Assessing the Knowledge of Kurdish Consumers about the Presence and Health Impacts of Arsenic in Rice

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Abstract

Background: Rice is a staple food in most countries around world including Kurdistan region of Iraq. Rice is one of the main sources of arsenic to transfer it to human body

Objectives: to assess the knowledge of Kurdish people who consume rice in their daily meal and increase their awareness about arsenic in rice.

Methodology: A cross – sectional study was conducted from November 11, 2022, to April 20, 2023. This article provides an overview of the Kurdish consumer knowledge about the issue of arsenic presence in rice. Overall, this article highlights the importance of addressing the issue of arsenic in rice in order to protect the health of rice consumers worldwide. The research composed of three parts questionnaire. Part I (7 questions) contains sociodemographic data; section (II) contains covers items related to height, weight and physical activity; section (III) (19 questions) contains the knowledge of Kurdish consumers about arsenic in rice. 282 people participated in this survey (from the age of 18 to more than 46 years old) from both genders.

Results: The results revealed that 94% of participants eat rice as a staple food and consume more than 2 cups of rice per single meal. 51% (143) of the participants don't know that rice contains arsenic and cause health issues. This article will help people to look at rice more seriously because of the fact that rice contains arsenic. Therefore, 88% of the participants think that this information will help them to rethink about the quantity of rice they eat. Lastly, 72% of the participants have decided that they will reduce the amount of rice that they normally consume after this study, and 28% of them decided to keep eating it as they would like.

Conclusion: majority of the participants did not have any knowledge on existence of arsenic in rice and those who had information about it mostly were medical students or doctors.

Index Terms: **Arsenic, cancer, rice, speciation, toxicity.**

I. Introduction

Over half of the world's population eats rice as a staple food, making it a significant cereal crop. In Asia and developing nations, rice consumption is very high and the majority of it is produced in Asian nations. Rice farming is the third - largest producer of agricultural products after maize and sugarcane. In 17 nations, it serves as the primary dietary source of energy [1].

The world produces over 480 million metric tons of rice each year. The Republic of China, India, Indonesia, Bangladesh, the United States, and Vietnam are the top producers of rice. When compared to other grain crops, rice (Oryza sativa) accumulates higher levels of arsenic, most likely as a result of the high plant availability of arsenic in poor soil conditions[2].

In recent times, there has been a growing focus on the accumulation of heavy metals and metalloids in vegetables. Vegetables are susceptible to environmental pollution to a greater extent than other food systems due to their exposure to airborne contaminants. The accumulation and uptake of heavy metals by vegetables, both in edible and non-edible fractions, when reaching a certain level, can pose health concerns for both living organisms and humans[3,4].

Arsenic (As) ranks as the 12th most abundant metalloid in the human body and the 20th most abundant in nature. Its derivatives find extensive use in diverse industries, such as agriculture, electronics, metallurgy, and chemical production. As is utilized in various applications, including cattle-related products, insecticides, fertilizers, and even as a component in certain medicines[5,6]. Plant species have the ability to absorb As and distribute it among different parts of the same plant. This process is occasionally described as compartmentalization[2,7]. As is a prevalent element in the environment, entering through both natural and anthropogenic process [8, 9]. It is present in the atmosphere, pedosphere, hydrosphere, and biosphere. Apart from biological mechanisms, which involve microbiological processes, the biogeochemical behavior of As is influenced by physico-chemical processes like oxido-reduction, precipitation/solubilisation, and adsorption/desorption [5,10].

