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EFFECT OF COOKING METHOD ON THE CONTENT OF HEAVY METALS IN RICE THAT AVAILABLE IN LOCAL MARKET

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Abstract

Rice holds a large food position for most Asians, including Iraqis, since it accounts for 50 percent of daily food, the greater consumption cause higher risk of exposure to heavy metals in rice, thus, 30 samples of polished Iraqi rice named Amber were collected from six governorates of the country for purpose of studying the impact of soaking and cooking rice on reducing heavy metals levels (arsenic, lead, and cadmium), it was divided into four groups that were soaked for 20 minutes, the first with distilled water, the second with water and table salt 2%, the third with water and citric acid 2%, the fourth with water, table salt 2%, and citric acid 2%, heavy metals were estimated in each of them, the treatments were individually cooked with distilled water for 20 minutes and heavy metals were estimated there as well, the results showed that the treatment of soaking with water and table salt 2% and citric acid 2% together this resulted in decreased levels of heavy metals, lowest concentrations were recorded for As, Pb and Cd, 0.1012, 0.0988 and 0.00081 mg/ kg respectively compared to their concentrations in raw polished rice 0.5335, 1.3892 and 0.1993 mg/ kg respectively, cooking for the same treatment contributed to a further decrease in its concentrations, recording 0.0771, 0.0120, and 0.0010 mg/ kg respectively, heavy metal levels studied will be within or slightly above the limits permitted by the FDA and the World Food Organization, and in simple and inexpensive methods that can be used at home.

Keywords: rice, cooking method, heavy metals

Introduction

Rice (*Oryza sativa* L.) is amongst the most important cultivated food widely consumed worldwide, particularly in Asia, as it is an important source of energy obtained by the individual. Rice occupies a special place in the daily meals of the Iraqi people; it is an indispensable dish in any home. Rice is widely cultivated in Iraq, especially in the center and south of the country, Amber the variety is known is one of the most important cultivars, and because of its unique taste and aroma, it is distinguished by that makes it desirable for both Iraqis and neighboring countries (Abu-Almaaly *et al.,* 2018). The interest has increased recently in contamination of crops with heavy metals, which can be transmitted to humans through eating these crops and the effects this has on public health, and many studies around the world have shown that rice crops are polluted with heavy metals, which its presence attributed to environmental and technical factors it mainly depends on soil pollution with these minerals depending on its geographical location, in addition to other important factors such as the rice variety and agricultural techniques that include the use of pesticides, fertilizers, water source watering, industrial emissions and pollution that may occur during harvesting, storage, transportation and crop sales (Ziarati and Azizi, 2014; Rohman *et al.,*2014).

The accumulation of heavy minerals in the human body due to cumulative effect of dietary exposure to them, through food, water, and environmental pollution might have serious implications for human health, it depends on its type, degree of toxicity and concentration that accumulates in the human body, The degree of danger of these minerals is related to their ability to shape protein complexes, such as their association for example with Amiens groups -NH_2 or -COOH and Thiol groups- SH, when these complexes are bound, the structures of important enzymes and proteins in the human body are affected (Dhiraj *et al.,*2008; Volesky and Schiewer, 1999).

The toxic metals include arsenic, lead and cadmium that are most harmful, human when exposure to arsenic poisoning can cause a develop tumors and the risk of them turning into cancer and causing acute abdominal pain and many skin diseases, while acute or chronic exposure to cadmium causes damage to the kidneys, high blood pressure, and clear effects on delayed bone healing in fractures (Zeng *et al.,* 2015; Abu-Almaaly, 2019), lead is a highly toxic element and is found largely in the contaminated environment as a result of unregulated manufacturing and fertilizing processes and has a serious effect on the nervous system and may lead to some types of cancer (Duran *et al.,* 2007).

Recent studies have tended to find materials and compounds that bind these minerals in the soil and turn them into inert materials that the plant cannot absorb, thus reduce the risk of plant contamination with these elements, the method of treating watering water has emerged as one of the most important chemical methods that contribute to binding the heavy elements in the soil and preventing its absorption by the plant, but it is a complex and inexpensive method, so studies have recently moved to produce inexpensive adsorbent materials that treat materials in the soil, Among the methods of treatment with materials are the use of chemical spray, ion exchange, electric flotation, membrane separation techniques, reverse osmosis, electrolysis of water and the use of solvents, etc. Some studies have shown that the adsorption method, which is a Physico-chemical method, has proven effective in treating water and removing the ability to form heavy metal complexes in solutions through physical and chemical mechanisms, Such as pH, the volume of substances that bio pollutant, ionic strength, and temperature, due to the availability of plant extracts and some chemical compounds and their cheapness, most studies have focused on their use in the adsorption or bio-binding process of pollutants (Zazouli *et al.,* 2010; Solidum *et al.,* 2012; Batista *et al.,*2012; Karm, 2019) Based on foregoing and the importance of this crop in the food basket of the Iraqi citizen and to find the best and safest methods in the process of preparing and cooking rice to get as much as possible from contamination with heavy metals, this study examined impact of method of cooking on the heavy metals content of Iraqi rice available in the local market.

