

Chapter 2

Radiation Contamination of Agricultural Products

The Fukushima nuclear disaster started when the Tohoku-Pacific Ocean Earthquake hit the Tohoku and Kanto region at 14:46 JST on *March 11*, 2011. The epicenter of this earthquake was located about 130 km off the coast of Oshika Peninsula of Miyagi Prefecture, and was about 24 km below sea level. The scale of the quake was estimated to be magnitude 9.0, which was the greatest earthquake ever recorded in Japan.¹ It is still vivid in our memory that the effect of the earthquake had devastating impacts on not only in the Tohoku region, but also in the Tokyo metropolitan area located more than 300 km apart from the epicenter. According to the Asahi newspaper, in the 12 prefectures, about 15,890 people died from the catastrophe, and in the six prefectures, 2589 people became missing as of February 2015.

The Tohoku-Pacific Ocean Earthquake, later named the Great East Japan Earthquake, or simply 3.11, after the disaster. The big difference of this earthquake from other large earthquakes that occurred in the world is that the earthquake led to a major nuclear accident. There are several earthquakes in the world where the earthquake triggered a tsunami like the 2004 Indian Ocean earthquake and the 2006 Pangandaran earthquake of West Java.² However, the Tohoku-Pacific Ocean Earthquake is the world's first earthquake where the tsunami triggered by an earthquake led to a nuclear accident.

¹Magnitude scales used in seismology represents the size of an earthquake as the power of energy using a logarithmic function.

²The 2004 Indian Ocean earthquake occurred on the morning of December 26. Its epicenter was located off the west coast of Sumatra, Indonesia. After the earthquake, the coastlines of Indonesia, Thailand, and Sri Lanka were hit by a tsunami. About 230 thousand people died or became missing due to this tsunami. It is reported that the maximum height of the tsunami was greater than 30 m (NILIM 2005).

The 2006 Pangandaran earthquake occurred in the evening of July 17. The earthquake had a moment magnitude of 7.7 and the epicenter was along the southern coast of the Island of Java, Indonesia. It is known that more than 600 people died from a tsunami that was triggered by this earthquake. The maximum height of the tsunami is estimated to be over 5 m (Nanayama et al. 2007).

This chapter will provide a brief overview of the Fukushima Daiichi nuclear power plant (FDNPP) accident and the situation of the radiation contamination of agricultural products after the nuclear disaster.

2.1 The Fukushima Daiichi Nuclear Power Plant Accident

2.1.1 Overview of the Accident

The FDNPP accident started when a magnitude 9.0 earthquake, whose epicenter was offshore Sanriku occurred at 2:46 pm on March 11, 2011. After this first earthquake, more than eight earthquakes with a seismic intensity of 5 or greater occurred near the FDNPP. At the FDNPP, the transmission steel towers collapsed and power lines were cut and the plant lost its all seven electricity transmission lines. Moreover, the FDNPP lost its connection with the external power source, which led to a station blackout.

Every nuclear power plant is installed with an emergency diesel generator (EDG). When the power plant loses its external power source, the power will be supplied from this EDG. Right after the Tohoku-Pacific Ocean earthquake occurred, the EDG was running normally at the FDNPP and supplying electricity to the plant. However, after 45 min of the first earthquake, the first wave of tsunami hit the nuclear plant and the second wave of tsunami that was about 13 m high continuously hit the nuclear plant. This tsunami watered the four reactor units of the FDNPP, and this turned off the function of the EDG. This is how the FDNPP lost all the power supply for its four reactor units, and this blackout situation continued for 10 days.

As Unit 1 through Unit 4 reactors of the FDNPP lost their power, the cooling function of the reactor stopped working and this triggered the reactor core to start melting. And finally, due to this nuclear meltdown, radioactive materials that were trapped in the fuel pellet were released into the air along with the water vapor. This is how the FDNPP accident led to a nuclear disaster causing a radioactive contamination of its surrounding areas.

Thus, although the main cause of the FDNPP accident is the earthquake and the tsunami, the reason for this accident to become a nuclear disaster is attributed to the station blackout that lasted for ten days. It is suggested that if the electricity recovered earlier, the plant could have controlled the reactor from melting (Ishikawa 2014).

On the day of the earthquake, the Fukushima Daini nuclear power plant, which was only about 12 km apart from the FDNPP (see Fig. 2.1), was also hit by the tsunami.³ The Fukushima Daini power plant was also drown with water after the tsunami arrived, but it did not become a disaster that led to a nuclear meltdown.

³“Daiichi” and “Daini” means the No.1 and No. 2 in Japanese and as seen in Fig. 2.1 the Fukushima Daiichi and Daini nuclear plants were located very close (about 12 km) to each other.

