Grain Quality and Nutritional Value of Some Egyptian and Exotic Rice (*Oryza sativa* L.) Varieties

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ABSTRACT

This investigation was conducted at Grain Quality Laboratory, Rice Research and Training Center and Department of Home Economics, Faculty of Specific Education, Kafrelsheikh University, Egypt during 2014 and 2015 seasons. Four different rice (*Oryza sativa* L.) genotypes *i.e.*; Jiegnou 9601, Egyptian Yasmine, CIASEM and JH15-1-1-1 were selected to study the grain quality, grain composition and mineral composition due to their superiority in these traits. Jiegnou 9601 variety recorded the best hulling and milling percentage, while Egyptian Yasmine was the lowest in amylose content. For nutritional value, Jiegnou 9601 also showed the highest value for protein content followed by CIASEM Cv., while Egyptian Yasmine recorded the lowest value of fat content. All studied rice genotypes showed high levels of minerals content especially JH15-1-1-1 Cv., which recorded the highest values of minerals content. The studied varieties could be recommended as a good source of protein and minerals especially Jiegnou 9601, which also had the lowest value of carbohydrate content. Grain length was highly negative correlated with grain width, hulling, milling, protein, ash, fiber and Na percentages. While, it was highly positive correlated with carbohydrate, K and Ca percentages. Grain width was highly positive correlated with hulling, milling, amylose, protein, fiber, Na and Zn percentages. This reflects the importance of bold grain shape in obtaining high milling %. The obtained data were utilized in studying the clustering relationships among studied rice varieties.

Key words: ***Rice, grain quality, nutritional value, mineral content, Clustering analysis.***

INTRODUCTION

Food security, which is the condition of having enough food to provide adequate nutrition for a healthy life, is a critical issue in the developing world. About three billion people, nearly half the world's population, depend on rice for survival (Cantral and Reeves, 2002, Basu *et al*., 2012 and Samarendu, 2013) and has now been considered by FAO a strategic crop for food security of the world population due to its ample adaptation to climates and soils (FAO, 2006). In Asia, as a whole, much of the population consumes rice in every meal. In many countries, rice accounts for more than 70% of human caloric intake. According to various estimates, from 25 to 50% more rice must produce by 2025 (Khush and Virk, 2000 and Bhuiyan *et al*., 2002), to satisfy the growing demand without adversely affecting the resource base. This increased demand will have to be met from less land, using less water, less labour and fewer chemicals. Rice is a good source of protein, phosphorus and minerals (Ravindra, 2013). It also contains some amounts of calcium, magnesium, potassium, sodium and zinc (Oko and Ugwu, 2011). Most of the nutrients and minerals in rice are concentrated in the outer brown layers known as husk and germs (Ziarati and Azizi, 2013). Hence brown rice, in which only husk has been removed, is the most nutritious type of rice. Unfortunately, many consumers prefer pseudo cosmetic preferences and demand white rice or polished rice, in which the germ and bran has been removed. Rice contains vitamin B in small quantities (FAO, 2006 and Abbas *et al*., 2011). The nutritional value of rice makes it good for indigestion, diarrhea, dysentery, nausea, skin disorders and high blood pressure (Umadevi *et al*., 2012). Brown rice has a greater food value than white (Vora *et al*., 2015), since the outer brown coatings contain the proteins and minerals, the white endosperm is chiefly carbohydrate (GRiSP, 2013). As a food, rice is low in fat and protein (compared with other cereal grains). The modern rice varieties have grains richer in protein than the old ones. The most common rice consumed by humans is white to dull white polished grains, followed by brown rice; however, rice genotypes with either red, purple or black bran layer have been cultivated for a long time in Asia (Ahuja *et al*., 2007). So, this investigation aims at studying grain quality traits, nutritional value, mineral composition and biochemical active ingredients of rice varieties under study.

MATERIALS AND METHODS

The present investigation was conducted at Grain Quality Laboratory of Rice Research and Training Center (RRTC) and Lab of Department of

Home Economics, Faculty of Specific Education, Kafrelsheikh University, Egypt during 2014 and 2015 seasons.

Plant materials

In this investigation one local and three exotic rice genotypes *viz*., Jiegnou 9601 which called also Black Rice due to the dark purple color of its grains, Egyptian Yasmine which has a scented smell and taste rice variety, CIASEM which is sticky rice and JH15-1-1-1 which has brown polished grains. The studied genotypes have variable characteristics according to the evaluation of these varieties at Experimental Farm of RRTC during 2014 and 2015 seasons at randomized complete block design with three replicates. The studied rice genotypes, their pedigree, grain type and origin are presented in Table (1), the main characteristics of these genotypes are presented in Table (2) and the images for polished grains of these genotypes are shown in Figure (1).

