Minufiya J. Agric. Res. Vol.41 No. 1(1): 53 – 64 (2016) "http://www.mujar.net"

PHYSICAL PROPERTIES, CHEMICAL AND TECHNOLOGICAL EVALUATION OF WAXY AND NON WAXY RICE

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(Received: Nov. 16 , 2015)

ABSTRACT: *The present study was carried out to compare different varieties of rice (Waxy , black, Giza 178 and Egyptian Jasmine) as brown and white rice physically, chemically and technologically.*

The obtained results revealed that, physical properties of brown and white rice varied from one variety to another. It was found that Egyptian Jasmine had the longest length when compared with other varieties. It had also the lowest width among all of the tested ones, whereas Waxy had the highest value in grain index. The paddy rice of raw Egyptian Jasmine had the highest percentages of broken kernels and the lowest percentages of head and brown rice as compared with other rice varieties.

Water uptake of white rice was significantly higher than that of brown rice. Brown black rice had the longest cooking time (40 min) compared to the others.

Gel consistency (GC) varied significantly among varieties in both brown and white rice. Alkali spreading value in brown rice varieties showed lower values in comparing with white rice varieties. . Waxy rice had the highest gel consistency (GC) and gelatinization temperature (GT) among the other varieties; but it had the lowest content of amylose.

Black rice had the highest amylose content and elongation. Furthermore, Black rice contains high content of ether extract, ash and crude fibers, but lower content of total carbohydrate, compared with other varieties. In addition, brown rice of all varieties had higher contents of crude protein, ether extract, ash and fiber but lower content of total carbohydrates, whereas the rice variety of black rice had a relatively high levels of mineral contents comparing with the other rice varieties.

Key words: *Giza 178; Jasmine; Waxy; Black rice; physical; chemical; technological properties.*

INTRODUCTION

Rice is a major cereal crop in the developing world. It is consumed as a staple food by over one-half of the world's population with approximately 95% of production in Asia (Bhattacharjee *et al.*, 2002). Although widely consumed as white rice, there are many special cultivars of rice that contain colour pigments, such as black rice, red rice and brown rice. Their name refer to the kernel colour (black, red or purple) which is formed by deposits of anthocyanins in different layers of the pericarp, seed coat and aleurone (Chaudhary, 2003).

Nowadays, colored rice (*Oryza stiva L.*) consumption is increasing rapidly. Both waxy and non-waxy black rice are particularly importantly colored rice species, and derive their names from their naturally purple or black pigments that have been confirmed as anthocyanins (Kong and Lee, 2010).

Black rice has a number of nutritional advantages over common rice, such as a higher content of protein, vitamins and minerals, although the latter varies with cultivar and production location (Suzuki *et al.*, 2004).

Pigmented rice grains (*Oryza sativa L.*), such as black and red rice, possess phenolic compounds distributed in their bran layers. Phenolics compounds have been shown to promote several health benefits for consumers, including antioxidant, anticarcinogenic, antiallergic, anti-inflammatory, antiatherosclerosis and hypoglycemic activities (Deng *et al.*, 2013).

Differences in quality of rice products, made from waxy rices are correlated with gel consistency and gelatinization temperature of waxy rice starch (Villareal *et al.,* 1993).The same authors found that, the preferred waxy rices have soft, sticky texture and correspond to starches with low gelatinization temperature .

Rice, unlike most cereals, is consumed as the milled whole grain. The relationship between the physicochemical properties of its principal component, starch, and the texture of the cooked kernel has been difficult to determine. The wide range of cooking and textural qualities in rice is largely determined by the relative proportions of amylose and amylopectin in the starch (Ibanez *et al.,* 2007)

Genetics plays a major role in determining rice functionality. Environment and cultural practices also have been shown to significantly affect composition and consequently, cooking characteristics of rice (Dang and Copeland 2004).

