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Elemental Content and Properties Change of Akre Rice After Harvesting Process in Kurdistan Region

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Abstract

Rice is considered one of the main nutritional foods in the world, generally in Asian countries especially in the Kurdistan region widely consumed as a stable food. This research provided essential engineering data on the physical properties of Akre- Duhok rice during the harvesting stages 3,5 and 6 months. Some physical properties of rice throughout the three stages of harvesting were observed and compared. The average length, width, thickness, elongation, arithmetic mean diameter, geometric mean diameter, equivalent diameter, surface area, volume, sphericity and aspect ratio were 5.466 ± 0.26 to 5.766 ± 0.87mm, 1.823 ± 0.13 to 1.993 ± 0.13mm, 2.876 ± 0.18 to 2.906 ± 0.14mm, 0.503 ± 0.09 to 0.526 ± 0.03 mm, 3.436 ± 0.06 to 3.530 ± 0.26 mm, 3.106 ± 0.22 to 3.296 ± 0.30 mm, 3.230 ± 0.61 to 3.533 ± 0.42 mm, 30.463 ± 4.29 to 32.19 ± 2.18 mm^2, 33.210 ± 6.60 to 35.336 ± 7.04 mm^3, 0.543 ± 0.06 to 0.576 ± 0.01%, and 0.313 ± 0.04 to 0.353 ± 0.02 respectively. On the other hand, the composition of 13 elements of Kurdish rice was determined by employing inductively coupled plasma mass spectrometry (ICP-MS). The obtained results indicated that there was a significant difference among the samples, the highest amount of minerals was stated in Al was 10.52 ± 2.53 mg/kg in sample A, Ca and K were 380.95 ± 2.71and 868.41 ± 2.18 mg/kg in sample B respectively and Mg was 303.77 ± 2.49 mg/kg in sample C, while rice grains had zero mg/kg content of each Pb, Cd and Na. Moreover, the minimum quantity of minerals was Cu and Se that ranged between 0.93 ± 0.03 to 3.52 ± 0.04 and 0.05 ± 0.03 to 0.26 ± 0.03 mg/kg, respectively.

Keywords: Rice (Oryza sativa L.), Physical properties, Mineral composition, ICP, Mass spectroscopy.
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Introduction

Food is essential in our daily life and survival. One of the most important sources of daily food is rice (Oryza sativa L.), which is a monocot plant of the Oryza genus belonging to the Poaceae family. Severely, this species has been cultivated in Asia for human consumption [1]. Nowadays, two-thirds of the world's population depends on this unique grain that provides about 20% of the world's dietary energy.

Asia is the region that produces about 90% of the world's crops. More than 75% of worldwide production is consumed by people in Asia countries [2] involving Kurdistan people. In the Kurdistan region especially in the Akre district, there are more than eight varieties of Kurdi rice available and all of them are cultivated in Iraqi- Kurdistan region. According to [3] the production and cultivated area of rice was 14.49 tons and 2000 ha, respectively.

Generally, the knowledge and determining the quality of the cereal grain depending on the physical and mechanical properties also is of vital importance for the correct storage and manufacturing design, these properties include (length, width, thickness, elongation, size or arithmetic mean diameter, geometric mean diameter, equivalent diameter, surface area, volume, and sphericity) [4] and [5].

According to [6], rice is introduced as a very important source of energy compared to other grains. However, [7] reported that rise has a great nutritional value due to its high nutritional content such as protein, carbohydrates, lipids, vitamins, dietary fiber, and minerals.

Rice is the main source of dietary minerals which include Calcium (Ca), Potassium (K), Magnesium (Mg), Iron (Fe), Sodium (Na), Zinc (Zn), Copper (Cu), Manganese (Mn), Selenium (Se) and Cadmium (Cd), Lead (Pb), Chromium (Cr) and Aluminum (Al) [8]. The difference in the mineral composition of rice depends on the quality or chemical nature of the soil, fertilizers, herbicides that are used during rice cultivation, and other factors [9]. The dietary minerals are essential for human to maintain health and their lack may cause different diseases in the human body [10].

The aim of this study was to determine of some physical properties of Kurdi rice that change after harvesting stage in Akre city, Kurdistan region. However, the study aimed to determine and compare the minerals composition of rice by using inductively coupled plasma mass spectrometry (ICP-MS).

