

# Chapter 8

## Radiocesium Accumulation in Koshiabura (*Eleutherococcus sciadophylloides*) and Other Wild Vegetables in Fukushima Prefecture



Naoto Nihei and Keisuke Nemoto

**Abstract** Wild vegetables naturally grow in the mountains, and their new buds and leaves are routinely eaten by local residents. In Fukushima, wild vegetables are more contaminated than agricultural products because most forests have not been decontaminated and radiocesium still remains in the forest soil. Radiocesium concentrations in wild vegetables can vary depending on the species, and in the case of koshiabura (*Eleutherococcus sciadophylloides*), it was found to have the highest concentration among wild vegetables. To acquire basic knowledge about radiocesium accumulation in koshiabura, we collected young trees which had been grown in the forest of Date City, Fukushima and investigated the radiocesium concentration in each part and its seasonal transition.

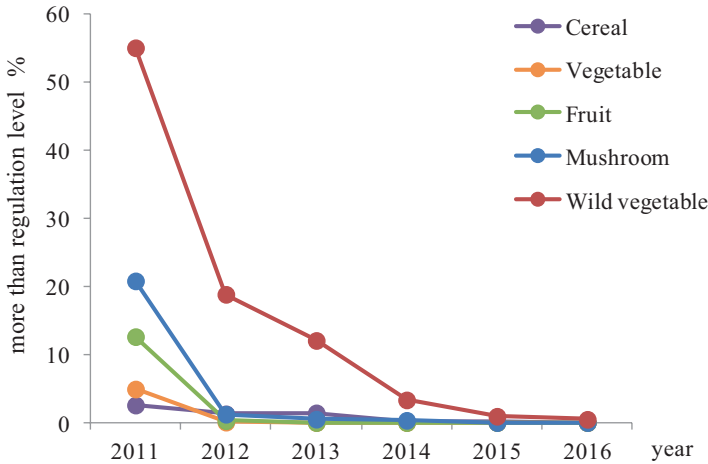
**Keywords** Koshiabura · Radiocesium · Wild vegetable

### 8.1 Monitoring and Examination of Agricultural Products

A large amount of radioactive substances, especially radiocesium ( $^{134}\text{Cs}$  and  $^{137}\text{Cs}$ ), were spread throughout the environment by the Fukushima Daiichi Nuclear Power Plant Accident, and forests, croplands, and residential areas were contaminated. Agriculture is an important industry in Fukushima Prefecture, and it produces various agricultural products in its warm climate and rich natural environment. Since the accident, several measures in the production process such as deep plowing, stripping, and applying potassium fertilizer have been performed to prevent agricultural products from absorbing radiocesium.

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**Fig. 8.1** The percentage of agricultural products whose radiocesium concentration exceeded regulation levels in the monitoring investigation

In addition, agricultural products are examined before being sent to markets and confirmed that their radiocesium concentrations are lower than the standard value of 100 Bq/kg (Nihei et al. 2016). Approximately 500 kinds or 100,000 agricultural products (excluding rice and grass) were examined up until March 2016. The results of these investigations describe how the circumstance of contamination of agricultural products in Fukushima Prefecture had changed since the accident. Figure 8.1 shows the percentage of agricultural products whose radiocesium concentration exceeded regulation levels (i.e., 500 Bq/kg in 2011 and 100 Bq/kg after 2012), as expressed within the categories of cereals (e.g., wheat and soybeans, excluding rice), vegetables (e.g., tomatoes, eggplants, and spinach), fruits (e.g., peaches, apples, and grapes), mushrooms, and wild vegetables. Although the percentage of products that exceeded regulation levels in 2011, just after the accident, was 3% for cereals, 5% for vegetables, 13% for fruits, 21% for mushrooms, and 55% for wild vegetables, the percentage of all categories decreased considerably from 2012. It is estimated that this is a result of the measures to reduce radiocesium uptake as well as the physical decrease of radiocesium. Mushrooms and wild vegetables were more contaminated than the other categories. Though there are several studies about the high concentration of radiocesium in mushrooms (Yoshida et al. 1994), few studies have focused on radiocesium in wild vegetables which are an important part of the Japanese diet (Kiyono and Akama 2013).

