Journal of Ethnic Foods

REVIEW ARTICLE

Open Access

Introduction to heirloom vegetables in Kyoto prefecture (*Kyo-yasai*), Japan

Yutaka Mimura[1*]

Abstract

The group of vegetables known collectively as *Kyo-yasai* is a key part of food culture in Kyoto, once Japan's capital city for over 1000 years. A favorable climate and other cultural influences enabled *Kyo-yasai* culture to flourish. This study reviews the history, work to preserve, and marketing of *Kyo-yasai*. It also summarizes the scientific research conducted in the past few decades concerning breeding, functionality, nutrition, and taxonomy to provide an overview of *Kyo-yasai* today. The first record of heirloom vegetables in Japan was in the third century. After Kyoto became the capital in 794, a variety of vegetables were gradually introduced, and these have been developed and selected as *Kyo-yasai* for many centuries now. However, F_1 vegetable cultivars became the national norm after World War II, and *Kyo-yasai* faced the risk of extinction. Consequently, farmers, researchers, municipalities, and other groups decided to preserve *Kyo-yasai*. In 1974, the Kyoto prefectural government began preserving *Kyo-yasai* seeds. At the time it also defined 37 heirloom vegetables as 'traditional *Kyo-yasai*.' Additionally, agricultural cooperatives, wholesale markets, restaurants, and municipalities started to promote sales of *Kyo-yasai*. Furthermore, a breeding program was set up by Kyoto prefectural institutes looking at ways of improving cultivation suitability. Functional and taxonomical research by Kyoto Prefectural University and other organizations has revealed not only that *Kyo-yasai* has higher functionality overall compared than common F_1 cultivars, but also the genomic uniqueness of *Kyo-yasai*. These efforts collectively improved our understanding of *Kyo-yasai* and promoted their production. The preservation of these heirloom vegetables has a clear benefit in that it would contribute to the diversity of species and food cultures.

Keywords Traditional, Brand, Indigenous, History, Cultural methods, Capital, Taxonomy, Breeding, Food functionality

Introduction

Since ancient times, Japanese farmers have cultivated a wide variety of vegetables, owing to its warm and humid climate, and also because of cultural influences from neighboring countries. While serving as the capital for over a thousand years, the cultural and population center of Kyoto helped the cultivation of vegetables to flourish in areas surrounding the city. The cultural significance of vegetables in Kyoto, along with the abundance of varieties, has been documented and passed down to the present day. However, seed companies have introduced new cultivars, particularly of the hybrid (F_1) type, and these have become increasingly competitive in the market in the past sixty years [1]. Therefore, it is necessary to improve the cultivation suitability, quality, and yield of heirloom vegetables in Kyoto (*Kyo-yasai*) for growers and markets in the region.

The word '*Kyo-yasai*' is generally used to denote vegetables produced in Kyoto in a broad sense, although there is no clear definition. In this paper, it means the vegetables grown using heirloom seeds in Kyoto.

This paper aims to provide an overview of the history, efforts at preservation, and sales promotion of *Kyo-yasai*. Additionally, it summarizes the scientific research conducted in the past few decades regarding breeding,

*Correspondence:
Yutaka Mimura
yu63.capsicum@gmail.com
[1] Biotechnology Research Department, Kyoto Prefectural Institute of Agriculture, Forestry and Fishery Technology Center (KAFF), 74 Oji, Kitainayazuma, Seika-cho, Soraku-gun, Kyoto 619-0244, Japan

functionality, nutrition, and taxonomy to provide a current understanding of *Kyo-yasai*.

The relationship between the description of old literature and the current classification may be unclear. Therefore, ancient references are summarized in Table 1, and literature after 1602 is listed in the 'References' section.

