Journal of Agriculture and Environmental Sciences
December 2023, Vol. 12, No. 2, pp. 50-67
ISSN: 2334-2404 (Print), 2334-2412 (Online)

Published by American Research Institute for Policy Development
DOI: 10.15640/jaes.v12n2a5
URL: https://doi.org/10.15640/jaes.v12n2a5

Varietal Differentiation and Diversity of Native Vegetable in Japan: A Case in *Ōmi-no-Dentō-yasai* (Traditional Vegetable in Shiga Prefecture)

Naoki Hata[1]*, Yūki Toyonaga[1], and Tatsuya Uemachi[1]

Abstract

There is renewed interest in cultivating and using various traditional vegetables in Japan. In Shiga Prefecture, it is being desired to promote vegetable production through developing production area of some native vegetable varieties certified as *Ōmi-no-Dentō-yasai*, but the available scholarly information regarding these varieties is limited and has not been thoroughly compiled. In this review, we present the available information for the *Ōmi-no-Dentō-yasai* and describe the background and research trends of specific varieties, while also clarifying their relationships with other native vegetables in Japan. The compiled information may be useful for increasing the production and improving the marketing of each variety certified as *Ōmi-no-Dentō-yasai* as well as for future studies on these native vegetables in Japan as well as in Shiga Prefecture. In addition, the differences among the *Ōmi-no-Dentō-yasai* reflect the varietal differentiation and diversity of the traditional vegetable species cultivated in Japan.

Keywords: anthocyanin, Lake Biwa, native variety, pungency, turnip

1. Introduction

Traditional vegetables mean native varieties of vegetables that have been grown and used in specific regions for a long time, with diverse varieties in various regions. Since these native varieties have been repeatedly cultivated in a specific region and maintained by growers, they have developed characteristics adapted to the local climate and food culture (Tomiyoshi and Ueno, 2016). Therefore, these varieties are valuable not only as breeding materials or genetic resources for developing new varieties, but also as a medium for communicating the history, cultures and traditional diets of specific regions.

In Japan, prior to World War II, most of the vegetables grown and distributed throughout the country were native varieties. However, after the period of rapid economic growth in the 1960s, government policy reform resulted in the mass production of vegetables through monoculture farming, which led to the rapid replacement of native varieties by first-generation hybrid varieties (F_1 varieties) that enabled the planned production of crops with uniform quality (Kawai, 2022; Yamashita, 1973). In parallel, the production of native varieties decreased in many regions of Japan because of their non-standard and irregular shapes and the fact that their cultivation required substantial labor. In the 1990s, however, consumer interest turned to food safety and quality and there was a growing movement to promote local production for local consumption. As a result, traditional vegetables that have a deep relationship with the local climate and food culture became to bring a renewed interest and there are increasing efforts to certify traditional vegetables and revive them throughout Japan (Uchiyama et al., 2017).

Information regarding the varietal differentiation and diversity of traditional Japanese vegetables can generally be obtained from those that have made exhaustive classifications of each type of vegetable on a national basis or from those that have researched and characterized each vegetable variety on a prefectural or regional basis. In the former case, it is difficult to obtain regional information for each variety, whereas in the latter case, it is difficult to obtain systematic information for each variety within and beyond each prefecture. To comprehensively identify and describe the traditional vegetables in specific regions of Japan, each prefecture should consolidate the information concerning each vegetable and maintain records that combine both regional and national information.

[1] School of Environmental Science, The University of Shiga Prefecture, Hikone, Shiga 522-8533, Japan
*Corresponding author (E-mail: hata.n@ses.usp.ac.jp)

For this review, we collected the currently available information regarding the traditional vegetables of Shiga Prefecture. We herein describe the background and research trends for each vegetable variety and type, while also clarifying their relationships with other native vegetables in Japan. In particular, by systematically compiling the information derived from ancient and modern research in English, we believe that this content will be of value to both domestic and international readers.

2. Overview of traditional vegetables in Shiga Prefecture

Shiga Prefecture is located almost in the middle of the Japanese archipelago, and Lake Biwa, the largest lake in Japan, occupies about 1/6 of the prefectural area (approximately 4,017 km^2) (Figure 1). The rain that falls on surrounding mountainous area (around 1,000 m above sea level) flows into Lake Biwa through more than 400 rivers that vary in size. The region around river basins and Lake Biwa comprises fertile agricultural land formed by the incoming rivers (Department of Lake Biwa and the Environment, Shiga Prefectural Government, 2008; Ministry of Land, Infrastructure, Transport and Tourism, Japan, 2011) and the vast alluvial plain in the south and east has long been known as a rice granary (Ministry of Land, Infrastructure, Transport and Tourism, Japan, 2003). Even today, paddy fields account for 92% of the total agricultural land in Shiga Prefecture, which limits the farmland available for vegetable production. To meet the increased demands for promoting vegetable production, multiple management of rice and vegetable farming or expanding the production of local specialties, including traditional vegetables are expected (Department of Agriculture and Fisheries, Shiga Prefectural Government, 2016).

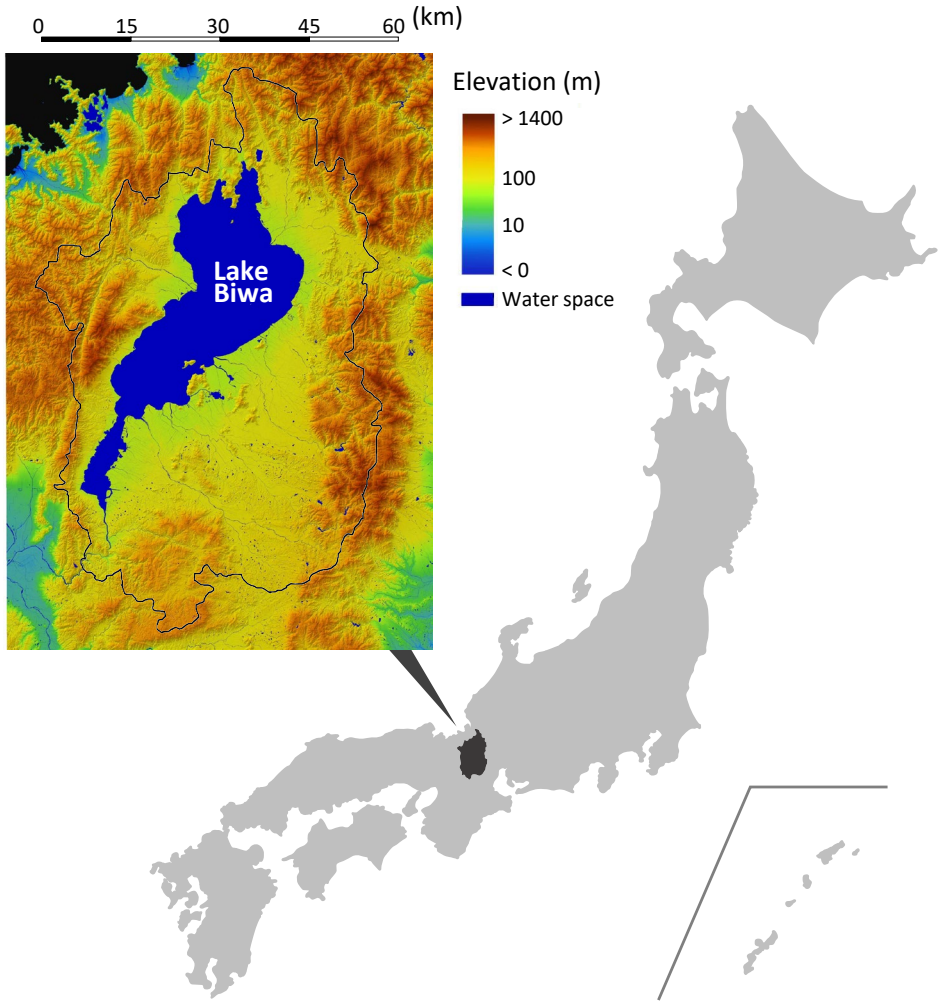

Figure 1. Location of Shiga Prefecture in Japan. The upper left map is based on the digital elevation model map published by Geospatial Information Authority of Japan.

In many cases, traditional vegetables are not synonymous with native vegetables, but instead refer to native vegetables that satisfy certain criteria. Such traditional vegetables are certified according to the standards of each prefecture (Uchiyama et al., 2017). In Shiga Prefecture, the criteria are as follows: (1) cultivation in the prefecture must have started by the Meiji era (1868–1912) and seeds must have been preserved (e.g., by growers) and (2) one or more of the following must be recognized as clearly different from other varieties: taste, appearance (shape, color, etc.), or other genetic traits (Department of Agriculture and Fisheries, Shiga Prefectural Government, 2021). A variety certified from among several native varieties in the prefecture is called *Ōmi-no-Dentō-yasai* (Japanese for traditional vegetable in Shiga Prefecture). In total, 19 varieties have been certified as of August 2018 (Figure 2, Table 1).

