Ambient-Temperature Extraction of Rice Bran Oil with Hexane and Isopropanol

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ABSTRACT: Hexane and isopropanol were compared as solvents for use in ambient-temperature equilibrium extraction of rice bran oil (RBO). Isopropanol was as effective as hexane in extracting RBO when 20 mL of solvent was used to extract 2 g of bran. Free fatty acid levels were 2–3% in both solvents and similar to that previously reported for hexane extraction of RBO hexane extraction by this method. Larger-scale extractions with 30 g of bran and 150 mL of solvent produced oil with a similar free fatty acid content and a phosphorus level of approximately 500 ppm. The oil extracted with isopropanol was significantly more stable to heat-induced oxidation than hexane-extracted oil. Antioxidants that are more easily extracted by isopropanol than hexane may be responsible for the increased stability.

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KEY WORDS: Oil composition, oil quality, oxidative stability.

There is increasing interest in using rice bran oil (RBO) in food systems. However, rice bran has considerable lipase activity, which can increase free fatty acid (FFA) levels of extracted oil (1). Therefore, oil extraction should be done soon after milling (2) to limit FFA formation and to ensure oil quality. Rapid oil extraction decreases the FFA and phospholipid (PL) content of the oil, reduces the oil processing needs, and avoids the removal of natural oil antioxidants (3). Furthermore, subsequent oil processing, such as deodorization, fixes the oil color and makes color removal difficult (2).

Results obtained from soy flour oil extraction may be relevant to RBO processing. A rapid equilibrium extraction method for measuring total soy oil from soy flour by hexane extraction was reported by Sheu (4). A one-minute extraction time removed 98% of the oil (5). One percent less oil was extracted by this technique than by the official American Oil Chemists' Society (AOCS) extraction method (6). Significantly less PL was extracted from soy flour than from soy flakes, which represents an important increase in oil quality (7). Similar results were obtained in a pilot-plant study (8), and the process was patented (7).

The rapid equilibrium hexane extraction method was later applied to RBO extraction (8). A good-quality oil was obtained, with 90% of the RBO being extracted in 1 min and 93% oil after 10 min.

Currently, alternative solvents, such as isopropanol (IPA), are being considered as a vegetable oil extraction solvent to avoid flammability problems associated with hexane (10). The objective of this study was to compare ambient-temperature RBO extraction yields and oxidative stability obtained with hexane and IPA.

MATERIALS AND METHODS

Bran preparation. Rice bran was recovered after dehulling long-grain rice with a Satake Rice Machine (Satake, Tokyo, Japan) and subsequent milling in a McGill No. 2 mill (McGill, Brookshire, TX). Only bran that could pass through a 40-mesh screen was used. The moisture of the rice before milling was 13% as measured by a Motomco Inc. (Paterson, NJ) moisture meter.

Effect of extraction time on yield. The extraction method described by Proctor *et al.* (9) was used, which is an adaptation of Clark and Snyder's technique (5). Fresh rice bran (2 g) was mixed with 20 mL hexane or IPA and mixed with a vortex stirrer for 1, 2, 5, and 10 min. The solvent/oil miscella was centrifuged for 5 min at 1,700 rpm and filtered, and the solvent was evaporated under nitrogen. The amount of extracted oil was then measured gravimetrically. Determinations were made in duplicate, and control oil yield data were obtained by the AOCS Goldfisch extraction method (6). Controls were run simultaneously with ambient-temperature extractions for both hexane and IPA. FFA content was measured by the AOCS method (11) with the modification of Lin (12).

RBO quality. Rice bran (30 g) was mixed with 150 mL solvent for 1 min and centrifuged for 10 min at 35,000 rpm. Analyses of FFA (12) and PL (13) were carried out.

RBO oxidative stability. The oxidative stability of RBO was determined by the method described by Kwon *et al.* (14) by measuring the change in oil weight over time at an elevated temperature. Duplicate 500-mg samples of hexane- and IPA-extracted oil were placed in 10-mL beakers and placed in an oven at 64°C for 32 d. The change in weight of each sample was recorded daily. Results were expressed as weight change per 500 mg of oil.

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RESULTS AND DISCUSSION

Table 1 shows the RBO extraction yield obtained with hexane and IPA extraction. RBO yield by IPA extraction was similar to that of hexane. The amount of oil obtained by a 10-min IPA extraction was comparable to that of its control. IPA extraction was comparable with the 98% of oil extracted by carbon dioxide critical fluid (15).

Alcohols are generally regarded as being poor triglyceride solvents relative to alkanes, but in this study there is little to distinguish hexane and IPA. This may be due to the severe cellular disruption of rice bran during the milling operation, which greatly reduces the barriers to solvent extraction compared to oil-rich particles where cellular structures are intact.

