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Changes in total minerals and their HCl extractabilities in rice varieties as affected by cooking methods

SUMAN AND PINKY BOORA

The study examined the effect of four cooking methods on total minerals and their HCl extractabilities among rice varieties. The cooking led to a significant ($p<0.05$) decrease in total mineral contents (calcium, phosphorus, magnesium, iron and zinc) in rice upon cooking by all methods, while HCl extractability of minerals in cooked rice increased significantly in comparison to raw rice. The differences among various cooking methods were not significant for calcium, magnesium and zinc contents as well as for HCl extractability of calcium and zinc. The ordinary cooked rice samples had significantly ($P<0.05$) lower phosphorus and iron contents than the rice cooked by other methods which did not differ significantly to each other. Pressure, microwave and solar cooked rice samples had similar HCl extractability of phosphorus and magnesium, whereas, HCl extractability of iron was significantly higher in solar cooked than ordinary and pressure cooked rice samples.

Key Words : Minerals, HCl extractability, Rice, Cooking methods

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INTRODUCTION

Micronutrient malnutrition affects more 2 billion people currently and the number is increasing. Mineral elements play a vital role in metabolism and maintenance of tissue function. Rice serves as staple food for more than half of the world's population and has great nutritional value in human life. It is considered as the grain of life and is synonymous with food for Asians as it supplies majority of starch, protein and micronutrient requirements. The ability of cereals to supply dietary micronutrients largely depends on their concentrations and bioavailability in the grain. Rice is the only cereal crop cooked and consumed mainly as whole grains, and quality considerations are much more important than for any other food crop. Rice is generally cooked by washing and boiling in water, which leads to loss of some nutrients. The most commonly used domestic cooking methods include ordinary and pressure cooking. The increase in two-working person households has increased the demand for foods that can be rapidly prepared. As a result, microwave ovens in households have increased. A country where plenty of sunshine is available, solar cooker serves as an alternative method to routine cooking methods. With this prospect, an attempt has been made to find out the effects of different cooking methods on the level of total minerals and their HCl extractabilities in six rice varieties.

METHODOLOGY

Six varieties namely Improved Pusa Basmati-I,

MEMBERS OF RESEARCH FORUM

Author for correspondence :
SUMAN, Department of Food and Nutrition, C.C.S. Haryana Agricultural University, HISAR (HARYANA) INDIA
Email : sumanambawato3@yahoo.com

Associate Authors' :
PINKY BOORA, Department of Food and Nutrition, C.C.S. Haryana Agricultural University, HISAR (HARYANA) INDIA

Taraori Basmati (HBC 19) and CSR 30 of basmati and HKR 47, HKR 127 and IRBB 60 of coarse rice were procured in a single lot from Rice Research Station, Kaul (District Kaithal), C.C.S. Haryana Agricultural University, Hisar. The paddy seeds were dehulled, polished, cleaned, made free of dust, dirt and foreign materials and packed in air tight containers at room temperature prior to cooking.

Cooking of rice :

All the six rice varieties were cleaned, washed twice and soaked for 30 minutes in distilled water prior to cooking with ordinary, pressure, microwave and solar cooking methods. Cooking time and water uptake for individual rice samples were standardized. For ordinary cooking, rice grains were cooked in a sauce pan covered with lid using seed to water ratio as 1:2.5 w/v. Whereas, seed to water ratio was 1:2 w/v, 1:2.5 w/v and 1:2 w/v for pressure, microwave and solar cooking, respectively. The pressure cooker was made up of aluminium (capacity 3 L of Hawkins Model). Microwave cooking was done in a rectangular glass tray with a lid by using high power in a microwave oven (Model INALSA-ED8525S-A, 2450 MHz, 1450 watts). Solar cooking was carried out on a bright sunny day in mid of April in a solar cooker (Model Beco, The Bharath Engg. Co.WZ-1, Phool Bagh Rampura Delhi, India). The direction of mirror was set in such a way that sun rays fell directly on it.

