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Study of Agronomical and Technological Quality Characteristics of Some Special Egyptian Rice Varieties

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THIS STUDY aimed to evaluate the agronomic and technological quality characteristics of Jasmine, Waxy and Black rice varieties under Egyptian conditions during seasons 2012-2013 compared to traditional one. Jasmine rice variety out yielded other varieties and gave the highest values for yield and yield component characters. Black rice had the smallest values for yield and yield component followed by Sakha 106 characters except panicle weight which recorded the second value with both Waxy and Sahkha 106. Jasmine rice characterized by low % broken and % paddy which related to reduced grain loss. Black rice had higher antioxidant activity (70.52 % DPPH). In addition, its high nutritional value relates to its chemical and mineral contents, jasmine rice recorded the highest numerical value for most parameters and the lowest cooking time 9.33 min, husk ranged from 20.8 to 24.4% in the studied varieties while milled rice ranged 65.5-68.5% in varieties. Waxy rice had the highest 1000 kernels weight (22.7gm), the physical parameters (0.83 g/ml), 5.34% amylose and the highest gel consistency 95.1mm. Black rice recorded the highest protein content (8.69%) and minerals; 1874.8 (mg cy-3-glc/100g db) anthocynins; 716.4 (mg/GAE/100g) total phenols; 187.4 (mg quarstine/100g DW) flavonoids.

Keywords: Rice varieties, Physical properties, Chemical composition, Minerals, Anthcyanins, Total phenol, Flavonoids, Cooking quality.

Rice is a major cereal crop in the developing world and an important stable food source for over half of the world population. Although widely consumed as white rice, there are many special cultivars of rice that contain color pigments, such as Black rice and red rice (Sompong *et al*., 2011). Egypt is the largest producer of rice in Africa, with supplying 5.9 million tons of rice in 2013 (more than 22% of rice production in Africa). The quality of milled parboiled rice is being assessed based on physical parameters like degree of milling ، percentage head rice, broken grain, chalkiness, red streak grain, grain size, color, and shape 1000 grains weight (Abdelhady *et al.*, 2014).

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Generally, rice is consumed as a whole kernel of white rice obtained by milling (dehulling and polishing) rough rice. The degree of milling depends on purposes of milling required. Therefore, degree of milling is one of the key factors affecting several aspects of rice quality such as nutritional, chemical, physicochemical, cooking, and eating quality. Also, the degree of milling brought about variations in nutrient contents (Mahajan & Kaur, 2014).

The distinct divergence in waxy rice is in the gelatinization temperature. Waxy rice can be divided into a high and a low gelatinization temperature group. High- gelatinization temperature waxy rice is harder after cooking and show accelerated staling compared to low- gelatinization temperature rice, but significant differences are also observed among some low gelatinization temperature pairs. In many food applications, waxy rice is preferred to non waxy rice due to its starch physiochemical properties. The economic value of rice depends on its cooking and processing quality, which can be measured in terms of water uptake ratio, grain elongation during cooking, solids in cooking water and cooking time. Rice varieties with amylose content of more than 25% absorb more water and have afluffy texture after cooking (Thomas *et al.*, 2013).

The physicochemical characteristics include grain length (L), grain breadth (B), L/B ratio, hulling and milling percentage. The cooking qualities are amylose content, alkali spreading value, water uptake, volume expansion ratio and kernel elongation ratio. Grain quality is a very wide area encompassing diverse characters that are directly or indirectly related to exhibit one quality type (Siddiqui *et al.*, 2007). It also has been reported that a diet containing Black rice extracts which had anthocyanin (31.3g/100 g) decreased cholesterol, LDL- cholesterol and concentration of triacylglycerol in plasma of rats (Yodmanee *et al.*, 2011).

The aimed of the present study is to evaluate quality characteristics (agronomic ,physical, chemical, and cooking) of the new rice grain varieties cultivated in Egypt in compared to conventionally one (Sakha 106).

Materials and Methods

Experiments were laid out in a completely randomized design with three replications. Rice varieties under these studies are (Sakha 106, Waxy, Jasmine and Black rice). Were obtained from research component of seed production-Rice Research Department, Field Crop Research Institute, ARC, Giza, Egypt. Agronomic characters yield and its components were recorded from the experimental plots during two rice growing seasons 2012 and 2013 at Sakha research station, agronomic practices were carried out as recommended.