Determination of grain quality traits

Grain length (mm): Grain length is a measure of milled rice grain in its greatest dimension in mm; it was measured from the base to the top of the grain. Grain length was classified using the Standard Evaluation System, SES for rice (IRRI 2014) as extra-long (over 7.50 mm), long (6.6 – 7.5 mm), medium (5.51 – 6.60 mm) and short (5.50 mm or less).

Grain width (mm): The actual measurement of width in millimeters as the distance across the fertile lemma and palea at the widest point (IRRI, 2014).

Hulling percentage: About 150g cleaned rough rice samples at moisture content 12-14 % were estimated using experimental huller machine (Satake).

Hulling % = (Brown rice weight / Rough rice weight) x 100

Milling percentage: The objective of rice milling is the removal of bran and germ with the minimum breakage of the endosperm from de-hulled grains. Milling percentage was determined according to Ghosh et al., (2004) as follows:

Milling % = (Milled rice weight / Rough rice weight) x 100

Amylose content %: It was estimated according to Juliano (1971) and Jain et. al., (2012) as follows: 10 whole milled rice grains were grind to fine powder in Wig-L-Bug amalgamator for 40 seconds. One hundred mg of the sample weighted into a 100 ml volumetric flask and 1 ml of 95% ethanol and 9 ml of 1N sodium hydroxide were added. Samples are heated for 10 minutes in a boiling water bath to gelatinize the starch. Cool for 1 hour, bring the sample up to volume with distilled water and mixed well. With a pipette 5 ml of the starch solution transferred to 100 ml volumetric flask. One ml of 1N acetic acid and 2 ml of iodine solution were added, and make up to volume with distilled water, shake and let stand for 20 minutes. The absorbency of the solution was recorded at 620 nm, with a spectrophotometer Baush and lamb spectronic 20 apparatus. Amylose content was determined by using a conversion factor, and genotypes were classified, on basis of their amylose content, into: very low (7-11%); low (11-20%); intermediate (20-25%) and high amylose content (>25%).

Determination of proximate composition of rice grains

The proximate composition of rice grains for studied genotypes was performed and calculated according to the standard methods of analysis (AOAC, 1990).

Crude Protein%: Nitrogen content of rice was determined by using Micro-kjeldahl method. Crude protein content of the tested rice samples was calculated by multiplying the total nitrogen by the factor of 5.95.

Table 1: The studied rice genotypes, their pedigree, grain type and origin.

Genotypes	Pedigree	Grain type	Origin
Jiegnou 9601	Chinese line (Black Rice)	Short	China
Egyptian Yasmine	IR262-43-8-11/KDML 105	Long	Egypt
CIASEM	IR65/B8203B-MR-1-17-1	Long	Indonesia
JH15-1-1-1	Chinese line	Long	China

Table 2: Main characteristics of studied rice genotypes.

Traits / Genotypes	Days to heading		Plant height (cm)		panicles plant^{-1}		Spikelet fertility %		1000-grain weight (g)		Grain yield (t ha^{-1})	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
Jiengou 9601	85.4	86.7	99.8	102.3	15.6	17.0	93.1	91.8	26.5	26.8	6.65	6.30
Egyptian Yasmine	111.6	113.3	108.5	110.4	24.2	22.4	90.5	89.6	26.9	26.7	9.80	9.42
CIASEM	110.4	109.2	105.7	107.9	20.5	21.7	92.7	91.3	27.3	27.0	8.64	8.71
JH15-1-1-1	104.0	105.8	112.2	114.0	22.3	19.6	96.4	95.8	36.9	36.1	9.43	9.10
CV %	11.76	11.34	4.90	4.52	17.86	12.03	2.61	2.84	17.04	15.90	16.29	16.92

Figure 1: Photos for milled rice grains of the studied genotypes

Moisture%: Moisture of the samples was calculated according to standard method.

Fat %: Crude fat was estimated by standard method (AOAC, 1990) using Soxhlet extraction apparatus.

Ash %: Ash content of rice grains was determined in an electric muffle at 525-550 º C until reaching the complete ashing.