Brief history of vegetables in Japan

The Japanese archipelago is a long stretch of islands from south to north, covering northern latitudes of 24° and 46°. As a result, climatic conditions vary from semi-tropical to cold, depending on the region. Consequently, various heirloom vegetables are available in each district of Japan. Vegetables such as *Asatsuki*, Chinese chive, Goldband lily, Japanese butterbur, Japanese hornwort, Japanese pepper, mioga ginger, *rakkyo*, Udo ginseng, wasabi, water dropwort, and water shield have been grown and domesticated through selection for over 2000 years. Brassicaceae leaf vegetables, including *Komatsuna* and *Mizuna*, Japanese radish (*daikon*), pickling melon, taro, and Welsh onion, were introduced from China, Korea, and Southeast Asia before the seventh century [2]. Cowpeas, cucumbers, eggplants, lettuce, and turnips were introduced up until the ninth century. Many of these species have several variations depending on their growth areas. Heirloom *daikons* and turnips have diverse shapes and colors, while *Mizuna* and *Komatsuna* have many useful varieties of leafy vegetables. Welsh onion also has many variations and cultural methods [3].

After the arrival of the Portuguese in Japan in 1543, many vegetables originating from North and South America were introduced in the late sixteenth and early seventeenth centuries, such as chili pepper, corn, potato, and squash.

During the Edo era (1603–1868), Japanese society experienced over 250 years of peace and the country effectively cut itself off from the rest of the world. During this time horticulture became popular in all sections of society.

Starting in the Meiji era (1868), the Japanese government introduced various crops from European countries, the USA, and China, and attempted to produce them throughout Japan. Tomatoes, cabbages, and other vegetables were adopted, and agricultural public research stations established in every prefecture conducted cultivation experiments and bred cultivars suitable for the Japanese climate. Notably, Japanese plant breeders pioneered the development of F_1 hybrid vegetables in the early twentieth century. Although F_1 hybrid cultivars currently dominate in Japan, some heirloom vegetables have been conserved. Local organizations and groups continue to promote the production and distribution of these varieties. [4].

Brief introduction of Japanese culture related to vegetables and the role of Kyoto

By the end of the fourth century, the Kinki region, including Kyoto prefecture, became the center of the most powerful administration in Japan. Heian-Kyo was founded as the ancient capital of Japan in 794 where Kyoto City is located today. It remained the imperial capital of Japan

Table 1 List of ancient pieces of literature before Edo-era (-1602)

Year of issue	Title	Contents	Mentioned vegetable species
Third century	Biographies of the Wuhuan, Xianbei, and Dongyi (*Wajin-Den*)	Biographies written about the peoples living in the east of China. It also describes Japan, and this part is called "Wei-Shi-Wajin-Den" in Japan	Mioga ginger
712	Kojiki	The oldest extant book in Japan, it is a history book that includes myths	Watershield, Brassicaceae leaf vegetables
720	Nihon-shoki	The oldest authentic history handed down in Japan	Cowpea, Pickling melon
783	Manyoshu	The oldest extant collection of waka poems in Japan, believed to have been established in the late Nara period (710–794), describes vegetables in some of its poems, citing them as strong evidence of the vegetables that existed at that time	Taro
869	Shoku-Nihonkouki	A history book established in the Heian period, dealing with the 18 years from 833	Water dropwort
918	Honzo-Wamyo	This book was written by Fukane no Suketo. It describes the aliases, Japanese names, and localities of the drugs listed in "Shinshuhonzo" and other Chinese herbalists' books	Udo ginseng, Brassicaceae leaf vegetables, Burdock, Cowpea
931–938	Wamyorui-Jusho	Dictionary created in the mid-Heian period	Arrowhead
1005	Shui-Wakashu	The third imperial anthology of waka poetry after Kokin and Go-Sen	Pickling melon

until 1869, although Ieyasu Tokugawa established an administrative center in Edo (now Tokyo) in 1603 (Fig. 1).

During the Heian era (794–1191), it is estimated that Kyoto's population was between 150,000 and 200,000 [5]. As a result, many novel varieties of vegetable seeds were collected and cultivated around the capital to supply large quantities of fresh vegetables to the residents.

