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Extent of Quality Alteration in low Temperature Parboiling Cum Vacuum Drying in Paddy

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The intensity and duration of heat treatment during parboiling and drying influence the quality. The extent of quality change in low temperature parboiling cum vacuum drying was studied. Three varieties of paddy was parboiled at 80° and 90°C by closed heating for 10min and dried under vacuum at 80°, 90°, 100° and 120°C. The hydration pattern, alkali test value, optimal cooking time, linear elongation and breadthwise expansion in cooked kernel and the palatability were determined. The EMC-S of paddy right after parboiling/vacuum drying was also determined. Samples parboiled at low temperatures sustained less quality alteration than in the customary open steamed paddy. Rapid vacuum drying by maintaining a high temperature did not alter the quality to such an extent as happened in hot-air drying. Perceptible quality change had occurred only when the grain moisture fell below 17%. The starch retrogradation accompanying low temperature parboiling as well as vacuum drying was minimal; the cooking and eating qualities of these samples were comparatively better.

Parboiling of paddy results in changes such as gelatinization of starch (Raghavendra Rao and Juliano, 1970), retrogradation of the gelatinized starch (Ali and Bhattacharya, 1976 a, b) or the solubilization of amylose and amylopection fractions and their subsequent complexing (Priestley, 1976, 1977) and, disruption of protein bodies (Raghavendra Rao and Juliano, 1970). The degree and intensity of heat treatment during each step of (soaking, steaming and drying) parboiling process (Roberts *et al.*, 1954; Mecham *et al.* 1961; Jayanarayanan, 1964; Bhattacharaya and Subba Rao, 1966; Ali and Bhattacharya, 1972; Mokandoss and Pillaiyar, 1978) greatly influence the nature and extent of change in the end product. The colour, hardness, (Pillaiyar and Mohandoss, 1981 a) cooking (Pillaiyar and Mohandoss, 1981 b) and eating (Mohandoss and Pillaiyar, 1980) qualities in parboiled rice are correlated with the intensity and duration of parboiling temperature. Hot-air drying also influences the quality (Mohandoss and Pillaiyar, 1981). A method for production of parboiled rice at low temprature (80° and 90°C followed with vacuum drying had been indicated (Pillaiyar and Mohandoss, 1981 c) and the qualities of the resultant samples were studied.

MATERIAL AND METHODS:

IR 20, IR 34 and Co 25 paddy was soaked in warm water (Bhattacharya and Indudhara Swamy, 1967) and parboiled at 80°C and 90°C by closed heating (Pillaiyar and Mohandoss, 1981c) and also by the customary open steaming (0 psig) methods for 10 min. Samples parboiled at 80° and 90°C

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were dried by vacuum by connecting the closed heating box right after parboiling to a Jebivak high vacuum pump by still immersing the box in the oil bath maintained at desired temperatures to attain 80°, 90°, 100°, and 120° C of drying temperatures and under a vacuum of 450 mm Hg throughout (Pillaiyar and Mohandoss, 1981 c). Samples parboiled by open steaming and a lot at 90°C were dried in shade as such. After drying in vacuum for 10, 15, 20 and 25 min, drying was completed in shade. To compare the quality of these samples with the hot-air dried sample, a lot of soaked paddy (IR 20) was open steamed and dried in LSU dryer by maintaining a hot-air temperature of 120° C and with an air flow rate at 200 cfm/qtl for 3 hr to a moisture content of 14% (as practised in regular operation). All the samples were dehulled in a Satake grain testing mill and polished in a McGill miller no. 3 to 6±0.1% bran removal. Only sound whole kernels were taken for different tests.

The equilibrium moisture content attained by rice on soaking in water at room temperature (EMC-S) was determined as described by Indudhara Swamy *et al.*,(1971). To study the starch retrogradation, the EMC-S of paddy right after parboiling/vacuum drying was determined by immersing samples in water, cutting grains longitudinally into two halves each, removing the husks and allowing to soak for 24 hr (Ali and Bhattacharya, 1976 b).

The water uptake values at 60°C ($W_{60}°$) and at boiling temperature ($W_{96}°$) were determined by hydrating the samples at the respective temperature for 15 min. and their ratio $W_{60}°$: $W_{96}°$ was calculated (Bhattacharya and Sowbhagya, 1971). The linear elongation and breadthwise expansion of cooked kernels were determined by cooking 20 whole kernels to optimal cooking time and measuring their length and breadth before and after cooking with the aid of a graduated card board (Pillaiyar and Mohandoss, 1981 b).