Carbohydrate %: Total carbohydrate content of rice grains was determined by difference between 100 and the other components of rice grains.

Crude Fiber %: Fibers content in white rice grains was estimated as described by (AOAC, 1990).

Determination of the mineral content

The mineral content of rice samples was determined using the methods of the AOAC (1990). Six minerals *i.e*., Magnesium, Potassium, Sodium, Calcium, Iron and Zinc were determined by Atomic Absorption Spectrometry. Briefly, about 1.0g of rice sample was first digested with 20 ml of acid mixture (65 ml Conc. HNO_3, 80 ml Perchloric acid, 20 ml H_2SO_4) by weighing the sample into a digestion flask followed by addition of the 20 ml acid mixture. The digestion flask containing the sample and the digestion acid mixture was heated until a clear digest was obtained. The digest was later diluted with distilled water to 500 ml. After obtaining the digest, aliquots of the clear digest were used for atomic absorption spectrophotometry using filters that matched the different elements. The concentration of Calcium, Magnesium, Sodium, Iron, Zinc and Potassium were determined with their calibration curves prepared with their standard solutions.

Biochemical active ingredients

Biochemical active ingredients were analyzed according to AOAC (1990).

Cluster analysis

Genetic relationships among studied genotypes were measured by similarity of studied traits as reported by Zhang *et al*., (1995) and Dinghuhn and Asch (1999). Analysis for clustering was conducted using the Numerical Taxonomy and Multivariate Analysis system, Ver. 2.1 (NTSYS-PC; Rolhf, 2000). Cluster analysis was conducted using distance matrix with un-weighed pair-group method based on arithmetic mean, UPGMA (Sneath and Sokal, 1973).

Statistical Analyses

Statistical analysis was performed using analysis of variance technique by means of "MSTAT" computer software package.

RESULTS AND DISCUSSION

Grain quality traits

The black rice variety, Jiegonou 9601, classified as a short length grain (Table 3). The other three varieties classified as a long grain and JH15-1-1-1 scored the longest grain (7.3 mm). Egyptian Yasmine recorded the lowest grain width (2.1 mm), while Jiegonou 9601 recorded the highest value (2.9 mm) of grain width.

Table 3: Mean performance of grain quality traits for the studied rice genotypes.

Traits / Genotypes	Grain length (mm)	Grain width (mm)	Hulling %	Milling %	Amylose %
Jiegnou 9601	5.4b	2.9a	85.54a	71.41a	23.76b
Egyptian Yasmine	7.0a	2.1c	83.24b	69.20bc	15.08d
CIASEM	6.9a	2.2c	84.65ab	70.10b	17.52c
JH15-1-1-1	7.3a	2.5b	83.74b	68.79c	29.13a
Mean	6.7	2.4	84.29	69.87	21.37
F test	**	**	*	*	**

According to these data the variety Jiegonou 9601 could be classified as a short bold grain variety, which make it also recorded the highest values for hulling and milling percentages (Table 3). The lowest amylose content % was recorded for the variety Egyptian Yasmine (15.08%), while the Chines variety JH15-1-1-1 recorded the highest value (29.37%). The low (11 - 20%) amylose content is preferred for Egyptian consumer.

Proximate composition of studied rice grains

The estimates of moisture % for studied rice genotypes ranged from 11.6 to 12.2% with a mean value of 11.77 % (Table 4). The variety Egyptian Yasmine had the highest value of moisture content. Significant variation of protein content was observed among the studied rice varieties and ranged between 3.07 and 5.86 % with a mean value of 4.38 %. The rice variety Jiegonou 9601 had the highest value of protein content followed by CIASEM and JH15-1-1-1, while Egyptian Yasmine had the least value for this trait. The fat content ranged between 1.06 and 1.69% with the mean value of 1.29%. The exotic rice variety JH15-1-1-1 recorded the highest value of fat content, while Egyptian Yasmine recorded the lowest fat content. The values for percentage ash content obtained in this study ranged between 1.57 and 3.36% with the mean value of 2.43 %. The rice variety JH15-1-1-1 recorded the highest value for ash content, while CIASEM recorded the lowest value for this trait. The carbohydrates content of the studied varieties ranged from 71.58 to 77.88 % with mean value of 74.7 %. The results indicated that all rice varieties have appreciably high carbohydrates content and the rice variety JH15-1-1-1 scored the highest value (Table 4). This observed high carbohydrates content among the varieties is not surprising as rice is a well-known carbohydrates food source. However, the low percentage of carbohydrates may be attributed to high moisture content and other environmental factors (USA Rice Federation, 2002). The variation in values of carbohydrates among rice varieties was found to be statistically significant with real differences occurring among varieties in their carbohydrates content. The significant variations of fiber content % among studied rice varieties reflect real differences in their levels of variation for crude fiber (Table 4). The values of fiber content ranged from 3.27 % for Egyptian Yasmine variety to 6.73 % for Jiegonou 9601 variety.

