



## Original article

Genetic studies for grain quality traits and correlation analysis of mineral element contents on Al-Ahsa rice and some different varieties (*Oryza Sativa* L.)

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## ABSTRACT

One of the most significant goals in plant breeding programs is to generate new rice varieties with increased elements and good grain quality. In this experiment, ten rice genotypes were evaluated for grain quality traits and protein percentage. Also, milled rice of the ten genotypes were used for analysis of mineral elements. The results revealed that mean squares attributable to genotypes were significant for all traits during the two growing seasons, showing the presence of broad genetic variability among genotypes for all traits under consideration. However, the Indica type (Egyptian Yasmin and Giza 182) gave the highest value for grain length (7.10, 6.52 mm) and grain shape (2.87, 2.82 mm) under the two seasons. While, Al-Ahsa Type1 and Al-Ahsa Type2 rice varieties gave the highest values in protein percentage, which gave 10.80 and 9.80%. Correlation coefficients among the nine grain quality traits clarifying eight absolute positive correlation grain length with grain shape, grain width with hulling % and head rice %; grain shape with amylose content %; hulling % with milled rice and head rice %; milled rice % with head rice %; head rice % with gelatinization temperature. On the other hand, there were seven absolute negative correlations between grain length with grain width; grain width with grain shape and amylose content %; grain shape with hulling % and head rice %; amylose content % with milled rice %, head rice % and gelatinization temperature. In micronutrient elements Al-Ahsa Type1 and Al-Ahsa Type2 varieties gave the heights value for N, P, K, Mg %. Also, gave the heights value for Na (73.25, 73), Fe (20.12, 19.80), and Zn (125.60, 122.70). Pearson's correlation observed eight absolute positive and significant correlations, which were between; nitrogen content (N), P, K, Mg, Na, Fe, Zn, Cu and protein percentage.

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## 1. Introduction

Rice (*Oryza sativa* L.) is the primary source of nutrition for more than half of the world's population and suitable food for different human stage. The high quality for rice is determined fine rice varieties and it's also controlled for the price of varieties and spread to growing the best variety in the large area. Earlier studies indicated that the quality of rice comprised several characteristics such as grain size, shape, and appearance, milling quality, and cooking fea-

tures. These characteristics made consumers want to use the variety (Cruz and Khush, 2000; Ratna et al., 2016; Zeng et al., 2005). Anyway, this improvement can be producing through conventional breeding methods, which produced new genotypes (Zeng et al., 2005; Welch and Graham, 2004; Cuevas et al., 2016). Furthermore, different factors influenced quality, for example, rice millers select varieties with high milling, whereas consumers emphasize physicochemical properties (Merca and Juliano, 1981). Furthermore, crop growing environment, harvesting, processing, and milling systems all played a significant role in grain quality features (Zeng et al., 2005; Nelson et al., 2011). On the other hand, milled rice riche by 17 amino acid and mineral element contents these mineral included K, Ca, Na, Mg, Fe, Zn, Cu, Mn (Jiang et al., 2007). Micronutrient deficiency is seen as one of the major issues to food and nutrition security, particularly in poor countries, and there is growing acceptance of a food-based approach to tackling this (Maganti et al., 2020). The correlations between most mineral elements were

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analyzed and they discovered significant positive correlations between most mineral element contents Mg, Fe, and Mn contents, however Cu was negative significant with K and Mg contents of rice (Zeng et al., 2005; Sha et al., 2017; El-Habet et al., 2014).

In contrast, the distribution of elements and correlation in rice bran were tested using 446 rice grains obtained from paddy fields in China, with 8 elements in rice bran, and the results revealed a good linear association between rice bran and polished rice (Tattibayeva et al., 2016; Yao et al., 2020). Grain quality characteristics, such as grain length, grain breadth, grain shape, hulling percent, milling percent, head rice percent, elongation, gelatinization temperature (GT), and amylose content percent (AC), are significant to progeny heredity. The current study's major goals are to measure grain length (mm), grain width (mm), grain shape (mm), hulling, milling percentage, head rice (mm), elongation percentage, gelatinization temperature, and amylose content percentage. Also, study the genetic advance through genotypic and phenotypic as well as heritability and correlation coefficient for all traits under study.

## 2. Materials and methods

### 2.1. Plant-based materials

Ten rice genotypes were selected to this investigation and growing at two years (Table 1). These genotypes from different origin, two from Kingdom of Saudi Arabia (Al-Ahsa Type1 and Al-Ahsa Type2), five from Egypt (Egyptian Yasmin, Giza182, Giza179, Giza177, and SKC23808), two from Japan (Shin2 and Reiho) one from Korea (Milling95).

#### 2.1.1. Laboratory test

10 traits were measured for ten genotypes during a two-year period: grain length (mm), grain width (mm), grain shape (mm), hulling %, milling percentage, head rice (mm), elongation percentage, gelatinization temperature, amylose content, and protein percentage.

