A STUDY ON THE EFFECT OF PARBOILING ON QUALITY CHARACTERS AND CHEMICAL COMPOSITION OF RICE GRAIN

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Abstract

Four rice varieties, Giza 175, IR 28 (high amylose) and Giza 181, Giza 176 (low amylose) were parboiled at Rice Technology Training Center (RTTC) to study the effect of parboiling treatment on milling output, breakage percentage, chemical composition characteristics as well as cooking quality and pasting characteristics of milled rice.

After parboiling the milling out-turn increased and broken rice decreased. The protein content was slightly affected, total P, K, Fe, Ca and Mg were definitely greater in parboiled rice. Cooking and eating quality characters were also affected by parboiling. Amylose content and total ash were significantly increased. Kernel elongation, alkali spreading value also increased and gel consistency was softened with parboiling.

Meanwhile, parboiled rice required longer time for cooking (20-25 min.) and water absorption ratio was lower than unparboiled rice.

Parboiling caused an increase in transition point and decreased in max. Peak viscosity. IR 28 and Giza 176 varieties had higher set back values 330,415 B.U. and decreased after parboiling, however, Giza 181, Giza 176 has lower set back -30,175 B.U and increased after parboiling.

Moreover, most of the chemical composition were affected by parboiling. As a result, it could be concluded that parboiling increased the utilization of rice grain as well as increased its nutritional value.

INTRODUCTION

In Egypt, the main concern is to increase the production of Food for the fast growing population and concerted efforts to reduce or even prevent losses in food production have focused the attention on certain prospects offered by parboiling of rice paddy prior to its conservation into milled rice.

Southeast Asian countries and the countries of tropical Africa have long been among the major countries that produce parboiled rice for consumption and export. In recent time, some countries in America and in Europe also began producing or consuming parboiling rice. The term parboiling (also known as boiling or overheating, hydrothermic rice treatment), as defined by Gariboldi (1974), covers the operations to which the paddy (or rough rice) is subjected before milling.

It is stated that through the process of parboiling, more milled rice can be produced compared to the processing of raw (non-parboiled) paddy, that breakage in milling will be less resulting in an improved quality and that milled rice produced is of a high nutritional value and of favorable redistribution of nutrients, oil, minerals and fats throughout the grain (Gariboldi 1974).

Many investigators found that parboiling process affected significantly the cooking and eating quality characters of rice. El-Dash *et al.* (1975) and Ali and Bhattacharya (1982) reported that parboiling rice doubled the time required for cooking (20-45 min.). Water absorption was influenced significantly by both variety and parboiling. Insignificant effect on the amylose content and gelatinization temperature were found. The peak viscosity of parboiled rice was significantly lower than of untreated samples, viscosity after 20 min. at 95°C showed the same trend, also viscosity (peak viscosity minus viscosity after 20 min. at 95°C) lower than that for the untreated samples.

The water content for parboiled rice was higher for the varieties that possess low gelatinization temperature (GT) than the other with intermediate (GT) steamed at 100°C only. Apparent amylose content was the major factor influencing parboiled rice quality, such as head rice yield, gel consistency, viscosity, cooked rice hardness and stickiness. Apparent amylose could be used in breeding programs as an index of parboiled rice quality, and (GT) was also a factor in rice parboiled at 100°C. (Biswas and Juliano 1988)

Unnikrishnan and Bhattacharya (1989) indicated that low or intermediate amylose yielded acceptable parboiled rice of textural quality (firmness and elasticity) where high amylose produced unacceptable hard cooked rice, even after excessive cooking time.

Normand and Marshall (1989) showed that gelatinization temperature for all long, medium and short grain varieties decreased with decreasing grain length.

Kaur *et al.* (1991) found that pressure parboiling (steaming for 20 min, and 15 psi) was more beneficial in increasing the head rice yield and reducing the free fatty acid content. Varieties and treatments has a significant effect on mean length/breadth ratio of milled rice kernels. Parboiling increased the amylose content of rice as compared to the control, also increased the elongation ratio and reduced losses of solids and gruel during cooking.