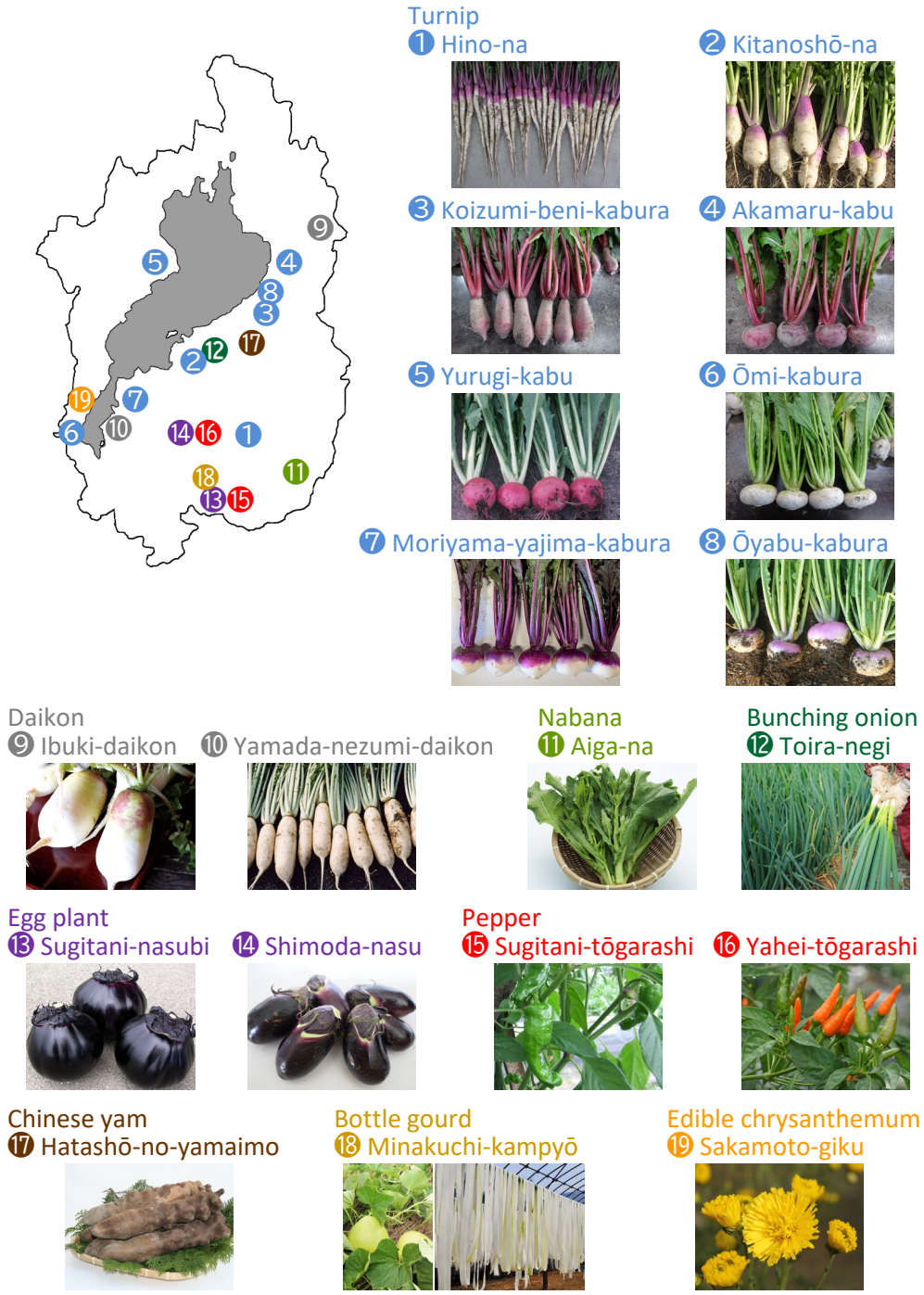

Figure 2. Areas in which the 19 varieties of *Ōmi-no-Dentō-yasai* are cultivated in Shiga Prefecture and their plant characteristics.

Table 1. Nineteen native vegetable varieties in Shiga Prefecture certified as *Ōmi-no-Dentō-yasai*.

Vegetable classification	APG classification		Local name (in Japanese)	Cultivation area		Harvest period		Edible parts
	Family	Scientific name		Municipality	District	Start	End	
Turnip	Brassicaceae	*Brassica rapa*	Hino-na	Hino-chō		Oct.	late Dec.	Hypocotyl-tuber, leaves
			Kitanoshō-na	Ōmihachiman	Kitanoshō	Nov.	early Feb.	
			Koizumi-beni-kabura	Hikone	Koizumi	Nov.	Dec.	
			Akamaru-kabu	Maibara	Maibara	Nov.	early Mar.	
			Yurugi-kabu	Takashima	Adogawa	Dec	early Mar.	
			Ōmi-kabura	Ōtsu	Obanagawa	Nov.	Jan.	
			Moriyama-yajima-kabura	Moriyama	Yajima	Nov.	Jan.	
			Ōyabu-kabura	Hikone	Ōyabu	Nov.	Dec.	
Daikon		*Raphanus sativus*	Ibuki-daikon	Maibara	Ibuki	Nov.	early Feb.	Tuberous root
			Yamada-nezumi-daikon	Kusatsu	Yamada	late Nov.	late Dec.	
Nabana		*Brassica* spp.	Aiga-na	Kōka	Ayukawa	mid Mar.	mid Apr.	Flower stalk, leaves, flower bud
Bunching onion	Amaryllidaceae	*Allium fistulosum*	Toira-negi	Ōmihachiman	Shimotoira	late Nov.	late Mar.	Leaf blade and sheath
Egg plant	Solanaceae	*Solanum melongena*	Sugitani-nasubi	Kōka	Sugitani	mid Jul.	mid Oct.	Fruit
			Shimoda-nasu	Konan	Shimoda	early Aug.	late Sep.	
Pepper		*Capsicum annuum*	Sugitani-tōgarashi	Kōka	Sugitani	early Jul.	late Oct.	Fruit (green pepper)
			Yahei-tōgarashi	Konan	Shimoda	Aug.	late Oct.	Fruit (chili pepper)
Chinese yam	Dioscoreaceae	*Dioscorea opposita*	Hatashō-no-yamaimo	Aishō-chō	Abiko Kitayagi Higashide	late Oct.	late Dec.	Tuber (rhizophore)
Bottle gourd	Cucurbitaceae	*Lagenaria siceraria*	Minakuchi-kampyō	Kōka	Minakuchi	mid Jul.	early Aug.	Fruit (dried shavings)
Edible chrysanthemum	Asteraceae	*Chrysanthemum morifolium*	Sakamoto-giku	Ōtsu	Sakamoto	late Oct.	Nov.	Petals

Ōmi-no and *Dentō-yasai* mean "in Ōmi (former name of Shiga Prefecture)" and "traditional vegetable," respectively, in Japanese.
Most of the local names consist of the vegetable name in Japanese and the name of the district in which the vegetable is cultivated and/or originated. However, *Akamaru* of 'Akamaru-kabu' means "red and round" and *Yahei* of 'Yahei-tōgarashi' refers to the first name of Mr. Yahei Kida.
In addition, *beni* of 'Koizumi-beni-kabura' refers to the vermilion coloration of the hypocotyl-tuber, whereas *nezumi* of 'Yamada-nezumi-daikon' refers to the mouse tail-like appearance of the tuberous root tip.

The 19 varieties certified as *Ōmi-no-Dentō-yasai* are mainly turnips (eight varieties), followed by daikon radishes, eggplants, and peppers (two varieties each), and other vegetables (five varieties). Additionally, 17 of these varieties (the exceptions are 'Akamaru-kabu' and 'Yahei-tōgarashi') are named by combining the vegetable names in Japanese with the names of the districts in which they are cultivated and/or originated. By municipality, Kōka City has the most varieties (four), followed by Hikone, Konan, Maibara, Ōmihachiman, and Ōtsu Cities (two each), and five other regions (one each). Most varieties are grown in the plains, mainly around Lake Biwa, but 'Ibuki-daikon' and 'Aiga-na' are grown in the mountainous areas and 'Akamaru-kabu', 'Ibuki-daikon', and 'Hatashō-no-yamaimo' are grown in sandy, limestone, and paddy soils, respectively.

In Shiga Prefecture, to further promote vegetable production, each region has focused on marketing *Ōmi-no-Dentō-yasai* on the basis of vegetable shapes and flavors. However, the differences between *Ōmi-no-Dentō-yasai* and common vegetables on the market in terms of cultivation and uses in food remain relatively unknown. Thus, to promote the increased cultivation and sales of *Ōmi-no-Dentō-yasai*, their characteristics must be clarified according to reliable information.

3. Details regarding *Ōmi-no-Dentō-yasai*

3.1. Turnip

Turnip is the most representative vegetable cultivated in Shiga Prefecture. Despite the limited farmland area compared to other production areas, Shiga Prefecture is one of the highest-ranking prefectures for production volume of turnip, with a largest proportion of the turnip-planted area per total farmland area (Table 2). In addition, various

turnip varieties, including many native varieties, are cultivated in Shiga Prefecture, which has been called the "Turnip Kingdom" (refer to Shiga Prefecture website). More specifically, there are 13 native varieties of turnip in the prefecture, eight of which are certified as *Ōmi-no-Dentō-yasai* (Satoh et al., 2020)

Table 2. Turnip production in Japan (2020).

Rank by production	Prefecture	Turnip		Total farmland area (ha)	Ratio of turnip-planted area per total farmland area (%)
		Production (t)	Planted area (ha)		
1	Chiba	25,300	904	50,500	1.790
2	Saitama	16,100	427	33,000	1.294
3	Aomori	6,840	186	70,400	0.264
4	Kyōto	4,740	152	6,640	2.289
5	Shiga	4,570	177	3,850	4.597
6	Fukuoka	3,760	104	15,600	0.667
7	Yamagata	3,360	238	24,700	0.964
8	Hokkaidō	3,290	101	921,400	0.011
9	Niigata	3,110	140	19,000	0.737
10	Gifu	3,000	147	13,000	1.131

Data were obtained from the 2020 Crop Survey (Fundamental Statistical Survey).
This survey is conducted annually by the Ministry of Agriculture, Forestry and Fisheries of Japan.

Table 3. Morphological characteristics of eight turnip varieties among the *Ōmi-no-Dentō-yasai*.

Local name	Hypocotyl-tuber							Leaf petiole color
	Shape	Size (cm)		Color			Type of anthocyanin	
		Diameter	Length	Aboveground	Underground	Inner part		
Hino-na	Elongated	2-3	20-30	Purple	White	White	Cyanidin	Purple
Kitanoshō-na	Cylindrical	3-4	10-15	Purple	White	White	Cyanidin	Purple/Green
Moriyama-yajima-kabura	Round	8	6	Purple	White	White	Cyanidin	Purple
Ōyabu-kabura	Flat	10	5	Purple	White	White	Cyanidin	Purple/Green
Koizumi-beni-kabura	Cylindrical	3-4	10	Vermilion	Vermilion	Vermilion/White	Pelargonidin	Vermilion
Akamaru-kabu	Round	9-10	9-10	Vermilion	Vermilion	Vermilion/White	Pelargonidin	Vermilion
Yurugi-kabu	Round	9-10	9-10	Vermilion	Vermilion	White	Pelargonidin	Green
Ōmi-kabura	Flat	12-15	7	Green	White	White		Green

Information regarding the anthocyanins in the hypocotyl-tuber was obtained from studies by Shibutani and Okamura (1956) and Satoh et al. (2020).

