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Effect of Germination on Improving Grain Quality, Chemical Composition, Antioxidants, and Phytic Acid in Rice (*Oryza sativa*)

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Abstract

This study aimed to study the effect of the germination process on grain quality, chemical composition for brown rice and comparing them with white rice for use it is on a commercial scale . Three rice varieties namely Sakha 104(Japonica), Giza 178(Japonica- Indica), and Giza 182(Indica) were used in this study. And the three statuses (milled rice, brown rice, and germinated brown rice). A completely randomized design in the factorial arrangement was used in this experiment to determine some cooking and eating quality characters i.e. gelatinization temperature, amylose content and elongation %, Water uptake, hardness, chemical composition: Phytic acid, total antioxidant capacity, and panel test evaluation for rice samples. The results indicated that there were significant differences in amylose content and gelatinization temperature among the three rice statuses and no significant difference in these characters with the three rice varieties under study. Germinated brown rice showed the lowest amylose content (15.58%), followed by brown rice (17.26%) and white rice (18.39%). Brown rice gave the highest temperature followed by germinated brown rice then milled rice. A maximum elongation ratio was observed in Giza178 (Japonica Indica). White rice gave the maximum elongation (47.18%) followed by germinated brown (24.56 %) then brown rice (16.08 %). Japonica rice exhibited lower hardness than indica rice. The strongest value (4.82) was recorded at brown rice, while the weakest value (3.64) was in white rice. The Indica rice variety Giza181 had the highest protein and fat%. The germinated brown rice had the highest value of protein, crude fiber, and fat (7.27, 1.98, and 2.87%, respectively), compared with compared to brown rice and white rice. White rice had lower Phytic acid (%) followed by germinated brown rice, then brown rice. Japonica rice cultivar (Sakha 104) has a higher antioxidant level than Indica rice cultivar (Giza 182). Brown rice contains the highest value of antioxidant followed by germinated brown rice, while white rice gave the lowest level. Germinated brown rice recorded the second two good tastes after white rice. So, this study recommended that we can increase the nutritional value of rice by germinated brown rice with little change in taste.

Keywords: Germinated brown rice; Protein; Amylose; Antioxidant.

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Introduction

Rice (*Oryza sativa* L.) is one of the important food crops that feed more than 50% of the world's population, (Thuengtung et al., 2018). White rice is the most common type of rice that humans consume. However, ground rice serves as a major source of carbohydrates for your daily energy needs. Brown rice offered additional health benefits (Bassuony and El Abed 2016). A comparison to white and brown rice, brown rice is a rich source of many bioactive compounds, such as γ-oryzanol, tocopherol, tocotrienol, amino acids, dietary fibers, and minerals. The advantages for health with the consumption of brown rice mainly come from the phytochemicals found in its bran layers (Ravichanthiran et.al, 2018). Consumption of brown rice is less than milled rice because it is more difficult to cook than milled rice due to slow absorption in water, and the palatability of brown rice is the lowest of milled rice. (Ohtsubo et al., 2005), while the soaking process improves the nutrients in brown rice easily to be digested and brown rice texture is better. (Wu et al., 2013). Starch digestibility, the extent rate of starch hydrolysis by amylolytic enzymes. Flours prepared from germinated grains were documented to obtain better nutritional values than those of ungerminated flours. Grains germination has changes in enzyme activity and subsequent changes in composition. The production of germinated brown rice grain has gained big attention as a way to improve the eating quality and potential health-promoting functions of cooked brown rice (Cornejo et al., 2015). Accordingly, grain brown rice has become popular among health-conscious consumers due to its bioactive compounds (Cho and Lim, 2016). Phytic acid is regarded as a potent inhibitor of minerals in plants. (Raboy, 2003). Phytic acid has also been reported to form stable complexes with proteins, which may result in decreased protein solubility, enzymatic activity, and proteolytic digestibility (Ravindran et al., 1995). Great efforts have been made to reduce the amount of phytate in foods through various processes, including the addition of exogenous enzymes. Germination has been reported to reduce Phytic acid and increase inorganic. It could thus improve the bioavailability of minerals in cereals (Ghavidel and Prakash, 2007). The consumption of germinated brown rice is increasing because of its improved quality of palatability and potential health functions (Phattayakorn et al., 2016). Several nutrients and total protein were increased while sugar was reduced in germinated brown rice compared with ungerminated brown rice (Trachoo et al., 2006). Germinated brown consumption rice is associated with human health-improving due to a big range of biological properties (Sutharut and Sudarat, 2012). The aim of this study is 1-Study changes in total starch, sugars, and physicochemical properties as well as being affected by the germination process and comparing them with milled rice and brown rice. 2- Study the possibility of enhancing the antioxidant of germinated brown rice. 3-Evaluating the possibility of increasing the antioxidant properties of germinated rice.