**Phenotyping for grain quality traits:** Mature seeds from each genotype were harvested individually, and rice grains had a moisture content of 14%.

**Grain length (GL) and grain width (GW):** Grain length (grain size) and grain width of 10 random samples of whole rice grains from each of the ten genotypes were measured manually, and the average length and width (in mm) were utilized in this investigation.

**The grain length and width (GL: WR)** is the ratio of the length of the grain to the width of the grain. The grain length width ratio (grain shape) was calculated using the measurements listed above.  $GLWR$  (grain length width ratio) =  $GL$  (grain length)/ $GW$  (grain width).

**Gelatinization temperature (GT)** was determined by applying normal alkali digestion and spreading scores (Little et al., 1958).

Ten healthy grains from each of the ten rice genotypes studied were placed in a plastic Petri plate containing 10 ml of 1.7% KOH. The grains are deposited and arranged independently of one another. Following that, the petri dishes were covered and incubated at 300 °C for 23 h. The visual appearance and disintegration of the endosperm were used to collect data.

**Rice Milling Methods:** Collecting 200 g paddy from each genotype, the paddy was hulled in a tiny "Satake Rice Machine" to produce brown rice. To obtain consistent polished grains, the brown rice was put through the "Satake Rice whitening and caking machine." To separate the whole kernels from the fractured ones, the polished samples were sieved. The samples of complete form grains were used to continue the study. Rough rice, brown rice, and cooked rice whole grain length and width were measured using a digital vernier model number 270A, and 10 entire kernels from each genotype were utilized in each case. The average length of polished grain was used to determine its size. Long grain (Ahuja et al., 1995) classified it into four categories: extra-long (>7.50 mm), long (6.61 to 7.50 mm), medium (5.51 to 6.60 mm), short (5.50 mm to less), and round. Shape was determined by the length and width ratio, which was slender (over 3.0), medium (2.1 to 3.0), bold (1.1 to 2.0), and round (1.0 or less).

#### 2.1.2. Protein percentage estimation

The total nitrogen content in milled rice was utilized to estimate protein % using the classical Kjeldahl method, and protein content was estimated by multiplying the total nitrogen data by the 5.95 factor provided (Johari et al., 2000).

#### 2.1.3. Estimation of nutrients contents

Milled grain samples for ten rice genotypes were dried at 60 °C for 48 hrs. The samples were then reduced to a fine powder in a stainless-steel grinder and stored in plastic bags until they were analyzed. One gram of plant material was dry-washed for 5 h in a muffle furnace at 450 °C before being extracted with 20% hydrochloric acid (Jones et al., 1991).

The P concentration was determined using a colorimetric process called the Ascorbic Acid Method (Murphy and Riley, 1962) and a +80 UV visible spectrophotometer, whereas the Ca, Fe, Na, K, and heavy metals in the samples were evaluated using flame atomic absorption spectrometry FAAS (GBC Avanta E, Victoria, Australia; Ser. No. A5616).

All of the equipment used was calibrated, and the uncertainties were computed. Internal and external quality assurance systems were implemented in Kafr Elsheikh University's Central Laboratory of Environmental Studies in accordance with ISO/IEC 17025 (2017). For quality control, all measurements, blanks, triple measurements of elements in extracts, and examination of certified reference materials for each metal (Merck) were routinely included.

**Table 1**  
Ten genotype, parentage, origin and type under study.

No.	Genotypes	Parentage	Origin	Grain type	Type
1	Al-Ahsa Type1	Exotic	KSU	Short	Japonica
2	Al-Ahsa Type2	Exotic	KSU	Short	Japonica
3	Egyptian Yasmin	IR262-43-8-11/KDML105	Egypt	Long	Indica
4	Giza182	Giza181/IR39422-163-247-2-2-3	Egypt	Long	Indica
5	Giza179	Gz1368/IRAT112	Egypt	Short	Japonica
6	Giza177	Giza171/Yamji No.1//PiNo.4	Egypt	Short	Japonica
7	SKC23808	L204/Giza177	Egypt	Short	Japonica
8	Shin2	KAMANO/KAIRYOAIKOKU	Japan	Short	Japonica
9	Reiho	Exotic (Japan)	Japan	Short	Japonica
10	Milling95	Exotic	Korea	Short	Japonica

2.2. Statistical analysis

The analysis of variance (ANOVA) was used in the statistical analysis of experimental data, and statistical MSTATC was used (Snedecor, 1956). Duncan’s multiple range estimation was used to evaluate differences between individual averages (Duncan, 1955; Singh, 1985). All values are reported as means ± standard deviation (Khan et al., 2015).

