EFFECT OF PARBOILING ON THE SWELLING QUALITY OF RICE[1]

P. P. KURIEN[2], R. RADHAKRISHNA MURTY[2], H. S. R. DESIKACHAR[2], AND V. SUBRAHMANYAN[2]

ABSTRACT

The swelling rates and the expansion ratios during cooking of parboiled rice were lower than those of raw rice. Raw rice required cooking for 15–20 min., while parboiled rice required 30–40 min. to attain a soft consistency. At this stage of cooking the average length, breadth, volume, and weight of the cooked parboiled grains were generally greater than the corresponding values for cooked raw rice. The importance of an optimum steaming period to obtain a balance between swelling quality and increased yield of head rice has been emphasized. The data also indicated minor alterations in the dimensions of the milled grains as a result of the parboiling treatment.

Parboiled rice grains, after cooking, appear bigger than cooked raw rice grains of the same variety, giving the impression that the former belong to a coarse, bold-grained strain. This could be due to differences in the time needed for cooking, water-absorption capacities, and/or changes in the dimensions of the grains as a result of the parboiling treatment. Studies were, therefore, undertaken to determine swelling capacities and expansion in length and breadth during cooking of raw and parboiled rice samples. Changes in the dimensions of the grain as a result of parboiling treatment were also measured. These studies were carried out on a number of varieties of paddy during three seasons. Since the results obtained are essentially similar in nature, investigations pertaining to two representative samples are presented here.

Materials and Methods

Two local varieties of paddy, *Ratnachudi* (medium) and *Bangarasanna* (fine), were obtained from a paddy breeding farm for the studies. The samples were parboiled by soaking in water at 70°C. for 3½ hr., draining off the soak water, and steaming until the husk on the grain split. A batch of semiparboiled paddy representing an intermediate stage of parboiling was prepared by soaking the paddy in water at 50°C. for 3½ hr. and steaming as above. The parboiled samples were then sun-dried and milled. These and samples of raw rice from the

[1]Manuscript received March 25, 1960. Communication from the Division of Biochemistry and Nutrition, Central Food Technological Research Institute, Mysore, India.

[2]Central Food Technological Research Institute, Mysore, India.

same batch of paddy were kept at room temperature (25°–30°C.) for a week to obtain moisture equilibration (10–11% as determined). Broken, undersized or immature grains were removed by sieving.

Swelling capacities were determined by cooking 10-g. samples of rice in 70 ml. of boiling water, draining off the excess water, and determining the increase in weight and volume. Volume of the grains was measured by displacement of water. Six replicates were run in each case. Swelling capacity was expressed as ratio of final to the initial weight or volume.

Expansion of the grains during cooking was measured with a microscope under low magnification (× 10) (1). The dimensions of the cooked to the uncooked grains were expressed as the expansion ratios.

Length and breadth of 150 grains selected at random from the raw and parboiled rice samples were also measured to see if parboiling affected these dimensions.

To study the influence of severity of the steaming treatment, one variety (*Bangarasanna*) was soaked in water at 60°–65°C. for 3½ hr., steamed for periods ranging from 0 to 40 min., dried, and milled as above. The swelling quality of these samples in comparison with raw rice from the same lot of paddy (*Bangarasanna*) was determined as described above.

Results and Discussion

The raw rice samples from both the varieties — *Bangarasanna* and *Ratnachudi* — needed 15–20 min. to become fully cooked (as judged by pressing between two glass plates), while parboiled rice samples

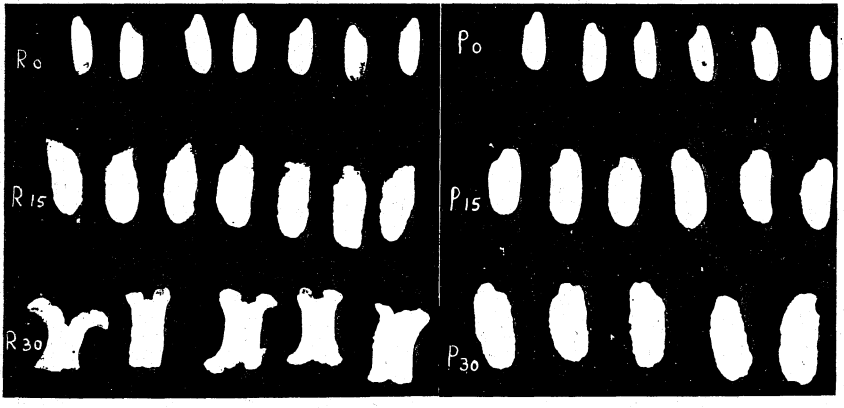

Fig. 1. Raw and parboiled rice samples cooked for different periods. R = raw rice; P = parboiled rice. Subscripts indicate the time of cooking, in minutes.

