Chemical and Sensory Properties of Black Rice Compared with Giza 177 Rice Cultivar

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ABSTRACT

The present work was carried out to evaluate the chemical and technological characteristic of Egyptian Giza 177 rice and black rice (BR) as well as to investigate the possibility of using black rice flour as substitution materials of wheat flour in preparing enriched biscuits. The obtained results revealed that black rice (BR) variety had a higher level of crude protein, ether extract, ash, fiber content than Giza 177 rice variety. Gel consistency was significantly higher in Giza 177 than (BR). BR contained higher amylose content than Giza 177. From the obtained results, BR could be considered as a good source of fatty acids, anthocyanin, total phenol and minerals compared with Giza 177. Regards to sensory evaluation of cooked rice, black rice was lower acceptance than Giza 177. Results of the organoleptic evaluation indicated that biscuit samples prepared using black rice flour (2.5 and 5%) to wheat flour were acceptable. Also, biscuit samples prepared using mushroom flour with black rice flour as substitutions instead of wheat flour (2.5%) were acceptable. The present study could be a guide in using black rice and mushroom flours to increase protein and other nutrients contents in some food products, as well as preparation of some functional foods. Also, gluten-free bakery products are advantageous to persons who suffer from celiac disease.

Keywords: Black rice, chemically, technologically, biscuits, mushroom flour, black rice flour, gluten-free.

INTRODUCTION

Rice (*Oryza sativa*) is the second main crop besides major nourishment of half of the total populace in terms of global production 740.96 million tons of rough rice in 2014 (FAO/UN, 2016). In 2014, the production of rice in Egypt was 6.00 million tons. Egypt recorded the second yield in the world (3.86 tons/acre) per year during the years 2010–2014 (FAO/UN, 2016).

Rice is used in many foods such as bread, cakes and noodles. Rice starch is also used in many food applications. Rice flour is mainly used for making desserts, noodles, and sweets and as a thickener for custards, gluten free bread, salad dressing, tortillas besides sauces (Chandra and Samsher, 2013).

A few rice varieties have unique characteristics in terms of their chemical composition, color and aroma. BR is rich in carbohydrates and micronutrients. It is also a good source of antioxidants, including phenolic compounds, which protect against diseases (Saenkod *et al*., 2013) such as cardiovascular diseases and cancer (Sompong *et al*., 2011).

BR is applied as a component in confectionery besides crackers. It is considered to be a functional food since it has a phenolic combination, particularly anthocyanins. Due to black rice value as a health foodstuff besides organic foodstuff color, its demand is increasing fast in United State and European Union. BR extract enhanced the plasma profile. BR has a quantity of nourishing benefits over common rice as higher protein besides minerals. It has low fat content, protein with excellent biological value, also, it is a decent source of vitamins besides insoluble fiber (Oko *et al*., 2012, American Culinary Federation Education Foundation 2016).

The gluten-free food remainder till nowadays the lone management for celiac disease. The gluten-free diet has assistances such as the recovery of the villi of the small intestine besides hazard decrease of malignant complications (Hussein *et al.*, 2012). According to the definition free gluten foods it is contain no more than 20 ppm of gluten .

Mushrooms is evaluated as decent possible basis of therapeutic bioactive compounds as essential amino acids, lipopolysaccharides, polysaccharides, besides many essential nutrients. *Agaricus bisporus* is the greatest vital trading cultured mushroom in the world, it belongs to *Basidiomycetes* family. Nutrients like proteins, minerals, vitamins, fibers, lipids and carbohydrates are present in this mushroom as known healthy foodstuff. (Atila et *al.*, 2017).

Food fortification is very important process, defined as the addition of one or more nutrients rich ingredients together aimed to improve nutritional composition of foodstuff. Usual goal of food fortification is to control nutrient deficiency problems. In this line, present study is designed and aimed to evaluate the chemical and sensory properties of black rice compared with Giza 177 rice cultivar and use black rice flour, mushroom flour with wheat flour to increase protein and other nutrient content in biscuits.

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MATERIALS AND METHODS

Materials:

Two varieties of rice (*Oryza sativa* L.) namely Giza 177 and Black rice were employed in this study. These samples were obtained from Rice Research and Training Center (RRTC) at Sakha, Kafr El-Sheikh Governorate, Egypt during season 2016. The pedigree of these varieties are presented in Table (1).