Soil and climatic conditions have played a key role in the development of *Kyo-yasai* [6]. However, aspects of culture, politics, and religion also helped to make these vegetables more popular. In Kyoto, a palace-style cuisine called *Yusoku-ryori* was enjoyed by the Imperial Court, court nobles, and top-ranking members of the shogunate in the old days. Nowadays, a few restaurants still serve these dishes. Furthermore, since most Buddhists were

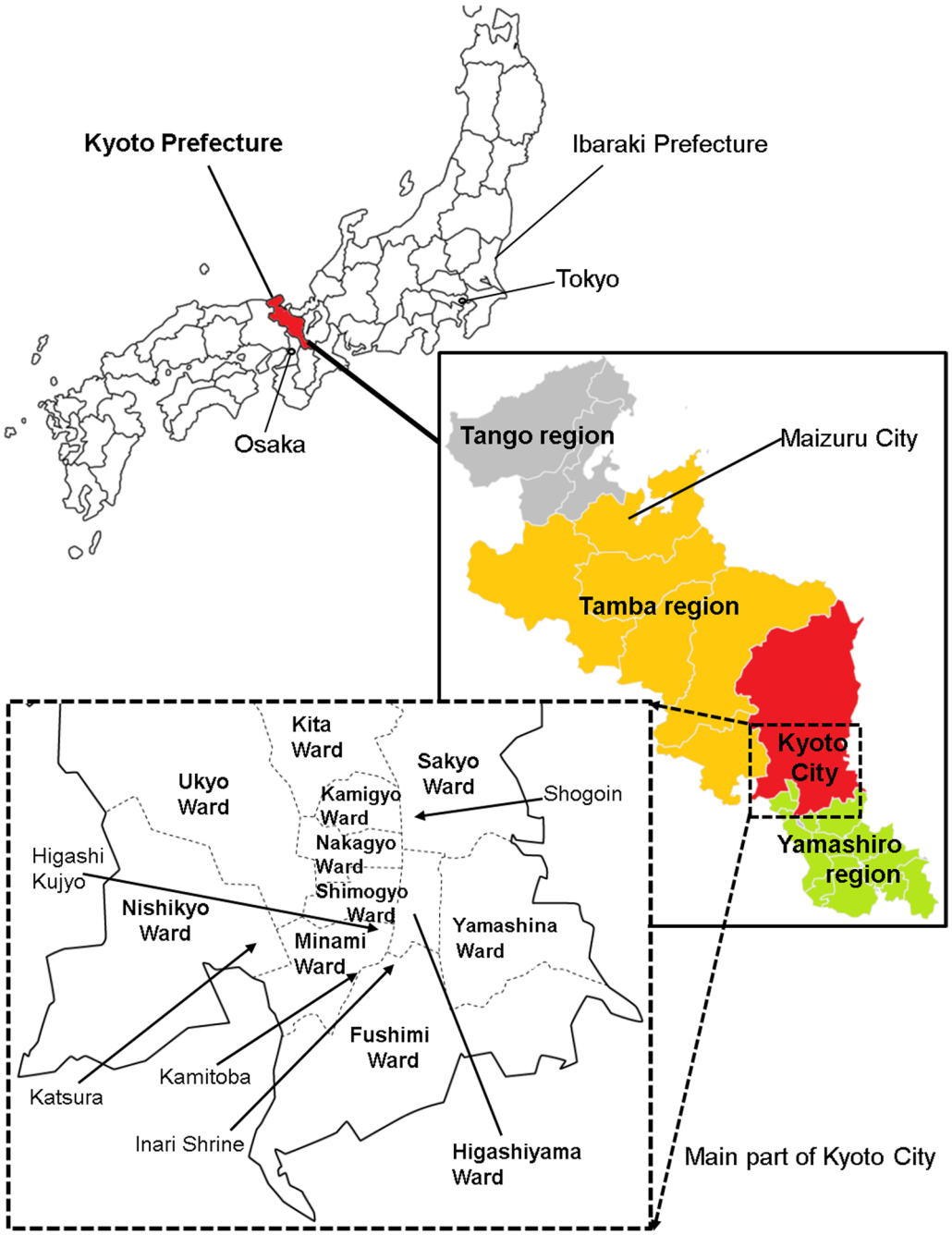

Fig. 1 Location of Kyoto prefecture, and major names of places in the prefecture. *Source* Created and edited by the author from free illustrations

vegetarians, so *Shojin-ryori*, a special vegetarian cuisine, was developed. Lastly, tea ceremonies have been popular in Kyoto since the sixteenth century [7], and *Kaiseki-ryori* dishes were served during these events. Vegetables are one of the main ingredients in these dishes [7, 8].