Preparation of rice samples for technological, eating, cooking quality and chemical studies conducted at Crops Technology Research Department, Food Technology Research Institute, Agricultural Research Center, Egypt. Raw rice samples were dehulled by sataky machine and kept in polyethylene bags and stored in freezer at -18ºC until further analysis.

Determination of milling characteristics

Husk, milling output and head rice percentage were estimated according to the method of Adair (1952).

Determination of physical properties

The kernel physical attributes (1000 kernel weight, kernel length, breadth and kernel length to breadth ratio) were measured according to Dorsey-Redding *et al*.(1991). Grain size and shape (FAO, 1975). Amounts of immature, mouldy, discolored, red rice, paddy, chalky grains and stones (Warda, 1995), level of broken rice (Adu-Kwarteng *et al*., 2003) and bulk density (Singh *et al*., 2005).

Determination of chemical composition

Proximate analysis including moisture, protein, lipid, ash and crude fiber were carried out according to the methods of AOAC (2005). Carbohydrates content was calculated by difference.

Determination of minerals

Magnesium, sodium, potassium, manganese, iron, calcium and zinc were determined according to AOAC (2005). Perkin Elmer (Model 3300, USA) Atomic Absorption Spectrophotometer was used to determine these minerals.

Energy value

The energy value for tested varieties was calculated from the following equation as reported by Hawk *et al.* (1949), Energy value = 4 (g protein + g carbohydrates) + 9 (g fat).

Determination of antioxidants

Total anthocyanin pigment content of the rice samples was determined, according to the modified pH differential methods of Giusti & Wrolstad (2005) and Hosseinian *et al.* (2008). Total phenols were estimated by the Folin-Ciocalteu method reported in Elfalleh *et al*. (2009).The amount of total flavonoids was measured spectrophotometrically by the method of Nasri *et al*. (2011). The DPPH (2,2 diphenyl-1- picric hydrazyl) radical scavenging activity of methanolic extracts was determined according the method reported by Okonogi *et al.* (2007).

Determination of cooking quality

Amylose content determined by according to the method of Juliano *et al.* (1981). Cooking time was determined as described by Batcher *et al.* (1956). Water uptake ratio and gruel solid loss as described by Singh *et al*. (2003). Elongation ratio and volume expansion ratio as described by Singh *et al*. (2005). Gelatinization temperature (GT) was determined according to the method described by Bhattacharya (1979). Gel consistency (GC) was determined according to the method described by Little (1958).

Statistical analysis

The obtained data from chemical, physical and sensory evaluation were exposed to analysis of variance. Duncan's multiple range tests at ($P \leq 0.05$) level was used to compare between means.

Results and Discussion

Yield and its components

Data in Table 1 show that highly significant differences were found among the tested varieties (Sakha 106, Jasmine, Waxy and Black) for all the studied parameters. Whereas, Jasmine rice variety recorded the highest numerical value for all the studied parameters except for 1000 grain weight which recorded the second value after both Sakah 106 and Black rice with no significant differences between them. On the other hand, Black rice recorded the smallest numerical values among all the other studied parameters except panicle weight which recorded the second numerical value with both Waxy and Sakha 106 and Jasmine variety which recorded the highest panicle weight.

Our results are in parallel with the observation by Sadhukhan & Chattopadhyay (2000) who stated that aromatic rice had more number of grains per panicle and small grain size than basmati types. Yield and nutritional value are mostly determined by the synthesis and storage of carbohydrates, proteins and minerals during grain filling, and culinary quality is affected by the interaction of various enzymes to produce the final structure of the starch at the molecular and granule levels.

TABLE 1. Combined analysis of yield and its components of some Egyptian rice varieties.