Preparation of cooked samples for analysis :

For chemical analysis, all the cooked rice samples were dried in hot air oven at 55-60^{0}C to a constant weight, ground in an electric grinder (cyclotec, M/S Tecator, Hoganas, Sweeden using 0.5 mm sieve size) to fine powder and packed in air tight containers at room temperature. Respective raw samples of all the rice varieties were also analysed for comparision.

Chemical analysis :

For total minerals the samples were wet acid digested using diacid mixture (HNO_3: $HClO_4$:: 5:1, v/v) and calcium, iron, magnesium and zinc in acid digested samples were determined by Atomic absorption spectrophotometer according to the method of Lindsey and Norwell (1969) while phosphorus in acid digested samples was determined colorimetrically by using the method of Chen *et al.* (1956). For HCl extractabilities of minerals the samples were extracted in 0.03 N HCl (Peterson, 1943) and wet acid digested with nitric acid and perchloric acid mixture (5:1, v/v). The amount of HCl extractable minerals in the digested samples were determined by the methods described for estimation of total minerals.

Statistical analysis :

Values obtained are mean and standard error of three independent determinations. Statistical analysis of the obtained data was carried out using Completely Randomized Design according to the standard method (Panse and Sukhatme, 1961) to find the level of significant differences due to cooking and among cooking methods by OPSTAT software C.C.S. Haryan Agricultural University, Hisar.

OBSERVATIONS AND ASSESSMENT

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Total minerals :

The data on total mineral composition of various rice varieties as influenced by different cooking methods have been presented in Tables 1 and 2. Cooking brought about a significant ($P<0.05$) decrease in calcium, phosphorus, magnesium, iron and zinc content as compared to uncooked samples. The per cent decrease ranged from 16.7 to 22.2 for calcium, 24.7 to 29.2 for phosphorus, 11.2 to 15.0 for magnesium, 23.2 to 31.2 for iron and 12.5 to 15.3 for zinc under various cooking methods. However, among cooking methods, the differences were non-significant for calcium, magnesium and zinc content, whereas, phosphorus and iron contents were significantly ($P<0.05$) lower in ordinary cooking as compared to pressure, microwave and solar cooking method which were at par to each other. Similar results were reported by Khatoon and Prakash (2006) with significantly lower content of Ca (6.0 to 44.0%), P (24.0 to 44.0%) and Fe (33.0 to 50.0%) of rice varieties after cooking as compared to uncooked samples, though there was no significant difference between the microwave and pressure cooking methods. Noreen *et al.* (2009) reported significant loss in P content (50.2%) of rice upon cooking as a result of solubilization in water, but loss of Zn content was 13.1 per cent after cooking. Ebuehi and Oyewole

(2007) reported comparatively lesser loss of Ca, Fe and P and higher loss of Mg than the results of the present study. The losses incurred in the study might be attributed to the combined effect of washing and cooking as the samples were washed prior to soaking which was a pre-requisite for cooking. Shekib *et al*. (1985) reported considerable loss of minerals *i.e.* 40.3, 23.1, 25.7, 39.4 per cent for Ca, P, Fe and Zn, respectively as a result of cooking and leaching out of minerals during washing. Cheigh *et al*. (1982) also reported a loss of 22 per cent for Ca and Fe due to the washing and cooking of the rice. Losses from washing and cooking methods used in India were calculated as 75 per cent for Fe and 50 per cent for Ca and P (Grist, 1986).

The calcium content in variety CSR 30 and HKR 47, magnesium in HKR 127, iron in Taraori Basmati and zinc in Taraori Basmati and Improved Pusa Basmati-I were significantly (P<0.05) higher as compared to other varieties after cooking. Phosphorus content in variety Taraori Basmati and CSR 30 was significantly lower than coarse rice varieties after cooking. Abbas *et al.* (2010) also reported significant differences in mineral content among varieties after cooking of rice.