3. Results

ANOVA (Table 2) was performed to test the difference amongst genotypes for all studied traits. The data revealed that mean squares attributable to genotypes were significant for all traits across the two growing seasons. The differences between genotypes were very significant for all attributes, demonstrating that there is a high level of genetic variability among genotypes for practically all traits.

Grain types included long, short grains, row rice, brown rice and milled rice traits for ten rice genotypes are showing in (Fig. 1). The genotypes including two Indica type; Giza 182 and Egyptian Yasmin, one Indica-Japonica type Giza179 and seventh Japonica type (Al-Ahsa Type1, Al-Ahsa Type2, Giza177, SKC23808, Shin2, Reiho and Milling95) are presented in (Table 3). The findings revealed a large range of variability for all attributes tested. This wide range reflected the variation and among variability tested the genotypes. However, the Indica type (Egyptian Yasmin and Giza 182) gave the highest value for grain length (7.10, 6.52 mm) and grain shape (2.87, 2.82 mm) under the two seasons, while the Shin2(1.70), Reiho (1.84), SKC23808-125-2-3-1(1.84) Milling95(1.88) and Giza 177(1.88) gave the lowest value for grain shape (Table 3). For milling percentage, Reiho and Giza177 gave the highest value under two years (73.35, 72.66%), while the genotypes Egyptian Yasmin and Milyang95 gave the lowest value (63.49, 64.71%). According for head rice percentage, the genotypes Reiho, Shin2 and Giza177 gave the high percentage 69.42, 68.60 and 67.74%, respectively. In elongation trait the genotypes Reiho and Giza 177 were the highest value, while Giza 182 and Egyptian Yasmin gave the lowest value (Table 3). Concerning for gelatinization temperature, most of the genotypes are close together except the two cultivars Al-Ahsa Type1 and Al-Ahsa Type2 that were less in this trait.

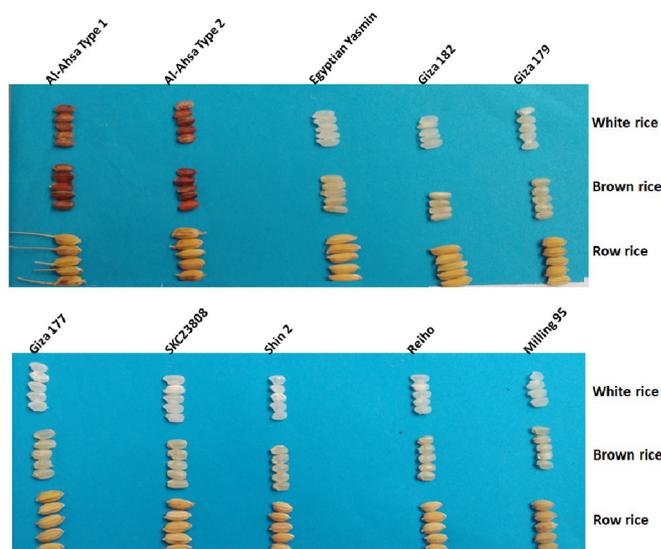


Fig. 1. Ten rice genotypes including two Indica (Egyptian Yasmin and Giza182), one Indica-Japonica (Giza179) and seven Japonica (Al-Ahsa Type1, Al-Ahsa Type2, Giza177, SKC23808, Shin2, Reiho and Milling95).

3.1. Estimation of protein percentage

The content of protein in milled rice of ten rice genotypes are shown in (Table 3). The results showed that the highest values of protein percentage were estimated in the genotypes, Al-Ahsa Type1 (10.80%) and Al-Ahsa Type2 (9.80%). These results revealed that the two genotypes had a high protein percentage and may be used to boost rice protein value through conventional breeding or current technological methods. The lowest value of protein was observed in the four genotypes; Shin2 (7.00%) and Giza 182 (7.02%). On the other hand, the genotypes Reiho, SKC23808-125-2-3-1, Egyptian Yasmin, Milling95 Giza179 and Giza177 gave 8.40, 8.00, 7.80, 7.80, 7.77 and 7.65%, respectively.

3.2. Estimates of genetic parameters

Estimates of genotype variance, phenotypic and genotypic coefficients of variability, heritability, and genetic advance percentage for grain quality variables are provided in (Table 4). The ten rice

Table 2  
Variance analysis for grain quality attributes in rice for the two years 2019–2020.

