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Influence of Parboiling and Drying Methods on the Quality of Parboiled Rices

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Besides parboiling, dehydration step also alters the quality of rices-the extent depending on the systems followed. To understand the individual and combined influence of the above two steps in quality alteration, three cultivars varying in their original physicochemical properties were subjected to four parboiling and four drying methods and their hydration properties at different temperatures, cooking and eating qualities were determined. The intensity and duration of the heat treatment at the time of parboiling as well as during dehydration step seem to alter the quality to a great extent; severe the heat treatment, greater is the change in the property and *vice versa*. Even while employing identical processing conditions, the extent of quality alteration differs among varieties. Not only the GT but also other factors seem to influence the varietal response to parboiling

The cooking and eating qualities of raw rices are greatly governed by their composition, particularly the total amylose (Juliano *et al.*, 1965 and 1972), the insoluble amylose (Manohar Kumar *et al.*, 1976; Bhattacharya *et al*, 1978) and amylopectin (Juliano, 1979) contents. Additional quality factor slike the gel consistency and gelatinization temperature differences also seem to influence the quality of rices having similar amylos econtent (Juliano, 1979). On the other hand, the processing conditions, particularly, the intensity and duration of the thermic treatment during parboiling (Bhattacharya and Subba Rao, 1966b; Raghavendra Rao and Juliano, 1970; Indudhara Swamy *et al.*, 1971; Ali and Bhattacharya, 1972; Pillaiyar and Mohandoss, 1981) mostly modify the quality of parboiled rices. Though the influence of different drying conditions on the milling performance of parboiled paddy had been well established (Bhattacharya and Indudhara Swamy, 1967; Bhattacharya *et al*, 1971; Pillaiyar *et al*, 1981), their role in quality alteration has not been fully understood. Since drying (dehydration) is an integral part of rice parboiling, a study of its complementary effect on rice quality is considered of practical significance and hence this study.

MATERIAL AND METHODS

Cleaned Co 25, IR 8 and IR 20 paddy was utilized.

A. *Parboiling* :

i) Single steaming (SS): Paddy was soaked in water at room temperature (RT) for 72 hr and then steamed at 0 psig for 10 min

ii) Double steaming (DS): Raw paddy as such was steamed at 0 psig for 10 min, soaked for 24 hr and again steamed at 0 psig for 10 min

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iii) Hot soaking (HS): Paddy was soaked at 65°C for 4 hr and steamed at 0 psig for 10 min

iv) Pressure parboiling (PP) : After presoaking in water at RT for 15 min, the paddy was autoclaved at 10 psig for 20 min followed by 20 psig for 20 min

B. *Drying*

The parboiled paddy immediately at the close of parboiling was divided into two lots.

i) One lot was quickly transferred to an aluminium vessel to its full capacity with the lid on and maintained in hot condition for 30 min; thereby simulating a condition of "retention" (R) of hot paddy awaiting drying in commercial practices. At the close of the 'retention' period a portion of this material was dried in shade (RS) and another portion mechanically (RM)

ii) Another lot was immediately transferred to peforated wooden trays, spread in a thin layer and dried in shade (S) and mechanically (M). Mechanical drying was carried out in a laboratory Kilburn oven fitted with electrical coils and circulating fans. The paddy was dried at 110°C for 30 min followed by 80°C for 30 min. tempered for 8 hr and spread in trays in thin layer for equilising the moisture content before milling.

In commercial practices followed here, parboiled paddy is dried continuously in LSU dryers using furnace oil/husk as fuel by maintaining a temperature of 120°C for 3 to $3\frac{1}{2}$ hr with 1800 to 2500 cfm air per tonne of paddy.

C. *Milling*

Samples were dehulled in a Satake grain testing mill and polished in a McGill miller No. 3 to 7±0.1% bran removal. Whole sound kernels alone were used for tests.

D. *Testing methods* :

The length, breadth and thickness of 20 uniform sized raw brown rice in each sample were measured with a Mututoyo dial caliper. Total (Sowbhagya and Bhattacharya, 1971), and soluble amylose (Bhattacharya *et al.*, 1972) content and the alkali score (Bhattacharya and Sowbhagya, 1972) were determined as described. EMC-S (Indhudhara Swamy *et al.*, 1971) and apparent water uptake (Bhattacharya and Sowbhagya 1971) at 60°C and at boiling temperature (98°C) for 20 min (W'_{60} and W'_{98}), optimal cooking time (Bhattacharya and Sowbhagya, 1971) (o.t) and sensory score (Juliano *et al.*, 1965) for both raw and parboiled samples were determined. The gelatinization temperature (GT) was determined from alkali score and water uptake ratio (Bhattacharya, 1979) The moisture content was determined at 105±1°C for 24 hr. Two to four replicates in each test were carried out and the mean values reported.

