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Determination of Alpha Particles and Heavy Metals Contamination in Meat Samples in Najaf, Iraq

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ABSTRACT

Introduction: The aim of the present study was to determine the levels of alpha particles and heavy metals contamination in the meat products consumed in Najaf, Iraq. Moreover, this study was also targeted toward comparing the results with those in the literature and making appropriate conclusion and recommendations.
Material and Methods: This study determined the track of alpha particles and heavy metals pollution in meat samples collected from the open markets in Najaf, Iraq. These meat samples included cow, sheep (lamb), chicken, and fish. The alpha particles contamination was determined using nuclear track detectors (CR-39). The heavy metal concentrations were analyzed using atomic-absorption spectroscopy.
Results: The highest alpha particles emission rate was 0.0204 mBq cm^{-2} in Ascary sheep (lamb). On the other hand, the lowest rate of alpha particles (0.00008 mBq cm^{-2}) was associated with Kufa fish. Gadeer sheep and Kufa chicken had the highest and lowest concentrations of cadmium, which were obtained as 0.2600 and 0.0020 ppm, respectively. Regarding the lead concentration, the highest and lowest concentrations were found in Kufa cow (0.8936 ppm) and Kufa chicken (0.0542 ppm), respectively.
Conclusion: This study indicated that alpha particle and heavy metal contamination in the meat samples were within permissible limits. Therefore, the consumption of the selected meat products did not pose any significant hazard to the public health in Najaf. Moreover, the findings suggested that there would be no increase in the current rates of not only particle contamination, but also heavy metal pollution, compared to those of international studies.

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Introduction

The term "heavy metals" is any mineral elements which has a relatively high density (5 $g.cm^{-3}$) and is toxic even in low concentrations [1]. Heavy metals are classified as necessary and unnecessary according to their benefits to human and living organisms. They are toxic to living organisms when their level of concentration exceeds the tolerable limit of the body cells [2]. The occurrence of heavy elements in the food is caused by industrial and environmental pollutions [3].

Heavy metals pollution in developing countries is a severe problem caused by mining, smelting, and tanning [4]. Another factor that leads to this type of pollution is the excessive use of chemicals and fertilizers to meet the higher demands of food production for human consumption [5]. Cadmium and arsenic are toxic elements that can be found in a variety of foods, and they have long environmental half-lives after being absorbed by humans and animals.

These toxic elements can have adverse effects on humans, such as causing damage organs of the body [6]. Heavy elements are dangerous and tend to bio accumulate (the level of a chemical in the biological organism is increased as compared to the concentration of a chemical in an environment) [7]. The excessive concentration of lead causes damage to the nervous system, as well as problems like brain disruption and blood disorders in mammals [8].

Alpha particles have a short range in solid and liquid materials, and they have no risk as other radiological patterns because the human can stop these particles through their skin. However, when these particles are inhaled or ingested, they can lead to mucous membrane dysfunction, which must be treated with caution [9]. Ionizing rays are often referred to as alpha particles. In a process called blood ionization, alpha-ionized particles enter or collide with the blood cells and cause leukemia as a result of the alpha particle interaction with the external electrons of the atom [10].

The radiation absorbed by tissue has sufficient energy to remove an electron from molecule [11]. These particles are detected by a nuclear track detector (CR39), with $C_{12}H_{18}O_7$ structure and the density of 1.31 $g.cm^{-1}$. The CR-39 monomer can

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polymerize and bind to homogeneous polymers [12]. The general composition of a monomer contains two groups of alleles. The CR39 contains weak carbon bonds, which break quickly when exposed to radiation. Therefore, it has a high detection sensitivity and is used to detect protons, alpha particles, or fission fragments. The aim of the present study was to determine the levels of alpha particles and heavy metals contamination in the meat products consumed in Najaf, Iraq. Moreover, this study was also targeted toward comparing the results with those in the literature and making appropriate conclusion and recommendations.