Mushroom was obtained from the Cultivation and production of mushroom Unit; Agricultural Botany Department, Saba Basha Faculty, Alexandria university.

All ingredients used for biscuit preparation such as wheat flour, glucose syrup, shortening, salt, sodium bicarbonate, sucrose, dry milk and vanilla were obtained from the local market of Alexandria .

Chemicals and Reagents:-

Chemicals, reagents and Solvents were obtained from Sigma–Aldrich (Steinheim, Germany) and El-Gomhouria Company, Alexandria, Egypt. All chemicals and reagents used were of analytical grade.

Table 1. Pedigree, origin and type of two used rice varieties

Rice cultivar	Origin	Type	Pedigree
Giza 177	Egypt	Japonica	Cross bet. Giza 171/ - Yomji No.1 //Pi No. 4
Black rice	China	Japonica	Jingu 96

Methods:

Preparation of white rice samples:-

Raw rice samples were dehulled and then milled to obtain the white rice. The white rice was kept in polyethylene bags and stored in freezer at -18 ºC until further analysis. All grains quality test (grain technology and cooking characters) were conducted at Rice Technology Training Center, Laboratories, Hager El-Nawatia, Alexandria Governorate, while the chemical composition of rice grains was determined at Rice Research and Training Center, Agronomy Laboratories, Sakha, Kafr El- Sheikh , Egypt.

Preparation of cooked rice:-

Rice were thoroughly washed in tap water at ambient temperature in order to remove any dust particles , present , drained and then cooked in rice cooker as reported by Rewthong *et al.*, (2011) .

Preparation of rice and mushroom flours:-

Rice flour and mushroom flour were prepared as described by Okpala and Egwu (2015) and (Alemu *et al.*, 2017), respectively.

Determination of milling properties :-

Hulling and milling percentages were estimated according to the methods reported by (Roberts, 1979).

Determination of cooking and eating quality:-

Amylose content, gel consistency and gelatinization temperature were determined according to Williams *et al.* (1958), Cagampang *et al*. (1973) and Little *et al.* (1958); respectively.

Chemical composition of raw materials:-

Moisture, ash, crude protein, ether extract and crude fiber contents of rice, wheat and mushroom were determined according to the methods of A.O.A.C. (2005). Total carbohydrates content was calculated by difference. Magnesium, potassium, iron, calcium and zinc were determined according to A.O.A.C. (2005) using Atomic Absorption Spectrophotometer, Perkin Elmer (Model 3300, USA).

Determination of antioxidants:-

Total anthocyanin pigment content of the rice grain was determined, according to Giusti and Wrolstad (2005) and Hosseinian *et al.* (2008). Total phenols were estimated with the Folin-Ciocalteu method as reported by Elfalleh *et al*. (2009).

Determination of fatty acids profile:-

Mixed (1g) ground rice grains with chloroform: methanol (2:1, v/v) to obtain the lipid extracts (Folch *et al*., 1957). The fatty acids composition of the lipid extracts was determined according to the method described by (Chung, 1991) by using GC-MS analysis. Concisely, the lipid extracts were saponified with 0.1 N potassium hydroxide in methanol at 70–75 ºC and followed by methanolysis with 1.2 M hydrochloric acid in methanol at the same temperature. The methyl esters of fatty acids were extracted with n-hexane prior to GC-MS analysis. The gas chromatograph (6890 plus, Hewlett Packard, Co., USA) was equipped with a DB-225 capillary column (30 m × 0.25 mm × 0.25 µm) and coupled with a mass spectrometer (JMS700, Jeol, Japan). The column temperature was held at 140 ºC for 1 min, then increased up to 200 ºC at a rate of 1 ºC /min, and finally increased to 230 ºC at a rate of 10 ºC /min and held for 10 min. Helium was used as the carrier gas and the flow rate was 1 mL/min. The amount of each fatty acid was calculated based on the peak area compared with that of the standards.

Functional properties of rice varieties:-

Water uptake at 75 ± 2 ºC and 80 ± 2 ºC and cooking time of rice varieties were determined following to procedures of Simpson *et al.* (1965).