As is recognized as a toxic element with adverse effects on humans, animals, and plants. Contamination has led to health issues in different countries, primarily due to elevated concentrations of As in the food stuffs. This contamination can stem from both drinking and irrigation waters, as well as from crops (through the soil), vegetables, and meat products[11]. The field of elemental speciation has become a well-established area of research. Examining the chemical forms of elements is crucial for understanding the mobility, biological availability, distribution, and toxicity of the chemical element[12]. The species Inorganic As (InAs), consisting of arsenite (As^{III}) and arsenate (As^{V}), is classified as cancer-causing[13]. On the other hand,

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Organic As species, including monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA), while less toxic than InAs [14,15], are still categorized as cancer-promoting species[13, 16]. Arsenicholine (AsC) and arsenobetaine (AsB), however, are considered non-toxic arsenic species[17]. It's noteworthy that intermediate metabolites like monomethylarsonous acid (MMA^{III}) and dimethylarsinous acid (DMA^{III}) exhibit higher toxicity compared to As^{III}, As^{V}, DMA^{V}, or MMA^{V} [18].

The World Health Organization (WHO) has characterized the situation as the "largest mass poisoning of a population in history." This designation is due to the widespread As poisoning in Bangladesh, representing a severe public health hazard for the entire country [19]. Pollution, identified as a known human carcinogen, impacts hundreds of millions of people globally. InAs is a significant contributor to various forms of cancer, including skin, lung, bladder, liver, prostate, and kidney cancer in humans[20]. In cases of acute toxicity, As, a toxic metalloid, can induce symptoms such as nausea, vomiting, and severe diarrhea. On the other hand, chronic exposure to arsenic may lead to more serious health conditions, including cardiovascular disease, diabetes, bladder cancer, kidney cancer hypertension, gangrene, respiratory diseases, renal diseases and reproductive issues [21,22].

To the best of our knowledge, this is the first survey that has been conducted in Erbil city regarding the knowledge of Kurdish consumer on As specifically in rice. The aim of this study was to assess the knowledge of Kurdish people who consume rice in their daily meal and increase their awareness about arsenic in rice.

II. Methodology and Materials

A cross-sectional design was adopted for the research methodology. The data were collected from November 11, 2022, to April 20, 2023 using a questionnaire. The recruits were invited by distributing the questionnaire in the supermarket in Erbil City. The participants were told that their participation is voluntary and the data will be utilized for research purposes and will be confidential.

A. Characteristic of Methodology

The study was included selecting random people who visited the supermarkets and rice distributes in Erbil city. Individuals were excluded they did not fully fill out the questionnaires. The study population was 282 people randomly different ages, genders and races. In this section we designed a questioner to evaluate people's opinion about the As in rice and the extent to which the people of the Kurdistan region are familiar with this arsenic in rice and their eating of rice. The survey is 29 questions and took participants approximately 5-10 minutes to complete.

B. The Questionnaire design and data collection

Section 1: includes sociodemographic data such as (age, gender, marital status, number of family members, education level, economic level, and job). Section 2: contained three items correlated to height, weight and physical activity. Section 3: includes 19 questions regarding participant's knowledge on arsenic in rice. The survey was launched on 20/2/2023 until 26/3/2023 a total of, 282 participated and filled in the survey.

C. Pilot test

One of the most important tool to support and strength research quality as well as to eliminate the bias and increase research truthfulness is the reliability and validity of the methodology including the questionnaire survey 23. To ensure the reliability and validity of this questionnaire, the prepared questionnaire was first giving to several academic staff of Nutrition and Dietetics Department at Cihan University Erbil. The purpose of this pilot study was to ensure the reliability and validity of the questionnaire and re-construct to avoid any ambitus items and improve the questions format. The observations were in term of length of questions, wording, and minor adjustment which were taken into account before conducting the official survey.

D. Inclusion and Exclusion criteria

Inclusion criteria: The people should be over 18 years old and the place not outside of Erbil. Exclusion criteria: Less than 18 years old are not included. All ethnic groups are included but they must live in Erbil. Participants outside Erbil city are not allowed.

E. Sample size

A total of 282 of people (N=282) were randomly selected from both genders. The size of the sample was finalized following the Yamane's formulation considering 50% prevalence at the finite targeted population:

$$n = N/ (1 + Ne^2)$$

282 participants involved in this questionnaire, where, n = size of the targeted sample, e = error of margin of 0.05 and N = size of the population. The size of the targeted sample is 165.