Parameters	Rice varieties			
	Sakha106	**Jasmine**	**Waxy**	**Black**
Total duration (days)	126.6^{c}	147^{a}	136^{b}	120.6^{d}
Plant height (cm)	101.87^{b}	110.5^{a}	95.13^{c}	90.53^{d}
No. of tillers /panicle	23.33^{b}	25.33^{a}	18.66^{c}	13.33^{d}
No. of panicle /plant	19.33^{b}	21.35^{a}	16.33^{c}	9.33^{d}
Panicle weight (g)	3.59^{b}	4.62^{a}	3.42^{b}	3.9^{b}
Panicle length (cm)	22.7^{b}	25.83^{a}	19.96^{c}	18.66^{d}
1000 grain weight (g)	28.35^{a}	27.35^{b}	26.32^{c}	28.33^{a}
No. of grains /panicle	131.33^{b}	151.30^{a}	126.69^{c}	107.66^{d}
Grain yield /plant	43.64^{b}	46.82^{a}	38.79^{c}	23.92^{d}

Means within a column with different letters are significantly different at ($P \leq 0.05$)

Milling quality characters

The de-hulling of rice is one of the important postharvest processes. If the hulling percentage is high, then the recovery of rice is also increased. It could be

observed from Table 2 that Sakha 106 rice variety had the highest value of milled rice 71.4%, while the waxy rice variety recorded the lowest 65.5% . The result agreed with Rita & Sarawgi (2008) who reported that the traditionally cultivated rice varieties, hulling percentage ranged from 63 to 81%.On the other hand, the head rice is recorded the highest value of Jasmine rice 62.5%, and the lowest value Black rice 55.6%. Dipti *et al.* (2003) showed that the head rice recovery indicates that weight of whole grains after industrial processing. For quality evaluation, head rice recovery is one of the most important characters and more than 65% of head rice recovery is desirable. Head rice is the proportion of the intact grain in the milled rice. Head rice value ranged from 55.6-62.5% in all the rice varieties.

TABLE 2. Milling characteristics tested of rice varieties.

Parameters g/100g	**Rice varieties**			
	Sakha106	**Jasmine**	**Waxy**	**Black**
Husk	21.3^{c}	24.4^{a}	20.8^{d}	23.4^{b}
Milled rice	71.4^{a}	68.5^{b}	65.5^{d}	66.5^{c}
Head rice	61.5^{b}	62.5^{a}	56.6^{c}	55.6^{d}

Means within a column with different letters are significantly different at ($P \leq 0.05$) .

Physical properties

Physical properties of rice varieties were evaluated to provide important facts in determining their appropriate uses. Results of the 1000-kernel weight for different rice varieties analyzed in this study showed significant differences as shown in Table 3. Waxy rice had the highest 1000-kerneal weight (22.7g) followed by Sakha106 (22.5 g), Black rice (21.4g) and Jasmine rice 18.4g. There were significant differences in the L/b ratio for Sakha 106, Jasmine rice, Waxy rice and Black rice. Overall, highest L/b ratio was recorded for the Jasmine rice (3.77%) whereas, the lowest ratio was recorded for waxy rice (1.31%). Size and shape are among the grain characteristics that indicate the market ability and commercial viability of rice these result agreed with Majzoobi & Farahnaky (2008).

Therefore, local varieties can be marketed based on the size and shape preference of consumers. Diako *et al.* (2011) who reported that the analysis shape; (L/b ratio) was performed to determine the shape of individual rice grains. A length to breadth ratio of more than 3 is generally considered as slender (2.1-3.0: medium), (1.1-2.0: bold), (2.0 round).Size of (>7.0:extra-long);(6.0-6.99: long), (5.0-5.99: medium) and (<5.0: short). Determining the rice grain shape and width are highly essential as both, cooking and eating properties are strongly influenced by these parameters. In this study it was clear that grain shape of Sakha106 and Black rice is medium, Jasmine is slender, and Waxy is bold. On the other hand, the size of rice grain Sakha106 variety is long, Jasmine rice is extra long, waxy rice is medium and Black rice is long. The grain size and shape of most high yielding rice varieties is short to medium bold with translucent

appearance (Banu *et al.*, 1992). From the Table 3 it could be observed that significant differences of immature grains percentage the highest value in Sakha106 rice variety (0.36%) and the lowest value in Jasmine rice (0.17%), and not detected mouldy grains of rice verities. Physical examination showed more broken in the local varieties. The tolerance levels are for red rice, 4%, for chalky grains, 6%, and immature grains 2% according to Codex Alimentarius Commission (1990). In this study all the varieties examined were below the tolerance levels and, therefore, meet these quality criteria for market competitiveness.

TABLE 3. Physical measurements of some rice varieties.