HCl extractability of minerals :

The data on HCl extractability of minerals of various rice varieties as influenced by different cooking methods have been presented in Table 3 for calcium, phosphorus and magnesium and in Table 4 for iron and zinc. The HCl extractability under various cooking methods improved significantly (P<0.05) by 19.0 to 24.1 for calcium, 12.7 to 17.3 for phosphorus, 13.1 to 17.8 for

Table 1: Effect of cooking methods on total calcium, phosphorus and magnesium contents (mg/100 g) of rice varieties (on dry wt. basis)

Variety	Raw	Cooking methods				
		Ordinary	Pressure	Microwave	Solar	Mean
Total calcium						
IPB-I	14.92±0.18	11.95±0.41	12.15±0.46	12.45±0.77	12.75±0.38	12.33
TB	14.62±0.09	11.75±0.48	12.25±0.36	12.50±0.42	12.70±0.42	12.30
CSR 30	16.05±0.15	12.70±0.42	13.15±0.60	13.40±0.31	13.65±0.52	13.22
HKR 47	16.65±0.18	12.60±0.85	12.95±0.41	13.13±0.81	13.45±0.39	13.03
HKR 127	15.30±0.15	11.70±0.43	12.05±0.51	12.20±0.90	12.45±0.41	12.10
IRBB 60	14.85±0.12	11.20±0.50	11.50±0.43	11.80±0.74	12.00±0.43	11.63
Mean	15.40	11.98	12.34	12.58	12.83	
CD (P≤0.05) Variety 0.77 Raw v/s Method 0.57 Method NS Interaction NS						
Total phosphorus						
IPB-I	169.26±1.2	120.18±1.8	125.78±1.9	126.40±1.8	127.85±1.8	125.05
TB	166.75±1.3	118.45±1.9	124.28±1.9	124.85±2.3	126.02±1.8	123.40
CSR 30	165.44±1.2	117.33±1.7	123.34±1.9	123.70±1.9	125.08±2.3	122.36
HKR 47	172.88±1.2	121.95±1.6	127.65±1.8	128.31±1.6	129.65±2.0	126.89
HKR 127	174.08±1.2	122.85±1.7	128.75±1.8	129.36±1.5	130.47±1.7	127.86
IRBB 60	171.25±1.1	121.15±1.7	126.76±1.7	127.68±1.7	128.73±2.0	126.08
Mean	169.94	120.32	126.09	126.72	127.97	
CD (P≤0.05) Variety 2.61 Raw v/s Method 1.99 Method 2.13 Interaction NS						
Total magnesium						
IPB-I	49.75±0.20	42.26±0.73	43.06±1.02	43.84±1.47	44.23±1.28	43.35
TB	49.21±0.54	41.84±1.11	42.54±1.42	43.28±1.14	44.09±1.38	42.94
CSR 30	48.60±0.50	41.39±1.44	42.10±1.64	42.16±1.09	43.36±1.12	42.25
HKR 47	51.62±0.21	43.74±1.44	44.06±1.19	44.28±1.30	45.54±1.28	44.40
HKR 127	52.24±0.14	44.80±1.14	45.66±1.07	45.82±0.90	46.06±0.88	45.58
IRBB 60	46.91±0.19	39.46±0.74	40.22±1.09	41.12±0.99	41.58±0.86	40.60
Mean	49.72	42.25	42.94	43.42	44.14	
CD (P≤0.05) Variety 1.68 Raw v/s Method 1.23 Method NS Interaction NS						

Values are mean ± SE of three independent determinations
IPB-I - Improved Pusa Basmati-I and TB - Taraori Basmati

Table 2 : Effect of cooking methods on total iron and zinc contents (mg/100 g) of rice varieties (on dry wt. basis)

