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EFFECT OF DEGREE OF MILLING ON THE CHEMICAL COMPOSITION AND NUTRITIONAL VALUE OF THE MILLED RICE

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Abstract

The present investigation was carried out in 1998 and 1999 rice growing seasons to study the effect of different milling time on chemical composition and nutritional value of milled rice. Five Egyptian rice varieties and strains i.e. Giza 177, Giza 178, Gz 1368, Sakha 101and Sakha 102 and three milling times (30", 60" and 90") beside the brown rice were used. Protein content, crude oil, ash beside macro and micro nutrients (P, K, Mg, Zn, Fe, Mn and amylose content were measured at different milling time beside the brown rice. On the other hand cooking time, water absorption ratio (WAR) and volume expantion ratio (VER) were also determined as cooking properties.

The results showed that all varieties differed significantly in regard to all studied chemical composition and mineral content when the brown rice samples of these varieties were compared. Milling has a profound effect on rice composition, as non-starch consistuents decrease from surface to core of the grain. In general , increasing degree of milling decreased the nutritional value of the milled rice by decreasing protein content, crude oil content and all macro and micro elements for all tested varieties. Protein content, oil content and ash content decreased significantly by increasing milling time, however, amylose content increased by the same treatments. Both macro and micro elements contents also behaved by the same manner and decreased by increasing milling time and this decrease ranged between 68.2% (for Mn) and 48.44 % (for Mg.). On the other hand, the cooking properties of the different varieties also affected by the milling time. Cooking time was decreased by increasing milling time, however water absorption ratio and volume expansion ratio increased significantly.

INTRODUCTION

Rice competes closely with wheat as the world's most important food crop. It is grown in more than 100 countries including Egypt, and when compared with other cereals, it has the highest food yield. Together with wheat and maize, rice directly supplies more than half of all the calories humans consume. Moreover, the contribution of rice to protein in the diet, based on FAO food balance sheets for 1979-81, was 69.2 %

in South Asia, and 51.4 % South East Asia (FAO, 1984). These percentages are higher than the contribution of any other cereal protein in any region of the world .

Rice is consumed as milled rice after dehulling (hull removal from rough rice) and whitening (removal of pericarp, bran layer and embryo from brown rice). These removed parts after whitening has a very low starch content but has high percentage of oil, protein, vitamins and minerals. However, the remained part, the endosperm or the milled rice, mainly composed of carbohydrates and protein. In the milling processes, the higher milling degree of grains indicate a greater percent of bran removal. Thus, the milled rice appears shiny and white especially when it is well milled or over milled. However, its vitamins (mostly vitamin B complex), protein, minerals and oil content are lessened. This probably explains why persons who stick to eating well-milled rice are brone to be protein dificient and even malnourished. With 10% bran-polish removal, milled rice retained 13% thiamine, 40% riboflavin, 33-50 % crude ash, phosphorus, potassium, magnessium, silicon and manganese, 54-66% calcium, iron, and zinc and 82-90% Kjedlahl nitrogen, aluminium, sulfer and chlorine (Villareal et al, 1991). Furthermore, they found that micronutrient loss was much lower than micronutrient loss during extended milling, suggesting that micronutrients are concentrated in the pericarp and aleurone layer which are lost during milling, while micronutrients are more uniformly distributed in the grain.

From another point of view, Bajaj and Sidhu (1989) studied the effect of extended milling of 6 rice varieties on cooking and sensory quality characteristics. They found that milling reduced cooking time, while elongation ratio, water uptake ratio and gruel solids loss were significantly increased.

Kin and Jeon (1996) studied the effect of degree of milling on physicochemical and gelatinization properties of rice flour. They reported that protein, ash, lipid and fiber decreased significantly as degree of milling increased, while water uptake of rice grains decreased by increasing the milling degree.

Keeping in view the importance of the nutritional value of the milled rice as a stable food in Egypt as well as more than one hundred rice growing countries, the present study aimed to determine the effect of different degrees of milling on the chemical composition of milled rice as indication of its nutritional value.

MATERIALS AND METHODS

Five rice varieties and strains namely; Giza 177, Giza 178, Gz 1368, Sakha 101 and Sakha 102 were used in the present study to determine the effect of different milling degrees on the chemical composition and the nutritional value of rice. Paddy samples of these varieties were taken from the Rice Research and Training Center, Sakha, Kafr El-Sheikh during 1998 and 1999 rice growing seasons. In addition, milling process was done at the Rice Technology Training Center, Alexandria. Meantime the chemical analysis was done at the laboratories of the Food Technology Research Institute, A.R.C. Giza, Egypt.

