

## PHYSICAL, CHEMICAL, THERMAL AND TECHNOLOGICAL PROPERTIES OF SOME EGYPTIAN RICE VARIETIES

Osman, M. F. and M. A. Abd El-Galeel

Food Science and Technology Dept., Fac. of Agric., Kafr El-sheikh Univ., Egypt.

### ABSTRACT

This study was carried out to compare physical, chemical, thermal and technological properties of four rice varieties (Hybrid1, Jasmine, Waxy and Black) grown in Egypt as well as to investigate the possibility of using their rice flour as substitution of wheat flour in preparation of some bakery products namely biscuits. Physical properties such as milling output, head rice percentage and kernel physical attributes of rice varieties were measured. Chemical composition, gelatinization temperature (GT), gel consistency (GC), *in vitro* starch digestibility and cooking properties of rice were also determined. In addition, biscuit using milled rice flours as substitution of wheat flour at levels of 25 and 50% was prepared, and its sensory analysis as well as its functional properties were evaluated. The results revealed that Hybrid1 rice had the highest milled percentage but Jasmine variety had the highest head rice percentage. Waxy rice had the highest contents of total carbohydrates and starch. Black rice contains high content of ether extract, ash and crude fibers, but it contain lower content of total carbohydrates and starch compared with another varieties. In addition, brown rice in all varieties had higher contents of crude protein, ether extract, ash and crude fibers but it contain lower contents of total carbohydrates and starch compared with those of milled rice. 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 lowest GT and the highest amylose content. Also, the results cleared that no significant differences were found among all rice varieties in starch digestibility using  $\alpha$ -amylase. Cooking qualities revealed that Hybrid1 rice had the longest cooking time (22 min) compared to the others, while the other varieties had somewhat similar cooking time. Generally, brown rice had significantly cooking time higher than that of milled rice. Water uptake of milled rice was significantly higher than that of brown. In milled rice, water uptake were in order; Hybrid1 > Jasmine > Black > Waxy. Organoleptic evaluation indicated that, biscuit samples prepared using rice flour of studied varieties as substitutions of wheat flour until 50% were very acceptable, where most samples have sensory characteristics scores higher than those of control (wheat flour biscuit). Water loss during baking of biscuit was higher in formulas contained rice flour than that of control and it increased with increasing of rice replacement ratios. Water uptake of samples prepared with rice flours as substitution of wheat flour was significantly higher than that of control sample (free from rice flour). Water uptake values of biscuits contained higher substitution ratio (50%) were significantly higher than those of samples contained lower ones. Specific lightness of biscuit made using rice flour as substitution of wheat flour was somewhat lower than that of wheat flour biscuit with the exception of black rice was the highest.

**Keywords:** *Hybride1; Jasmine; Waxy; Black rice; physical; chemical; technological properties.*

### INTRODUCTION

The rice is the second cereal most cultivated in the world. There are two species cultivated in the world, Asian (*Oryza sativa* L.) and African (*Oryza glaberrima* steued). Water plays a key role in the physical, mechanical

and thermal properties of rice (Kamst *et al.*, 2002). The amylose and protein contents of the main components are very important indicators for determining the basic grain quality or palatability (Juliano, 1985).

Black rice (*Oryza sativa* L. var. Indica), a kind of brown rice, contains anthocyanin pigments (Choi *et al.*, 1994). The increase of Black rice production creates the opportunity for new product development (Eun *et al.*, 1998) such as Black rice gruel (Lee and Eun, 1999; Lee *et al.*, 1999), and Black rice bread (Chung and Eun, 1999). Very few studies have been reported on Black rice processing.

The chemical composition of grains varies widely, depending on environment, soil and variety. Values for starch, lipid and protein also vary with the method of analysis, which means that comparisons can be misleading. Nevertheless, brown rice is generally regarded as having the lowest protein content among the common grains and is low in fiber and lipid contents. However, the net protein utilization and digestible energy in rice are the highest amongst the common cereal grains (Zhou *et al.*, 2002).

Quality evaluation of rice involves the application of sensory tests (Matsue and Ogata, 1998) and physicochemical determinations (Ohtsubo *et al.*, 1993) based on the chemical composition, cooking quality, gelatinization temperature and/or the physical properties of cooked rice (Bhattacharjee *et al.*, 2002).

The consumer's concern is to get rice of good cooking and eating qualities, this is largely dependent on the physico-chemical properties of starch which make up 90% of milled rice. Several component traits like apparent amylose content (AC), gel consistency (GC), water absorption, volume expansion and final starch gelatinization temperature (GT) collectively determine cooking and eating qualities of rice (Sidhu, 1989; Ahuja *et al.*, 1995).

Waxy rice constitute a large proportion of the landraces (Ying, 1993; Zhang, 2000). Some are recognized as special germplasm for particular traits and hence special applications such as different colors and fragrances (Zhang, 2000).

