date (1980)	1000-kernel wt of brown rice (g)	Degree of milling (g bran/100g brown rice)
Indica-Type			
Tainung-sen No. 12	Apr 23	23.0	7.6
Taichung native No. 1	Apr 25	19.1	7.5
Taichung-sen No. 5	Apr 25	17.8	8.4
Chianung-sen No. 11	Apr 25	18.6	8.6
Kaosen No. 7	Apr 26	20.8	7.6
Chianung-sen-yu No. 14	Apr 26	20.7	8.2
Kaosen No. 2	Apr 29	21.5	8.2
Kaohsiung-sen-yu No. 104	Apr 29	20.3	8.2
Taichung-sen No. 10	May 3	19.5	9.2
Chianung-sen No. 6	May 4	18.4	7.3
Japonica-Type			
Tainan No. 6	May 1	18.4	9.8
Taichung No. 65	May 4	20.7	9.9
Kaohsiung No. 135	May 4	19.6	9.4
Hsinchu No. 56	May 5	19.0	8.9
Hualien No. 18	May 5	20.1	9.5
Tainung No. 61	May 5	21.3	8.9
Taipei No. 309	May 6	21.6	10.2
Chianan No. 8	May 6	19.5	9.9
Taitung No. 27	May 6	19.9	9.1
Taitung No. 28	May 8	21.5	9.9

TABLE 2

Oil Content and Fatty Acid Composition of Indica- and Japonica-Types of Rice Bran and Milled Rice