Cooking and eating quality of rice have never caused a serious problem in Egypt since nearly more than 95% of the rice area is planted by Japonica rice varieties because of their moistures, tenderness, gloss and taste. Recently, however, emphasis of development of long grain Indica rice has brought in to focus the problem of cooking and eating quality in breeding program (El-Hissewy and El-Kady 1992).

The objective of this study was to compare the physical attributes, chemical composition and physicochemical properties of waxy and non waxy rice varieties grown together in the Kafrelsheikh Governrate.

MATERIALS AND METHODS

Materials

Three varieties of rice (*Oryza sativa L.*) namely Waxy , black, Giza 178 and Egyptian Jasmine were employed in this study. These samples were obtained from Rice Research and Training Center (RRTC) at Sakha Kafr El-Sheikh Governorate, Egypt during the season of 2014, under the recommended conditions for date of culture, fertilization, harvesting time and irrigation.

Methods

Preparation of rice samples

Raw rice samples were dehulled to obtained the brown rice. The brown rice was divided into two parts the first one was used as brown rice, where the second was milled to obtained the white rice. The brown and white rice were kept in polyethylene bags and stored in freezer at -18oC until further analysis.

Determination of physical properties

Hulling, milling output and head rice percentages were estimated according to the method of Khan and Wikramanayake (1971) at Rice Research and Training Center (RRTC) Sakha, Kafr El-Sheikh, Egypt.

The grain physical attributes (1000 grain weight, grain dimension (length and width), grain shape (grain length to width ratio) were measured. The 1000 grain from each variety of rice were counted randomly in triplicate and weighted separately. Grain length and width were measured using a micrometer with accuracy of 0.001 mm where 10 uniform rice grain were randomly selected

and their length and width were measured in duplicate (Suwansri and Meullenet, 2004).

Bulk density of rice was determined according to the method of Myklestad *et al.* (1968).

Water uptake, sedimentation values at 77oC and 82oC and cooking time: water uptake, sedimentation values and cooking time of brown and white rice varieties were determined following to procedures of Simpson *et al.* (1965).

Determination of cooking and eating quality

Alkali spreading value was determined according to the method described by Bhattacharya and Sowbhagya (1980).

Gel consistency (GC) was determined according to the method described by Cagampang *et al.* (1973). Elongation percentage was measured using the method of Tomar (1985).

Amylose content was measured according to Juliano *et al.* (1981) procedure. Pasting characteristics of rice flour were carried out using Brabender amylograph as described by A.A.C.C. (1995) procedure.

Chemical composition of rice samples

Moisture, ash, crude protein, ether extract and crude fiber contents were determined according to the methods of A.O.A.C. (2005). Total carbohydrates content was calculated by subtracting protein, ash, and ether extract from total mass of 100 as reported by A.O.A.C. (2005). Total phosphorus was determined colorimetrically using ascorbic acid method as described by Murphy and Riley (1962). Potassium and sodium contents of rice samples were estimated using flame photometer as given by Pearson (1976). Calcium, iron, zinc and copper contents of rice samples were conducted using the atomic absorption spectrophotometer Perken Elmer Model 20180 following the method of Pearson (1976).

Statistical analysis

Most of the received data were analyzed statistically using the analysis of variance and the means were further tested using the least significant difference test (LSD) as outlined by Stell and Torrie (1980).

RESULTS AND DISCUSSION

Physical properties of some rice varieties

Data presented in Table (1) indicated that, the length of brown rice grains ranged between 5.25 to 9.48 mm, whereas the length of white rice grains ranged from 5.10 to 9.26 mm, Egyptian jasmine rice was significantly the longest among all rice varieties.

The width of brown rice in the four different varieties of rice (wax ,black , Giza 178 and Egyptian jasmines) were 3.91, 2,90, 2.83 and 2.49 mm, and white rice grains had the values of 3.75, 2.74, 2.76 and 2.26 mm, respectively. As for grain shape the results referred that, Egyptian jasmines variety was slender shape. wax, black and Giza 178 were bold shape according to Ahuja *et al.* (1995). Kent and Evers (1994) classified the shape as slender > 3.00, medium (3.01-3.00), bold (1.01-2.00) and round (< 1.0).