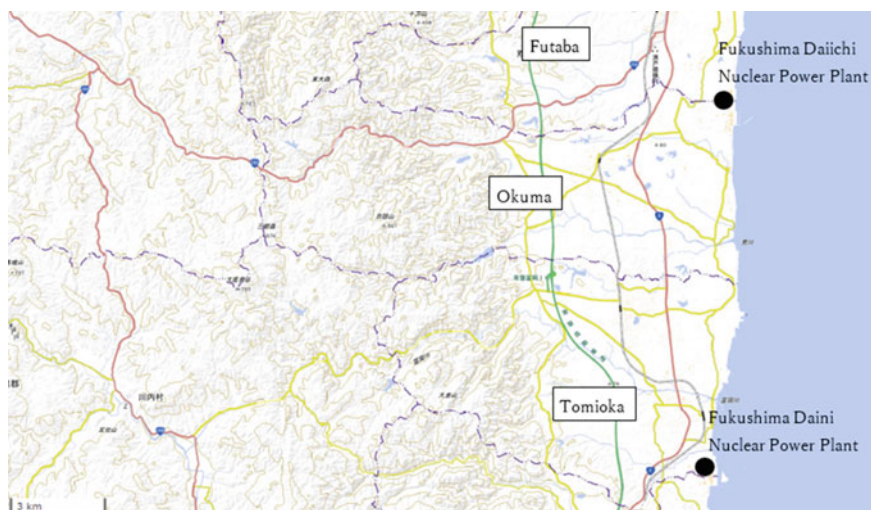


Fig. 2.1 Location of the Fukushima Daiichi Nuclear Power Plant and the Fukushima Daini Nuclear Power Plant (Reproduced from Aruga 2016)

According to Ishikawa (2014), it is believed that the Fukushima Daini nuclear power plant had electricity even after the tsunami because the EDG continued to work normally and was able to cool down the nuclear reactor. Hence, the reason why the FDNPP led to a nuclear meltdown is due to losing all its electricity supply.

2.1.2 Degree of the Nuclear Accident

Here, we would like to compare the extent of the Fukushima nuclear accident with the 1986 Chernobyl nuclear accident so that we can understand the severeness of the nuclear accident compared with the previous accidents of the world. The Nuclear Safety Commission (NSC) [the current Nuclear Regulation Authority (NRA)] of Japan has estimated the total amount of radioactivity released from the Fukushima accident to be 0.77 quintillion Bq. As seen in Table 2.1, the estimated amount of radioactivity released from the Fukushima accident is around one-seventh of the amount released from the Chernobyl disaster (NERH 2011). However, the Fukushima accident has been rated level 7 on the International Nuclear and Radiological Event Scale (INES), which is the highest level within the INES scale and the same scale as the Chernobyl accident.⁴ Hence, it is certain that the FDNPP accident is among one of the worst nuclear disasters in the world.

⁴INES is an international index used to describe the relative magnitude of a nuclear accident. The scale is established by the IAEA (International Atomic Energy Agency) and the OECD.

Table 2.1 Comparison of the amount of radioactivity released from the Fukushima and Chernobyl accidents (*Unit 10¹⁶ Bq*)

	Physical half-life time	Fukushima accident	Chernobyl accident
Iodine-131	8 days	16	180
Cesium-134	2 years	1.8	4.4
Cesium-137	30 years	1.5	8.5
Strontium-90	29 years	0.014	0.8
Plutonium-239	24 thousand years	0.003×10^{-4}	0.003
Total emission in Iodine equivalent	–	77	520

Source Aruga (2016, p. 4)

2.1.3 Meaning of the Level 7 INES Scale

How serious is the level 7 INES scale that was rated for the Fukushima nuclear disaster? Figure 2.2 illustrates the naming of the INES level 1 through 7 scales. As seen in the figure, the INES use the word “incident” for the levels 1–3 nuclear events while the word “accident” is used for the levels 4–7 events. One level of

