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Nutrient value and contamination by arsenic, mercury and cadmium in rice types available in local markets

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Abstract

Rice (*Oryza sativa L.*) is one of the most important cereal and food crops of most of the population of Asia, due to its extensive consumption in Iraq, 36 rice samples were collected and divided into 12 groups (local and imported) for the purpose of assessing the nutritional value and pollution of heavy metal elements (arsenic, mercury and cadmium), the results showed a high humidity in some samples of the food ration amounted to 12.3% , the proportions of ash, protein, fat and fiber were among the natural limit, As for the carbohydrates, the sample R9 recorded the lowest percentage of 77.7%, heavy metals were measured , most of the samples examined rice, whether local or imported contain levels of the elements mercury and arsenic reached to 0.7984 and 1.8368 mg / kg respectively it is higher than the limits prescribed by Food and Drug Administration (FDA) and (FAO).

Key words: rice, Nutrient value, heavy metals

INTRODUCTION

Rice (*Oryza sativa L.*) is one of the most important cereal and food crops for most of the population of Asia. Recently, its consumption has increased in most countries. Rice provides the most part daily needs of the people in Asia. The unique taste of rice makes it the most preferred food for food balance. As well as food intake and more benefit when collected with rice [1, 2]. The studies showed many health benefits of rice and its products, which are very important in the prevention of some diseases that threaten human health because it contains the essential nutrients that provide the body with energy, proteins, fats, vitamins and minerals [1, 3 and 4], while some pigments that found in rice prevent atherosclerosis and its development they contain antioxidant and anti-inflammatory substances [5]. Rice is one of the most important foods that are an effective and potential means of promoting nutrition in poor countries because of their calorie content and nutritional value as well as their regular consumption by these peoples [6]. The nutritional value of rice varies depending on the type of soil planted and germination conditions, as well as the type and color of rice. The brown rice during the germination process has twice as much protein as white rice, it contains 14.6 g / 100 g rice versus 7.3 g / 100 g of rice for white rice, and Brown sprouts rice have a high fat content of 24.8 g / 100 g while white contains 1.5 g / 100 g rice [7]. Several types of rice (commercial white rice, Brown rice, bleaching rice) have the same proportion of protein and fat, while the percentage of ash is slightly different among rice types, especially among white rice, although rice is a good source of thiamin B1, riboflavin B2 and niacin B3 [8,9]. The method of treatment, such as drying and bleaching, influences nutrient content in rice. Crane and bran contain high concentrations of minerals, proteins and vitamins. Removal of the embryo and bran from brown rice to produce bleaching rice will reduce nutrients in white rice [3], rice resulting from this process enhanced by minerals such as iron and zinc to compensate for deficiencies and prevent diseases associated with mineral deficiency [10]. In the rice, there may be accumulations of the basic mineral elements that contribute to the promotion of human health; in contrast, some of the toxic metal elements may accumulate in it. High levels of some heavy metal elements have been recorded in rice and its products, such as arsenic, mercury, cadmium and others [11]. Soil can be contaminated with high percentages of heavy metals either from irrigation water deposition or wind-bearing and is likely to be absorbed by the rice plant and accumulate these elements within the plant parts [12], the intake of doses of heavy metals, albeit a small percentage causes accumulation within the human body and lead to the subsequent appearance of dysfunction in the organs of the human body, especially the nervous system and the incidence of some serious and chronic syndromes, and arsenic is the most toxic metal when found even in very small percentages in food, including rice, leads to the development of serious brain and nerve diseases [13]. Because of the wide consumption of rice by the Iraqi consumer and the existence of different types and varieties of rice and various international originators as well as its distribution within the ration card items by the Iraqi Ministry of Commerce and the various segments of Iraqi society, this study aimed to estimate the nutritional value and pollution of heavy metals of some types of rice available in local markets

MATERIALS AND METHODS

Collection of samples

A total of 36 samples of rice(locale and imported) were collected by three replicates per sample from different markets and areas of the Iraqi cities during April and May 2017 and divided into 12 groups depending on the type of rice or sampling area as shown in (Table ,1) the samples were transported in closed plastic bags to the laboratories of the Market Research and Consumer Protection Center of the University of Baghdad for analysis and testing, including chemical analysis and estimation of heavy metals.

Table (1): Types of rice samples according to the areas from which they were collected.

Samples	The description	Country
R1	Imported rice	Thailand
R2	Imported rice	Thailand
R3	Imported rice	Vietnam
R4	Imported rice	Vietnam
R5	Imported rice	Pakistan
R6	Imported rice	Pakistan
R7	Imported rice	India
R8	Imported rice	India
R9	Imported rice	India
R10	Locale Anbar rice	Iraq/ Maysan
R11	Locale Anbar rice	Iraq/ Najaf
R12	Locale Anbar rice	Iraq/ Nasiriyah

Chemical analysis of rice samples

The chemical analyzes of the rice samples were carried out according to the methods in [14], which included protein estimation using the Microkjeldah device, fat estimation using Soxhlet, ash estimation using method of incineration furnace (method 14: 006), fiber estimation (method14: 020) moisture estimation and calculation of carbohydrates.

