EFFECT OF ADDING BROKEN RICE FLOUR ON THE PHYSICAL AND CHEMICAL PROPERTIES OF BREAD

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Introduction

There are excess amounts of broken rice in Egypt, which is a by-product in rice mills [10]. It is possible to substitute broken rice flour or rice flour for part of wheat flour [25].

Starch is the principal constituent of rice. The polished rice contains only traces of reducing, and only small amounts of non-reducing sugars (1). Milled rice or rice flour contains much less protein than does wheat flour [29, 30]. The low protein and high starch content of rice flour are significant factors, governing the qualities of the flour because they depend upon the protein, starch, and protein–starch interaction [22]. The indispensable amino acids are present in rice protein with various concentrations [29].

The wheat–rice bread can substitute common wheat bread without diminishing the organoleptic qualities and the nutritional value expected in good wholesome bread with 30% rice flour replacing wheat flour [25, 28].

This study was carried out in order to find out the possibilities of partially substituting wheat flour by broken rice flour in making bread.

Materials and Methods

Materials

Wheat Triticum vulgare variety Giza 155 and broken rice grains Oryza sativa, L. were used in this study. Wheat grains were obtained from Assiut University farm. The broken rice grains, by-products of rice milling, were obtained from rice mills.

Methods

The flour milling, flour mixing, and bread making procedures; sampling, and methods of physical, chemical and organoleptic analysis of flours and breads are similar to those presented earlier [27], except that the straight flour products from rice where used directly.

* Based on a research program at the Department of Biochemistry and Food Technology, Technical University, Budapest.

Results and discussion

1. *Physical properties of wheat–rice doughs*

Table 1 presents data of wet and dry gluten, sedimentation value, farinography and extensography for wheat flour and wheat–rice flour mixtures.

Table 1

Physical properties of wheat flour and wheat–rice flour mixtures (Referring to 14% moisture)

Physical tests* \ Rice flour % (w/w)	00	20	30	40
Gluten				
a) Wet	30.86	23.35	18.75	16.78
b) Dry	12.18	9.28	7.51	7.03
Sedimentation value	18.9	10.4	8.4	0.65
Farinograph results				
a) Water absorption (%)	63.7	65.6	67.8	69.8
b) Mixing time (min)	2.50	2.50	2.00	2.50
c) Stability (min)	1.50	1.25	1.50	1.75
d) Weakening (B. U.)	100	120	140	140
e) Valorimeter number	51	44	40	42
Extensograph results				
a) Energy (cm^2)	61.30	38.40	34.40	30.80
b) Resistance to extension (B. U.)	240	250	250	270
c) Extensibility (mm)	156	110	99	85
d) Proportional number	1.54	2.27	2.52	3.17

* The results are averages from two samples and the tests were done in duplicate

The wet dry gluten as well as the sedimentation value of the flour mixtures were markedly lower than those for wheat flour. The percentage of wet and dry gluten, and the sedimentation value of the flour mixtures gradually decreased as the amount of rice flour increased. Generally, the influence of rice flour on the physical properties of wheat flour might be due to the dilution of wheat flour gluten as well as to changes in gluten and protein properties. PINCKNEY et al. [24] found a high significant positive correlation between sedimentation value and both protein content and gluten quality of flour.

Farinography showed a higher water absorptivity of the flour mixture than of wheat flour. This value gradually decreased as the percentage of rice flour increased. The addition of rice flour to wheat flour did not noticeably change the mixing time or the stability period. The mixing time indicates the time required to form stable dough, while stability is an important index for the strength of the flour.

The weakening value of the wheat dough was slightly lower than those of doughs made from wheat–rice flour mixtures. These values, which indicate the loss of dough structure, increased as the amounts of rice flour present in the flour mixtures increased. The valorimeter number which summarizes the farinography data indicated a strength decrease of wheat dough mixed with increasing quantities of rice flour. These observations could be attributed to the low protein and high starch content of rice flour [15, 16, 22, 31].

The extensograph results revealed that the dough energy and extensibility gradually and markedly decreased as the amount of wheat flour in the mixtures decreased. The flour mixtures had more or less the same resistance to extension as had wheat flour. The proportional number of the wheat flour gradually but markedly increased by increasing the rice–wheat ratio in the flour mixtures. These changes probably resulted from rice flour increasing the distance between gluten particles preventing the formation of regular gluten network, in addition to the competition between rice flour and gluten for water.