## 8.2 Wild Vegetables and Local People

Wild vegetables naturally grow in the mountains of Japan, and it is the new buds and leaves of these plants that are commonly eaten. These plants have been an important part of peoples' lives in the mountain villages, not just providing nutrition but also

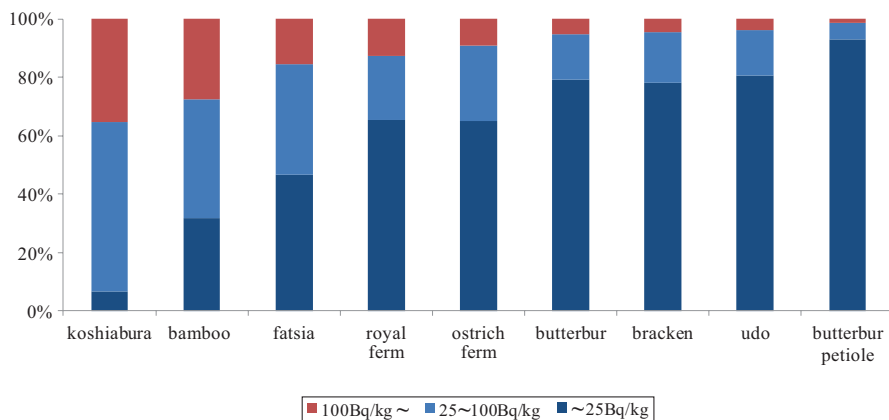
allowing the local people to experience more intimately the changing of the seasons. These edible plants are sometimes preserved by drying or salting. Collecting wild vegetables is a great pleasure for local people. The locations of rare wild vegetables are so precious that they are sometimes kept a secret from other family members. Wild vegetables have been closely related to Japanese people's lives for a long time, and have no doubt contributed to enriching Japanese culture. In addition, they have supported the local traditions in communities by creating a unique food culture in each region as well as being a food source for the local people. In Fukushima Prefecture, 70% of the land area is forested, and the Fukushima citizens have a strong connection with the forests. Unfortunately, most forests near Fukushima Daiichi Nuclear Power Plant were contaminated by the nuclear accident, and high concentrations of radiocesium have been found in wild vegetables in many regions.

### 8.3 Reasons for High Radiocesium Concentration in Wild Vegetables

The forests where wild vegetables grow are too expansive to decontaminate – cleaning up contaminated fallen leaves and other debris on the ground was performed only within 20 m from residential areas. Radiocesium still remains in forest soil, and wild vegetables growing there are thought to absorb radiocesium from the soil. In addition, the application of potassium fertilizer which is used as a countermeasure to prevent crops from absorbing radiocesium has not been performed in forests, as wild vegetables are not cultivated but grow naturally. Also, because the ratio of organic matter is high and clay mineral is low in the forest soil, the sorption of radiocesium to the soil is mild and thus transfer of radiocesium to wild vegetables will be higher than in cultivated soil. Finally, because wild vegetables are perennial plants or trees, it is considered likely that these plants absorbed and accumulated radiocesium which fell directly on their leaves and barks at the time of the accident in 2011.

### 8.4 Radiocesium Concentration of Each Category of Wild Vegetables

There are many kinds of wild vegetables and their edible parts can vary depending on the species. In the case of koshiabura (*Eleutherococcus sciadophylloides*) and fatsia (*Aralia elata*), new buds on the top of branches are eaten, and for bamboo (*Phyllostachys bambusoides*), butterbur (*Petasites japonicas*) and Udo (*Aralia cordata*), new sprouts growing from rhizomes are eaten; the petioles of butterbur can also be consumed when mature. In addition, new fronds of ferns, such as royal fern (*Osmunda japonica*), bracken (*Pteridium aquilinum*), and ostrich fern (*Matteuccia struthiopteris*), are considered to be wild vegetables. Figure 8.2 shows the results of



**Fig. 8.2** The radiocesium concentration of nine types of wild vegetables (expressed as the average values measured during the monitoring survey from 2011 to 2015)

a monitoring survey of contaminated wild vegetables over a 6-year period (2011–2016). More than 10% of koshiabura, bamboo, fatsia, and royal fern have had radiocesium concentrations of over 100 Bq/kg, but less than 10% of ostrich fern, butterbur (both sprout and petiole), bracken, and Udo exceeded the standard value. Therefore, not all wild vegetables had high radiocesium concentrations but variation in radiocesium concentrations did exist, with koshiabura having the highest concentration.

Koshiabura is a deciduous tree belonging to the Araliaceae family and found in every part of Japan from Hokkaido to Kyushu region. Although it is a popular wild vegetable with tasty and nutritious new buds, its sale continues to be regulated in many regions of Fukushima Prefecture 6 years after the accident. Therefore, to acquire the basic knowledge about radiocesium accumulation in koshiabura, we collected young trees which had been grown in the forest of Date City, Fukushima and investigated the radiocesium concentration in each part and its seasonal transition.