Native turnip varieties in Japan can be roughly classified as Japanese, European, and intermediate types depending on the presence (dominant) or absence (recessive) of a mucilaginous coat after seeds have absorbed water; this trait is controlled by a single gene. The Japanese-type can form a mucilaginous seed coat, but the European-type cannot. The segregation of this trait has been observed for the intermediate-type (Aoba, 1961a, b, 1963; Ohi and Sato, 2002; Shibutani and Okamura, 1954, 1955, 1957; Takahashi et al., 2016). A number of native turnips in Shiga Prefecture have been examined, which revealed that of the eight turnip varieties recognized as *Ōmi-no-Dentō-yasai*, all except 'Akamaru-kabu', which has not been examined, are Japanese-type turnips that produce seeds with a mucilaginous coat.

Although there is little variation in the formation of seed mucilage, plant morphological features and coloration vary considerably among the eight native turnip varieties (Table 3). On the basis of hypocotyl-tuber (the term for turnip vegetative storage organ [Liu et al., 2019]) coloration, turnips are classified as white turnips, which lack anthocyanins, and red turnips, which contain anthocyanins. Red turnips are further divided as purple turnips that contain cyanidins and vermilion turnips that contain pelargonidins (Satoh et al., 2020; Shibutani and Okamura, 1956). In purple turnips, the skin of the aboveground part of the hypocotyl-tuber, which is exposed to light, and the leaf petioles can be purple, but the underground and inner parts of the hypocotyl-tuber remain white. Moreover, their hypocotyl-tuber shape varies from elongated ('Hino-na') to flat ('Ōyabu-kabura'). In vermilion turnips, the skin of the entire hypocotyl-tuber is vermilion. The inner part of the hypocotyl-tuber and the leaf petioles are also vermilion for 'Koizumi-beni-kabura', but not for 'Yurugi-kabu', whereas 'Akamaru-kabu' has an intermediate vermilion coloration.

Among the *Ōmi-no-Dentō-yasai*, the most detailed records are available for 'Hino-na', which was first cultivated around 1500 (Hino-chō-Kyōikukai eds., 1930). In the 22nd volume of *Honzō-Kōmoku-Keimō*, published in 1805, 'Hino-

na' was described as a famous product of the Hino district (Figure 3). However, description of its root being approximately 15–18 cm long indicates that the hypocotyl-tuber of 'Hino-na' at that time was shorter and even wider than the currently cultivated one. We can also recognize the feature of 'Hino-na' at that time from an illustration produced by a Ukiyoe artist, Tsukioka Settei (1710–1786), who was born in Hino-chō (Figure 4). The elongated hypocotyl-tuber form that we see today is said to be the result of selection during the Meiji era. It is now cultivated outside of Shiga Prefecture and has become a national standard.

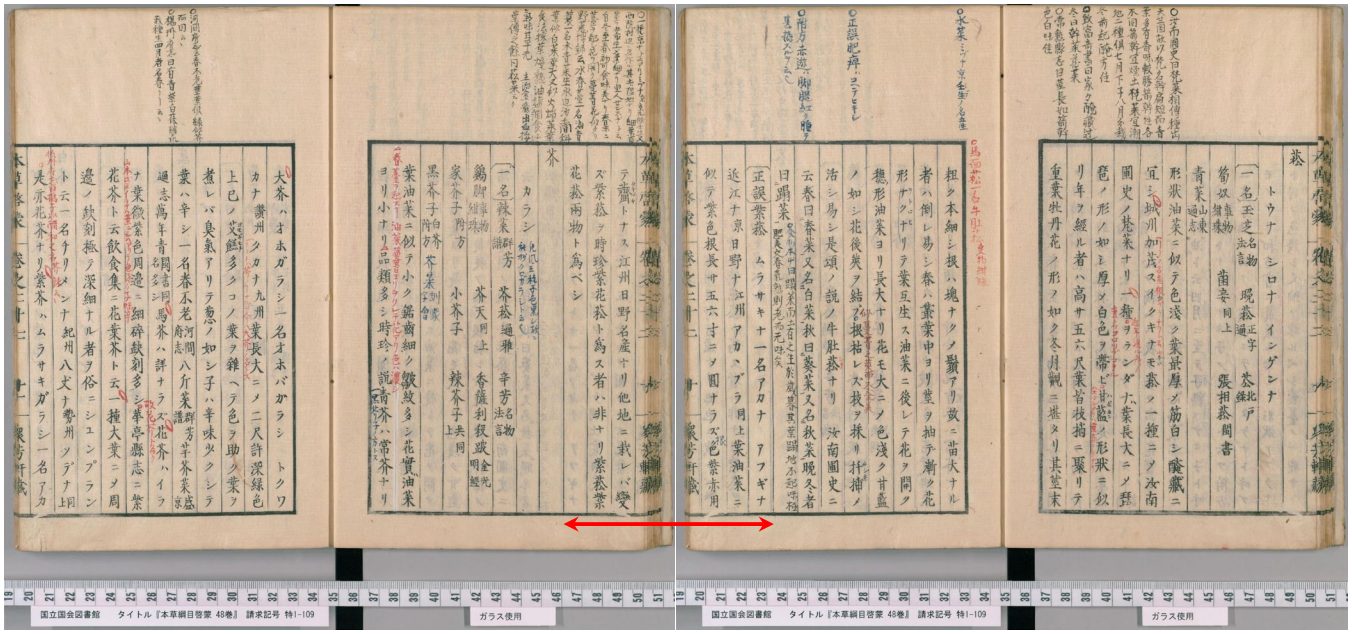

Figure 3. Description of 'Hino-na' in *Honzō-Kōmoku-Keimō*, which includes transcripts of lectures regarding materia medica by Ranzan Ono (vol. 22 published in 1805). The relevant part on two facing pages is indicated by a red double arrow (from the National Diet Library Digital Collections in Japan).

Figure 4. Illustration of 'Hino-na' painted by the Ukiyoe artist Tsukioka Settei (1710–1786), who was born in Hino-chō. The image was reproduced from *Ōmi-Hino-chō-Shi*, the lower volume, with permission from the Hino-chō Board of Education.

'Kitanoshō-na' was previously on the verge of extinction, but it has been revived using the few remaining seeds, which are now sold commercially. A recent simple sequence repeats (SSR) marker analysis revealed that 'Kitanoshō-na' is genetically close to 'Hino-na' (Kubo et al., 2019b).

Compared with 'Hino-na' and 'Kitanoshō-na', 'Moriyama-yajima-kabura' and 'Ōyabu-kabura' are more similar to common turnips in terms of their hypocotyl-tuber morphological characteristics. 'Moriyama-yajima-kabura' has a wholly deeper color than 'Ōyabu-kabura' and often forms purple leaf blades.

'Koizumi-beni-kabura', which is also known as 'Hikone-kabu' (Ohi and Sato, 2002; Shibutani and Okamura, 1954, 1955, 1956, 1957), was first identified in the garden of Hikone Castle approximately 250 years ago and then introduced to the Koizumi district (Department of Agriculture and Fisheries, Shiga Prefectural Government, 2007). Its hypocotyl-tuber shape is similar to that of 'Kitanoshō-na'.

Both 'Akamaru-kabu' and 'Yurugi-kabu' have a spherical hypocotyl-tuber, but they can be distinguished on the basis of the color of the inner part of the hypocotyl-tuber and the leaf petioles. The production of 'Akamaru-kabu', which is grown in the sandy soil of Maibara district, increased with the decline of sericulture and the associated decrease in the demand for mulberry plants (Department of Agriculture and Fisheries, Shiga Prefectural Government, 2007). Fields that were traditionally used for mulberry cultivation were converted to fields for turnip production. 'Yurugi-kabu' was bred by Mr. Tōsuke Minakuchi in the early period of the Meiji era through the selection of seeds of native turnip strains. Its original name was 'Tōsuke-kabu', but in the mid-Meiji era, it was changed to the present name according to the production area. 'Yurugi-kabu' seeds can be obtained from seed companies and are useful research material for studying anthocyanin biosynthesis (Zhou et al., 2007).

'Ōmi-kabura' is characterized by its flat hypocotyl-tuber, which was described in *Honzō-Kōmoku-Keimō* (Figure 5). The results of an SSR marker analysis suggested 'Ōmi-kabura' is genetically related to 'Mizuna' in Kyōto Prefecture (see Figure 6), while also distantly related to the other seven red turnip varieties that contain anthocyanins in their hypocotyl-tubers (Kubo et al., 2019b).

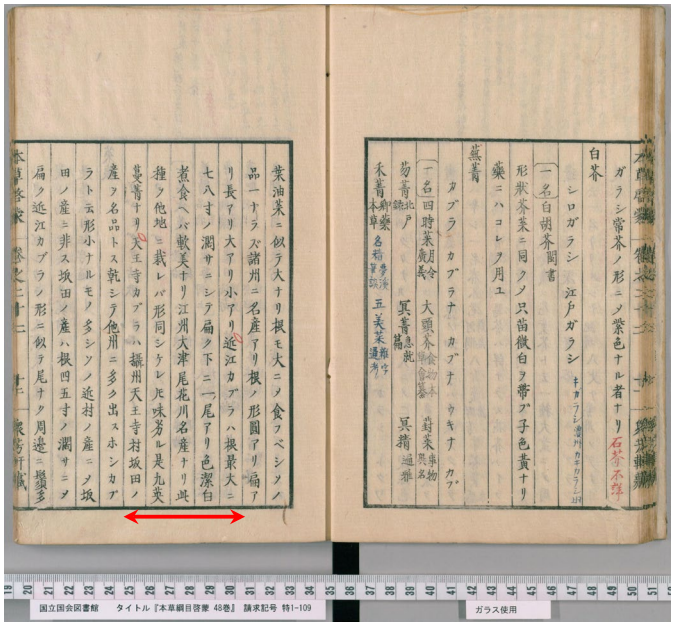

Figure 5. Description of 'Ōmi-kabura' in *Honzō-Kōmoku-Keimō* (vol. 22 published in 1805). The relevant part on the left side of the facing pages is indicated by a red double arrow (from the National Diet Library Digital Collections in Japan).