2. *Gross chemical composition of wheat–rice flour mixtures*

Table 2 shows moisture, fat (ether extract), crude protein, starch, reducing and non-reducing sugars, crude fibers, ash, calcium and phytic acid phosphorus present in wheat and rice flour as well as their mixtures. These chemical constituents were calculated on dry weight of solids basis.

The crude fat and crude protein present in rice flour were between two thirds and one half of those in wheat flour. The percentage of these two major constituents gradually and markedly decreased in the flour mixtures as the rice–wheat ratio increased. These results are in general agreement with those reported before [17, 21, 22, 29, 30].

The starch content of rice flour was noticeably higher than that of wheat flour, rice flour contained less reducing sugars and much less non-reducing sugars than wheat flour. As the rice flour in the flour mixtures increased their starch gradually and markedly increased, but their sugars gradually and markedly decreased. These findings are due to the fact that the starch is the principal chemical constituent of the polished rice and it contains only trace amounts of reducing sugar and small quantities of non-reducing sugar [12, 22, 28, 29, 30].

Table 2

Gross chemical composition of wheat, rice flours and wheat–rice flour mixtures
(Calculated on dry weight basis)

Constituents* \ Rice flour % (w/w)	00	20	30	40	100
Moisture (%)	10.43	10.77	10.83	11.05	11.58
Crude fat (%)	1.25	1.13	1.10	1.05	0.80
Crude protein (%)	12.35	11.37	10.98	10.51	6.97
Starch (%)	77.58	79.42	81.86	83.53	87.49
Reducing sugars (%)	0.49	0.40	0.40	0.34	0.28
Non-reducing sugars (%)	1.68	2.28	2.02	1.96	0.38
Crude fiber (%)	0.42	0.40	0.38	0.32	0.25
Ash (%)	1.34	1.10	1.07	0.97	0.95
Calcium (mg/100 g)	26.45	24.42	21.71	20.15	18.18
Phytic acid phosphorus (mg/100 g)	128.12	106.12	92.65	87.28	51.82

* The results are averages from two samples and the tests were made in duplicate

Rice flour contained markedly lower percentage of crude fiber and ash than wheat flour. Partial replacement of wheat flour with rice flour gradually and pronouncedly increased its crude fiber and ash. These results are in general agreements with those reported before [12, 17, 30].

Wheat flour contained much more calcium and phytic acid than rice flour. The addition in increasing amounts of rice flour to wheat flour gradually and markedly decreased their calcium and phytic acid contents. The calcium and phytic acid results may be due to the correlation of calcium and phytic acid to ash and crude fiber [9].

Generally, these changes in the chemical composition of wheat flour after mixing with rice flour can be attributed to the variations in the chemical composition of wheat and rice flours.

3. *The indispensable (essential) amino acids of wheat and rice flour*

The concentration of indispensable amino acids in the protein hydrolyzates of wheat and rice flour as well as their mixtures appears in Table 3. Their concentrations were calculated as percentage of protein.

Table 3

The indispensable (essential) amino acids of wheat, rice flours, and wheat–rice flour mixtures
(Percentage of protein)

Rice flour % (w/w) / Amino acids*	00	20	30	40	100
Arginine	3.95	3.84	3.52	3.00	2.00
Histidine	2.21	2.22	2.23	2.23	2.25
Leucine + isoleucine	14.07	13.47	12.24	11.77	10.30
Lysine	2.49	2.51	2.58	2.61	2.73
Methionine	1.13	1.15	1.19	1.24	1.40
Phenylalanine	4.50	4.45	4.37	4.23	3.64
Threonine	2.91	2.87	2.83	2.78	2.71
Tryptophan	1.03	0.89	0.81	0.75	0.40
Valine	4.67	4.16	4.07	3.84	2.98

* The results are averages from two samples and the tests were made in duplicate

The data indicated that the ten tested indispensable amino acids were present in the protein of these flours, but in variable concentration. These variations may be due to the kind of cereal grains flour as well as to the concentration and the kinds of protein in these flours. These findings were reported earlier [18, 20, 29]. The biological value of the flour proteins also depends upon the number and quantity of the indispensable amino acids contained. The protein of wheat flour was found to contain the following amino acids in decreasing order: leucine–isoleucine mixture, valine, phenylalanine, arginine, threonine, lysine, histidine, methionine, and tryptophan. This order became in the rice flour protein leucine–isoleucine mixture, phenylalanine, valine, threonine, lysine, histidine, arginine, methionine and tryptophan.