Parameters	Rice varieties			
	Sakha106	**Jasmine**	**Waxy**	**Black**
1000 kernel grain (gm)	22.5[a]	18.4[c]	22.7[a]	21.4[b]
Length (mm)	6.15[b]	8.52[a]	5.25[c]	6.52[b]
Breadth (mm)	2.53[b]	2.21[c]	4.19[a]	2.29[c]
L/B ratio (%)	2.45	3.77	1.31	2.84
Grain size	Long	Extra long	Medium	Long
Grain shape	Medium	Slender	Bol[d]	Medium
Immature (%)	0.36[a]	0.17[c]	0.26[b]	0.18[c]
Mouldy (%)	ND	ND	ND	ND
Discolored (%)	0.24[a]	0.15[b]	0.13[c]	0.17[d]
Red rice (%)	0.14[a]	0.0[c]	0.09[b]	0.0[c]
Paddy (%)	0.35[b]	0.27[c]	0.47[a]	0.22[d]
Chalky grains (%)	0.92[a]	0.75[b]	0.28[c]	0.18[d]
Stones (%)	0.27[b]	0.15[d]	0.25[c]	0.32[a]
Broken (%)	5.62[a]	3.32[d]	3.57[c]	4.73[b]
Bulk density (g/ml)	0.75[c]	0.81[a]b	0.83[a]	0.77[bc]

Source : (Diako *et al.*, 2011).
Size : (>7.0 mm : extra long ; 6.0-6.99 mm : long; 5.0-5.99 mm : medium ; <5.0 mm : short).
Shape : (>3.0 mm: slender; 2.1-3.0 mm: medium; 1.1-2.0 mm : bold ; = 2.0 mm round).
ND ; not detectable
Means within a column with different letters are significantly different at ($P \leq 0.05$).

On the other hand, discolored of rice verities (Sakah106, Jasmine, Waxy and Black rice) to (0.24, 0.15, 0.13 and 0.17%), respectively. Also, red rice in Sakha106 rice variety (0.14%), Waxy rice (0.09%), Jasmine and Black was not detected for red grains, no significantly differences of results. The results in Table 3 clear that chalky grains in rice varieties (Sakha106 rice variety was the highest value 0.92% and the lowest value is Black rice 0.18%).From the same table, no significant difference the stones in rice varieties, Sakha106 rice (0.27%), Jasmine (0.15%), Waxy (0.25%) and Black rice (0.32%). On the other hand, there is no significant no differences of broken rice (Sakha106, Jasmine, Waxy and Black rice).

In high yielding rice varieties, the percentage of broken rice grains ranged from 3.34 to 5.32% the greater amount of chalkiness in the grain indicates that it is more prone to grain breakage during milling, which results in lower head rice recovery. Among the different varieties, bulk density was observed to be highest in Waxy rice (0.83 g/ml), followed by Jasmine rice (0.81 g/ml), Black rice (0.77 g/ml) and Sakha106 rice (0.75 g/ml). These result agreed with Rachel *et al.* (2013) who reported that bulk density of rice varieties (white rice, brown rice, Jasmine rice and Black rice range 0.81-0.86 g/ml).

Chemical properties

Results in Table 4 shown significant differences in the proximal composition between different varieties of rice moisture content, which plays a significant role in determining the shelf-life (Rachel *et al*., 2013) was recorded to vary between 10.9-12.6 g/100g. Total protein content for all the rice varieties evaluated ranged from 5.66 to 8.69 g/100g, the protein content was highest in Black rice 8.69 g/100g while as the lowest in Waxy rice (5.66 g/100g). Protein content was White rice (5.96 g/100g), Jasmine rice (7.75 g/100g) and Black rice (8.16 g/100g).

TABLE 4. Chemical composition of some rice varieties .

Parameters g/100g	**Rice varieties**			
	Sakha106	**Jasmine**	**Waxy**	**Black**
Moisture	11.3^{b}	12.6^{a}	11.2^{bc}	10.9^{c}
Protein	7.53^{b}	6.33^{c}	5.66^{d}	8.69^{a}
Fat	1.47^{c}	0.89^{d}	1.62^{b}	1.84^{a}
Ash	1.54^{a}	0.95^{c}	0.81^{d}	1.94^{b}
Crude fiber	0.76^{c}	0.93^{c}	1.61^{b}	1.73^{a}
Carbohydrate	77.4^{bc}	78.3^{a}	79.1^{ab}	74.9^{c}

Means within a column with different letters are significantly different at ($P \leq 0.05$).

