BIOCHEMICAL AND NUTRITIONAL INVESTIGATION ON RICE AND RICE PRODUCTS OF EAST PAKISTAN

Part I.—Differential Study of the Change of the Size of the Paddy* and Rice and Photomicrographic Investigations on the Alteration of Starch Constituents due to Parboiling

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Fourteen improved strains of unboiled and sun-dried paddy (*Oryzae sativa*, var. *indica*) of East Pakistan so far studied revealed a variation of their length from 6.10 mm. in the case of Badshabhog to 10.72 mm. in the case of Patnai. The dorsiventral diameters varied from 2.30 mm. to 3.58 mm. The ratio between the length and the dorsiventral diameter ranged from 2.18 to 3.93.

Due to parboiling and subsequent drying, there is a decrease in the length by 1.7% and an increase in the dorsiventral diameter by only 2.3%. Due to dehusking of paddy to rice there was a decrease in the length by 23 to 29% and in the dorsiventral diameter by 13 to 20%, in the case of both paddy and rice.

Photomicrographic study shows a partial degradation of the starch granules due to parboiling but the degree of change depends on the variety of paddy.

By iodine staining there is definite change of the colour from deep blue and violet to light blue and pink depending on the variety of paddy. The significance of this change in colour has been discussed in the light of the shifting of the amylose and amylopectin ratio due to parbiling.

Introduction

In East Pakistan different varieties of rice, mostly in parboiled condition, are consumed as the main cereal foodstuff. The parboiling process has been developed in this region as an indigenous traditional technique for the preservation of the paddy and rice in this humid region. It is the experience of all here that parboiled paddy and rice keep better than the raw sun-dried ones. F.A.O. in its report[1] on 'Rice and Rice Diets' has stated that parboiled rice is less infested by pests and insects than the unboiled ones. But the factor or factors which are responsible for a longer storage life of parboiled rice do not appear to have yet been fully investigated. Moreover, the cooking quality of parboiled rice is also considered better than that of unboiled ones. Small amount of work so far reported in the literature by Basu and Sirkar,[2] Basu and Mukherjee,[3] and Kalaker and Banerjee,[4] relates only to the study of the difference in the nutritive value of protein and starch due to parboiling of paddy. Other work on rice carried out in Western countries[5-11] relates mainly to the cooking quality and other aspects of unboiled rice which is generally consumed in those regions.

In view of the paucity of information in the above fields, systematic investigations have been directed towards the study of the changes undergone by the different constituents of rice and rice products as effected by parboiling treatment of paddy so that definite clues as to the longer storage life of the parboiled rice and its products and changes in the nutritive value of their protein and starch may be evaluated. This will also help to modify the present technique of parboiling, if necessity arises, and for the simultaneous improvement of the nutritive value as well as the storage life of the parboiled rice and its products. The present paper presents information on the change in the structure of the granules of rice starch and its constituents due to parboiling treatment through photomicrographic studies. Physical changes such as the alteration of the size of the paddy and rice grains etc., due to parboiling are also reported in this communication.

Attempts in the photomicrographic study of the starch granules of rice have recently been made by Little and Hilder[11] but their work was directed only to investigate the changes in the starch granules during the cooking of raw rice at 62°C. In the course of compilation of the results of the present investigation the authors came across another report by Little and Dawson[12] which also dealt with the changes of the starch, protein and other constituents of unboiled rice and its cooked kernels by histological and histochemical studies. But since the cooking of unboiled rice and the parboiling of unboiled paddy are two quite different processes, the information reported by the above group of workers does not

*Unboiled paddy discussed in the paper refers to 'raw' paddy which has not been parboiled. Unboiled rice refers to raw rice prepared by dehusking unboiled paddy.

throw much light on the changes in the starch as effected by parboiling treatment.