Materials and methods

1. Reagents and Glassware

All chemicals used in this present experiment were provided by Salahaddin University in Erbil-Kurdistan region. High-purity deionized water from a water purification system (Thermo Fisher Scientific, India) was employed during the study. Ultra-pure HNO3 (69%, Biochem., France) was used for microwave digestion. The calibration standard was prepared by diluting 10 mg/L for all mentioned elements. The rice sample was spiked with multi-element. All glassware was kept overnight in 10% (v/v HNO_3) and washed with deionized water before use for the experiment. This present work was done at the Food Technology Department, Salahaddin University, and at the Physio-chemical Laboratory in the General Direction of Industrial Development – Directorate of Quality Control in Kurdistan Region-Erbil.

2. Sample Collection and Preparation

Rice samples were collected from the villages around the Akre district. The rice was harvested and rice husks were removed throughout three stages of harvesting which are sample A (3 month), sample B (5 month) and sample C (6 month). After that the samples were crushed and sieved by the sieve (250μm), about 0.5 g of homogenized rice samples were weighed and transferred to 250 mL dry, clean polytetrafluoroethylene vessel, and 10 mL of ultra-pure 69% nitric acid was added. The digestion was achieved by placing the powdered rice in the microwave oven at 800 W for about 30 min up to 180 ^{O}C, afterward the samples were cooled for about 30 min and the samples were filtered by Whatman filter paper

NO. 5, then the filter paper was rinsed with deionized water [11]. The samples were analyzed by Inductively Coupled Plasma Mass Spectrometer (Agilent Technologies 7900, Japan).

3. Physical Properties Determination

The principal dimensions of the rice grains were measured by using digital vernier calipers that had the least count of 0.001 mm by taking three replications. The rice grains were randomly selected from each stage of harvesting for measuring their dimensions length (L), width (W) and thickness (T), elongation (E), arithmetic mean diameter (Da), geometric mean diameter (Dg), equivalent diameter (De), surface area (S), volume (V), sphericity (Sp or Ø) and aspect ratio (Ra) [12].

3.1 Elongations (E) ratio

Elongation is one of the most important characteristics of rice and a very important trait that determines the quality of rice grains. The elongation can be measured by dividing the thickness (T) of the rice grains to the length (L) of the same rice grains [13]. The elongation ratio was calculated with the following equation:

$$E = \frac{T}{L}$$

3.2 Arithmetic and Geometric Mean Diameter (Da)

Three rice grains were selected randomly from 100 g of the rice that was used for the experiment. The arithmetic and geometric mean diameters of rice for each of the harvesting stage were calculated by employing the equation that was suggested by [14].

$$AMD \text{ or } Da = \frac{T+L+w}{3}$$

$$GMD \text{ or } Dg = (L*W*T)^{1/3}$$

3.3 Equivalent Diameter (De)

The equivalent diameter considering a prolate spheroid shape for rice grains during the harvesting stage was determined by using the equation that was recommended by [15], and [16]. The equivalent diameter was calculated as follows:

$$De = \left(\frac{L\,(W+T)^2}{4}\right)^{1/3}$$

3.4 Surface Area (S)

The surface area is considered an important property of the rice grains that helps the designer in assessing the hopper, processing chamber, and chute. [17] who has expressed the surface area of the rice grain samples by using the following equation:

$$S = \pi\,(Dg)^2$$

3.5 Sphericity (Sp or Ø)

Sphericity is defined as the ratio of the diameter of a sphere of the same volume as that of the particle and the diameter of the smallest inscribing sphere. The sphericity of rice grains was calculated using the equation reported by [18].

$$\text{Sphericity} = \frac{(LWT)^{1/3}}{L}$$

3.6 Volume (V)

The rice grain volume (V) of each sample was calculated by using the equation that was reported by [17]. The volume was calculated as the following formula:

$$V = 0.25\left[\frac{\pi}{6}\,L\,(W+T)^2\right]$$

3.7 Aspect ratio

The aspect ratio (Ra) is used in classifying the rice grain shapes and it was calculated by the formula which was suggested by [19]

$$R\alpha = \frac{w}{L}$$

3.8 Statistical analysis

The statistics software Statistical Package for Social Sciences (SPSS) version 22 for Windows was used to analyze the physical properties and the results were conveyed as average ± standard deviation (SD). The comparison of the 13 elements were analyzed using one-way analysis of variance (ANOVA) analysis. A significant difference was determined by $p< 0.05$ using triplicate samples from each stage of harvesting rice sample were analyzed.