Figure 6. Location of several prefectures around Shiga Prefecture in Japan.

3.2. Daikon (Japanese radish)

There is a long history of 'Ibuki-daikon' cultivation on the hillsides of Mt. Ibuki (see Figures 1 and 2). For example, it was introduced as "a specialty of Mt. Ibuki" in *Nōgyō-Zensho* (1697), which is the earliest published agricultural encyclopedia in Japan. The purple coloration of the aboveground part of the tuberous root and the leaf

petioles of 'Ibuki-daikon' is similar to that of 'Kitanoshō-na'. In contrast, 'Yamada-nezumi-daikon' lacks anthocyanins, resulting in a completely white tuberous root. It is a kind of "*Nezumi-daikon*" whose tip of tuberous root looks like the tail of a mouse (i.e., *nezumi* in Japanese) and cultivated in the Yamada district. Notably, it was once extensively produced and distributed to Kyōto Prefecture (Department of Agriculture and Fisheries, Shiga Prefectural Government, 2007).

In a recent report, 45 phenotypic traits were compared among 52 native daikon varieties in Japan (Tsubaki, 2017). The cluster analysis of the phenotypes classified 'Ibuki-daikon' in the same group as several native varieties in Nagano Prefecture (see Figure 6), including 'Shinshū-jidaikon' and 'Maki-daikon'. Although 'Yamada-nezumi-daikon' was not investigated, the cluster analysis also indicated that 'Shiroagari-kyō-daikon', which is a native variety in Kyōto Prefecture that is considered to be closely related to 'Yamada-nezumi-daikon', does not belong to the same group as 'Ibuki-daikon' and the native varieties in Nagano Prefecture. Therefore, the relationship between 'Yamada-nezumi-daikon' and 'Ibuki-daikon' seems similar to that between 'Ōmi-kabura' and other native turnips. Furthermore, they may belong to different lineages.

Mount Ibuki has also long been known as a source of high-quality buckwheat grain (Cabinet Office, the Government of the United Kingdom, 2021). 'Ibuki-daikon' is a kind of pungent daikon variety, thus grated tuberous root has been used as a condiment for *Ibuki-soba* (buckwheat noodle) made from the native buckwheat variety. According to available information, 4-methylthio-3-butenyl isothiocyanate (i.e., a pungent compound) content in 'Ibuki-daikon' is 1.3- to 2.3-times greater than that in commercially produced common varieties (Kinki Chūgoku Region Agricultural Research Promotion Initiative, 1999). On the other hand, 'Ibuki-daikon' may be characterized as only mildly pungent variety, because its 4-methylthio-3-butenyl isothiocyanate content is only 1/2 to 1/3 of that in the pungent daikon varieties native to Nagano Prefecture (Karasawa et al., 2012). Interestingly, in *Yamato-Honzō* (vol. 5), a book about herbs written by Ekiken Kaibara in 1709, the taste of 'Ibuki-daikon' produced at that time was described as "extremely pungent" (Figure 7), suggesting that the less pungent variety grown today was selected over time. 'Ibuki-daikon' also has been reported to have moderate sugar content and be relatively soft among 52 native daikon varieties in Japan (Tsubaki, 2017).

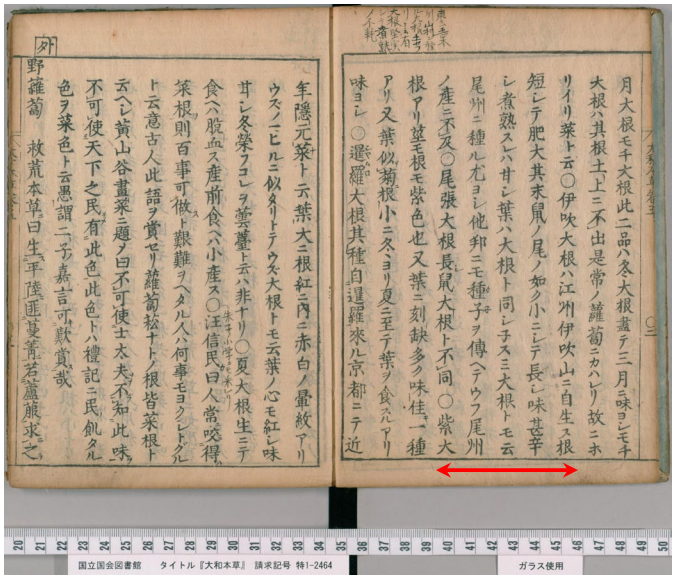

Figure 7. Description of 'Ibuki-daikon' in *Yamato Honzō*, a book describing herbs in Japan (vol. 5 written by Ekiken Kaibara in 1709). The relevant part on the right side of the facing pages is indicated by a red double arrow (from the National Diet Library Digital Collections in Japan).

Recent research on 12 daikon varieties revealed that allele of *RsF3'H* (*Raphanus sativus flavonoid 3'-hydroxylase*) in the flavonoid biosynthesis pathway is homozygous dominant in 'Ibuki-daikon', although the skin of the underground part of its tuberous root is white (Masukawa et al., 2019). This allele determines whether the skin color of tuberous root skin turns purple by cyanidin or vermilion by pelargonidin. Furthermore, 40 varieties of Brassicaceae native vegetables in Japan were compared in terms of their growth, sulfur content, and sulfate transporter gene expression in response to various rhizosphere sulfur concentrations (Yamaya-Ito et al., 2020). The results showed that sulfur deficiency has drastic effects on 'Hino-na', whereas 'Ibuki-daikon' is unaffected. Thus, there is growing interest in the utility of 'Ibuki-daikon' as a research material.

3.3. Nabana

The harvests of young parts consisting of leaves, flower stalks, and buds in rapeseed plants, that have begun to bolt in early spring, are called as "*nabana*" in Japanese and eaten as vegetable (Kim et al., 2003; Kubo et al., 2019a). 'Aiga-na' is a traditional vegetable used as a *nabana* and harvested by hand breaking off the flower stalks, whose parts are eaten together with their leaves (Department of Agriculture and Fisheries, Shiga Prefectural Government, 2007).

Generally, rapeseed varieties used for *nabana* production in Japan are broadly classified as *Brassica rapa* (Japanese old-type rapeseed) and *Brassica napus*. Although the scientific name of 'Aiga-na' is unknown and the identification of this species has not been verified, we believe 'Aiga-na' is a *B. rapa* variety because of its leaf morphological characteristics and the development of a mucilaginous seed coat following the absorption of water. According to several reports, *B. napus* seeds do not form a mucilaginous coat (Aoba, 1971; Shibutani and Okamura, 1955), but we observed that 'Aiga-na' seeds can form them.

3.4. Bunching onion

The Shimotoira district, where 'Toira-negi' is produced, used to border the lagoon attached to Lake Biwa, called Benten-naiko (now reclaimed), from which bottom sediments and waterweeds were collected, composted, and spread on agricultural fields (Matsuo and Ide, 2006, 2007). Accordingly, the soil in the fields used to produce 'Toira-negi' may still contain many shells (Department of Agriculture and Fisheries, Shiga Prefectural Government, 2007).

Many Japanese local bunching onion varieties are adapted to various climatic conditions and have been classified into the following four groups according to morphological and ecological traits: *Kaga*, *Senju*, *Kujō*, and *Yagura-negi* (Inden and Asahira, 1990). 'Toira-negi', which belongs to the Kujō group, has a larger white part (leaf sheath) and a smaller green part (leaf blades) than 'Kujō-negi', which is one of the traditional vegetables in Kyōto Prefecture.

3.5. Eggplant

Since their introduction to Japan, eggplant has been cultivated for more than 12 centuries, with many local varieties grown in the Edo era (1603–1868) (Fujime, 2012; Nakagawa et al., 2021). Because of their long-term cultivation, various varieties suited to the climate and soil conditions as well as local tastes in each region in Japan have been established, with diverse fruit shapes and sizes (e.g., small round, round, egg-shaped, long egg-shaped, long, and extremely long).

There are also several native varieties of eggplant in Shiga Prefecture. According to a country-wide survey of native eggplant varieties in 1988, of the native eggplant varieties in Shiga Prefecture, 'Sugitani-nasubi' was already known, but 'Shimoda-nasu' was known only locally and its existence was first revealed in this survey (Monma and Sakata, 1989). Although not certified as *Ōmi-no-Dentō-yasai*, there is other variety called 'Takatsuki-maru-nasu'. This variety is cultivated in the Takatsuki district, Nagahama City near the eastern part of the northern tip of Lake Biwa.

'Sugitani-nasubi' is a type of eggplant variety bearing a round fruit with grooves that extend vertically on the pericarp, whose fruit shape is expressed as "*Kinchaku-nasu*" in Japanese. It is harvested at fruit size weighing 300–400 g. Compared with 'Kamo-nasu', which is a native eggplant variety in Kyōto Prefecture that also produces a round fruit, the 'Sugitani-nasubi' fruit has softer skin and can be consumed with the skin (Department of Agriculture and Fisheries, Shiga Prefectural Government, 2007). 'Shimoda-nasu' has a long egg-shaped fruit with a characteristic lack of purple coloration on the pericarp at the margin of the calyx. The fruit is harvested relatively early (weight of 30–50 g) and is pale purple, making it suitable for pickling.