F. Ethical Consideration

Participate consent was taken once the participant reads the information sheet and cover letter and then filling out the questionnaire. The cover letter contained the study aim, requiring time to complete the questionnaire, and the contact information of the principles investigators. Joining the study was voluntary and all personal data were treated confidentially for academic purposes, and Participants assured that they can withdraw at any stage if they would feel uncomfortable with questions.

G. Statistical Analysis of Data

Various statistical analyses were performed to analyze data using SPSS statistical package for social sciences v. 21.0 (IBM). Statistical significance was set at a significant level of $p < 0.05$. The Shapiro-Wilk and Kurtosis test was employed to assess the normal distribution of the data. None of the group data was normally distributed. The Mann-Whitney U test was performed to compare the data between groups with two variables. Kruska test was used to compare the data between groups with more than two variables.

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- Grouping Variable: eating of rice
  The data analysis of eating rice showed that there is a significant difference (P<0.05) between eating rice in relation to marital status, education and job.
- Grouping Variable: source of rice
  The data analysis of source of rice showed that there is a correlated with marital statues (P<0.019) and education (p<0.047) and age (0.000) and income (0.043) but not associated with (gender, physical activity, family, job).
- Grouping Variable: breeding of rice
  The data analysis test revealed that the type of rice prefers was significantly correlated with gender (p<0.027) and marital status (0.024) and family (0.060) but not associated with age, physical activity, education, income, job.

III. Results and Discussion

Characteristics of the participants

A. Characteristics of Sociodemographic

The number of the participants was 282 volunteers from different supermarkets in Erbil city and all of them responded by filling the questionnaire. The data on socio demographic data showed that more than half 57% (162) of the participants were females and 43% (120) were males, and most of the participants 39% (110) were aged between (18 and 25 years old) the age group of (26 to 36 years old) was 35% (99) and the age group of (37 to 46 years old) was 20% (56). Whereas, the lowest percentage of participants were the group more than 46 years old by 6% (17) (Table 1).

Also, 56% (157) of them are married, and 44% (125) of the participants are single. Regarding the family members, the data on socio demographic information showed that most of them 45% (126) were (3 to 5 members), and the lowest percentage 6% (17) were more than (9 members). The results showed that 3% (9) of participants have a doctorate degree, some of them 20% (57) have not completed school, and 25% (71) of the participants are in high school. The highest percentages of the participants 51% (145) had bachelor's degrees.

Regarding income level, more than half 76% (215) of the participants had medium income, high income 18% (51), and low income had the lowest percentage of about 6% (16). In terms of job experience, the highest percentage of the participants was an employee 52% (148), and the lowest percentage was unemployed 21% (60), as were the student participants in this study was 26% (74).

B. Participants shape and physical activity

Regarding weight and height, the majority of the participants 43% (120) weight was between 51 and 65 kg, and 46% (131) of their height were between 161 and 170 cm, and the lowest 6% (17) participants weight was more than 90 kg, and 8% (23) their height was more than 180 cm. More than half 57% (160) of the participants have physical activity, and 43% (122) of them did not have any physical activity.

C. Participant's knowledge on As in rice

The data in Figure 1 shows that 94% (264) of the participants eat rice as a staple food in their diet. whereas 6% (18) of participants didn't use rice in their daily lives. This figures proves that how important rice is in Kurdish cuisine.

