A Simple Chemical Method for Stabilization of Rice Bran

J.V. Prabhakar* and **K.V.L. Venkatesh**
Confectionery and Convenience Foods, Central Food Technological Research Institute, Mysore - 570 013, India

A new simple chemical method for stabilization of rice bran is described. The process, based on the principle that lipase activity will be low at low pH, uses hydrochloric acid at 40 l/ton of bran for lowering the pH of rice bran from 6.9–6.0 to 4.0. The acid can be applied easily by sprinkling or spraying. The operation on small lots can be done by hand mixing of bran, but it is more efficient and effective if mechanical mixing, like a rotary or a trough mixer, is used. This simple method, which takes less than 4 min for a batch of 15 kg, will be useful for stabilization of rice bran in rice mills or where steam or electricity is unavailable. The process is being evaluated in commercial trials.

The rice grain contains 2–3% fat, most of which is concentrated in the embryo or germ and in the outer seed layers (1,2). Milling of rice separates the germ and bran layers from the endosperm and concentrates the fat in the residue commonly known as "bran," which contains 10–26% oil (3,4). Although rice bran has considerable potential as a contributor to world oil supply (Table 1), it is seldom considered in the list of edible oil raw material sources. In certain countries, among them Japan and Burma, rice bran oil already contributes significantly to the edible oil supply. In other countries, for example, India, production of rice bran oil has been increasing steadily. Industrial grade oil in India increased from 21,000 tons in 1970–71 to 161,000 tons in 1984–85, and edible grade oil from 2,500 tons in 1978–79 to 15,800 tons in 1984–85. Several problems of raw bran management have restricted production of edible grade rice bran oil. One of the problems is high lipase activity in the bran, which quickly hydrolyzes the oil into fatty acids.

Several studies have been conducted on stabilization of rice bran, using dry or moist heat treatment (5,6). However, difficulties have been experienced in commercial applications of these methods in countries like India. Other attempts to stabilize rice bran, by methods like gamma irradiation (7), low temperature storage (7,8), or chemicals (5,7), generally have not been successful. A new simple chemical method for stabilization of rice bran (based on the principle of reducing lipase activity by lowering the pH of the bran) was developed in this laboratory and reported earlier in our annual report (9) and Newsletter (10). Details of the process are described in this paper.

MATERIALS AND METHODS

Freshly milled raw rice bran, containing an average of 15% oil, was obtained from a local rice mill. Commercial hydrochloric acid (28–30% strength) was used for acid treatment.

Acid treatment. Hand mixing: Rice bran was spread in a layer about 5 cm thick and the required amount of hydrochloric acid was sprinkled on and mixed well by hand using protective gloves.

Treatment in a rotary mixer: A rotary drum (concrete mixer type) with a capacity of about 20 kg of bran per batch was used. The drum was filled to half its volume with bran, and the angle of the drum adjusted so its axis was about 10 degrees from the horizontal. The mixer was turned on and the required quantity of hydrochloric acid (40 l/ton of bran) was sprayed on the tumbling bran with an all-glass atomizer, of the type usually used for spraying chromatogram. About 1 min was required for spraying 800 ml of acid. Total time for loading the mixer, spraying the acid and discharge of the bran was about 4 min. The treated bran was bagged in jute sacks and stored at ambient temperature (25–30 C), humidity 50–65%.

Treatment in trough mixer: Two trough batch mixers with bran-holding capacities of 15 and 75 kg were used. Mixers were filled with rice bran and the lids closed, leaving a 2–3-cm wide longitudinal slit open. The calculated quantity of hydrochloric acid was sprayed by moving the atomizer to and fro continuously along the longitudinal slit with the mixer running. Treated bran was discharged and stored in jute sacks.

Analytical methods: Oil content of rice bran and free fatty acid content of extracted oil were determined using AOCS methods (11). The pH was determined on an aqueous suspension of the bran (10 g/100 ml) using an Elico pH meter. Color of the bran was determined as Tintometer units using a Lovibond Tintometer and reflected light.

RESULTS AND DISCUSSION

Rice bran lipase is known to have a pH optimum of 7.5–8.0 (12), with activity declining with either an increase or decrease in pH (Fig. 1). Although the purified enzyme is reported to have little activity at pH 4.5 (12), the en-

TABLE 1

Estimated Potential of Rice Bran Oil in Major Rice Growing Countries

Country	Paddy[a]	Rice[b]	Rice bran[c]	Rice bran oil potential[d]
China	155,111	103,397	8,271.0	1,240.8
India[e]	89,579	59,800	4,784.0	717.6
Indonesia	34,104	22,736	1,818.9	272.8
Bangladesh	21,000	14,000	1,120.0	168.0
Thailand	17,500	11,667	933.4	140.0
Burma	14,000	9,333	746.6	112.0
Vietnam	13,780	9,187	735.0	110.3
Japan	12,838	8,559	684.7	102.7
Philippines	8,346	5,564	445.1	66.8
World	411,897	274,598	21,967.8	3,295.2

All figures are ×1,000 tons.
[a]FAO production year book, 1982.
[b]Estimated at .666 of paddy.
[c]Calculated as 8% of rice.
[d]Calculated as 15% yield of oil.
[e]1983–84 production.