Variety	Raw	Cooking methods				
		Ordinary	Pressure	Microwave	Solar	Mean
Total iron						
IPB-I	2.41±0.02	1.70±0.06	1.84±0.05	1.87±0.06	1.90±0.03	1.83
TB	2.57±0.02	1.82±0.04	1.96±0.06	1.94±0.04	1.97±0.02	1.92
CSR 30	2.17±0.01	1.44±0.03	1.58±0.04	1.62±0.04	1.65±0.08	1.57
HKR 47	2.31±0.01	1.58±0.03	1.71±0.05	1.74±0.07	1.77±0.04	1.70
HKR 127	2.37±0.01	1.64±0.04	1.75±0.04	1.80±0.06	1.83±0.05	1.75
IRBB 60	2.37±0.03	1.60±0.06	1.74±0.07	1.78±0.02	1.80±0.07	1.73
Mean	2.37	1.63	1.76	1.79	1.82	
CD (P≤0.05) Variety 0.07 Raw v/s Method 0.05 Method 0.06 Interaction NS						
Total zinc						
IPB-I	1.55±0.03	1.32±0.03	1.33±0.03	1.33±0.03	1.35±0.03	1.33
TB	1.59±0.04	1.36±0.02	1.38±0.03	1.38±0.02	1.39±0.02	1.38
CSR 30	1.50±0.02	1.26±0.02	1.30±0.03	1.28±0.03	1.31±0.03	1.29
HKR 47	1.35±0.01	1.16±0.03	1.20±0.02	1.19±0.05	1.20±0.02	1.19
HKR 127	1.33±0.02	1.13±0.04	1.15±0.03	1.15±0.03	1.16±0.04	1.15
IRBB 60	1.30±0.03	1.11±0.03	1.13±0.02	1.14±0.04	1.15±0.04	1.13
Mean	1.44	1.22	1.25	1.25	1.26	
CD (P≤0.05) Variety 0.04 Raw v/s Method 0.04 Method NS Interaction NS						

Values are mean ± SE of three independent determinations

Table 3 : Effect of cooking methods on HCl extractability (%) of calcium, phosphorus and magnesium in rice varieties (on dry wt. basis)

Variety	Raw	Cooking methods				
		Ordinary	Pressure	Microwave	Solar	Mean
HCl extractability of calcium						
IPB-I	37.41±0.52	44.62±1.12	45.31±1.10	46.60±1.07	45.53±1.43	45.52
TB	39.21±0.18	47.00±1.06	47.17±1.45	48.58±1.11	47.67±1.10	47.60
CSR 30	39.39±0.33	45.82±1.11	46.16±1.25	47.97±1.45	46.84±1.08	46.70
HKR 47	41.23±0.51	49.57±1.70	49.79±1.12	51.72±1.09	50.14±1.10	50.30
HKR 127	37.02±0.33	43.61±1.35	44.63±1.43	45.76±1.10	44.74±1.49	44.68
IRBB 60	37.89±0.52	45.73±1.49	46.01±1.48	47.42±1.32	46.58±1.12	46.44
Mean	38.69	46.06	46.51	48.01	46.92	
CD (P≤0.05) Variety 1.80 Raw v/s Method 1.33 Method NS Interaction NS						
HCl extractability of phosphorus						
IPB-I	54.90±0.45	60.04±1.14	61.95±0.90	62.10±0.84	62.38±1.36	61.62
TB	52.64±0.34	58.95±0.97	61.42±1.28	61.69±1.29	61.95±0.86	61.00
CSR 30	49.28±0.54	55.73±1.21	57.06±0.64	57.71±1.25	58.10±0.88	55.15
HKR 47	54.45±0.53	62.64±0.90	64.26±1.10	65.45±1.24	65.13±0.54	64.37
HKR 127	56.60±0.51	64.23±0.58	65.84±1.24	66.12±1.13	66.42±1.10	65.65
IRBB 60	54.18±0.41	61.45±1.26	62.89±0.69	64.02±1.04	63.74±0.78	63.02
Mean	53.68	60.51	62.24	62.85	62.95	
CD (P≤0.05) Variety 1.47 Raw v/s Method 1.10 Method 1.20 Interaction NS						
HCl extractability of magnesium						
IPB-I	60.56±0.31	68.12±1.51	69.90±1.70	71.20±1.47	71.30±1.55	70.13
TB	60.80±0.62	68.81±2.05	70.66±1.69	71.82±1.50	71.46±1.73	70.69
CSR 30	59.24±0.55	66.58±2.09	68.38±1.49	69.54±1.80	69.40±1.72	68.48
HKR 47	61.10±0.63	70.02±1.54	71.25±1.77	72.40±1.52	72.68±1.34	71.59
HKR 127	59.30±0.17	65.76±1.50	67.25±1.69	68.92±1.71	69.02±1.20	67.74
IRBB 60	57.75±0.56	66.38±1.68	67.82±1.50	68.64±1.71	68.86±1.72	67.92
Mean	59.79	67.61	69.21	70.42	70.45	
CD (P≤0.05) Variety 2.34 Raw v/s Method 1.72 Method 1.91 Interaction NS						

