# Properties of Pressure-Parboiled Rice as Affected by Variety

K. R. UNNIKRISHNAN and K. R. BHATTACHARYA[1]

Cereal Chem. 64(4):321–323

**ABSTRACT**

Five varieties of low- to high-amylose rice were parboiled by normal (full soaking, steam) and pressure-parboiling (partial or no soaking, pressure steam) methods. The hardness of cooked rice increased from mild, normally parboiled rice to severely pressure-parboiled rice, but the values sharply decreased from high- to low-amylose rice in each processing method. As a result, pressure-parboiled rice prepared from a low- or intermediate-amylose type was not very hard. Its rather long cooking time remained unaffected, however. Pressure parboiling appeared to be especially suited for parboil-canning processing.

Parboiling of rice is an important industry in India and the surrounding countries of South Asia, for about half the rice produced in this region is consumed as parboiled rice (Bhattacharya 1985). Parboiling is normally done by soaking paddy to saturation (about 30% moisture, wet basis [wb]), draining, and steaming under atmospheric or elevated pressure, after which it is dried and milled. Recently a new process of parboiling was developed at the Paddy Processing Research Centre at Tiruvarur in Tamil Nadu State, India (Iengar et al 1972, 1974a,b). In this process, paddy is only partially soaked, or even just washed, and then gelatinized by steaming under high pressure. The process has been called "pressure parboiling," which is somewhat unfortunate, for it causes confusion with normal parboiling (i.e., after soaking paddy to saturation) by steaming under pressure as is done in many modern processes (Bhattacharya 1985). It would better have been called "low-moisture parboiling," for that is precisely its distinguishing feature. In any case, the process has some outstanding technological advantages, for having largely dispensed with the soaking step, the plant turnover is greatly increased, and the time and cost of drying are greatly reduced. Nevertheless, the process has not been popular, for the pressure-parboiled rice takes a long time to cook, and the cooked rice is very hard; in fact the rice has been nick-named "iron rice" (Ali and Bhattacharya 1982).

In our study on effect of varietal difference on properties of parboiled rice (Unnikrishnan and Bhattacharya 1987), we found that the initial varietal differences in eating quality of rice were largely retained even after parboiling. In other words, although parboiling hardened the rice in general, inherently hard-cooking rice hardened more and soft-cooking rice hardened less after parboiling. This suggested that if inherently soft-cooking rice was subjected to pressure parboiling, the product might not be so unacceptable to consumers. This possibility prompted the present study.

[1] Discipline of Grain Science and Technology, Central Food Technological Research Institute, Mysore, India.

## MATERIALS AND METHODS

Five varieties of paddy belonging to different quality types were procured from the University of Agricultural Sciences, Agricultural Research Station at Nagenahalli. The paddy was air-dried (11–12% moisture), cleaned, fumigated, and stored in metal containers for six months in the laboratory at ambient temperature and then in the cold room (4–6° C) until use.

Rice was parboiled by normal soaking and steaming methods to produce mild (MPB) and severely (SPB) parboiled rice; the steaming was done under 0 and 1 kg/cm$^2$ gauge pressure for 10 min, respectively (Unnikrishnan and Bhattacharya 1987). Samples were pressure parboiled (PPB) under three conditions (Ali and Bhattacharya 1982): PPB1 was made by just washing the paddy with water (moisture content 16.5–17.5%, wb) and then steaming under 2.5 kg/cm$^2$ gauge pressure for 15 min; PPB2 and PPB3 were made by directly steaming the original paddy (11–12% moisture) under 3 kg/cm$^2$ gauge pressure for 15 and 30 min, respectively. PPB1 and PPB3 had no white belly (ungelatinized opaque core), but PPB2 had about 20% of the grain area covered by white belly. All parboiled paddy was air-dried, then milled with McGill laboratory equipment to about 8% degree of milling; the small amount of broken rice was separated and discarded.

Total and hot-water-insoluble amylose were determined in raw rice (Unnikrishnan and Bhattacharya 1987). Water uptake by rice when cooked at 96° C for 1 hr ($W_{96}$) was determined as described previously (Ali and Bhattacharya 1972). Solids loss after parboil-canning processing was measured by the basic method of Webb and Adair (1970), and texture of cooked rice was measured in terms of firmness (F) and elastic recovery (ER) using the Chopin-INRA viscoelastograph (Laignelet and Feillet 1979, Unnikrishnan and Bhattacharya 1987). As all the rice varieties had rather similar milled-grain weights (21.4, 19.1, 16.1, 17.2, and 17.7 mg per grain, respectively, for the varieties in Table I in the order listed), three cooked grains were used for the texture test in all cases.

## RESULTS AND DISCUSSION

The results are presented in Table I. The varieties were assigned quality types based on their total and insoluble amylose contents (Bhattacharya et al 1982).