Materials and Methods

Materials

All the chemicals, reagents, and standard solutions for the high purity heavy metals were purchased from Merck, Germany. High-purity non-ionic water was prepared for use in sample preparation, The glass bottles and plastic containers used in the work were thoroughly cleaned and soaked for 48 hours with 8% nitric acid solution, then rinsed with non-ionic water several times well,, All tests were done in the laboratories of Market Researches and Consumer Protection Center/ University of Baghdad.

Devices

This study was conducted to estimate some of the heavy elements (arsenic, lead and cadmium) in the samples of local rice treated in several methods, as the estimate was made using the atomic absorption device (Shimadzu AA-6200 supplied with ASC 6100 auto sampler atomic absorption spectrometer) by following the methods of work on this device as mentioned in Alsoufi *et al.* (2020).

Experiment

30 samples of polished rice (Amber) were purchased from its production areas in the governorates of Iraq (Najaf, Babylon, Maysan, Al-Kote, Thee Qar and Al-Muthanna), 5 samples were collected from each governorate and 3 replicates for each sample, toxic metals (arsenic, lead, and cadmium) were measured in all samples at laboratory arrival, samples that heavy metal concentration within the acceptable limits in Codex, 2011 were neglected (arsenic below 0.01 mg/kg, lead below 0.01 mg/kg and cadmium below 0.1 mg/kg), the samples in which the heavy-metal concentrations were higher than allowable levels, they were used in the experiment and were divided into four treatments, the first quarter was soaked with distilled water (DW) only, the second quarter with distilled water and salt (NaCl) 2%, the third quarter with distilled water and citric acid 2%, and the last quarter soaked with distill water and salt 2% and citric acid 2%, all samples were soaked for two hours, after which they were filtered from the soaking solution and washed with distilled water three times, and heavy metals were estimated in all it individually, then the treatments were individually cooked with distilled water for 20 minutes, then filtered from the water, and the heavy metals were evaluated.

Samples digested

The samples were digested to estimate levels of heavy metals in the wet digestion method mentioned by Megamage *et al.,* 2017; weighing 10 g of each sample and putting it in a glass jar, Apply 25 ml nitric acid (65% Merk) and 8 ml hydrochloric acid to it. (36.5% Merk), jugs were placed on a hot plate at a high temperature to ensure completion of digestion, and the remainder after digestion was used in the sample estimation process for heavy metals, all digestion, and metals estimation was done according to the standard protocols and instructions are given in A.O.A.C., 2005 and A.S.T.M., 2000.

Statistical analysis

The SAS, 2012 statistical analysis program was used to analyze the data to test the effect on samples of different parameters according to a full random design (CRD) in two directions; the Least Significant Difference-LSD test compared the significant differences between all the averages. Percentages of positive samples used for the examination of heavy metals (arsenic, lead and cadmium) where heavy metal concentrations.

Results and Discussion

(Table 1) shows the areas and the number of Iraqi rice samples examined before conducting treatments on them and the percentages of positive samples used for Heavy Metals evaluation (arsenic, lead and cadmium) In which the Codex,2011 standard, and European Commission, 2006 concentrations were higher than those acceptable (arsenic below 0.01 mg/kg, lead below 0.01 mg/kg and cadmium below 0.1 mg/kg), table 1 shows that the positive samples for examining the proportions of heavy elements in rice samples for governorates (Babylon, Al-Kote, and Al-Muthanna) were within 40% of the total samples taken from those governorates, While those samples were higher in the governorates (Najaf and Maysan), they reached 60% of the total samples, and Thee Qar Governorate recorded the highest percentage of positive samples, reaching 80% of the total samples.

Table 1: The areas and the number and positive samples of Iraqi rice examined before conducting treatments.