The FFA levels of RBO samples are given in Table 2. FFA data from the different samples are similar and do not differ from previously published data on ambient-temperature hexane RBO extraction (9). To produce a food-grade oil, further processing would be required to reduce FFA levels, which is usual for RBO (2).

FFA and PL levels of hexane- and IPA-extracted oil from a larger-scale extraction are shown in Table 3. Changing the solvent-to-bran ratio did not change FFA levels appreciably; also, there was little difference between PL in the ambient-temperature extractions and that of Goldfisch extracts. The PL levels were considerably higher than reported in a previous study, where a PL content of less than 100 ppm was reported from bran with a moisture content of less than 10% (9). The greater moisture content (13%) may be responsible for the larger amount of extracted PL. Clark and Snyder (5) found that increasing soy flour moisture elevated the PL content extracted at ambient temperature with hexane.

Figure 1 shows the oxidative stability of two IPA-extracted RBO samples relative to that of hexane-extracted oil, as shown by weight increase at 64°C. The hexane-extracted oil shows a classical oxidation curve, with an initial lag phase followed by a weight increase due to peroxide formation from day 7 to 25. The rapid weight reduction after day 25 indicates that the rate of peroxide breakdown and volatile formation

TABLE 1
Oil Yield from 2 g of Rice Bran Extracted with Hexane and Isopropanol[a]

Extraction time (min)	Hexane extracted oil weight (% of bran)	% of Control	Isopropanol extraction oil weight (% bran)	% of Control
1	14.70 ± 0.69a	88.93	14.20 ± 1.45ab	88.17
2	14.43 ± 1.11a	87.27	13.67 ± 0.74b	84.88
5	14.95 ± 0.34a	90.44	16.28 ± 0.02a	101.09
10	15.21 ± 1.44a	92.02	16.28 ± 0.01a	101.12
Control	16.53 ± 0.54a	100	16.10 ± 1.04a	100

[a]Data are the means of duplicate determinations, and numbers with the same letter in each column are not significantly different.

TABLE 2
Free Fatty Acid Levels of Oil Extracted from 30 g of Rice Bran with 150 g of Solvent

Extraction time	Hexane	Isopropanol
1	2.40 ± 0.03	2.40 ± 0.09
2	2.39 ± 0.06	2.46 ± 0.04
5	2.39 ± 0.06	2.30 ± 0.00
10	2.41 ± 0.06	2.58 ± 0.07
Control	1.95 ± 0.32	1.33 ± 0.30

TABLE 3
Free Fatty Acid and Phospholipid Contents of Rice Bran Oil Extracted with Hexane and Isopropanol from 30 g Bran with 150 g of Solvent

	Free fatty acid (%)	Phosphorus (ppm)
Hexane	2.88 ± 0.06	559.79 ± 14.26
Isopropanol	2.74 ± 0.10	549.52 ± 57.57
Control	2.01 ± 0.42	534.46 ± 74.76