Materials and Methods

Three rice varieties namely Sakha 104, Giza 178, and Giza 182 were used in this study (Table 1). The samples were used from freshly harvested grains of paddy rice at 14% moisture content from 2020 season planting.

Brown rice: was prepared by removing a husk of the ungerminated paddy rice using an experimental huller machine (Satake).

Milled rice: Brown rice was consequently milled using McGILL Miller No. 2. The sample was milled for 60 sec.

Germinated brown rice (GBR): Paddy rice (5kg) for all cultivars was soaked in tap water at room temperature for 24 h and water was changed every

Table 1. Parentage, types, and Origin of the three cultivars used under study.

No.	Cultivar	Parentage	Types	Origin
1	Sakha 104	GZ 4096/GZ 4100	Japonica	Egypt
2	Giza 178	Giza 175/Millyang 49	Japonica – Indica	Egypt
3	Giza 182	Giza181/IR39422//Giza181	Indica	Egypt

Fig. 1. Rice cultivars (Sakha 104, Giza 178, and Giza 182, respectively after germination.

Fig. 2. Milled rice, brown rice, and germinated brown for three cultivars under study.

7-8 h. All rice cultivars were distributed that soaked in baskets of plastic by cheesecloth covered and germinated in locker germination of for 48 H at 28-30°C and 90-95% relative humidity. After germination, the germinated grains were dried at 50°C to approximately 10% of moisture content (Fig. 1). The hulls, shoots, and roots were separated using an experimental huller machine (Satake).

The milled were prepared and brown rice and germinated brown were dehulled at the grain quality Lab., RRTC. Sakha, Egypt (Fig. 2).

Samples were taken in random sampling (three replications for three cultivars) completely randomized design in the factorial arrangement was used in this experiment. About 150 grams (three replication) of rough rice for all samples(Brown rice and germinated brown) were taken and well mixed and cleaned for the gelatinization temperature, water uptake, hardness, and elongation % analyses. Grind 10 whole milled rice grains of all samples to a fine powder to obtain rice flour and use in the analyzes of amylose content, chemical component, Phytic acid, and total antioxidant capacity.

Cooking and eating quality characters i.e. Gelatinization temperature, amylose content, and elongation % were estimated for rice samples following the methods of Little et al., (1958). Juliano (1971), Azeez and Shafi (1966) respectively. Water uptake was calculated according to the procedure of Singh et al.,(2005).

Hardness: The Universal Testing Machine (UTM) (Model: LR Five Series, M / S Llyod Instrument, England) was employed to measure the hardness of raw rice

Chemical composition: Flours were analyzed for the following chemical compositions protein content (NX 5.95), lipids content, ash content (%), crude fibbers content, and total carbohydrate content (%) following the method described by A.O.A.C. (1990).

Phytic acid: A method by Wheeler and Ferrel(1970).

Total antioxidant capacity: The total antioxidant capacity of the extracts was evaluated by the method of Banerjee et al., (2005) using phosphor molybdenum reagent (3.3 ml sulphuric acid, 335 mg sodium phosphate, and 78.4 mg ammonium molybdate in 100 ml of distilled water) with 0.1ml of the extract. The absorbance of the samples was measured at 695 nm after boiling in a water bath for 95 ° C for 90 min against an empty reagent, which included the appropriate volume of the same solvent instead of samples.

Panel test evaluation: Brown rice, milled rice, and germinated brown rice samples (1kg) were cooked and were served to a panel of 10 Judges for evaluation. The cooking recommendation was to use the same water volume temperature and time of cooking. The samples were evaluated translucency and oder then after cooking for, kernel expansion, cooked kernel hardness, stickiness, odor, whiteness, expansion, hardness. Stickiness and taste according to Julino (1965).