Samples	Production areas (Governorates)	No. of samples tested	No. of positive samples	Percentage %
T_1	Najaf	5	3	%60
T_2	Babylon	5	2	%40
T_3	Maysan	5	3	%60
T_4	Al- Kote	5	2	%40
T_5	Thee Qar	5	4	%80
T_6	Al-Muthanna	5	2	%40

The results of treatments in (Table 1) carried out on the rice samples (soaking treatments: with distilled water, 2% table salt, citric acid 2%, table salt + citric acid), and the cooking of the samples after soaking and washing, concentrations of heavy metals Displayed big difference in scale ($P \leq 0.05$) in treatments before and after soaking and cooking.

From the observation of Table 2, it appears that arsenic rates in tests of rice polished before soaking and cooking ranged from 0.5335 mg/kg to 1.8102 mg/kg in T2 and T6 treatments, respectively, Abu-Almaaly, 2019 and Yim *et al.,* 2017 indicated in their study, (Iraqi polished rice samples and Vietnamese rice Respectively), that higher concentrations than the acceptable limits for the arsenic element, the ratios ranged from 0.2352-1.8368 mg/kg and 0.3526-1.2354 mg/kg respectively.

Rice soaking (Table 2) showed clear differences in reducing arsenic concentrations in the treatments. Soaking treatment with distilled water with table salt and citric acid was superior to reducing the element concentration by a high percentage compared to its concentration before the treatments, The lowest arsenic concentration was 0.1012 mg/ kg in treatment T_1, it was followed in efficacy by citric acid soaking that lowest concentration reported in transaction T_2 was 0.2024 mg / kg, and then comes the treatment of soaking with table salt where the lowest concentration of the element was 0.2101 mg/kg in the treatment T_2 and finally soaking with distilled water only, it also reported the lowest 0.4762 mg / kg concentration in T_2 treatment, Behrouzi *et al.,* 2020 stated that soaking Iranian rice samples with citric acid 2% for 20 minutes led to a decrease in arsenic concentration from 0.4322 mg/kg to 0.1011 mg/kg, when soaking with water only, In a study the concentration was 0.2341 mg/kg (Ziarati and Azizi, 2014), no significant differences were observed between arsenic levels on samples of Iranian rice before and after soaking with distilled water only.

Table 2: Average arsenic concentration (mg/kg) in Iraqi rice samples after soaking and cooking treatments.

			Treatments				
Samples	**Polished rice**		**distilled water (DW)**	**(DW) Salt 2%+**	**(DW) %2+ citric acid**	**(DW) Salt 2%%+ citric acid 2%+**	**LSD value**
T_1	1.3559	soaking	1.0251	0.9311	0.3121	0.1012	* 0.377
		cooking	0.7081	0.5341	0.0966	0.0771	* 0.296
T_2	0.5335	soaking	0.4933	0.2101	0.2024	0.2925	* 0.218
		cooking	0.4762	0.3885	0.2001	0.1023	* 0.244
T_3	1.0522	soaking	0.9923	0.8702	0.6101	0.4043	* 0.315
		cooking	0.7235	0.4922	0.2505	0.2701	* 0.266
T_4	1.0472	soaking	0.9832	0.8573	0.5918	0.3203	* 0.306
		cooking	0.5722	0.4014	0.2023	0.2175	* 0.215
T_5	0.7253	soaking	0.5044	0.4937	0.3952	0.3504	0.226ns
		cooking	0.3112	0.2105	0.1782	0.0993	* 0.209
T_6	1.8102	soaking	1.5221	1.3503	1.2972	1.3091	0.225ns
		cooking	1.1011	1.0337	0.8733	0.4124	* 0.461
LSD value	---	---	* 0.439	* 0.471	* 0.384	* 0.327	---
(P≤0.05) ns: not significant*							

The process of cooking the soaked and washed rice affected the concentration of the arsenic element, as all treatments recorded a clear decrease and significant differences occurred for them at (P≤0.05). (Table 2) Figure 1, the lowest arsenic levels in the samples T_1, T_5, T_2 and T_5 were 0.0771, 0.1782, 0.2101 and 0.3112 mg/kg, respectively for soaking treatments with salt, sour, then sour, salt, and water, respectively, Behrouzi *et al.* 2020 indicated that the process of washing Iranian rice after being soaked with acid and then cooking it resulted in a decrease arsenic concentration in it, reaching 0.0861 mg/kg, as for the study (Naito *et al.* 2015) of rice grown in Japan, the process of soaking, washing and cooking affected the arsenic concentration in it from 0.2104 to 0.01032 mg/kg.