Cultivar	Oil (% of dry wt)	Fatty acid (wt % of total acids)										
		14:0	16:0	16:1	18:0	18:1	18:2	18:3	20:0	20:1	22:0	24:0
Rice Bran												
Indica-Type												
Tainung-sen No. 12	24.5	0.3	19.1	0.2	2.0	41.8	32.7	1.4	0.8	0.5	0.4	0.7
Taichung native No. 1	25.6	0.2	20.6	0.2	2.2	41.5	31.2	1.5	0.9	0.6	0.4	0.7
Taichung-sen No. 5	21.5	0.2	20.2	0.2	2.3	41.1	32.1	1.5	0.9	0.5	0.4	0.6
Chianung-sen No. 11	25.6	0.2	18.8	0.2	1.9	44.4	30.7	1.3	0.8	0.6	0.4	0.7
Kaosen No. 7	25.8	0.2	18.7	0.2	2.0	44.1	30.9	1.3	0.9	0.5	0.4	0.7
Chianung-sen-yu No. 14	27.9	0.2	20.0	0.2	2.1	44.0	29.7	1.3	0.8	0.6	0.4	0.7
Kaosen No. 2	24.2	0.4	19.7	0.2	2.0	41.9	31.8	1.4	0.9	0.6	0.4	0.7
Kaohsiung-sen-yu No. 104	23.5	0.4	18.8	0.2	2.2	45.2	29.6	1.3	0.8	0.5	0.4	0.7
Taichung-sen No. 10	21.9	0.4	18.3	0.2	2.2	43.1	32.0	1.4	0.8	0.5	0.4	0.8
Chianung-sen No. 6	27.1	0.3	18.8	0.2	1.9	44.8	29.9	1.4	0.9	0.6	0.4	0.8
Mean	24.76	0.28	19.30	0.20	2.08	43.19	31.06	1.38	0.85	0.55	0.40	0.71
SD	2.07	0.09	0.77	0	0.14	1.51	1.09	0.08	0.05	0.05	0	0.06
Japonica-Type												
Tainan No. 6	21.7	0.2	15.5	0.2	1.8	44.9	33.2	1.2	0.8	0.7	0.4	0.9
Taichung No. 65	23.7	0.3	15.5	0.2	1.9	44.8	33.3	1.1	0.8	0.7	0.4	0.8
Kaohsiung No. 135	21.7	0.2	15.6	0.2	2.2	45.9	32.4	1.1	0.8	0.7	0.3	0.7
Hsinchu No. 56	22.5	0.2	16.2	0.2	1.9	46.7	31.0	1.0	0.8	0.7	0.4	0.8
Hualien No. 18	21.2	0.3	15.8	0.2	1.8	44.9	32.9	1.2	0.8	0.7	0.4	0.9
Tainung No. 61	20.4	0.4	15.4	0.2	1.9	48.8	29.3	1.1	0.7	0.8	0.4	0.8
Taipei No. 309	21.8	0.3	16.3	0.2	1.9	43.8	33.6	1.1	0.8	0.7	0.4	0.9
Chianan No. 8	24.3	0.2	16.5	0.2	2.0	44.5	32.9	1.1	0.8	0.7	0.4	0.7
Taitung No. 27	20.8	0.3	16.1	0.2	1.6	43.5	34.9	1.1	0.7	0.6	0.3	0.6
Taitung No. 28	23.5	0.2	15.5	0.2	1.8	44.9	33.9	1.1	0.7	0.6	0.3	0.6
Mean	22.16	0.26	15.84	0.20	1.88	45.27	32.74	1.11	0.77	0.69	0.37	0.77
SD	1.30	0.07	0.40	0	0.15	1.54	1.57	0.06	0.05	0.06	0.05	0.12
Diff between types	**	n.s.	**	n.s.	**	**	*	**	**	**	n.s.	n.s.
Milled Rice												
Indica-Type												
Tainung-sen No. 12	0.62	0.4	18.5	0.2	2.0	42.9	32.2	1.4	0.8	0.5	0.4	0.8
Taichung native No. 1	0.86	0.3	20.6	0.2	2.3	40.9	32.0	1.3	0.9	0.5	0.3	0.7
Taichung-sen No. 5	0.52	0.5	19.3	0.2	2.0	41.5	32.1	1.5	0.9	0.7	0.4	1.0
Chianung-sen No. 11	0.97	0.3	19.1	0.2	2.1	43.5	30.6	1.4	1.0	0.6	0.5	0.8
Kaosen No. 7	0.76	0.4	18.8	0.2	2.2	42.8	31.7	1.2	0.9	0.6	0.4	0.8
Chianung-sen-yu No. 14	0.94	0.2	20.7	0.2	2.4	42.4	30.4	1.1	0.9	0.6	0.4	0.8
Kaosen No. 2	0.72	0.5	19.5	0.2	2.1	41.1	32.5	1.3	1.0	0.6	0.4	0.9
Kaohsiung-sen-yu No. 104	0.78	0.4	18.4	0.2	2.4	46.0	28.7	1.1	0.9	0.5	0.4	0.8
Taichung-sen No. 10	0.65	0.6	18.5	0.2	2.4	41.5	32.5	1.3	0.9	0.7	0.4	1.0
Chianung-sen No. 6	0.76	0.3	17.7	0.2	2.0	45.9	29.9	1.2	0.9	0.6	0.4	0.9
Mean	0.758	0.39	19.11	0.20	2.19	42.85	31.26	1.28	0.91	0.59	0.39	0.85
SD	0.141	0.12	0.96	0	0.17	1.84	1.29	0.13	0.06	0.07	0.03	0.10
Japonica-Type												
Tainan No. 6	0.91	0.3	16.4	0.2	1.7	43.1	34.4	1.0	0.8	0.8	0.4	0.9
Taichung No. 65	0.79	0.4	15.4	0.2	1.8	45.3	33.3	0.9	0.8	0.8	0.4	0.8
Kaohsiung No. 135	0.93	0.4	15.9	0.2	2.1	44.4	33.0	1.2	0.9	0.7	0.4	0.8
Hsinchu No. 56	0.75	0.3	17.1	0.2	1.9	45.2	31.5	1.0	0.8	0.8	0.3	0.8
Hualien No. 18	0.82	0.6	15.7	0.2	1.8	45.1	32.8	1.1	0.8	0.8	0.4	0.8
Tainung No. 61	0.73	0.5	15.4	0.2	1.6	50.4	28.0	1.0	0.8	1.0	0.3	0.9
Taipei No. 309	0.60	0.4	16.9	0.2	2.0	42.3	34.3	1.0	0.8	0.7	0.4	0.9
Chianan No. 8	0.89	0.3	17.2	0.2	1.8	43.7	33.1	0.9	0.8	0.7	0.3	0.8
Taitung No. 27	0.69	0.5	16.4	0.2	1.6	41.7	35.7	1.2	0.7	0.7	0.4	0.9
Taitung No. 28	0.72	0.4	15.6	0.2	1.7	44.0	34.4	1.1	0.7	0.7	0.4	0.8
Mean	0.783	0.41	16.20	0.20	1.80	44.52	33.05	1.04	0.79	0.77	0.37	0.84
SD	0.106	0.10	0.70	0	0.16	2.40	2.12	0.11	0.06	0.09	0.05	0.05
Diff between types	n.s.	n.s.	**	n.s.	**	n.s.	*	**	**	**	n.s.	n.s.