Sowbhagya and Ali (1991) showed that parboiled rice requires longer time (21-32 min.) for cooking depending on parboiling condition. The cooked parboiled rice is shorter (2-1%) in length, but thicker (15-20 %), firmer about (5%) and more elastic (15-20%) than cooked raw rice.

Marshall *et al.* (1993) reported that maximum head rice yield was achieved when the starch was about 40 % gelatinized. Extensive parboiling is not necessary to obtain maximum head rice yield.

Kohlwey *et al.* (1995) mentioned that parboiled rice decreased the rate at which the grain absorbs water or digested. The parboiled flour peak viscosity decreased and the cold paste viscosity was higher than ungelatinized flour.

Sheng (1995) reported that differences in amylose to amylopectin ratio greatly affect the gelatinization temperature of rice flours. Long grain which has the highest amylose content has the highest GT at 74°C. Medium grain showed the highest peak and cool-off viscosity, however long grain has a similar shape but lower viscosity.

This investigation is set to study the effect to parboiling on quality characters and chemical composition of rice grain.

MATERIALS AND METHODS

A cleaned paddy of 4 rice varieties i.e., IR28, Giza 175, Giza 181 and Giza 176 were obtained from the Rice Research Section, Field Crops Research Institute to be used in the present study. These varieties differed in amylose content and were parboiled at the Rice Technology Training Center (RTTC), Alexandria, Egypt in which involved soaking and steamed under pressure then vacuum dried. Raw paddy is cleaned and graded, weighed and mechanically conveyed to the vertical soaking tank (70°C for

3.5 hours) under pressure. The soaked paddy is heated by steam under pressure (5-8 min), and followed by vacuum drying until the moisture content is ideal for milling (14%) as described by Gariboldi (1984). After drying rough rice was dehulled and milled using Satake testing machine. Total milled rice and breakage percentage were calculated.

Chemical characteristics as well as cooking quality of the milled rice were evaluated. Moisture, protein (NX5.95) crude oil and minerals i.e.; P, K, Mg., Zn, Fe and Mn contents were determined according to the methods of A.O.A.C. (1990). Amylose content was detected by the simplified assay method of Juliano (1971). Gelatinization temperature was estimated by the extent of alkali spreading of milled rice soaked in 1.7% KoH for 23 hours at room temperature (Little,1958). Kernel elongation was defined as the ratio of length of cooked rice grains to the length of milled rice grains following the methods of Azeez and Shafi (1966).

Cooking Properties:

Whole grains of milled rice of the different varieties were used to determine cooking time, water absorption ratio (WAR) and volume expansion ratio (VER) according to Bhattacharya and Sowblagya (1971).

Amylograph pasting characteristics were determined using Brabender viscoamylograph (Juliano *et al.*,1985) by heating at 1.5°C/min. between 30 and 95°C, 20 min. cooking at 95°C and cooking at 1.5°C/min. to 50°C. Set back was calculated as final viscosity cooled to 50°C minus peak viscosity.

Statistical Analysis

Four random samples of each rice varieties were subjected to determine the aforementioned characters. Three of these samples were parboiled while the forth one left unparboiled. The collected data were statistically analyzed as split-plot design according to Gomez and Gomez (1983). The main plots were the varieties, while the methods were located in sub-plots.

RESULTS AND DISCUSSION

Parboiling leads to many changes in the properties of milled rice. Milled rice after parboiling appears rather glassy, translucent, and hard with a color of light amber. The effect of parboiling on different characters of rice grain are discussed as follow:

1. Milling Characters:

Table (1) shows the effect of parboiling on milling out-put. As shown from the table, after parboiling the milling output increased and broken rice decreased. The reason for this can be found in the basic principle of parboiling, i.e., that the steaming and gelatinization effect give the endosperm a harder and more resistant structure, which can better endure the force applied during the milling process. The results are in agreement with Biswas and Juliano (1988) who found that parboiling increased head rice yield and had low broken percent.