Values are mean ± SE of three independent determinations

Table 4 : Effect of cooking methods on HCl extractability (%) of iron and zinc in rice varieties (on dry wt. basis)

Variety	Raw	Cooking methods				
		Ordinary	Pressure	Microwave	Solar	Mean
HCl extractability of iron						
IPB-I	61.98±1.11	71.59±0.71	71.93±0.70	72.63±0.85	73.66±0.69	72.45
TB	62.39±1.36	72.63±0.88	72.77±0.68	73.32±0.88	75.25±0.24	73.49
CSR 30	53.81±0.88	62.11±1.05	61.84±0.72	63.36±0.71	62.66±0.94	62.49
HKR 47	58.93±0.82	67.78±0.72	68.62±0.89	68.89±1.32	70.21±0.69	68.87
HKR 127	58.38±0.75	70.69±0.92	70.89±0.83	71.52±0.33	72.63±0.77	71.43
IRBB 60	58.45±0.73	66.54±0.99	67.79±1.20	67.92±1.02	68.00±0.52	67.56
Mean	58.99	68.56	68.97	69.61	70.40	
CD (P≤0.05) Variety 1.19 Raw v/s Method 1.00 Method 0.97 Interaction NS						
HCl extractability of zinc						
IPB-I	26.03±0.53	28.35±0.69	29.14±0.65	29.36±0.78	29.08±0.53	28.98
TB	26.46±0.24	28.66±0.69	29.33±0.38	29.25±0.71	29.42±0.75	29.17
CSR 30	25.60±0.18	27.96±0.17	28.68±0.40	28.89±0.16	28.76±0.17	28.57
HKR 47	25.80±0.09	28.14±0.66	28.92±0.14	29.02±0.66	28.88±0.66	28.74
HKR 127	24.92±0.28	27.76±0.16	28.30±0.73	28.25±0.55	28.46±0.79	28.19
IRBB 60	23.45±0.16	26.52±0.67	26.90±0.62	27.10±0.14	26.88±0.16	26.85
Mean	25.38	27.90	28.55	28.65	28.58	
CD (P≤0.05) Variety 0.79 Raw v/s Method 0.59 Method NS Interaction NS						

Values are mean ± SE of three independent determinations

magnesium, 16.2 to 19.3 for iron and 9.9 to 12.9 per cent for zinc as compared to uncooked samples. HCl extractability of calcium and zinc did not differ significantly (P<0.05) among various cooking methods. The HCl extractability of phosphorus and magnesium under pressure, microwave and solar cooking and iron under microwave and solar cooking were almost similar and higher than ordinary method of cooking. HCl extractability of calcium in variety HKR 47, phosphorus in HKR 127, magnesium in HKR 47, Taraori Basmati and Improved Pusa Basmati-I, iron in Taraori Basmati, Improved Pusa Basmati-I and HKR 127, and zinc in Taraori Basmati, Improved Pusa Basmati-I and HKR 47 was significantly higher than other varieties after cooking. Increase in HCl extractability of minerals (Ca, Fe and Zn) have been reported in other crops by pressure, microwave and solar cooking methods by Pasrija (1998) and Negi (1999) as compared to uncooked samples. The lower mineral extractability of raw samples may be because minerals are generally bound with phytic acid and can be reduced in appreciable amount by different cooking methods (Noreen *et al.*, 2009). According to Gasim *et al*. (2008) the reduction in the level of phytic acid by cooking was effective in improving the HCl-extractability of minerals.

Conclusion:

It may be concluded from the present study that cooking by different methods had significant effects on total and HCl extractable minerals among rice samples. HCl extractability of minerals is an index of bioavailability of minerals. Therefore, bioavailability of minerals was significantly higher in pressure, microwave and solar cooking methods compared to ordinary cooking.

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