2015 FERN Rapid Detection and Identification of Gamma Radionuclides in Food

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What is FERN?

- Food Emergency Response Network
  - Chemical, Biological, Radiological
- Network of Laboratories coordinated to respond to threats to the nation’s food supply
  - FDA/ USDA
- Need for Radiological Proficiency Testing
  - Alpha
  - Beta
  - Gamma
Background

- Radioactive contamination of food is mostly heterogeneous from either direct (by surface deposition), indirect (via food chain), or induced (expose to neutrons) contaminations.
- Reliable detection of radioactive contamination in food requires test sample to be taken from homogenized food composite
- High-throughput food screening calls for exercising simple, efficient, and practical sample preparation procedure
- Rapid screening capability needs to be demonstrated at a measurable activity significantly below the maximum permissible level to minimize the need for confirmatory analysis

Objectives

- Practice handling and preparation of different types of radioactive foods in real-world conditions
- Validate FERN radiological labs’ ability to correctly identify gamma radionuclides in foods
- Prove capability of γ-ray spectrometry methods with heterogeneous samples and quick 10-min counting
- To test speed and efficiency of receiving samples by the FERN labs during emergency response

Approach

- Make use of composite food samples consisting of contaminated and uncontaminated subs
- Conduct proficiency test with regular food products containing blind gamma radionuclides
- Inclusion of blind blank sample to detect potential sample cross contamination
- Test method’s detectability at gamma activity levels <1/3 FDA derived intervention levels (DILs)
- Avoid radioactive contamination by limiting sample’s activity under the DOT exempt quantity
2015 FERN Gamma Sample Preparation Scheme

Primary Radionuclide Standards

- $^{134}\text{Cs}$
- $^{137}\text{Cs}$
- $^{60}\text{Co}$
- $^{133}\text{Ba}$

Sample Preparation Scheme:

- Refried Bean (D)
- Tomatoes (A)
- Chicken Pot Pie (B)
- Yogurt (E)
- Orange (C)

$^{134}\text{Cs}/^{137}\text{Cs}$ Spike

$^{60}\text{Co}/^{133}\text{Ba}$ Spike

Blank
Test Sample Basics

Test sample sizes: 0.5 – 1.5 kg

\[ ^{134}\text{Cs} = 27.47 \pm 0.60 \text{ Bq/sample} \]
\[ ^{137}\text{Cs} = 30.09 \pm 0.71 \text{ Bq/sample} \]
\[ ^{60}\text{Co} = 99.88 \pm 1.81 \text{ Bq/sample} \]
\[ ^{133}\text{Ba} = 17.25 \pm 0.47 \text{ Bq/sample} \] (Outside the scope of study)

\[ ^{134}\text{Cs} / ^{137}\text{Cs} \text{ activity ratio} = 0.91 \]

Test sample gamma activities were 5 – 36 folds below regulatory limits

**Codex Guideline Level:**

\[ ^{134}\text{Cs} = 1000 \text{ Bq/kg} \]
\[ ^{137}\text{Cs} = 1000 \text{ Bq/kg} \]
\[ ^{60}\text{Co} = 1000 \text{ Bq/kg} \]

**FDA DIL Level:**

\[ ^{134}\text{Cs} + ^{137}\text{Cs} = 1200 \text{ Bq/kg} \]
Spiking Tomatoes
Spiking Chicken Pot Pie
No Spike addition for Oranges
Chicken Pot Pie

Ba-133

Status of Detection

Laboratory ID

Co-60

+ ++ ++ ++++++++ ++++

Yogurt

Ba-133

Status of Detection

Laboratory ID

Co-60

+ ++ ++ ++++++++ ++++

Laboratory ID

Yogurt

Ba-133

Status of Detection

Laboratory ID

Co-60

+ ++ ++ ++++++++ ++++

Laboratory ID
Radionuclide Identification

- $^{134}\text{Cs}$: 100% Correct Identification Rate
- $^{137}\text{Cs}$: 100% Correct Identification Rate
- $^{60}\text{Co}$: 100% Correct Identification Rate
- $^{133}\text{Ba}$: 100% Correct Identification Rate
Photos of Damaged Sample Containers
Photos of Intact Sample Containers
Damaged Sample Containers Around Nation

26% package survived
74% package compromised

- Green: Intact
- Orange: Minor damage/cracked open
- Red: Largely damaged/spilled
Lessons Learned