The alkali reaction value was determined by immersing six kernels in 0.5 (Co 25), 0.6 (IR 34) and 1.1% (IR 20) KOH (by titration) taken in a closed petri dish (Bhattacharya and Sowbhagya, 1972) and the breadthwise expansion measured at the end of 4 hr reaction (Mohandoss and Pillaiyar, 1980 b). The obtimal cooking time was determined by cooking hernels till the disappearance of opaque-core (Bhattacharya and Sowbhagya, 1971). The palatability of the cooked samples was determined by extrusion test (Mohandoss and Pillaiyar, 1980).

The moisture was determined by drying in an oven at 105°±1°C for 24 hr, the moisture content of materials expressed on wet basis (w. b.); while water uptake values on dry basis(d.b.).

RESULTS AND DISCUSSION :

The grain moisture at the end of parboiling by closed heating ranged from 30. 4 to 31.8% and of vacuum drying from 22. 6 to 14. 3% (Table 1). The extent of quality change depended mostly on the temperature of parboiling-the EMC-S, $W_{60}°$: $W_{96}°$ and alkali reaction values were higher for open steamed lots (100°C) than that for the samples parboiled by closed heating (80° or 90° C) (Fig.1). Although high temperature drying affects the quality (Mohandoss and Pillaiyar. 1981) the changes noticed in this study (vacuum drying at 90° for IR 20 and 90° to 120°C for IR 34) were not perceptible-the EMC-S of the vacuum dried samples was lower than that of the respective dried samples. The EMC-S of the parboiled paddy determined right after parboiling was higher than that after usual shade drying, suggesting starch retrogradation following parboiling (Ali and Bhattacharya, 1976 b); but the magnitude of difference in EMC-S of paddy and rice (i. e. the extent of retrogradation) was rather low in 90°C parboiled samples (Fig. 2), demonstrating the positive influence of parboiling temperature on the starch retrogradation. Even within the open steamed paddy the extent of starch relrogradation depended on the duration of steaming-longer the steaming time, the greater would be the starch retrogradation (Ali and Bhattacharya, 1976 b). The influence of drying temperature during vacuum drying on the starch retrogradation seemed to be minimal (Table 2). Holding parboiled paddy at hot condition and/or hot-air drying severely altered the quality of parboiled paddy (Mohandoss and Pillaiyar, 1981). But on the other hand, even after retaining the paddy at 90°C or at a higher temperature for different durations during vacuum drying, (though equol to hot-conditioning) the rapid moisture extraction would have retarded starch retrogradation in these cases. Vacunm drying of Co 25 samples resulted in a d;fferent pattern of change. In this case, the drying conditions (0° and 100°C) adopted seemed to be some what severe to this low GT variety and consequently a marginal increase in both the EMC-S and $W_{60^\circ}:W_{96^\circ}$ values had occurred (Fig. 1). A similar behavioural pattern for this variety was noticed in hot-air drying and/or hot-conditioning of parboiled paddy (Mohandoss and Pillaiyar, 1981). Alkali reaction test values also indicated a more or less similar trend in quality following parboiling cum vacuum drying. The changes brought about in the 80°C-parboiled paddy dried at 80°C under vacuum were the least. Considering its close hydration values with the raw samples, the 80°C- parboiled sample was rated high (Pillaiyar and Mohandoss, 1981 b).

The water uptake values at low and high temperature hydration of the samples drawn at the close of 10, 15, 20, 25 min. of vacuum drying of 90°-parboiled samples indicated that the change in quality upto 20 min. drying was comparatively samll and thereafter the change could be felt appreciably (Table 3); but undoubtedly at a low ebb than that in the open steamed paddy dried in shade throughout The magnitude of change was the greatest in the hot-air dried sample (Fig.3).

Cooking characteristics :

Not much difference in optimal cooking time (18-19 min.) existed among the samples. The texture of cooked raw rice was very tender and that of the cooked sample of open steamed paddy after shade and hot-air drying was slightly tough to very tough; other parboiled sample, remained to be tender on cooking. Hot-air drying of parboiled paddy at 110°C for 30 min. followed by at 80°C for 30 min. adversely affected the cooking quality (Mohandoss and Pillaiyar, 1981); but vacuum drying even on maintaining a high temperature right after parboiling did not downgrade the quality. This may partly be due to the retarding effect on the starch retrogradation. Rapid removal of moisture right after parboiling retarded starch retrogradation) Ali and Bhattachacharya, 1976 b). Starch retrogradation can be prevented by rapidly reducing the moisture to 18% as retrogradation was progressive only above this moisture level (Ali and Bhattacharya, 1976 b).