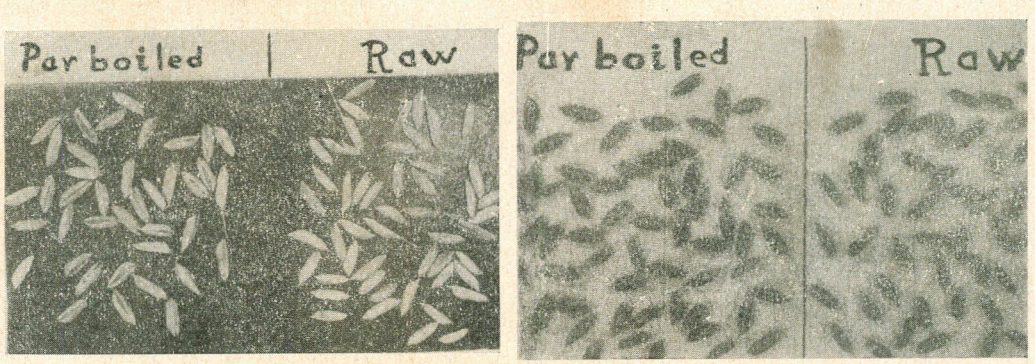
Experimental

The improved strains of paddy samples (*Oryzae sativa*, var. *indica*) as listed in Table 1 were collected from the Government Agricultural Farm and one lot from each variety was parboiled according to the traditional process in which the sample after soaking in water for 2 hours is boiled in closed earthenware pots until the husk showed the tendency to burst out. This took 60 to 90 minutes depending on the variety of the paddy. The parboiled paddy was then carefully dried in the open sun and thereafter dehusked by manual methods so that the bran layer and germ are retained on the grain. The other lot of the paddy, without any parboiling, was similarly dried in the open sun and then dehusked according to the technique as mentioned above. The size of the unboiled and parboiled paddy and their rice products were then determined by the measurement of the length and the horizontal diameter towards the dorsiventral side with the aid of ocular micrometer. The ratio of the above length and diameter and the total and percent decrease of the length and diameters with respect to the values of unboiled paddy, due to parboiling treatment, and due to dehusking of the unboiled and parboiled paddy, to unboiled and parboiled rice, was then computed from the above values of length and dorsiventral diameters so as to evaluate how far parboiling and dehusking affect change in the size in the above two processes. The results are presented in Tables 1 and 2.

For the histochemical study of the changes in the starch constituents due to parboiling treatment, the husked rice grains of unboiled and parboiled paddy after softening by soaking in water for 6 hours, was sectioned by hand by holding between pitch sticks (jute stick). One set of the sections was then photographed in black and white film to show the change in the pattern of the cell and its starch contents. Another batch of the section was stained with iodine and different shades of colour, varying from pink to deep blue as developed due to change in the starch constituents on parboiling treatment, have been studied by coloured microphotography. Photographs of the unboiled and parboiled rice samples are presented in the figures.

Results

Size of the Unboiled and Parboiled Paddy and Rice.— From the results presented in Table 1, it would appear that there is a great variation in the length of the paddy and rice depending on the variety, the minimum value was noticed in case of Badshabhog and maximum in the case of Patnai under both unboiled and parboiled conditions. With respect to dorsiventral diameter, Badshabhog showed similar low value but the maximum diameter was noticed in case of Dharial. On the basis of the above measures of the length and the dorsiventral diameter, the paddy and rice have been classed under major groups as long, medium and short grains. The grains having greater values of length but lesser values of dorsiventral diameter, i.e. higher ratios of the length and of the dorsiventral diameter, are classed under long grain group. On the basis Dular, Kataktara, Dudswar, Jhingasail, Dholasaitha, Kumari, Bhasamanik and Patnai, possessing higher ratio values above 3, may be classed under long grain group of paddy. Hashikalmi and Khasiapanja, though possessing higher values in their length but because of having equally higher values in their dorsiventral diameters, yielded the ratios less than 3 and so are classed under the medium grain group of paddy. Dharial, on the other hand, having comparatively lesser length but higher dorsiventral diameters, gave the minimum ratio