In addition, the starch qualities of Waxy rice vary greatly (Juliano and Villareal 1987; Bao *et al.*, 2004). The distinct divergence in waxy rice is in the gelatinization temperature (GT). Waxy rice can be divided into a high and a low GT group. High-GT waxy rice is harder after cooking and show accelerated staling compared to low-GT rice, but significant differences are also observed among some low-GT pairs. In many food applications, waxy rice is preferred to non waxy rice due to its starch physiochemical properties (Villareal *et al.*, 1993).

In particular, rice cake, which is made from glutinous rice flour or rice flour, is a very popular traditional food in Korea (Chun and Yoo, 2004). Glutinous rice flour is also frequently used in commercial product formulations for its functional attributes, which include a freeze–thaw stability superior to that of native and Waxy starches from other crops and resistance against high-temperature process (Wilkinson and Champagne, 2004)

The objectives of the present study were to compare the physical, chemical, thermal and cooking properties of some rice varieties and to

investigate the possibility of using the rice flour as a substitute of wheat flour in preparation of some bakery products that may use for the people, which have allergy against wheat flour gluten.

## **MATERIALS AND METHODS**

### **Rice varieties**

Rice varieties in this investigation were Hybrid1, Jasmine, Waxy and Black rice. These samples were obtained from Rice Research Center at Sakha, Kafr El-sheikh Governorate, Egypt. Rice varieties were cultured at 2007 season, under the recommended conditions for date of culture, fertilization, harvest time and irrigation.

### **Preparation of rice samples**

Raw rice samples were dehulled to obtain the brown rice. The brown rice was divided into two parts the first was used as brown rice and the second was milled to obtain the milled rice. The brown and the milled rice were kept in polyethylene bags and stored in freezer at -18 °C until further analysis.

### **Determination of Physical properties**

Hulling, milling output and head rice percentages were estimated according to the methods of Adair (1952) at Rice Research Center, Sakha, Kafr El-sheikh, Egypt.

The kernel physical attributes (1000 kernel weight, kernel length, breadth and kernel length to- breadth ratio) were measured. The 1000 kernels from each variety of rice were counted randomly in triplicate and weighted separately. Kernel length, breadth were measured using a micrometer with accuracy of 0.001 mm where 10 uniform rice kernels were randomly selected and their length and breadth were measured in duplicate (Suwansri and Meullenet, 2004).

### **Determination of thermal properties of rice**

Gelatinization temperature (GT) was determined according to the method described by Little *et al.* (1958). Gel consistency (GC) was determined according to the method described by Cagampang *et al.* (1973).

### **Determination of chemical composition**

Moisture, ash, crude protein, ether extract and crude fibers contents were determined according to the method of A. O. A. C. (2000). Total carbohydrates were determined by phenol- sulphuric acid reagent according to the method outlined by Dubois *et al.* (1956). The available carbohydrates were calculated by subtracting crude fibers from total carbohydrates content. Starch was determined by anthrone reagent according to the method of Thimmaiah, (1999). Reducing sugars were estimated as described by Somogyi (1952). Amylose content was determined according to the method of Juliano, (1971).

### ***In vitro* digestibility**

*In vitro* digestibility of milled rice flours was determined by the method of Yokoyama *et al.* (1994), with some modifications by Tulyathan and Leecharatanaluk (2007). Rice samples were cooked in boiled distilled water

with ratio 1: 1.5 for 20 min and blended in blender jar for 5 sec. One gram of sample was mixed with 24 ml of distilled water, 20 ml of 0.5 M phosphate buffer (pH 6.9) and 5 ml of 30 mM calcium chloride. The flasks were swirled to mix for 5 sec; 1 ml of salivary  $\alpha$ - amylase (Sigma) containing 100 units in 1 mM calcium chloride was added to the sample flasks and incubated in shaking water bath at 37 °C. The flasks were removed at 15, 30 and 60 min intervals, heated in boiling water for 8 min and centrifuged for 15 min at 8000 xg. The supernatant was removed and analyzed for reducing sugars (as maltose equivalent) (Bruner, 1964).

#### **Determination of cooking properties**

Milled rice was cooked for the minimum cooking time as described by Batcher *et al.* (1956). The head rice (2 g) was taken in test tube from each sample and cooked in 20 ml distilled water in a water bath at 90 °C. The minimum cooking time was determined by removing a few kernels at different time intervals during cooking and pressing between two glass plates until no white core was left. Water absorption of cooked rice was determined by the increase in weight of rice after cooking to optimum cooking time. Solid loss in gruel was determined by drying an aliquot of cooking water in Petri dish at 70°C in an oven until completely dry. Elongation ratio was determined by dividing the cumulative length of ten cooked kernels by length of ten uncooked raw kernels (Sodhi *et al.*, 2003).