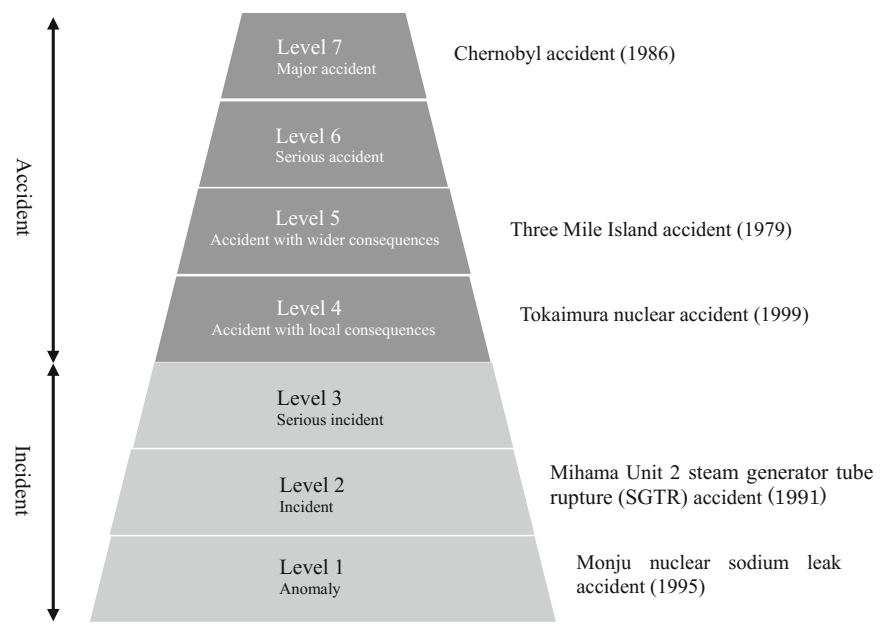


Fig. 2.2 International Nuclear and Radiological Event Scale (INES). Source Aruga (2016, p. 5)

increase in this scale represents that the nuclear event is about ten times more severe than the previous level. The difference between the INES incident and accident is whether there was at least one death from radiation by the nuclear event. The levels 1–3 nuclear events use the word “incident” because there was no death from the incident and the event only caused an injury to some person. On the other hand, in the levels 4–7 scales that are categorized by the word “accident,” at least one person has died from the nuclear event.

The Fukushima nuclear disaster was rated the level 7 scale, which means that the disaster was rated the highest level of scale among the 7 INES scales. The criteria for the level 7 scale is based on whether the event is “resulting in an environmental release corresponding to a quantity of radioactivity radiologically equivalent to a release to the atmosphere of more than several tens of thousands of terabecquerels of iodine-131” (IAEA 2008 p. 28).

The Fukushima disaster did release an enormous amount of radioactive materials to its surrounding areas so that the people who lived within the 20 km radius from the FDNPP were forced to evacuate after the nuclear accident and some of these people were never able to return to their houses. In this sense, it is certain that the Fukushima disaster was one of the worst nuclear accident ever happened in the world.

2.1.4 The Number of Evacuees After the Accident

After April 2011, regions within the 20 km radius from the FDNPP was designated as the warning zone and entering this zone was restricted and prohibited. These zones have been established to prevent the people living near the FDNPP from getting exposed to high level of radiation. After this zone was built, about 78,000 people had to evacuate from the area.

Besides, regions that are 20–30 km radius distance from the FDNPP was selected as the emergency evacuation preparation zone. People who belonged to this zone had to either evacuate or prepare for evacuation. There were about 58,510 people who evacuated from this zone.

Finally, for regions more than 20 km radius distance from the FDNPP that had a high risk of getting exposed to radiation was chosen as the planned evacuation zone. The high risk here meant the expected amount of radiation dose in the area was more than or equal to 20 mSv per year. People in this zone had to evacuate immediately and the number of evacuees in this zone was about 10,010.

By adding all the evacuees from these zones, there were a total of about 146,520 evacuees (see Table 1.2) who had to evacuate from their houses after the accident (Table 2.2).

Table 2.2 Evacuation zones and the number of evacuees per zone

Zone	Distance from the FDNPP	Number of evacuees
Warning zone	Within 20 km radius distance	About 78,000
Emergency evacuation preparation zone	20–30 km radius distance	About 58,510
Planned evacuation zone	More than 20 km radius distance but high risk of radiation exposure	About 10,010
Total		About 146,520

Source Aruga (2016, p. 7)

2.2 Basics of Radiation

In this section, we first explain some basic terms that are relevant to radiation and are important when understanding the effects of radiation on food products. Then, we discuss the food safety standards of protection against radiation in Japan. Finally, we investigate the differences of the levels of radioactive contamination among the different types of agricultural products by showing which products contained radioactive materials above the national food safety standard after the Fukushima disaster.

2.2.1 Radiation, Radioactive Materials, and Radioactivity

A radiation in general, is a particle or wave that transmits or emits high energy through space at a high velocity. A radioactive material is a material that releases radiation. Moreover, radioactivity is the ability and characteristic of an unstable atomic nucleus to transform into stable or unstable products while emitting radiation.