Preparation of biscuits:-

Biscuits prepared from wheat flour (72% extraction) was used as control sample. Substitution levels of 2.5, 5, 7.5 % black rice flour, mushroom flour were used to prepare the biscuit samples. The ingredients were mixed well, laminated sheeted, shaped and baked in oven at 215 ºC for 12 min (Nnam and Nwokocha, 2003). The samples were removed and cooled on a rack for 5 min then served for the sensory evaluation.

Sensory evaluation of cooked rice:-

Sensory evaluation of Cooked rice varieties were performed according to the characteristics of color, taste, odor, texture, over all acceptability were determined as described by (Ghufran *et al*., 2009).

Sensory evaluation of biscuits:-

The prepared biscuit sensory evaluation of different organoleptic properties *viz.*, color, appearance, texture, flavor and overall acceptability were carried by panel of 10 judges of different groups and food habits on basis of 9 point hedonic scale (More *et al* ., 2013) .

Statistical analysis:-

All the analyses were carried out at least in triplicates and expressed as mean and standard deviation (SD). Data were statistically analyzed by analysis of variance (ANOVA) and significant differences were identified by Duncan's Multiple Range test ($P<0.05$) (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Chemical analysis of the two rice varieties:-

Black rice (BR) has a quantity of nourishing benefits over common rice, as it contain a higher contents of protein, vitamins besides phenolic (Lee *et al.*, 2008). Data displayed in Table (2) showed, the moisture of rice varieties ranged between 10.9 to 11.3%. Amorim *et al.*, (2004) reported that, moisture content plays a great role during the storage for rice. Black rice variety had higher content of crude protein (7.96%) as compared with Giza 177 rice.

There were significant differences ($P\leq0.05$) in both ether extract and ash contents between the two varieties ,the BR variety had higher of ether extract and ash content, where it was 1.32% and 1.17 %, respectively. Similar results had been reported by Amorim *et al.*, (2004). Rice is a rich source of carbohydrate; starch is the main component. The data presented in the same table showed that, Giza 177 had higher carbohydrate content than black rice. Additionally, carbohydrates content of rice samples was increased as a result of milling. Process which remove some components such as embryo, aleurone and bran layers to obtain milled rice which poor in its content from fat, protein, fiber and ash. (Singh *et al*., 2000 and Suwansri and Meullenet, 2004). The bran layer of black rice is rich in anthocyanins, a plant compound that gives black rice its dark complexion. Anthocyanins act as antioxidants which play an important role to improve the memory function enhance vision and act as an anti-inflammatory (American Culinary Federation Education Foundation 2016). Additionally, anthocyanin dyes have been described to be very successful in decreasing cholesterol level in the human.

The phenolic complexes have been establish as a main effective constituent for antioxidation. The highest ingredient of phenolic combination in pigmented rice has been stated as anthocyanins (Iqbal *et al.*, 2005, Zhang *et al.*, 2006, Yawadio *et al.*, 2007). These phytochemical compounds usually are accumulated in pericarp or bran of rice kernels (Sutharut and Sudarat, 2012).Polyphenols are the most effective antioxidative constituents in plant products consumed (Escribano-Bailón *et al.*, 2004). BR is more abundant in anthocyanin and other phenolic compounds compared to white rice (Rye *et al.*, 1998, Zhang *et al.*, 2006). From our results, it could be noticed that anthocyanins content in Giza 177 rice variety not detected. On the contrary, anthocyanin content in black rice was 305 mg / 100g. Also , Black rice had the highest values of total phenol compared with Giza 177 rice variety . Our results were in harmony with (Thomas *et al*., 2013, Metwally *et al*.,2014, Badawy and Mahgoub, 2015, Kushawa, 2016).