#### **Biscuit preparation**

Biscuits were produced from each of the nine composite flours. Wheat flour (72% extraction) biscuit was used as control sample. Substitution levels 25 and 50% of rice flour were used to prepare the biscuit samples. The biscuit formulas were 300g of flour mixture, 100g of margarine, 100g of ground sugar, 35ml of water, 6g of double acting baking powder and 12g of whole egg. All the dry ingredients were blended together by stirring 12 strokes with a wooden spoon. Fat was rubbed into the flour mixture until the consistency of bread crumbs was achieved. The egg was whisked for 3 min. and folded into the flour mixture. Water was added to the mixture and a wooden spoon was used to stir 10 strokes to get a homogenous dough. The dough was rolled on a pasty board with a rolling pin to 3 mm thickness. The flat dough was cut with biscuit cutter. The biscuits were baked on an aluminum baking pan slightly greased with margarine in a gas oven at 200 °C for 15 min (Nnam and Nwokocha 2003). The samples were removed and cooled on a rack for 5 min before the sensory evaluation

#### **Sensory analysis:**

Organoleptic evaluation of baked samples was performed by a semi-trained panel of judges using nine-point hedonic-scale ratings for color, taste, odor, texture and overall acceptability with 9 being the highest score, extremely liked, and 1 being the lowest score, extremely disliked, (Watts *et al.*, 1989).

#### **Physical properties of baked products**

The loss of water in the oven during baking was calculated as the difference in the weight of 6 biscuits before and after baking (Wade, 1971).

The biscuit volume was measured by the displacement of small seeds (alfalfa seeds). The biscuit lightness data were transferred to the score

card scale indicated by Elling and Max (1951). Values of specific lightness were derived as follows:

$$\text{Specific lightness} = \frac{\text{volume of 7 biscuit pieces}}{\text{weight of 7 baked biscuit dough}} \times 20$$

Water uptake of baked biscuit was calculated by the difference between the samples weight before and after dipping in water for 1 min at room temperature dividing on initial weight according to Kramer and Twigg (1973).

## RESULTS AND DISCUSSIONS

### Milling characteristics

It could be observed from Table (1) that brown rice recovery differed significantly between the samples. Waxy rice had the highest value of brown rice (78.64%) but Jasmine rice had the lowest one (75.25%). No significant difference in percentage of brown rice was observed between Hybrid1 and Black rice; both of them were the second.

For the milled rice percentage, Hybrid1 was significantly the highest, Jasmine and Black rice were the second but Waxy rice was the lowest. Head rice percentage of Jasmine rice was significantly the highest followed by Hybrid1. No significant difference in head rice percentage was found between Waxy and Black rice and both of them were the third. Changes in relative humidity during ripening/maturing of rice kernels reportedly lead to the development of stress cracks due to internal stress and therefore causes more breakage during milling (Kunze and Hall 1965; Kunze 1977).

**Table (1): Milling characteristics of some rice varieties.**

Varieties	Milling characteristics %			
	Brown rice	Husk	Milled rice	Head rice
Hybrid1	77.59b	22.41b	69.12a	59.86b
Jasmine	75.25c	24.75a	66.08b	62.46a
Waxy	78.64a	21.36c	65.74c	55.38c
Black	77.26b	22.74b	66.83b	54.72c

Means of values between varieties having the same right case letter(s) (small letter within a column) are not significantly different at ( $p > 0.05$ ).

### Kernel physical attributes

The 1000 kernel weight of used milled varieties is presented in Table (2). The results indicate that Black rice had the highest weight among all samples that recorded 23.8 g/1000 kernels. Waxy rice was the second (21.20g). No significant difference was found between Hybrid1 and Jasmine rice; both of them were the third. Youssef *et al.* (1992) found that rice Giza 172 and IR 28 had grain index (weight of 1000 grains) 24.0 and 18.9g; respectively. El-Bana (2003) found that grain index of varieties Sakha 101 and Giza 182 was 20.4 and 20.3g; respectively.

**Table (2): Kernel physical properties of milled rice.**

Varieties	1000 kernel weight (gm)	Length (mm)	Breadth (mm)	l/b ratio
Hybrid1	18.30c	8.60b	2.90b	2.97b
Jasmine	18.80c	9.60a	2.23c	4.30a
Waxy	21.20b	7.47c	3.73a	2.00d
Black	23.80a	7.48c	3.53a	2.12c

-Milled rice has been classified into four categories on the basis of the average length (mm) of the kernels. Extra long ( > 7.50), Long (6.61 - 7.50), Medium (5.51 - 6.60) and short (≤5.50).

-Grain shape is expressed by l/b ratio of kernels (l, length and b, breadth). Slender (> 3.0), Medium (2.1 - 3.0), Bold (1.1 - 2.0) and Round (≤1.0).

Source: Ahuja *et al.* (1995).

It could be noted from Table (2) that Jasmine rice was significantly the longest among all rice varieties and Hybrid1 was the second. No significant difference was observed between Waxy and Black rice and both of them were the third. Generally, Jasmine and Hybrid1 were classified into extra long varieties (> 7.50 mm); while Waxy and Black rice were classified into long varieties (6.61–7.50 mm) as described by Ahuja *et al.* (1995).