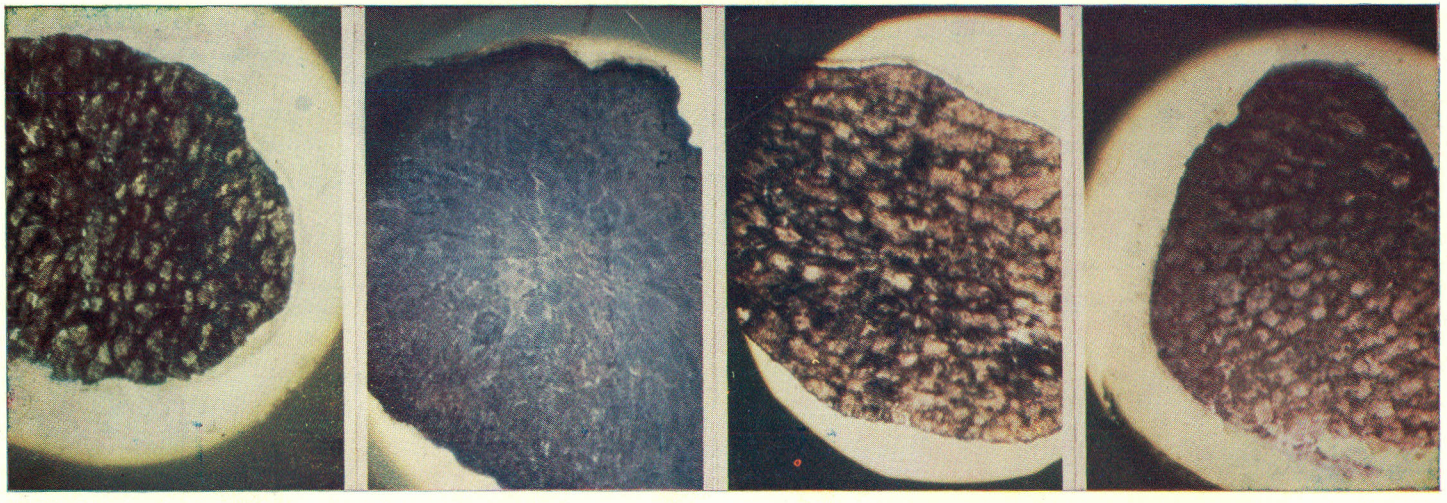


Parboiled and unboiled (raw) long-grain Bhasamanik paddy (left) and short-grain Dharial paddy (right). Slight increase in dorsiventral diameter and decrease in length may be noted.

TABLE 1.—THE LENGTH AND THE DORSIVENTRAL DIAMETERS OF UNBOILED RAW AND PARBOILED PADDY AND RICE AND THE RATIOS OF THESE DIAMETERS.

Name of the improved strains of rice variety (*Oryzae sativa*, var. *Indica*)	Paddy size in mm.				Rice size in mm.				Ratio of length and dorsiventral diameters					
	Length		Dorsiventral dia.		Length		Dorsiventral dia.		Paddy			Rice		
	Raw (unboiled)	Parboiled	Raw (unboiled)	Parboiled	Raw (unboiled)	Parboiled	Raw (unboiled)	Parboiled	Raw (unboiled)	Parboiled	Decrease due to parboiling	Raw (unboiled)	Parboiled	Decrease due to parboiling
Dular ..	9.85	9.78	2.85	2.85	7.0	6.9	2.48	2.55	3.51	3.44	0.07	2.82	2.70	0.12
Hashikalmi ..	8.48	8.35	3.03	3.16	6.01	5.95	2.53	2.56	2.79	2.64	0.15	2.38	2.32	0.06
Dharial ..	7.83	7.71	3.58	3.60	5.90	5.68	3.00	3.02	2.18	2.14	0.04	1.96	1.88	0.03
Kataktara ..	9.11	8.91	2.51	2.63	6.36	6.20	2.15	2.25	3.47	3.41	0.06	2.95	2.79	0.16
Nigersal ..	7.63	7.46	2.50	2.60	5.48	5.36	2.08	2.13	3.05	2.87	0.18	2.63	2.45	0.18
Dudswar ..	9.70	9.41	2.70	2.75	7.11	6.95	2.21	2.28	3.59	3.41	0.18	3.04	2.91	0.13
Jhingasail ..	9.70	9.61	2.48	2.60	7.23	7.18	2.01	2.08	3.91	3.70	0.21	3.60	3.30	0.30
Dholasaitha ..	9.18	9.04	2.56	2.63	6.63	6.47	2.17	2.20	3.58	3.43	0.15	3.09	2.94	0.05
Kumari ..	8.93	8.68	2.64	2.71	6.84	6.56	2.20	2.24	3.38	3.20	0.18	3.10	2.92	0.18
Khasia Panja ..	9.32	9.14	3.30	3.34	6.58	6.38	2.83	2.86	2.82	2.73	0.05	2.32	2.23	0.09
Bhasamanik ..	9.68	9.52	2.67	2.70	6.82	6.56	2.20	2.24	3.62	3.52	0.10	3.10	2.93	0.17
Patnai ..	10.72	10.64	2.73	2.80	7.58	7.47	2.20	2.26	3.93	3.80	0.13	3.44	3.30	0.14
Badshabhog ..	6.10	6.00	2.30	2.36	4.40	4.26	1.96	2.0	2.65	2.54	0.11	2.24	2.13	0.11
										Average =	0.12		Average =	0.14

CROSS SECTIONS OF DIFFERENT RICE GRAINS SHOWING THE CHANGE IN THE IODINE-STARCH COLOUR DUE TO PARBOILING.