While fat content ranged from 0.89 to 1.84 g/100g. Overall, highest fat content was recorded in Black rice variety (1.84g/100g), while lowest fat content was recorded in Jasmine rice variety (0.89g/100g). These results were similar with Osman & Abd El-Galeel (2008) who reported that fat content was in white rice (0.66 g/100g), Jasmine rice (0.65 g/100g), Waxy rice (0.60 g/100g) and Black rice (1.93 g/100g). Also, the ash content high in Black rice (1.94 g/100g) and low in Waxy rice (0.81 g/100g). There are a significant differences recorded for crude fiber content White, Jasmine, Waxy and Black rice varieties. The values of crude fiber were ranged from 0.76 to 1.73 g/100g. Black rice is also known to be a good source of fiber and it was the highest in this study. Carbohydrate content was high in all varieties (>70 g/100g) and hence can be considered to be a good source of carbohydrate. The Waxy rice contained the highest amount of carbohydrates (79.1 g/100g), while the Black rice contained the lowest amount of carbohydrates (74.9 g/100g) these result agreed with Rachel *et al*. (2013) who showed that the carbohydrates content in White rice (80.14g/100g), Jasmine rice (79.34g/100g) and Black rice (78.26 g/100g).

Energy value

Energy value in Fig. 1 measures the available amount of energy obtained from food via cellular respiration. In this study, Waxy rice provided the highest energy value (353.62k. cal. /100g), while Jasmine rice contained the lowest energy (346.53k. cal. /100g), also Sakha106 rice variety contained (352.52k. cal./100g) and Black rice (350.92k. cal./100g). These data were agreed with Sompong *et al.* (2011) who reported that the Black rice contained energy 362.6 k. cal. /100g these result similar with Rachel *et al*. (2013) who showed that rice varieties (White, Brown, Black and Jasmine rice) contained energy value (355.56, 354.42, 355.76 and 357.54 k. cal. /100g) respectively.

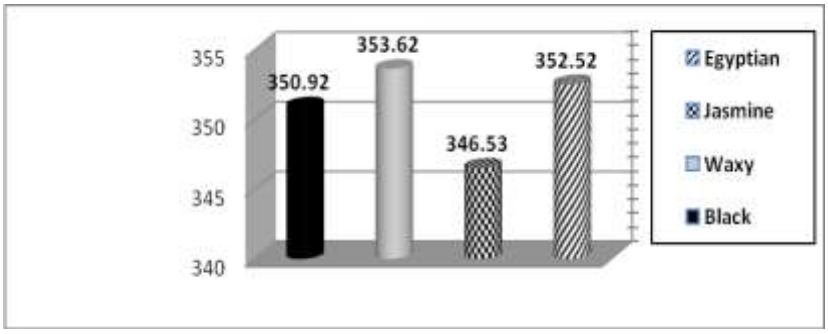

Fig. 1. Energy value of 100g rice.

Mineral contents

Here is a significant differences in minerals composition (mg/100g) were recorded of rice varieties, Sakha 106, Jasmine, Waxy and Black were presented in Table 5. Results showed that the varieties of Sakha106 contained the lowest values of calcium 9.67, magnesium 35.7, potassium 131.3, manganese 23.3, iron 4.21 and zinc 3.13 mg/100g, respectively. On the contrary, Black rice contained the highest values of the previous minerals, calcium 23.7, magnesium, 81.3, potassium 186, manganese 59.6, iron 8.33 and zinc 6.26 mg/100g, respectively. On the other hand, sodium content in different rice varieties was higher in Waxy 11.6 mg/100g and the lowest in Black rice which was 4.67 mg/100g .These result agreed with Diako *et al.* (2011) who reported that the white rice contained iron 5.3 mg/100 and Jasmine 5 mg/100g.

TABLE 5. Minerals of some rice varieties .