Figure 2.3 illustrates these three words by metaphorizing them to a firefly, a firefly's light, and the ability of the firefly to release light from its body. As seen in the figure, if the firefly represents radioactive material, radiation will be the firefly's light, and radioactivity will be the ability of the firefly to release light from its body. The difference between a firefly and a radioactive material is that while the activities of a firefly have no negative influence to us, those of a radioactive material can become harmful and is invisible. Although there is a way to visualize a radioactive material using a special camera, a radioactive material is a very tiny particle and it is normally impossible to see with our eyes even if it was on the ground or was attached to some buildings or animals. Thus, there is a danger of being exposed to radiation without noticing it.

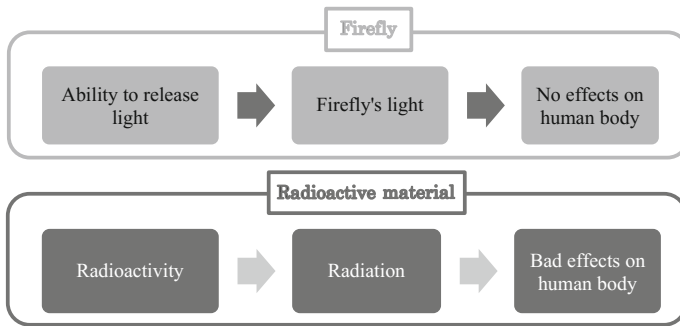


Fig. 2.3 Relations between radiation and radioactivity

2.2.2 Radiation Exposure

Radiation exposure means that the human body is exposed to radiation, but we should note that radiation exposure involves internal and external exposures. The external radiation exposure occurs when our body is exposed to a penetrating radiation field from outside our body. On the other hand, internal radiation exposure arises when we eat or drink food that contains a radioactive material and this material releases radiation inside the body.

As the word radiation exposure reminds us of how people suffered after the atomic bombing of Hiroshima and Nagasaki, many of us may think radiation exposure is by no means critical to the human body. However, we should know that we have always been exposed to radiation from nature since long time ago. It just did not harm us because the amount of the radiation dose we get from nature is usually subtle. Such radiation that exists in nature is called the natural radiation, and we are all exposed to a certain level of this natural radiation every year.

Then why are we so cautious about radiation exposure? That is because when the amount of radiation dose we receive is greatly increased it can have adverse effects on our body. Hence, to understand what amount of radiation dose can be harmful to our body, we will next look into the units of measurement used to configure the radiation dose.

2.2.3 Units of Radiation Dose

First, the unit becquerel (Bq) is a unit to measure the degree of radioactivity. A radioactive material will spontaneously emit energy as a result of the radioactive decay and becquerel measures the level of this emitted energy. To explain the meaning of this unit in terms of the firefly light, becquerel would be the level of the intensity of a light released from the firefly.

Becquerel is named after the French physicist Henri Becquerel, who discovered the radioactivity in 1896 and shared a Nobel Prize with Pierre Curie and Marie Curie. Becquerel indicates the number of radioactive nuclei that disintegrates per second in a radioactive material. For example, if 400 nuclei decay in 10 s, the level of the radioactivity for this material will be 40 becquerels. Becquerel is often used to show the degree of radioactivity per weight or volume such as becquerels per kilogram (Bq/kg), becquerels per liter (Bq/l), and becquerels per cubic meter (Bq/m³).

Another important unit used to describe the intensity of radiation is the unit sievert. Sievert (Sv) is a unit to measure the health effect of ionizing radiation on a human body. Simply, it represents how much a human body can be affected when exposed to radiation. Sievert is named after a Swedish medical physicist Rolf Maximilian Sievert, who is renowned for his work on radiation dosage measurement and the biological effects of radiation during the nineteenth century. As sievert is a enormous unit, sievert is often represented in millisievert (mSv), one thousandth of sievert, or microsievert (μSv), one millionth of sievert. Sievert is often used to show how many levels of radiation one has received in a certain period such as mSv/year. For example, the effect of a radiation dose from a natural radiation on an average person is 2.4 mSv per year (RSC 2013) and this can be expressed as 2.4 mSv/year.

2.2.4 Radiation Dose Limit

The radiation dose limit in Japan is now set to 1 mSv per year. This limit does not include the radiation dose from nature in a year. Although there is an argument whether or not this 1 mSv per year radiation dose is scientifically an adequate amount, on Nov. 11, 2011, the Japanese government established a regulation to set the annual limit of the radiation dose a person can receive besides the natural radiation to be 1 mSv. This radiation dose limit was the advisory level established by the International Commission on Radiological Protection (ICRP) (ICRP 2007).