As for grain breadth, no significant difference was found between Waxy and Black rice; both of them were the highest, followed by Hybrid1, then Jasmine rice. Grain shape was calculated and the results referred that Jasmine variety was slender shape, Hybrid1 and Black rice were medium shape, but Waxy rice was bold shape according to Ahuja *et al.* (1995). Kent and Evers (1994) reported that grain shapes of rice were > 3.40, 2.30 to 3.30 and ≤ 2.20 for long, medium and short grain; respectively.

#### **Chemical composition of rice varieties**

Gross chemical composition of brown and milled rice varieties under study was determined and the results are recorded in Table (3). The results show that the moisture content was similar in all varieties except the Black rice which had lower moisture content compared to the others. The moisture content of milled and brown (unmilled) rice was nearly similar and it ranged between 12.37 (Black rice) and 13.92 (Waxy rice). Amorim *et al.* (2004) reported that the moisture content plays a great role during the storage of rice. From the same Table, it could be observed that the total carbohydrates and starch of brown rice were lower than those of milled rice in all varieties under study. In contrary, crude protein, ether extract, ash, crude fibers and reducing sugars of brown rice were higher than those of milled rice. There were significant differences in the protein contents of studied varieties. Jasmine and Hybrid1 brown rice contained the highest protein content (7.76 and 7.62 respectively) while Black brown rice had the lowest protein content (7.01) among the brown rice.

**Table(3): Chemical composition (%) of rice varieties (on dry weight basis).**

Constituents (%)	Rice varieties							
	Hybrid1		Jasmine		Waxy		Black	
	Brown	Milled	Brown	Milled	Brown	Milled	Brown	Milled
Moisture	13.54a	13.68a	13.64a	13.80a	13.92a	13.71a	12.37b	12.37b
Dry matter	86.46b	86.32b	86.36b	86.20b	86.08b	86.29b	87.63a	87.63a
Crude protein	7.62a	6.03ef	7.76a	6.38de	7.42ab	5.60f	7.01bc	6.83c
Ether extract	2.34a	0.66c	2.27a	0.65c	2.20a	0.60c	2.33a	1.93b
Ash	1.33b	0.82d	1.15c	0.49e	1.58a	0.58e	1.64a	1.26bc
Total carbohy.	88.71d	92.49b	88.82d	92.48b	88.80d	93.22a	89.02d	89.98c
Avail. Carbohy.	87.41c	91.60a	87.54c	91.57a	87.10cd	91.85a	86.68d	88.62b
Crude fibers	1.30c	0.89d	1.28c	0.91d	1.70b	1.37c	2.34a	1.36c
Starch	87.60cd	87.90c	87.40d	88.40b	87.80c	88.93a	85.40f	86.20e
Reducing sugar	0.52n.s	0.48	0.53	0.42	0.51	0.43	0.42	0.38

Means of values between varieties having the same right case letter(s) (small letter within a row) are not significantly different at ( $p > 0.05$ ).

For the milled rice, it could be noticed that the Black rice variety was found to have the highest protein content (6.83) followed by Jasmine rice (6.38) but Waxy milled rice had the lowest value (5.60). From the same Table, there were high significant differ in ether extract between brown and milled rice of the same variety also, between the varieties. The Black rice variety had the highest ether extract content 2.33 for brown and 1.93 for milled. The Waxy rice variety had the lowest content of ether extract, 2.20 for brown and 0.60 for milled. Siebenmorgen and Sun (1994) reported that surface fat content was inversely related to the degree of milling. Suwansri and Meullenet (2004) found that significant differences in fat and protein contents of domestic and imported Jasmine rice. They maintained that these are probably a result of differences in postharvest handling techniques (drying, storage and milling) between domestic and imported rice samples. Kadan *et al.*, (1997) found that the protein content of milled Waxy and Jasmine rice were 6.9 and 6.7, and the lipid content were 0.6 and 0.3, respectively. Pal *et al.*, (1999) stated that the fat and protein contents decreased linearly with increase in degree of polish, as these constituents were mainly concentrated in the peripheral layers of the kernel

High significant differences in ash content between the varieties as well as between brown and milled in the same variety were found. The Black variety contained the highest ash content (1.64 and 1.26) for brown and milled rice respectively, followed by Hybrid1 variety which contained 1.33 and 0.82 for brown and milled samples respectively. The Jasmine variety had the lowest content of ash (1.15) for its brown and (0.49) for milled rice. Amorim, *et al.*, (2004) found the ash content in the rice was 0.4 and they reported that the ash content indicates the amount of minerals. As shown in Table (3), there were no significant differences in total carbohydrates content of all brown rice samples but in case of milled rice there were significant differences between the varieties, where the Black rice had lowest content of carbohydrates (89.98%) and Waxy rice had highest value (93.22%). Similarly results for the starch were obtained, where Black rice either brown or milled had the lowest values (85.40 and 86.20% respectively), while Waxy rice

contained highest values for its brown and milled (87.80 and 88.93%). As for the fiber content, it could be noticed that there are high significant differences either between the varieties or between the brown and milled of same variety. The highest fiber content of milled rice was in Waxy (1.37%) and in Black (1.36%), while the lowest values were in Hybrid1 (0.89%) and Jasmine (0.91%). For the brown rice, the highest fiber content was in Black rice (2.34%) while the lowest was in Jasmine (1.28%) and Hybrid1 (1.30%). High significant differ between brown and milled rice due to the milling process that remove outer layers of grain which contains more fiber content.