The concentration of all tested amino acids was higher in wheat flour protein than in rice flour protein except that of lysine and methionine which were less and histidine which was almost the same.

Addition of increasing amounts of rice flour to wheat flour slightly and gradually decreased the quantities of phenylalanine and threonine in the flour proteins. The mixing had no effect on the flour's histidine. Partial replacements of wheat flour with rice flour gradually but markedly decreased its content of leucine–isoleucine mixture, lysine, tryptophan and valine but it gradually and markedly increased its methionine. These may be due to the different amino acid concentrations in these two flours.

4. *Gross chemical composition of breads*

The moisture, crude fat, crude protein, starch, reducing and non-reducing sugars, crude fiber, ash, calcium and phytic acid phosphorus present in the Baladi bread made from wheat flour and wheat–rice flour mixtures are tabulated in Table 4.

Table 4

Gross chemical composition of Baladi bread made from wheat flour and wheat–rice flour mixtures (Referred to dry weight basis)

Constituents* \ Rice flour % (w/w)	00	20	30	40
Moisture	33.50	40.64	42.27	42.96
Crude fat	0.62	0.58	0.56	0.52
Crude protein	12.96	11.50	11.19	10.72
Starch	73.57	74.58	76.09	77.40
Reducing sugars	1.66	3.67	3.92	4.25
Non-reducing sugars	1.19	1.14	1.00	0.34
Crude fiber	0.79	0.78	0.69	0.62
Ash	1.71	1.67	1.61	1.52
Calcium (mg/100 g)	30.35	29.16	27.55	24.02
Phytic acid phosphorus (mg/100 g)	77.50	57.30	52.51	50.30

* The results are averages of two samples and the tests were made in duplicate

The chemical composition of the bread reflected that of the flour from which it was made, in addition to the changes that might occur during the baking process.

The data indicated that the wheat–rice breads had higher percentage of water than had wheat bread. The moisture content of the bread gradually increased as the amount of rice flour increased in the flour mixtures.

Generally, bread was found to contain less crude fat than the flour. This might be due to extraction of most of flour lipids by the fat solvent and difficulties of extraction of bread lipids because they became tightly bound with bread proteins [19]. Gradual substitution of wheat flour with rice flour gradually decreased the crude fat detected in the bread.

The protein content of bread was slightly higher than that of the flour from which it was made. This could be attributed to the presence of bran which

coated the loaf bottom [17, 26]. Increasing additions of rice flour to wheat flour caused gradual but slight decreases in the bread protein.

The starch and non-reducing sugars of the bread were markedly lower, while the reducing sugars were pronouncedly higher than those of the flour of which the bread was made. The decrease in the bread starch might be due to the degradation in the flour resulting from the diastatic action during fermentation [6, 26]. The decrease in non-reducing sugars of bread might be caused by yeast fermentation before enzymatic formation of maltose [3, 17]. The increase in the reducing sugars of bread might result from conversion of starch to glucose [6].

Addition of increasing quantities of rice flour to wheat flour caused gradual increase in the bread starch and reducing sugars but caused gradual decrease in its non-reducing sugars.

The crude fiber and ash present in the bread were noticeably higher than those in the flour. The increase in the crude fiber was due to the presence of the bran, while the ash increase was attributed to sodium chloride added to the flour during the preparation of the dough and to the bran [17]. Addition of increasing amounts of rice flour to wheat flour slightly and gradually reduced the bread crude fiber and ash.

The bread had more calcium but less phytic acid than flour. The high calcium content of the bread might be due to the presence of bran, but the low phytic acid content resulted from the destruction of this compound by phytase during fermentation and baking processes [14, 17, 23, 26]. Mixing the wheat flour with increasing quantities of rice flour gradually and markedly decreased the calcium and phytic acid contents of the bread.

5. *The indispensable (essential) amino acids in breads*

The concentration of indispensable amino acids in the proteins of Baladi bread made from wheat flour and wheat–rice flour mixtures are illustrated in Table 5.

The indispensable amino acids present in the flour were qualitatively and quantitatively determined in the breads in order to follow changes likely to occur during the baking process. Generally, the amino acid composition of bread reflected that of the flour from which it was made, aside than the losses during baking processes.