RESULTS AND DISCUSSION

i) Original quality:

The three varieties differed very much in their physicochemical properties (Table 1). Since the protein content seemed to be unrelated to quality factors (Juliano, 1970; Juliano *et al.*, 1972) this was not analysed. Parboiling and drying had considerably altered the hydration characteristics of the samples. Their interactions also seemed to affect the quality significantly (Table 2 and 3).

ii) Influence of parboiling methods:

The rate of hydration of parboiled rices extremely depended on the intensity and duration of the heat treatment they received. Based on the EMC-S and W'98°: W' 60° values, the parboiled rices can be graded for their quality into SS>DS>HS>PP: the last one exhibiting extreme change in quality probably because of its complete gelatinization. Steaming of soaked paddy for 60 min at 0 psig resulted in only 80% gelatinization whereas gelatinization was complete in 20 min at 10 psig (Priestley, 1976a). Parboiling is practised with the aim of reducing the milling breakage; but the conditions need not be so severe as in certain cases, as it had been established that whenever drying was in shade or under appropriate conditions, milling breakage after parboiling had been very low or negligible, irrespective of its incidence in the original raw paddy (Bhattacharya and Subba Rao, 1966a). Milling breakage was found to be negligible even in the samples parboiled at 80° or 90°C (Pillaiyar and Mohandoss, 1981).

iii) *Influence of drying methods*:

Shade dried (S) samples exhibited high values for W'98°:W'60° than RM samples and a reverse pattern existed for EMC-S values. Retention as well as mechanical drying under the conditions employed adversely downgraded the quality. This may probably be due to further gelatinization (in SS, DS and HS) or to the accompanying starch retrogradation (Ali and Bhattacharya, 1976) during retention/mechanical drying. Peculiarly enough, mechanical drying even under the adverse conditions adopted here, did not alter the quality of PP rices very much, probably, because of the completion of the gelatinization at the parboiling step itself and the minimal influence of the subsequent heat treatment during drying. Considering this, it would be of interest to study the accompanying retrogradation (Ali and Bhattacharya, 1976) or the extent of the formation of insoluble helical amylose complexes (Prestley, 1976b) in PPS and PPM samples.

iv) *Cooking and eating qualities*:

Parboiling increased the o. t. only marginally (upto 6 min). The colour of the cooked PP rices was cream whereas it was white in SS, DS and HS rices. The texture of the Co 25 cooked raw rice was very tender and moderately sticky whereas in other two varieties it was moderately tender and well separated. But after parboiling, the textural behaviour of cooked rices was entirely different. The Co 25 and IR 20 cooked parboiled rices (SS to HS) were moderately tender to tender and well separated but the IR 8 sample was slightly

tough and well separated. The texture of Co 25 and IR 20 cooked rices obtained from PP samples were tough and well separated and that of IR 8 rice was very tough. Such hardness in the PP cooked rices may be related to the extreme apparent starch solubilisation during parboiling(Priestley 1976a) or to the extent of amylose retrogradation after parboiling (Ali and Bhattacharya, 1976). A highly significant negative correlation was observed between the temperature of parboiling and the soluble amylose present in the excess cook water (Pillaiyar and Mohandoss, 1981). The cooking and eating characteristics of different parboiled samples produced from the same original paddy varied very widely and were negatively related to the temperature of parboiling (Mohandoss and Pillaiyar, 1980; Pillaiyar and Mohandoss, 1981).

v) *Varietal response to parboiling*:

Each parboiling treatment altered the quality of different varieties differently; the magnitude of change being more in PP and the least in SS method. IR 20 sustained the least alteration whereas among Co 25 and IR 8, it was quite different. The IR 8 parboiled rices produced by different methods of parboiling had low va'ues for EMC-S and $W_{60}°$ when compared to the identical Co 25 rices; but contrary to expectation, a quite different pattern was observed for the W' values at boiling temperature-IR 8 continuing to register low W' values. This obscure behavioural pattern of IR 8 may be due to its resistance to disintegration after gelatinization and this may be related to the observed *in situ* retrogradation of the amylose (Raghavendra Rao and Juliano, 1970). Though it was observed that the greater the severity of heat treatment during parboiling, the higher would be the retardation in cooking time (Bhattacharya and Subba Rao, 1966b), it may not be so in all cases. Among the three varieties, the Co 25 sample (GT-64°C) received comparatively severe heat treatment during parboiling; but it cooked quickly, whereas IR 8 (GT-68.9°C) took more time for cooking. This again explains that it is not the degree of gelatinization alone that matters much in the alteration of the quality in the end product but the extent of apparent starch solubility (Priestley, 1976a) or the accompanying retrogradation of the starch (Ali and Bhattacharya, 1976) also. Varietal differences in the degree of amylose retrogradation during parboiling had been indicated (Rahavendra Rao and Juliano, 1970).

vi) *General*:

Though the GT seems to be the major determinant in deciding a particular cultivar for its suitability for processing (Beachel and Stansel, 1963; Perdon and Juliano, 1975), this property is not strictly variety-specific, for it may vary by several degrees within a single variety. This is because, a high ambient temperature during grain development in rice results in its having a higher GT and *vice versa* (Juliano *et al.*, 1969; Resurreccion *et al*., 1977). Other properties of starch also as explained above seem to affect the quality of parboiled rices. By and large, it is the method of processing, particularly, the duration and intensity of heat applied at each processing step

that determines the ultimate quality of the end product. Though, theoretically it would appear possible to produce parboiled rices from cultivars differing in their original properties to behave alike by manipulating the thermic treatment during gelatinization and dehydration steps, perhaps, some of the complexing nature of their constituents may still influence certain properties.