METHODS:

1. Milling Processing:

Random samples (200 gr)each of paddy rice for the above mentioned varieties were taken in three replicates for milling processing. The samples were dehulled using (Satake) testing huller to produce the brown rice and then equal weight of the brown rice for each variety was milled for 30, 60 and 90 seconds using (Satake) testing milling machine. Hulling %, milling % and head rice % were determined according to Khush et al (1979).

2. Chemical analysis:

Samples of brown rice as control and milled rice at the three degrees of milling for the tested rice varieties were ground and the produced flour was used to determine crude protein (NX5.95), crude oil, ash and macro and micro nutrients (P, K, Mg, Zn , Fe, and Mn) according to A.O.A.C.(1990). Besides, amylose content was measured following the simplified assay method developed by Juliano (1971).

3. Cooking properties:

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

4. Statistical analysis:

The obtained results of the two seasons were subjected to combined analysis according to Gomez and Gomez (1984). Meanwhile decrease or increase % were calculated as the percentage of the differences between values of brown rice samples and well milled samples after 90 " milling time devided by values of brown rice samples.

RESULTS AND DISCUSSION

I. Effect of degree of milling on chemical composition of the grain

Table (1) shows the values of protein, oil, ash and amylose contents in the different rice varieties with different degrees of milling for 1998 and 1999 seasons.

In general, significant differences were found between the different varieties in respect to the chemical composition of the brown rice and well milled rice. This could be attributed to different genetic background of the studied varieties. Same findings were reported by El-Kady et al (1991).

Further, data in table (1) revealed that protein content in the brown rice of the different varieties ranged between 7.97% (for Gz 1386 strain) and 9.19 (for Sakha 102 variety).Protein content was significantly affected by milling time. It gradually decreased by increasing milling time. This decrease ranged between 6.71% and 20.10% after 90" milling time. This result proved that the protein of the rice grain existed as discrete particles located among the compound starch granules. This would mean an improvement in milling rice protein and an increase in protein intake in the diet could be achieved. Same results were reported by Juliano (1972), del Rosario et al (1968), Nauda and Coffman (1979) and Champagne et al (1996).

Significant differences between varieties were determined with respect to oil content in the brown rice. The highest percentage of oil content was found in case of Gz 1386 (strain) ,while the lowest value was detected for Giza 178. These percentages were 3.00% and 2.00% for these varieties, respectively. Increasing milling time caused significant decrease in oil content which ranged between 68.5% and 84.62%. This result indicated that most of the rice oil content are located in the outer layers of the rice grain.

Ash contents were significantly differed in the brown rice of the different varieties and significant decrease of such contents was obtained with increasing milling time. The decrease percentage was maximized in case of Sakha 102 (77.50%) and minimized in Gz 1368 and Giza 178 (69.53% and 69.39%), respectively. This could be attributed to the increase of outer layers removal that contain most of the protein , fat and other nutrients of the rice grain as a result of increasing the milling time. These results were in agreement with those reported earlier by Kim and Jeon (1996).

In contrast, Table (1) revealed that amylose content increased significantly by increasing milling time. In the brown rice, amylose content ranged between 17.40 % and 19,29% with significant differences between varieties. This is mainly because all these varieties were selected as low amylose varieties under the Egyptian rice breeding program to cover the requirements of the Egyptian consumer. After 90"milling time, the amylose content increased significantly. This increase differed from 2.08% to 8.41% for Giza 178 and Gz 1368 varieties, respectively. This may be due to the relatively increase in starch percent in milled rice with respect to brown rice. Amylose and starch increase toward the center of rice kernal while protein , fat and other nutrients are located in the peripheral layer below the bran coat.

In addition, the interaction between varieties and milling time was significant meaning that these varieties react significantly with milling time. These findings were in harmony with the results found by Paul (1977) and Gomez (1979).

II. Effect of degree of milling on mineral content of rice grain:

Table 2 presents the mean of mineral contents of rice grain for the different rice varieties as affected by degree of milling in the two seasons 1998 and 1999.

The decrease in percentages for each mineral ranged from 69.4% to 43.3 % (for P), 70.7 to 33.3 % (for K), -59.3 to –37.5% (for Ms), -72.5% to –44.3% (for Zn), -88.7 % to –38.7 % (for Fe) and from –85.3 to –52.2% (for Mn).