The extent of starch gelatinization and solubilisation in 80° and 90°C parboiling and under the drying conditions (vacuum) adopted in this study may be low than that occurred in open steamed samples as these two properties are extremely temperature dependent (Priestly, 1976). Gelatinization was complete in 20 min at 10 psig while 60 min was necessary in order to achieve 80% gelatinization at 0 p sig; but the Kernels had not reached a maximum apparent starch solubility after 60 min. at this pressure (Priestley, 1976). The interconnected effect of a low degree of starch gelatinization during parboiling and the retarding effect of quick drying on starch retrogradation may be responsible for maintaining a good qulity.

Not much difference in the linear elongation of cooked kernel among different samples of IR 20 and IR 34 existed; but there seemed to be a differential influence of parboiling conditions on the breadthwise expansion. Parboiling conditions particularly the open steaming greatly affected the linear elongation and breadthwise expansion in Co 25 kernel after cooking (Table 4). Parboiling temperature and linear elongation of cooked kernel were correlated negatively (Pillaiyar and Mohandoss, 1981 b). The selective influence of parboiling and drying conditions on certain properties observed in this study may be due to the application of uniform processing conditions to all samples irrespective of their gelatinization temperatures. Varietal influence on parboiling had been observed (Mohandoss and Pillaiyar, 1981).

Eating quality:

The palatability of parboiled rice samples are related to their processing condition (Mohandoss and Pilllaiyar, 1980a; Pillaiyar and Mohandoss, 1981 b). Negative correlation existed between the extrusion test values and the temperature of parboiling (Mohandoss and Pillaiyar, 1980). The palatability as determined from the extraction test value of the opitimally cooked samples of the vacuum dried lots dried to 10, 15, 20, 25 min. was better than that of the open steamed paddy dried in shade and hot-air (Fig. 4). The cooked rice of the sample parboiled at 80°C had been rated along with raw cooked rice for its palatability (Mohandoss and Pillaiyar, 1980 a)

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TABLE 1. Conditions of Parboiling and Drying and the Grain Moisture at the Close of vacuum drying

Variety	Parboilіug tempt. (°C)	Drying tempt. (°C)	Moisture at the end of vacuum drying (%) *
IR 20	80	80	19.9
	90	90	16.4
	80	80	20.1
		90	18.5
IR 34	90	100	16.8
		120	16.7
	80	80	22.6
		90	14.8
Co 25	90	100	14.3

*Drying completed in shade to a moisture of 14% and miled

TABLE. 2. EMC-S of Parboiled paddy before and after vacuum drying and rice.

Variety	EMC-S in paddy at the end of Par-boiling (%, d.b.)	EMC-S in paddy at the end of Vacuum drying (%, d.b.)	Tempe-rature of drying (°C)	Moisture at the end of drying (%, w.b.)	EMC-S in rice after milling* (%, d. b.)
			RT		98.5
		108.1	90	18.5	95.1
IR 34	115.1	84.6	100	16.8	78.5
		97.6	120	16.7	95.8
			RT		98.9
Co 25	109.0	92.5	90	14.8	109.8
		99.5	100	14.3	111.5

*After completing drying in shade to a moisture of 14%, the samples were milled

Table 3 Effect of Different drying Conditions on the Hydration Characteristics of rice

Condition of drying	Moisture at the end of vacuum drying* (w. b.)	EMC-S (%,d. b.)	$W_{60}°$ (g/g, d. b.)	$W_{95}°$ (g/g, d. b.)
Parboiled at 90°C				
Vacuum dried for 10 min	20.9	68.4	0.57	2.01
" 15 min	18.5	70.2	0.57	1.98
" 20 min	17.1	69.7	0.54	1.87
" 25 min	16.5	71.3	0.58	1.89
Open steaming				
Shade dried		71.1	0.63	1.89
Hot-air dried		79.2	0.69	1.79

*Initial moisture 32.0% in the samples parboiled 90°C and 33.5% in open steamed sample. All samples were milled at 14% moisture by completing drying in shade.

Table 4 Influence of Paroboiling and drying Conditions on Kernel Elongation and Expansion after cooking

Samples	Increase over uncooked Samples %	
	Lengthwise elongation	Breadthwise Expansion
IR 20		
Raw	42.0	30.0
OSS	42.1	35.7
80/80	43.5	34.6
90/S	41.3	32.1
90/90	42.9	42.9
IR 34		
Raw	44.8	46.6
OSS	45.1	43.2
80/80	42.3	43.2
90/S	40.4	42.0
90/90	40.6	40.6
90/100	42.5	40.9
90/120	40.7	40.9
Co 25		
Raw	60.0	50.0
OSS	36.1	28.1
80/80	44.0	36.0
90/S	40.8	36.0
90/90	44.1	36.1
90/100	39.8	31.5

SSS-Open steamed paddy drie in shaded 90/S-Parboiled at 90°C and dried in shade; in other cases the first figure under first column refers the parboiling and the second figure the drying (vacuum) temperature in °C.