All collected data were presented for analysis of variance according to Gomez and Gomez (1984). Treatments means by which Duncan's multiple range test were compared (Duncan, 1955). All statistical analysis was performed using variance technique using "MSTAT" software package.

Table 2. ANOVA analysis of characters under study performance.

Source of variance	D.F	Ms					
		Amylose content%	Gelatinization temperature (GT)	Elongation %	Hardness	Water uptake	Ash (%)
Genotype	2	0.046	0.083	38.27**	0.365**	1.63**	0.004
Statues	2	0.177**	34.94**	2350.04**	3.098**	241.28**	0.018 *
GxS	4	0.187**	0.535**	5.49**	0.357**	2.136**	0.16**
Error	18	0.023	0.037	1.73	0.036	0.153	0.003
Source of variance	**D.F**	**Ms**					
		Protein (%)	Fat (%)	Carbohydrate (%)	Fiber %	Phytic acid	T. antioxidant capacity
Genotype	2	4.76**	0.046	2.650**	0.135	0.049**	1536.37**
Statue	2	4.38**	3.440**	2.374**	1.895**	0.056**	7600.31**
GxS	4	0.36**	0.029	0.350	6.078	0.012**	293.96**
Error	18	0.02	0.024	0.321	0.045	0.02	0.675

Table 3. Effect of rice cultivars and statuses on some cooking and eating characters during 2020 season.

Main Effect	Amylose Content %	Gelatinization Temperature (GT)	Elongation %	Hardness N (kg·m/s)	Water Uptake %
Cultivars					
Sakha 104	17.32±0.208a	4.40±0.577a	28.43±4.931 b	4.10±0.142 b	13.05± 1.603 a
Giza 178	17.73±0.327a	4.21±0.552a	31.42±4.720 a	4.14±0.096 b	12.35± 1.374b
Giza 182	17.53±0.302a	4.33±0.601a	27.47±4.404 b	4.46±40.293a	13.13± 1.550a
Statue of rice					
White rice	18.39± 0.096a	6.17± 0.067a	47.18± 0.647a	3.64±0.091c	18.59± 1.82a
Brown rice	17.26± 0.042b	2.29± 0.094c	16.08± 0.375 c	4.82± 0.164a	8.56± 0.189c
Germinated brown rice	15.58±0.076 c	4.53± 0.124b	24.56± 0.082b	4.24±0.082 b	11.37± 0.264b

Data represent means ± SE. Values with the same letter in a column of the same cultivar are not significantly different ($p < 0.05$).

Results and Discussion

Analysis of Variance (ANOVA)

Data shown in Table 2 represent the mean square (MS) of the sources of variance for characters under study. The analysis of the mean square showed there was a very highly significant difference among the cultivars for all characters evaluated except amylose content%, gelatinization temperature, ash (%), fiber, and fat (%), while the mean square estimates showed highly significant differences among the three statues for all characters under study. Cultivars and statues interaction for the mean square was significant for all the characters except for fat (%), carbohydrate (%), and fiber. These findings indicated the presence of large variation among cultivars and statues under study.

Cooking and Eating Quality Characteristics

Amylose content (%): The data shown in Table 3

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indicated some cooking and eating characters. The amylose content affected on the stickiness of cooked rice was similar in the three types under study and classifying it as low-amylose varieties. The amylose content was highly significant between the statuses under the study. Germinated brown rice showed the lowest amylose content (15.58%) among all, followed by brown rice (17.26%) and white rice (18.39%). Germinated brown rice had a reduction of amylose content % but gradually increased in brown rice then increase in white rice. Gelatinization temperature and amylose content of germinated brown rice starch, when compared with brown starch, indicated that the germination process can indeed reduce the amylose content. (Kaneko and Morohashi,2003). Similarly, Charoenthaikij et al. (2009) had reported that germination increased not only the activity of amylose but also increased in reducing sugars in brown rice, supporting our findings of lower amylose content in germinated brown rice when compared with brown rice. Similar findings have also been reported by other researchers (Mohan et al., 2010). The amylose content in rice affects the softness and palatability of steamed rice (Feng et al., 2017) and so its reduction in brown rice will bring about a softer texture. Additionally, amylose content was reported to have a positive correlation with hardness and a negative correlation with stickiness after cooking (Musa et al., 2011). It means that germination reduces the hardness of brown rice, while it increases its stickiness, indicating that germinated brown rice would be more acceptable than brown rice taking into consideration its amylose content.