n.s. = not significant. * = sigificant at the 5% level. ** = significant at the 1% level.

nitrogen at a flow rate of 40 ml/min. Compound retention times and areas were recorded automatically, and the results were calculated by means of a Shimadzu Chromatopac C-R2A. Standard methyl ester fatty acid mixtures were separated under identical conditions to identify the compounds and to calculate the response factors of the acids. Moisture content was determined by heating the ground samples for 1 h at 135°C, and oil contents were reported on a dry weight basis.

RESULTS AND DISCUSSION

The oil content and fatty acid composition of the Indica- and Japonica-types of bran and milled rice are shown by means of duplicates in Table 2. Tests in the significant difference between both types for oil and fatty acid contents of bran and milled rice were done by the Student's *t*-test. Results of the tests are also shown in Table 2.

The Indica-type bran, as compared with the Japonica-type, was significantly higher in oil content and palmitic, stearic, linolenic, and arachidic acid contents and lower in oleic, linoleic, and eicosenoic acid contents. The Indica-type/Japonica-type ratios of fatty acids were 1.24 for linolenic acid, 1.22 for palmitic acid, 1.11 for stearic acid, 1.10 for arachidic acid, 0.95 for oleic and linoleic acids, and 0.80 for eicosenoic acid. For the milled rice, the Indica-type was significantly higher in palmitic, stearic, linolenic, and arachidic acid contents and lower in linoleic and eicosenoic acid contents than the Japonica-type. The Indica-type/Japonica-type ratios of fatty acids were 1.23 for linolenic acid, 1.22 for stearic acid, 1.18 for palmitic acid, 1.15 for arachidic acid, 0.95 for linoleic acid, and 0.77 for eicosenoic acid.

As for the oil content, the Indica-type gave significantly higher yields in the bran but showed significantly lower yields in the nonglutinous brown rice of a second crop in Taiwan (7). From the results, the difference in oil content of the bran in Indica- and Japonica-types may be due to the influence of milling rather than a difference between types, for it can be assumed that the Indica-type was higher than the Japonica-type in oil content because of a lower degree of milling or less rice polish in bran.

The fatty acid composition of the bran and milled rice and also the brown rice of the second crop (7) showed significant differences between Indica- and Japonica-types in palmitic, stearic, linoleic, arachidic, and eicosenoic acid contents. The variation of those fatty acids had a similar tendency among the bran, milled rice, and brown rice. In regard to the fatty acid composition of bran, the differences between Indica- and Japonica-types in this study were in accord with the data of one nonglutinous cultivar each of both types by Lugay and Juliano (1) in palmitic, linoleic, linolenic, and arachidic acid contents except stearic and oleic acid contents. On the basis of the results, it is presumed that nonglutinous Indica- and Japonica-types differ in fatty acid composition of bran, milled rice, and brown rice oil, or nonstarch lipids.

Resurreccion and Juliano (2) reported that oils extracted with petroleum ether from bran-polish and milled rice of two cultivars had similar fatty acid compo-

