Determination of Radio Nuclides for some Local Foodstuffs in Republic of Yemen by using Gamma Rays Spectral Analysis Technique

Khalid AL-Maqtary, Mohammad Murshid*, Abdulaziz Bazohair ** and Mohammad AL-Zuhairy*

Received on Dec. 10, 2006 Accepted for publication on March 17, 2008

Abstract

This study is considered as the first research study on locally produced consumed food in the Republic of Yemen. The objective of this study is to measure concentration of radio nuclides $^{137}$Cs and $^{40}$K in food samples produced in Yemen. Twenty two local foodstuffs samples were collected from provinces,Themar, Ibb, Hudaidah and Lahj, due to the massive crops production. Gamma spectroscopy consist of high purity germanium (HPGe) detector with resolution of 2.11 keV at 1332 keV energy which related to $^{60}$Co isotope. The detector is interfaced to two amplifiers and multichannel analyzer (mca). The maximum concentration of $^{137}$Cs was found in garden pea samples brought from Lahj province $13\pm 1.5$ Bq/kg. The minimum concentration was found in wheat samples brought from Themar province $2.5\pm 0.2$ Bq/kg. The maximum concentration of $^{40}$K was found in garden pea samples brought from Lahj, $1000\pm 15$ Bq/kg. The minimum concentration was in forage sorghum samples brought from Hudaidah $40\pm 1.5$ Bq/kg. The studied samples are radiological safe and okay for human consumption.

Keywords: Yemen, Foodstuffs, Concentration, Radioactivity.

I. Introduction

There is a clear link between exposure to radiation and the contamination of food. Nuclear releases are directly deposited in crops, water and soil, or they are indirectly transferred to man by food or water [1] or directly by cosmic rays and radon. (Figure 1) shows the contamination ways of food and water intake by human. The radionuclide contaminating food is of four sources. One of these is natural. The others are all artificial.

a. The natural source includes all the natural radioactive isotopes $^{40}$K, Uranium, and thorium series, Cosmic rays etc.

b. The artificial sources which include:
   1. Nuclear weapon testing,
   2. Nuclear accidents,

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* Physics Department, Faculty of Science, IBB University, Yemen.
** Physics Department, Faculty of Science, Haghramout University, Yemen.
3. Operating of nuclear facilities, and
4. Retainment of nuclear fuel.

Because of the hazardous effects of these sources on human health, the permissible annual limits intake (ALI) were determined for every single radioactive isotope by the International Commission on Radiological Protection (ICRP)[2].

Furthermore, many studies are increasingly promoted to estimate the contents of natural and artificial radioactivity in foodstuffs[3-12]

The purpose of this study is to investigate the contamination of local foodstuffs in Yemen by forms of radiation, natural or artificial. It determines $^{40}$K and $^{137}$Cs contents in such local foodstuffs.

![Diagram](image)

**Figure 1:** The contamination ways of foodstuffs via the radio-nuclides

**II. Experimental procedures**

The samples of foodstuffs were collected from provinces Themar, Ibb, HudaIdah and Lahj and brought to the laboratory, thoroughly cleaned from impurities and dried at room temperature and kept in Marinelli beakers for 40 days.

The laboratory gamma spectrometry setup consists of horizontal high purity germanium (HPGe) detector with a sealed preamplifier, a bias high voltage supply, a liner amplifier, a detector shield made of 5 cm thick lead lined with aluminium and iron plates for x-ray degradation, and a multichannel analyzer (mca) of Ortec-model with 1024 channels as shown in the block diagram (Fig. 2)
The Hp Ge is a Canberra model with a crystal having diameter of 15.2cm, a length of 7.5cm and a resolution of 2.11 keV at the gamma line 1332kev for $^{60}$Co radioactive source. Energy calibration (Fig.3) is needed to identify the photo-peaks present in the spectrum.