After the Meiji Restoration, the emperor moved to Tokyo, and Kyoto City ceased to be the capital of Japan. The population declined for a period, but various industrial promotion projects were implemented, resulting in an increase until 1970. This also meant that the amount of farmland decreased. The production areas of heirloom vegetables shifted, and farmers stopped cultivating some varieties. However, the urbanization of Kyoto was relatively slow compared to other major cities such as Tokyo, Osaka, and Nagoya, and many varieties of *Kyo-yasai* have been preserved than the ones in other cities. This was largely due to persistent consumer demand for each variety of *Kyo-yasai* [9–12].

Natural conditions and climates of Kyoto

Kyoto prefecture is composed of Kyoto City and three regions named Yamashiro, Tamba, and Tango (Fig. 1). The prefecture is long and narrow, stretching from north to south, with the northern area facing the Sea of Japan, and the rest consisting of hilly and mountainous areas. Most cities, including Kyoto, are situated in basins, and most vegetable farms are located around the cities and valleys.

The winter in Kyoto prefecture is mild, and even if it snows in the Tango region that faces the Sea of Japan, it does not snow heavily in the southern regions, such as Kyoto City and Yamashiro. In summer, there is a lot of rain, and the air temperature and relative humidity are high. Therefore, varieties of vegetables with tropical origins grow well in the summer.

Variation of *Kyo-yasai*

Indigenous species

Out of all the indigenous vegetables in Japan, Japanese butterbur, Mioga ginger, Udo ginseng, water dropwort, and water shield are the most important *Kyo-yasai* species (Fig. 2). The history and characteristics of these five species are summarized in Table 2.