2.2.5 Japanese Food Safety Standards of Radioactive Cesium

Based on the 1 mSv upper limit of radiation dose, the Japanese government has set safety standards for radioactive cesium in food as shown in Table 2.3. The unit of the cesium limit in the table is 1 becquerel of cesium per 1 kg of food. The reason for using cesium as the radiation safety standards is that as seen in Table 1.1, the physical half-life of cesium is relatively long and it is known that a significant amount of cesium-137 was released into air after the Fukushima disaster.

Table 2.3 Japanese food safety standards for radioactive cesium (Bq/kg)

Until March 2012 (Radiation dose limit: 5 mSv)		After April 2012 (Radiation dose limit: 1 mSv)	
Category	Limit	Category	Limit
Drinking water	200	Drinking water	10
Milk and dairy products	200	Raw milk	50
Vegetables	500	Infant food	50
Grains	500	General food products	100
Meat, eggs, fish, and others	500		

Source Aruga (2016, p. 11)

Until March 2012, the safety standards for radioactive cesium in food was limited to the total of 5 mSv per year in Japan but to enforce the safety standards the Japanese government established a more stringent standard in April 2012 and set the radiation dose limit to 1 mSv per year.

The numbers in Table 2.3 provided for different types of food represents the upper limit of radioactivity for these foods. The limit means that if the radioactivity in the food is below this level the effect of the radioactivity on the human body will stay within the 1 mSv per year level even if one continues to eat this food on a daily basis.

2.2.6 International Comparison of the Safety Standards for Radioactive Cesium in Food

Comparing the current food safety standards for radioactive cesium in Japan with other parts of the world, you can see from Table 2.4 that Japan has a comparatively strict standard. The reason for the European Union (EU) and the United States (US) having a lower limit of Bq/kg compared with Japan is because these EU and US standards are set under a normal condition having very low risk of distributing food contaminated with radioactive materials. Japan had to set a severe standard compared with these regions because the risk of distributing food with radioactive materials became very high after the Fukushima disaster.

The EU and the US soon restricted importing food products from Japan after the Fukushima disaster if the products did not meet the Japanese safety standards set

Table 2.4 Food safety standards for radioactive cesium in Japan, the EU, and the US(Bq/kg)

	Japan (current)	EU	US
Drinking water	10	1000	1200
Milk and dairy products	50	1000	1200
Infant food	50	400	1200
General food products	100	1250	1200

Source MHLW (2012)

after April 2012. Moreover, they prohibited to import any food products that are produced in regions near the FDNPP. Thus, although the food safety standards for the EU and US had lower standards than the Japanese standards, these standards only applied to their domestic products, and it is not possible to say that the Japanese standards are more severe compared with those of other countries.

In the next session, I would like to show how much radioactive materials were detected in different types of agricultural products and compare the level of radioactivity for these products with the Japanese safety standards as indicated in Table 2.3.

2.3 Conditions of the Radioactive Contamination of Agricultural Products After the Fukushima Disaster

After the Fukushima disaster, nuclear materials have been detected in various agricultural products such as rice, vegetables, fruit, mushrooms, and edible wild plants. These agricultural products became contaminated with radioactivity because radioactive materials adhered to plant leaves and soils, and these plants absorbed radioactive substances from their leaves and stems. Thus, high level of radioactive materials has been identified in products such as spinach whose product form is leaf. Fruit products such as Japanese plum (ume), Japanese citrus (yuzu), and loquat where the fruiting began in March also became highly contaminated because of the Fukushima disaster occurred in March. The soils of areas near the FDNPP had a serious level of contamination because the radioactive cesium, having a long physical half-life, stays in the soil for a long time.

For forest products, as fungal species are known to accumulate radiocesium (Yamada 2013), a high level of radioactive materials has been found in wild mushrooms. In particular, when the hardwoods used for cultivating wood mushrooms are contaminated with radioactive materials, the mushrooms harvested from this hardwood have a high probability of being contaminated. Hence, shipments of wild mushrooms from Tohoku regions, Ibaraki prefecture, and Tochigi prefecture were prohibited by the government after the Fukushima disaster.

2.3.1 Conditions of the Radioactive Contamination of Rice, Vegetables, Fruit, and Forest Products

Here I would like to explain the amounts of radioactive cesium detected in rice, vegetables, fruit, and forest products such as mushrooms and wild edible plants by comparing these amounts with the Japanese food safety standards for radioactive cesium.