2. Chemical Composition:

Table (2) shows the effect of parboiling on some chemical composition of milled rice. The protein content of milled rice seems to be slightly affected by parboiling, and ash content showed a highly significant increase. The content of P, K, Mg, Fe, Cu (table 3) are definitely greater in parboiled rice. While Mn, Ca, and Zn decreased in parboiled rice. The most widely accepted theory is that water-soluble constituents diffuse into the endosperm during parboiling. Also, Ali and Bhattacharya (1982) suggested that the reduction in mineral content loss is not caused by inward migration of the constituents but by their adhesion to the endosperm during gelatinization. While Mn, Ca, and Zn these findings indicate that these minerals are probably bound more tightly and lost during milling.

3. Cooking and Eating Quality Characters:

Table (4), shows the effect of parboiling on some grain quality characters. As shown from the table, the total amylose content of the milled rice showed highly significant increase on parboiling, moreover the kernel elongation increased, it ranged between 29.6 and 52.2 for unparboiled rice and it reached 46.8 to 67.2 for parboiled rice. Kaur *et al.* (1991) reported that parboiling increased the amylose content of rice as compared to control. Also, increased the elongation ratio.

It is clear from table (4) that the gel consistency softened with parboiling, it differed from 35.6 to 8.8 for unparboiled rice and form 56.6 to 97.6 for parboiled rice. The alkali spreading value also increased with parboiling. Biswas and Juliano (1988) found that gel consistency of milled rice softened progressively with parboiling. The softening in gel consistency was usually accompanied by decrease in gel viscosity. The changes must be due to starch degradation during parboiling. The degradation however, was not extensive enough to reduce the apparent amylose content of parboiled rice.

4. Cooking Properties

Table (6) shows the cooking properties of unparboiled and parboiled rice varieties. Parboiled rice requires longer time for cooking (20-25 min.) than unparboiled rice varieties (15-20 min.). This may be due to the hardening of the grain after the hydrothermic process.

In addition, water absorption ratio for parboiled rice varieties was less than that of the unparboiled rice.

Same trend was observed for volume expansion ratio. In this respect, Kohlwey *et al.* (1995) found that parboiling gelatinizes the starch, which decreases the rate at which the grain absorbs water.

Parboiled rice hydrates at a slower rate than unparboiled rice during cooking. Parboiled rice has less lower water uptake and hence needs a longer time to cook than raw rice, however it retains better shape, fluffier and less sticky.

5. Pasting Characteristic

Table (7) shows the pasting characteristics of unparboiled and parboiled rice flour of different rice varieties. As shown in the table, parboiling resulted in an increase in transmission point in all samples, (relatively lower transmission point was obtained for unparboiled rice, while relatively higher ones were noticed for parboiled samples). Lower transmission point for unparboiled rice may be explained on the basis that the granules have been weaker and swell freely at relatively lower degree.

Higher amylose rice variety Giza 175 have the lower max. peak viscosity (245 B.U.), while Giza 181 low amylose one showed the highest max. peak viscosity (650 B.U.).

Parboiling led to a decrease in max. peak viscosity. It dropped to 145, 15 B.U. in high amylose rice varieties IR 28, Giza 175 and to 530, 175 B.U. in low amylose rice varieties Giza 181, Giza 176, respectively.

Biswas and Juliano (1988) found that high amylose rice varieties had lower peak viscosity and the peak viscosity disappeared on parboiling at 100°C except for the peak viscosity of 650 B.U. for low amylose. Kohlwey *et al.* (1995) showed that parboiled gelatinized rice, which decreases the rate at which the grain absorbs water, or is digested.The parboiled flour peak viscosities therefore decreased and the cold paste viscosity will be higher than the ungelatinized flour.

Higher amylose rice varieties (IR 28, Giza 175) had higher setback values 330, 415 B.U., and decreased after parboiling to 75, 100 B.U. But lower amylsoe rice varieties Giza 181, Giza 176 had set back -30, 175 B.U. and increased after parboiling to 430 , 3375 B.U., respectively.