Table 2. Proximate chemical composition of the two rice varieties on dry weight basis

Rice variety	Moisture (%)	Crude protein (%)	Ether extract (%)	Ash (%)	Crude fiber (%)	Total carbohydrate (%)	Anthocyanin (mg /100 g)	Total phenol (mg / GAE /g)
Giza 177	$11.3^{a}\pm0.85$	$6.33^{b}\pm0.79$	$0.77^{b}\pm0.61$	$0.53^{b}\pm0.02$	$0.83^{b}\pm0.02$	$89.24^{a}\pm0.90$	0.00^{b}	$18.3^{b}\pm 0.2$
Black rice	$10.9^{b}\pm0.99$	$7.96^{a}\pm0.84$	$1.32^{a}\pm0.08$	$1.17^{a}\pm0.05$	$1.07^{a}\pm0.06$	$77.58^{b}\pm0.88$	$305^{a}\pm0.20$	$69^{a}\pm 0.08$

Each value is the mean± SD

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

Chemical analysis of the wheat and mushroom flours:-

Data presented in Table (3) showed that mushroom and wheat flour had moisture and carbohydrate contents of 9.45, 12.4 and 63.93m75.41 %, respectively. On the other hand mushroom had higher content in the rest of components .The previous data are in agreement with the data reported by Prodhan *et al* ., (2015).

Hulling and milling properties of the two rice varieties:-

Hulling includes removing the husk from the paddy with the lowest loss to the grain to produce rice. Rita and Sarawgi (2008) reported that the hulling percentage ranged from 63 to 81%. Milling output is of the greatest vital standards of rice processing, storage, quality and also in trade. Degree of milling affects milling recovery and consumer acceptance (Childs 2006).

Data present in Table (4) indicated that the hulling percentage of raw paddy rice ranged between 75.05 % (Black rice) to 82.60 % (Giza 177). Milling percentage was significantly high in Giza 177 compared with black rice. However these data may be due to the genetic characters among tested rice varieties. The previous data are in agreement with the data reported by Kong and Lee (2010), Maisuthisakul and Changchub (2014), Paiva *et al.* (2014).

Minerals content of rice varieties: -

Minerals such as phosphorus and calcium as well as some traces of zinc, manganese, copper and iron (Verma and Srivastav 2017). Subudhi *et al*. (2013) mentioned that iron food content > 10.0 mg/kg is very good iron source. Black rice (BR) could be considered as good sources of Fe, Mg and Zn in relative to the recommended daily dietary allowances (for children aged 6-59 months) which amounted by 4.1 mg/24h for Fe, Mg and Zn; respectively. (WHO/WFP/UNICEF 2007).

Ash content of rice varieties was important to some extent, it contained the nutritionally important minerals. Some of these minerals are shown in Table (5). Black rice had a relatively high ($P \leq 0.05$) levels of iron (8.20), zinc (2.50), potassium (143.20), magnesium (79.1) and calcium (10.30mg / 100g) compared with Giza 177 variety. These results were in harmony with those stated by (FAO, 1993 and Abd El-Rassol *et al.*, 2005, Badawy and Mahgoub 2015).

Fatty acids profile of two rice varieties:-

It could be noticed from the data in Table (6) the main fatty acids presence in black rice samples were oleic ($C_{18:1}$) (39.2%), linoleic ($C_{18:2}$) (37.4%), besides palmitic ($C_{16:0}$) (17.75%) acids that represent more 90% of the total fatty acid contents in the samples. It is notable that the ratio of palmitic is high in Giza 177, these results were in harmony with that stated by (Lee *et al*., 2006, Kang *et al*.,2011, El-Refai, *et al.*, 2017).

Table 3. Chemical compositions of wheat and mushroom flours on dry weight basis

Flour Samples	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fiber (%)	Carbohydrate (%)
Wheat	12.4±0.60	10.2±0.30	1.22±0.16	0.77±0.10	0.55±0.12	75.41±0.55
Mushroom	9.45±0.75	20.5±0.65	1.71±0.18	4.40±0.76	11.0±0.94	63.95 ±0.64

Each value is the mean± SD

Means within a column followed by different letters are significantly different at (P≤ 0.05)

Table 4. Milling characters of the two rice varieties

Varieties	Hulling (%)	Milling (%)
Giza 177	82.60^{a}±0.95	71.92^{a}±0.80
Black rice	75.05^{b}±0.88	66.85^{b}±0.65

Each value is the mean± SD

Means within a column followed by different letters are significantly different at (P≤ 0.05).