Apparent also from the same table that, grain index values of brown and white rice of the four rice varieties (wax, black, Giza 178 and Egyptian jasmines) were (24.30, 23.65, 20.78 and 20.70 g); (21.20, 20.46, 17.48 and 18.40 g), respectively. In addition the data in the same table revealed that, bulk density were higher in white rice samples than those of brown rice. Apparent also from the above mentioned data that, milling process led to a pronounced increase of bulk density, where a noticeable decrement in grain index values were recorded. Data in this respect were in agreement with the findings of numerous investigators (FAO, 1993; Perdon *et al.,* 2000; Kamel *et al.,* 2001 and Jiamyangyuen and Ooraikul, 2008).

Table (1): Some Physical properties of the tested rice varieties.

Rice variety	Treatment	Grain dimension		Grain shape	"Grain index (g)	Bulk density (g/cm3)
		Length (mm)	Width (mm)			
Waxy	Brown	7.25 d	3.91a	1.85 c	24.30 a	0.85b
	White	7.47 c	3.75 a	1.99 c	21.20 c	0.89a
Black	Brown	5.25 e	2.90 b	1.81 c	23.65 b	0.83 b
	White	5.10 f	2.74 b	1.86 c	20.46 e	0.87 a
Giza 178	Brown	5.35 e	2.83 b	1.89 c	20.78d	0.84 b
	White	5.12 f	2.76 b	1.85 c	17.48g	0.88 a
Egyptian jasmines	Brown	9.48 a	2.49 c	3.81 b	20.70d	0.86 b
	White	9.26 b	2.26 d	4.09 a	18.40 f	0.89 a

*Each value was an average of ten determinations
+Values followed by the same letter in column are not significantly different at P < 0.01.
"Grain index = weight of 1000 grains.

Milling characteristics of some rice varieties

Data present in Table (2) indicated that, the hulls percentage of raw paddy rice ranged between 24.50 to 21.20%. Apparent also from the same table that, brown rice recovery differed significantly between the samples. Waxy rice had the highest value of brown rice (78.80%) where Egyptian jasmines rice had the lowest value (75.50%). For the milled rice percentage, Black rice was significantly the highest, but Waxy rice was the lowest.

The percentages of head and broken rice varied according to the length and width of the rice varieties as given in Table (1) the japonica rice variety (Black) had lower percentages of broken rice than those of Indica rice variety (Egyptian jasmines). These results were in the same trend with those reported by (El-Kady and Draz, 1995; Wiset *et al.*, 2001 and Abd El-Rassol *et al.*, 2005).

Water uptake, sedimentation value and Cooking time of some rice varieties.

Results given in Table (3) show that, brown black rice had the highest cooking time compared to the other samples (40 min.). Generally, brown rice had cooking time higher than that of milled rice. The obtained results were in line with those reported by (Lee *et al.*, 1995 and Paiva *et al.*,2016) who reported that , faster rate of water uptake indicated a shorter cooking time. As for water uptake it could be noted that, water uptake values of 77oC and 82oC were higher in white rice samples than those of brown rice ones. This may be related to the removal of protein, lipid and minerals in brown rice samples. Dharmaputra (1997) found that, water uptake could be easily bound by carbohydrate compared to lipid or protein.

Table (2): Milling characteristics of some rice varieties.

Rice variety	Hulls %	Brown rice %	Milled rice %	Head rice %	Broken rice %
Waxy	21.20 c	78.80 a	65.70 d	56.90 c	8.80 b
Black	21.30 c	78.70 a	69.50 a	64.10 a	5.40 d
Giza 178	21.90 b	78.10 b	68.80 b	62.50 b	6.30 c
Egyptian jasmines	24.50 a	75.5 0 c	66.50 c	54.40 d	12.10 a

*Each value was an average of three determinations
+Values followed by the same letter in column are not significantly different at P < 0.05.

