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

Part VI.—Differential Culinary Properties of Raw and Parboiled Rice Evaluated by Water Absorption Ratio and Starch Loss in the Gruel

H.N. De, Moshinul Haque, and M. Yasin

Nutrition Section, Food and Fruit Research Division, East Regional Laboratories, Pakistan Council of Scientific and Industrial Research, Dacca

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The culinary properties of thirteen varieties of raw and parboiled rice were investigated by determination of the Water Absorption Ratio, the volume of the gruel discarded and loss of starch in it. The results show less water absorption by the parboiled rice and less loss of starch in their gruel. The water Absorption Ratio seems to maintain direct relationship with the breadth of the grain rather with their length. Patna variety rice, inspite of having maximum length, behaved like medium-size grain with respect to water absorption because of its breadth size equivalent to that of the medium-size grain. The significance of the results of less water absorption and less loss of starch in the gruel of the parboiled rice as compared to those of the raw ones has been discussed in the light of the hardening of the surface and the partial inactivation of amylase due to parboiling treatment.

Introduction

In the series of the investigations on the biochemical and nutritional studies on raw and parboiled Rice it was reported by Qudrat-i-Khuda, De and coworkers [1,2,3], that the improved storage characteristics of the parboiled rice are due to the inactivation of amylase, esterase and other enzymes and decreased absorption of atmospheric moisture etc., which would otherwise help in infestation by the microorganisms to cause fermentation, rancidity and off-odour production. Reports were also submitted [4,5] about the changes in the size of the paddy and rice due to parboiling treatment and in the starch constituents like amylose and amylopectin as evaluated by photomicrographic and spectrophotometric studies of their iodine complex. Since the size of the grain, starch constituents and other chemical and physical characteristics of rice grain play important roles in determining the culinary properties as reported in the literature [6-17] it was thought desirable to study the differential culinary properties of some varieties of raw and parboiled rice consumed in this region.

Rao *et al.*[7] in determining the culinary properties of some varieties of Indian rice reported that the swelling number denoting the water imbibition capacity during cooking is related with their amylose contents. Williams *et al.*[8] and Hogan *et al.*[9] noted that the short grain rice possessing less amylose fraction absorbed more water than the long grain varieties with the exception of Century Patna 231 which behaved like the medium grain varieties. Batcher *et al.*[10,11] could not find satisfactory relationship between grain size, water absorption and the starch loss in the gruel. Helick *et al.*[12] viewed that the above relationship between the amylose contents and the swelling number is not applicable for the evaluation of the culinary properties of the American varieties of rice. They rather showed that culinary property is related with the gelatinisation temperature which is independent of the amylose content of the grain.[13,14]

All the available reports point to show that there is still controversy about the factor or the factors in the rice grain which determine its culinary properties. Moreover all the work so far reported in the literature was based on the investigations on the raw (rough) rice which is generally consumed in those regions. But there is no literature about the changes in the culinary properties which the rice may undergo when it is prepared by parboiling of the paddy—a traditional process practiced for the preservation of paddy and rice in this region. The present report aims to submit some information on this.

Experimental

Thirteen varieties of rice—both raw and parboiled—were selected for the present investigation. Trial cooking showed that the raw rice samples took nearly 20 minutes on an average and the parboiled more than 30 minutes to make the cooked product soft and non-sticky without showing any bursting tendency. Systematic cooking experiments were then carried out by taking replicate samples of 25 g. of rice in 100 ml. distilled water in a 250 ml. flat bottom flask fitted with a ground-joint condenser. After preliminary soaking for 10 minutes in the above water in cold conditions the samples were boiled for the periods of 20 and 30 minutes specified for raw and parboiled rice respectively. After cooking, the product was cooled in the flask and the gruel was screened off until the last traces of water poured out of the cooked rice, and its volume was then measured.

Since the loss of cooking water by evaporation was avoided by fitting up the condenser, the rest of the water not appeared as gruel was considered as the quantity absorbed by the rice samples. From the above values of the volumes of water absorbed by 25 g. of rice, Water Absorption Ratio expressing the quantity of water absorbed by 100 g. of rice was then calculated, and average values of the replicate experiments are shown in Table 1.

In spite of larger volume of gruel, the parboiled rice lost less starch in the gruel than the raw one—the averages being 216 mg. and 241 mg. total starch in the gruel of 25 g. of parboiled and raw rice respectively. This combined effect of larger gruel volume with less starch content has effected greater decrease in the per ml. starch content in the gruel of the parboiled rice which showed the average value of 5.2 mg. against the higher value of 6.9 mg. per cc. of the gruel of raw rice.

Table 1.—Showing the Water Absorption Ratio, Quantity of Gruel Discarded, Total and per ml. Loss of Starch in Gruel due to Cooking of Raw and Parboiled Rice.