Gelatinization temperature (GT): The gelatinization temperature of the rice samples has been classified as high, intermediate, and low which means the temperature required for normal cooking time is below 70-74°C.And no significant difference with the three rice varieties under study. It is evident from data shown in Table 3 that there were significant differences in gelatinization temperature among the three rice statuses. Brown rice gave the highest temperature followed by germinated brown rice then milled rice.The amylose content % and gelatinization temperature among types and statuses of rice were evaluated (Fig. 3).

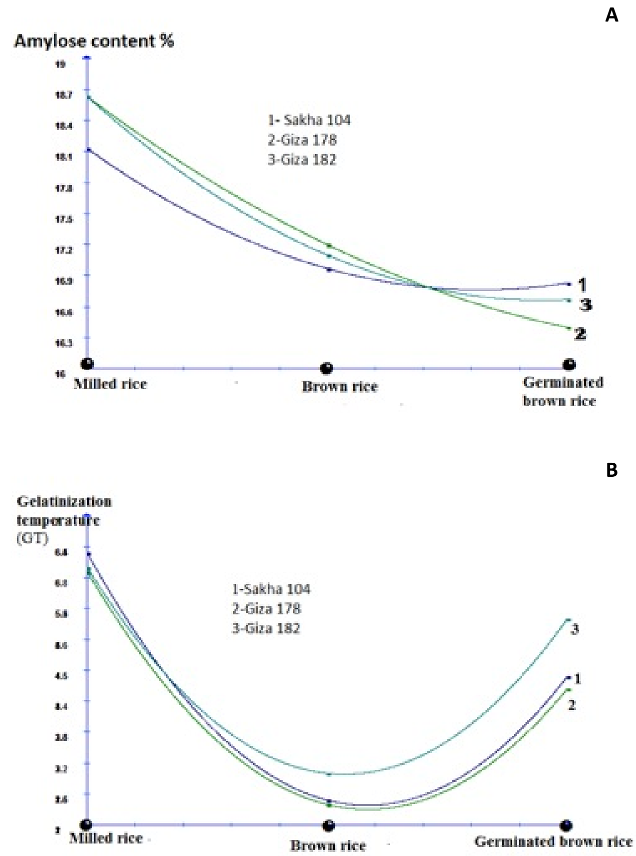

Fig. 3. Effect of rice cultivars and statuses under study on (A) Amylose content% and (B) Gelatinization temperature.

Elongation (%): In this study elongation of rice kernel% (Table 3), maximum elongation ratio was observed in Giza178 (Japonica Indica) (31.42) followed by Sakha 104 (28.43). No significant was found among Sakha104 (Japonica), and Giza182 (Indica). (Bassuony and El Abed 2016). Also, results in Table (3) showed significant differences were detected for elongation ratio among statuses. White rice gave the maximum elongation %(47.18). Whereas brown rice recorded the minimum value (16.08 %). While germinated brown rice gave a medium value between them (24.56 %).

Hardness: Japonica rice exhibited lower hardness than Indica rice (Table 3). These results suggest that the ultrastructure of rice affects the texture of the cooked product (Kang et al 2006). There were significant differences among statuses for hardness. The

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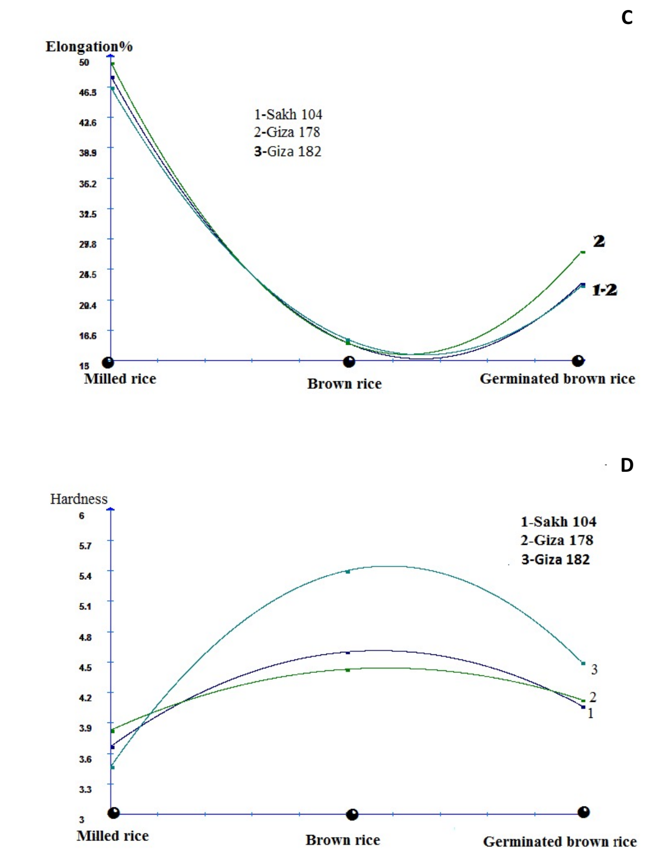