The concentrations of these amino acids in wheat bread protein followed the decreasing order: leucine–isoleucine mixture, valine, phenylalanine, arginine, threonine, histidine, lysine, methionine, and tryptophan. This order in the wheat-rice bread protein changed to leucine–isoleucine mixture, phenylalanine, valine, arginine, threonine, lysine, histidine, methionine and tryptophan.

Table 5

The indispensable (essential) amino acids of Baladi bread made from wheat flour and wheat–rice flour mixtures

(Percentage of protein)

Amino acids* \ Rice flour % (w/w)	00	20	30	40
Arginine	2.87	2.63	2.41	1.97
Histidine	1.72	1.70	1.64	1.62
Leucine + isoleucine	12.89	12.00	11.31	10.66
Lysine	1.69	1.62	1.65	1.65
Methionine	0.83	0.87	0.91	0.94
Phenylalanine	3.72	3.63	3.47	3.31
Threonine	2.45	2.38	2.33	2.25
Tryptophan	0.74	0.55	0.48	0.35
Valine	4.06	3.52	3.41	3.15

* The results are averages from two samples and the tests were made in duplicate

The data revealed that all the indispensable amino acids decreased during baking, but to different degrees. The losses in lysine, tryptophan, methionine, arginine, histidine, threonine, and phenylalanine were higher than that of the other amino acids. Lysine, tryptophane, methionine, histidine, threonine, and phenylalanine were involved in the browning reaction, while leucine–isoleucine mixture, and valine were not [7]. The losses of amino acids during baking affected mainly the crust proteins, attributed to Maillard-type reaction, i. e. the reaction of sugars with amino acids [2, 13].

The concentrations of arginine, leucine–isoleucine mixture, phenylalanine, tryptophan, and valine gradually and markedly decreased in the wheat-rice bread with increasing the percentage of rice flour, but methionine relatively increased. The other amino acids did not noticeably change. The variations in the concentration of these amino acids in the breads were due to their variations in the flours as well as to the quality and quantity of their proteins.

6. *The organoleptic qualities of breads*

The organoleptic qualities of wheat-flour bread and wheat-rice bread are shown in Table 6.

The bread loaves prepared from mixtures of wheat and rice flours were less in weight and smaller in volume than those made from wheat flour.

Table 6

The organoleptic qualities of fine bread made from wheat flour and wheat–rice flour mixtures

Qualities \ Rice flour % (w/w)	00	20	30	40
Baking results*				
a) Weight (g)	416	410	407	402
b) Volume (cm^3)	1120	990	920	850
c) Specific volume (cm^3/g)	2.70	2.41	2.26	2.11
Panel results (scores)**	10	10	9	8
a) Crust color (10)	10	10	9	8
b) Crumb color (10)	10	10	10	10
c) Grain cell structure (10)	10	7	6	3
d) Texture (10)	10	8	6	3
e) Flavor (10)	10	7	6	4
f) Odor (10)	10	9	9	7
Total	60	51	46	35

* The results are averages from two samples and one sample consisted of five loaves

** The results are averages from two samples. The samples were judged by ten testers

These changes became more noticeable as the amounts of rice flour mixed with wheat flour increased. The changes in the loaves volume are due to the changes in the quality and quantity of protein [4, 5, 8].

The color of crust and crumb of loaf was improved upon addition of rice flour. It became whiter and brighter. These effects might be due to variations in maltose present in flour [1, 11].

The bread made from wheat flour had good normal grain, excellent uniform cell structure, and fine texture. The grain of bread crumb prepared from wheat flour containing 20 or 30 per cent rice flour had coarse cell structure with large sound cell having thick cell walls. The grains became close upon using flour mixtures containing 40% rice flour and crumb texture was slumby and coarse. These changes were due to the low qualities and quantities of rice flour proteins.

The flavor and odor of wheat bread were ideal. All the wheat–rice breads had acceptable odor and flavor.

The organoleptic qualities of wheat-rice breads slightly but gradually deteriorated as the rice flour present increased.

Summary

The effect of adding broken rice flour on the physical and chemical properties of wheat bread, as well as the quantity of indispensable amino acids were studied. Wet and dry gluten content as well as sedimentation value of wheat flour decreased with increasing amount of additive, water absorption and dough weakening increased, energy and extensibility of wheat dough also decreased, and so did loaf volume and weight.

The results recommend mixing wheat flour with amounts up to 30% by weight with rice flour in making bread. These levels will not noticeably affect the nutritive value and organoleptic qualities of bread.

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