Concentrations of lead (Table 3) in the treatments of Iraqi rice soaking with distilled water, table salt, citric acid, salt and citric acid showed considerable differences together (P≤0.05) between them, the concentrations of the metals were 1.2058, 0.8362, 0.5331 and 0.0988 mg/kg, respectively, in the samples T_5, T_2, T_2, and T_5 compared to the lead concentration in raw rice before soaking ranged from 2.5331-1.3892 mg/kg, studies performed by (Zazouli *et al.,* 2010; Perello *et al.,* 2008) showed a significant decrease in lead concentration. When treating rice with washing and soaking for a period of 20-60 minutes, the lead concentration decreased from 2.0432 to 1.0093 mg/kg in the first study and from 1.9344 to 0.5622 mg/kg in the second study.

When cooking rice samples resulting from different soaking treatments (Table 3) and (Fig. 2) the lead concentration in them remained lower than when soaking, the lowest levels of the element in the soaking and cooking treatments with salt and acid reached 0.0120 mg/kg and with acid 0.0335 mg/kg with salt 0.4042 mg/kg and with distilled water 0.8266 mg/kg in the samples T_5, T_2, T_2, and T_5, respectively, a study of Razafsha, 2016 indicated a decrease in the lead concentration in Iranian sour and cooked rice from 2.0141 to 0.1023 mg/kg.

Table 3: Average lead concentration (mg/kg) in Iraqi rice samples after soaking and cooking treatments

			Treatments				
Samples	**Polished rice**		**Distilled water (DW)**	**(DW) Salt 2%+**	**(DW) %2+ citric acid**	**(DW) Salt 2%%+ citric acid 2%+**	**LSD value**
T_1	2.5331	soaking	2.0122	1.7031	1.6817	1.2335	* 0.492
		cooking	1.7311	1.4403	1.2355	0.8581	* 0.379
T_2	1.3892	soaking	1.1032	0.8362	0.5331	0.2104	* 0.428
		cooking	0.8266	0.5302	0.2101	0.0993	* 0.388
T_3	1.6205	soaking	1.2248	1.3015	1.1022	1.0357	0.322ns
		cooking	1.0043	0.6877	0.2153	0.2018	* 0.438
T_4	2.4033	soaking	2.1502	1.8352	1.5507	1.2063	* 0.407
		cooking	1.8205	1.6722	1.2033	1.1004	* 0.394
T_5	1.8724	soaking	1.2058	1.0786	0.9201	0.0988	* 0.502
		cooking	1.0435	0.4042	0.0335	0.0120	* 0.459
T_6	2.0751	soaking	1.5534	1.2871	1.0552	1.0133	* 0.387
		cooking	1.0112	0.7501	0.3572	0.1257	* 0.437
LSD value	---	---	* 0.533	* 0.607	* 0.548	* 0.519	---
			(P≤0.05) ns: not significant*				

Table (4) shows total concentration of cadmium (mg/kg) in samples of Iraqi rice after soaking and cooking treatments, the analysis indicated specific differences (P≤0.05) between the treatments, Except for the samples T_3 and T_4, there were no specific differences between their treatments, Concentrations of cadmium element decreased in soaking treatment, the lowest value was 0.0081 for salt and acid soaking treatment, followed by salt soaking 0.0473, then soaking with distilled water 0.1007 and finally soaking with citric acid 0.1017 mg/kg in samples T_6, T_2, T_2 and T_5, respectively, Ziarati and Azizi, 2014 mentioned in their study decline in cadmium concentrations in Iranian rice samples after soaking and rinsing three times, so its concentration was 0.2217 mg/kg compared to raw rice before soaking 0.3276 mg/kg, whereas, Razafsha, 2016 indicated a slight decrease in the concentration of cadmium in rice soaked with lemon for 20 minutes from 0.1808 mg/kg before soaking to 0.10433 mg/kg after soaking.

The results of cooking Iraqi rice samples (Table 4) Figure 3 after being soaked and washed with water showed a clear decrease in cadmium concentrations between the treatments, as significant differences were recorded, except for the samples T3 and T4, as their differences did not show between these treatments, the samples recorded the lowest concentrations of element 0.0010, 0.0062, 0.0344 and 0.0553 mg/kg in soaking, cooking with salt and acid, then an acid, salt, and distilled water, respectively, several studies have found a clear decrease in the concentration of cadmium in rice when soaked with salt and acid and then cooked.