The drop in viscosity after 20 min. at 95°C. for Giza 181 was from 650 to 365 B.U., after parboiling the drop decreased from 530 to 485. For Giza 176 the drop from 330 to 270 and the viscosity increased after parboiling from 175 to 255 B.U. Also, the viscosity after 20 min. at 95°C. for IR 28 and Giza 175 increased from 350 to 355 B.U. and 245 to 335 B.U. for the two varieties, respectively. After parboiling the increase was from 145 to 150 and from 15 to 190 B.U. for the same two varieties, respectively.

This difference in break down in viscosity may be attributed to the difference in hydrogen bonding forces within the linear and branched chain in the granular structure. The hydrogen bonding forces between the long linear and branched chain is stronger than those between short linear one.

Finally it may be concluded that parboiling affect all the studied characters and improved the cooking and eating quality of the tested varieties. Also parboiling increased the nutritional value of the rice grain as the mineral contents increased after parboiling.

Table 1. Effect of parboiling on milling output

Varieties	Milling out put %		Breakage %	
	Unpb*	Pb**	Unpb	PB
IR 28	63.7	69.3	11.5	6.0
Giza 175	70.8	72.2	5.8	2.0
Giza 181	67.7	70.2	8.9	4.1
Giza 176	67.9	72.2	4.6	1.3

* Unparboiled ** Parboiled

Table 2. Chemical Composition of milled rice before and after parboiling

Varieties		Moisture%	Protein % d.b	Amylose %	Ash % d.b.
IR 28	Unpb	11.65	7.36	29.00	0.26
	Pb	11.00	7.81	30.20	0.39
Giza 175	Unpb	10.65	8.51	28.50	0.31
	Pb	10.85	8.69	28.40	0.81
Giza 181	Unpb	11.40	7.62	20.60	0.69
	Pb	11.00	7.86	20.79	0.69
Giza 176	Unpb	10.75	6.63	20.79	0.53
	Pb	10.13	7.02	20.88	0.76

Table 3. Minerals contents of unparboiled and parboiled rice

Varieties		P%	K%	Mg %	Ca %	Mn %	Fe %	Cu %	Zn %
IR28	Unpb	0.154	0.309	0.023	0.004	2.4	1.2	4.3	7.9
	Pb	0.310	0.310	0.029	0.003	1.0	3.0	2.7	5.5
Giza 175	Unpb	0.157	0.123	0.014	0.032	18.4	1.8	1.9	10.7
	Pb	0.482	0.282	0.063	0.004	3.7	5.8	2.7	10.7
Giza 181	Unpb	0.178	0.117	0.013	0.007	3.6	3.0	3.2	10.6
	Pb	0.446	0.320	0.039	0.005	2.7	4.5	5.6	6.0
Giza 176	Unpb	0.133	0.147	0.018	0.006	5.5	3.0	4.9	6.7
	Pb	0.194	0.173	0.091	0.003	2.0	4.2	7.4	4.15

Table 4. Effect of parboiling on cooking and eating quality character

Varieties	Kernel Elongation ratio		Gel Consistency m.m.		Alkali spread*	
	Unpb	pb	Unpb	pb	Unpb	Pb
IR28	29.6	46.8	35.6	56.6	2	2
Giza 175	37.0	56.3	53.0	69.6	2.3	4.7
Giza 181	52.2	67.2	74.0	91.7	5.0	5.7
Giza 176	41.9	60.9	88.8	97.6	6	7

*Alkali spread	G.T range
6-7	55-69
4-5	70-74
2-3	75-79

Table 5. Effect of parboiling on cooking properties at the proper cooking time

Varieties	Water absorption ratio		Volume expansion ratio		Cooking time min.	
	Unpb	pb	Unpb	pb	Unpb	pb
IR28	2.8	2.7	4.8	4.0	20	25
Giza 175	3.1	2.6	4.3	4.0	20	25
Giza 181	2.3	2.3	3.3	3.7	15	20
Giza 176	2.4	2.4	3.0	3.4	15	20