Preparation of samples to estimate heavy metal elements (arsenic, mercury and cadmium)

The rice samples were washed with distilled water, well dried and grinded using a clean laboratory mill for fine powder and kept in dry, clean polyethylene bags until the process of digestion.

Samples digestion and estimation of heavy elements

The method which Megamerger *et al*. did [15] was used to digest the samples, taking 1 g of rice and placed in a flask of digestion and adding 20 ml of acid mixture (650 ml of HNO3, 80 ml of perchloric acid and 20 mL of HCL) until a clear solution was obtained. The product was diluted to 500 ml and used to estimate the heavy elements (arsenic, mercury and cadmium) by atomic absorption spectrophotometric device.

Statistical analysis of results

The statistical program SAS was used to analyze the results obtained. Morale differences were compared with the least significant difference (LSD) probability (P <0.05), as indicated by SAS [16].

RESULTS AND DISCUSSION

Nutritional value

(Table, 2) shows the results of the chemical analysis for rice samples group, which included moisture, ash, protein, fat, fiber and carbohydrate calculation. The results showed significant differences at the mean level of P<0.05 in moisture, ash, protein and fiber. The rice samples contained high levels of carbohydrates ranged between 77.7% and 82.9%, these values were higher than Megamerger *et al*. found [15]. The carbohydrate ratio ranged between 75.3% and 76.3% in the rice samples of one of the states of Nigeria and had the lowest carbohydrate ratio in R9 (77.7%), this decrease in carbohydrates may be due to high water content and other environmental factors, and high carbohydrate content in rice indicates that it is a good source of energy [17].

The percentage of ash content in rice samples ranged from 1.0% to 1.8% and [18] found that the rate of ash in rice samples in Pakistan was 2.8%. Studies have indicated that the high ash content in rice indicates a high mineral content [15, 17].

In the 12 samples group of rice R7 and R9 recorded the highest percentage of protein content (6.8%), these results were consistent with what Ambreen *et al.* found [18] when analyzed for some rice samples in one city in Pakistan, the protein rate was (6.7%), while Xheng and Lan [19] showed that the protein content in rice samples in China was 8.7%, higher than this study found.

Table (2): Chemical analysis results of rice samples

Samples	Moisture %	Ash %	Protein %	Fat%	Fiber %	%Carbohydrate
R1	10.4	1.1	5.8	0.5	2.5	79.7
R2	9.7	1.0	6.1	0.4	2.3	81.5
R3	7.5	1.8	5.7	0.5	2.1	82.4
R4	9.5	1.2	6.3	0.5	1.7	80.8
R5	8.3	1.3	6.4	0.4	1.5	82.5
R6	7.2	1.8	6.5	0.5	1.1	82.5
R7	11.2	1.0	6.8	0.5	2.8	82.9
R8	10.6	1.0	5.9	0.4	2.4	79.7
R9	12.3	1.1	6.8	0.4	1.7	77.7
R10	8.5	1.0	6.2	0.5	1.9	81.9
R11	9.6	1.2	6.5	0.5	1.2	81
R12	10.5	1.0	6.3	0.5	2.2	79.5
LSD	**2.061 ***	**0.477 ***	**0.794 ***	**0.163 NS**	**0.452 ***	**4.869 NS**

(NS): Not Significant, * (P<0.05)

Fiber content in rice samples under study ranged between 1.1% and 2.5% in R6 and R1, respectively. The ratio of fiber was 1.5% to 2% in the rice samples of one of the states of southeastern Nigeria [20], while the percentage of fiber ranged between 1.9% and 4.3% in study of Ambreen *et al.* [18], which is higher than the percentage mentioned in the current study. Studies have shown that the removal of the crust caused a significant reduction in the proportion of fiber in rice [18, 20, 21].

The moisture content in sample R6 was 7.2%, while the ratio was 12.3% in sample R9. The results were close to study of Oko and Ugwu [21] in Nigeria , which determined the average moisture content in the rice samples 7.3%. The high moisture content in the rice is due to the low temperature, the process of drying or high humidity during storage, marketing operations, the poor bags and packing cans that allow moisture to seep into the rice [8, 19].

The percentage of fat ranged between 0.4% and 0.5% in the rice samples under study, these results were agreed with the studies [11, 21] that determined the ratio of fat in rice between 0.42% and 0.51%, while Ambreen *et al.* [18] indicated that rice samples contain 3.2% fat, and the process of removing crust and fetus from brown rice contribute to significantly reduce the proportion of fat in white rice.