Phylogenetic and population structure analyses involving 12 SSR markers were recently conducted for 46 native Japanese eggplant varieties, including 'Sugitani-nasubi', 'Shimoda-nasu', and 'Takatsuki-maru-nasu' (Nakagawa et al., 2021). The results indicated that 'Sugitani-nasubi' and 'Shimoda-nasu' are genetically related and their lineage differs from that of 'Takatsuki-maru-nasu', which seems to be closely related to 'Kamo-nasu' in Kyōto Prefecture.

3.6. Pepper

There are five major cultivated *Capsicum* species worldwide, of which *C. annuum* is the only one to become established as native varieties in Japan, except for some varieties in subtropical regions (Yazawa et al., 1989). On the basis of their morphological characteristics, these pepper species in Japan may be divided into the following six groups: *Goshiki*, *Enomi*, *Takanotsume*, *Yatsubusa*, *Fushimi*, and *Taika* (large fruit) (Kumazawa et al., 1954). This general classification may be slightly modified by dividing the *Taika* group into the Bell and *Zairai-shishi* subgroups (for

example, Hirose et al., 1956). The *Goshiki* and *Enomi* varieties are grown for ornamental uses, whereas *Takanotsume* and *Yatsubusa* varieties are typically used as spices (pungent species) and the Bell varieties are cultivated as vegetables (sweet species). In addition, most of the *Fushimi* and *Zairai-shishi* varieties are sweet species, but their fruits can become pungent under certain conditions (Kondo et al., 2021).

There are several native pepper varieties in Kyōto Prefecture, of which 'Fushimi-tōgarashi' and 'Tanaka-tōgarashi' belong to the *Fushimi* and *Zairai-shishi* groups, respectively (Hirose et al., 1956; Kumazawa et al., 1954). According to the Kyōto City website, 'Tanaka-tōgarashi' was initially cultivated using seeds brought back from Shiga Prefecture in the early Meiji era. It is unknown whether 'Sugitani-tōgarashi' seeds were used, but 'Sugitani-tōgarashi' and 'Tanaka-tōgarashi' have morphologically similar fruits, indicating that 'Sugitani-tōgarashi' is a variety classified in the *Zairai-shishi* group. The fruits are wrinkled and long (approximately 10 cm), but tend to bend near the center, resulting in a J shape. The harvested fruits, which have a thin skin and are only slightly pungent, are used as a vegetable, similar to the fruit of 'Shishitō', which is a representative *Zairai-shishi* variety.

'Yahei-tōgarashi' is a typical pungent pepper species, with a pungency (100,000 Scoville) that is double that of 'Takanotsume', which is another typical pungent species in Japan (refer to Shiga Prefecture website). 'Yahei-tōgarashi' has been cultivated along with 'Shimoda-nasu' in the Shimoda district and have been used to season 'Shimoda-nasu' dishes (Department of Agriculture and Fisheries, Shiga Prefectural Government, 2007). The *Yahei* of 'Yahei-tōgarashi' comes from the first name of Mr. Yahei Kida, who is credited with obtaining seeds from Gifu Prefecture (see Figure 6) more than 150 years ago to begin cultivating, which has become a native pepper variety in the region (Yahei-tōgarashi Preservation Society, personal communication). Its existence has recently become well known outside the prefecture and demand for its use as a spice has been increasing.

'Yahei-tōgarashi' has a conical fruit that is approximately 5 cm long. The mature fruit is bright orange, which is unusual for a native Japanese pepper. However, 'Yahei-tōgarashi' plants bear white flowers with black anthers and a dentate calyx margin, which are characteristic of *C. annuum* plants (Shiragaki et al., 2020). It remains unclear whether it belongs to the *Takanotsume* group or the *Yatsubusa* group. In the databases of NARO (National Agriculture and Food Research Organization) Genebank, the variety is registered under the scientific name "*Capsicum annuum*" and its varietal name is "YAHEI TOUGARASHI-B".

In addition to two varieties certified as *Ōmi-no-Dentō-yasai*, other native pepper varieties with distinct characteristics also exist in Shiga Prefecture. One is a variety marketed by a local seed company under the name *Murasaki-namba* and is cultivated in the Takatsuki district, which is where 'Takatsuki-maru-nasu' is grown. The harvested immature fruit is not only dark purple, but also it does not synthesize capsaicin because of a defective *Pun1* allele, which results in a lack of pungency (Sano et al., 2022; Yazawa et al., 1989). The existence of the 'Yonomi' variety bearing cherry-like pungent fruits recently became to be known. This variety has been cultivated in the Yogo district, which is further north than the Takatsuki district. The characteristics of these two varieties along with 'Sugitani-tōgarashi' and 'Yahei-tōgarashi' should be explored further for leading to successful brand-building.

3.7. Chinese yam

Yams (*Dioscorea* spp.) are distributed almost ubiquitously in tropical and subtropical regions, but Chinese yam (*D. opposita*) is better able to tolerate much colder conditions than its relatives. Hence, it is cultivated mainly in temperate regions (Epping and Laibach, 2020). Its tuber can be used for cooking (e.g., as a food additive) or consumed directly as a vegetable, but it is also commonly grated in Japan to produce *tororo*, which has several beneficial effects on human health (Nagai et al., 2014).

The diverse types of native Chinese yam varieties cultivated in Japan have been classified in the following three groups according to their tuber shape: *Nagaimo* (cylindrical), *Tsukuneimo* (round), and *Ichōimo* (flattened) (Babil et al., 2013). Chinese yam varieties belonging to the *Tsukuneimo* group, such as 'Ise-imo', 'Tamba-yamanoimo', and 'Kaga-maru-imo', are cultivated in several prefectures around Shiga. Especially, 'Ise-imo' in Mie Prefecture (see Figure 6) is believed to be the ancestor of 'Hatashō-no-yamaimo' (Department of Agriculture and Fisheries, Shiga Prefectural Government, 2007). Therefore, 'Hatashō-no-yamaimo' possibly belongs to the *Tsukuneimo* group, although Takayanagi et al. (1984) previously classified it in the *Ichōimo* group.

Bulbils (aerial tubers) in leaf axils, which are used for propagation, are formed in the *Nagaimo* and *Ichōimo* varieties, but rarely in the *Tsukuneimo* varieties (Fukushima et al., 1995; Mori et al., 1993). 'Hatashō-no-yamaimo' also

forms few bulbils under field conditions, which necessitates the use of tuber division-based propagation methods that are inefficient in propagation. Furthermore, the use of unmarketable tubers as seed tubers has led to a decline in seed tuber quality, which causes certain problems, including the formation of abnormally shaped tubers and a high incidence of viral diseases. Therefore, methods for the mass propagation of high-quality seedlings in a tissue culture system have also been considered for 'Hatashō-no-yamaimo' (Akita and Ohta, 2002; Watanabe et al., 1993, 1994).

'Hatashō-no-yamaimo' is typically cultivated on the high ridges of rice paddies, rather than on farmland. *Tsukuneimo* varieties are also often grown in paddy fields, unlike the varieties in the other groups (Okamoto, 2001). Thus, 'Hatashō-no-yamaimo' is similar to *Tsukuneimo* varieties in this respect. The harvested tuber, which is cultivated for 3 years to increase in size, is cylindrical and approximately 30 cm long, but the shape is highly variable because of the humps and irregularities that occur on the surface. Furthermore, the *tororo* produced using the 'Hatashō-no-yamaimo' tuber is highly viscous.

3.8. Bottle gourd

In Japan, cultivated varieties of bottle gourd (*Lagenaria siceraria*) are broadly grouped into inedible and edible types. The inedible types (i.e., *hyōtan* and rarely *hisago* in Japanese) have a hard rind and contain large amounts of cucurbitacins, which are bitter and sometimes toxic (Yoshioka and Yoshida, 2017). Thus, the inedible bottle gourd varieties have been used as water containers or as handicrafts because of their unique shapes. In contrast, the edible bottle gourd varieties (*yūgao* in Japanese) produce a pulpy fruit with a soft rind and a low cucurbitacin content. The *yūgao* varieties were likely introduced into Japan via China during the Heian era (794–1185), whereas *hyōtan* seeds have been recovered at many Jōmon sites, including the Awazu submarine archeological site (8500–9000 B.C.E) located in the southern basin of Lake Biwa (see Figure 1) (Fuller et al., 2010; Matsui and Kanehara, 2006).

In some African and Asian countries, immature bottle gourd fruits are eaten after being cooked, similar to *Cucurbita* spp., while the shoots, tendrils, and leaves are also consumed as a leafy vegetable (Sari et al., 2021). In Japan, however, bottle gourd (*yūgao*) fruits are mainly eaten after they have been processed into *kampyō*. More specifically, the immature fruit pulp is shaved into thin strips and dried. After being rehydrated in water, *kampyō* is used in various Japanese dishes (e.g., sushi).

Figure 8. *Minakuchi*, subtitled as *Meibutsu-kampyō*, from the series "*The Fifty-three Stations of the Tōkaidō*" painted by Hiroshige Utagawa (1833). The painting (from the National Diet Library Digital Collections in Japan) shows women who are hanging long and thin strips of gourd shavings onto ropes to dry in the sun for the subsequent production of *kampyō*, which was already a famous product (*meibutsu* in Japanese).

The cultivation of bottle gourd (*yūgao*) and the production of *kampyo* probably started in the Kizu district of Ōsaka Prefecture (see Figure 6), which likely explains why *kampyō* was traditionally called *kizu* in some regions, including Ōsaka and Kyōto Prefectures. Bottle gourd cultivation in Shiga Prefecture is believed to have been initiated around 1600 in the Minakuchi district following a request by the lord of Minakuchi-Okayama Castle (Department of Agriculture and Fisheries, Shiga Prefectural Government, 2007). The Minakuchi district where 'Minakuchi-kampyō' is produced was a post town along the *Tōkaidō*, which is one of the two old routes that linked Kyōto and Edo (Tōkyō) in the Edo era. In the series of paintings based on the 53 post towns along the *Tōkaidō* (i.e., "*The Fifty-three Stations of*

the Tōkaidō" by Hiroshige Utagawa, 1833–1834), 'Minakuchi-kampyō' is depicted, suggesting that it was already a famous product in the Minakuchi district at that time (Figure 8). Even today, 'Minakuchi-kampyō' is produced by peeling off the fruit pulp using a special hand-operated tool and then drying the pulp under the sun. The fruits used for this purpose are almost spherical, with a diameter of approximately 30 cm and a weight of just under 10 kg. These can be regarded as characteristic features of the native *yūgao* variety in the Minakuchi district.