Fig. 4. Effect of rice cultivars and statuses under study on (C) Elongation% and (D) Hardness.

strongest (4.82) was recorded at brown rice. While the weakest value (3.64) was found in white rice. The elongation% and hardness among types and statuses of rice were evaluated (Fig. 4).

Water uptake: The water uptake ratio is a good indication of the volume expansion of rice (Table 3). High significant was observed in the water uptake ratio, which ranged from 12.35 to 13.13. Giza 182 variety produced the maximum water uptake (13.13), while Giza 178 gave the minimum value (12.35). There were significant differences in water uptake due to the statuses of the study. White rice gave the maximum number value (18.59). While brown rice recorded the minimum value (8.56). While germinated brown rice gave a medium value between them (11.37). Water uptake among types and statuses of rice was evaluated (Fig. 5).

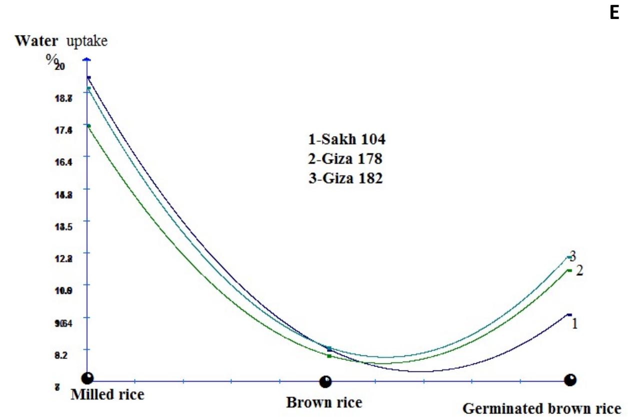

Fig. 5. Effect of rice cultivars and statuses under study on (E) water uptake.

Chemical Composition

The Indica rice variety Giza181 had the highest protein and fat% in compared the other types under study (6.98) and 2.46 respectively), while the japonica rice variety Sakha 104 gave (5.57 and 2.32) (Table 4). (Kang et al 2006) recorded the same results, while Japonica -Indica Giza 178 gave the medium value between them in protein content %. Whereas no significant differences were detected between the japonica rice variety Sakha 104 and Japonica Indica Giza 178 in fat % Table 4.

Data showed that (Table 4) the germinated brown rice had the highest value of protein, crude fiber, and fat (7.27, 1.98, and 2.87%), respectively, compared with brown rice and white rice. Brown rice had the highest value of protein, fat, ash, and crude fiber content compared with white rice El-Hissewy et al., (2002) reported that increasing milling caused a significant decrease in oil, protein, and ash may be due to most of the nutrients present in the outer layer of the brown rice grain which were removed during the milling process. It may be the metabolic activity of dry seed increases as soon as it is hydrated during soaking. Complex biochemical changes occur in different parts of the seed during germination. Because no external nutrients are added during the germination process, only water and oxygen are consumed by the germinating seed,

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Table 4. Chemical composition of cultivars and statues under study in 2020 seasons.

Main effect	Protein (%)	Carbohydrate (%)	Fat (%)	Fiber %	Ash (%)
Cultivars (v)					
Sakha 104	5.57±0.199c	88.88±0.332a	2.32±0.212	1.78±0.172a	1.033±0.024a
Giza 178	6.54±0.358b	88.53±0.224a	2.43±0.172	1.54±0.137a	1.08±0.032a
Giza 182	6.98±0.251a	87.75±0.091b	2.47±0.170	1.67±0.141a	1.06±0.024a
Statue of rice					
White rice	5.47±0.204c	89.03±0.294a	1.70± 0.656c	1.15±0.053b	1.011±0.015 a
Brown rice	6.35±0.171b	87.83±0.257b	2.65± 0.067b	1.87±0.060a	1.05± 0.26ab
Germinated brown rice	7.27±0.292a	88.22± 0.131b	2.87±0.032a	1.98 ±0.82a	0.88±0.033a

Data represent means ± SD. Values with the same letter in a column of the same cultivar are not significantly different (p < 0.05).