Table 2.5 Percentages of test samples above the safety standards for rice, vegetables, fruit, and forest products

	Rice			Vegetables		
	Number of test samples	Between 50 to 100 Bq/kg (%)	Above 100 Bq/kg (%)	Number of test samples	Between 50 to 100 Bq/kg (%)	Above 100 Bq/kg (%)
2011	26,464	3.1	2.2	12,671	1.2	3.0
2012	About 10.37 MM	2.0×10^{-4}	8.1×10^{-6}	18,570	5.4×10^{-4}	2.7×10^{-4}
2013	About 11.04MM	7.4×10^{-5}	2.5×10^{-6}	19,657	1.0×10^{-4}	0
	Fruit			Mushrooms and edible wild plants		
	Number of test samples	Between 50 to 100 Bq/kg (%)	Above 100 Bq/kg (%)	Number of test samples	Between 50 to 100 Bq/kg (%)	Above 100 Bq/kg (%)
2011	2732	7.5	7.7	3856	7.7	20.2
2012	4478	1.3	0.3	6588	8.6	9.2
2013	4243	0.7	0	7581	4.2	2.6

Source Aruga (2016, p. 13)

Table 2.5 is created based on the radiation test conducted on the agricultural products of 17 prefectures that are designated by the Japanese government to perform radiation tests for their products. These 17 prefectures consist of Fukushima, Ibaraki, Tochigi, Gunma, Chiba, Kanagawa, Miyagi, Iwate, Aomori, Akita, Yamagata, Niigata, Nagano, Saitama, Tokyo, Yamanashi, and Shizuoka. The percentage numbers in the table represent the ratio of test samples that contained radiation above the Japanese food safety standard for radiation. As the agricultural products in the table all belong to the general food products category in Table 2.3, any test samples whose level of radioactive cesium was above the 100 Bq/kg safety standard were included in these percentages. Table 2.5 also shows the percentages of the test samples whose radioactive cesium dose were more than 50 Bq/kg and less than or equal to 100 Bq/kg.

For the radiation test of rice conducted in 2011, 592 out of the 26,404 test samples (2.2% of the whole test samples for rice) contained radioactive cesium above the 100 Bq/kg safety standard (see Table 2.5). The number of test samples above the safety standard for rice decreased dramatically in 2012 and 2013, but this figure did not become zero. Thus, there were samples whose level of radiation cesium was above the safety standard even after one or two years from the Fukushima disaster.

For vegetables, 3% of the whole test samples contained radioactive cesium above the 100 Bq/kg safety standard.⁵ Among the highly consumed vegetables in

⁵The definition of vegetable here is based on the classification of the Ministry of Agriculture, Forestry, and Fisheries of Japan.

Japan, cabbage, tomatoes, lettuce, Japanese green onion, broccoli, spinach, strawberries, macrophyll, perillas, and Chinese chives were the ones whose level of radioactive cesium exceeded the safety standard. On the other hand, onions, Japanese white radish (daikon), carrots, and cucumbers were the ones whose radiation dose of the test samples were all below the 100 Bq/kg safety standard. As seen in Table 2.5, percentages of the test samples of vegetables whose radiation dose was above the safety standard became tiny in 2012, and in 2013, none of the test samples in the vegetables contained radiation dose above the safety standard.

Compared with rice and vegetables, fruit had a high percentage of test samples that contained radioactive cesium above the food safety standard in 2011. However, the high percentage only lasted for a year, and as seen in Table 2.5, the percentage of samples above the safety standard became 0.3% in 2012. In 2013, none of the test samples had radioactive cesium above the safety standard. The fruit that was found to be contaminated with radiation includes Japanese plums, persimmons, kiwifruit, blueberries, mandarin oranges, peaches, prunes, Japanese citrus (yuzu), loquats, chestnuts, and so on. It is suggested that these fruits became contaminated with radiation because these fruits normally start to bear fruit in March where the Fukushima disaster occurred. In fact, for fruits whose fruiting occurs after May like apples and pears did not contain radioactive materials above the safety standard in their test samples.

Finally, mushrooms and edible wild plants had the highest percentage of test samples that contain radioactive cesium above the safety standard. As seen in Table 2.5, a high level of radioactive cesium was detected in mushrooms and edible wild plants even after 2 years from the Fukushima disaster compared with other agricultural products in the table. It is believed that these products are especially prone to radioactive contamination because fungi like the shiitake mushrooms have the characteristics of absorbing radioactive cesium.

2.3.2 Conditions of the Radioactive Contamination for Livestock Products

In this session, I would like to explain the conditions of the radioactive contamination for livestock products. After the Fukushima disaster, radioactive cesium has been detected in various livestock products. It is suggested that this contamination is attributed to the use of fermented rice straw as animal feed because the straws used for the feed were from the rice harvested in 2011 near the FDNPP (Aruga 2016). The Japanese government has set a provisional tolerance standard for animal feed to restrict the use of animal feed that contain radioactive cesium above this standard level to cope with the problem (see Table 2.6).