S.O.V	d.f	Grain length (mm)		Grain width (mm)		Grain shape (mm)	
		2019	2020	2019	2020	2019	2020
year							
Replication	2	0.002	0.002	0.0005	0.0005	0.0007	0.0004
Genotypes	9	1.35**	1.25**	0.232**	0.222**	0.719**	0.604**
Error	18	0.004	0.003	0.0004	0.0003	0.001	0.001
S.O.V	d.f	Hulling%		Milling%		Head rice(mm)	
year		2019	2020	2019	2020	2019	2020
Replication	2	0.0001	0.24	0.77	1.86	0.07	0.50
Genotypes	9	10.63**	12.14**	40.07**	35.04**	63.02**	70.89**
Error	18	0.32	0.73	3.65	3.86	0.90	1.30
S.O.V	d.f	Gelatinization temperature		Amylose content (%)		Protein %	
year		2019	2020	2019	2020	2019	2020
Replication	2	0.23	0.13	0.02	0.26	0.43	0.46
Genotypes	9	7.87**	4.16**	16.62**	18.58**	8.23**	6.67**
Error	18	0.23	0.04	0.24	0.24	0.27	0.22

**Table 3**  
Mean performance for grain quality traits in rice at the two years of 2019–2020.

Genotypes	Grain length (mm)		Grain width (mm)		Grain shape (mm)		Hulling %		Milling %	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Al-Ahsa Type1	5.35	5.18	2.48	2.61	2.16	1.98	81.67	79.94	69.14	67.41
Al-Ahsa Type2	5.53	5.35	2.50	2.63	2.21	2.03	79.33	77.60	67.56	65.83
Giza 177	5.17	4.99	2.75	2.88	1.88	1.73	82.33	80.60	72.66	70.93
Giza 178	5.39	5.21	2.52	2.65	2.14	1.96	81.29	79.56	70.99	69.26
Giza 182	6.52	6.34	2.19	2.32	2.97	2.82	80.73	79.00	70.22	68.49
E. Yasmin	7.10	6.92	2.27	2.40	3.12	2.87	80.22	79.39	64.70	63.87
Reiho	5.23	5.06	2.85	2.98	1.84	1.70	82.29	83.05	72.37	73.35
Shin 2	5.18	5.00	3.05	3.18	1.70	1.57	81.11	82.09	70.63	71.61
SKC23808-125-2-3-1	5.23	5.05	2.85	2.98	1.84	1.69	80.98	81.96	<b>63.73</b>	<b>64.71</b>
Milyang 95	5.12	4.94	2.73	2.86	1.88	1.73	75.88	76.86	<b>62.51</b>	<b>63.49</b>
<b>LSD 0.05 0.01</b>	<b>0.11</b>	<b>0.10</b>	<b>0.03</b>	<b>0.03</b>	<b>0.07</b>	<b>0.06</b>	<b>0.97</b>	<b>1.47</b>	<b>3.28</b>	<b>3.37</b>
	<b>0.13</b>	<b>0.11</b>	<b>0.04</b>	<b>0.03</b>	<b>0.06</b>	<b>0.06</b>	<b>1.17</b>	<b>1.78</b>	<b>3.97</b>	<b>4.09</b>
Genotypes	Head rice %		Elongation %		Gelatinization temperature		Amylose content (%)		Protein%	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Al-Ahsa Type1	62.77	61.04	62.58	62.85	3.00	4.50	21.53	20.88	10.80	10.60
Al-Ahsa Type2	57.74	56.01	66.34	63.61	2.33	3.83	20.34	19.37	9.75	9.80
Giza 177	67.74	66.01	69.55	66.82	7.00	7.00	17.55	16.05	7.65	7.70
Giza 178	65.68	63.95	64.00	61.27	6.67	7.00	18.34	18.84	7.77	7.65
Giza 182	62.72	60.99	44.41	46.39	6.33	7.00	18.45	19.95	7.02	7.10
E. Yasmin	56.12	55.29	45.12	49.45	5.33	6.67	18.71	19.21	7.75	7.80
Reiho	68.44	69.42	67.62	71.95	6.67	7.00	19.60	18.09	8.40	8.36
Shin 2	67.62	68.60	53.99	58.32	6.00	7.00	16.03	15.53	7.62	7.00
SKC23808-125-2-3-1	60.70	61.68	44.55	48.88	5.33	6.67	18.57	17.07	8.00	7.95
Milyang 95	57.62	58.60	56.37	60.70	6.67	7.00	20.04	18.54	7.80	7.77
<b>LSD 0.05 0.01</b>	<b>1.63</b>	<b>1.96</b>	<b>3.26</b>	<b>3.74</b>	<b>0.83</b>	<b>0.35</b>	<b>0.84</b>	<b>0.85</b>	<b>0.96</b>	<b>1.03</b>
	<b>1.97</b>	<b>2.37</b>	<b>3.95</b>	<b>4.53</b>	<b>0.99</b>	<b>0.41</b>	<b>1.02</b>	<b>1.02</b>	<b>1.23</b>	<b>1.45</b>

**Table 4**  
Estimates of component of variance; genotypic (GCV) and phenotypic (PCV) coefficients of variability, broad sense heritability (h<sup>2</sup>B), and genetic progress for grain quality traits for the two years 2019–2020 are presented.