Removal of the hull during milling produces brown rice (Hinton and Shaw, 1954). Further milling to yield milled or white rice results in a disproportionate loss of lipid, protein, fiber, ash and reducing sugars (Park *et al.*, 2001).

From the data in Table (3), it could be concluded that Black rice contain high contents of ether extract, ash and crude fiber compared with that of other varieties, but it contains lower contents of total carbohydrates and starch. In addition, brown rice in all varieties has higher contents of crude protein, ether extract, ash, crude fiber and reducing sugar but it contains lower contents of total carbohydrates and starch compared with those of milled rice.

#### Gel consistency (GC)

The results 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 Hybrid1, then Black, 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.

**Table(4): Gel consistency, gelatinization temperature and amylose content of rice varieties.**

Varieties	<sup>1</sup> Gel consistency (GC)		<sup>2</sup> Gelatinization temp. °C (GT)		Amylose%	
	Brown	Milled	Brown	Milled	Brown	Milled
Hybrid1	n.s90.32b	91.0b	n.s5.41b	5.33b	<sup>b</sup> 20.67b	<sup>a</sup> 21.40b
Jasmine	n.s84.33d	85.0d	n.s4.53c	4.67c	<sup>b</sup> 21.23b	<sup>a</sup> 22.57b
Waxy	n.s97.17a	97.67a	n.s4.15d	4.13d	<sup>b</sup> 7.00c	<sup>a</sup> 7.57c
Black	n.s89.00c	89.33c	n.s5.86a	5.67a	<sup>b</sup> 31.33a	<sup>a</sup> 32.57a

<sup>1</sup>= GC hard (27 – 40 mm), medium (41 – 60 mm) and soft (61 – 100 mm)

<sup>2</sup> = GT rating of 1 - 3 = high GT (greater than 74 C), rating of 4 – 5 = intermediate GT (70 - 74 C) and rating of 6 - 7 = low GT (below 70 C).



#### **Gelatinization temperature (GT)**

It could be observed from the same Table (4) that Waxy rice had the highest gelatinization temperature among the other varieties. It may be due to the lowest contents of amylase. Gelatinization temperature was affected by several factors including water content of the gel, amylose content and degree of crystallinity in the amylopectin chain length. For instance, Waxy rice starch had higher gelatinization temperature and degree of gelatinization (Lai, 2001) than non-waxy starch, but the peak viscosity of waxy rice occurred at a lower temperature than that of non-waxy rice (Shi and Seib, 1992). GT for Jasmine rice was the second followed by Hybrid1, then Black rice. Juliano (1972) confirmed that the endpoint of the starch gelatinization temperature varied from 55 °C to 79 °C for most rice. Cameron *et al.* (2008) cleared that pasting and gelatinization properties are often used as quality indicators for processing or product characteristics. Pasting or gelatinization temperature gives an indication of the temperature at which the rice must be processed to fully cook the starch.

#### **Amylose content**

The results in Table (4) show also that, amylose content of Waxy rice variety significantly had low content (7.57% in milled and 7.00% in brown) compared to other varieties. The highest contents for amylose were found in Black rice variety (32.57% in milled and 31.33% 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 El-Bana (2003). Kadan *et al.*, (1997) found that amylose content of short-, medium- and long-grain rice ranged from 12% to 21%, but the Waxy rice is a short grain cultivar with almost 100% amylopectin starch. Juliano, (1979) reported that amylose content is considered the most important characteristic for predicting rice cooking and processing properties. He also reported that amylose content varies greatly between varieties, from a low of 0 - 2% in Waxy rice (milled) to a high of greater than 25% in non-waxy rice. Cooking characteristics, texture, water absorption ability, stickiness, volume expansion, hardness and even the whiteness and gloss of the cooked milled rice are affected by the amylose content (Juliano, 1985). For example, Waxy varieties produce only amylopectin and these starches are non-gelling because of the lack of amylose. Both the amylose content and amylopectin branch chain-length distributions affected starch pasting properties (Jane *et al.*, 1999).