It is interesting that almost two of third (211) of the participants prefer the local source of rice, and 25% (71) prefer the imported rice source. A study conducted by Sadee et al. (2016) on local Kurdish rice, their results showed that the content of As of rice ranged 0.054-0.161 µg/kg which was within global normal range (80-200 µg/kg) [24],[25]. 54% (152) of

TABLE I
SOCIODEMOGRAPHIC DATA OF PARTICIPANTS PRESENTED FREQUENCY AND PERCENTAGE

Characteristics		Frequency	%
Gender	Male	120	43%
	Female	162	57%
Age	18 – 25 years old	110	39%
	26 – 36 years old	99	35%
	37 – 46 years old	56	20%
	Older than 46 years old	17	6%
Marital Status	Married	157	56%
	Single	125	44%
Family member	2 or less	52	18%
	3 to 5	126	45%
	6 to 8	87	31%
	More than 9	17	6%
Education level	No schooling completed	57	20%
	High school	71	25%
	Bachelor degree	145	51%
	Doctorate degree	9	3%
Income level	High income	51	18%
	Medium income	215	76%
	Low income	16	6%
Employment	Student	74	26%
	Employee	148	52%
	Unemployed	60	21%

TABLE II
PARTICIPANTS BODY WEIGHT, HIGH AND PHYSICAL ACTIVITY PRESENTED IN FREQUENCY AND (%)

Characteristics		Frequency	%
Weight (Kg)	Less than 50 kg	37	13%
	51 – 65 kg	120	43%
	66 – 90 kg	109	39%
	More than 90 kg	16	6%
Height (cm)	Less than 160 cm	69	24%
	161 – 170 cm	131	46%
	171 – 180 cm	59	21%
	More than 180 cm	23	8%
Physical Activity	Yes	160	57%
	no	122	43%

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the participants prefer eating long grain rice than short grain and the rest which is 46% prefer eating short grain. It is quiet fascinating that 87% of the participants preferred white rice, and 13% (36) of the participants interested in brown rice. In terms of how to serve rice, 36% (101) of the participants chose biryani as their favorite dish; dolma and cooked rice were 30% (86) and 29% (83) respectively; and other dishes were 4% (12) as it can be seen in Figure 2.