Results and discussion

1. Physical Properties Determination

A summary of the results for all the parameters of the rice grains that were determined is displayed in Table 1. The length, width and thickness of the rice grains throughout the harvesting stage were shown in figure 1 and stated between 5.466 – 5.766,

1.823 – 1.993 and 2.876 – 2.906 mm respectively. [20] were reported approximately the similar results of the length and width while the lower range of the thickness. The elongation of the rice grains in 3 and 5 months stated similar results whereas six months recorded the highest ratio of elongation.

The arithmetic, geometric and equivalent mean diameters of rice after the harvesting stage varied from 3.436 – 3.530, 3.106 – 3.296 and 3.230 – 3.533mm, respectively. There is no significant difference between the rice grains after the harvesting stage. The obtained results of arithmetic diameter for rice grains are within the range of 3.46 to 3.98 mm which was presented by [19]. On the other hand, rice grains after the harvesting stage represented the highest value of geometric mean diameter as stated by [21]. However, [5] reported the lowest value of equivalent diameter which was found for five varieties of rice.

In the case of both surface area and volume of the rice grains varied from 30.463 – 32.193 mm^2 and 33.210 – 35.336 mm^3 respectively. the lowest value of the surface area for five different samples of rice was reported by [22] Also, [23] mentioned the lowest results of four type of rice in his study which was 11.83, 14.17, 18.36 and 19.66 mm^3 respectively.

It is shown in Table 1. The sphericity and aspect ratio of the rice during the harvesting stage varied from 0.543 to 0.576 % and 0.313 to 0.353, respectively. [18] reported the lowest value of sphericity in the three types of rice. Approximately a similar value of the aspect ratio was registered by [22] The highest value of aspect ratio was stated by [24] who worked with three types of rice, they found an aspect ratio of 3.60, 4.13, and 4.54 respectively.

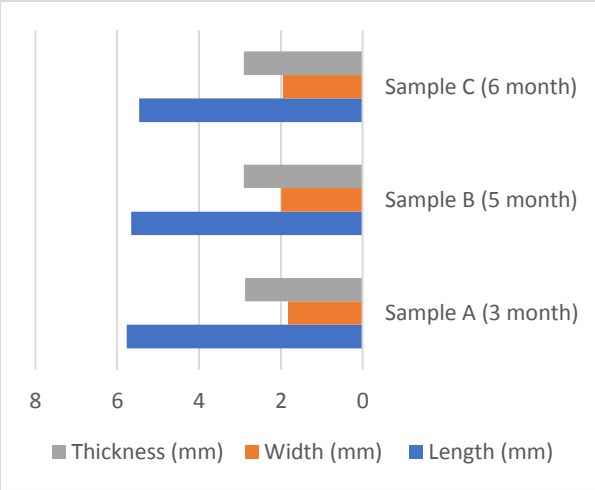

Figure 1: Correlation between the length, width and thickness of Akre rice during harvesting stage.

Table 1: Some of Physical Properties of Rice Grain After Harvesting Stage

Properties	Sample A (3 month)	Sample B (5 month)	Sample C (6 month)
Length (mm)	5.766 ± 0.870[a]	5.660 ± 0.474[a]	5.466 ± 0.262[a]
Width (mm)	1.823 ± 0.137[a]	1.993 ± 0.135[a]	1.950 ± 0.078[a]
Thickness (mm)	2.876 ± 0.186[a]	2.886 ± 0.221[a]	2.906 ± 0.148[a]
Elongation	0.503 ± 0.095[a]	0.503 ± 0.208[a]	0.526 ± 0.037[a]
Da (mm)	3.486 ± 0.305[a]	3.530 ± 0.260[a]	3.436 ± 0.066[a]
Dg (mm)	3.106 ± 0.220[a]	3.296 ± 0.303[a]	3.136 ± 0.050[a]
Equivalent diameter (mm)	3.230 ± 0.613[a]	3.533 ± 0.421[a]	3.523 ± 0.107[a]
Surface area $(mm)^2$	30.463 ± 4.291[a]	31.450 ± 4.263[a]	32.193 ± 2.189[a]
Volume $(mm)^3$	33.210 ± 6.605[a]	35.336 ± 7.046[a]	33.500 ± 1.473[a]
Sphericity %	0.543 ± 0.060[a]	0.576 ± 0.011[a]	0.570 ± 0.026[a]
Aspect ratio	0.313 ± 0.040[a]	0.340 ± 0.043[a]	0.353 ± 0.025[a]

*Different letters indicate presence of statical differences at the level of $\rho \leq 0.05$ and Values are means± SD of three replicates.