Shipping Test Samples Requires:
Strong sample container
Secondary containment
2016 FERN Exercise on Detection and Identification of Gamma-Emitting Radionuclides in Food
2016 FERN Gamma Sample Preparation Scheme

Primary Radionuclide Standards

- **$^{134}\text{Cs}$**
- **$^{137}\text{Cs}$**
- **$^{60}\text{Co}$**

Sample Preparation Scheme:

1. **$^{134}\text{Cs}$**
2. **$^{137}\text{Cs}$**
3. **$^{60}\text{Co}$**

- **Mixed Salad (A)**
- **Parmesan Cheese (B)**
- **Ground Beef (C)**
Test Sample Basics

Types of food samples:  
(A) Mixed salad  
(B) Parmesan cheese  
(C) Ground beef

Range of sample weights:  0.3 – 2.4 kg

Sample Activity:  
$^{134}\text{Cs} = \sim 229 \text{ Bq/kg}$  
$^{137}\text{Cs} = \sim 271 \text{ Bq/kg}$  
$^{60}\text{Co} = 176 – 212 \text{ Ba/kg}$

Sample activities were 4.4 – 5.7 times below regulatory limits

Codex Guideline Levels:  
$^{134}\text{Cs} = 1000 \text{ Bq/kg}$  
$^{137}\text{Cs} = 1000 \text{ Bq/kg}$  
$^{60}\text{Co} = 1000 \text{ Bq/kg}$

FDA DIL Level:  
$^{134}\text{Cs} + ^{137}\text{Cs} = 1200 \text{ Bq/kg}$
Preparation of Spiked Mixed Salad Samples

Spiking
One piece of lettuce per bag

Sealing
Use of original commercial packing

Weighing
Sample activity concentration per fresh weight
Preparation of Spiked Parmesan Cheese Samples

Spiking
One spot at the center of product

Weighing
Sample activity concentration per sample net weight
Preparation of Spiked Ground Beef Samples

Preparation
Make one hole at the center of the product

Spiking
Add spike to the hole

Weighing
Activity concentration per net sample weight
All participants correctly identified the radionuclides presented in the test samples.
Method Detectability

Mixed Salad

Cs-134

Cs-137
Method Detectability

Parmesan Cheese

Status of Detection

Co-60

Laboratory
Method Detectability

Ground Beef

Co-60

Status of Detection

Laboratory
## Difference Between Measured and Known Values, %

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Participation and Sample Shipping Around Nation

100% of packages were received in good condition

- **Intact**
- **Minor damage/cracked open**
- **Largely damaged/spilled**
Summary of Study

- Composite and homogenization of heterogeneously contaminated food products for gamma spectrometric analysis were realistically practiced.

- Sample homogenization methods used by some participating laboratories need improvement.

- All laboratory’s methods were able to correctly identify gamma radionuclides presented in the test food samples.

- Radionuclides of interest were detectable down to 1/4 of regulatory limits with 10-min count time.

- Previous problems on sample shipping were resolved.
List of Participants

Colorado Department of Public Health and Environment
Dr. Katherine A. Kelley Connecticut State Public Health Laboratory
Florida Department of Health Bureau of Radiation Control
Idaho State University Environmental Monitoring Laboratory
Illinois Emergency Management Agency
Indiana State Department of Health Laboratories
State Hygienic Laboratory at the University of Iowa
Kentucky State Public Health Laboratory
Maryland Department of Health and Mental Hygiene
Minnesota Department of Health
New Hampshire Department of Public Health-Radiochemistry Laboratory
New Jersey Department of Health, Public Health and Environmental Laboratories
NY Wadsworth Center- Biggs Laboratory
Commonwealth of Massachusetts Radiation Control Program, MA Environmental Radiation Laboratory
South Carolina Department of Health and Environmental Control Bureau of Environmental Services
Sandia National Laboratoires-Radiation Protection Semple Diagnostics
Tennessee Department of Health Nashville Division of Laboratory Services
Texas Department of State Health Services Laboratory
Vermont Department of Health Laboratory
Virginia Division of Consolidated Laboratory Services
State of Washington, Department of Health Public Health Laboratories
Wisconsin State Laboratory of Hygiene, University of WI-Madison
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Missouri State Public Health Laboratory
State of Maine Health and Environmental Testing Laboratory