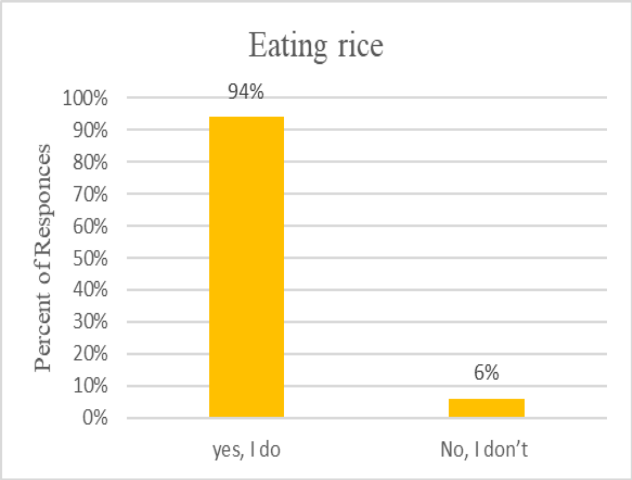

Fig. 1. Participants responses regarding eating rice

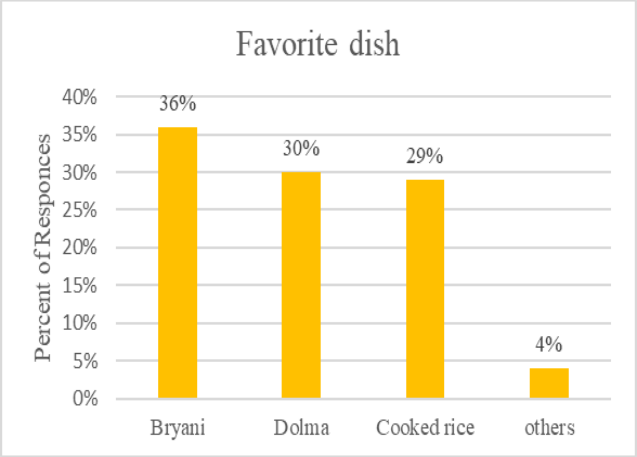

Fig. 2. Participants Favorite Dish

The number of meals that a participant eats rice at once in a week: 15% (41), twice, and three times: 24% (67), and 35% (99), respectively. Whereas only 27% (75) of the participants eat rice more than three times a week. 36% (101) of the participants consumed 1/2 cups of rice per single meal, 1 cup and 2 cups per single meal were used by 32% (90), 24% (69) of consumers respectively. However, only 8% (22) of the participants consumed more than 2 cups of rice per single meal (1 cup = 200 grams) (Figure 3). The cooking method also affects the alterations of the quantity of As that transfers to human body. For example, whether the rice is cooked in a closed cooker, an open pot over an open fire (or another source of heat), a lot of water, or very little water [26].Therefore a question was asked regarding the methods of cooking rice, 61% (172) of the participants used the boiling method, 26 % (74) of the participants used the absorption method, and the steaming method was used by 13% (36) of the participants.

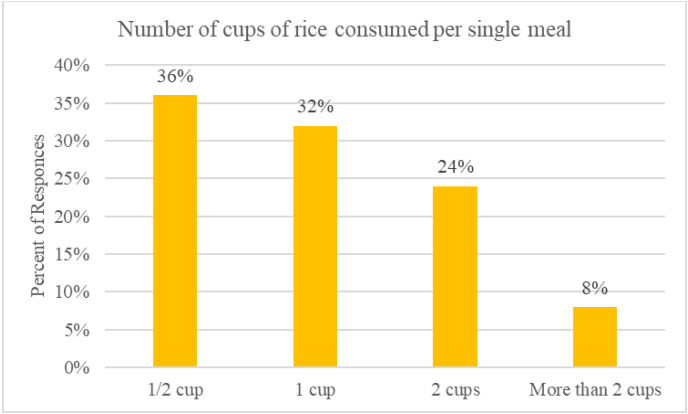

Fig. 3. Number of rice cups that participants consumed per single meal

As contamination commonly results from rice because of how quickly As transfer to the grain. The bioaccessibility of As, or the degree to which it is released from the food matrix, determines the health risk it poses. The bioaccessibility in the simulated small intestine slightly increased during digestion and gradually decreased in the simulated colon [27]. Based on that participants were asked about their knowledge on As and it turned out that more than half (54%) of the participants did not have information about As, and 32% (90) of the participants have had knowledge about As. Whereas 14% (40) of the participants were not sure about what As is. In addition, 51% (143) of the participants don't know that rice contains arsenic; however, 36% (101) know that rice contains arsenic, and 13% (38) of them are not sure about it. Several Kurdish rice samples have been examined including four well-known local rice samples grown in Akre and Harir in the Kurdistan region of Iraq, the total As concentrations ranged between 0.054 and 1.00 µg g-1. In addition, one famous Iraqi rice which is called Hamber short grain has also been analysed and was found to contain 0.149 µg g-1 total As. However, measuring the overall content of inorganic As in foods is typically satisfactory for risk assessment. The predominant As species in these samples were inorganic, encompassing both inorganic AsIII and AsV, constituting 63–100% of the total As [24,14]. These findings affirm that rice serves as a bioaccumulative plant for the most toxic forms of arsenic [5].

49 % of the participants don't know that As may cause health issues, 36% (102) of them already acknowledge that As can cause health issues, and 15% (41) of the participants are not sure about it. Figure 4 shows the knowledge of participants about InAs species, which are generally more toxic than organic As species. The results showed that 59 % (166) of the participants didn't have knowledge that InAs species are more toxic than organic forms. On the other hand, 27 % (77) were acknowledged of the variability in the degree of toxicity between various As species and the rest which is 14% (29) were not sure about it. Figure 5 shows the knowledge of participants that InAs species are classified as carcinogenic compounds. The results show that the majority of participants (60%) don't know

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have knowledge that InAs are carcinogenic compounds, while only 26% (77) revealed that they were aware of carcinogenicity of InAs species, and the rest which is 14% (39) were not sure about it. More than half of the volunteers that participated in this questioner (60%) are not aware that rice may contain both organic and inorganic species, while 28% of them already knew that realized that rice can accommodate both species and 12 % of them were not sure about it.