Characters	Component of variance						h <sup>2</sup> B	
	$\sigma^2_g$		$\sigma^2_e$		$\sigma^2_{ph}$		2019	2020
	2019	2020	2019	2020	2019	2020		
<b>Grain length (mm)</b>	0.44	0.41	0.004	0.003	0.45	0.42	99.12	99.28
<b>Grain width (mm)</b>	0.07	0.07	0.0004	0.0003	0.08	0.07	99.48	99.60
<b>Grain shape (mm)</b>	0.23	0.20	0.001	0.001	0.24	0.20	99.58	99.50
<b>Hulling %</b>	3.43	3.803	0.32	0.73	3.76	4.53	91.48	83.90
<b>Milling %</b>	12.14	10.39	3.65	3.86	15.79	14.25	76.88	72.92
<b>Head rice (mm)</b>	20.70	23.1	0.9	1.3	21.61	24.50	95.83	94.69
<b>Elongation %</b>	366.00	380.17	3.6	4.75	369.60	384.92	99.03	98.77
<b>Gelatinization temperature</b>	2.54	1.37	0.23	0.04	2.78	1.41	91.72	97.17
<b>Amylose content (%)</b>	5.46	6.11	0.24	0.24	5.70	6.35	95.79	96.22
<b>Protein%</b>	2.88	2.67	0.27	0.22	3.10	2.89	94.80	96.54
Characters	Genetic advance				Expected Genetic advance		Genetic variability	
					PCV		GCV	
	2019	2020	2019	2020	2019	2020	2019	2020
<b>Grain length (mm)</b>	1.37	1.32	24.62	24.51	12.06	11.98	12.00	11.94
<b>Grain width (mm)</b>	0.57	0.56	21.79	20.32	10.63	9.91	10.60	9.89
<b>Grain shape (mm)</b>	1.01	0.92	46.35	46.06	22.59	22.47	22.54	22.42
<b>Hulling %</b>	3.65	3.68	4.53	4.60	2.41	2.66	2.30	2.44
<b>Milling %</b>	6.29	5.67	9.19	8.35	5.81	5.56	5.09	4.75
<b>Head rice (mm)</b>	9.18	9.65	14.63	15.53	7.41	7.96	7.26	7.75
<b>Elongation %</b>	39.22	39.92	86.86	85.99	42.58	42.26	42.37	42.00
<b>Gelatinization temperature</b>	3.15	2.38	56.93	37.36	30.13	18.66	28.86	28.40
<b>Amylose content (%)</b>	4.71	5.00	24.52	27.99	12.43	14.12	12.16	13.85
<b>Protein%</b>	6.44	5.88	55.70	44.38	32.20	29.65	30.70	31.20

genotypes showed a wide range of mean performance under different seasons. In separate years, mean squares for all attributes of all twelve genotypes were extremely significant. As a result, selecting for all attributes among these cultivars would be effective in improving traits of all genotypes. In two years, the phenotypic

coefficient of variability (PCV%) was larger than the genotypic coefficient of variability (GCV%) in all genotypes for all attributes, showing that environmental factors and cultural practices contributed the most to PCV percent. GCV percent values for grain length, grain breadth, grain shape, hulling percentage, milling per-

centage, head rice, elongation percentage, gelatinization temperature, and Amylose content percentage and protein percentage are presented in (Table 4) and the ranged were 2.30 for hulling percentage to 42.37 for elongation percentage. Concerning for genetic advance the was ranged from 0.57 for grain width to 39.92 for elongation percentage.

Heritability ( $h^2 B$ ) under selection were computed and the obtained results are illustrated in (Table 4). High heritability estimates were reported in all characters studied, indicating the presence of both additive and non-additive genetic variance in the inheritance of most features.

### 3.3. Estimation of correlation coefficients for grain quality traits

Correlation coefficients among the nine grain quality traits were presented in Table 5. Results indicated that grain length was negative correlation and significant with grain width (-0.539) this indicated that increasing the long of grains will decrease the width of grains, while positive and highly significant was observed with grain shape (0.674). This means increasing the grain length trait will increase the grain shape. Also, grain width was negative significant with grain shape and amylose content and the value (-0.886 to 0.449 respectively). While, positive and significant with hulling percentage (0.539) and head rice percentage (0.584). In terms of grain form, there was a negative significant link with hulling percentage and head rice percentage, but a positive significant correlation with amylose content percentage. Hulling % was significantly higher than milling percentage (0.600) and head rice percentage (0.689), this means an increase in the hulling percentage of heeling leads to an increase milling percentage and head rice percentage. Also, milling percentage was positive and highly significant with head rice percentage (0.733), while negative significant with amylose content percentage (-0.467). On the other hand, positive significant was found between head rice percentage and gelatinization temperature (0.471), negative significant with amylose content (-0.467), also gelatinization temperature was negative significant with amylose content percentage (-0.526).