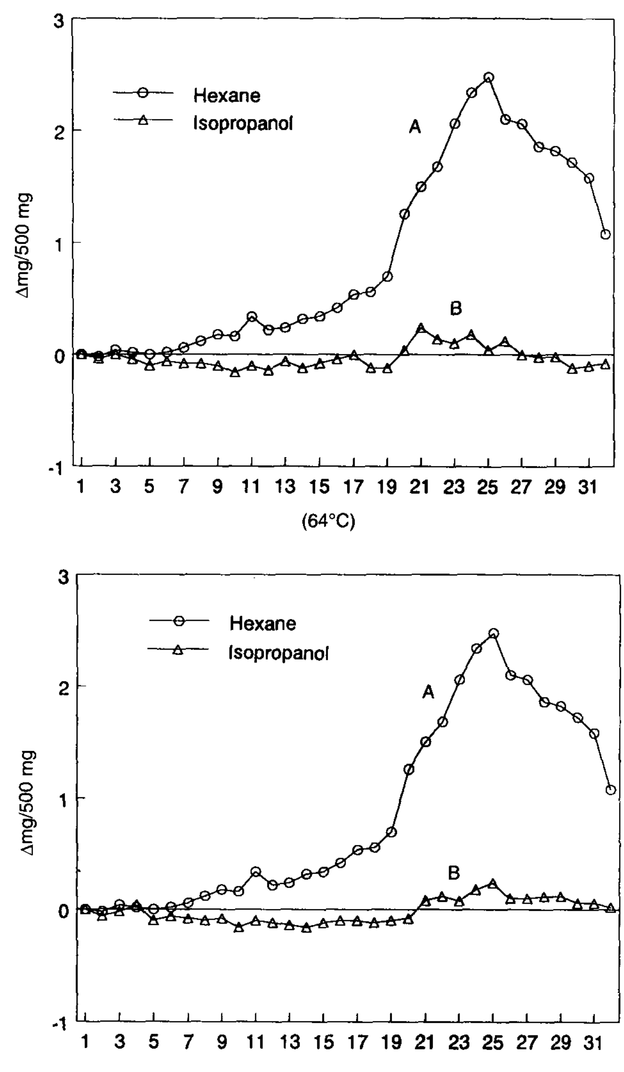

FIG. 1. The weight change of 500-mg samples of isopropanol-extracted oil at 64°C relative to an oil extracted with hexane; ○ = hexane; △ = isopropanol.

exceeds the rate of peroxide formation. In contrast, the IPA-extracted oil shows little weight change during the incubation period. The slight reduction in weight may be due to removal of residual IPA, which may have been H-bonded to oil components. However, there is a small weight increase beginning at day 20, indicating peroxide formation, but it is negligible relative to that obtained with the hexane-extracted oil. IPA-extracted oil seems to be oxidatively more stable than oil obtained by hexane extraction. Perhaps, IPA oil contains antioxidants that are not extracted by hexane. It is improbable that this effect is due to PL because both oils contain similar levels. However, the IPA-extracted oil may contain tocopherols that are contributing to oxidative stability, and these may not be extracted readily by hexane.

REFERENCES

1. Prabhakar, J.V., and V.K.L. Venkatesh, A Simple Method for Stabilization of Rice Bran, *J. Am. Oil Chem. Soc. 63*:644–646 (1986).
2. Young, K.B., G.L. Wailes, and G.L. Cramer, Economic Analysis of Rice Bran Processing and Potential Use in the United States, Arkansas Agricultural Experiment Station Bulletin, Fayetteville, 1994, pp. 15–20.
3. Sleeter, R.T., Effects of Processing on Quality of Soybean Oil, *J. Am. Oil Chem. Soc. 58*:239–247 (1981).
4. Sheu, G., Analysis of Soybean Varieties for Oil and Pigments by a New Rapid Method, Master's Thesis, University of Arkansas, Fayetteville, 1987.
5. Clark, P.K., and H.E. Snyder, Factors Affecting the Rapid Equilibrium Method for Analysis of Total Oil in Soybean Cultivars, *J. Am. Oil Chem. Soc. 66*:1316–1320 (1989).
6. *Official Methods and Recommended Practices of the American Oil Chemists' Society*, edited by D. Firestone, American Oil Chemists' Society, 1985, Method Ba 11–65.
7. Snyder, H.E., K.L. Wiese, G. Sheu, H.G. Brown, C. Nieh, and P.K. Clark, U.S. Patent 5,085,808 (1992).
8. Nieh, C.D., and H.E. Snyder, Solvent Extraction of Oil from Soybean Flour—Pilot Plant and Two Solvent Extractions, *J. Am. Oil Chem. Soc. 68*:250–253 (1991).
9. Proctor, A., V.M. Jackson, M. Scott, and P.K. Clark, Rapid Equilibrium Extraction of Rice Bran Oil at Ambient Temperature, *Ibid. 71*:1295–1296 (1995).
10. Lusas, E.W., L.R. Watkins, S.S. Koseoglu, K.C. Rhee, E. Hernandez, M.N. Riaz, W.H. Johnson, and S.C. Doty, New Isopropanol System Shows Promise, *INFORM 5*:1245–1253 (1994).
11. *Official Methods and Recommended Practices of the American Oil Chemists' Society*, edited by D. Firestone, American Oil Chemists' Society, 1985, Method Ac 5–41.
12. Lin, S.C., Removal of Free Fatty Acids from a Crude Soybean Oil Miscella by Adsorption on Alumina, Master's Thesis, University of Arkansas, Fayetteville, 1987.
13. Bartlett, G.R., Phosphorus Assay in Column Chromatography, *J. Biol. Chem. 234*:446–468 (1959).
14. Kwon, T.W., H.E. Snyder, and H.G. Brown, Oxidative Stability of Soybean Oil at Different Stages of Refining, *J. Am. Oil Chem. Soc. 61*:1843–1846 (1984).
15. Ramsey, M.E., J.T. Hsu, R.A. Novak, and W.J. Reightler, Processing Rice Bran by Supercritical Fluid Extraction, *Food Tech. 45*:98–104 (1991).

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