TABLE I

SWELLING RATIOS BY WEIGHT AND VOLUME OF RAW AND PARBOILED RICES

VARIETY	COOKING TIME	SWELLING RATIO BY WEIGHT[a]			SWELLING RATIO BY VOLUME[a]		
		Raw A	Semiparboiled B	Parboiled C	Raw A	Semiparboiled B	Parboiled C
	min.						
Ratnachudi	10	2.22±0.014	2.16±0.014[c]	2.06±0.014[a]	2.57±0.023	2.46±0.023[b]	2.32±0.019[a]
	15	2.74±0.010	2.52±0.009[a]	2.45±0.008[a]	3.32±0.016	2.98±0.007[a]	2.84±0.015[a]
	20	3.15±0.011	2.84±0.006[a]	2.68±0.010[a]	3.86±0.019	3.43±0.020[a]	3.22±0.010[a]
	30	.....	3.44±0.015	3.25±0.014[d]	.....	4.24±0.028	3.98±0.011[d]
	40	.....	3.90±0.033	3.55±0.007[d]	.....	4.93±0.038	4.54±0.027[d]
Bangarasanna	10	2.45±0.011	2.16±0.007[a]	2.13±0.007[a]	3.17±0.017	2.69±0.010[a]	2.66±0.015[a]
	15	2.97±0.014	2.58±0.014[a]	2.48±0.009[a]	3.98±0.020	3.29±0.020[a]	3.13±0.012[a]
	20	3.51±0.010	2.91±0.005[a]	2.96±0.009[a]	4.71±0.008	3.77±0.011[a]	3.79±0.011[a]
	30	.....	3.53±0.009	3.46±0.005[d]	.....	4.67±0.016	4.50±0.013[d]
	40	.....	4.00±0.009	3.93±0.012[e]	.....	5.33±0.015	5.20±0.022[d]

[a] Superior letters a, b, c below indicate significance at 0.1, 1.0, and 5% level respectively when treatments B and C were compared with A; d and e indicate significance at 0.1 and 1.0% level respectively between treatments B and C.

required 30–40 min. to be cooked to a comparable degree of softness. Raw rice cooked beyond 20 min. continued to absorb water, but the grains lost their shape, becoming almost flat, burst along the ventral line of fusion (Fig. 1), and became pasty.

Changes in Swelling Quality and Dimensions during Cooking. The water absorption capacities as reflected by the swelling ratios are significantly low for parboiled rice as compared with raw rice cooked for the same periods (Table I). However, samples of raw and parboiled rices cooked to an equivalent degree of softness show that parboiled rice can absorb more water without losing its shape. Raw rice cooked for 15 and 20 min. had lower swelling ratios than parboiled rice cooked for 30 and 40 min. respectively (significant at 0.1% level). Semiparboiled rice had a swelling capacity intermediate between that of the raw and parboiled samples. Similar observations were made with both varieties of rice tested.

Studies on the swelling of individual grains as measured by the expansion in length and breadth during cooking (Table II) generally confirm the data on the swelling qualities reported above. The expansion ratios both along the length and breadth of the parboiled rice were lower than those of raw rice cooked for the same period. At an equivalent stage of softness of cooking, the parboiled grain had expanded more along the breadth than the raw rice. The differences in the expansion along the breadth were significant; those along the length were not significant in all cases. Semiparboiled rice presented a picture intermediate between the raw and parboiled rice.

Effect of Duration of Steaming on Swelling Quality. The mere soaking of paddy in hot water at 60°–65°C. significantly reduced the swelling quality of the rice (Table III). The steaming operation following the soaking of paddy further reduced the swelling ratio: the longer the steaming period, the lower the swelling quality of rice. The rate of fall of swelling quality as a result of steaming is observed to be greater in the first 10 to 15 min. of steaming. While an increase in the period of steaming might harden the grain, resulting in a higher yield of head-rice during milling, the swelling quality of rice would be adversely affected. This stresses the importance of an optimum steaming period for the parboiling process. The steaming of paddy should not be prolonged beyond the stage of splitting of the husk.

Changes in Dimensions Due to Parboiling. The process of parboiling involves operations like soaking and steaming, which cause swelling, and subsequent drying causes contraction. Incomplete shrinkage during drying may also cause an over-all change in the dimensions of

TABLE II

EXPANSION RATIOS OF RICE GRAINS ALONG THE BREADTH AND LENGTH AXES DURING COOKING

VARIETY	COOKING TIME	RATIO OF EXPANSION ALONG BREADTH AXIS[a]			RATIO OF EXPANSION ALONG LENGTH AXIS[a]		
		Raw A	Semiparboiled B	Parboiled C	Raw A	Semiparboiled B	Parboiled C
	min.						
Ratnachudi	10	1.49±0.010	1.34±0.019[a]	1.33±0.010[a]	1.43±0.009	1.32±0.015[a]	1.30±0.010[a]
	15	1.53±0.027	1.42±0.025[a]	1.37±0.015[a]	1.63±0.055	1.40±0.007[b]	1.38±0.007[b]
	20	1.61±0.032	1.54±0.014[b]	1.46±0.020[b]	1.69±0.034	1.50±0.007[a]	1.46±0.009[a]
	30	.....	1.63±0.017	1.61±0.016[ns]	.....	1.61±0.022	1.56±0.018[ns]
	40	.....	1.73±0.033	1.71±0.024[ns]	.....	1.69±0.012	1.62±0.007[c]
Bangarasanna	10	1.49±0.014	1.45±0.010[c]	1.42±0.019[c]	1.43±0.008	1.37±0.007[a]	1.37±0.009[a]
	15	1.60±0.026	1.55±0.019[c]	1.53±0.015[c]	1.55±0.012	1.45±0.003[a]	1.43±0.010[a]
	20	1.60±0.027	1.59±0.015[c]	1.59±0.017[c]	1.62±0.029	1.48±0.007[a]	1.44±0.010[a]
	30	.....	1.69±0.027	1.67±0.010[ns]	.....	1.54±0.011	1.54±0.011[ns]
	40	.....	1.80±0.016	1.78±0.028[ns]	.....	1.66±0.019	1.63±0.011[ns]