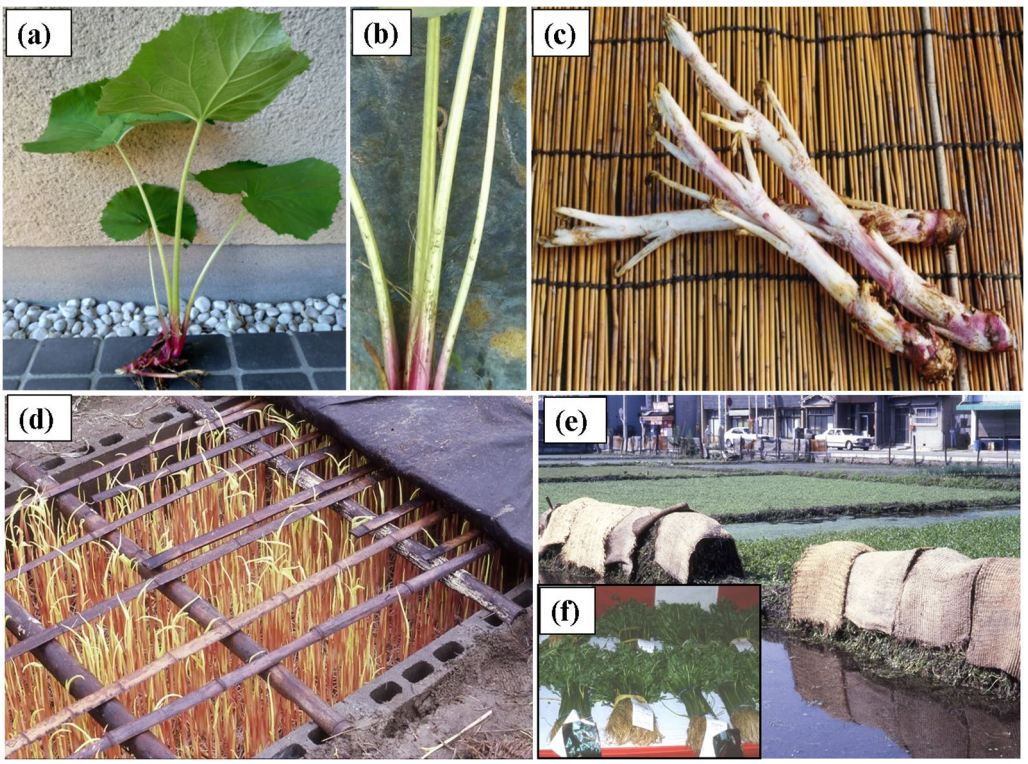

Fig. 2 Indigenous species of *Kyo-yasai*. **a** Japanese Butterbur, **b** the petiolar part is mainly edible; **c** shaded soft-grown Udo ginseng; **d** shaded soft-grown Mioga ginger; **e** water dropwort in paddy fields (upper), straw-covered water dropwort seedlings (center), **f** water dropwort harvested for a fair. *Source* Photos **a** and **b** were taken by the author. Photos **c**, **d**, **e** and **f** by the Kyoto Prefectural Institute of Agriculture, Forestry and Fishery Technology Center (KAFF)

Table 2 Indigenous species of *Kyo-yasai* and their cultural method and history

Plant name	Botanical name	Japanese name	Vegetation distribution	Cultural method and/or History in Kyoto	References
Japanese butterbur	*Petasites japonicus* (Siebold et Zucc.) Maxim	Fuki	Hokkaido to Kyushu	Grown in Southern Kyoto around year 700	Iwamoto [13]
Mioga ginger	*Zingiber mioga* (Thunb.) Roscoe	Mioga	perennial native to East Asia	Habituated in Japan until the late third century Etiolated with spring water and harvested in winter in Kyoto around 150 years ago	Biographies of the Wuhuan, Xianbei, and Dongyi (3ed century)
Udo ginseng	*Aralia cordata* Thumb	Udo	North East Asia	Shaded and Etiolated with spring water and harvested in winter and spring in Kyoto	Honzo-Wamyo (918)
Water dropwort	*Oenanthe javanica* (BL.) DC	Seri	East and South Asia, and Australia	Grown in paddy field. The shoots are used as seedlings in February and March	Shoku-Nihonkouki (869)
Water shield	*Brasenia schreberi* V.F. Gmel	Jhunsai	East Asia	The long stem trails in the water and is covered with short hairs which produce a mucilaginous substance covering the stem and the underside of the leaves. This mucilaginous coating is used as food	Kojiki (712) Misaki and Smith [14] Kakuta and Misaki [15]

Non-native species

Leaf vegetables Brassicaceae leafy vegetables have also been popular in Japan. *Mizuna* has a pinnatisect leaf type and originally had enlarged turnip-like roots, although, at present, *Mizuna* has been developed to decrease the size of the root. Another leaf vegetable in Kyoto, *Mibuna*, which has simple spatulate leaves, was obtained by selecting *Mizuna* in the mid-nineteenth century (Fig. 3) [16]. Research results of genome studies of *Mizuna*, *Mibuna*, and turnips have indicated that *Mibuna* may have been established by crossing a simple-leaf turnip with *Mizuna* [17]. Recent genetic analysis has revealed that the typical modern *Mizuna* cultivar, *Jonan-sensuji*, is closely related to the local turnip variety *Omi-kabura* among several local varieties of leaf and root vegetables [18].

Welsh onion also has many variations spread across three types named *Kujyo*, *Kaga*, and *Senju* in Japan [19]. The *Kujo* type is mainly cultivated in Kyoto prefecture. It is said that Welsh onion spread to Japan in prehistoric times. Therefore, according to *Kyotofu-Engeiyoukan* [20], there is an oral monument that says they started cultivating Welsh onion when the Inari Shrine was built in 711 (Fig. 1,4).