A wide range of different mineral content was observed between varieties regarding the brown rice. This could be attributed to the differences in the genetic constitutions of the different rice varieties tested in the present study.

Obviously, a general trend was noticed for all mineral contents as affected by the milling time. All mineral contents decreased by increasing milling time and the lowest values were resulted after 90 " milling time regardless of the varieties.

The decrease in percentages after 90" milling time differed from variety to another, the highest Mg and Mn contents in the milled grains after 90" was detected for the rice varieties Giza 178. However, the well milled grains of Sakha 101 had the highest contents of Zn and Fe only.

Accordingly, it could be concluded that the losses % of the different minerals depend upon the presence of each element in the different layers of the rice grain. A significant loss of mineral content was found by Ghose et al (1960) and by Villareal et al (1991). Furthermore, Giza 178 rice variety proved to be the best variety from the nutrition point of view as it had the highest mineral content in the milled rice compared with the other rice varieties under the present investigation.

III. Effect of degree of milling on cooking and eating properties :

With respect to the effect of degree of milling on the cooking properties Table 3 revealed that in case of the brown rice, insignificant differences were detected between varieties used under this study regarding cooking time, water absorption ratio and volume expansion ratio characteristics. This could be attributed to that the rice breeding program in Egypt concentrates on such cooking and eating quality characters as the local consumer requires in the new local selected rice varieties. Similar results were reported by El-Hissewy and El-Kady (1992).

Consequently, these characters behaved in the same manner after milling. Significant decrease in cooking time was observed for all varieties. The highest decrease (25 min.) was recorded for the rice variety Sakha 102, while the lowest decrease (10 min.) was detected for the two varieties Giza 178 and Sakha 101 after complete milling. Insignificant differences were found with regard to cooking time, between different milling times.

Regarding the water absorption ratio (WAR), it is clear from Table (3) that this ratio increased after milling. Significant increase was computed for this character for all varieties comparing the brown rice with the millied rice. This increase was maximized in case of the variety Giza 178 and minimized with respect to the variety Sakha 102, in the two seasons of study.

Furthermore, volume expansion ratio (VER) also increased significantly as the milling time increased. The highest value was recorded for the variety Giza 178 being 4.80% in mean , however in 1999 most of the tested varieties increased by the same ratio. The interaction between varieties and milling time with respect to this character (WAR, VER)was significant.

These results were in complete agreement with those reported earlier by Bajaj and Sidhu (1989) and Kin and Jeon (1996). They found that milling, in general, reduced cooking time and increased both kernel elongation ratio and water uptake ratio.

Finally, it could be concluded that increasing degree of milling decreased the nutritional value of the milled rice by decreasing protein content, crude oil content, and all macro and micro elements for all tested varieties. With regard to the cooking and eating properties, increasing milling time increased amylose content, water absorption ratio and volume expantion ratio , and decreased the cooking time.

Table 1. Means of chemical composition as affected by time of milling of 1998 and 1999 rice growing seasons.

Varieties	Time	Protein	Oil	Ash	Amylose
Giza 177	Brown	8.90 a	2.51 a	1.34 a	18.22 b
	30"	8.30 bc	1.77 b	0.81 b	18.45a b
	60"	8.22 cd	1.41 c	0.30 c	18.98 a
	90"	8.08 d	0.76 d	0.23 c	19,.28 a
Decrease (%)		-9.21	-69.72	-74.63	5.5
Giza178	Brown	8.94 a	2.00 a	1.47 a	17.91 a
	30"	8.89 a	0.88 b	0.85 b	17.90 a
	60"	8.62 b	0.82 bc	0.57 c	18.15 a
	90"	8.34 c	0.62 c	0.45 c	18.29 a
Decrease (%)		-6.7 1	-68.5	-69.39	2.08
GZ 1368	Brown	7.97 a	3.00 a	1.28 a	19.27 a
	30"	7.51 b	1.60 b	0.80 b	19.87 a
	60"	7.13 c	1.07 c	0.51 c	20.94 a
	90"	6.37 d	0.57 d	0.39 c	21.04 a
Decrease(%)		-20.1	-81	-69.53	8.41
Sakha101	Brown	8.67 a	2.37 a	1.33 a	17.40 b
	30"	8.43 b	1.45 b	0.77 b	17.90 b
	60"	8.31 b	0.83 c	0.54 c	18.75 a
	90"	7.62 c	0.69 c	0.34 c	18.87 a
Decrease (%)		-13.69	-70.89	-74.44	7.8
Sakha102	Brown	9.19 a	2.34 a	1.20 a	17.61 b
	30"	9.05 a	1.81 b	0.54 b	17.70 b
	60"	8.76 b	0.52 c	0.36 c	18.75 a
	90"	7.98 c	0.36 c	0.27 c	19.11 a
Decrease (%)		-13.17	-84.62	-77.5	7.85
L.S.D.0.05 Vars		0.205	0.251	0.043	n.s
L.S.D0.05 time		0.217	0.187	0.167	0.735
L.S.D.0.05 Interaction		0.316	0.465	0.559	0.382

