NOTE *Public Health*

Early-Stage Bioassay for Monitoring Radioactive Contamination in Living Livestock

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ABSTRACT. Soil samples from the ground surface and feces and blood from a mixed-breed male pig were collected on April 10, 2011 at a farm within 20 km of the Fukushima Daiichi nuclear power plant. The radioactivity of each sample was measured using a Ge semiconductor detector. Despite the fact that the pig had been fed non-contaminated imported feed, ^{131}I, ^{134}Cs and ^{137}Cs were detected in the feces, and ^{134}Cs and ^{137}Cs were detected in the blood clots. Because it is considerably difficult to measure radioactive contamination in the edible muscle of living livestock, bioassays are an option for the screening of radioactive contamination in living livestock to ensure food safety.
KEY WORDS: bioassay, cesium, Fukushima, iodine, radioactive contamination.

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The earthquake and subsequent tsunami that occurred in March, 2011 resulted in an accident at the Fukushima Daiichi nuclear power plant, and the consequent radioactive contamination of farm products has become a serious problem. Newspapers and news broadcasts report that spinach, milk, and Konago fish (*Ammodytes personatus*) were affected in March 2011 immediately after the accident, as a result of the accident. Vegetables, milk, and fish were inspected before shipment; thus, these products contaminated with radioactive substances were not distributed. The surface radiation dose in livestock was screened with gamma-ray survey meters when animals were moved from the surrounding controlled area to other areas. However, beef that was contaminated with radioactive material had been widely distributed all over Japan in July 2011 (http://www.mhlw.go.jp/stf/houdou/2r9852000001jc5x.html). If we can detect the amount of internal contamination present in the living livestock, this procedure would greatly contribute to ensuring food safety.

On April 10, 2011 (noon, 30 days after the accident), we collected soil samples from the ground surface and feces and blood from a mixed-breed male pig (weight: approximately 100 kg, age: 4 months) at a farm located within 20 km of the Fukushima Daiichi nuclear power plant. Radioactive contamination of the edible muscle had been confirmed in another pig at this farm [6]. Feces were collected from the rectum by hand in order to avoid contamination from the feces of other pigs, and blood was sampled through the auricular vein. Samples were subsequently stored in a freezer at −80°C. The gamma-ray spectrum (0.03–1.5 MeV) of each 1-g sample was measured using a Ge semiconductor detector (GMX-10180; ORTEC, Advanced Measurement Technology Inc., Oak Ridge, TN, U.S.A.), and the measurement time was 12 hr. The detection limits for ^{129m}Te (0.106 MeV), ^{131}I (0.364 MeV), ^{134}Cs (0.605 MeV), ^{136}Cs (1.048 MeV) and ^{137}Cs (0.662 MeV) were 0.181, 0.058, 0.056, 0.058 and 0.062 Bq/g, respectively. The radioisotope with beta-ray emission, ^{90}Sr, could not be detected by the gamma-ray spectrum. The radioisotope concentrations at the time of sampling (noon; April 10, 2011) were recalculated from the number of counts based on the respective radioisotope half-lives.

The level of radioactivity among the soil samples, feces, blood clots, and serum is shown in Table 1. ^{129m}Te (0.106 MeV), ^{131}I (0.364 MeV), ^{134}Cs (0.605 MeV), ^{136}Cs (1.048 MeV) and ^{137}Cs (0.662 MeV) were detected in the soil samples. Even though the pig had been fed non-contaminated imported feed, ^{131}I, ^{134}Cs and ^{137}Cs were detected in its feces, indicating that radioactive substances were ingested orally. The levels of radioactivity of ^{131}I in the feces were 0.10% of that in the soil, and the levels of radioactivity of ^{134}Cs and ^{137}Cs in the feces were 0.28% of that in the soil. Therefore, certain amounts of radioisotopes might be absorbed into the body. In fact, ^{134}Cs and ^{137}Cs were detected in the blood clots. ^{136}Cs was detected in the soil, but not in the serum, clots or feces. We believe this was because a very small amount of ^{136}Cs was released from the nuclear power plant wreckage. In addition, ^{131}I was detected in feces despite its short physical half-life (8 days). Therefore, an early-stage bioassay can play an important role in the screening of radioactive contamination in livestock. There have been several reports of bioassay experiments [2, 5], but this is the first report of an early-stage bioassay of radioactive contamination in livestock.

The origin of beef, wherever available in Japan, can be

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Table 1. Radioactivity (Bq/kg) in the soil, feces, blood clots, and serum samples collected on April 10, 2011 at noon from a pig at a farm within 20 km of the Fukushima Daiichi nuclear power plant

Radioisotope (Energy)	Soil	Feces	Blood clots	Serum
^{129m}Te (0.106 MeV)	192,057	N.D.[a)]	N.D.	N.D.
^{131}I (0.364 MeV)	111,207	1,098	N.D.	N.D.
^{134}Cs (0.605 MeV)	200,199	552	203	N.D.
^{136}Cs (1.048 MeV)	9,067	N.D.	N.D.	N.D.
^{137}Cs (0.662 MeV)	24,152	687	280	N.D.

a) N.D.: Peaks were not detected.

traced through individual identification numbers; however, a similar tracing system does not exist for pork. Therefore, we may have ingested contaminated pork unknowingly. Thus, humans may also be affected by food-chain radioactive contamination, as observed in the Nevada Test Site in 1950s [3] and Chernobyl in 1986 [1, 4]. Countermeasures that reduce the contamination of food products should be considered.

Because it is considerably difficult to measure radioactive contamination in the edible muscle of living livestock, bioassays are an option that can be used for the screening of radioactive contamination in living livestock to ensure food safety.

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