3.9. Edible chrysanthemum

Although it is known for its ornamental value, chrysanthemum was originally imported to Japan as a medicinal plant (Breedlove and Arguin, 2016). The dried flower-heads of *Chrysanthemum morifolium*, which is one of an oriental drug, have been used to treat eye diseases in Japan and China (Miyazawa and Hisama, 2003). In addition to their decorative uses, the flower petals of native chrysanthemum varieties, which have been bred for food use, are also used in various food dishes and pickles (Endo and Iwasa, 1982). Such edible chrysanthemums are called *shokuyō-giku* or *ryōri-giku* in Japanese (i.e., edible chrysanthemums for culinary use), but they were also referred to as *ama-giku* or *kan-giku* (i.e., sweet chrysanthemum) in Japanese books written in the early 1800s (Figure 9).

Figure 9. Description of "sweet chrysanthemum" in *Honzō-Kōmoku-Keimō* (vol. 11 published in 1803; left) and *Honzō-Zufu* (vol. 13 compiled in 1828; right), which is an illustrated guide to medicinal plants written by Kan'en Iwasaki. The relevant part on the facing pages is indicated by a red double arrow (from the National Diet Library Digital Collections in Japan).

Mount Hiei, located on the border of Kyōto and Shiga Prefectures, is famous for *Enryakuji* Temple, which is located near the summit and was founded by the Japanese monk Saichō in 788. 'Sakamoto-giku' is grown in the Sakamoto district at the eastern foot of Mt. Hiei (see Figures 1 and 2). Saichō, who was also a Japanese envoy to the Tang Dynasty in China, reportedly brought tea seeds back from China and started the cultivation of tea plants in the Sakamoto district (Okakura, 1906; Yamashita, 2020). According to tradition, Saichō also introduced a chrysanthemum that was later used as 'Sakamoto-giku' (Department of Agriculture and Fisheries, Shiga Prefectural Government, 2007). This could be supported by other records. For example, the *Tenyakuryō* (Bureau of Medicine) described "yellow chrysanthemum flowers" as a tribute paid to the imperial court by Ōmi Province (Shiga Prefecture) in *Engishiki* (a book about laws and customs compiled in 927) (Figure 10). In 1691, the haiku poet Matsuo Bashō composed one haiku describing the consumption of food containing edible chrysanthemum that was likely 'Sakamoto-giku' in the northern town of the Sakamoto district.

'Sakamoto-giku' is an autumn-flowering chrysanthemum variety that bears yellow flowers from late October to early November (Department of Agriculture and Fisheries, Shiga Prefectural Government, 2007). In an earlier study on the various morphological characteristics of 52 native Japanese edible chrysanthemum varieties, which did not include 'Sakamoto-giku', most of the varieties were indicated to have a flower diameter of at least 6 cm (Endo and

Iwasa, 1982). On the other hand, the flower diameter of 'Sakamoto-giku' is approximately 3 cm, which is quite small for an edible chrysanthemum. Furthermore, the petals were generally flat or spoon-shaped in 52 varieties, but the petals of 'Sakamoto-giku' are characterized by their tubular shape. Notably, varieties with only tubular petals, which are crispier than flat petals, are preferred as edible chrysanthemums (Endo and Iwasa, 1982). Thus, 'Sakamoto-giku' has a very distinct inflorescence morphology among the edible chrysanthemum cultivars and is considered to have superior textural traits.

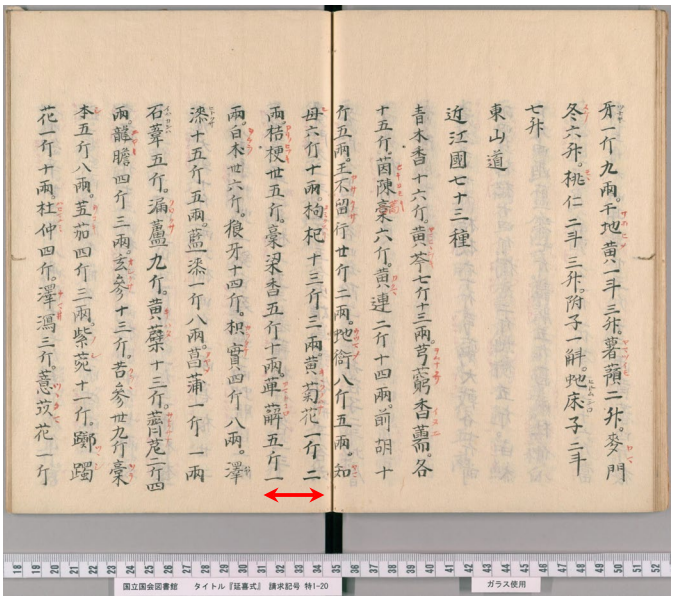

Figure 10. Description of "yellow chrysanthemum flowers" in *Engishiki*, a book about laws and customs in Japan (vol. 37 compiled in 927). The relevant part on the facing pages stating Ōmi Province (Shiga Prefecture) contributed approximately 700 g yellow chrysanthemum flowers is indicated by a red double arrow (from the National Diet Library Digital Collections in Japan).

4. Conclusions

In summary, we reviewed the available literature regarding research on the 19 varieties certified as *Ōmi-no-Dentō-yasai* and compiled the information for nine vegetable types. For the vegetables with more than two native varieties in Shiga Prefecture, namely turnip, daikon, eggplant, and pepper, the varieties differed in terms of the morphological characteristics of the edible parts and the pigments (anthocyanins) and pungency-related compounds. There was considerable diversity among the turnip and pepper varieties in Shiga Prefecture alone. In addition, we could also introduce the diversity in the daikon and eggplant varieties in Shiga Prefecture combined with the findings of taxonomic studies on 52 and 46 native varieties of daikon and eggplant, respectively, distributed in Japan. In other words, these diversities of four vegetable types in Shiga Prefecture may explain some of the diversity in the traditional vegetables grown in the 47 prefectures of Japan.

For the vegetable types with only one variety in Shiga Prefecture [i.e., *nabana*, bunching onion, Chinese yam, *kampyō* (*yūgao*), and edible chrysanthemum], the native varieties of bunching onion and Chinese yam in Japan were classified into four and three groups, respectively. For edible chrysanthemum, we described the results of an earlier study that compared the characteristics of 52 native varieties from several prefectures. For these three vegetable types, we propose that some of the diversity in Japanese traditional vegetables may be shown by comparing 'Toira-negi', 'Hatashō-no-yamaimo', and 'Sakamoto-giku' with varieties from other groups. In contrast, the diversity in *nabana* and *kampyō* (*yūgao*) has not been thoroughly elucidated because of the limited progress in the classification of each native variety, although we indicated their characteristics as *Ōmi-no-Dentō-yasai*. Therefore, a nationwide taxonomic survey will need to be conducted for *nabana* and *kampyō* (*yūgao*).

Focusing on Shiga Prefecture, the presentation of the varieties according to vegetable types clearly showed the unequal amounts of information for each *Ōmi-no-Dentō-yasai*. For example, there is a paucity of information specific to 'Moriyama-yajima-kabura' and 'Ōyabu-kabura', but the comprehensive information regarding these two varieties is not scarce because the turnip group has various available information. In addition, a substantial amount of information was obtained for 'Hatashō-no-yamaimo', 'Minakuchi-kampyō', and 'Sakamoto-giku', although all of which were the only native varieties in their respective vegetable categories. In contrast, 'Aiga-na' and 'Toira-negi' are relatively uncharacterized. To promote the production of these vegetables, they must be examined in greater detail.

While collecting the relevant information, we discovered that 'Yahei-tōgarashi', 'Hatashō-no-yamaimo', and 'Sakamoto-giku' may be unique varieties. Although 'Hino-na', which has a unique shape among turnips, is already known nationwide, a concerted effort to disseminate information regarding 'Yahei-tōgarashi', 'Hatashō-no-yamaimo', and 'Sakamoto-giku' beyond Shiga Prefecture is necessary.

This review describes the traditional vegetables cultivated in Shiga Prefecture and introduces traditional Japanese foods, such as grated daikon (*daikon-oroshi*), *tororo*, *kampyō*, and *shokuyō-giku*, while also summarizing the details provided in Japanese historical documents, including *Engishiki* and *Nōgyō-Zensho*. We prepared this review so that it is comprehensible to global readers so its use will not be restricted to Japan.

Acknowledgments

We would like to express our appreciation for the contributions by Satoru Yamashita and Shin'ichirō Matsuda (Shiga Prefecture Agricultural Technology Promotion Center) and the following organizations: Aishō Town, Azuchi Chamber of Commerce, JA Kōka, JA Lake Moriyama, Maibara City, and Yahee-tōgarashi Hozon-Kai. We also thank Chikashi Kitamura and Momoko Kawamura for providing photographs and Edanz (https://jp.edanz.com/ac) for editing a draft of this manuscript.

Declarations

All authors declare there are no competing interests regarding this publication.