Table 5. Minerals content of the two rice varieties

Varieties	Minerals content (mg / 100g)				
	Fe	Zn	K	Mg	Ca
Giza 177	3.1^{b}±0.11	1.20^{b}±0.12	74.0^{b}± 0.18	33.2^{b}±0.77	8.1^{b}±0.45
Black rice	8.20^{a}±0.13	2.50^{a}±0.14	143.20^{a}±0.66	79.1^{a}±0.65	10.30^{a}±0.33

Each value is the mean± SD

Means within a column followed by different letters are significantly different at (P≤ 0.05)

Table 6. Fatty acid composition of the two rice varieties (g / 100 g rice)

Fatty acid (%)	Rice varieties	
	Giza 177	Black rice
Palmitic ($C_{16:0}$)	$19.85^a \pm 0.18$	$17.75^b \pm 0.15$
Palmitoleic ($C_{16:1}$)	$0.14^b \pm 0.22$	$0.33^a \pm 0.25$
Stearic ($C_{18:0}$)	$3.5^a \pm 0.40$	$1.80^b \pm 0.34$
Oleic ($C_{18:1}$)	$37.1^b \pm 0.20$	$39.2^a \pm 0.26$
Linoleic ($C_{18:2}$)	34.1^b±0..23	$37.4^a \pm 0.30$
Linolenic($C_{18:3}$)	$1.35^b \pm 0.35$	$1.42^a \pm 0.88$
Arachidic ($C_{20:0}$)	$0.67^a \pm 0.25$	$0.58^b \pm 0.13$
Saturated (SFA)	$24.02^a \pm 0.99$	$20.13^b \pm 0.67$
Unsaturated (MUFA+PUFA) fatty acid	$72.49^b \pm 0.55$	$77.75^a \pm 0.88$

Each value is the mean± SD
Means within a row followed by different letters are significantly different at ($P \leq 0.05$)

The fatty acid profile of rice bran oil is nearly comparable to that of peanut oil and slightly higher in saturation level than soybean oil (Mccaskill and Zhang, 1999). The fatty acid profile of rice bran oil reveals approximately 19% saturated (palmitic acid), 42% monounsaturated (oleic acid) and 39% polyunsaturated (linoleic acid) (Mezouari. *et al.,* 2006).

Cooking quality parameters of rice varieties:-

There are different parameters could be applied to measure the cooking and eating quality of rice such as gelatinization temperature, gel consistency, water uptake ratio, amylose content besides cooking time . Gel consistency (G C) means that the cooked rice changes to harden on cooling. G C is correlated to the eating quality of rice, higher the gel consistency the harder the rice (Kanlayakrit and Maweang, 2013).

Gelatinization temperature determines the time it takes for a particular variety of rice to cook (Table 7). Higher gelatinization temperature is an indicator of a more crystalline structure and more resistance to water penetration and swelling of rice kernels (Yadav and Jindal, 2007). The varieties that have intermediate gelatinization temperature are either intermediate or high in amylose content. (Cruz and Kush 2000).

Amylose content is considered to be one of the greatest vital standards of rice quality in cooking besides pasting properties (Adu-Kwarteng *et al.,* 2003). Japonica/Indica rice variety of amylose content was intermediate. Most consumers prefer rice with intermediate amylose content ranged among 20-25% (Thomas *et al.*, 2013). Rice types were categorized into five groups according to their amylose content: waxy (1–2%), very low (2–9%), low (10–20%), intermediate (20–25%) and high (25–33%) (IRRI, 2009, Bassuony and El abed 2016). The differences in amylose % are attributed to genetic background of the cultivars and in part to the differences in the environmental conditions in which the crop is grown (Anonymousm, 1997, Hettiarachchy *et al.*, 1997, Dipti *et al.,* 2002 and Chukwuemeka *et al*., 2015).

Data presented in Table (7) showed the Giza 177 had higher GC than black rice. Generally, these varieties could be classified under soft rice which their GC ranged between 61-100 mm as described by (El-Bana *et al* ., 2010) . IRRI (2002) classified the gel consistency in grains as hard (40 mm or less), medium (41-60mm) and soft (>61mm). Cohesiveness, tenderness, color and gloss are differ greatly based on the gel consistency. Rani *et al*.,(2006) stated that there are a great differences in gel consistency exist among varieties of similar amylose content.