*To whom correspondence should be addressed.

zyme showed considerable activity in its native state in the bran. The pH of rice bran had to be lowered to 4.0 to achieve a commercially acceptable low level of enzyme activity. The pH of commercial rice bran varies from 6.0 to 6.9, and about 4 ml of concentrated hydrochloric acid (28–30% strength) was required for 100 g of rice bran (or 40 l/ton of bran) to lower the pH to 4.0 (Fig. 2). In all the experiments on acid stabilization of rice bran, a minimum of 40 ml of concentrated hydrochloric acid per kg of bran was used.

Data in Table 2 show the efficacy of hand mixing of hydrochloric acid with rice bran in controlling its lipase activity as measured by increase in the free fatty acid (FFA) content of the bran oil. FFA content of oil from untreated raw bran increased rapidly to 47.5% after 30 days of storage, but the increase was much slower, from 3.0 to 9.3%, after 51 days storage in the hydrochloric acid treated bran. The observed increase in FFA from 3.0 to 9.3% probably resulted from nonuniformity in distribution of hydrochloric acid in the bran mass, with some pockets of bran remaining at higher pH. This was evident from variations of up to one pH unit among different portions of the treated bran. Increasing the quantity of hydrochloric acid from 40 ml/kg to 50 ml/kg of bran did not further improve (FFA increased from 3.0 to 7.4 in 51 days) the efficacy of the process.

Acid stabilization of bran was improved by constantly agitating the bran and spraying the acid instead of sprinkling it. Typical data collected on a batch of 20 kg bran treated with acid in a rotary mixer is shown in Table 3. Uniform mixing of bran with acid resulted in low variations in pH between different portions of the bran mass, and the lipase activity was well controlled with the FFA increasing by as little as 2.0% in a period of 59 days. Mixing of bran was effective in both small (FFA increased from 3.3 to 5.6 in 35 days) and large (FFA increased from 4.1 to 5.8 in 27 days) trough mixers.

Acid treatment of the bran resulted in a slight increase in the red and yellow Tintometer color units, but this slight darkening was similar to that observed in steam stabilization of bran (Table 4). Acid stabilized bran is not easily infested. In well designed experiments Narasimhan et al. (personal communication) introduced 30 adult insects of *Tribolium castaneum* into acid stabilized, heat stabilized and untreated bran (100 g each). Rapid proliferation of insects was observed within a month in heat

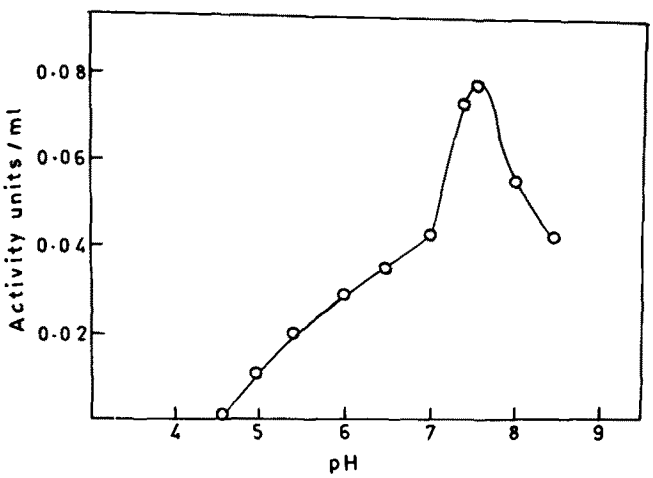

FIG. 1. Effect of pH on lipase activity (12).

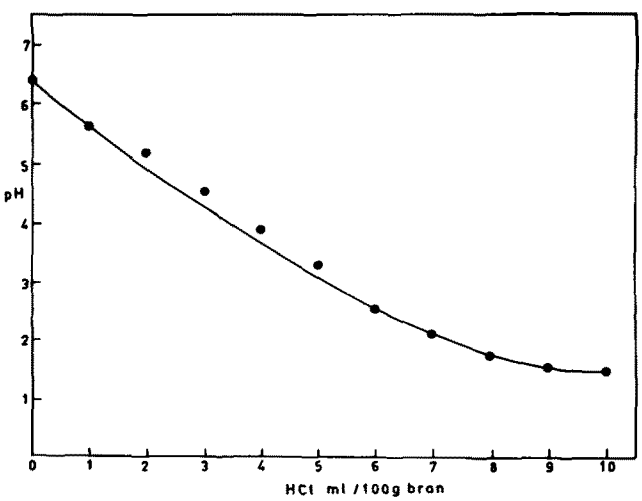

FIG. 2. Change in pH of bran on addition of hydrochloric acid.