References

Akita, M. and Y. Ohta. 2002. A simple bioreactor system for production of storage organs of Chinese yam (*Dioscorea opposita* Thumb.). Plant Biotechnol. 19: 353–356. https://www.jstage.jst.go.jp/article/plantbiotechnology/19/5/19_5_353/_article/-char/en

Aoba, T. 1961a. Studies on the classification and the geographical distribution of local varieties of vegetables in Japan. II. Manifestation of characters in F_1 hybrids of crossings among local varieties of turnip native to eastern Japan. J. Japan. Soc. Hort. Sci. 30: 147–152 (in Japanese with English summary). https://www.jstage.jst.go.jp/article/jjshs1925/30/2/30_2_147/_article/-char/en

Aoba, T. 1961b. Studies on the classification and the geographical distribution of local varieties of vegetables in Japan. III. On the relationship and geographical distribution of the local varieties of turnip in the north-western part of Central Japan. J. Japan. Soc. Hort. Sci. 30: 318–324 (in Japanese with English summary). https://www.jstage.jst.go.jp/article/jjshs1925/30/4/30_4_318/_article/-char/en

Aoba, T. 1963. Studies on the classification and the geographical distribution of local varieties of vegetables in Japan. IV. On the classification and the geographical distribution of local varieties of non-heading mustard in Japan. J. Japan. Soc. Hort. Sci. 32: 311–318 (in Japanese with English summary). https://www.jstage.jst.go.jp/article/jjshs1925/32/4/32_4_311/_article/-char/en

Aoba, T. 1971. Morphological observation of seed coat of the species belonging to *Brassiceae*. Bull. Yamagata Univ. Agric. Sci. 6: 315–324 (in Japanese with English summary). https://yamagata.repo.nii.ac.jp/?action=pages_view_main&active_action=repository_view_main_item_detail&item_id=2179&item_no=1&page_id=13&block_id=29

Babil, P., S. Kondo, H. Iwata, S. Kushikawa, and H. Shihiwachi. 2013. Intra-specific ploidy variations in cultivated Chinese yam (*Dioscorea polystachya* Turcz.). Trop. Agric. Dev. 57: 101–107. https://www.jstage.jst.go.jp/article/jsta/57/3/57_101/_article/-char/en

Breedlove, B. and P.M. Arguin. 2016. Inspiration and insecticide from the flower garden. Emerg. Infect Dis. 22: 941–942. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4861543/

Cabinet Office, the Government of the United Kingdom. 2021. Statement of objection: Japanese GI product names, 26. Ibuki Soba: product specification. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1041711/26._Ibuki_Soba_tranche_1.pdf

Department of Agriculture and Fisheries, Shiga Prefectural Government. 2007. Report on excavation of famous products in Shiga Prefecture (*Ōmi-no-Tokusanbutsu-Hakkutsuchōsa-Hōkokusho*). 1–114 (in Japanese).

Department of Agriculture and Fisheries, Shiga Prefectural Government. 2016. Basic plan for agriculture and fisheries in Shiga Prefecture (*Shigaken-Nōgyō-Suisan-Kihon-Keikaku*). 1–67 (in Japanese).

Department of Agriculture and Fisheries, Shiga Prefectural Government. 2021. Certification guidelines for *Ōmi-no-Dentō-yasai* (*Ōmi-no-Dentō-yasai-Ninsyō-Yōkō*). (in Japanese).

Department of Lake Biwa and the Environment, Shiga Prefectural Government. 2008. Long-term concept of biotope network in Shiga Prefecture (*Shiga-ken-Biotope-Network-Chōki-Kōsō*). 1–66 (in Japanese).

Endo, M. and S. Iwasa. 1982. Characteristics and classification of edible and garnish chrysanthemums, *Chrysanthemum morifolium* Ramat. J. Japan. Soc. Hort. Sci. 51: 177–186 (in Japanese with English summary). https://www.jstage.jst.go.jp/article/jjshs1925/51/2/51_2_177/_article/-char/en

Epping, J. and N. Laibach. 2020. An underutilized orphan tuber crop—Chinese yam: a review. Planta 252: 58. https://doi.org/10.1007/s00425-020-03458-3.

Fujime, Y. 2012. Introduction to some indigenous vegetables in Japan. HortSci. 47: 831–834. https://journals.ashs.org/hortsci/view/journals/hortsci/47/7/article-p831.xml

Fukushima, A., T. Iwai, and M. Iwamoto. 1995. Effects of using seed bulbils on yields and qualities of *Dioscorea opposita* Thumb. Bull. Hyogo Pref. Agric. Inst. (Agriculture) 43: 75–78 (in Japanese with English summary). https://hyogo-nourinsuisangc.jp/archive/3-k_seika/kenpo/khn43pdf/khn4314.pdf

Fuller, D.Q., L.A. Hosoya, Y. Zheng, and L. Qin. 2010. A contribution to the prehistory of domesticated bottle gourds in Asia: rind measurements from Jomon Japan to Neolithic Zhejiang, China. Econ. Bot. 72: 357–359. https://link.springer.com/article/10.1007/s12231-010-9122-3

Hino-chō-Kyōikukai eds. 1930. Chapter 11-9, Hino-na. p. 767–768. In: Historiography of Hino-chō in Shiga Prefecture, middle volume (in set) (*Ōmi-Hino-chō-Shi, Kan-Chū*). Ōmi Hino-chō-Kyōikukai Press (in Japanese).

Hirose, T., S. Ukita, and S. Takashima. 1956. Studies on the characteristics of pepper varieties. Sci. Rep. Saikyo Univ. Agric. 8: 44–50 (in Japanese with English summary). https://kpu.repo.nii.ac.jp/?action=pages_view_main&active_action=repository_view_main_item_detail&item_id=5706&item_no=1&page_id=13&block_id=17

Inden, H. and T. Asahira. 1990. Japanese bunching onion (*Allium fistulosum* L.). p. 215–232. In: Rabinowitch H., Brewster J. (eds). Onions and allied crops. CRC Press, USA. https://www.taylorfrancis.com/books/edit/10.1201/9780429355752/onions-allied-crops-rabinowitch-james-brewster

Karasawa, H., S. Hiraide, S. Yamazaki, H. Ogahara, and H. Ohinata. 2012. Study on ingredient analysis of nezumi daikon and other sharp taste daikon. Res. Rep. Nagano Pref. Gen. Ind. Tech. Cent. 7: F28–32 (in Japanese). http://www.gitc.pref.nagano.lg.jp/reports/pdf/H24/04Shokuhin/H24F06_28-32.pdf

Kawai, A. 2022. The diversity of seed-saving governance and sharing systems in contemporary Japan. p. 79–90. In: Nishikawa Y., Pimbert M. (eds). Seeds for diversity and inclusion. Palgrave Macmillan, Cham. https://link.springer.com/chapter/10.1007/978-3-030-89405-4_5

Kim, S.J., S. Kawaguchi, and Y. Watanabe. 2003. Glucosinolates in vegetative tissues and seeds of twelve cultivars of vegetable turnip rape (*Brassica rapa* L.). Soil Sci. Plant Nutr. 49: 337–346. https://www.tandfonline.com/doi/abs/10.1080/00380768.2003.10410018

Kinki Chūgoku Region Agricultural Research Promotion Initiative. 1999. Pungent constituents of Ibuki-daikon (Shiga Prefecture). Accomplishment reports on important recent technologies in the Kinki and Chūgoku regions (*Kinki-Chūgoku-Chiiki-Jyūyō-Shin-Gijyutsu-Seika-Hōkoku*). 17: 72–73 (in Japanese).

Kondo, F., K. Hatakeyama, A. Sakai, M. Minami, K. Nemoto, and K. Matsushima. 2021. Parthenocarpy induced fluctuations in pungency and expression of capsaicinoid biosynthesis genes in a Japanese pungency-variable sweet chili pepper 'Shishito' (*Capsicum annuum*). Hort. J. 90: 48–57. https://www.jstage.jst.go.jp/article/hortj/90/1/90_UTD-216/_html/-char/en

Kubo, N., K. Onnazaka, S. Mizuno, and G. Tsuji. 2019a. Classification of "nabana" (*Brassica rapa*) cultivars and landraces based on simple sequence repeat markers. Breed. Sci. 69: 179–185. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6507715/

Kubo, N., H. Ueoka, and S. Satoh. 2019b. Genetic relationships of heirloom turnip (*Brassica rapa*) cultivars in Shiga Prefecture and other regions of Japan. Hort. J. 88: 471–480. https://www.jstage.jst.go.jp/article/hortj/88/4/88_UTD-071/_article/-char/en

Kumazawa, S., T. Ohara, and K. Niiuchi. 1954. The differentiation of varieties of peppers in Japan. J. Japan. Soc. Hort. Sci. 23: 152–158 (in Japanese with English summary).
https://www.jstage.jst.go.jp/article/jjshs1925/23/3/23_3_152/_article/-char/en

Liu, M., N. Bassetti, S. Petrasch, N. Zhang, J. Bucher, S. Shen, J. Zhao, and G. Bonnema. 2019. What makes turnips: anatomy, physiology and transcriptome during early stages of its hypocotyl-tuber development. Hortic. Res. 6: 38.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6395767/

Masukawa, T., K.S. Cheon. D. Mizuta, M. Kadowaki, A. Nakatsuka, and N. Kobayashi. 2019. Development of mutant *RsF3'H* allele-based marker for selection of purple and red root in radish (*Raphanus sativus* L. var. *longipinnatus* L. H. Bailey). Euphytica 215: 119.
https://link.springer.com/article/10.1007/s10681-019-2442-1

Matsui, A. and M. Kanehara. 2006. The question of prehistoric plant husbandry during the Jomon period in Japan. World Archaeol. 38: 259–273.
https://www.tandfonline.com/doi/full/10.1080/00438240600708295?scroll=top&needAccess=true

Matsuo, S. and S. Ide. 2006. A study on Shōnakano-ko, an ex-attached lake of Lake Biwa—With a focus on Benten-naiko—. Environ. Syst. Res. 34: 75–82 (in Japanese with English summary).
https://www.jstage.jst.go.jp/article/proer2000/34/0/34_0_75/_article/-char/en

Matsuo, S. and S. Ide. 2007. A study on Shōnakano-ko, an ex-attached lake of Lake Biwa, with a focus on Iba-naiko. Environ. Syst. Res. 35: 401–405 (in Japanese with English summary).
https://www.jstage.jst.go.jp/article/proer2000/35/0/35_0_401/_article/-char/en

Ministry of Land, Infrastructure, Transport and Tourism, Japan. 2003. Lake Biwa comprehensive preservation initiatives—Seeking harmonious coexistence with the lake's ecosystem—. 1–32.
https://www.mlit.go.jp/crd/daisei/biwako_hozen/pamphlet/pamphlet_en.pdf

Ministry of Land, Infrastructure, Transport and Tourism, Japan. 2011. Planning and survey work for the comprehensive conservation of Lake Biwa (*Biwako-no-Sōgōteki-na-Hozen-no-Tame-no-Keikaku-Chōsa-Gyōmu*). 1–202 (in Japanese).