Name of the rice variety.	Length of the grain in mm. X.		Breadth of the grain in mm.*		Water absorption ratio		ml. of gruel discarded per 100 ml. of water per 25 g. rice.		Total starch in gruel in mg.		Starch per ml. gruel in mg.	
	Raw	Parboiled	Raw	Parboiled	Raw	Parboiled	Raw	Parboiled	Raw	Parboiled	Raw	Parboiled
Dharial ..	5.90	5.68	3.00	3.02	284	252	29	37	257	227	8.8	6.1
Khasia-Panja ..	6.58	6.38	2.83	2.86	280	240	30	40	255	212	8.5	5.3
Hashikalmi ..	6.01	5.95	2.53	2.56	272	240	32	40	230	192	7.2	4.8
Dular ..	7.0	6.9	2.48	2.55	272	248	32	38	205	177	6.4	4.6
Patnai ..	7.58	7.47	2.20	2.26	264	264	34	34	272	237	8.0	7.0
Dudsar ..	7.11	6.95	2.21	2.28	263	232	34.3	42	232	232	6.7	5.5
Kumari ..	6.84	6.56	2.20	2.24	256	232	36	42	267	245	7.4	5.8
Bhasamanik ..	6.82	6.56	2.20	2.24	256	228	36	43	245	225	6.8	5.2
Kataktara ..	6.36	6.20	2.15	2.25	252	222	37	44.6	235	228	6.3	5.1
Dholasaitha ..	6.63	6.47	2.17	2.20	252	236	37	41	228	165	6.1	4.1
Nigersail ..	5.48	5.36	2.08	2.13	252	220	37	45	252	235	6.0	5.2
Jhingasail ..	7.23	7.18	2.01	2.08	244	232	39	42	265	255	6.5	6.0
Badshabhog ..	4.40	4.26	1.96	2.0	240	196	40	51	195	175	4.9	3.4
Averages:-					260.5	234	34.9	41.5	241	216	6.9	5.2

*The values of length and breadth are quoted from the previous paper of the authors.[4]

The starch contents of the gruel was determined by the calcium chloride dispersion method as described in A.O.A.C. and previously followed by the authors in the determination of the starch contents of various tubers and roots.[19] The values are expressed as the total quantity in the gruel and also as per ml. content of the gruel.

Rice samples utilised in these expriments belong to similar varieties as were used in the previous experiments reported from these Laboratories[1] and these were prepared from the paddy according to the same technique as was followed there.

Results

The results of Table 1 show that Water Absorption Ratio of thirteen varieties of raw rice on cooking varied from 240 to 284. Under similar condition of cooking the parboiled rice samples showed lower range of the values from 196 to 264. Consequently the volume of gruel discarded was more in case of parboiled than in case of raw rice.

The effect of parboiling on the absorption of cooking water, loss of starch in the gruel and other aspects are more explicit from the values of Table 2 which show that 19.4 percent increase of the gruel volume and 10.3 percent decrease of the total starch content in the gruel due to cooking of parboiled rice effected a combined decrease of the per ml. starch to the extent of 24.6 percent.

From these tables it would further appear that the per ml. loss of starch in the gruel is dependent on the variety of rice, *e.g.*, the Patnai rice in the raw condition loses more starch in the gruel although the volume of the gruel in its parboiled and raw rice is the same (Table 1). This has ultimately resulted in a 12.5 percent increase of the per ml. starch loss in the gruel (Table 2). On the other side, in the case of the Dudsar variety where the total loss of starch in the gruel of both parboiled and raw rice is the same (232 mg.), as per Table 1 the loss of starch per c.c. gruel due to parboiling decreased by 17.8 percent because of the increase of the gruel volume by about 22.7 percent (Table 2

TABLE 2.—SHOWING THE CHANGE IN WATER ABSORPTION RATIO, QUANTITY OF GRUEL, TOTAL AND PER ML. LOSS OF STARCH IN GRUEL AS AFFECTED BY PARBOILING TREATMENT EXPRESSED AS PERCENTAGES OF RAW RICE VALUES.

Name of the variety of rice	Decrease of water Absorption Ratio		Increase of quantity of gruel		Decrease of starch in gruel		Decrease of per ml. starch in gruel	
	Total	As percent of raw rice value	Total in ml.	As percent of raw rice value	Total in mg.	As percent of raw rice value	Total in mg.	As percent of raw rice value
Dharial ..	32	11.2	8	27.5	30	11.6	2.7	30.6
Khasiapanja ..	40	14.3	10	33.3	43	16.8	3.2	36.4
Hashikalmi ..	32	11.8	8	25	38	16.5	2.4	33.3
Dular ..	24	11.7	6	20	28	13.6	1.8	28.2
Patnai ..	Nil	Nil	Nil	Nil	37	12.8	1.0	12.5
Dudsar ..	31	11.8	7.7	22.7	Nil	Nil	1.2	17.8
Kumari ..	24	9.3	6.0	16.6	22	8.2	1.6	21.7
Bhasamanik ..	28	10.9	7	19.4	20	8.0	1.6	23.5
Kataktara ..	30	11.9	7.6	20.5	7	2.9	1.2	19.5
Dholasaitha ..	16	6.3	4	10.8	63	27.6	2.0	32.8
Nigersail ..	32	12.7	8	21.5	17	6.7	0.8	13.3
Jhingasail ..	12	5.0	3	7.7	10	3.8	0.8	11.8
Badshabhog ..	44	17.1	11	27.5	20	10.2	1.4	30.0
Average:- ..	26.5	10.1	6.6	19.4	25	10.3	1.7	24.6

Thus the decrease of the per ml. starch loss in the gruel of parboiled rice with respect to the raw one is related with the volume of the gruel water discarded and the total loss of starch in the gruel—which are ultimately associated with the rheological characters of the paddy from which the raw and parboiled rice are prepared.