TABLE 2

Efficacy of Hand Mixing of Hydrochloric Acid for Stabilization of Rice Bran

Period (days)	Control pH	Control FFA g oleic acid/100 g oil	Treated with HCl @ 40 ml/kg bran pH	Treated with HCl @ 40 ml/kg bran FFA g oleic acid/100 g oil
0	6.9	2.3	4.1	3.0
3	6.9	10.2	4.3	4.7
7	6.8	17.5	4.3	5.3
14	6.5	28.3	4.2	6.3
31	6.5	47.5	4.3	8.3
51			4.1	9.3

Batch size, 5 kg.

TABLE 3

Efficacy of Rotary Mixer for Stabilization of Rice Bran Using Hydrochloric Acid

Period (days)	Control pH	Control FFA g oleic acid/100 g oil	Treated with HCl @ 40 ml/kg bran pH	Treated with HCl @ 40 ml/kg bran FFA g oleic acid/100 g oil
0	6.1	6.2	3.3,3.5,3.4, 3.6,3.3[a]	6.7
11	6.1	27.9	3.5	8.1
31	5.7	75.0	3.7	8.4
45	5.5	78.2	3.3	8.3
59	5.5	76.6	3.7	8.8

Batch size, 20 kg.

[a]Variation between replicates drawn from the bran mass.

TABLE 4

Effect of Acid Treatment on Color of Rice Bran

Bran		Tintometer units		
		Red	Yellow	Blue
Raw control	1	1.6	3.5	0.2
	2	2.4	3.6	1.0
Acid stabilized	1	3.3	5.6	0.9
	2	4.0	6.1	2.0
Steam stabilized		3.4	6.1	1.5

TABLE 5

Effect of Acid Stabilization on Extractability of Oil from Rice Bran

Hexane added to column ml	Raw bran		Acid stabilized bran	
	Eluate ml	Oil in eluate g	Eluate ml	Oil in eluate g
500	Nil	—	Nil	—
1000	520	72	700	99
1500	550	25	515	9
Total oil		97		108

500 g bran packed identically in 5 cm dia. glass columns.

stabilized (1300 larvae) and untreated (2200 larvae) bran. The bran turned dark and moldy after about two months. The acid-treated bran, on the other hand, had only 100/150 larvae and showed no visible mold growth after two months of storage.

Acid stabilization appears to facilitate extraction of the crude oil. A known volume of hexane percolated through identically filled columns of bran extracted more oil from acid stabilized bran than from the untreated bran (Table 5).

Feed quality of bran does not appear to be affected by the acid treatment. Haleem et al. (personal communication) assessed the feed quality of acid stabilized bran for poultry, using 264 layers over a period of one year at 20, 30 and 40% levels of bran in the composite diet. They found no statistically significant difference among acid stabilized, heat stabilized and untreated brans with regard to feed consumption, egg weight, albumin and yolk indices, shell thickness and Haugh units. However, at all three levels of bran in the diet, the layers fed acid stabilized bran always recorded less feed consumption per egg (137.6 g/egg) compared to heat stabilized (168.0 g/egg) or untreated (150.0 g/egg) brans. Also, the number of hen house eggs was always higher for the acid stabilized bran fed group (6,410 in 13 weeks, mean wt 58.8 ± 0.95) compared to heat stabilized (6,167, mean wt 58.8 ± 0.95) or untreated (6,109, mean wt 57.5 ± 0.95) brans.

This simple chemical method for stabilization of rice bran might provide an answer to the problems of handling raw bran in developing countries (like India) with numerous small rice mills which lack adequate steam and electricity, and where stabilization of rice bran using heat is expensive. The acid stabilization process has other advantages, as well. The required equipment is simply a 15-kg capacity trough mixer (with 1 HP motor), costing only about $500. The process is quick, and a trough mixer of 15-kg capacity can handle about two tons of bran in eight hr, which is adequate for most small and medium rice mills. The cost for stabilizing one ton of bran is about $2.60 (acid, $1.20; power, $0.10; labor, $0.80; depreciation on machinery, $0.20, and interest on capital, $0.30). After treatment, the bran can be transferred directly to sacks without further operations like cooling, which is necessary for heat stabilized bran. The process is undergoing commercial trials.

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