Table 7. Cooking and eating quality of rice varieties

Varieties	Gel consistency (GC) (mm)	Gelatinization temperature (GT)	Amylose content (%)	Water uptake (ml H_2O/100 g rice)		Cooking time (min.)
				75 ±2 ºC	80 ± 2º C	
Giza 177	$95.19^a \pm 0.99$	$5.00^b \pm 0.85$	$17.27^b \pm 0.75$	$245.20^a \pm 0.98$	$288.0^a \pm 0.88$	$19^b \pm 0.38$
Black rice	$91^b \pm 0.77$	$5.85^a \pm 0.35$	$21.37^a \pm 0.33$	$232.3^b \pm 0.75$	$268.5^b \pm 0.45$	$22^a \pm 0.25$

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) (Diako *et al*., 2011).
Each value is the mean± SD
Means within a column followed by different letters are significantly different at ($P \leq 0.05$)

Table 8. Sensory evaluation of cooked rice

Rice varieties	Color	Taste	Odor	Texture	Overall acceptability
Giza 177	$9^{a}\pm0.36$	$8.7^{a}\pm0.17$	$8.1^{b}\pm0.56$	$8.2^{a}\pm0.55$	$8.3^{a}\pm0.36$
Black rice	$7.9^{b}\pm0.18$	$7.7^{b}\pm0.36$	$8.7^{a}\pm0.65$	$6.9^{b}\pm0.33$	$6.8^{b}\pm0.55$

Means within a column followed by different letters are significantly
Each value is the mean± SD
different at (P≤ 0.05)

Table 9. Sensory evaluation of biscuit prepared by substituting different levels of black rice flour to wheat flour

Sample	Color	Appearance	Taste	Crispiness	Over all acceptability
T1	$7.5^{b}\pm0.2$	$7.4^{c}\pm0.1$	$6.9^{c}\pm0.3$	$7.0^{d}\pm0.5$	$7.2^{c}\pm0.3$
T2	$8.5^{a}\pm0.5$	$8.6^{a}\pm0.3$	$8.2^{a}\pm0.7$	$8.4^{a}\pm0.1$	$8.4^{a}\pm0.5$
T3	$7.8^{b}\pm0.4$	$8.0^{b}\pm0.5$	$7.4^{b}\pm0.6$	$7.7^{b}\pm0.2$	$7.8^{b}\pm0.3$
T4	$6.9^{c}\pm0.3$	$6.6^{d}\pm0.4$	$6.3^{d}\pm0.3$	$7.3^{c}\pm0.6$	$6.5^{d}\pm0.2$

Each value is the mean± SD
Means within a column followed by different letters are significantly different at (P≤ 0.05)
T1 (100% wheat flour) , T2 (97.5% wheat flour, 2.5% black rice flour)
T3 (95% wheat flour, 5 % black rice flour), T4 (92.5 % wheat flour, 7.5% black rice flour)

Black rice higher gelatinization temperature than Giza 177 . Milling process was considered as one of the major factors that affect the amylose content of the rice samples. Black rice contained higher amylose (21.37 %) than Giza 177 (17.27%). The results of (Jane *et al.*, 1999 , Osman and Abd El-Galeel 2008 , Subudhi *et al*., 2013 , Abd-El Salam *et al.*, 2016 and Lum 2017) supported our findings.

Results in Table (7) show that, water uptake values at 75 ±2ºC and 80±2ºCwere higher in Giza 177 rice than black rice, due to water uptake is more related to carbohydrate content it is higher in Giza 177 (89.24 %) than black rice (77.58 %) .This results were agree with that reported by (Savita *et al.,* 2004). (El-Bana *et al* ., 2010), who stated that, faster rate of water uptake indicated a shorter cooking time.

Sensory evaluation of cooked rice:-

During cooking, the structure of rice, physical properties, chemical composition and nutritional quality are changed (Mahadevamma and Tharanathan 2007). Table (8) presented the means of the scores given by the panels to cooked rice. There were significant variations among the black rice that had the highest value of odor (8.7) than Giza 177 (8.1). Giza 177 had the best taste (8.7) followed by black rice (7.7). Also, Giza 177 rice had the highest score of color (9), texture (8.2) and overall acceptability (8.3) compared to black rice. The texture of the rice is a key indicator of cooked rice quality as it affects consumer acceptability (Bassuony *et al.,* 2014). The black rice had the lowest acceptability than Giza 177 because its use is limited, unknown and the consumer Egyptians did not get used to it in food. Based on the results of sensory evaluation the current work aimed to use black rice flour in particular to prepare free gluten products such as biscuit to be as functional food product gluten-free. Additionally, it has high nutrients as protein, minerals (Ca, P, Fe, and Zn) , anthocyanin besides dietary fiber compared to white rice The present results are in harmony by (Adu-Kwarteng *et al.*, 2003, Frei and Becker, 2003, Puspitowati and Driscoll 2007, Asghar, *et al* ., 2012).