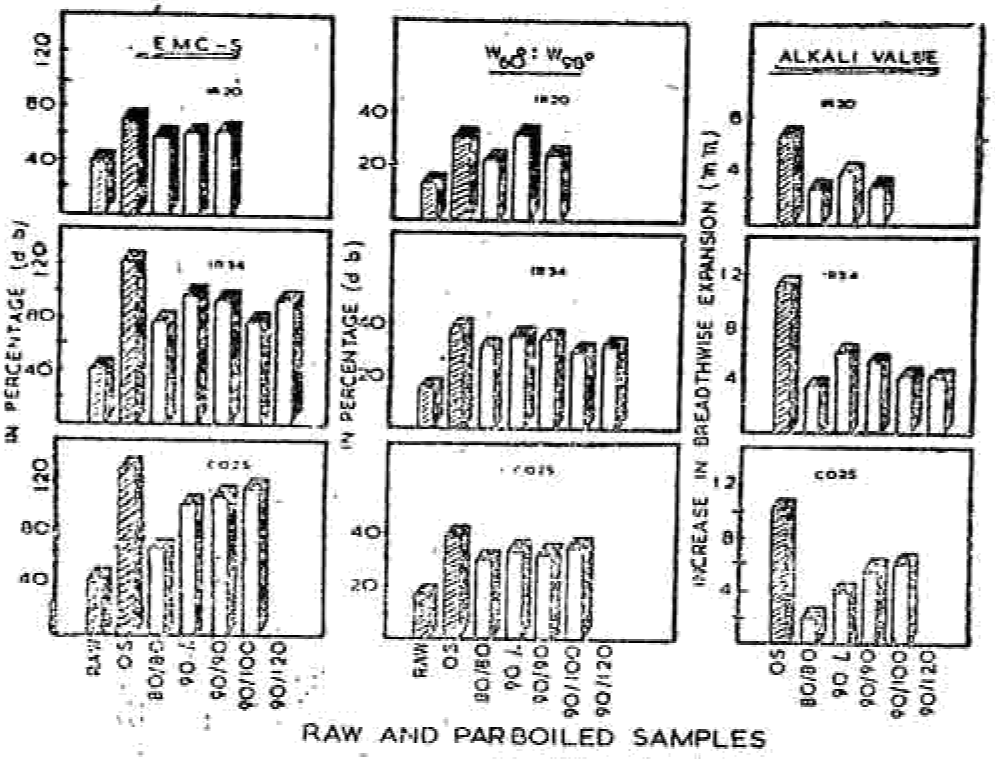

Fig. 1. Effect of Parboiling and Drying Conditions on EMC-S, $W_{60}°$: $W_{98}°$ and Alkali Reaction values

OS, Open steaming, S, Dried in Shade; first numbers in X-Axis indicate the Parboiling Temperature (80° and 90°) and the second numbers indicate the Drying Conditions (80°, 90°, 100°C) under vacuum.