Parameters	**Rice varieties**			
mg/100g	**Sakha106**	**Jasmine**	**Waxy**	**Black**
Calcium	9.67^{d}	12.7^{c}	15.1^{b}	23.7^{a}
Sodium	7.33^{bc}	8.66^{ab}	11.6^{a}	4.67^{c}
Magnesium	35.7^{d}	41.6^{c}	56.5^{b}	81.3^{a}
Potassium	131.3^{d}	142.7^{c}	158.3^{b}	186.6^{a}
Manganese	23.3^{b}	20.2^{b}	22.7^{b}	59.6^{a}
Iron	4.21^{c}	4.62^{c}	5.33^{b}	8.33^{a}
Zinc	3.13^{c}	3.51^{c}	4.16^{b}	6.26^{a}

Means within a column with different letters are significantly different at ($P \leq 0.05$)

Antioxidants

The results in Table 6 showed anthocyanins, total phenol, total flavonoids and antioxidant activity (DPPH%) of the studied rice varieties. From these results it could be noticed that anthocyanins content in rice varieties Sakha106, Jasmine and Waxy not detected. On the contrary, anthocyanin content in Black rice was higher 1874.8 (mg cy-3-glc/100 g db) compared to the other varieties. Total phenol in some rice varieties ranged from 18.1 (mg/GAE/100g) in 106 to 23.6 (mg/GAE/100g) for Waxy rice, respectively.

TABLE 6. Antioxidants of some rice varieties .

Parameters	Rice varieties			
	Sakha106	**Jasmine**	**Waxy**	**Black**
Anthocyanins	0.00^{b}	0.00^{b}	0.00^{b}	1874.8^{a}
Total phenols	18.1^{d}	19.8^{c}	23.6^{b}	716.4^{a}
Flavonoids	58.9^{d}	61.9^{c}	69.3^{b}	187.4^{a}
DPPH	11.9^{d}	13.6^{c}	15.7^{b}	70.52^{a}

Means within a column with different letters are significantly different at ($P \leq 0.05$)

On the other hand, total phenols was the highest value 716.4 (mg/GAE/100g) for Black rice variety. Flavonoids values were 58.9, 61.9, 69.3 and 187.4 (mg quarstine/100g DW) for Sakha106, Jasmine, Waxy and Black rice varieties, respectively. Black rice had the highest value of DPPH (70.52%) compared to the other varieties which were 11.9, 13.6 and 15.7%, respectively.

These results agreed with Sompong *et al.* (2011) who reported that total anthocyanins and total phenol in Black rice were 1095.2 (mg cy-3-glc/100 g db) and 665.2 (mg/GAE/100g), respectively. while as rice pigment variety contained anthocyanins 1130 (mg cy-3-glc/100 g db). On the other hand, our results agreed with Saenkod *et al.* (2013) who found that total flavonoids in Black rice was 58.47 (mgquarstine/100gDW), while DPPH % was 70.52%. These may be due to Black rice contained higher amounts of total flavonoids, anthocyanins and total phenol which had antioxidants activities.

Amylose content

Amylose content is considered to be the single most important characteristic for predicting rice cooking and processing behaviors. Most consumers prefer rice with intermediate amylose content ranged between 20-25%. Disorganized cellular structure can enhance the probabilities for high water absorption during cooking and can contribute to longer cooking time. Amylose contents determine the texture of cooked rice and rice varieties with amylose content of more than 25 % absorb more water and have a fluffy texture after cooking according to Rachmat *et al*. **(**2006).

Results in Fig. 2 Showed that amylose content recorded 5.34 to 28.3 for Waxy and Sakha106 rice varieties, respectively. On the other hand, amylose value of Black rice was 12.7. These results agreed with Dipti *et al*. (2002) who reported that amylose content in different rice varieties in the range of 18.60 to 28.0%. Also, amylose content in Jasmine rice was 20.2%. While this percentage

was 9.66% in Black rice. In addition of the Waxy rice contained 7.57% according to Osman & Abd El-Galeel (2008).