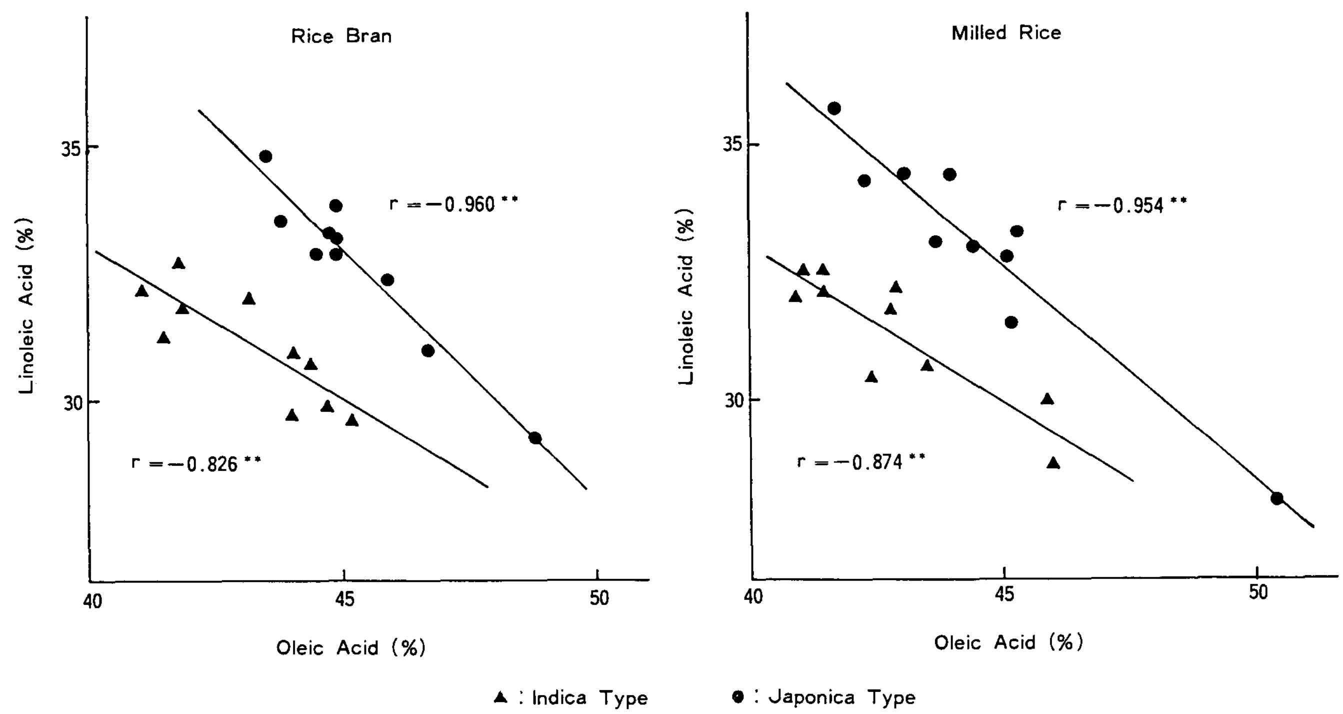

FIG. 1. Relationship between oleic and linoleic acid contents of Indica- and Japonica-types of bran and milled rice.
Bran
Indica-type: y=−0.60x + 56.91 Japonica-type: y=−0.98x + 77.07
Milled rice
Indica-type: y=−0.61x + 57.58 Japonica-type: y=−0.84x + 70.50
**** = significant at the 1% level.**

sitions. From the results in this study, the significant differences between bran and milled rice were recognized in myristic, linolenic, arachidic, and lignoceric acid contents on Indica type and in myristic, palmitic, and eicosenoic acid contents on Japonica-type by analysis of variance for a two-way layout. The bran/milled rice ratios of fatty acids were 1.08 for linolenic acid, 0.93 for arachidic acid, and 0.84 for lignoceric acid, and 0.72 for myristic acid on Indica-type and 0.98 for palmitic acid, 0.90 for eicosenoic acid, and 0.63 for myristic acid on Japonica-type.

As to the relationship between oleic and linoleic acids, or the major fatty acids of bran and milled rice, the correlation coefficient was negative in Indica- and Japonica-types and the highest between all fatty acid contents. Figure 1 shows the relationship between oleic and linoleic acid contents of the bran and milled rice. The regression line in the scatter diagrams could be divided into Indica- and Japonica-type lines as also shown in brown rice (7). From the regression lines of bran and milled rice, it was shown that the Indica-type was lower than the Japonica-type in linoleic acid content in the case of the same oleic acid content between both types.

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