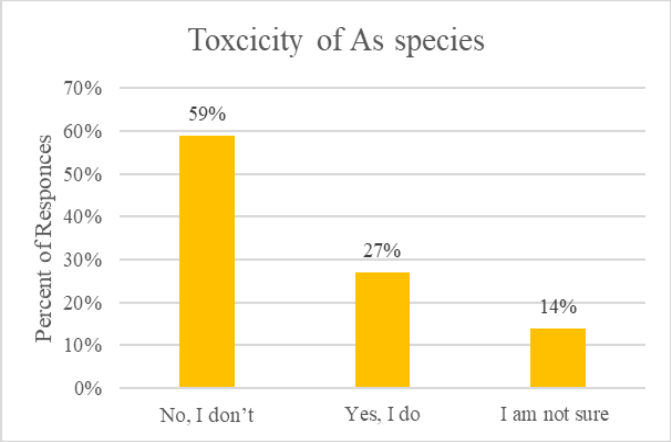

Fig. 4. Knowledge of inorganic As species generally indicates that they are more toxic than organic As

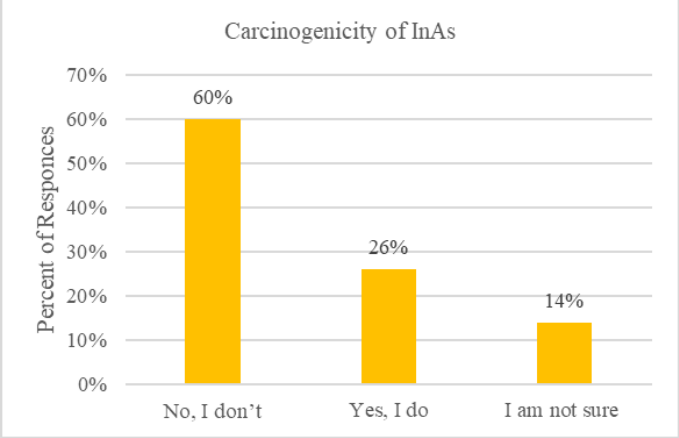

Fig. 5. Knowing that inorganic As species are classified as carcinogenic compounds

Figure 6 shows the participants responses about knowing that washing and cooking rice with the boiling method can help to reduce a partial amount of As from the rice, 55% of the participants don't know or have information about coking rice in extra amount of water then discard excess water led to remove partial quantity of As in rice. However, 35% of them were familiar with this approach to reduce As content in rice and 10% (29) are not sure about that. This is in line with a study that has been concluded that As is removed from white rice through milling, but between 75 and 90 percent of its nutrients are also lost. Previous research has demonstrated that cooking rice with too much water can remove As, but it also decomposes other nutrients.

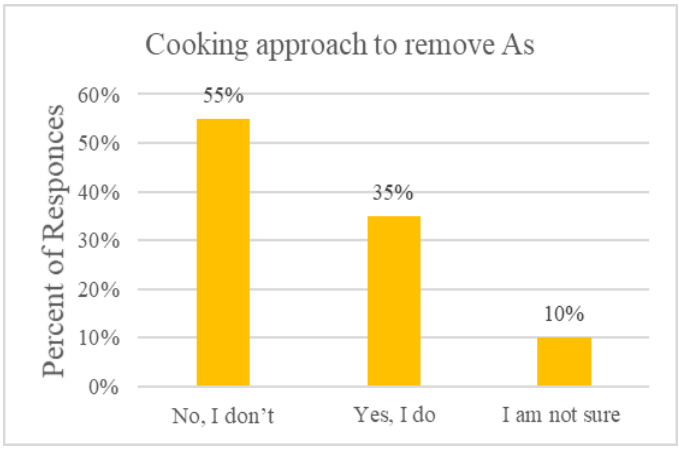

Fig. 6. Participants knowledge that washing and cooking rice with the boiling method can help remove a partial amount of As from the rice

The data in Figure 7 shows that more than half (89%, 251) of the participants believe that this information of this study is helpful for public health awareness about As, and 11% (31) of them think that's not useful. Figure 8 shows that 88% (249) of the participants think that this information will help them to reconsider about the amount of rice they eat, but 12% of the participants (33) decided not to rethink about the amount of rice they consume. Lastly, 72% (203) of the participants have decided that they will reduce the amount of rice they eat after this study, and 28% of the participant decided to not to avoid consuming or reducing rice in their diet.