Table (3): Water uptake, sedimentation value and Cooking time of some rice varieties.

Rice variety	Treatment	Water uptake (ml H2O/100 g rice)		Sedimentation value ml sed./ 100 g rice)		Cooking time (min.)
		77 0C	820C	770C	820C	
Waxy	Brown	210.61d	242.11 f	1.26c	1.50c	34b
	White	230.90 b	273.32b	1.60b	2.10b	20e
Black	Brown	212.50d	246.35e	1.15c	1.45c	40a
	White	242.10a	276.50b	2.35 a	2.65a	25d
Giza 178	Brown	231.45b	267.77c	1.70b	1.80c	30c
	White	245.50a	283.91a	2.45a	2.65a	22e
Egyptian jasmines	Brown	222.70c	251.30d	1.50b	1.90b	35 b
	White	243.20a	281.80a	2.30a	2.70a	21 e

*Each value was an average of three determinations
+Values followed by the same letter in column are not significantly different at P < 0.05

Apparent also from the same table that, sedimentation values at 77oC and 82oC were higher in white rice samples than those of brown rice. Furthermore, sedimentation values at 82oC were higher than those of 77oC for different rice varieties. Furthermore Brown Black rice and Brown Waxy rice had the lowest sedimentation value among all of the tested rice varieties (1.15 and 1.45 ml sed./100 g rice) and (1.26 and 1.50 ml sed./100 g rice) at 77oC and 82oC, respectively.

The obtained results were in line with those reported by (Chrastil, 1994; Zhout *et al.,* 2002 and Sodhi *et al.,* 2003 ; Jiamyangyuen ; Ooraikul, 2008 and El-Bana *et al.,* 2010).

Cooking and eating quality of some rice varieties.

Data presented in Table (4) show that , gel consistency (GC) varied significantly among varieties in both brown and milled rice. GC in brown rice decreased significantly compared with that of milled rice. These results are in agreement with those reported by El-Bana (2003).

Waxy rice had the highest GC in both brown and milled rice, followed by Black, then Giza 178, then Jasmine rice. Generally, all varieties classified under soft rice which ranged between 61-100mm as described by Cagampang *et al.* (1973). Perez (1979) concluded that GC of milled rice or rice starch was a good measurement of gel viscosity which in turn was an index for the texture of cooked rice. Because of the relationship between gel viscosity and amylograph consistency, the last can be used as a tool for rapid screening of eating quality in a rice breeding program.

It should be also noted from the same table that, alkali spreading value in brown rice varieties showed lower values in comparing with those of white rice varieties.

As for brown rice, it seems to require a longer time to cook. Alkali spreading value is used as an inverse indicator of gelatinization temperature of rice starch granules that affected by several factors including water content of the gel, amylose content and degree of crystalinity in the amylopectin chain length (Lai, 2001; Irshad, 2001 and El-Bana *et al.*, 2010).

Waxy rice had the highest gelatinization temperature among the other varieties. It may be due to the lowest contents of amylose.

The results in Table (4) show also that, amylose content of Waxy rice variety significantly had low content (6.50% in milled and 7.47% in brown) compared to other varieties. The highest contents for amylose were found in Black rice variety (26.60% in milled and 25.59% in brown). The amylose contents of milled rice were higher than those of brown rice in all varieties. These results are in agreement with those reported by Jane *et al.* (1999) , El-Bana (2003), Ibanez *et al.*, 2007 and Osman and Abd El-Galeel (2008).

Table (4): Cooking and eating quality of some rice varieties.