Table 6. Cooking properties of milled rice before and after parboiling

Varieties	Water absorption ratio		Volume expansion ratio	
	At 15 min.			
	Unpb	Pb	Unpb	Pb
IR28	2.8	2.0	4.5	3.0
Giza 175	3.0	1.6	4.0	3.0
Giza 181	2.3	1.9	3.3	3.3
Giza 176	2.4	2.4	3.0	3.5
	At 20 min.			
IR28	2.8	2.4	4.8	3.8
Giza 175	3.1	2.2	4.3	3.5
Giza 181	2.5	2.3	3.8	3.8
Giza 176	2.4	2.4	3.5	3.5
	At 25 min.			
IR28	4.0	2.7	5.0	4.0
Giza 175	3.6	2.6	4.5	4.0
Giza 181	2.5	2.4	4.0	3.9
Giza 176	2.6	2.5	3.6	4.2
	At 30 min.			
IR28	4.0	2.7	5.3	4.1
Giza 175	3.8	2.8	5.0	4.3
Giza 181	3.1	3.0	4.8	4.5
Giza 176	2.7	2.7	4.5	4.5
	At 35 min.			
IR28	4.4	3.5	5.5	4.5
Giza 175	4.3	3.3	5.5	4.8
Giza 181	3.5	3.1	5.0	4.8
Giza 176	3.4	3.2	5.1	4.8

Table 7. Pasting characteristics of unparboiled and parboiled rice flour

Varieties	Viscosity at 50°C B.U	Viscosity at 95°C B.U	Max. Viscosity B.U	Temp.at max Viscosity °C	Transition point °C	Set-back point B.U
High amylose						
IR28						
Unph	680	355	350	96	71.5	330
Pb	220	150	145	96.5	87	75
Giza 175b						
Unp	660	335	245	94.5	75	415
Pb	115	90	15	94.5	90	100
Low amylose						
Giza 181						
Unpb	620	365	650	91.5	66	30
Pb	960	485	530	94.5	75	430
Giza 176						
Unpb	505	270	330	94.5	81	175
Pb	550	255	175	94.5	84	375

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التقييم الكيميائى والتكنولوجى للأرز المجهز بالغليان

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إستخدم فى هذا البحث أربعة أصناف من الأرز ، جيزة ١٧٥ - IR28 (عال الأميلوز) جيزة ١٨١ ، جيزة ١٧٦ (منخفض الأميلوز) تم غلى الأرز فى مركز تدريب تكنولوجيا الأرز بالإسكندرية لدراسة تاثير عملية الغلى على ناتج الضرب، نسبة الكسر ، التركيب الكيميائى وأيضا إختبار الطهى والأميلوجراف.

ولقد وجد أن ناتج الضرب يزداد بينما تنخفض نسبة الكسر بعد عملية الغلى ولم يظهر تاثير واضح على محتوى البروتين بينما زادت نسبة الأميلوز معنوياً. بمتوسط ٠,٤٥ ٪ كما زادت نسبة الرماد أيضا زيادة معنويه

وأوضحت النتائج أن الفسفور ، البوتاسيوم ، الحديد ، الماغنسيوم أظهرت زيادة واضحة بعد الغلى. ولقد وجد أن الأرز المغلى يتطلب زمن أطول للطهى (٢٠ - ٢٥) دقيقة ودرجة أمتصاص الماء أقل وكما تأثرت صفات الطهى .

وأوضحت نتائج الأميلوجراف زيادة فى نقطة التحول وإنخفاض فى قيم اللزوجة القصوى وأظهر الصنفان IR 28 وجيزة ١٧٥ إرتفاع فى قيم Setback 33، ٤١٥ وحدة برابيندر وإنخفض بعد الغلى وكانت Setback للصنفان جيزة ١٧٦ وجيزة ١٧٥ - ٣٠ ، ١٧٥ وحدة بيرابيندر وزادات بعد الغلى.

ومن ذلك إستنتج أن عملية غلي الأرز أثرت على جميع الصفات . كما حسنت من صفات الطهى والأكل كما انها زادت من القيمة الغذائية لحبوب الأرز وذلك بزيادة محتوى الحبوب من المعادن.