Materials and Methods

The samples in this study were composed of 20 meat products of sheep, cow, chicken, and fish obtained from the markets in Najaf. The meat products were cut into pieces and kept inside the Petri dishes, on which the name and details of the samples were recorded. The samples were dried using an oven (MEMMERT, Germany) at 150ºC for 5 h. After drying, they were ground using a ceramic vase and weighed by a sensitive scale (Adam Equipment Inc, UK, CT 06478, PW 214), with an error rate of 0.0001 g. The homogeneous samples were then set in contact with the CR39 detector (Track Analysis Systems Ltd. Bristol, UK, 25×25×1.5 mm TASTRAK) to count the tracks of alpha particles.

Afterwards, the samples and the detector were placed inside a vacuum polyethylene bags and sealed to prevent entering the air. Later, the samples were kept in the freezer at -20°C for 33-142 days. The samples were then removed from the CR39 detectors and etched in 6.25 M NaOH solution to count the tracks of alpha particles in meat samples. These tracks were counted by a microscope (Kruss, Optronic, Germany), along with a camera (MDCE-5C) at 10× magnification as illustrated in Figure 1.

The calibration of the CR39 detector was used to enable the quantitative assessment of the alpha particles contaminations. Moreover, CR-39 and RAD7 detectors were used to determine the alpha particles. RAD7 detector used in the current study was model 711 (Durridge Co., USA) calibrated using ^{226}Ra source (85 kBq) obtained from the International Atomic Energy Agency in a closed system. The calibration factor for CR-39 was about 0.0296 track/cm^{-2} per Bq.day.m^{-3}. The calibration results revealed that the response was linear. The alpha spectra showed two peaks of 6.00 and 7.68 MeV for ^{218}Po and ^{214}Po, respectively [13].

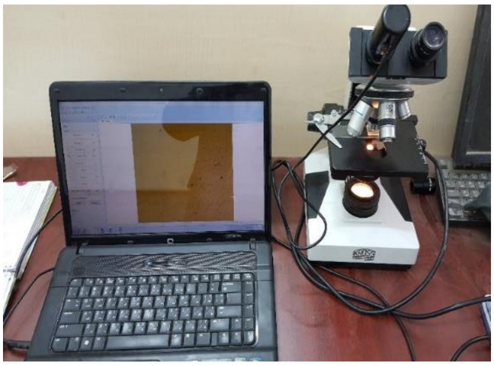

Figure 1. Process of counting the track of alpha particles

Figure 2 demonstrates the typical alpha particle tracks in the different types of meat from fish, sheep, chicken, and cow under the optical microscope.

After extracting the samples from the freezer, 100 ml of distilled water was added to the meat, and then heated using a hitter with a magnetic field (Velp Scientifica, Usmate, Italy) for 30 min as illustrated in Figure 3a. The samples were filtered using a paper filter (Figure 3b) and placed in a test tube for measuring heavy metals (Figure 3c). Heavy metals in the samples were measured by an atomic absorption spectrophotometer (Shimadzo 6300 AA., Japan) as it was used in previous studies [13]. The atomic spectroscopy analyzes heavy metals by its electromagnetic or mass spectrum. The calibration of the equipment used to enable the quantitative assessment of the heavy metal concentration was performed by using standard elements of Cd and Pb.