Figure 2: Illustrates the system of detection and measurement of $\gamma$ - rys

Figure 3: The energy calibration curve
Efficiency calibration is necessary for radioactivity measurement. For this reason we used a standard sealed $^{152}$Eu radioactive source contained in Marinelli beaker. This source has a long half-life (13.50 years) and produces multilined spectra, which contain the major photo peaks usually encountered in natural radioactivity measurements. The Efficiency is given by the following

$$Efficiency(\varepsilon) = \frac{C_{ps}}{A I_{\gamma}} \times 100$$

Where:

- $C_{ps}$: is the count rate or count per second
- $A$: is the activity of reference radio nuclide in (Bq)
- $I_{\gamma}$: is the intensity decay (%) of photon emission at energy (E)

The calculated efficiency curve is illustrated in fig. (4)

**Figure 4: The Efficiency Curve**
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For the radionuclide measurements in samples, radioactivity levels were found very low. For this reason, large containers were to be used and longer measuring time were to be allowed. Large containers can make auto-absorption error on the results; therefore, it is recommended to use the Marrinelli beaker geometry which gives optimum results for counting times of 4000 sec.

III. Results and Discussion

Minimum Detectable Concentration (MDC) [13] is given by:

\[ MDC = 4.66 \left( \frac{S_n}{\epsilon I} \right) \] ......................................................... (2)

\( S_n \) is the estimated standard error of the net count rate.

\( \epsilon \) is the counting efficiency at the specific energy (%)

\( I \) is the intensity per decay (%) of photon emission at the energy (E)

\( W \) is the weight of the sample in kg.

The specific activity of the sample (Bq/kg) is calculated as follows [13].

\[ S.A. = \frac{C}{\epsilon t_w} \] .................................................................................. (3)

Where:

\( C \) : is the net counts of the photo peak (Bq).

\( t_w \) : is the time count of measurements (sec).

The Detection Limit (DL) of our method is calculated by Currei equation [14] as follows:

\[ D.L. = 2077 \pm 3.29 \sqrt{B.G.} \cdot \frac{Concentration(c)}{NetArea(a)} \] ........................................ (4)

Where

B.G. : is the background

\( C \) : is the concentration of the sample

\( a \) : is the net area

In (table 1) we present our measurements of \( ^{137}\text{Cs} \) concentration in various food crops at the different locations of study.

In (table 2) we present our measurements of \( ^{40}\text{K} \) concentration in various food crops at the different locations of study.

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The results showed that the concentration of Cesium ranges from $2.5 \pm 0.2$ to $13\pm1.5$ Bq/kg, and for Potassium from $(40.5 \pm1.5 \text{ to } 1000\pm30)$ Bq/kg.

By comparing the results of this work with those published by World Health Organization (WHO)[16,18] or the International Commission on Radiological Protection (ICRP) [17] and the Annual Limit on Intake (ALI)[16,19] it was found that the radioactivity of the nuclides in the investigated local foodstuffs is less than the internationally permissible limits. In other words, we can conclude that such foodstuffs are radiological safe and okay for human consumption.

Table (1): Concentration of $^{137}$Cs Bq/kg

<table>
<thead>
<tr>
<th>Sample</th>
<th>Province</th>
<th>Themar</th>
<th>Hudaidah</th>
<th>Ibb</th>
<th>Lahj</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td></td>
<td>2.5±0.2</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Barley</td>
<td></td>
<td>4.4±0.3</td>
<td></td>
<td>-</td>
<td>-</td>
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<tr>
<td>Indian Corn</td>
<td></td>
<td>B.D.L</td>
<td>3.6±0.4</td>
<td>4.2±0.3</td>
<td>3.3±0.2</td>
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<tr>
<td>Forage Sorghum</td>
<td></td>
<td>3.7±0.3</td>
<td>3±0.2</td>
<td>4±0.3</td>
<td>10±1</td>
</tr>
<tr>
<td>Pros Millet</td>
<td></td>
<td></td>
<td>3.5±0.3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chocolate Corn</td>
<td></td>
<td></td>
<td></td>
<td>5±0.3</td>
<td>7±0.3</td>
</tr>
<tr>
<td>Broad Bean</td>
<td></td>
<td></td>
<td>4±0.3</td>
<td>-</td>
<td>B.D.L</td>
</tr>
<tr>
<td>Sesame</td>
<td></td>
<td></td>
<td>B.D.L</td>
<td>B.D.L</td>
<td>4±0.3</td>
</tr>
<tr>
<td>Garden Pea</td>
<td></td>
<td>8.5±0.7</td>
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<td>13±1.5</td>
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<tr>
<td>Arachide</td>
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<td></td>
<td></td>
<td>-</td>
<td>8±0.8</td>
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<tr>
<td>Coffee</td>
<td></td>
<td></td>
<td></td>
<td>-</td>
<td>5.6±0.5</td>
</tr>
</tbody>
</table>