Mineral composition

The rice variety JH15-1-1-1 recorded the highest values for most of the mineral composition analyzed (Table 5), such as magnesium (0.366%), potassium(2.91%), calcium (0.259%), iron (0.061%) and zinc (0.031%), followed by Jiegonou 9601 with higher value for sodium content with value of (2.18 %).

Table 4: The proximate composition of rice genotypes grains under study.

Traits / Genotypes	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Carbohydrate (%)	Crude fibers (%)
Jiegonou 9601	11.6b	5.86a	1.22b	3.01b	71.58b	6.73a
Egyptian Yasmine	12.2a	3.07d	1.06b	1.77c	74.54ab	3.27c
CIASEM	11.7b	4.60b	1.19b	3.36a	74.80ab	4.35b
JH15-1-1-1	11.6b	3.99c	1.69a	1.57d	77.88a	3.27c
Mean	11.77	4.38	1.29	2.43	74.70	4.40
F test	**	**	**	**	*	**

Table 5: The mineral composition of rice genotypes grains under study.

Genotype	Mg%	K%	Na%	Ca%	Fe%	Zn%
Jiegonou 9601	0.135b	1.90c	2.18a	0.076b	0.050ab	0.031a
Egyptian Yasmine	0.112b	2.32b	0.91d	0.097b	0.044b	0.018b
CIASEM	0.153b	1.90c	1.10c	0.106b	0.040b	0.022b
JH15-1-1-1	0.366a	2.91a	1.65b	0.259a	0.061a	0.031a
Mean	0.191	2.26	1.46	0.135	0.049	0.026
F test	**	**	**	**	**	**

Table 7: Bio-active ingredients for the grains of studied rice genotypes.

Jiegnou 6901		**Egyptian Yasmine**	
Compound Name	%	**Compound Name**	%
2-Heptenal	21.86	2-Heptenal	47.32
2,2-dimethyl-4-methylaminobutanone	1.69	2-Decenal	31.51
(R)-alpha-methylphenylaniline	2.14	Guanosine	10.92
Piprazine,2-methyl	1.42	2-Heptanamine,6-methyl	10.25
N,N'-Dimethylcyclobutane-1,1-bis(methylamine)	1.43		
2-Decenal	17.58		
Trans, cis-2,4-Decadienal	4.71		
Trans, trans-2,4-Decadienal	5.78		
Cytidine	11.88		
Oleic Acid	31.51		
CIASEM		**JH15-1-1-1**	
Compound Name	%	**Compound Name**	%
Alpha Curcumene	3.04	Fluoxetine	2.51
Para Cymene	2.53	Erythro-1,2-dimethyl-1-methylthio-2-aminoethane	2.16
4- Methoxyamphetamine	5.04	Northiaden	2.48
Alpha-Turmerone	12.70	Amphetamine	4.86
2,2 dimethylaminobutanone	4.27	n-Hexylmethylamine	10.59
Aminononadecane	3.75	Guanosine	7.39
Palmitic Acid	33.71	3,3',5,5'-Tetra-tert-butyldiphenoquinone	70.15
L-Histidine Hyroxamic Acid	34.96		