Miyazawa, M. and M. Hisama. 2003. Antimutagenic activity of flavonoids from *Chrysanthemum morifolium*. Biosci. Biotechnol. Biochem. 67: 2091–2099.
https://www.jstage.jst.go.jp/article/bbb/67/10/67_10_2091/_article/-char/en

Monma, S. and Y. Sakata. 1989. Collection of local varieties of eggplant in the Tokai and Kinki districts. Ann. Rep. Explor. Intro. Plant Gen. Res. 5: 99–105 (in Japanese with English summary).
https://repository.naro.go.jp/records/6893

Mori, T., M. Shoka, and I. Nishiguchi. 1993. Methods for the rapid propagation of *Dioscorea opposita* cv. lse-imo. Particularly making the in vitro techniques fit for practical use in the field. Bull. Mie Agric. Tech. Cent. 21: 33–39 (in Japanese with English summary).
https://www.pref.mie.lg.jp/common/content/000166541.pdf

Nagai, T., N. Suzuki, N. Kai, and Y. Tanoue. 2014. Functional properties of autolysate and enzymatic hydrolysates from yam tsukuneimo (*Dioscorea opposite* Thunb.) tuber mucilage *tororo*: antioxidative activity and antihypertensive activity. J. Food Sci. Technol. 51: 3838–3845.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4252447/

Nakagawa, A., H. Takahashi, K. Ueda, A. Watanabe, H. Akagi, and K. Sakurai. 2021. Genetic relationship and introduction pathways of eggplant cultivars originating in Akita Prefecture. Hort. Res. (Japan) 20: 379–385 (in Japanese with English summary).
https://www.jstage.jst.go.jp/article/hrj/20/4/20_379/_article/-char/en

Ohi, M. and Y. Sato. 2002. Relationship among turnip and tsukena (*Brassica rapa* L.) cultivars originated in Nagano Prefecture. Hort. Res. (Japan) 1: 237–240 (in Japanese with English summary).
https://www.jstage.jst.go.jp/article/hrj/1/4/1_4_237/_article/-char/en

Okakura, K. 1906. The schools of tea. p. 7–12. In: The book of tea: a Japanese harmony of art culture and the simple life. Fox, Duffield & Company, USA.

Okamoto, T. 2001. Present situation and several ways to improve productivity in Chinese yam (*Dioscorea opposite* Thunb.) cultivation. Japan. J. Crop Sci. 70(Suppl.2): 383–386 (in Japanese with English summary).
https://www.jstage.jst.go.jp/article/jcs1927/70/Supplement2/70_Supplement2_383/_article/-char/en

Sano, T., H. Yoneda, and S. Kamikawa. 2022. Conservation and evaluation of purple-fruited native sweet pepper strains. Bull. Nara Agric. Res. Cent. 53: 45–52 (in Japanese with English summary). https://www.pref.nara.jp/secure/265397/6.pdf

Sari, N., E. Silverman, D. Reiland, and T.C. Wehner. 2021. Seed characterization and relationships between seed and cotyledon properties in *Lagenaria* spp. accessions. HortSci. 56: 185–192. https://journals.ashs.org/hortsci/view/journals/hortsci/56/2/article-p185.xml

Satoh, S., N. Kubo, and K. Nakatani. 2020. Characteristics and diversity of heirloom red turnips in Shiga Prefecture. Hort. Res. (Japan) 19: 1–6 (in Japanese with English summary). https://www.jstage.jst.go.jp/article/hrj/19/1/19_1/_article/-char/en

Shibutani, S. and T. Okamura. 1954. On the classification of turnips in Japan with regard to the types of epidermal layers of the seed. J. Japan. Soc. Hort. Sci. 22: 235–238 (in Japanese with English summary). https://www.jstage.jst.go.jp/article/jjshs1925/22/4/22_4_235/_article/-char/en

Shibutani, S. and T. Okamura. 1955. Studies on the morphological characters of seeds in *Brassica*. J. Japan. Soc. Hort. Sci. 24: 195–198 (in Japanese with English summary). https://www.jstage.jst.go.jp/article/jjshs1925/24/3/24_3_195/_article/-char/en

Shibutani, S. and T. Okamura. 1956. On the mode of coloring in various kinds of colored turnips. II. Survey of the anthocyans of colored turnip. J. Japan. Soc. Hort. Sci. 25: 111–115 (in Japanese with English summary). https://www.jstage.jst.go.jp/article/jjshs1925/25/2/25_2_111/_article/-char/en

Shibutani, S. and T. Okamura. 1957. Heredity of the characters in turnip hybrids. J. Japan. Soc. Hort. Sci. 26: 15–20 (in Japanese with English summary). https://www.jstage.jst.go.jp/article/jjshs1925/26/1/26_1_15/_article/-char/en

Shiragaki, K, S. Yokoi, and T. Tezuka. 2020. Phylogenetic analysis and molecular diversity of *Capsicum* based on rDNA-ITS region. Horticulturae 6: 87. https://www.mdpi.com/2311-7524/6/4/87/htm

Takahashi, Y., S. Yokoi, and Y. Takahata. 2016. Genetic divergence of turnip (*Brassica rapa* L. em. Metzg. subsp. *rapa*) inferred from simple sequence repeats in chloroplast and nuclear genomes and morphology. Genet. Resour. Crop Evol. 63: 869–879. https://link.springer.com/article/10.1007/s10722-015-0290-y

Takayanagi, K., H. Nishida, and K. Osawa. 1984. Characterization of yam varieties and lines by principal component analysis. Bull. Breed. Dep. Veg. Orn. Crops. Res. Sta. (*Yasai-Shikenjyō-Ikushu-bu-Kenkyū-Nenpō*). 11: 136–144 (in Japanese).

Tomiyoshi, M. and S. Ueno. 2016. Characteristics of perception and consumption of traditional vegetables by local residents and tourists: case study of Kumamoto Prefecture. J. Rural. Problems 52: 229–234 (in Japanese with English summary). https://www.jstage.jst.go.jp/article/arfe/52/4/52_229/_html/-char/en

Tsubaki, N. 2017. Breeding of local varieties of radish in Akita Prefecture with genetic-breeding studies in radish. Bull. Akita Agric. Expt. Sta. 56: 1–79 (in Japanese with English summary). https://www.pref.akita.lg.jp/uploads/public/archive_0000008683_00/56-1.pdf

Uchiyama, Y., Y. Fujihira, H. Matsuoka, and R. Kohsaka. 2017. Tradition and Japanese vegetables: history, locality, geography, and discursive ambiguity. J. Ethn. Foods 4: 198–203. https://www.sciencedirect.com/science/article/pii/S2352618117300379

Watanabe, K., H. Uno, and K. Toyooka. 1993. Studies on the masspropagation of 'Hatashoyamanoimo' by tissue culture. 1. Development of masspropagation method of Chinese yam by combination of the tissue culture and cutting. Bull. Shiga Agric. Expt. Sta. 34: 65–70 (in Japanese with English summary). https://agriknowledge.affrc.go.jp/RN/2010491573

Watanabe, K., M. Shiwa, H. Uno, K. Toyooka, and K. Yoshizawa. 1994. Studies on the masspropagation of 'Hatashoyamanoimo' by tissue culture. 2. Productivity of plants originated from tissue culture and cuttings. Bull. Shiga Agric. Expt. Sta. 35: 43–51 (in Japanese with English summary). https://agriknowledge.affrc.go.jp/RN/2010532521

Yahei-tōgarashi Preservation Society (*Yahee-tōgarashi Hozon-Kai*), personal communication.

Yamashita, T. 1973. Current utilization of F_1 hybrids for vegetable production in Japan. JARQ Japan Agric. Res. Q. 7: 195–201. https://www.jircas.go.jp/en/publication/jarq/7/3/195

Yamashita, H. 2020. A study of genetics and plant nutritional physiology in tea plants based on omics approaches. Doctoral Diss. Gifu Univ. 1–208 (in Japanese).
https://gifu-u.repo.nii.ac.jp/record/74434/files/ak0763.pdf

Yamaya-Ito, H., F. Shinmachi, A. Noguchi, and I. Hasegawa. 2020. Effects of rhizosphere sulfur concentration on sulfur content and sulfate transporter gene expression in Japanese heirloom vegetables of the Brassicaceae family. Soil Sci. Plant Nutr. 66: 854–863.
https://www.tandfonline.com/doi/full/10.1080/00380768.2020.1833364

Yazawa, S., N. Suetome, K. Okamoto, and T. Namiki. 1989. Capsaicinoids content in the fruit of interspecific hybrids in *Capsicum*. J. Japan. Soc. Hort. Sci. 58: 353–360 (in Japanese with English summary).
https://www.jstage.jst.go.jp/article/jjshs1925/58/2/58_2_353/_article/-char/en

Yoshioka, N. and M. Yoshida. 2017. Determination of cucurbitacin B by LC/MS in food poisoning caused by bottle gourd. Bull. Hyogo Pref. Inst. Public Health Consum. Sci. Public Health Res. Cent. 8: 26–29 (in Japanese with English summary).
https://web.pref.hyogo.lg.jp/iphs01/kikikanribu/kankoubutu/documents/2017-5.pdf

Zhou, B., Y. Li, Z. Xu, H. Yan, S. Homma, and S. Kawabata. 2007. Ultraviolet A-specific induction of anthocyanin biosynthesis in the swollen hypocotyls of turnip (*Brassica rapa*). J. Exp. Bot. 58: 1771–1781.
https://academic.oup.com/jxb/article/58/7/1771/516961