#### **Cooking qualities of rice varieties**

The results in Table (5) shows that, milled rice from Hybrid1 had the highest cooking time compared to the others (recorded 22 min.). No significant differences were found in cooking time among Jasmine, Waxy and Black rice, all of them recorded 20 min. Generally, brown rice had significantly cooking time higher than that of milled rice. Hybrid1 was the highest followed by Black, then Waxy, then Jasmine rice. The differences between Hybrid1 and other varieties may be attributed to differences in amylose and protein contents (Sodhi *et al.*, 2003). They also found that cooking time of some varieties of basmati rice ranged between 18 and 26 min.

Table (5): Cooking qualities of rice varieties.

Rice varieties	Cooking quality							
	Cooking time (min)		Water uptake (%)		Gruel solid loss (%)		Elongation (%)	
	Brown	Milled	Brown	Milled	Brown	Milled	Brown	Milled
Hybrid1	<sup>A</sup> 37a	<sup>B</sup> 22a	<sup>B</sup> 254.5a	<sup>A</sup> 362.0a	<sup>A</sup> 1.5b	<sup>B</sup> 0.5b	<sup>B</sup> 1.65a	<sup>A</sup> 2.00a
Jasmine	<sup>A</sup> 33d	<sup>B</sup> 20b	<sup>B</sup> 235.5c	<sup>A</sup> 322.0b	<sup>A</sup> 2.25a	<sup>B</sup> 1.65a	<sup>B</sup> 1.60b	<sup>A</sup> 1.88b
Waxy	<sup>A</sup> 34c	<sup>B</sup> 20b	<sup>B</sup> 242.0b	<sup>A</sup> 273.5d	<sup>A</sup> 2.0a	<sup>B</sup> 1.50a	<sup>B</sup> 1.62ab	<sup>A</sup> 1.70d
Black	<sup>A</sup> 36b	<sup>B</sup> 20b	<sup>B</sup> 224.5d	<sup>A</sup> 297.0c	<sup>A</sup> 2.15a	<sup>B</sup> 1.50a	<sup>B</sup> 1.55c	<sup>A</sup> 1.76c

Means of values between varieties having the same right case letter(s) (small letter within a column) and means of values between brown and milled rice having the same left case letter(s) (capital letter within a row) are not significantly different at ( $p > 0.05$ ).

As for water uptake, it could be noted that, water uptake of milled rice was significantly higher than that of brown rice. It may be due to the presence of thin layer around the grains of brown rice which lowered water uptake or the presence the lipids that hydrophobic in outer layers. In milled rice, these values were in order: Hybrid1 > Jasmine > Black > Waxy. Water uptake during cooking is related positively with grain elongation, which in turn is influenced by environmental factors, especially temperature, at the time of ripening. The ambient temperature of 25/21 °C (day/night) at ripening has a favorable effect on grain elongation, which decreases with increase in temperature (Ahuja *et al.*, 1995).

The results in Table (5) show also, gruel solid loss during cooking decreased as a function of milling process. It may be due to that, the protein, minerals, sugars and lipids are highly concentrated in the outer layers and starch in the endosperm of the kernel. Understanding the increased degree of polishing resulted in progressive decreases in protein, sugars, free fatty acids contents but an increase in the amylose content of the milled rice (Bajwa *et al.*, 1999). In both brown and milled samples, Hybrid1 was the lowest in gruel solid loss among all of the used samples. No significant differences were found among the others. Also, those authors found that cooking time decreased but water uptake, elongation and gruel solids loss on cooking increased as degree of milling increased. Our results are in agreement with earlier findings (Bajwa *et al.*, 1999) with the exception of gruel solid loss which decreased as a function of milling process.

#### ***In vitro* starch digestibility**

Rice starch is classified as one of the most digestible starch (Dreher *et al.*, 1981), and simple *in vitro* systems are useful for initial screening and for measuring rates of starch hydrolysis in foods (Snow and O'Dea 1981). The digestibility of rice flour was studied using  $\alpha$ -amylase. Rice and rice-based products are digested and absorbed quickly in healthy humans, producing the highest glycemic answer and low colonic fermentation (Casiraghi *et al.*, 1993). The results in Table (6) show that no significant differences were found among all rice varieties in starch digestibilities (expressed as maltose) at various times.

**Table (6): *In vitro* starch digestibility of milled rice.**

Rice varieties	Starch digestibility for different times (min)			
	Maltose (mg/g sample)			
	0	15	30	60
Hybrid1	51.13 n.s	86.11 n.s	114.17 n.s	135.09 n.s
Jasmine	51.22	86.24	113.79	134.65
Waxy	50.98	85.86	114.16	134.49
Black	51.02	86.97	113.86	135.11

Means of values between varieties having the same case letter(s) within a column are not significantly different at ( $p > 0.05$ ).