Table 5. Effect of some rice cultivars on Phytic acid and Total antioxidant capacity.

Cultivars (v)	Phytic acid (%)	Total antioxidant capacity (Mg/100 g)
Cultivars (v)		
Sakha 104	0.706±0.026a	193.260±10.67a
Giza 178	0.598±0.048b	165.158±9.92b
Giza 182	0.565±0.005 b	111.908±5.68c
Status of rice		
White rice	0.549± 10.07b	133.359±0.026b
Brown rice	0.705± 14.82a	189.298±0.033a
Germinated brown rice	0.615± 11.06ab	147.669±0.023b

Data represent means ± SE. Values with the same letter in a column of the same cultivar are not significantly different (p < 0.05).

desirable nutritional changes mainly stem from the decomposition of complex compounds to more simple forms, and their transformation into basic constituents (Chavan and Kadam, 1989). Zheng et al.(2007) found that the bioavailability of proteins was improved by the changes in the storage proteins of brown rice during germination. During germination, the content of amino acids increased significantly. The germination conditions exhibited an effect on the changes in amino acid content, and that treatment was useful to the accumulation of a higher concentration of amino acids in germinated brown rice (Fengfeng et al., 2013). Concerning carbohydrate content, the data observed that white rice had the highest value (89.03 %), compared with germinated brown rice (88.22%). While the lowest value (87.83 %) was found by brown rice. This means that the germination process is caused by the decrease in carbohydrate values compared with white rice. The chemical composition among the types and statuses of rice was evaluated (Fig 6).

Phytic Acid and Total Antioxidants Capacity

Phytic acid: Data shown in Table 5 illustrate Phytic acid (%) and total antioxidant capacity (mg/100g) of cultivars under study. No significant difference was between white rice and germinated brown rice. Data revealed that white rice had lower Phytic acid (%) comparing with the other two statues under study followed by germinated brown rice, then brown rice, Liang et al. (2008) pointed out that germination could decrease Phytic acid levels in brown rice also they found that hydrolysis of