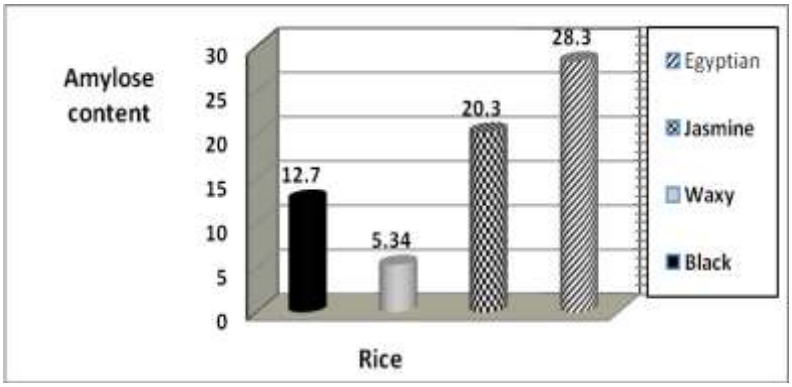

Fig.2. Amylose of some rice varieties.

Cooking quality characters

The cooking properties are very important for as rice is consumed almost immediately after cooking. Rice being a major stable food in most of the developing countries, reduced cooking time can be beneficial especially when fuel consumption is of concern (Rachel *et al*., 2013).

Cooking time of a rice grain is usually ascertained when an opaque center is no longer visible by 90% of the starch in the grain (Dipti *et al.*, 2003). Results in Table 7 showed that cooking time of Black rice took the longer 27.6 min. This may be due to the fibrous bran layer might have not yet be removed and hence it requires longer time for the starchy endosperm to cook. The minimum cooking time was found in Jasmine rice 9.33 min. Also, Sakha106 rice variety had 14.3 min cooking time.

TABLE 7. Cooking quality of some rice varieties.

Parameters	Rice varieties			
	Sakha106	**Jasmine**	**Waxy**	**Black**
Cooking time (mm)	14.3^{b}	9.33^{d}	11.7^{c}	27.6^{a}
Water uptake ratio %	1.92^{a}	1.62^{b}	1.06^{d}	1.25^{c}
Gruel solid loss %	0.89^{a}	0.82^{b}	0.64^{c}	0.79^{b}
Elongation %	2.33^{a}	$1.66a^{b}$	0.73^{c}	0.92^{bc}
Volume expansion %	13.7^{a}	11.7^{b}	5.37^{d}	7.67^{c}
(GT)*	5.24^{b}	4.84^{c}	4.17^{d}	5.85^{a}
(GC)**	85.7^{d}	87.3^{c}	95.1^{b}	92.3^{a}

(Diako *et al*., 2011)

*****Gelatinization temperature (GT) : Rating of 1-3= high GT (greater than 74ºC), Rating of 4-5= intermediate (70-74ºC) and Rating of 6-7= low GT (low 70ºC) ; ******Gel consistency (GC) : Hard (27-40 mm), medium (41-60 mm) and soft (61-100 mm).

Water uptake ratio is an important parameter while cooking rice. If the bulk density is higher, then correspondingly water uptake ratio will also be high. This has been attributed to the compact structure of a rice variety. Water up take ratio in this study was observed to be highest for Sakha106 rice variety and the lowest 1.06 for Waxy rice variety. On the other hand, water uptake ratio was 1.25 and 1.62 for Black and Jasmine rice varieties, respectively. Amylose content might be responsible for high water uptake ratio, the result agreed with Frei & Becker (2003) who reported that the rice with high amylose content tends to absorb more water upon cooking. It is worthy to note that high water uptake ratio affects the palatability of the cooked rice negatively.

Gruel solid loss recorded 0.64% and 0.89% in Waxy and Sakha106 rice varieties respectively, while Black and Jasmine contained 0.79% and 0.82% , respectively. These observations are comparable to the report of Hirannaiah *et al*. (2001) who have also observed minimum gruel solid loss in Basmati rice. Rice varieties with high amylose content are more prone to leaching out into the cooking water as starch grains expand during cooking. Elongation was different by rice varieties, from the results in Table 7 it could be noticed that Sakha106 rice variety with high amylose resulted in high elongation 2.10% followed by Jasmine rice 1.66%. On the other hand, Black rice contained 0.92% and Waxy rice 0.73%. Elongation of rice can be influenced by both the L/b ratio and the amylose contents Danbana *et al*. (2011), additionally, a positive correlation was also recorded by both amylose content and L/b ratio in relation to elongation of rice. In this study, maximum elongation ratio was observed in Sakha106 rice variety 2.33, followed by brown rice 1.68.