Radioactive contamination of livestock animals also occurs from the drinking water, so the Japanese government has advised the farmers to implement prevention measures such as to put a lid on the water tank.

Table 2.6 Provisional standards of radioactive cesium for Animal feed

Type of animal	Provisional standards (Bq/kg)
Calf and horse	100
Pig	80
Poultry	160

Source CAA (2014)

Next, I will explain the conditions of the radioactive contamination for the livestock products by comparing the amount of radioactive cesium detected in these products with the Japanese food safety standards.

First, for beef and pork products, although the percentage of the contaminated samples were less than 1% of the whole test samples, some of the test samples for these products contained radioactive cesium in 2011 (see Table 2.7). Only few test samples were identified to be contaminated in 2012, and in 2013, none of the samples contained radioactive cesium above the safety standard.

Second, I would like to discuss the level of contamination of raw milk. The food safety standard for raw milk is set to 50 Bq/kg to consider the amount of milk intake for infants. As seen in the table, the percentage of test samples for raw milk that contained radioactive cesium above the safety standard was less than 1% of the whole test samples in 2011. After 2012, none of the test samples for raw milk exceeded the national safety standard.

Finally, for chicken eggs, none of the test samples were found to be above the food safety standard even in 2011, and the risk of containing radioactive cesium has been low among the livestock products.

All in all, the potential of radioactive contamination disappeared within 1 year from the Fukushima disaster for all livestock products discussed in this session, and

Table 2.7 Percentages of test samples above the safety standards for livestock products

	Beef			Pork		
	Number of test samples	Between 50 to 100 Bq/kg (%)	Above 100 Bq/kg (%)	Number of test samples	Between 50 to 100 Bq/kg (%)	Above 100 Bq/kg (%)
2011	92,683	N/A	1.2	529	N/A	1.1
2012	148,644	6.7×10^{-6}	4.0×10^{-5}	773	2.6×10^{-4}	1.3×10^{-4}
2013	163,767	2.4×10^{-5}	0	619	0	0
	Raw milk		Chicken eggs			
	Number of test samples	Above 50 Bq/kg (%)	Number of test samples	Between 50 to 100 Bq/kg (%)	Above 100 Bq/kg (%)	
2011	1919	0.42	419	N/A	0	
2012	2421	0	464	0	0	
2013	2040	0	311	0	0	

Source Aruga (2016, p. 16)

it is likely that their level of the contamination was lower than the agricultural commodities explained in the previous session.

2.3.3 Conditions of the Radioactive Contamination of Seafood Products

In this session, we will investigate the conditions of the radioactive contamination of seafood products.

After the FDNPP accident, a large quantity of radioactively contaminated water spilled into the ocean and a high level of radioactive cesium has been detected in some fish caught near the FDNPP. Table 1.8 illustrates the percentage of test samples for seafood products that contained radioactive cesium above the level of food safety standards. As seen in the table, the percentage of test samples for Fukushima prefecture that surpassed the food safety standard was extremely high in 2011. Although the percentage decreased in 2012, nearly 3% of the whole test samples for Fukushima Prefecture detected a high level of radioactive cesium even in 2013. The Japanese government prohibited distribution of 28 seafood products that are caught near the coast of FDNPP, which include greenling, stone flounder, Japanese black porgy, Japanese halibut, and sea bass to cope with this situation.

Test samples conducted for seafood products outside the Fukushima Prefecture had a much lower percentage of test samples that contained radioactive cesium above the food safety standards (see Table 2.8). As seen in Table 2.8, the percentage in 2013 for seafood products outside the Fukushima prefecture was less than 1%.

Table 2.8 Percentages of test samples above the safety standards for seafood products

	All seafood products of Fukushima prefecture				All seafood products outside the Fukushima prefecture			
	Number of test samples		Above 100 Bq/kg (%)		Number of test samples		Above 100 Bq/kg (%)	
2011	3606		34.7		4970		4.5	
2012	6917		12.7		12,648		1.7	
2013	8521		2.8		12,174		0.5	
	Salmon		Bluefin tuna		Flounder		Wakame seaweed	
	Number of test samples	Above safety standards	Number of test samples	Above safety standards	Number of test samples	Above safety standards	Number of test samples	Above safety standards
Mar 2011–Aug 2015	438	0%	37	0%	4139	2.2%	571	0%

Source Aruga (2016, p. 17)

Finally, I would like to discuss the conditions of radioactive contamination among different types of seafood products. The results of the tests conducted for these samples are gathered from all parts of Japan and are freely available to the public. As seen in the table, highly migratory fish species like salmon and bluefin tuna did not have any test samples that exceeded the safety standard. Wakame seaweed, which is one of the most popular seafood products of the Tohoku region also did not contain test samples that were above the safety standard since the test began in March 2011. However, in flounder, which is a fish that live near the sea bottom, 2.2% of the test samples held radioactive cesium above the safety standard.