Rice variety	Treatment	Gel consistency (mm)	Alkali spreading value (GT)	Elongation %	Amylose %
Waxy	Brown	95.20b	4.00e	64.75e	6.50f
	White	97.77 a	4.50d	66.80c	7.47e
Black	Brown	88.50d	5.00c	67.23b	25.59b
	White	90.30c	5:50 b	69.42a	26.60a
Giza 178	Brown	84.5oc	5.60b	63.22f	17.52d
	White	85.20e	6.50a	65.91d	18.75c
Egyptian jasmines	Brown	80.30c	5.00c	59.00d	17.92d
	White	85.80e	5.50b	63.60f	18.88c

*Each value was an average of there determinations
+Values followed by the same letter in column are not significantly different at P < 0.05

It could be noted that, elongation values of white rice were higher than those of brown rice, some trand was recorded in case of short grain variety (black , Waxy , and Giza 178 rice) when compared with those of long grain variety (Egyptian jasmines) for all treatments. This was expected since water related positively with grain elongation during cooking. These results are in accordance with those of (Ahuja *et al.,* 1995 and El-Bana *et al.,* 2010).

Chemical composition of some rice varieties

Data presented in Table (5) showed that , the moisture content of brown and white rice varieties ranged between 11.45 to 13.70%. These values are in lien with those of (Perez, *et al.,* 1993 and Dharmaputra, 1997). Apparent also from the same table that, moisture content of brown rice varieties were lower than those of white rice. Amorim *et al.* (2004) reported that , moisture content plays a great role during the storage for rice. From the same table, it could be observed that, brown rice of Egyptian jasmines variety contains a relatively high level of crude protein content (8.30%), while, white wax rice variety had the lowest level of crude protein content (6.61%).

Results of the same table also revealed that, there were high significant differ in ether extract between brown and white rice of the same variety, also between the different varieties. The wax rice variety had the highest ether extract content 2.45% for brown and 1.31% for black white rice variety. Siebenmorgen and Sun (1994) and Pal *et al.* (1999) reported that surface fat content was inversely related to the degree of milling. High significant differences in ash content was recorded between the varieties as well as between brown and white rice in the same variety. The black variety contained the highest ash content (1.46 and 1.12%) for brown and white rice, respectively. Amorim *et al.* (2004) found that, the ash content in the rice was 0.4% . It was reported that, the ash content indicated the amount of minerals.

The data presented in the same table showed that, the white rice variety of waxy had the highest carbohydrates content in comparing with the other tested samples. In addition, carbohydrates content of rice samples was increased as a result of milling. These results may be due to the removal of the embryo and bran layer, to yield milled rice poor in fat, crude protein, fiber and ash. So, the level of available carbohydrates will be higher in milled rice than in brown rice (Singh *et al.*, 2000 ; Suwansri and Meullenet, 2004; Ibanez et al.,2007; Moongngarm and Saetung 2010 and Paiva *et al.*, 2016).

Minerals content

The ash content of rice varieties was important to some extent, it contained the nutritionally impotent minerals. The levels of these minerals showed in Table (6).Potassium content was element among all of the determined mineral contents.

Data indelicate that brown rice contained the highest mineral contents among of all tested rice samples, whereas the rice variety of black rice had relatively high levels of the mineral contents from brown and white rice comparing with the other varities . These results were in agreement with those reported by FAO, (1993) , Abd El- Rassol *et al.* (2005) and El-Bana *et al.* (2010) and Kenneedy (1980) found that the minerals content rice verities varied from 58 to 117; 7.8 to 25; 5.9 to 10.3; 0.2 to 2.7 and from 0.3 to 1.37 mg/100 g for Potassium, Calcium, Sodium, Iron and Zinc, respectively

Table (5): Chemical composition (%) of some rice varieties.