#### **Organoleptic evaluation of prepared biscuit**

The results of organoleptic evaluation recorded in Table (7) indicate that the samples contained Hybrid1 rice flour either 25 or 50% gave better scores for all characteristics except the color that was similar compared with control (wheat flour biscuit). No great differences between biscuit contained 25 and 50% hybrid1 rice flour were observed. This indicates the substitution of Hybrid1 rice flour instead of wheat flour at level until 50% to prepare biscuit has a positive effect on sensory characteristics. Sample contained 25% Jasmine rice flour has lower scores for the color, taste, odor and overall acceptability compared with those of control but the sample contained 50% Jasmine rice have high scores for all characteristics compared with control. Biscuit made using Waxy rice flour at level 25% instead of wheat flour have higher scores for taste, odor, texture and overall acceptability while it have similar scores for the color and appearance compared with control. In contrary, biscuit contained 50% of Waxy rice flour instead of wheat flour has lower scores for all characteristics than those of control. This means, using Waxy rice flour as replacement of wheat flour at level more than 25% have somewhat a negative effect on biscuit sensory characteristics. Biscuit samples prepared using Black rice flour as replacement of wheat flour at either level 25 or 50% gave lower scores for all sensory characteristics compared with those of control. Generally, biscuit samples prepared using varieties rice flours under study as substitution of wheat flour until 50% were very acceptable, where most samples have sensory characteristics scores higher than those of control and the lowest score was 6.73 for taste of sample contained 25% Black rice and this score considered liked.

**Table (7): Organoleptic evaluation of biscuit prepared by different levels of rice flour as substitution of wheat flour.**

Sample		Color	Taste	Odor	Texture	Appearance	Overall acceptability
Control		8.35a	8.12b	8.28c	8.12d	8.09c	8.19b
Hybrid1	25%	8.18a	8.56a	9.08a	8.53bc	8.77b	8.62a
	50%	8.35a	8.29ab	8.78ab	8.75b	8.75b	8.58a
Jasmine	25%	7.55b	7.78bc	7.62d	8.27cd	8.00c	7.84c
	50%	8.23a	8.00b	9.22a	9.26a	9.35a	8.81a
Waxy	25%	8.00a	8.77a	8.37bc	8.56bc	8.27c	8.39ab
	50%	7.51b	7.75c	8.00cd	7.48e	8.06c	7.76c
Black	25%	6.78c	6.73e	7.04e	7.21e	7.20d	7.01d
	50%	7.11c	7.08d	7.73d	7.57e	7.30d	7.34d

Means of values between varieties having the same case letter(s) within a column are not significantly different at ( $p > 0.05$ ).

### Physical properties of biscuit

The data given in Table (8) show that water loss during the baking of biscuit was higher in formula contained rice flour as replacement of wheat flour than that of wheat flour biscuit. The loss of water during baking increased with increasing of rice replacement ratio. The highest water loss value (13.82%) was occurred in case of formula contained 50% Waxy rice and the lowest value was in case of 25% Jasmine rice formula. These results may be related to the differences in chemical composition such as amylose or fiber contents, which affect on water holding capacity.

The results of water uptake indicated that there are high significant differences between control and other samples. Water uptake of samples prepared with rice as substitution of wheat flour was significantly higher than that of control sample (free from rice flour). Water uptake values of biscuit samples contained higher substitution ratio (50%) were significantly higher than those of samples contained lower one.

Specific lightness of biscuit samples contained 25 or 50% rice flour as substitution of wheat flour was lower than control, except the sample contained Black rice that had specific lightness higher compared with that of control. The differences in physical properties of biscuits may be due to the differences in chemical composition of ingredients used in processing. Abd EL-Moniem and Yaseen, (1993) found that the increasing of lightness of baked products related to increasing of fiber content.

**Table (8): Some physical properties of prepared biscuits.**

Sample		Water loss in oven (%)	Water uptake after baking (%)	Specific lightness
Control		10.44d	16.94h	33.26c
Hybrid1	25%	10.68d	20.05g	28.06f
	50%	11.83c	52.09a	29.08e
Jasmine	25%	10.50d	22.38f	23.56i
	50%	12.45b	42.14c	31.00d
Waxy	25%	13.65a	22.58f	25.86h
	50%	13.82a	29.89e	26.58g
Black	25%	11.95c	31.63d	34.64b
	50%	13.38a	50.40b	35.52a

Means of values between varieties having the same case letter(s) within a column are not significantly different at ( $p > 0.05$ ).

### Conclusion

From the obtained results, it can be concluded that:

- Waxy rice had the highest gel consistency (GC) and gelatinization temperature (GT) among the other studied varieties; but it had the lowest amylose content. Black rice had the lowest GT and the highest amylose content. Hybrid1 had the longest cooking time and the brown rice had significantly cooking time higher than that of milled rice. Water uptake of milled rice was significantly higher than that of brown.
- Waxy rice had the highest contents of total carbohydrates and starch. Black rice contain high contents of ether extract, ash and crude fibers. In addition, brown rice in all varieties had higher contents of crude protein,

ether extract, ash and crude fibers but it contain lower contents of total carbohydrates and starch compared with those of milled rice.

- According to the obtained results of sensory evaluation and functional properties of biscuit processed using rice flour as replacement of wheat flour, it could be used the rice flour until 50% substitution ratio to prepare very acceptable biscuit that may be also useful for the people especially children, which have allergy against wheat flour gluten.