a-Sensory evaluation of biscuit prepared by substituting different levels of black rice flour with wheat flour :-

The texture, flavor, and appearance of the biscuits are major attributes that affect biscuit acceptability (Torbica *et al*., 2012). Black rice flour (gluten-free) suitable to prepare products for celiac disease (Klunklin and Savage, 2018). There is a high demand to use natural antioxidants in foods to enhance the shelf life of biscuits. Hence replacing wheat flour with black rice flour in biscuit production was one scope of this study. Rice protein cannot generate a viscoelastic network like gluten in wheat, which retains carbon dioxide during biscuit dough fermentation (Sharma *et al* ., 2016).

The results in Table (9) indicate that the samples contained 2.5% and 5% black rice flour gain higher scores for all characteristics. Significant differences in all characteristics for all biscuit samples. Samples contained 2.5% black rice flour had the highest values of color among the other biscuit samples. Furthermore, samples contained 7.5% black rice flour had the lowest scores for the color, appearance, taste and overall acceptability compared with the other biscuit samples

Table 10. Sensory evaluation of biscuit prepared by substituting different levels of black rice and mushroom flours with wheat flour

Sample	Color	Appearance	Taste	Crispiness	Over all acceptability
T1	$7.0^{d}\pm0.4$	$6.5^{d}\pm0.5$	$6.7^{d}\pm0.2$	$6.6^{d}\pm0.3$	$6.5^{e}\pm0.2$
T2	$8.6^{a}\pm0.2$	$8.5^{a}\pm0.2$	$8.4^{a}\pm0.1$	$8.7^{a}\pm0.5$	$8.5^{a}\pm0.3$
T3	$8.1^{b}\pm0.1$	$7.8^{b}\pm0.3$	$7.9^{b}\pm0.4$	$8.0^{b}\pm0.6$	$7.9^{b}\pm0.4$
T4	$7.7^{c}\pm0.3$	$7.5^{b}\pm0.4$	$7.6^{b}\pm0.5$	$7.6^{b}\pm0.3$	$7.5^{c}\pm0.6$
T5	$7.5^{c}\pm0.5$	$7.0^{c}\pm0.7$	$7.1^{c}\pm0.7$	$7.1^{c}\pm0.4$	$7.0^{d}\pm0.7$
T6	$6.7^{e}\pm0.6$	$6.1^{e}\pm0.2$	$6.2^{e}\pm0.6$	$6.2^{e}\pm0.2$	$6.0^{f}\pm0.4$
T7	$6.0^{f}\pm0.3$	$5.8^{e}\pm0.4$	$5.7^{f}\pm0.4$	$5.5^{f}\pm0.5$	$5.3^{g}\pm0.5$

Each value is the mean± SD

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

T1 (100% wheat flour), T2 (96.5% wheat flour, 2.5% black rice flour, 1%musroom)

T3 (95.5% wheat flour, 2.5 % black rice flour, 2%musroom), T4 (94.5% wheat flour, 2.5% black rice flour, 3%musroom),T5(94% wheat flour , 5% black rice flour, 1%musroom), T6 (95% wheat flour , 5% black rice flour, 2%musroom), T7 (92% wheat flour, 5% black rice flour , 3%musroom).

The mean scores of overall acceptability for biscuit samples revealed that biscuit contained 2.5% black rice flour had the highest score of overall acceptability than the other biscuit samples. It could be noticed that replacing wheat flour with 2.5 % black rice flour in biscuit is acceptable. So, suggest that it is better for the consumer to add black rice flour in biscuit manufacture and the consumer will get more nutrient and bioactive components including anthocyanin, lipids, amino acids, phenolic compounds, and minerals. These data are in harmony by (More *et al*., 2013; Metwally *et al*., 2014; Cho and Lim, 2015; Klunklin and Savage , 2018).

b-Sensory evaluation of biscuit prepared by substituting different levels of black rice flour and mushroom *A. bisporus* flour with wheat flour:-

Mushroom proteins contain essential amino acids which necessary to humans (Kakon *et al*., 2012, Muszyńska *et al*., 2013, Correa *et al*., 2016). Moreover, it is rich in protein besides carbohydrates (Ahlavat *et al*., 2016).