We note from the above that all the samples of the tested rice (local and imported) had their nutritional value within acceptable limits approved by American and European organizations [4] and [6].

Contamination of rise samples by arsenic, mercury and cadmium

(Table,3) shows concentrations of heavy metal elements (arsenic, mercury and cadmium) in the tested rice samples. The results showed significant differences at the mean level of P<0.05 between concentrations of heavy elements in rice samples.

The concentrations of cadmium in the tested rice samples ranged from 0.01555 mg / kg to 0.12955 mg / kg in R12 and R8, respectively, within the permissible limits of 0.2 mg / kg set by FAO and WHO [22], studies conducted by [23, 24, 25and 26] indicated limited concentrations of cadmium in rice samples in Sri Lanka, Tanzania, China and India respectively with concentrations of 0.0481, 0.020, 0.089 and 0.012 mg / kg, respectively, while the ratio of this element was high levels of 0.48 mg / kg in rice samples planted on both sides of a river in southern China [27], the studies carried out Kibria *et al.* [28] and Hassan *et al.* [29] when irrigation of rice seedlings with water with a small percentage of wastewater, the percentage of cadmium in rise 0.87 and 0.91 mg / kg respectively, therefore, In a study of Cao *et al.* [30], cadmium was 0.85 mg / kg in rice grown close to mining areas.

Concentrations of mercury element in the tested rice samples (Table 3) ranged from 0.0408 and 0.7984 mg / kg in R2 and R7, respectively, it should be noted that mercury Concentrations in most tested rise samples were higher than those identified by FAO and WHO [22] should not exceed 0.1 mg / kg, both[22] and[24] indicated varying levels of mercury element of 0.221 and 0.226 mg / kg, respectively, while mercury

Table (3): Concentrations of heavy metal elements arsenic, mercury and cadmium

Concentrations of heavy metals mg/kg			
Samples	**As conc.**	**Hg conc.**	**Cd conc.**
R1	0.2352	0.1591	0.0987
R2	0.0908	0.0408	0.0643
R3	0.0226	0.6825	0.0811
R4	0.2911	0.6640	0.1071
R5	1.4362	0.1381	0.0918
R6	0.5823	0.1891	0.1406
R7	1.0322	0.7984	0.1696
R8	0.0864	0.7981	0.1955
R9	0.2089	0.3071	0.1132
R10	0.3827	0.1171	0.1360
R11	1.8368	0.3052	0.1147
R12	1.5446	0.3674	0.0155
LSD	**0.358 ***	**0.182 ***	**0.0355 ***

(P<0.05) * Not Significant, :(NS)

concentrations were high in the study of Kibria *et al.* [28] it reached to 0.921 mg / kg when a small percentage of wastewater was used for watering rice, in the Zeng *et al.* [25] and Cao *et al.* [30] research's, mercury concentrations in Indian and Chinese rice reached levels of 0.006 and 0.0411 mg / kg, respectively.

Arsenic concentrations were high in the tested rice samples ranged from 0.026 to 1.836 mg / kg in R3 and R11, respectively; it is noticeable that in 8 groups of rise samples above the limits allowed by FAO and WHO organizations (0.2 mg / kg), studies of [31], [32], [33] and [34] indicated an increase in arsenic in rice to 0.138, 1.152 and 1.921 mg / kg, respectively; while the study conducted by 25 recorded low percentage of arsenic in rice amounted to 0.061 mg / kg.

It is noted from the results of the estimation of heavy metal elements that most of the samples of the examined rice, whether local or imported contain levels of the elements mercury and arsenic is higher than the limits prescribed by [22] The contamination of Iraqi rise with heavy elements in samples R10, R11 and R12 may be due to the contamination of soil in the central and southern governorates of heavy elements as a result of the war residues resulting from the wars that lasted for many years, which led to large pollution in the agricultural soil of those areas This is what Abu-ALmaaly [35] referred to, which estimated the heavy metals in the coarse salt produced in those areas specifically, which was contaminated with high levels of heavy metal elements.

Many studies [36, 37 and 38], which investigated the relationship between soil pollution and cultured rice in these lands, indicated that high levels of heavy metals in the soil could lead to the absorption of these minerals by the plant's rice system, these studies concluded that there are many reasons for increasing heavy metals in agricultural soils such as mining activities near agricultural fields and heavy metals emitted with vapors generated from some industries that may be directly absorbed by soil and rice grains, as well as the improper disposal of industrial wastes rich in heavy metals, causing their accumulation in agricultural land as well as the use of phosphate fertilizers that may raise the levels of heavy metals in the soil and rice, and the use of water contaminated with sewage in the irrigation of crops increases the probability of exposure to heavy metals.

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