Determination of the Mineral Composition of the Rice Grains after Harvesting Stage

Minerals are considered essential nutrients behind the protein, fat and fiber and play an important role in the real functioning of the activity of the human body. White rice grain is a very good source of minerals usually present in varied quantities [25].

The ICP- Mass Spectrometer technique was applied for the detection of minerals in the local Kurdish rice samples during three stages of harvesting. The results and concentration of 13 minerals are displayed in Table 2. The maximum amount of aluminum was stated in samples A and B while the minimum amount was found in sample C. In the case of chromium, there was a significant difference between the samples that varied from 0.13 ± 0.01 to 2.29 ± 0.01 mg/kg. Al and Cr content in all three stages is lower than the range of values as stated by [26]. About, the level of Iron (Fe) and Zinc (Zn) content the average values of Fe for the three stages of rice harvesting were more than Zn. The concentration of Fe and Zn in samples ranged from 16.75 ± 0.15 to 29.27 ± 0.04 and 15.16 ± 0.03 to 20.57 ± 0.04 mg/kg, respectively. The obtained results are in agreement with [27] which reported approximately similar results of Fe with 7.84±1.31 and Zn with 19.42 ± 0.26. On one hand, rice grain samples in all stages of harvesting did not contain Cd, Pb and Na whereas contained a very low amount of Se that ranged between 0.05 ± 0.03 to 0.26 ± 0.03 mg/kg. [7] who has registered similar results in two samples of white rice. Potassium with which ranged from 3.43 to 3.79 mg/kg. 868.41 ± 2.18 in sample B, magnesium with 303.77 ± 2.49 in sample C and calcium with 380.95 ± 2.71 in sample B are the most abundant element that was found in the three-harvesting stage of rice. The Statistical test presented that there was a significant difference in K, Mg and Ca content among the rice samples.

The lower values of K, Mg and Ca were earlier stated by [28]. Moreover, [29] displayed a higher calcium value of 240 mg/kg in white rice than in this study. on the other hand, the manganese content of rice grains after the harvesting stage was in the range between 9.87 ± 0.05 to 16.51 ± 0.09 mg/kg. There was a significant difference in manganese content among the three stages of rice. The obtained results in the present study displayed that the Mn content is lower than the three varieties of rice that were reported by [30]. In addition, Copper was found in the rice grains ranged from 0.93 ± 0.03 for sample A to 3.52 ± 0.04 mg/kg for sample C and the medium content in sample B was 1.35 ± 0.03 mg/kg. A similar content of Cu with 1.82 mg/kg was observed by [31], who determined the Cu concentration of different rice. [30] stated the higher values of Cu content

Table 2: Mineral Composition of Rice Grain After Harvesting Stage that were analyzed by ICP-MS

Elements (mg/kg)	Sample A (3 month)	Sample B (5 month)	Sample C (6 month)
Al	10.52 ± 2.53^{c}	9.78 ± 1.96^{b}	9.13 ± 0.20^{a}
Cr	1.96 ± 0.02^{b}	2.29 ± 0.01^{a}	0.13 ± 0.01^{c}
Cu	0.93 ± 0.03^{a}	1.35 ± 0.03^{b}	3.52 ± 0.04^{c}
Fe	16.75 ± 0.15^{c}	26.59 ± 0.01^{b}	29.27 ± 0.04^{a}
Pb	0	0	0
Se	0.05 ± 0.03^{a}	0.26 ± 0.03^{a}	0.12 ± 0.04^{a}
Zn	15.16 ± 0.03^{c}	15.72 ± 0.03^{b}	20.57 ± 0.04^{a}
Mn	9.87 ± 0.05^{c}	15.71 ± 0.14^{b}	16.51 ± 0.09^{c}
Cd	0	0	0
Ca	301.92 ± 3.37^{b}	380.95 ± 2.71^{a}	202.71 ± 0.66^{c}
K	655.56 ± 3.50^{b}	868.41 ± 2.18^{a}	554.43 ± 4.93^{c}
Mg	209.16 ± 0.85^{c}	219.10 ± 1.40^{b}	303.77 ± 2.49^{a}
Na	0	0	0