Table 4: Average cadmium concentration (mg/kg) in Iraqi rice samples after soaking and cooking treatments

			Treatments				
Samples	**Polished rice**		**Distilled water (DW)**	**(DW) Salt 2%+**	**(DW) %2+ citric acid**	**(DW) Salt 2%%+ citric acid 2%+**	**LSD value**
T_1	0.3224	soaking	0.2127	0.0732	0.0671	0.0371	* 0.083
		cooking	0.0918	0.0502	0.0173	0.0113	* 0.055
T_2	0.2877	soaking	0.1007	0.0473	0.0145	0.0104	* 0.058
		cooking	0.0553	0.0491	0.0918	0.0257	* 0.102
T_3	0.3506	soaking	0.0228	0.0134	0.0101	0.0017	0.218ns
		cooking	0.0172	0.0125	0.0117	0.0012	0.0155ns
T_4	0.1993	soaking	0.0288	0.0113	0.0141	0.0035	0.0268ns
		cooking	0.0179	0.0121	0.0033	0.0012	0.0167ns
T_5	0.5024	soaking	0.2105	0.1052	0.1017	0.0113	* 0.088
		cooking	0.0633	0.0301	0.0121	0.0083	* 0.0402
T_6	0.2565	soaking	0.1172	0.0553	0.0164	0.0081	* 0.0626
		cooking	0.0875	0.0344	0.0062	0.0010	* 0.0583
LSD value	---	---	* 0.088	* 0.0947	* 0.077	* 0.0278	---
			(P≤0.05) ns: not significant*				

So Razafsha, 2016 mentioned that the concentration of the element decreased in Iranian rice when cooking from 0.1808 to 0.0024 mg/kg, as Naseri *et al.,* 2014 he reported that there was no big difference in cadmium concentration according to the method of cooking, it was found that cooking without filtering cooking water or with filtering reduced the element concentration from 0.3922 mg/kg before cooking to 0.0955 mg/kg with no filtering and 0.09102 mg/kg with filtering For cooking water, Ziarati and Azizi, 2014 indicated that cooking rice without soaking did not significantly reduce the concentration of cadmium, as it reached 0.3178 mg/kg after cooking compared to its concentration before 0.3276 mg/kg.

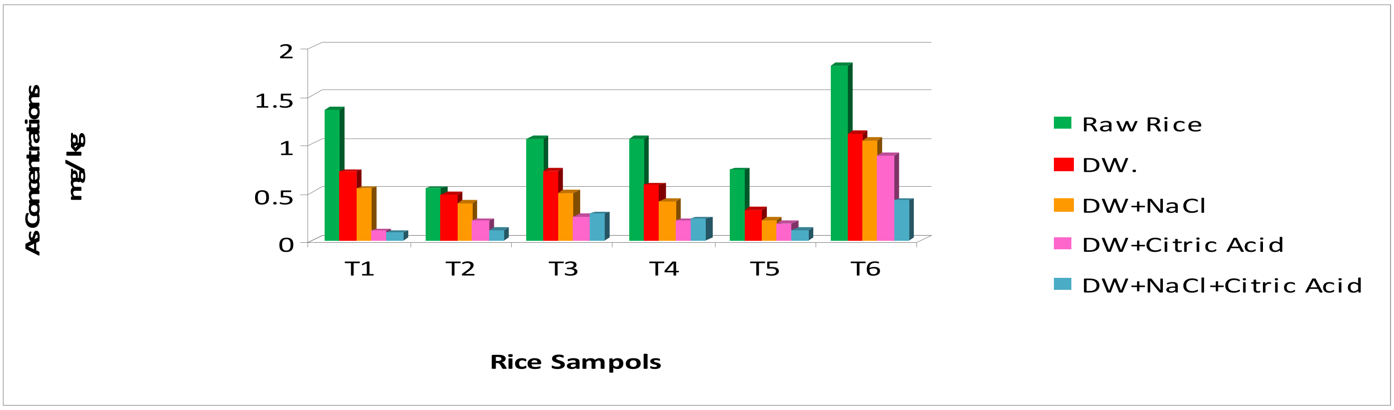

Fig. 1 : Cooking effect on concentration of Arsenic in samples of Iraqi rice.