It is suggested that the reason for the fish that live at the sea bottom to have a high level of radioactive cesium is because radioactive materials that were spilled into the ocean accumulates at the bottom of the ocean. However, it is also known that radioactive cesium tends to be absorbed by clay minerals and that it is less likely for fish to eat such clay. Hence, it is still uncertain whether fish like flounders contained a high level of radioactive cesium because they dwell at the sea bottom.

2.3.4 Forthcoming Challenges to Prevent the Spread of Radioactive Contamination in Food

In sum, during the year 2011, the FDNPP accident had a large impact on the agricultural commodities. The accident has contaminated many agricultural products with radioactive cesium as shown in this chapter. However, after 1 or 2 years from the accident, the level of the radioactive cesium found in most of the test samples conducted for various agricultural products became lower than the safety standard. This indicates that the condition of the radioactive contamination in food after the Fukushima disaster is improving and the risk of food contaminated with radioactive materials to be sold in the market is becoming smaller.

On the other hand, we need to note that not all agricultural products are entirely free from radioactive contamination and, though small it may be, there is still a jeopardy of getting exposed to radiation by eating products like wild mushrooms, edible wild plants, and fish that are harvested near the FDNPP.

In this sense, it is important for the government to continue to conduct radiation tests for agricultural products and to implement strict policies to prevent food that contains radioactive materials from being distributed in the market.

References

- Aruga, K. (2016). *Genpatsujiko to Fuhyou Higai (The nuclear accident and the reputation damage)*. Kyoto: Showado Inc.
- Consumer Affairs Agency (CAA). (2014). Q & A for food and radiation (in Japanese). http://www.caa.go.jp/jisin/pdf/141113_food_qa_ver9.pdf Accessed February 4, 2017.

- ICRP. (2007). The 2007 Recommendations of the International Commission on Radiological Protection. ICRP Publication 103. *Annals of ICRP* (Vol. 37, pp. 2–4).
- International Atomic Energy Agency (IAEA). (2008). The international nuclear and radiological event scale user's manual 2008 edition. <http://www-pub.iaea.org/MTCD/Publications/PDF/INES2013web.pdf>. Accessed January 20, 2017.
- Ishikawa, N. (2014). *Koushou Fukushima Genshiryokujiko (Investigation study of the Fukushima nuclear accident) (in Japanese)*. Tokyo: The Japan Electric Association.
- Ministry of Health, Labour and Welfare (MHLW). (2012). Shokuhin chu no houshaseibushitsu no aratana kijunchi ni tuite (About the new standards for radioactive materials contained in food) (in Japanese). <http://www.mhlw.go.jp/topics/bukyoku/iyaku/syoku-anzen/iken/dl/120117-1-03-01.pdf>. Accessed February 2, 2017.
- Nanayama, F., Saito, Y., Aziz, S., et al. (2007). Preliminary reports about tsunami traces and disasters of the 17th July, 2006 Java tsunami (in Japanese). *Chishitsu News*, 636, 42–51.
- National Institute for Land and Infrastructure Management (NILIM). (2005). Sumatra tou oki daijishin oyobi Indoyou tsunami higai ni kansuru kinkyu kenkyu (An urgent research on the great earthquake of Sumatra and the Indian Ocean tsunami disaster) (in Japanese). <http://www.nilim.go.jp/lab/beg/foreign/kokusai/sumatera2005.pdf>. Accessed January 20, 2017.
- Nuclear Emergency Response Headquarters (NERH). (2011). Report of Japanese government to the IAEA ministerial conference on nuclear safety: the accident at TEPCO's Fukushima Nuclear Power Stations (in Japanese). http://japan.kantei.go.jp/kan/topics/201106/iaea_houkokusho_e.html. Accessed January 20, 2017.
- Radiation Science Center (RSC). (2013). Houshasen no Mamechisiki: Kurashinonaka no Houshasen (Useful knowledge of radiation: radiation in our living) (in Japanese). <http://rcwww.kek.jp/kurasi/kurashi-all.pdf>. Accessed February 20, 2017.
- Yamada, T. (2013). Mushrooms: radioactive contamination of widespread mushrooms in Japan. In T. Nakanishi & K. Tanoi (Eds.), *Agricultural implications of the Fukushima nuclear accident* (pp. 163–176). Tokyo: Springer.

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