Discussion

In order to define the culinary properties in relation to size of the grain as has been viewed by previous workers,[7-9] the values of the length and the breadth of the different varieties of raw and parboiled rice as were previously reported by Qudrat-i-Khuda, De and Rahman[4] are reproduced in four separate columns in Table 1.

A comparative study of these sizes with the Water Absorption Ratio values shows that the grains of the four varieties like Dharial, Khasiapanja, Hashikalmi and Dular having higher ranges of breadth from 2.48 to 3.00 mm. tend to absorb more water than the other nine varieties having lower ranges of breadth varying from 1.96 to 2.20 mm. On the other hand raw Jhingasail and Badshabhog rice which, having two extreme lengths of 7.23 and 4.40 mm. respectively show almost equal values of the Water Absorption Ratios because of their almost equal size in respect of breadth of nearly 2 mm. Water Absorption Ratio thus seems to maintain direct relationship with the breadth of the grain rather with the length in an inverse manner as has been suggested by previous workers.[7-9]

It is also striking to note that the Patna variety raw rice having a maximum length of 7.58 mm. occupies fifth position in the order of the Water Absorption Ratio Values and this is because of its intermediate position with respect to its breadth size of 2.20 mm. Hogan *et al.*[9] also classified the Century Patna 231 rice under medium size grain with respect to its culinary properties and treated this as an "exception" to the reciprocal relationship between the length of the grain and the Water Absorption Ratio noted in other rice samples studied. But its position as a medium size grain is a "real" one and not an "exception" as viewed by Hogan *et al.*[9] when its Water Absorption Ratio is judged in relation to its breadth size discussed above.

The previous observations by De *et al.*[4] that parboiling of paddy effects an increase of the size towards the breadth and a decrease towards the length and by Deshikachar and Subramanyan[16] that during the cooking of old or new ricet here is more increase towards the breadth than towards the length further substantiate the fact that Water Absorption Ratio is related with the breadth rather than with the length of the grain.

In offering an explaination for the lower absorption of water during cooking of parboiled rice it may be argued that parboiling causes hardening of the surface of the grain by partial dextrinisation of the surface starch for which water penetration in, and the starch diffusion from the cell are lowered.

This may be the main cause behind the lower absorption of the atmospheric moisture by parboiled rice samples as compared to the raw ones when these are stored at ordinary room temperature for a year as previously observed by De and Hussein.[3] Similar view was also expressed by Deshikachar and Subramanyan [9] that storage of the rice grain causes similar hardening of the surface. But their view was not substantiated by the findings of more water absorption by stored old rice, though they agreed that old rice by soaking in ordinary water absorbs less water than the new one. Greater sweling volume, *i.e.*, the bulk density due to cooking of old rice as has been observed by them may be due to less moisture content of the old rice for which weight for weight old rice had more moisture free solid material which ultimately showed increased weight and volume.

Decrease in the autoamylolytic activity of the parboiled rice as has been reported previously by Qudrat-i-Khuda, De and Debnath[1] may be one of the factors for less starch loss in the gruel of parboiled rice. This fairly agrees with the views of Sreenivasan[20] that the lowering of the amylase activity of the stored rice is a factor responsible for the improvement of its cooking characteristics. But the persistent loss of starch in both raw and parboiled rice as noted even after the complete inactivation of amylase due to long heat treatment as applied in the cooking process further shows that in addition to amylase activity other factor or factors are also perhaps related in the cooking characteristics of rice. Similar view has also been expressed by Deshikacher and Subhramanyan.[16]

The findings reported in this communications are based on raw and parboiled samples prepared in the laboratories. Since the traditional processes adopted in this region are not based on any standard technique it is reasonable to think that the culinary properties of the different varieties as are sold in the market in the raw and parboiled condition may differ considerably because of the involvement of various variables in the processing operations. The results of some of the market samples will be communicated in due course to indicate the differences in the culinary properties as influenced by the various processing factors.

After the completion of this work the authors came across a communication by Kurien *et al.*[22] about the swelling quality of two varieties of parboiled rice in which they showed that for the same period of cooking, water absorption capacities were less in case of parboiled rice as compared to those of the raw ones although for the same degree of softness parboiled rice are reported to absorb more water than the raw ones. They also viewed that swelling numbers were more closely related with the expansion towards the breadth as has been noted in the present investigation also.

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