B.D.L. = Below Detection Limit
Table (2): Concentration of $^{40}$K Bq/kg

<table>
<thead>
<tr>
<th>Sample</th>
<th>Province</th>
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<th>Hudaidah</th>
<th>Ibb</th>
<th>Lahj</th>
</tr>
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<tr>
<td>Wheat</td>
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<td>160±16</td>
<td>-</td>
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<td>Barley</td>
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<td>750±20</td>
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<td>Indian Corn</td>
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<td>170±20</td>
<td>110±10</td>
<td>130±7</td>
<td>600±55</td>
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<tr>
<td>Forage Sorghum</td>
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<td>220±25</td>
<td>40.5±1.5</td>
<td>140±10</td>
<td>300±30</td>
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<tr>
<td>Pros Millet</td>
<td></td>
<td>-</td>
<td>250±30</td>
<td>-</td>
<td>200±15</td>
</tr>
<tr>
<td>Chocolate Corn</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>192±12</td>
</tr>
<tr>
<td>Broad Bean</td>
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<td>-</td>
<td>90±10</td>
<td>-</td>
<td>200±15</td>
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<tr>
<td>Sesame</td>
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<td>80.1±1</td>
<td>130±8</td>
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<tr>
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<td>-</td>
<td>1000±30</td>
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<tr>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>82±1.7</td>
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<tr>
<td>Fenugreek</td>
<td></td>
<td>200±15</td>
<td>-</td>
<td>-</td>
<td>90±2</td>
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</tbody>
</table>
قياس تراكيز النويعات المشعة في بعض الأغذية المحلية في الجمهورية اليمنية

المحفوظ
خالد المفتي، محمد مرشد، عبد العزيز بوزهير و محمد الزهيري

ملخص

تعد هذه الدراسة الأولى لتحديد تراكيز النويعات المشعة في الأغذية المنتجة في الجمهورية اليمنية. وتهدف هذه الدراسة إلى معرفة تراكيز النويعات المشعة 137Cs و 40K في بعض الأغذية المحلية في الجمهورية اليمنية، جمعت المثل وعشرون عينة من الأغذية المحلية من محافظات ذمار.الحديثة، ولحج، حضرت العينات لقياس تراكيز النويعات المشعة بوساطة منظومة مطيافية. أظهرت النتائج أن أعلى تراكيز للنظر هي 137Cs كائن في عينة البارز، المأخوذة من محافظة لحج وبلغ (13±1Bq/Kg) Constraints) والأخوذة من محافظة ذمار. بينما 1.5Bq/Kg (القصص) وعلاق تراكيز له كان في عينة البارز، المأخوذة من محافظة لحج وبلغ (1000±30Bq/Kg). ووحول تراكيز له كان في عينة الذرة البيضاء، المأخوذة من محافظة ذمار وبلغ (40±0.5Bq/Kg). من النتائج إمكانية الكشف عن 40K في جميع العينات. من خلال هذه الدراسة لا توجد تراكيز غير اعتيادية للنويعات المشعة في العينات المخصوصة، وعليه يمكن القول أن تراكيز النوات المشعة في تلك الأغذية أقل مما هو مسموح به من قبل اللجنة الدولية للوقاية من الإشعاع ICRP لذا فإن هذه الأغذية تعد سليمة وأمنة للإنسان البشري من حيث النفوذ الإشعاعي.

الكلمات المفتاحية: اليمن، الوعي الإشعاعي الطبيعي، التلوث الإشعاعي للغذاء المحلي

References


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