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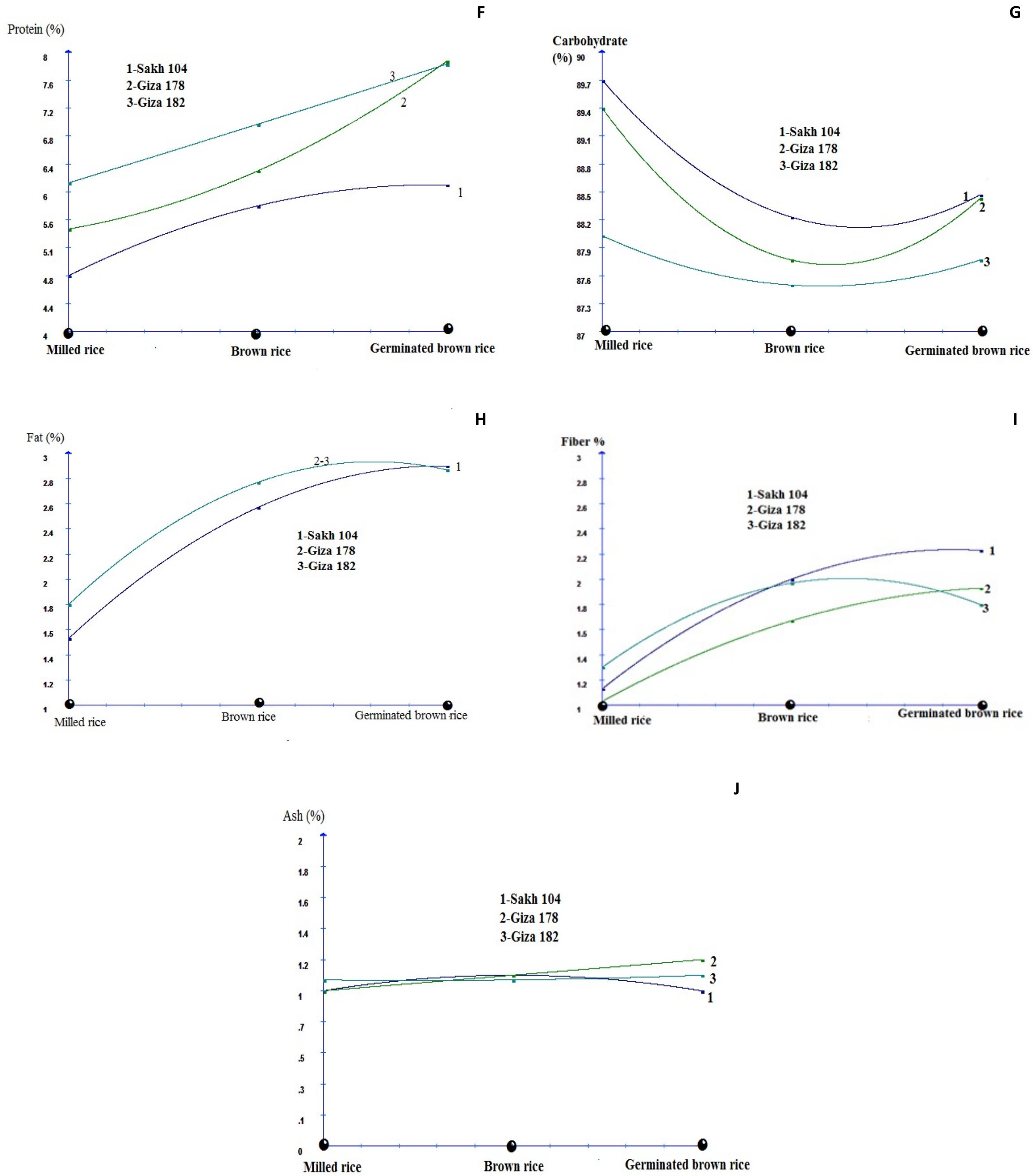

Fig. 6. Effect of rice cultivars and statuses under study on the chemical composition (F) Protein (%) (G) Carbohydrate (%) (H) Fat (%) (I) Fiber % (J) Ash (%).

phytate can be obtained by activation of the endogenous phytase during soaking germination. (Shallan et al., 2010) stated that the phytate content is lower in milled rice because of the separation of the bran layers throw the polishing process. More than 80% of the phytate in the rice grain is found in the bran and aleurone layers.

Total Antioxidants Capacity: Japonica rice cultivar (Sakha 104) has a significantly higher antioxidants level than Indica rice cultivar (Giza 182) (Ding et al., 2018). No significant difference have been observed between Indica rice (Giza 182) and Japonica

Table 6. Palatability characters of white, brown, and germinated brown rice under study.

Rice cultivars	Rice/water ratio	Before cooking			Cooking Time (min)	Oder	Whiteness	Expansion	Hardness	Stickiness	Taste	Total-100
		Grain length	Grain shape	Trans.								
Sakha 104 cultivar												
White	1:1.25	Short (8)	Medium (8)	Trans(8)	20-25 (6)	No (10)	White (6)	Half (6)	Broken (7)	Fluffy (9)	Good (9)	78
Brown	1:1.25	Short (8)	Medium (8)	Trans(6)	More than30 (3)	Medium (5)	Dark (2)	Quarter (2)	Unbroken (10)	Fluffy (8)	Accepted (5)	57
Germinated brown	1:1.25	Short(8)	Medium (8)	Trans(7)	20-30 (5)	Medium(5)	Dark Half (3)	Third (4)	Unbroken (10	Fluffy (9)	Accepted (5)	63
Giza 178 cultivar												
White	1:1.25	Short 7)	Medium (7)	Trans(8)	20-25 (6)	No (10)	White (6)	Half (6)	Broken (7)	Fluffy (9)	Good (9)	75
Brown	1:1.25	Short (7)	Medium (7)	Trans(6)	More than30 (3)	Medium (5)	Dark (2)	Quarter (2)	Unbroken(10)	Fluffy (8)	Accepted (5)	55
Germinated brown	1:1.25	Short(8)	Medium (7)	Trans (7)	20-30 (5)	Medium (5)	Dark Half (3)	Third (4)	Unbroken(10)	Fluffy (9)	Accepted (5)	62
Giza 182 cultivar												
White	1:1.25	Long (6)	Slender (6)	Trans(8)	20-25 (6)	No (10)	White (6)	Half (6)	Broken (7)	Fluffy (9)	Good (9)	73
Brown	1:1.25	Long (6)	Slender (6)	Trans(6)	More than30(3)	Medium (5)	Dark (2)	Quarter (2)	Unbroken(10)	Fluffy (8)	Accepted (5)	53
Germinated brown	1:1.25	Long (6)	Slender (6)	Trans (7)	20-30 (5)	Medium (5)	Dark Half (3)	Third (4)	Unbroken(10)	Fluffy (9)	Accepted (5)	61