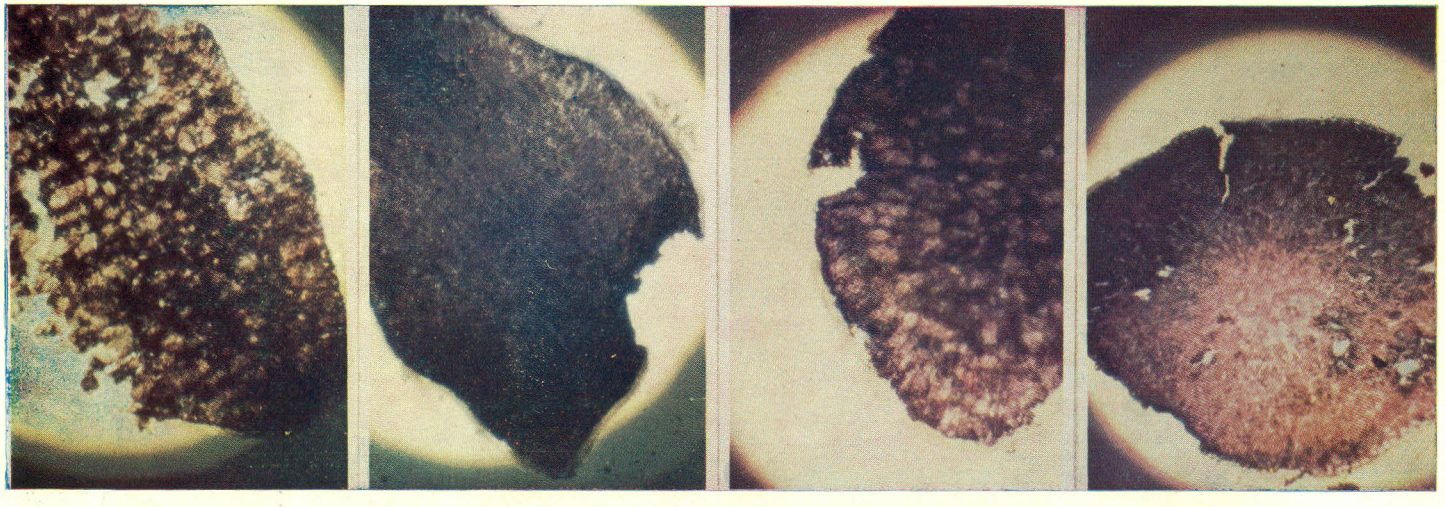


Bhasamanik raw unboiled
Mag. 30 ×

Bhasamanik parboiled
Mag. 30 ×

Latisail raw unboiled
Mag. 30 ×

Latisail parboiled
Mag. 30 ×



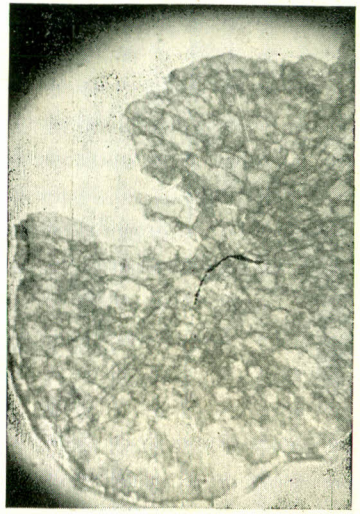
Dular raw unboiled
Mag. 30 ×

Dular parboiled
Mag. 30 ×

Patnai raw unboiled
Mag. 30 ×

Patnai parboiled
Mag. 30 ×

CROSS SECTIONS OF DIFFERENT RICE GRAINS SHOWING CHANGE IN THE STARCH GRANULES.