[a] See footnote of Table I for explanation of statistical significance. ns indicates nonsignificance between treatments B and C.

TABLE III

EFFECT OF DURATION OF STEAMING ON THE SWELLING RATIOS OF *Bangarasanna* RICE

STEAMING TIME	SWELLING RATIO BY WEIGHT AFTER COOKING			SWELLING RATIO BY VOLUME AFTER COOKING		
	10 min.	20 min.	30 min.	10 min.	20 min.	30 min.
min.						
Control[a]	2.40±0.006	3.51±0.013	.....	2.95±0.009	4.48±0.019	.....
0[b]	2.21±0.021	3.35±0.024	4.16±0.012(A)	2.77±0.034	4.28±0.045	5.31±0.029(A)
5	2.15±0.010	3.01±0.021	3.63±0.017(B)	2.64±0.017	3.78±0.021	4.64±0.026(B)
10	2.08±0.008	2.85±0.018	3.45±0.011(C)	2.58±0.010	3.65±0.021	4.46±0.015(C)
20	1.99±0.013	2.70±0.013	3.27±0.027(D)	2.43±0.009	3.40±0.019	4.22±0.035(D)
30	2.00±0.004	2.65±0.009	3.18±0.010(E)	2.46±0.011	3.30±0.017	4.03±0.011(E)
40	1.98±0.010	2.64±0.013	3.16±0.007(F)	2.40±0.010	3.26±0.018	4.03±0.010(F)

[a] Raw rice.
[b] Rice from paddy soaked for 3½ hr. at 60°-65°C., but not steamed.
Statistical differences were significant at the 0.1% level for all samples except E and F, which were not significant.

the grain. Results presented in Table IV show that the average breadth of the parboiled grains was more than that of the raw rice grains of the same variety, the differences being highly significant, while the length of the parboiled rice grains was significantly less than that of raw rice. These data further indicated that some minor changes or

TABLE IV
EFFECT OF PARBOILING ON THE DIMENSIONS OF RICE GRAINS

SAMPLE	BANGARASANNA		RATNACHUDI	
	Length	Breadth	Length	Breadth
	mm.	*mm.*	*mm.*	*mm.*
Raw rice (A)	5.03±0.018	1.71±0.008	5.61±0.032	2.02±0.011
Semiparboiled rice (B)	4.95±0.018	1.76±0.008	5.47±0.021	2.14±0.016
Parboiled rice (C)	4.78±0.018	1.82±0.008	5.49±0.020	2.15±0.009
Test of significance:				
A ~ B	**	**	**	**
A ~ C	**	**	**	**
B ~ C	**	**	NS	NS

**Significant at 0.1% level. NS, not significant.

readjustments in the length and breadth occur in the grain as a result of parboiling. Microscopic examination revealed rounding-off of the germ tip of the milled parboiled rice grains. This may account in part for a slight shortening in the length of grains due to parboiling. A slightly lower degree of milling generally given to parboiled rice as observed by Sreenivasan (2) may be responsible for the slightly greater breadth of the parboiled grain.

The object of the present study was to seek an explanation for the relatively big and stumpy appearance of cooked parboiled rice grains as compared with cooked raw rice. Since parboiling and consequent gelatinization harden the grain, it needs a longer time to cook to a soft consistency and swells more during this period without disintegration of cell walls (1). Its intrinsic water absorption rate is, however, low. Raw rice, on the other hand, imbibes water more quickly but loses its physical structure, owing to dispersal of cell contents, when cooked beyond 20 min. The appearance of the grain to the eye depends on the ratio of its length to breadth or thickness. The relatively greater expansion of parboiled rice along the breadth after cooking as compared with cooked raw rice gives it the characteristic short and plump appearance.

Acknowledgment

The authors wish to thank Mr. A. N. Sankaran and Mrs. K. Indiramma for the statistical evaluation of the data and Mr. K. V. Achyutha Rao for the photograph.

Literature Cited

1. DESIKACHAR, H. S. R., and SUBRAHMANYAN, V. Expansion of new and old rice during cooking. Cereal Chem. **36:** 385–391 (1959).
2. SREENIVASAN, A. Nutritive value of raw and parboiled rices. Proc. Soc. Biol. Chem. (India) **1:** 41–42 (1936).