The hardness of cooked rice increased in each variety, as expected, from MPB to PPB3. However, the most striking result was that the hardness values progressively decreased from type I to type VII rice not only in raw and normal parboiled rice but in pressure-parboiled rice also. In other words, the effect of parboiling in relation to varietal difference seen earlier (Unnikrishnan and Bhattacharya 1987) is maintained even in pressure parboiling, so that pressure parboiling of lower-amylose rice did not yield as hard a cooked rice as that of high-amylose rice. Clearly, the former would be more acceptable to consumers than the latter. For example, persons used to Jaya MPB or SPB would probably not object to S317 PPB1 or PPB2 or to Abor red PPB. Similarly, persons used to S317 SPB would likely accept Sukanandi PPB1. Quality type II rice, which is as popular as type III rice in India (Bhattacharya et al 1980), was unfortunately not included in this study; but looking at the data it would seem that people used to type II MPB or SPB rice might well accept PPB rice from type V or VI. These conclusions are of profound practical significance, for they show that by selecting appropriate varieties for processing, pressure parboiling with its striking technological advantages might yet be revived.

Such varietal selection would not reduce the rather long time needed to cook the rice, however. The cooking times of the samples were not determined, but were indicated by their water uptake values after cooking for 1 hr ($W_{96}$). The lower the $W_{96}$ value, the longer the cooking time and vice versa, for on full cooking, all rice absorbs about 2.5 g of water per gram of rice (Bhattacharya and Sowbhagya 1971). The $W_{96}$ values in Table I progressively decreased in each variety with increasing severity of processing, as expected (Ali and Bhattacharya 1972), but the values had no

**TABLE I**
**Properties of Parboiled Rice**

| Quality Type[a] | Variety | Amylose[b] (% db) Total | Amylose[b] (% db) Insoluble | Sample[c] | Parboil-Canning Solids Lost (% db) | $W_{96}$[d] (g/g) | Texture of Cooked Rice[e] F (%) | Texture of Cooked Rice[e] ER (%) |
|---|---|---|---|---|---|---|---|---|
| I | Jaya | 29.2 | 18.0 | MPB | 17.2 | 2.92 | 64.0 | 69.7 |
| | | | | SPB | 12.2 | 2.67 | 69.2 | 75.8 |
| | | | | PPB1 | 10.2 | 2.47 | 72.1 | 76.3 |
| | | | | PPB2 | 11.3 | 2.41 | 72.4 | 80.0 |
| | | | | PPB3 | 15.1 | 2.30 | 74.7 | 81.8 |
| III | S317 | 29.9 | 11.1 | MPB | 25.4 | 3.17 | 42.1 | 40.4 |
| | | | | SPB | 17.4 | 2.84 | 52.3 | 50.3 |
| | | | | PPB1 | 13.4 | 2.67 | 65.2 | 72.8 |
| | | | | PPB2 | 15.2 | 2.59 | 66.0 | 75.0 |
| | | | | PPB3 | 18.0 | 2.52 | 68.2 | 77.8 |
| V | Abor red A | 24.3 | 9.6 | MPB | 30.3 | 3.41 | 37.4 | 29.2 |
| | | | | SPB | 27.1 | 3.00 | 46.5 | 42.9 |
| | | | | PPB1 | 15.4 | 2.87 | 57.0 | 67.3 |
| | | | | PPB2 | 17.0 | 2.80 | 58.8 | 68.0 |
| | | | | PPB3 | 21.9 | 2.57 | 61.4 | 69.5 |
| VI | Sukanandi | 24.6 | 8.4 | MPB | 33.4 | 3.14 | 32.5 | 23.4 |
| | | | | SPB | 28.3 | 2.82 | 39.4 | 30.3 |
| | | | | PPB1 | 17.6 | 2.63 | 51.4 | 50.6 |
| | | | | PPB2 | 18.5 | 2.53 | 55.8 | 58.7 |
| | | | | PPB3 | 24.3 | 2.42 | 59.5 | 62.8 |
| VII | Changlei | 19.4 | 6.6 | MPB | 36.4 | 3.65 | 26.8 | 12.5 |
| | | | | SPB | 33.7 | 3.30 | 29.7 | 14.0 |
| | | | | PPB1 | 26.1 | 3.00 | 28.2 | 12.2 |
| | | | | PPB2 | 27.5 | 2.86 | 29.8 | 13.4 |
| | | | | PPB3 | 32.9 | 2.74 | 39.1 | 26.9 |

[a] Type assigned based on the total and insoluble amylose contents of the untreated (raw) rice according to the scheme of Bhattacharya et al (1982).
[b] Determined in raw (unprocessed) rice.
[c] Mild (MPB) and severely parboiled (SPB) rice made by soaking paddy to saturation (30–31% moisture, wb) and steaming for 10 min at 0 and 1 kg/cm$^2$ pressure, respectively. Pressure parboiled rice (PPB1) made by washing paddy with water (moisture, 16.5–17.5%, wb) and steaming at 2.5 kg/cm$^2$ for 15 min. PPB2 and PPB3 made by direct steaming of original paddy (11–12% moisture, wb) at 3 kg/cm$^2$ for 15 and 30 min, respectively.
[d] Water uptake of rice cooked 1 hr at 96° C.
[e] F = Firmness; ER = elastic recovery.