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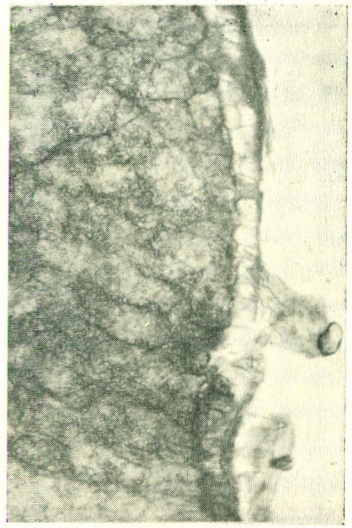
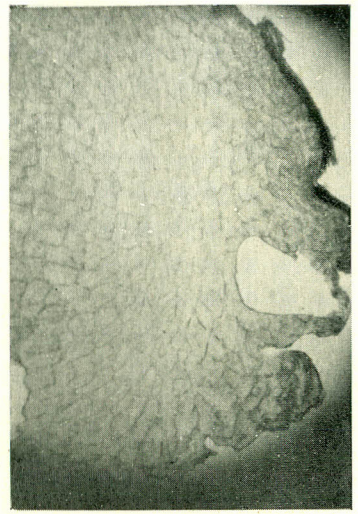


Mag. 85×

Bhasamanik raw unboiled



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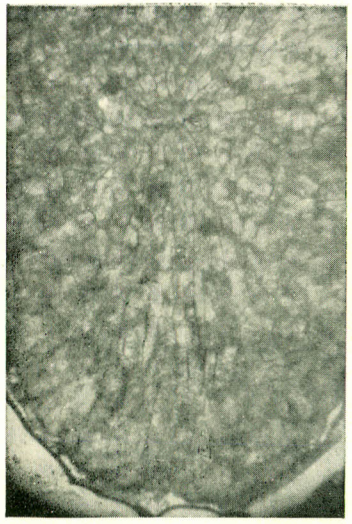
Mag. 85×

Bhasamanik parboiled



Mag. 30×

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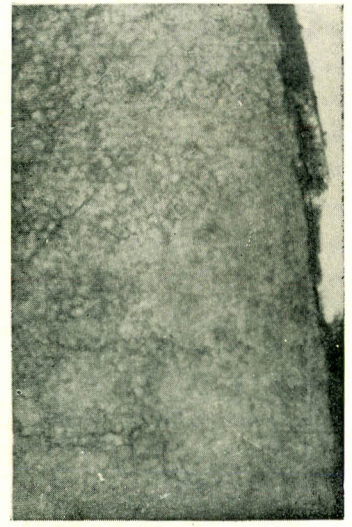
Latisail raw unboiled

Mag. 30×



Mag. 85×

Latisail parboiled

CROSS SECTIONS OF DIFFERENT RICE GRAINS SHOWING CHANGE IN THE STARCH GRANULES.

Mag. 30×

Mag. 85×

Dular raw unboiled

Mag. 30×

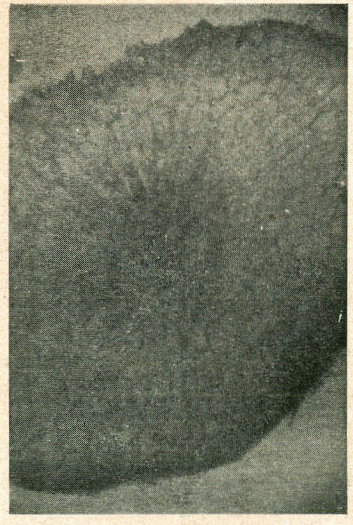
Mag. 85×

Dular raw parboiled

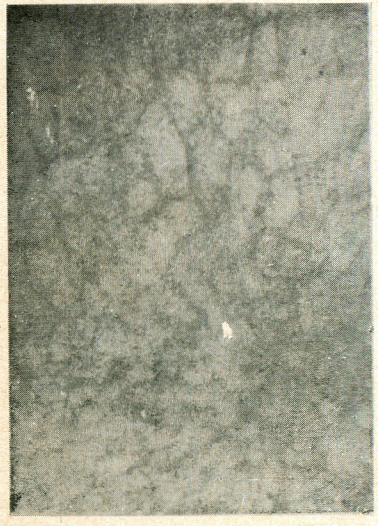
Mag. 30×

Mag. 85 ×

Patnai raw unboiled



Mag. 30×



Mag. 85 ×

Patnai parboiled

TABLE 2.—THE DIMINUTION OF THE SIZE OF THE PADDY DUE TO DEHUSKING AND PARBOILING. THE RESULTS PRESENTED BELOW ARE COMPUTED FROM THE DATA OF THE LENGTH AND DORSIVENTRAL DIAMETERS OF RAW AND PARBOILED PADDY AND RICE AS RECORDED IN TABLE 1.