### 3.4. Estimation of nutrients contents in milled rice grains

Analyses of the contents of nine nutrients in the milled grain for ten rice genotypes under study were presented in (Table 6). The findings demonstrated that there was a clear variation in the content of nine elements in milled rice between the rice genotypes tested. It survived the opportunity to choose the genotype rich in minerals from the genetic resource. The genotypes Al-Ahsa Type1 and Al-Ahsa Type2 calculated the heights of N, P, K, Mg, Na, Fe, and Zn. While the genotype Reiho provided the greatest values for Ca and Mg. The genotypes Ahsa Type1 and Al-Ahsa Type2 were generally rich in nutrient and could be used to improve the nutritional value of rice to be employed as donor parents, using either conventional or modern biotechnology methods). On the other hand, genotypes with high levels of macronutrients may be suit-

able for studying mineral element accumulation mechanisms. Furthermore, the improvement of rice varieties with abundant mineral elements in edible sections, such as milled rice, is widely acknowledged as an effective way for overcoming the hurdle of consumer mineral deficiency. In the current study, Ahsa Type 1 and Ahsa Type 2 genotypes with high portable mineral nutrients in milled rice were promising in this issue, which was superior to applying investigations of the physiological and genetic pathways responsible for mineral element absorption and accumulation.

### 3.5. Estimation of heavy metals

In Egypt, the usage of synthetic fertilizers and pesticides has remarkably progressed following the installation of high dame, resulting in increased soil and irrigation water contamination, especially by heavy metals. Heavy metals are harmful pollutants in the environment. Their accumulation in the atmosphere, soil, and water can cause serious problems for all organisms, and their bioaccumulation in the food chain can be exceedingly dangerous to human health. Six heavy metals were measured in milled rice using ten rice genotypes under study (Table 7). There were significant differences in heavy metal variation and distribution across the eleven rice genotypes assessed in grains. It implied that genotypic variability provided options to select materials with reduced heavy metal concentration. The results showed that five rice genotypes namely; Al-Ahsa Type1, Al-Ahsa Type2, Egyptian Yasmin, Giza 179 and Giza 182 were sensitive to detect possible Cu(mg/L) element and gave the value 3.380, 3.200, 1.100, 0.820 and 0.800 mg/L, respectively. While, the genotypes Giza177, SKC23808, Shin2 Reiho and Milling95 gave 0.300 and this ratio in Not detected (Nd). Concerning for Cobalt concentration (Table 7), the genotypes Al-Ahsa Type2 and Al-Ahsa Type1 gave the lowest value 1.330 and 1.400 mg/L, while the genotypes SKC23808, Milling95, Shin2, Giza177 and Giza182 gave the heist value (2.370, 2.120, 2.120, 2.0 and 1.90 mg/L respectively). As for Cd, Cr, Ni and Pb, the results showed that all the ten genotypes were not detected (Nd) for these elements (Table7). These results indicated that these genotypes more tolerant to absorption the four heavy elements (Cd, Cr, Ni and Pb) and could be used in breeding programs.

### 3.6. Correlation coefficient analysis nutritional value and protein

Pearson's correlation analysis for the nine nutritional elements and protein content traits for ten rice genotypes revealed different correlations degrees among all traits (Table 8). Pearson's correlation observed eight absolute positive and significant correlations, which were between; nitrogen content (N), P, K, Mg, Na, Fe, Zn, Cu and protein percentage (Table 8). Concertinaing for P element, eight positive correlation and significant with K, Mg, Na, Fe, Zn, Mn, Cu and protein percentage (0.952, 0.994, 0.727, 0.948, 0.783, 0.856, 0.752, and 0.742 respectively), while negative significant ratio -0.748 was Co (Table 8). Potassium (K) element was significant positive with Mg, Fe, Zn, Mn, Cu and protein percentage, while

**Table 5**  
Estimate of Correlation coefficient for grain quality traits.

Characters	G. L.	G. W	G. Sh.	Hul. %	Mil %	H. R. %	El. %	G. T.	A.C. (%)
G. L.	0.00								
G. W	-0.539*	0.00							
G. Sh.	0.674**	-0.886**	0.00						
Hul. %	-0.244	0.539*	-0.494*	0.00					
Mil %	-0.111	0.315	-0.360	0.600**	0.00				
H. R. %	-0.378	0.584*	-0.629**	0.689**	0.733**	0.00			
El. %	0.244	-0.045	0.135	-0.200	-0.156	-0.156	0.00		
G. T.	-0.360	0.224	-0.308	0.194	0.360	0.471*	-0.083	0.00	
A.C. (%)	0.289	-0.449*	0.449*	-0.244	-0.467*	-0.556*	0.244	-0.526*	0.00