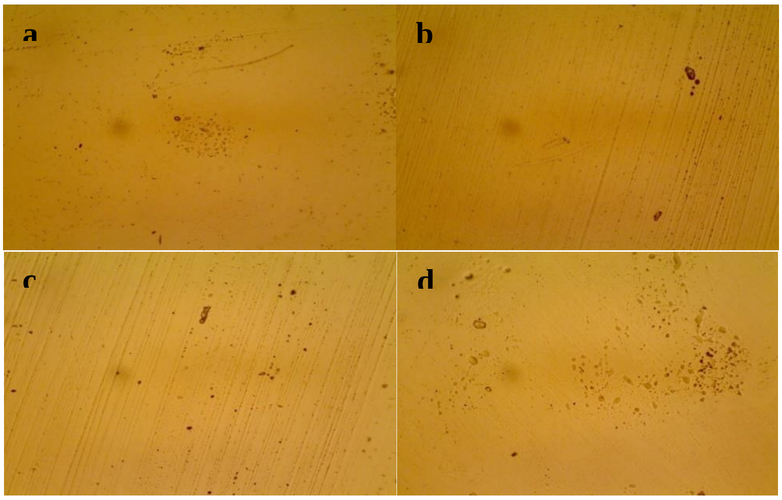

Figure 2. Typical alpha particle tracks in meat samples; a) fish, b) sheep, c) chicken, d) cow

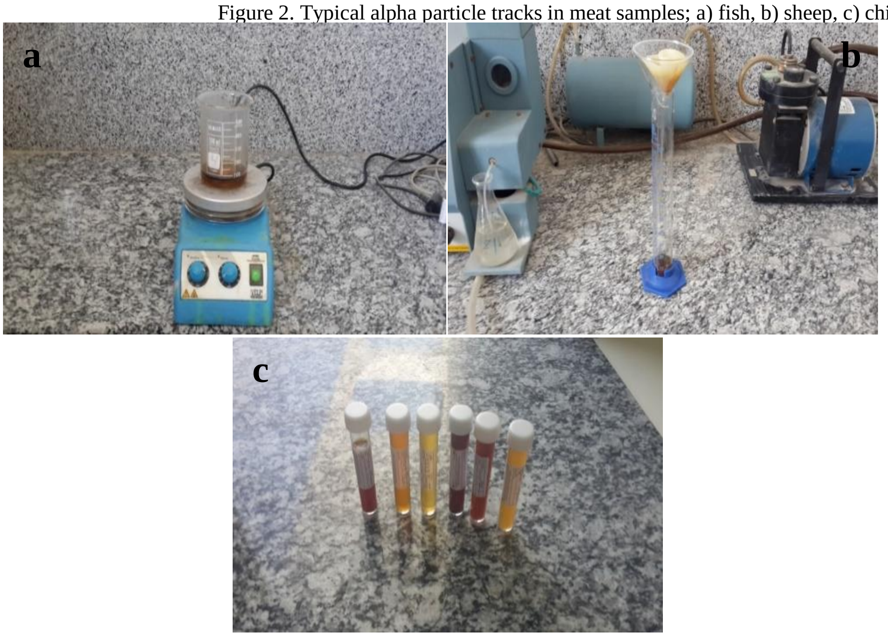

Figure 3. Process of sample preparation; a) heater, b) filtration, c) test tube

Results

Table 1 shows Cd and Pb contaminations in the samples of the current study. Gadeer sheep and Kufa chicken had the highest and lowest concentrations of cadmium, which were obtained as 0.2600 and 0.0020 ppm, respectively. Regarding the lead concentration, the highest and lowest concentrations were found in Kufa cow (0.8936 ppm) and Kufa chicken (0.0542 ppm), respectively. The mean concentrations of Pb (0.343±0.043) was higher than Cd (0.129±0.023).

Table 2 is showed mean rate of alpha particle emission. The highest alpha particles emission rate was 0.0204±0.0014 mBq cm-2 in Ascary sheep meat. On the other hand, the lowest rate of alpha particles (0.0001±0.0000 mBq cm-2) was associated with Kufa fish.