Name of the paddy variety	Decrease of length due to parboiling of				Increase of dorsiventral diameters due to parboiling of				Decrease of length due to dehusking				Decrease of dorsiventral diameters due to dehusking			
	Paddy		Rice		Paddy		Rice		Raw paddy to raw rice		Parboiled paddy to parboiled rice		Raw paddy to raw rice		Parboiled paddy to parboiled rice	
	Total in mm.	As percent of raw paddy value	Total in mm.	As percent of raw rice value	Total in mm.	As percent of raw paddy value	Total in mm.	As percent of raw rice value	Total in mm.	As percent of raw paddy value	Total in mm.	As percent of parboiled paddy value	Total in mm.	As percent of parboiled paddy value	Total in mm.	As percent of parboiled paddy value
1. Dular ..	—0.07	0.7	—0.10	1.4	+0.05	1.8	+0.07	2.8	—2.85	27.2	—2.88	29.5	—0.32	11.4	—0.30	10.9
2. Hashikalmi ..	—0.13	1.5	—0.06	0.9	+0.13	4.2	+0.03	1.1	—2.47	29.1	—2.53	30.3	—0.47	15.5	—0.60	18.9
3. Dharial ..	—0.12	1.5	—0.22	3.7	+0.02	0.6	+0.02	0.6	—1.93	25.0	—2.01	26.0	—0.58	16.2	—0.58	16.1
4. Kataktara ..	—0.20	2.1	—0.16	2.5	+0.12	4.7	+0.10	4.6	—2.75	30.1	—2.91	21.4	—0.26	10.3	—0.38	14.4
5. Nazersail ..	—0.17	2.2	—0.12	2.1	+0.10	4.0	+0.05	2.4	—2.15	28.0	—2.10	29.5	—0.37	14.8	—0.47	18.0
6. Dudswar ..	—0.29	3.0	—0.16	2.2	+0.05	2.0	+0.07	3.1	—2.59	26.9	—2.75	29.2	—0.42	15.5	—0.47	17.0
7. Jhingasail ..	—0.09	0.9	—0.05	0.7	+0.12	4.8	+0.07	3.4	—2.47	25.4	—2.43	25.2	—0.47	18.9	—0.52	20.0
8. Dholasaitha ..	—0.14	1.5	—0.16	2.3	+0.07	2.7	+0.03	1.4	—2.55	27.7	—2.57	28.4	—0.39	15.2	—0.43	16.3
9. Kumari ..	—0.25	2.8	—0.18	3.1	+0.07	2.5	+0.04	1.9	—2.09	23.4	—2.12	24.4	—0.44	16.6	—0.47	17.4
10. Khashiapanja..	—0.18	1.9	—0.20	3.0	+0.04	1.1	+0.03	1.4	—2.74	29.4	—2.76	30.2	—0.47	14.2	—0.44	13.3
11. Bhasamanik ..	—0.16	1.7	—0.32	4.7	+0.03	1.5	+0.04	1.8	—2.86	29.9	—2.96	30.9	—0.47	17.6	—0.46	17.0
12. Patnai ..	—0.08	0.7	—0.11	1.4	+0.07	2.6	+0.06	0.9	—3.14	29.2	—3.17	29.8	—0.53	19.4	—0.54	19.3
13. Badshabhog ..	—0.10	1.6	—0.14	3.1	+0.04	1.7	+0.04	2.0	—1.70	27.9	—1.74	29.0	—0.34	14.8	—0.36	14.6
Average ..	—0.15	1.7	—0.15	2.3	+0.07	2.6	+0.05	2.2	—2.48	26.1	—2.43	27.8	—0.42	15.4	—0.46	16.2

value of 2.18 and may, therefore, be classed as a short grain paddy. Badshabhog, on the contrary, even having shorter length of 6.1 mm. as compared to those of Hashikalmi and Khasiapanja yielded the ratio almost ranking with those of the above two varieties and this is because of its having the lowest value in its dorsiventral diameter to the range of 2.30 mm. This grain may be classed under fine grain group. The significance of the above values in relation to their cooking properties and digestibility of their protein and starch will be discussed in subsequent papers.