Means in a column showing the same letter are not significantly different at 0.05 level.

Table 2. Means of mineral contents as affected by milling time of 1998 and 1999 rice growing seasons.

Variety	Time	P %	K %	Mg %	Zn (mg/g)	Fe (mg/g)	Mn (mg/g)
Giza 177	Brown	0.585 a	0.215 a	0.056 a	21.05 a	13.60 a	4.35 a
	30"	0.515 b	0.198 ab	0.054 a	15.58 b	11.00 b	3.90 ab
	60"	0.280 c	0.165 b	0.048 ab	9.75 c	3.90 c	3.10 ab
	90"	0.210 d	0.113 c	0.035 b	6.60 d	2.25 c	1.98 b
Decrease (%)		-64.4	-47.4	-37.5	-68.6	-83.5	-59.5
Giza178	Brown	0.600 a	0.270 a	0.073 a	27.25 a	9.40 a	8.01 a
	30"	0.520 b	0.225 b	0.059 bc	11.90 bc	8.25 a	4.73 bc
	60"	0.410 c	0.220 b	0.055 cd	9.50 cd	5.55 b	4.23 bc
	90"	0.260 b	0.180 b	0.045 d	8.90 a	4.13 b	3.83 c
Decrease (%)		-156.7	-33.3	-40	-67.3	-56.1	-52.2
Gz1386	Brown	0.280 a	0.400 a	0.081 a	23.75 a	16.25 a	9.20 a
	30"	0.255 a	0.275 b	0.061 b	16.35 b	11.50 b	5.50 bc
	60"	0.175 b	0.255 b	0.045 c	7.65 c	7.60 c	4.15 cd
	90"	0.155 b	0.175 c	0.033 d	6.53 c	3.90 d	1.35 d
Decrease(%)		-44.6	-56.2	-59.3	-72.5	-76	-85.3
Sakha101	Brown	0.385 a	0.375 a	0.085 a	10.15 a	9.78 a	8.50 a
	30"	0.290 b	0.230 a	0.055 bc	9.33 ab	8.65 ab	6.58 ab
	60"	0.210 c	0.155 b	0.045 c	7.68 bc	7.00 bc	3.55 bc
	90"	0.165 c	0.114 b	0.042 cd	5.65 c	6.00 c	2.55 c
Decrease (%)		-59.1	-69.4	-50.6	-44.3	-38.7	-70.2
Sakha102	Brown	0.380 a	0.355 a	0.084 a	18.65 a	10.50 a	9.48 a
	30"	0.335 ab	0.265 b	0.052 bc	9.80 bc	8.90 ab	8.78 a
	60"	0.295 b	0.200 c	0.045	7.85 cd	7.25 bc	5.65 b
	90"	0.215 c	0.098 d	0.038 cd	6.03 d	5.50 c	2.05 c
Decrease (%)		-43.3	-70.7	-54.8	-67.7	-47.6	-78.8
L.S.D.0.05Vars		0.029	0.036	n.s	2.167	1.942	2.659
L.S.D.0.05 Time		0.064	0.048	0.012	2.801	1.995	2.984
L.S.D.0.05 Interaction		n.s	n.s	n.s	n.s	n.s	Ns

Means in a column showing the same letter are not significantly different at 0.05 level.

Table 3. Means of cooking properties as affected by milling time of 1998 and 1999 rice growing seasons.