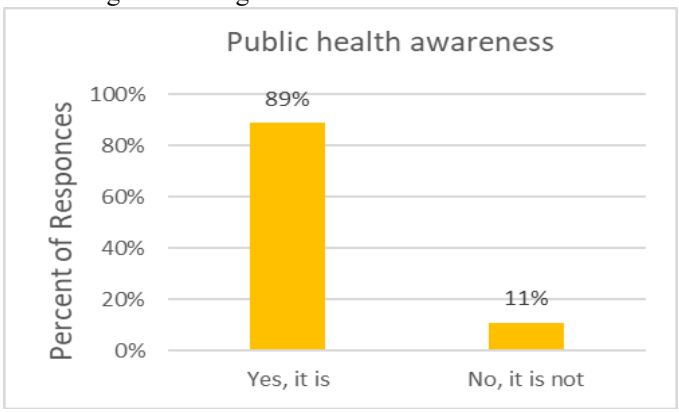

Fig. 7. Participants responses about this study indicate that the information is helpful for public health awareness about As

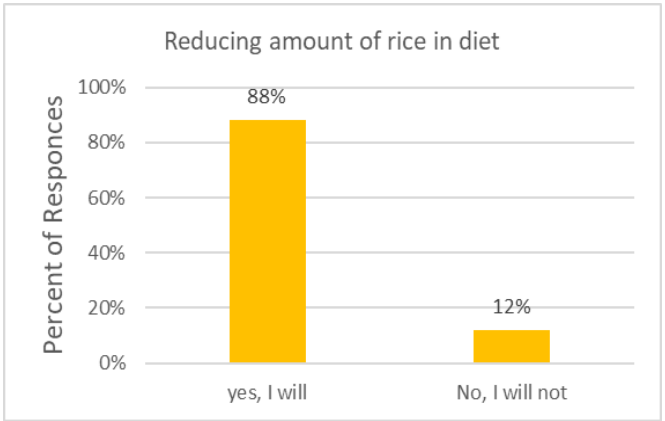

Fig. 8. Participants beliefs about whether this information will help them to rethink about the amount of rice they consume

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CONCLUSIONS

This study was conducted to evaluate the knowledge of Kurdish consumer about As in rice. Based on our findings, it was determined that 94% of the participants consume rice as a staple in their daily diet, with a preference for locally sourced white rice. In terms of cooking methods, over half of the participants utilize the boiling method, while some opt for absorption or steaming.

Interestingly, all participants possessed knowledge about arsenic, although prior to this study, only some were aware of its presence in rice. We speculate that this discrepancy may be attributed to varying educational backgrounds, as half of the participants are college students or hold bachelor's or doctorate degrees. The data reveals that more than half of the participants were unaware that inorganic arsenic species are generally more toxic than organic arsenic. Currently, most participants wash the rice thoroughly, believing it will help dissolve a significant portion of the arsenic. Additionally, they soak the rice in water before cooking it for an extended period to further reduce its arsenic content. participants agreed that this newfound information will prompt them to reconsider their rice consumption and have expressed their intention to reduce their rice intake following the conclusion of this study.