Results in Table (10) showed that the samples contained 2.5% black rice flour and 1%, 2%, 3% mushroom flour gain the highest scores for all characteristics. Moreover, the samples that contained 2.5% black rice flour and 1% mushroom flour had the highest values among of other biscuit samples. On the other hand, the samples contained 5% black rice flour, 3% mushroom flour had the least score of color, appearance, taste, crispiness and overall acceptability.

As a result of the mean scores of overall acceptability for biscuit, samples revealed that the acceptability of biscuit that contained 2.5% black rice flour and 1% mushroom flour had the highest score than the other biscuit samples. So, it could be noticed that replacing wheat flour with black rice flour and mushroom flour in biscuit production was acceptable for consumer and added more value because of the presence of nutrients and bioactive components including protein, amino acids, minerals, vitamins, antioxidant, anti-diabetic and antibacterial properties. These data are in agreement with (Atila et al., 2017 and Klunklin and Savage 2018).

CONCLUSION

It can be concluded that black rice flour has good nutritional value and good functional properties which enhance the nutritional quality of the products. The results could help food technologists and rice producers to encourage rice product consumption by increasing consumer consciousness of grains health usefulness. In this regard, Gluten-free bakery products are advantageous to persons who suffer from celiac disease. Besides using black rice flour and mushroom flour increased protein and other nutrients contained in the products.

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الملخص العربي

الخواص الكيمائية والحسية للأرز الأسود مقارنة بصنف الأرز جيزة ١٧٧

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أجريت هذه الدراسة بهدف تقييم الأرز جيزة ١٧٧والأرز الأسود من حيث الصفات الكيماوية والتكنولوجية وإمكانية الأستفادة من دقيق الأرز الأسود ليحل محل دقيق القمح فى صناعة بعض منتجات المخابز مثل البسكويت لتغذية الأفراد ذوى الحساسية لجلوتين القمح.

وأوضحت النتائج ما يلى:

- أظهرت النتائج أن الأرز الأسود يحتوى على نسبة أعلى من البروتين ومستخلص الدهون والرماد والألياف مقارنة بصنف جيزة ١٧٧.
- اختلفت قيم سيولة الجل معنوياً حيث أظهر صنف الأرز جيزة ١٧٧ على أعلى قيمة من سيولة الجل مقارنة بالارز الاسود.
- أحتوى الأرز الأسود على نسبة مرتفعة من الأميلوز مقارنة بالصنف جيزة ١٧٧.
- أظهرت النتائج بأن الأرز الأسود يعتبر مصدراً جيداً للبروتين والأحماض الدهنية والأنثوسيانين والفينولات الكلية والعناصر المعدنية مقارنة بالصنف جيزة ١٧٧.
- سجل الأرز الأسود أقل تقبلاً فى التقييم الحسى للأرز المطهى مقارنة بالأرز صنف جيزة ١٧٧.
- أظهرت نتائج التقيمات الحسية للبسكويت المحضر بنسب استبدال دقيق الأرز الأسود ٢،٥% و٥% تقبل عالى لدى المستهلك وكذلك البسكويت المحضر من دقيق الارز الاسود بنسبة ٢،٥% ودقيق المشروم بنسبة ١% و٢% و٣% كان مرغوب لدى المستهلك أيضا. واظهرت التقيمات الحسيه ان للبسكويت المحضر بنسب استبدال دقيق الأرز الأسود بنسبة ٢،٥% ودقيق المشروم بنسبة ١% كان من افضل النتائج المتحصل عليها.
- يمكن أن توجه هذه الدراسة إلى إستخدام دقيق الأرز الأسود والمشروم فى تحضير بعض المنتجات الغذائية الوظيفية وذلك لإرتفاع محتواه البروتين والعناصر الغذائية إضافة إلى إستخدامه فى تحضير بعض المنتجات الغذائية الخالية من الجلوتين للأفراد ذوى الحساسية لجلوتين القمح.