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## الخواص الطبيعية والكيمائية والحرارية والتكنولوجية لبعض أصناف الأرز المصرية

محمد فوزي عثمان و محمد عوض عبد الجليل

قسم علوم وتكنولوجيا الأغذية - كلية الزراعة - جامعه كفر الشيخ - مصر.

أجريت هذه الدراسة بهدف المقارنة بين الصفات الطبيعية والكيمائية والحرارية والتكنولوجية لأربعة أصناف من الأرز المصري وهي هجين ١ ، الياسمين ، الشمعي والأسود والمنزوعة تحت الظروف المثلى من حيث ميعاد الزراعة والتسميد والري وخلافه بمركز بحوث الأرز التابع لمحطة البحوث الزراعية بسخا- كفر الشيخ - مصر. وإمكانية الاستفادة من دقيق هذه الأصناف لتحل محل دقيق القمح في صناعه بعض منتجات المخازن مثل البسكويت لمواجهة النقص في دقيق القمح وكذلك لتغذية الأفراد ذوي الحساسية لجلوتين القمح. تم تقدير بعض الصفات الطبيعية مثل نسبة التبييض والأرز السليم وكذلك صفات الحبوب الشكلية. كذلك تم تقدير التركيب الكيمائي للحبوب ودرجة حرارة الجلته ودرجه تكوين الجل وأيضا الهضمية لنشا الحبوب. وكذلك تم تقدير صفات الطهي للحبوب وأيضا تم تصنيع البسكويت بنسب استبدال ٢٥ ، ٥٠ % من دقيق الأرز لتحل محل دقيق القمح وتم إجراء التقييم الحسي للمنتج وكذلك بعض الصفات الوظيفية للبسكويت الناتج. حيث أظهرت النتائج ما يلي:

- نسبة التبييض في صنف هجين ١ كانت الأعلى بين كل الأصناف، بينما نسبة الأرز السليم في صنف الياسمين كانت الأعلى بين كل الأصناف.
- بدراسة التركيب الكيمائي وجد أن الأرز الشمعي يحتوى على أعلى نسبة من الكربوهيدرات الكلية والنشا وأن الأرز الأسود يحتوى على أعلى نسبة من المستخلص الأثيرى والرماد والألياف الخام لكنه يحتوى على أقل نسبة من الكربوهيدرات الكلية والنشا مقارنة بباقي الأصناف.
- أظهرت النتائج أن الأرز المقشور لكل الأصناف أحتوى على نسب أعلى من البروتين الخام والمستخلص الأثيرى والرماد والألياف الخام ولكن نسب أقل في الكربوهيدرات الكلية والنشا مقارنة بالأرز المبيض.
- أمتلك الصنف الشمعي أعلى درجة تكوين الجل وكذلك درجة حرارة الجلته بين كل الأصناف ، لكنه أحتوى على أقل نسبة أميلوز.
- الأرز الأسود أمتلك أقل درجة حرارة للجلته وأحتوى على أعلى نسبة أميلوز.
- لا توجد فروق معنوية بين هضمية النشا لكل الأصناف باستخدام إنزيم ألفا- أميليز.
- وأظهرت اختبارات جودة الطهي لأصناف الأرز أن صنف هجين ١ أستغرق أطول فترة للطهي حوالي ٢٢ دقيقة بينما باقي الأصناف كان لهم نفس مدة الطهي. كما أظهرت النتائج أن زمن الطهي للأرز المقشور أعلى منها أعلى منها للأرز المبيض.
- بالنسبة للماء الممتص أثناء الطهي للأرز المبيض كانت أعلى منها في الأرز المقشور. وكانت ترتيب نسبة الماء الممتص في الأرز المبيض كالتالي: هجين ١ < الياسمين < الأسود < الشمعي.
- كما أظهرت نتائج الخواص الحسية للبسكويت المصنع بنسب استبدال من دقيق الأرز أنه حتى ٥٠ % استبدال مرغوب جدا لدى المستهلك وأن معظم العينات لها خواص حسية أفضل من الكنترول.
- وبدراسة نسبة فقد الرطوبة أثناء تصنيع البسكويت وجد أنها في العينات المضاف لها دقيق الأرز كانت أعلى منها في الكنترول وكلما زادت نسبة الاستبدال كلما زاد الفقد في الرطوبة أثناء الخبز.
- أيضا وجد أن نسبة الماء الممتص للعينات المضاف لها دقيق الأرز أكبر منها في الكنترول، وكلما زادت نسبة الاستبدال كلما زادت كمية الماء الممتص.
- أظهرت الدراسة أيضا أن الوزن النوعي للبسكويت المضاف إليه نسب استبدال من دقيق الأرز كان أقل مقارنة بالكنترول فيما عدا العينات التي بها نسب استبدال من دقيق الأرز الأسود كانت أعلى من الكنترول.