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TABLE : 1 Physicochemical properties of raw rice

Property	Co 25	IR 8	IR 20
A. Brown rice			
100 Kernel wt. (g)	1.79	2.19	1.68
Length (l) (mm)	5.33	6.65	6.00
Breadth (b) (mm)	2.53	2.55	2.25
Thickness (mm)	1.85	1.82	1.65
	2.13	2.61	2.67
Milled rice			
GT (°C)	64.0	68.9	73.3
Total amylose (% d. b.)	26.60	25.95	24.36
Insoluble amylose (% d. b.)	13.54	16.47	11.73
EMC-S (%)	29.95	28.90	26.37
$W'_{60}{}^{\circ}$ (g/g)	0.19	0.21	0.17
$W'_{98}{}^{\circ}$ (g/g)	1.37	1.65	2.20
$W'_{98}{}^{\circ}:W'_{60}{}^{\circ}$	7.21	7.86	12.94
Optimal cooking time (min)	18	18	11

TABLE II Hydration properties of parboiled rices produced by different methods of parboiling and drying

Properties	Variety	Single steaming				Double steaming				Hot soaking				Pressure parboiling	
		S	RS	M	RM	S	RS	M	RM	S	RS	M	RM	S	M
EMC-S (% wet basis)	IR 20	33.06	34.52	37.72	40.54	35.25	37.63	38.64	40.51	39.55	41.65	42.20	43.39	52.28	55.19
	CO 25	43.52	45.51	52.05	53.33	46.04	47.22	54.92	58.76	49.09	51.28	53.97	58.80	61.46	61.87
	IR 8	43.08	43.80	44.15	45.46	43.22	44.17	48.05	50.72	45.55	46.64	51.57	51.87	55.17	56.66
$W_{ss}°$(g/g)	IR 20	2.025	1.909	1.867	1.807	1.928	1.787	1.718	1.729	1.781	1.704	1.693	1.673	1.397	1.377
	CO 25	1.943	1.897	1.895	1.885	1.958	1.760	1.686	1.644	1.806	1.770	1 765	1.752	1.518	1.497
	IR 8	1.577	1.541	1.459	1.377	1.346	1.343	1.293	1.234	1.292	1.272	1.216	1.192	1.210	1.240
$W_{oo}°$(g/g)	IR 20	0.258	0.296	0.360	0.404	0.364	0.429	0.441	0.444	0.369	0.442	0.465	0.447	0.617	0.624
	CO 25	0.434	0.477	0.587	0.602	0.506	0.576	0.664	0.730	0.583	0.631	0.659	0.714	0.739	0.756
	IR 8	0.394	0.467	0.426	0.479	0.420	0 506	0.579	0.614	0.550	0.556	0.599	0.615	0.637	0.662
$W_{ss}°/W_{oo}°$	IR 20	7.893	6.453	5.203	4.472	5.304	4.169	3.894	3.873	4.895	3.872	3 648	3.510	2.265	2.210
	CO 25	4.481	3.992	3.239	3.134	3.867	3.059	2.541	2.255	3.036	2.815	2.682	2.476	2.055	1.983
	IR 8	4.010	3.303	3 427	2.983	3.216	2.657	2.240	2.011	2.352	2.289	2.031	1.940	1.900	1.873

For S, RS, M, RM refer text

TABLE III Analysis of variance for hydration properties of parboiled rices produced by different methods of parboiling and drying

Source of variable	EMC-S			W_{28}*			W_{20}*			W_{28}*:W_{20}*		
	S. Ed.	C. D. (P=0.05)	Sig.	S. Ed.	C. D. (P=0.05)	Sig.	S. Ed.	C. D. (P=0.05)	Sig.	S. Ed.	C. D. (P=0.05)	Sig.
Varieties (V)	0.0476	0.098	**	0.0167	0.034	**	0.0071	0.014	**	0.0674	0.136	**
Parboiling methods (P)	0.1028	0.298	**	0.0361	0.073	**	0.0152	0.031	**	0.1456	0.294	**
Drying systems within parboiling methods (D)	0.0128	0.208	**	0.0361	0.073	**	0.0152	0.031	**	0.1456	0.294	**
V X P	0.1779	0.260	**	0.0626	0.126	**	0.0264	0.053	**	0.2521	0.509	**
V X D	0.1779	0.360	**	0.0626	0.126	N.S.	0.0264	0.083	**	0.2521	0.509	**

** Significant at 1% level; N. S. Not Significant