Table 1. Cadmium and lead concentrations (ppm)

SC	Sample type	Sample location	Cd	Pb
278	Cow	Gadeer	0.260	0.433
211	Sheep		0.007	0.217
170	Chicken		0.013	0.244
205	Fish		0.222	0.190
167	Cow	Adala	0.139	0.135
284	Sheep		0.251	0.163
164	Chicken		0.023	0.406
189	Fish		0.009	0.515
155	Cow	Kufa	0.006	0.894
209	Sheep		0.020	0.379
271	Chicken		0.002	0.054
158	Fish		0.178	0.291
194	Cow	Ascary	0.217	0.298
147	Sheep		0.202	0.677
157	Chicken		0.224	0.244
250	Fish		0.239	0.487
266	Cow	Qadesia	0.230	0.325
221	Sheep		0.220	0.298
232	Chicken		0.038	0.324
251	Fish		0.088	0.293
Average			0.129±0.023	0.343±0.043

SC=Sample Code

Table 2. Mean rate of alpha particle emission

SC	Track/cm^{-2}d^{-1}	E_α (mBq.cm^{-2})	±SE of E_α mean
278	0.433	0.0043	0.0008
211	0.444	0.0044	0.0009
170	0.087	0.0009	0.0001
205	0.222	0.0022	0.0003
167	0.114	0.0011	0.0001
284	0.159	0.0016	0.0003
164	0.674	0.0066	0.0010
189	0.019	0.0002	0.0000
155	0.023	0.0002	0.0000
209	0.540	0.0053	0.0006
271	0.229	0.0023	0.0003
158	0.008	0.0001	0.0000
194	0.070	0.0007	0.0001
147	2.074	0.0204	0.0014
157	0.213	0.0021	0.0005
250	0.294	0.0029	0.0004
266	1.072	0.0105	0.0002
221	0.070	0.0007	0.0015
232	0.024	0.0002	0.0001
251	0.082	0.0008	0.0003
Average	0.3426	0.0033	0.0004

SC=Sample Code

Discussion

Cadmium Gadeer sheep higher than Kufa chicken. Lead Kufa cow higher than Kufa cow. The mean Pb higher than Cd. The alpha rate in Ascary sheep meat higher than Kufa fish. Table 3 summarizes the heavy metal and alpha particle emission rates of different samples obtained in the different parts of the world, as well as the results from the current study.

Table 3. Heavy metals and alpha particle emission rates of meat samples compared with the values reported from other countries

Country	Cd (ppm)	Pb (ppm)	E_α (mBq cm^{-2})
Turkey [14]	….	1.100	….
Iraq [15]	….	….	0.042
Iraq [16]	….	….	0.047
Iraq [17]	….	….	0.147
Malaysia [18]	….	….	0.392
Malaysia [19]	….	….	0.004
Bangladesh [20]	….	2.080	….
India [21]	BDL	6.000	….
China [22]	0.130	0.534	….
Egypt [23]	1.110	1.810	….
Nigeria [24]	0.010	0.007	….
Ghana [25]	0.044	3.665	….
Permissible limit [26]	0.100	0.20-0.50	….
Present study	0.129	0.343	0.003

BDL: below detection level

Alpha particle emission rates measured in this study were approximately compatible with the values obtained in Malaysia [19] and lower than that those reported in Turkey, Iraq, and the value is compatible with Malaysia [14-18]. The Cd value measured in this study seemed to match the value reported in China. Although Cd value was slightly higher than the permissible limit and the one reported in Egypt [23, 26], it was higher than those estimated in other areas [24, 25]. The Pb concentration determined in the current study was lower than those reported in Bangladesh, India, China, Egypt, and Ghana [20-23, 25]. However, it was within the range of the permissible limit and the value reported in Nigeria [24, 26]. This means that the meat samples in this study were free of environmental alpha particles and heavy metal contamination, compared to the other international studies as shown in Table 3. Therefore, there was no hazard in meat consumption regarding alpha particle and heavy metal contamination.

Conclusion

The variation in alpha particle rates as radioactivity in the meat collected from Najaf markets may depend on the transfer rate of alpha particles from the environment to the meat. All the heavy metals were within the permissible limit. Overall, the alpha particles rate was low, and there was no threat to the public health. In the present study, the alpha particle emission rate was lower than the minimum detectable value. The results of this study can be of significant importance in finding the intake rates and exposure to heavy metals and alpha particles. It is suggested to continuously monitor the quality of food sources in these locations.

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