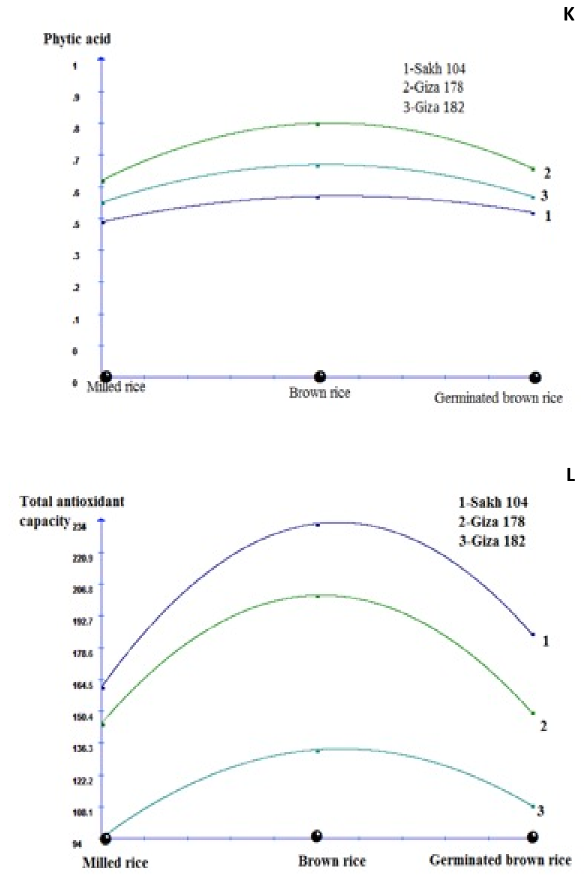

Fig. 7. Effect of rice cultivars and statuses under study on (K) Phytic acid and (L) total antioxidant capacity.

indica rice cultivars (Giza 178) (Table 5).

The antioxidants can protect cells against oxidative damage, thereby reducing the risk of diseases associated with oxidative damage (Shao and Bao2015). Brown rice contains the highest value of antioxidant followed by germinated brown rice, while the lowest level of antioxidant was recorded by white rice. Brown rice grains are harder to chew and have fewer taste qualities. Thus, pre-germinated rice is favored. It is also shown that pre-germinated brown rice increases mental health and immunity (Ravichanthiran et.al., 2018). The Phytic acid and total antioxidants capacity among types and statuses of rice were evaluated (Fig 7).

Panel Test

Data in (Table 6) showed the palatability characters of three rice cultivars under study and the three statuses to increase the nutritional value of the white rice. Rice to water ratios was constant to all statuses at 1:1.25. Translucency before cooking for a white status of all cultivars was the best then germinated brown rice, while brown rice was the lowest one due to having dark color resulted in bran. White rice recorded the lowest cooking time followed by germinated brown rice then brown rice for all cultivars. Brown rice had a strong odor than germinated brown rice and white rice for all cultivars under study. The whiteness of rice after cooking is affected directly by brown rice and germinated brown rice, it's clear from data shown in Table 6. Volume expansion of white rice status gave the highest value as shown in Table 6. Followed by germinated brown rice and brown rice gave the lowest one for all cultivars under study. Germinated brown rice and brown rice gave the highest values for hardness for all cultivars under study, white rice status was more stickiness than germinated brown rice and brown rice. Germinated brown rice recorded the second two good taste (Table 6) after white rice.

Conclusion

Germinated brown rice recorded the second two good tastes after white rice. So, this study recommended that we can increase the nutritional value of rice by germinated brown rice with little change in taste.

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