REFERENCES

1 T. S. Rathna Priya, A. R. L. Eliazer Nelson, K. Ravichandran and U. Antony, J. Ethn. Foods, 2019, 6, 1–11.

2 S. Muthayya, J. D. Sugimoto, S. Montgomery and G. F. Maberly, Ann. N. Y. Acad. Sci., 2014, 1324, 7–14.

3 B. A. Sadee and R. J. Ali, Environ. Nanotechnology, Monit. Manag., 2023, 19, 100761.

4 M. Quaghebeur, Z. Rengel and M. Smirk, J. Anal. At. Spectrom., 2003, 18, 128–134.

5 B. Sadee, M. E. Foulkes and S. J. Hill, J. Anal. At. Spectrom., 2015, 30, 102–118.

6 S. Fendorf, H. A. Michael and A. van Geen, Science , 2010, 328, 1123–1127.

7 B. A. Sadee, Cihan Univ. Sci. J., 2022, 6, 26–31.

8 M. M. Haque, N. M. Niloy, M. A. Khirul, M. F. Alam and S. M. Tareq, Heliyon.

9 A. Nabi, M. Naeem, T. Aftab, M. M. A. Khan and P. Ahmad, Environ. Pollut., 2021, 290, 118029.

10 D. Lièvremont, P. N. Bertin and M.-C. Lett, Biochimie, 2009, 91, 1229–1237.

11 B. A. Sadee, M. E. Foulkes and S. J. Hill, Food Chem., 2016, 210, 362–370.

12 V. K. Gupta, A. Nayak, S. Agarwal, R. Dobhal, D. P. Uniyal, P. Singh, B. Sharma, S. Tyagi and R. Singh, Desalin. Water Treat., 2012, 40, 231–243.

13 A. K. Sharma, J. C. Tjell, J. J. Sloth and P. E. Holm, Appl. Geochemistry, 2014, 41, 11–33.

14 M. E. Foulkes, B. A. Sadee and S. J. Hill, J. Anal. At. Spectrom., 2020, 35, 1989–2001.

15 M. F. Hughes, Toxicol. Lett., 2002, 133, 1–16.

16 E. Sanz, R. Muñoz-Olivas and C. Cámara, Anal. Chim. Acta, 2005, 535, 227–235.

17 Y. Liu, Y. Huang, L. Li, Y. Xiong, L. Tong, F. Wang, B. Fan and J. Gong, Food Control, 2023, 109876.

18 W. Ali, H. Zhang, M. Junaid, K. Mao, N. Xu, C. Chang, A. Rasool, M. Wajahat Aslam, J. Ali and Z. Yang, Crit. Rev. Environ. Sci. Technol., 2021, 51, 704–750.

19 A. H. Smith, E. O. Lingas and M. Rahman, Bull. World Health Organ., 2000, 78, 1093–1103.

20 B. A. Sadee, Y. Galali and S. M. S. Zebari, RSC Adv., 2023, 13, 30959–30977.

21 G. Bjørklund, P. Oliinyk, R. Lysiuk, M. S. Rahaman, H. Antonyak, I. Lozynska, L. Lenchyk and M. Peana, Arch. Toxicol., 2020, 94, 1879–1897.

22 A. P. F. Cardoso, K. T. Udoh and J. C. States, Toxicol. Appl. Pharmacol., 2020, 409, 115306.

23 S. M. Salih, 2017, authenticity and Quality of Muscle Foods: Assessing Consumer Trust and Fraud Detection Approaches (Doctoral dissertation, University of Plymouth). .

24 B. A. Sadee, M. E. Foulkes and S. J. Hill, Food Addit. Contam. Part A, 2016, 33, 433–441.

25 Y. J. Zavala, R. Gerads, H. Gürleyük and J. M. Duxbury, Environ. Sci. Technol., 2008, 42, 3861–3866.

26 D. A. Bender, R. Purchase, A. D. Ruthven, K. W. Waldron, I. T. Johnson, G. R. Fenwick, E. Kress-Rogers, B. Bergenstahl, V. Monnier and J. Baynes, Adv. Aquac. Hatch. Technol.

27 G.-X. Sun, T. Van de Wiele, P. Alava, F. Tack and G. Du Laing, Environ. Pollut., 2012, 162, 241–246.

DOI: http://doi.org/10.24086/biohs2024/paper.1266