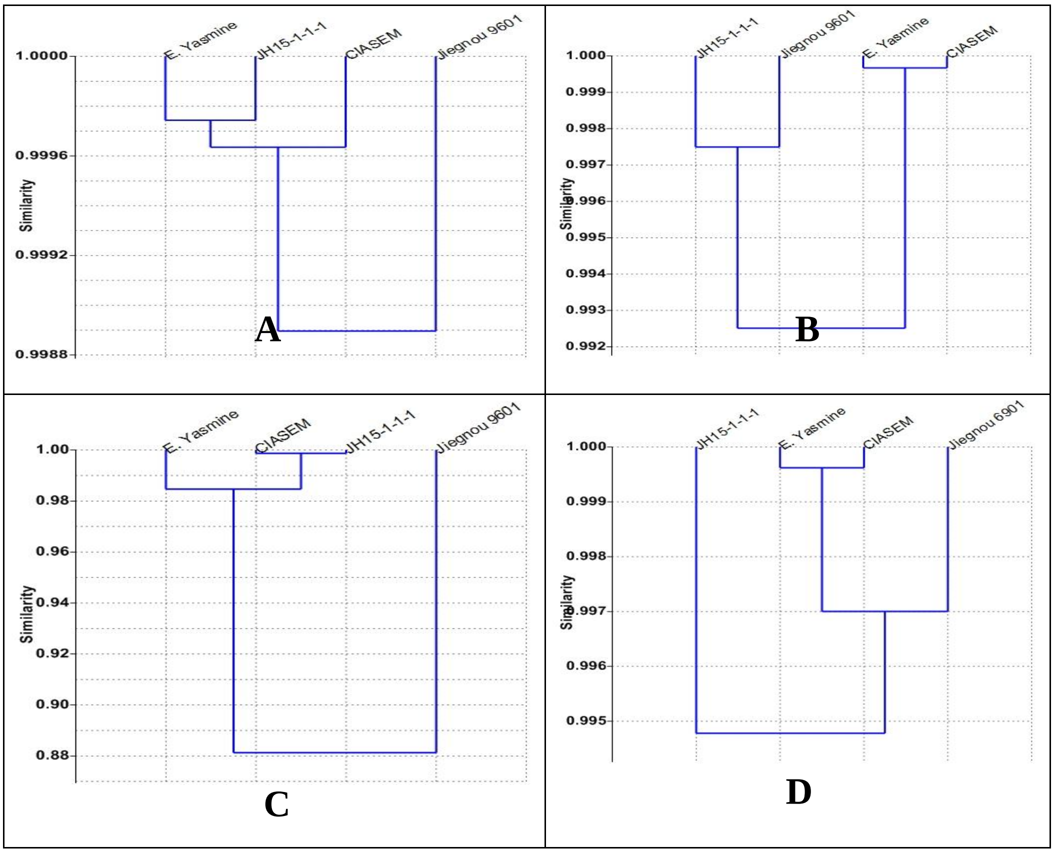

Figure 2: Cluster diagrams for the studied rice genotypes classified by; A) five grain quality, B) six proximate composition, C) six mineral composition and D) all studied traits.

On the other hand, the variety Egyptian Yasmine gave the lowest values for magnesium (0.112 %), sodium (0.91 %) and zinc (0.018 %), while Jiegonou 9601 was lower in potassium (1.9 %) and calcium (0.076 %) followed by CIASEM with lowest iron content (0.04%). In general, the levels of minerals composition are high for the studied varieties especially JH15-1-1-1 and Jiegonou 9601. This could be due to genetic background of these varieties and also to soil mineral composition (Rivero *et al*, 2007). The rate of fertilizer application and the native fertility of paddy fields have been shown to affect the mineral element levels of rice (Nwilene *et al*, 2007). Therefore, the increases in the values obtained for the mineral elements may be attributed to any/or all of these factors. However, the three rice varieties Egyptian Yasmine, Jiegonou 9601 and CIASEM were still within the acceptable standard in terms of mineral contents of rice (Table 5).

Phenotypic Correlation coefficients among studied traits

The phenotypic correlation coefficients among studied traits are presented in Table(6). Grain length was highly significant negative correlated with grain width, hulling, milling, protein, ash, fiber and Na percentages. While, it was highly positive correlated with carbohydrate, K and Ca percentages.

Grain width was highly significant positive correlated with hulling, milling, amylose, protein, fiber, Na and Zn percentages. That reflects the importance of bold grain shape in obtaining high milling %. Hulling and milling percentages are very highly positive correlated (0.934). Hulling % was also highly significant positive correlated with protein, fiber, ash and Na percentages. Amylose % was highly significant positive correlated with fat and all studied minerals percentages. Moisture % was negatively correlated with almost all studied traits. The percentage of protein was highly significant positive correlated with ash, fiber, Na and Zn percentages. Fat % was highly significant positive correlated with carbohydrate % and all minerals except Na. Carbohydrate % was highly significant positive correlated with the three minerals Mg, K and Ca percentages.

Biochemical analysis

The biochemical analysis for the grains of studied rice genotypes revealed some important bio-active ingredients which were varied in quality and quantity among studied grains (Table 7). Some of these compounds have anti-inflammatory, wound healing, antioxidant and free radical scavenging activity, anti-repellent, antitussive and anti-platelet activity (Maisuthisakul and Changchub, 2014; Setyaningsih *et al*., 2015 and Sikha *et al*., 2015).