**Table 6**  
Nine micronutrient elements concentrations for ten genotype under study.

Genotype	N %	P %	K %	Ca (mg/L)	Mg %	Na(mg/L)	Fe(mg/L)	Zn(mg/L)	Mn(mg/L)
Al-Ahsa Type1	1.815	0.200	0.096	56.62	0.296	73.250	20.120	125.600	9.520
Al-Ahsa Type2	1.639	0.200	0.096	55.90	0.295	73.000	19.800	122.700	9.300
Egyptian Yasmin	1.286	0.079	0.065	48.87	0.090	31.870	6.250	79.400	4.510
Giza182	1.306	0.088	0.068	57.62	0.109	36.500	7.370	95.310	5.080
Giza179	1.180	0.107	0.072	57.62	0.127	48.000	8.120	89.700	6.180
Giza177	1.303	0.048	0.048	62.00	0.071	52.120	6.750	92.200	4.010
SKC23808	1.412	0.077	0.046	64.75	0.098	51.250	8.120	99.100	4.820
Shin2	1.281	0.074	0.060	60.75	0.093	48.500	6.250	79.700	4.100
Reiho	1.345	0.183	0.087	69.50	0.273	66.250	15.000	95.000	14.750
Milling95	1.311	0.091	0.065	62.25	0.118	68.400	11.370	85.000	6.370
<b>Minimum</b>	<b>1.180</b>	<b>0.047</b>	<b>0.046</b>	<b>0.0049</b>	<b>0.071</b>	<b>31.870</b>	<b>6.250</b>	<b>79.400</b>	<b>4.010</b>
<b>Maximum</b>	<b>1.815</b>	<b>0.199</b>	<b>0.096</b>	<b>0.0070</b>	<b>0.295</b>	<b>73.250</b>	<b>20.120</b>	<b>125.600</b>	<b>14.750</b>
<b>Mean</b>	<b>1.387</b>	<b>0.114</b>	<b>0.072</b>	<b>5.958</b>	<b>0.156</b>	<b>54.914</b>	<b>10.91</b>	<b>96.37</b>	<b>6.86</b>
<b>Std. Deviation</b>	<b>0.192</b>	<b>5.682</b>	<b>1.791</b>	<b>5.619</b>	<b>9.184</b>	<b>14.734</b>	<b>5.47</b>	<b>16.03</b>	<b>3.40</b>

**Table 7**  
Five heavy metals elements Concentrations (mg/kg) for ten genotype.

Genotype	Cu(mg/L)	Co(mg/L)	Cd(mg/L)	Cr(mg/L)	Ni(mg/L)	Pb(mg/L)
Al-Ahsa Type1	3.380	1.400	0.030(Nd)	0.200(Nd)	0.100(Nd)	0.300(Nd)
Al-Ahsa Type2	3.200	1.330	0.030(Nd)	0.200(Nd)	0.100(Nd)	0.300(Nd)
Egyptian Yasmin	1.100	1.500	0.030(Nd)	0.200(Nd)	0.100(Nd)	0.300(Nd)
Giza182	0.800	1.900	0.030(Nd)	0.200(Nd)	0.100(Nd)	0.300(Nd)
Giza179	0.820	1.750	0.030(Nd)	0.200(Nd)	0.100(Nd)	0.300(Nd)
Giza177	0.300 (Nd)	2.000	0.030(Nd)	0.200(Nd)	0.100(Nd)	0.300(Nd)
SKC23808	0.300(Nd)	2.370	0.030(Nd)	0.200(Nd)	0.100(Nd)	0.300(Nd)
Shin2	0.300(Nd)	2.120	0.030(Nd)	0.200(Nd)	0.100(Nd)	0.300(Nd)
Reiho	0.300(Nd)	1.620	0.030(Nd)	0.200(Nd)	0.100(Nd)	0.300(Nd)
Milling95	0.300(Nd)	2.120	0.030(Nd)	0.200(Nd)	0.100(Nd)	0.300(Nd)

**Table 8**  
Estimate of correlation coefficient for nutritional value and protein percentage.

	N	P	K	Ca	Mg	Na	Fe	Zn	Mn	Co	Cu	Protein
N	1.00											
P	0.742*	1.00										
K	0.651*	0.952**	1.00									
Ca	-0.140	0.032	-0.0174	1.00								
Mg	0.766**	0.994**	0.929**	0.089	1.00							
Na	0.666*	0.727*	0.603	0.390	0.766**	1.00						
Fe	0.853**	0.948**	0.877**	0.051	0.961**	0.862**	1.00					
Zn	0.916**	0.783**	0.681*	-0.057	0.803**	0.662*	0.862**	1.00				
Mn	0.417	0.856**	0.772**	0.403	0.867**	0.665*	0.761*	0.478	1.00			
Co	-0.0517	-0.748*	-0.855**	0.507	-0.725*	-0.279	-0.654*	-0.534	-0.549	1.00		
Cu	0.873**	0.752*	0.779**	-0.501	0.740*	0.488	0.797**	0.859**	0.329	-0.772**	1.00	
Protein	0.958**	0.742*	0.651*	-0.141	0.766**	0.666*	0.853**	0.916**	0.417	-0.517	0.873**	1.00