relation to the quality type. This is not unexpected, for, as shown by Bhattacharya and Sowbhagya (1971), water uptake by raw rice during cooking is related primarily to its size and shape (surface area per unit weight) and other physical characteristics rather than to its inherent quality. So, as parboiling reduced the cooking rate uniformly for all varieties (Table I; Unnikrishnan and Bhattacharya 1987), varietal selection by quality would not help improve the cooking rate. However, one possibility would be to select slender or small-grained (high surface area per unit weight) varieties for pressure parboiling to keep the cooking rate as high as possible.

The solids loss after parboil-canning processing decreased from MPB to PPB1 (Table I). It is interesting that even a low-amylose soft-cooking rice such as Sukanandi gave a reasonably low solids loss, and hence would be suitable for parboil-canning processing after appropriate pressure parboiling. Conversely, high-amylose rice would give an excellent parboil-canned product after appropriate pressure parboiling. Clearly pressure parboiling has a great potentiality for producing canned rice; the high discoloration caused by this method (Ali and Bhattacharya 1982) can be eliminated with bisulfite (Chinnaswamy and Bhattacharya 1986).

Curiously, the solids loss again increased in PPB2 and PPB3. Remembering that these two products were made by direct high-pressure steaming of unwetted paddy (moisture content 11–12%, wb), it might be that some degradation of starch was occurring in this condition. This possibility might also provide a clue to the peculiar properties of pressure-parboiled rice in general discussed elsewhere (Bhattacharya and Ali 1985). Gel-chromatographic fractionation of the starch should provide an answer to this question.


## ACKNOWLEDGMENT

We are thankful to the farm superintendent, Agricultural Research Station, Nagenahalli, for multiplying the seeds.


## LITERATURE CITED


ALI, S. Z., and BHATTACHARYA, K. R. 1972. Hydration and amylose-solubility behaviour of parboiled rice. Lebensm. Wiss. Technol. 5:207.

ALI, S. Z., and BHATTACHARYA, K. R. 1982. Studies on pressure parboiling of rice. J. Food Sci. Technol. 19:236.

BHATTACHARYA, K. R. 1985. Parboiling of rice. Pages 289-348 in: Rice Chemistry and Technology. B. O. Juliano, ed. Am. Assoc. Cereal Chem.: St. Paul, MN.

BHATTACHARYA, K. R., and ALI, S. Z. 1985. Changes in rice during parboiling, and properties of parboiled rice. Pages 105-167 in: Advances in Cereal Science and Technology, Vol. 7. Am. Assoc. Cereal Chem.: St. Paul. MN

BHATTACHARYA, K. R., and SOWBHAGYA, C. M. 1971. Water uptake by rice during cooking. Cereal Sci. Today 16:420.

BHATTACHARYA, K. R., SOWBHAGYA, C. M., and INDUDHARA SWAMY, Y. M. 1980. Quality of Indian rice. J. Food Sci. Technol. 17:189.

BHATTACHARYA, K. R., SOWBHAGYA, C. M., and INDUDHARA SWAMY, Y. M. 1982. Quality profiles of rice: A tentative scheme for classification. J. Food Sci. 47:564.

CHINNASWAMY, R., and BHATTACHARYA, K. R. 1986. Pressure parboiled rice: A new base for making expanded rice. J. Food Sci. Technol. 23:14.

IENGAR, N. G. C., BHASKAR, R., and DHARMARAJAN, P. 1972. Studies on methods of parboiling—Pressure parboiling. J. Agric. Eng. (New Delhi) 9(4):40.

IENGAR, N. G. C., GANGADHARAN, N. S., and RAJENDRAN, G. 1974a. Recent developments in pressure parboiling of paddy. J. Agric. Eng. (New Delhi) 11(1):31.

IENGAR, N. G. C., GANGADHARAN, N. S., and RAJENDRAN, G. 1974b. Recent developments in the pressure parboiling of paddy—Direct parboiling. J. Agric. Eng. (New Delhi) 11(5, 6):28.

LAIGNELET, B., and FEILLET, P. 1979. Use of the viscoelastograph for measuring the texture of cooked rice. Pages 355-361 in: Chemical Aspects of Rice Grain Quality. Int. Rice Res. Inst.: Los Baños, Laguna, Philippines.

UNNIKRISHNAN, K. R., and BHATTACHARYA, K. R. 1987. Influence of varietal difference on properties of parboiled rice. Cereal Chem. 64:315.

WEBB, B. D., and ADAIR, C. R. 1970. Laboratory parboiling apparatus and methods of evaluating parboil-canning stability of rice. Cereal Chem. 47:708.


[Received September 24, 1986. Revision received April 29, 1987. Accepted May 1, 1987.]