Rice variety	Treatment	Moisture	Crude protein	Ether extract	Ash	Crude fiber	**Total carbohydrate
Waxy	Brown	13.50a	7.64b	2.45a	1.40a	1.60b	88.51d
	White	13.70a	6.61 e	0.51d	0.49b	1.21c	92.39a
Black	Brown	11.45d	7.89b	2.31a	1.46a	2.o1a	88.34d
	White	11.60d	7.01d	1.31c	1.12a	1.o3c	90.56c
Giza178	Brown	12.36c	7.91b	1.95b	1.29a	1.52b	88.85d
	White	13.03b	7.12d	0.77d	0.72b	1.00c	91.39b
Egyptian jasmines	Brown	12.12c	8.40a	1.91b	1.17a	1.05c	88.52d
	White	12.31c	7.55c	0.77d	0.71b	0.69d	90.97b

Each value was an average of three determinations
+Values followed by the same letter in column are not significantly different at P < 0.05
**Total carbohydrate were calculated by difference.

Table (6): Mineral contents of some rice varieties.

Rice variety	Treatment	P %	(mg/100g)					
			K	Na	Ca	Fe	Zn	Cu
Waxy	Brown	0.23	290	6.7	11.9	0.9	1.50	0.73
	White	0.16	136	5.7	7.5	0.6	0.90	0.67
Black	Brown	0.32	366	13.3	18.7	3.90	2.5	0.76
	White	0.21	132	7.5	10.0	2.1	1.70	0.43
Giza 178	Brown	0.28	215	9.4	12.21	1.o	1.76	0.55
	White	0.17	73	6.49	6.10	0.87	1.11	0.42
Egyptian jasmines	Brown	0.26	291	8.55	12.22	1.0	1.8	0.69
	White	0.16	113	6.45	7.9	0.7	1.1	0.58

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تقييم الخواص الطبيعية و الكيميائية والتكنولوجية للارز الشمعى والغير شمعى

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الملخص العربى

أجريت هذه الدراسة بهدف المقارنة بين الصفات الطبيعية والكيماوية والتكنولوجية لأربعة أصناف من الأرز المصري وهى (الشمعى – الاسود – حيزة ١٧٨ – ياسمين المصرى) .

واظهرت النتائج ما يلى:

- وجد ان هناك اختلاف فى الخواص الطبيعية للارز البنى والابيض وذلك تبعا للصنف ووجد ان حبوب الارز للصنف ياسمين المصرى اكثر الاصناف فى الطول واقل الاصناف فى العرض بينما كان الصنف الشمعى اكثر الاصناف فى وزن المائة حبة.
- وجد اختلاف فى نواتج الضرب بين الاصناف موضع الدراسة فقد اعطى الصنف ياسمين المصرى اعلى نسبة من الحبوب المكسورة واقل نسبة من الحبوب السليمة والارز البنى مقارنتا بباقى الاصناف.

- بالنسبة للماء الممتص اثناء الطهى للارز الابيض كانت اعلى منها فى الارز المقشور وان الارز الاسود المقشور استغرق اطول فترة للطهى حوالى ٤٠ دقيقة مقارنة بباقى الاصناف.
- اختلفت قيم سيولة الجل فى حبوب الارز المقشوروالابيض تبعا للصنف.
- لوحظ اختلافات فى قيم انتشار القلوى لحبوب الارز المقشور والمبيض وكانت قيم انتشار **القلوى** للارز المقشور اقل من الارز الابيض.
- أمتلك الصنف الشمعي أعلى درجة تكوين الجل وكذلك درجة حرارة الجلتنه بين كل الأصناف ، لكنه أحتوى على أقل نسبة أميلوز.
- الارز الاسود امتلك نسبة عالية من الاميلوز واستطالة الحبوب.
- احتوى الارز الاسود على اعلى نسبة من المستخلص الاثيرى . الرماد . الالياف الخام واقل نسبة من الكربوهيدرات بالمقارنة بباقى الاصناف.
- اظهرت النتائج ان الارز المقشور لكل الاصناف احتوى على نسب اعلى من البروتين الخام والمستخلص الايثيرى والرماد والالياف الخام و نسبة اقل من الكربوهيدرات الكلية مقارنة بالارز الابيض وان الارز الاسود احتوى على نسب اعلى من المعادن مقارنة بباقى الاصناف.