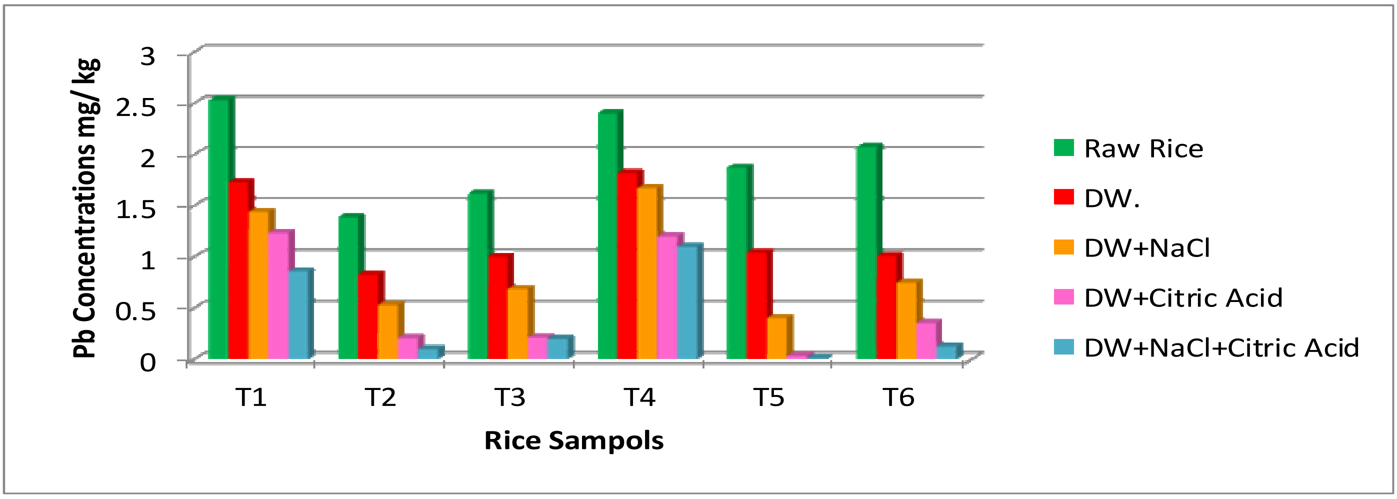

Fig. 2 : Cooking effect on concentration of Lead in samples of Iraqi rice.

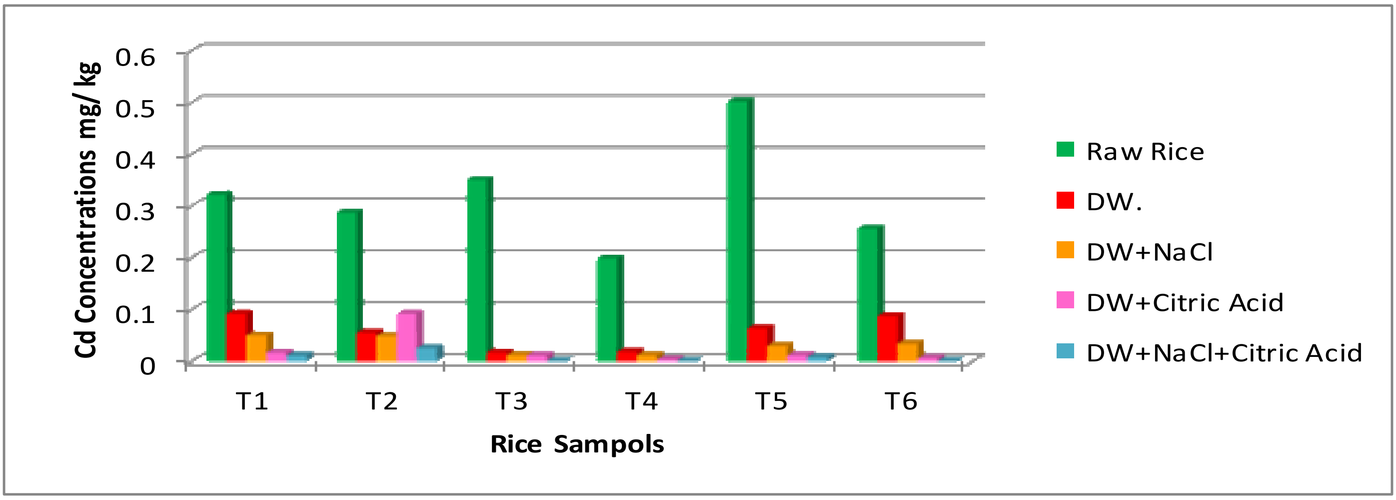

Fig. 3 : Cooking effect on concentration of cadmium in samples of Iraqi rice.

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