* Different letters indicate presence of statical differences at the level of $\rho \leq 0.05$ and Values are means± SD of three replicate

Conclusion

In conclusion, this study shows that the Kurdish rice in the three stages of harvesting could be an important source of minerals especially the Calcium, Potassium and Magnesium and the results presented a significant difference in mineral content. However, the obtained results indicated that the rice samples not contain of toxic elements like Pb and Cd but the lowest content was cu and Cr that is at safe level for health. In addition, the rice samples had significant amount of Fe and Zn, high level of both elements was recorded in the six month that considers a very good samples consumed in the high level and more desirable rice. The physical properties of the rice during the three stages of harvesting that were tested are a very good quality. The average geometric properties like arithmetic mean diameter, geometric mean diameter, equivalent diameter, surface area and sphericity were 3.436 ± 0.06 to 3.530 ± 0.26, 3.106 ± 0.22 to 3.296 ± 0.30, 3.230 ± 0.61 to 3.533 ± 0.42 mm, 30.463 ± 4.29to 32.193 ± 2.18 mm^2 and 0.543 ± 0.06 to 0.576 ± 0.01%, respectively. There was no variation between the geometrical properties of the rice.

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التغير في محتوى العناصر وخصائص الأرز ئاكرى بعد عملية الحصاد في إقليم كردستان

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الملخص:

يعتبر الرز أحد الأطعمة الغذائية الرئيسية في العالم، بشكل عام في الدول الأسيوية و بصورة خاصة في اقليم الكردستان يستهلك على نطاق واسع كغذاء دائمي. قدم هذا البحث بيانات هندسية اساسية عن الخواص الفيزياوية للرز في ئاكرى–دهوك خلال مراحل الحصاد وهو (6،5،3) شهر. بعض الخواص الفيزياوية للرز تحت ملاحظتها ومقارنتها من خلال ثلاث مراحل للحصاد. كان معدل الطول، العرض، السمك، الأستطالة، المتوسط الحسابى للقطر، المتوسط الهندسي للقطر، القطر المكافئ، مساحة السطح، الحجم، الكروية و نسبة العرض الى الأرتفاع (نسبة الأبعاد) كانت 5.466 ± 0.26 إلى 5.766 ± 0.87 مم، 1.823 ± 0.13 إلى 1.993 ± 0.13 مم، 2.876 ± 0.18 إلى 2.906 ± 0.14 مم، 0.503 ± 0.09 إلى 0.526 ± 0.03 مم، 436 .3 ± 0.06 إلى 3.530 ± 0.26 ملم، 3.106 ± 0.22 إلى 3.296 ± 0.30 مم، 3.230 ± 0.61 إلى 3.533 ± 0.42 مم، 30.463 ± 4.29 إلى 32.19 ± 2.18 مم2، 33.210 ± 6.60 إلى 35.336 ± 7.04 مم3، 0.543 ± 0.06 إلى 0.576 ± 0.01%، و0.313 ± 0.04 إلى 0.353 ± 0.02 على التوالي. من ناحية أخرى، تم تحديد تكوين 13 عنصرًا من الأرز الكردي من خلال استخدام قياس الطيف الكتلي للبلازما المقترنة حثيًا (ICP–MS). أشارت النتائج التي المتحصل عليها إلى وجود فروقات معنوية بين العينات، وكانت أعلى كمية في العناصر بينت في Al كانت 10.52 ±2.53 في نموذج Aو Ca وK كانتا 380.95 ± 2.71 و 868.41 ± 2.18 فى نموذج B على التوالي وMg كانت 303.77 ± 2.49 في نموذج C، بينما محتوى حبات الأرز لكل من Pb وCd وNa كانت صفر مليغم\ كجم. علاوة على ذلك، فإن الحد الادنى لكمية العناصر هو Cu و Se والتي تراوحت بين 0.93 ± 0.03 إلى 3.52 ± 0.04 و 0.05 ± 0.03 إلى 0.26 ± 0.03 مليغم\ كجم على التوالي.

الكلمات المفتاحية: الأرز (Oryza sativa L.)، الصفات الفيزياوية، تركيب العناصر، ICP، Mass spectroscopy