## 8.5 The Seasonal Transition of Radiocesium Concentration in Koshiabura

To investigate the seasonal transition of radiocesium concentration in koshiabura, leaves were collected from one individual plant in early May, late June, and late September in 2015 and 2016 (Fig. 8.3). The radiocesium concentration was found to be highest in early May, and decreased to less than half after late June and late September. When leaves of oak trees (*Quercus serrata*) were also investigated in the same site in late September, they showed almost similar radiocesium concentrations to that of koshiabura. Also, there was no difference in the radiocesium concentration



Fig. 8.3 Koshiabura (upper: early May, lower: late June)

in koshiabura between the same season of 2015 and 2016. Secondly, as koshiabura has several new leaves on its apical and lateral buds, each growing leaf was investigated for its radiocesium concentration in early May. Radiocesium concentration was highest in new leaves which had just started foliation, and decreased as the leaves finished foliation and aged. All leaves had finished foliation by late June, and there was no difference between the concentrations of each leaf at that time.

Factors such as the symbiosis with mycorrhizal fungi of koshiabura have been implicated as the reason for its high radiocesium accumulation potential (Sugiura et al. 2015), further research is needed considering that the concentration was the

same for another species (i.e., *Q. serrata*) in the current investigation in late September. On the other hand, newly grown leaves in early May showed the highest radiocesium concentration. The monitoring investigation was performed on the edible parts of each wild plant when its taste was optimum. Therefore, one reason why radiocesium concentration in koshiabura was so high was because the monitoring investigation coincided with the stage of newly grown leaves in early spring. Though further research is necessary to clarify why high radiocesium concentration occurs in newly grown leaves in early spring, one of the possible factors is that the behavior of radiocesium is similar to that of potassium. In the investigation in Date City, the concentration of potassium in leaves showed a similar seasonal transition as potassium. Several studies reported that Japanese cedar (*Cryptomeria japonica*) (Tubouchi et al. 1996) and butterbur (Kiyono and Akama 2015) also showed a high concentration of potassium in leaves in spring and the gradual decrease after spring. Potassium is an essential element for growth and photosynthesis, and it moves into growing cells quickly at the time of foliation. Cesium is also a group-1 alkali metal and its movement is considered to be similar to that of potassium and thus it is easily accumulated in new leaves. Although high concentrations of manganese have been reported to accumulate in the leaves of koshiabura (Mizuno 2008), the relationship between cesium and manganese is still unclear and the potential effect of manganese accumulation on cesium accumulation needs to be further investigated.

## 8.6 Conclusion

Seven years have passed since the accident, and agriculture is gradually resuming in the regions where the evacuation order has been cancelled. To help the agricultural industry recover while ensuring the production of safe agricultural products, we hope to continue the monitoring investigations as outlined in this chapter.

Wild vegetables are an irreplaceable pleasure for people residing in mountain villages. However, consuming wild vegetables is not completely without risk because high concentrations of radiocesium in spring corresponds to the season of collecting wild vegetables. Although we have performed some countermeasures such as the application of potassium fertilizer and the removal of the soil surface, it is assumed that it will take several years to find out whether these measures will suppress the absorption of radiocesium in koshiabura. The movement of radiocesium in wild vegetables is still unclear, and further research and continuous monitoring are necessary.

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## References

- Kiyono Y, Akama A (2013) Radioactive cesium contamination of edible wild plants after the accident at the Fukushima Daiichi Nuclear Power Plants. *Jpn J Environ* 55:113–118
- Kiyono Y, Akama A (2015) Seasonal variations of radioactive cesium contamination in cultivated *Petasites japonicas*. *J Jpn For Soc* 97:158–164
- Mizuno T (2008) Investigations on the metal hyperaccumulator plants and their application for plant nutrition study. *Bull Grad Sch Bioresour Mie Univ* 35:15–25
- Nihei N, Tanoi K, Nakanishi TM (2016) Monitoring inspection for radiocesium in agricultural, livestock, forestry and fishery products in Fukushima prefecture. *J Radioanal Nucl Chem* 307:2217–2220
- Sugiura Y, Takenaka C, Kanesasi T, Deguchi Y, Matsuda Y, Ozawa S (2015) Radiocesium accumulation characteristics in woody plants koshiabura. Abstract of The Ecological Society of Japan, <http://www.esj.ne.jp/meeting/abst/62/PA1-177.html> (in Japanese)
- Tubouchi A, Maekawa T, Hiyoshi S, Ueyama Y, Hisajima T (1996) Seasonal concentration changes of various compositions in plant leaf. *Ann Rep Environ Res Centre Fukui Prefecture* 23:53–62
- Yoshida S, Muramatsu Y, Ogawa M (1994) Radiocesium concentration in mushrooms collected in Japan. *J Environ Radioact* 22:141–154

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