highly significant negative with Cobalt (-0.855). In Mg element, highly significant positive was found with Na, Fe, Zn, Mn, Cu and protein percentage, while negative significant with Cobalt (Co). Sodium element was significant positive with Fe, Zn, Mn and protein percentage and the ratio was 0.862, 0.662, 0.665 and respectively. Also, Fe was positive correlation and significant with Zn, Mn, Cu and protein percentage, while negative significant correlations were found with Cobalt element. On the other hand, Zinc element was significant positive correlation with Cu and protein percentage, while Cobalt element was negative correlation (-0.772) with Copper and protein was positive significant with Copper (Table 8). Several studies have been conducted in recent years to suggest the correlations and inheritance of the major mineral element contents, which provided the foundation for a plant breeding program. Jiang et al. 2017 discovered substantial correlations between the contents of several mineral elements in milled rice, as well as tight relationships between the contents of some mineral elements and three cooking quality attributes, 17 amino acid contents, or protein content.

#### 4. Discussion

Possessing genetic resources rich in elements is considered a good source for improving rice productivity and also a natural source for safe and appropriate nutrition, especially for poor populations and developing countries (Xu et al., 2015b). There also many challenges to increasing the rice area, such as climate change, high temperature and shortage of water, are steadily increasing, and this is having a detrimental effect on the productivity of crops (Al-Zahrani et al., 2018).

However, genetic resources with beneficial qualities are an effective tool for improvement and high productivity of crops such as rice (Garris et al., 2005; Anis et al., 2016). In this study selected ten genotypes of rice from four different locations, Saudi Arabia, Egypt, Japan and Korea, to determine which cultivars are good quality and rich in the nutrients. The results showed that all selected rice genotypes were expected to show wide genetic variations that could be used in the breeding programme as proposed by (Olufowote et al., 1997). The ordinary analysis of variance for all

traits were highly significant for all traits indicating the presence of wide genetic variability among genotypes for almost all traits. In this study, correlation coefficients among grain quality traits were studied and the results showed that eight absolute positive correlation grain length with grain shape; grain width with hulling % and head rice %; grain shape with amylose content (%); hulling % with milling % and head rice%; milling % with head rice %; head rice % with gelatinization temperature. On the other hand, there were seven absolute negative correlations between grain length with grain width; grain width with grain shape and grain shape (%); grain shape with hulling % and head rice %; amylose content (%) with milling %, head rice % and gelatinization temperature. Our results are in agreement with those of previous studies (Sharifi and Naghi, 2011; Futakuchi et al., 2013; Adjah et al., 2020; Xu et al., 2015a). The process of producing varieties with high protein and nutrients using traditional or modern breeding methods is one of the main pillars in the development of healthy food suitable for all ages (Watanabe et al., 2006; Graham et al., 2001; Gregorio et al., 2000). The genetic variability of nutritional concentration in rice grain was investigated. They discovered variances in nutrient concentrations, showing that the rice genome has some genetic capacity and significant genetic diversity to raise the concentrations of certain micronutrients in rice grains. Previous research, however, discovered substantial connections between the contents of several mineral elements in milled rice, as well as a close relationship between the contents of some mineral elements and three cooking quality attributes, 17 amino acid concentrations, or protein content investigated the genotypic variation and connections between quality attributes and trace elements in conventional and enhanced rice genotypes and discovered visible changes in the mineral contents of the rice genotypes analyzed (Jiang et al., 2007; Al-Zahrani et al., 2018; Maganti et al., 2020; Anandan et al., 2011). Traditional genotypes have much greater Fe and Zn concentrations than improved cultivars (Welch and Graham, 2004). In the recent study, eight absolute positive and significant correlations, which were between; nitrogen content (N), P, K, Mg, Na, Fe, Zn, Cu, and protein elements percentage and the genotypes Al-Ahsa Type1 and Al-Ahsa Type2 were rich in protein % and micronutrients and could be used to improve the nutritional value of rice, using either conventional or modern biotechnology methods. Our findings are consistent with those of, who said that some rice cultivars have high grain quality features, particularly grain protein content (Jiang et al., 2007; Maganti et al., 2020; Al-Zahrani et al., 2018; Xu et al., 2015b; Lang et al., 2013). These could be applied in rice breeding programmes for the purpose of further improvement.

### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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