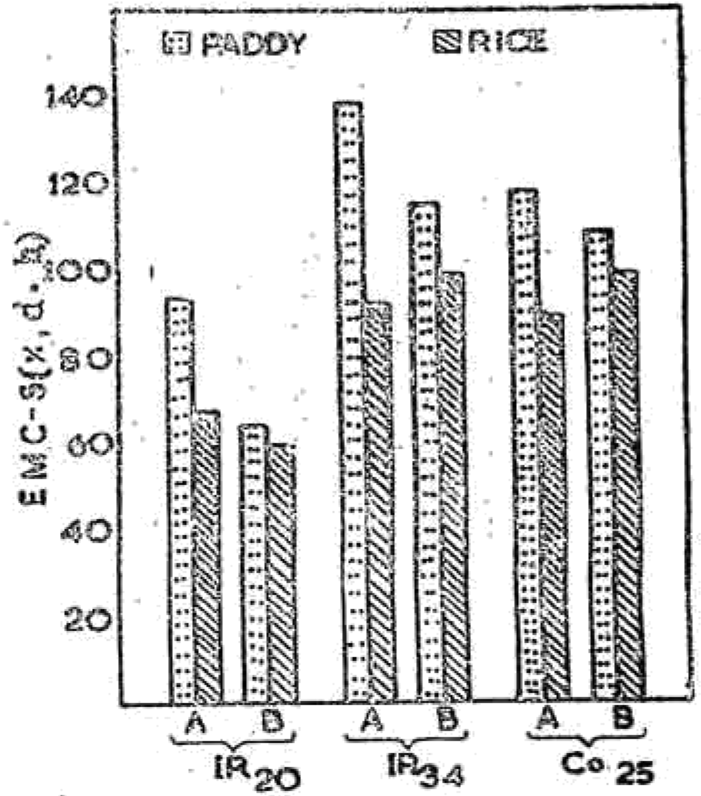

Fig. 2. EMC-S of Paddy and Rice for samples Parboiled at Different Temperatures. A and B-Samples parboiled at 100 and 90°C Respectively.

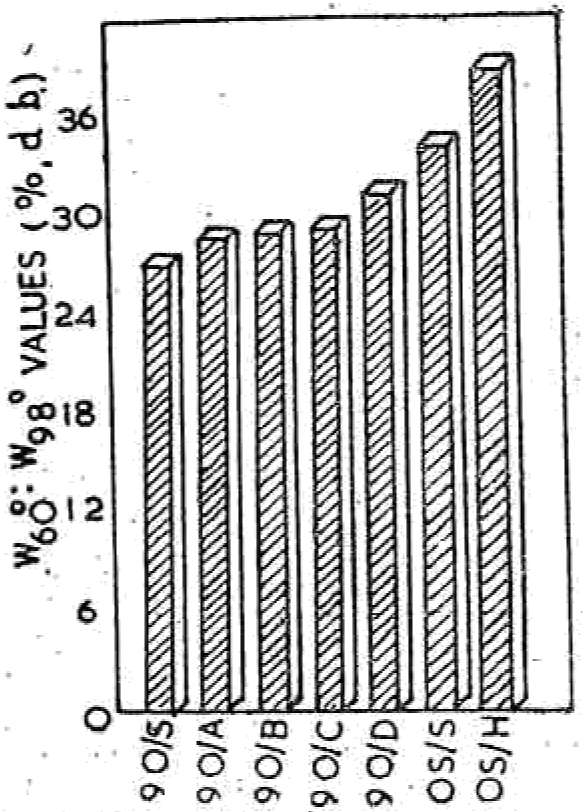

Fig. 3. Effect of vacuum drying to different duration, shade and Hot-Air Drying of paddy parboiled by closed heating (90°C) and open steaming on the W_{60}^{o} : W_{98}^{o} value OS-Open steamed Paddy ; S-Shade Drying; H-Hot-Air Drying ; 90-Parboiled at 90°C; A,B,C,D,-Vacuum drying for 10, 15, 20 and 25 min duration at 90°C

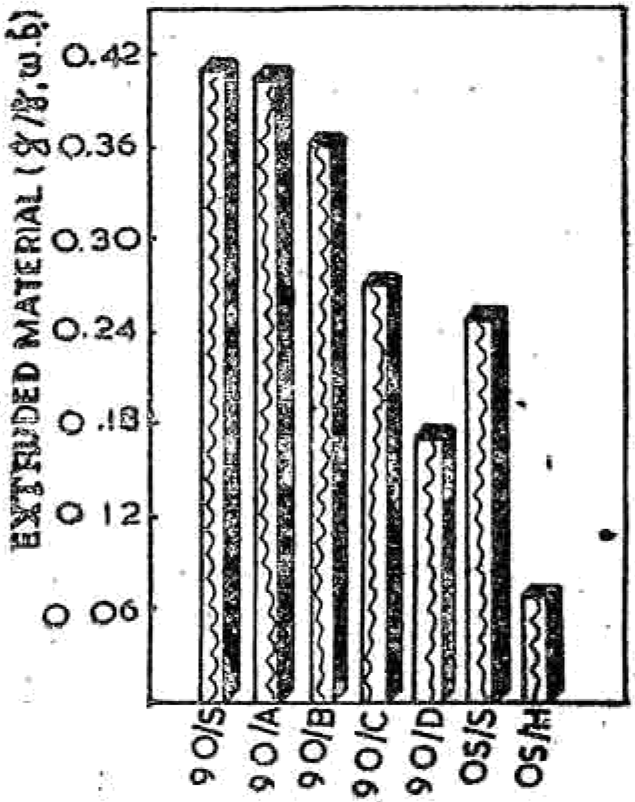

Fig. 4. Effect of Parboiling and Drying conditions on the Palatability of Cooked Rice (Extrusion test value,

(Sample Descriptions as in Fig. 3)