Effect of Parboiling on the Length and Dorsiventral Diameters.—From the results of Table 2 it will be noted that due to parboiling there was diminution in the length of both paddy and rice by 0.15 mm. As per cent of raw unboiled values, the above diminution showed the average value of 1.7% for paddy and 2.3% for rice. The dorsiventral diameter increased by 2.6 % in the case of paddy and 2.3% in the case of rice on an average. Though the total increase of the dorsiventral diameter was numerically half of the total decrease of the length, yet these on expression as per cent of the raw unboiled values showed similar range from 1.7 to 2.3 % in both the cases. Because of such almost equal per cent decrease of the length and per cent increase of the dorsiventral diameter that the ratios of the length and the dorsiventral diameters between unboiled and parboiled paddy and unboiled and parboiled rice do not show much significant difference as evident from the data enumerated in the last six columns of Table 1. It thus appears from these results that due to parboiling there is only a little decrease in the length and proportionately a slight increase towards dorsiventral diameter in both paddy and rice.

Effect of Dehusking on the Size of Raw and Parboiled Rice.—While evaluating the decrease of the size in the preparation of rice from paddy it is noted from the results of Table 2 that due to dehusking of unboiled and parboiled paddy there is high decrease of the length by 26.1 and 25.6% respectively on an average. Diminution towards the dorsiventral diameter by such a process occurred to a lesser extent of 15.4 and 16.1 % respectively for unboiled and parboiled paddy. Thus, in general, the decrease of the size due to dehusking is effected more towards the length and less towards the breadth (dorsiventral diameter) and this is because of greater thickness of the husk towards the length and less thicker portion of the husk lining the side of the grain.

Photomicrographic Study of Unboiled and Parboiled Rice.—The photomicrography of unboiled rice in black and white shows in most of the cases, the starchy endosperm being bounded by the seed coat and free starch granules visible within the cell. In Bhasamanik and Patnai varieties the starch grains appear as clusters and are represented by the opacity in the magnified sections. The cells in the centre are small but elongated towards the periphery. In case of Dular rice the cells towards the periphery are hexagonal.

Due to parboiling the starch granules show partial transparency. Some dark portions showing incomplete parboiling of starch are noted, specially at the centre, but the degree of change of the starch granules due to such parboiling treatment seems to be dependent on the variety. In Latisail, the boundary wall seems to have been ruptured and free starch granules are seen in the field of the section, specially in the magnified one. In Bhasamanik, Dular and Patnai, the cell structures remain unruptured but the starch granules become partially visible. This difference in the behaviour between the above four varieties of rice indicates that the cell boundary wall of Latisail rice as compared to the other three perhaps are very thin, swells very quickly and finally bursts out. By iodine staining the unboiled Bhasamanik attained deep to light pink colour as observed by colour photograph 1. The cells with starch grains which clustured together developed no distinctive colour due to opaqueness under transmitted light. After parboiling two zones of colour were noted: the centre blue and the periphery light violet.

In the case of Latisail unboiled variety two distinctive colours are noted. Portions which attained deep black in black and white photograph attained deep blue colour showing clustering of starch grains in these zones. Other portion shows violet colour. On parboiling, the colour changes to pink and violet, and the deep blue zones between the cells, which was noted in unboiled rice, disappeared here, showing clustering of starch grains in these zones. Other portion shows violet colour. On parboiling, the colour changes to pink and violet, and the deep blue zones between the cells, which was noted in unboiled rice, disappeared here showing dissolution of the starch grains. The colour within the cell wall is violet and in some cases mingled with blue. This shows that some of the starch has been partially dextrinised or its amylose fraction has undergone change during parboiling process. The cell walls are stained violet. In both unboiled and parboiled rice, the seed coats did not take up any colour.

Like the previous one, some deep blue zones

are noted in Dular raw rice also showing the clusters of the starch grains in these zones. Some grains attain violet colour mingled with blue tint. On parboiling there is change of colour from blue to pink. Patnai unboiled rice, unlike others, attained deep violet colour without any bluish tint. After parboiling less patches of deep violet colour is noted. The tone is light violet or more pinkish and this colouration is uniform throughout the field. It seems clear that during parboiling some change of starch constituents occur but whether this reaches the stage of dextrinisation or causes the shift of the ratio between amylose and amylopectin requires a more thorough investigation.

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