Variety	Time	WAR*	VER**	COOK.TIME
Giza 177	brown	1.02 c	2.18 c	37.50 a
	30"	1.80 b	3.25 bc	25.00 b
	60"	2.13 a	3.30 b	22.50 c
	90"	2.13 a	3.65 a	22.50 c
Decrease (%)		52.11	40.27	-40
Giza178	brown	1.65 a	3.000 b	35.00 a
	30"	2.21 c	3.90 a	2250 b
	60"	2.54 b	4.05 a	22.50 b
	90"	3.04 a	4.15 a	20.00 c
Decrease (%)		45.72	27.71	42.86
Gz1386	Brown	1.27 d	2.40 b	35.00 a
	30"	2.20 c	3.53 a	27.50 b
	60"	2.21 bc	3.63 a	20.00 c
	90"	2.65a	3.75 a	20.00 c
Decrease (%)		52.08	36	-42.86
Sakha101	Brown	1.06 a	2.50 c	32.50 a
	30"	1.84 b	3.13 b	22.50 b
	60"	1.90 ab	3.25 ab	20.00 c
	90"	2.10 a	3.53 a	20.00 c
Decrease (%)		49.52	29.18	38.46
Sakha102	Brown	1.17 c	2.30 c	32.50 a
	30"	2.14b	3.28 b	25.00 b
	60"	2.34 ab	3.40 ab	20.00 c
	90"	.2.64 a	3.63 a	17.50 d
Decrease (%)		55.68	36.64	-46.15
L.S.D.0.05Vars		n.s	n.s	n.s
L.S.D.0.05 Time		0.278	0.288	2.03
L.S.D.0.05 Interaction		n.s	n.s	n.s

Means in a column showing the same letter are not significantly different at 0.05 level.

* WAR : Water absorption ratio

** VER : Volume expansion ratio

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تأثير درجات التبييض المختلفة على المكونات الكيمائية والقيمة الغذائية للأرز الأبيض

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أجرى هذا البحث خلال موسمي ١٩٩٨ ، ١٩٩٩ لدراسة تأثير زمن التبييض(إزالة رجيع الكون من الأرز البني ليصبح أرز ابيض) فى المكونات الكيمائية والقيمة الغذائية للأرز الأبيض استخدمت فى هذه الدراسة خمسة أصناف أرز مصرية هي جيزة ١٧٧ ، جيزة ١٧٨ وجى زد . ١٣٦٨ سخا ١٠١ ، سخا ١٠٢ وقد تم تبييض عينات الأرز من هذه الأصناف لثلاث مدد مختلفة وهى ٣٠ ثانية ، ٦٠ ثانية ، ٩٠ ثانية والتي تمثل تبييض كامل واستخدمت العينات الناتجة بجانب الأرز المقشور من كل صنف لتقدير المكونات الكيمائية وهى محتوى البروتين – محتوى الزيت – نسبة الرماد ونسبة الأميلوز في الحبوب كما تم تقدير نسبة العناصر الكبرى والصغرى (الفوسفور – البوتاسيوم – ماغنسيوم – زنك – حديد – منجنيز) كما تم تقدير زمن الطهي ونسبة امتصاص الماء ونسبة الزيادة الحجمية للحبوب.

أوضحت النتائج أن الأصناف المستخدمة في الدراسة اختلفت معنويا في نسبة احتوائها على المكونات المختلفة وذلك عند تقديرها في الأرز المقشور لهذه الأصناف من ناحية أخرى تأثرت المكونات الكيمائية المختلفة للحبوب بزمن التبييض – فقد ظهر انخفاضا معنويا في نسبة كل هذه المكونات بزيادة زمن التبييض فيما عدا نسبة الأميلوز التي زادت معنويا بزيادة زمن التبييض كذلك انخفضت نسبة العناصر الكبرى والصغرى في الحبوب بزيادة زمن التبييض ويتراوح هذا الانخفاض ما بين ٦٨,٢ ٪ للمنجنيز ، ٤٨,٤٤ ٪ في الماغنسيوم.

تأثرت أيضا صفات الطهي تحت الدراسة فأنخفض زمن الطهي معنويا بزيادة زمن التبييض بينما زادت نسبة امتصاص الماء ونسبة الزيادة الحجمية زيادة معنوية بزيادة زمن التبييض.

ونستخلص من الدراسة أن زيادة زمن التبييض يقلل المكونات الكيمائية والقيمة الغذائية للحبوب بتقليل البروتين والزيت وكذلك العناصر الكبرى والصغرى وكذلك أوضحت النتائج أيضا أن كل الأصناف تأثرت بزيادة زمن التبييض كان الصنف جيزة ١٧٨ أفضلهم حيث احتوى على أعلى النسب من جميع العناصر فيما عدا الحديد بالمقارنة بالأصناف الأخرى.