Clustering analysis

The obtained data were utilized to construct clustering diagrams for studied genotypes (Figure 2). The grain quality traits clustered both genotypes E. Yasmine and JH15-1-1-1 in one cluster and CIASEM was the nearest to this cluster. The Jiegnou 9601 was in separate branch (Figure 2A). The data of grains proximate composition clustered the studied rice genotypes into two main clusters, E. Yasmine and CIASEM in one cluster and Jiegnou 9601 and JH15-1-1-1 in the other (Figure 2B). Both genotypes CIASEM and JH15-1-1-1 were very close to each other using the data of mineral composition and E. Yasmine was the nearest to them, Jiegnou 9601 illustrated in separate branch (Figure 2C).

Using all studied data, E. Yasmine and CIASEM were clustered in one cluster and Jiegnou 9601 was the nearest to them. JH15-1-1-1 was illustrated in separate branch. From the obtained results of these diagrams it could be concluded that the genetic diversity among studied varieties is high.

RECOMMENDATIONS

From the obtained data of this study, it might be recommended that both varieties E. Yasmine and CIASEM could be utilized in breeding programs for low amylose content and Jiegonou 9601 for high protein content. Both genotypes, Jiegonou 9601 and JH15-1-1-1 could be very helpful to breed new rice genotypes with high mineral content.

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الملخص العربى

جودة الحبوب والقيمة الغذائية لبعض أصناف الأرز المصرية والمستوردة

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[1]مركز البحوث والتدريب في الأرز، قسم بحوث الأرز، معهد بحوث المحاصيل الحقلية، مركز البحوث الزراعية، ٣٣٧١٧، سخا، كفرالشيخ، مصر.

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أجرى هذا البحث بمعمل صفات جودة الحبوب، مركز البحوث والتدريب في الأرز، سخا و معمل قسم الاقتصاد المنزلي، كلية التربية النوعية، جامعة كفرالشيخ، مصر خلال موسمي ٢٠١٤ و٢٠١٥. حيث تم اختيار أربعة تراكيب وراثية من الأرز وهي؛Egyptian Yasmine, Jiegnou 9601 CIASEM و JH15-1-1-1 لدراسة صفات جودة الحبوب، المكونات الغذائية للحبوب والمحتوي من المعادن لحبوب الأرز في الأصناف المدروسة، وذلك نظراً لتفوق هذه الأصناف في تلك الصفات. وقد سجل الصنف Jiegnou 9601 أفضل القيم للنسبة المئوية للتقشير والتبييض، في حين سجل الصنف Egyptian Yasmine أقل القيم لنسبة الأميلوز بالحبوب. فيما يخص القيمة الغذائية، سجل الصنف Jiegnou 9601 أيضاً أفضل القيم للمحتوي من البروتين تبعه الصنف CIASEM في حين سجل الصنف Egyptian Yasmine أقل القيم للمحتوى من الدهون. وقد أظهرت كل أصناف الأرز تحت الدراسة نسب مرتفعة للمحتوى من المعادن في الحبوب، خاصةً الصنف Jiegnou 9601 والذي سجل أعلى القيم للمحتوي من المعادن بين الأصناف المدروسة وكذلك أظهر أقل محتوى من الكربوهيدرات. وبالنسبة لمعامل الارتباط المظهري بين الصفات المدروسة، فقد أظهرت صفة طول الحبة ارتباطاً سالباً عال المعنوية مع كلا من صفات عرض الحبة، النسبة المئوية لكلا من التقشير والتبييض والبروتين، الرماد، الألياف والصوديوم. بينما كانت مرتبطة إيجابياً بصوره عالية المعنوية مع النسبة المئوية للكربوهيدرات، البوتاسيوم والكالسيوم. وأظهرت صفة عرض الحبة إرتباطاً إيجابياً عال المعنوية بصفات النسبة المئوية للتقشير، التبييض، الأميلوز، البروتين، الألياف، الصوديوم والزنك. ويعكس هذا أهمية الحبوب العريضة في الحصول على نسب عالية من تصافي التبييض. وقد تم الاستفادة من البيانات المتحصل عليها من هذه الدراسة في بناء أشجار النسب الوراثية ودراسة العلاقات بين الأصناف المدروسة.