Volume expansion (mm) in Sakha106 rice variety was the highest value 13.7 mm compared to the other varieties. On the contrary, the lowest value was 5.37 mm for Waxy rice. Jasmine and Black rice had 11.7 mm and 7.67 mm of volume expansion, respectively. The positive correlation of amylose content with water uptake, volume expansion ratio and alkali spreading value indicates that high amylose rice varieties will absorb more water at low gelatinization temperature and will produce a greater volume of cooked material (Hussain *et al*., 1987).

Gelatinization temperature of rice varieties were exhibited 4.17 and 5.82 for Waxy and Black rice. While Sakha106 rice varieties and Jasmine rice were 5.24 and 4.84, respectively. These results agreed with Osman & AbdEl-Galeel (2008) who reported that Waxy rice had the highest gelatinization temperature among the other varieties. It may be due to the lowest contents of amylose. 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.

The results in Table 7 howed that gel consistency (mm) was 92.3 and 95.1 for Black and Waxy rice varieties, respectively. While Sakha106 rice variety and Jasmine rice was 85.7 mm and 87.3 mm, respectively. Furthermore, a significant

but low correlation value was obtained between optimum cooking time and gelatinization temperature. Significant but negative correlation values were obtained between amylose content with amylopectin and gel consistency, suggesting that rice cultivars selected for high amylose content may be invariably low in amylopectin content and gel consistency. Our results are on the parallel with the observation of Thomas *et al.* (2013).

Conclusion

From the results of this study it could be concluded that the new rice varieties cultivated in Egypt during two growing seasons 2012 and 2013, namely Waxy, Jasmine and Black rice are considered to be a valuable addition to the rice varieties in Egypt. Where they exhibited good quality characteristics relate to agronomy and technology. Jasmine rice variety out yielded other varieties and gave the highest values for yield and yield component characters except for 1000 grain weight which recorded the second value after both Sakha 106 and Black rice. On the other hand, Black rice gave the smallest values for yield and yield component characters except panicle weight which recorded the second value with both Waxy and Sakha 106. Jasmine rice characterized by low % broken and % paddy which relates to reduced grain loss. Besides, Jasmine and Waxy rice had reduced cooking time which is very important in developing countries especially when fuel consumption is of concern. Black rice and its pigments has higher antioxidant activity relates to a lot of health and concerns. In addition, its high nutritional value relates to its chemical and mineral contents.

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دراسة الصفات المحصولية و خصائص الجودة التكنولوجية لبعض أصناف الأرز المصرية

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هدفت تلك الدراسة إلى تقييم خصائص الجودة المحصولية والتكنولوجية لأصناف أرز الياسمين – الشمعى – الأسود مقارنة بأحد الأصناف المصرية التقليدية سخا ١٠٦ تحت الظروف المصرية خلال موسمى ٢٠١٢-٢٠١٣م حيث سجل صنف أرز الياسمين أعلى أنتاجية محصولية ويلية صنف سخا ١٠٦ بينما كانت أقل إنتاجية مسجلة للأرز الأسود. وأظهر الأرز الياسمين تفوق على الأصناف الأخرى محل الدراسة. وتميز الأرز الشمعى – سخا ١٠٦ – الياسمين بقله المحتوى كنسبه مئوية من الحبوب المكسورة والحبوب غير المقشورة (الحبوب الشعير) ، وتميز الأرز الأسود بأرتفاع المحتوى من مضادات الأكسدة كذلك بالأضافة إلى محتواه العالى من الأملاح المعدنية مما يجعله أعلى فى القيمة الغذائية. سجل أرز الياسمين أعلى محتوى من الرطوبة والكربوهيدرات وأقل محتوى من الدهون وأقل زمن للطهى بلغ ٩,٣٣ دقيقة. تراوحت النسبه المئوية للقشور فى الأصناف محل الدراسة من ٢٠,٨-٢٤,٤% بنما نسبه التصافى للأرز بعد الضرب تراوحت بين ٦٥,٥-٦٨,٥% وبلغت قيمة الألف حبه أعلى قيمة فى الأرز الشمعى حيث بلغت ٢٢,٧جرام وبلغ المحتوى الجيلاتينى فى الأرز الشمعى ٩٥,١ملميتر. أحتوى الأرز الأسود على أعلى نسبه من الأنسوسيانين والفلافونيدات الكلية.