Root vegetables Arrowhead is a perennial that grows or is cultivated in the temperate and tropical zones of the Northern Hemisphere. It is used as a vegetable across Asia and has a bitter taste [21].

Burdock has been acknowledged as a medicinal plant in East Asia [22]. It is also abundant in Japan and has long been domesticated as a vegetable. Burdock root is crisp and has a sweet, mild, or pungent flavor with little muddy harshness. Burdock has only recently become popular outside Japan [6].

Carrot domestication occurred before the tenth century in Afghanistan [23]. Cultivated carrots can be divided into eastern and western carrot types. The eastern carrots originated in Central Asia [24], and these two types have genetically distinct differences [25]. Eastern carrots were introduced to Japan through China up until the seventeenth century [26]. In those days, the carrots were red, purple, yellow, and white [27]. The red variety is still cultivated in Japan and some other Asian countries, although western orange carrots have prevailed in Japan in the last half-century. This red carrot, named *Kintoki*, is popular in Western Japan (Fig. 5). Osaka was a production area in 1855 [28]. It was also produced in Higashi-Kujo and Kamitoba in Kyoto City during the Meiji era

Fig. 3 Harvested *Mizuna* and *Mibuna*. **a** *Mizuna* has a pinnatisect leaf type, while **b** *Mibuna* has simple spatulate leaves. *Source* Photos by KAFF

(1868–1912) [12]. The total carrot production was 1017 t and 67 ha in Higashi-Kujo in 1935 [29] (Fig. 1).

Japanese radish, belonging to the *Daikon* group, came to Japan in the prehistoric era and became one of the major vegetables in the production and planting areas in Japan. Depending on the variety, they differ in size, shape, color, and taste. Some even have curved roots. Kyoto prefecture has seven *Kyo-yasai* varieties of *Daikon*. Kyoto City has the round-rooted *Shogoin-daikon*, the long, normal-sized *Kuki-daikon*, *Momoyama-daikon*, and *Tokinashi-daikon*. *Sabaga-daikon* comes from Maizuru City (Fig. 1), which faces the Sea of Japan, and is known as a remarkably late variety. It was domesticated from a wild plant called *Hama-daikon* that grows along the coast [30]. *Karami-daikon* is a small variety used as a condiment because of its pungent taste. *Aomi-daikon* is a smaller variety characterized by the greenish color of the top of the root and the lack of straight root growth (Fig. 6).

It is said that a local Taro variety in Nagasaki was introduced to Kyoto in the Edo era. The variety was well-cultivated in rich soil and capable of producing large and curved taro (300 g). Because the shape resembled lobster, the variety was called *Ebi-imo* (*Ebi* means lobster in Japanese) (Fig. 7).

Turnip accessions and local varieties in Japan have been divided into three groups according to seed type [31] and geographical distribution [32, 33]. However, recent molecular studies have revealed that the three groups do not constitute genetic diversity, because most Japanese accessions and local varieties originate from central Asia [34]. At present, it is believed that various economic traits of turnip in Japan are created by local demand and selection. The genetic relationships between *Kyo-yasai* and the surrounding areas have been investigated in detail [35]. Some of the results contradicted the old records that say the *Omi* turnip was the ancestor of the *Shogoin* turnip [18]. Among the various turnip varieties in Kyoto, the *Suguki* turnip is a distinctive group used for Japanese salty lactic fermented pickles. After the Edo era, approximately 150 years ago, the production of *Suguki* pickles increased. The fast-increasing production led to a general deterioration in the quality of the lines, and a mixture of good and bad seeds were sold. Therefore, an attempt to uncover the standard *Suguki* appearance in 1973 contributed to subsequent breeding efforts [36] (Fig. 8).

In addition, six other *Kyo-yasai* varieties are available, including *Matsugasakiukina-kabu* and *Uguisuna*, whose leaves are also actively used. *Maizuru-kabu* is characterized by its purple upper root surface (Fig. 9).

Sprout vegetables Several types of bamboo shoots have been used as vegetables in Asia. In Japan, Moso bamboo

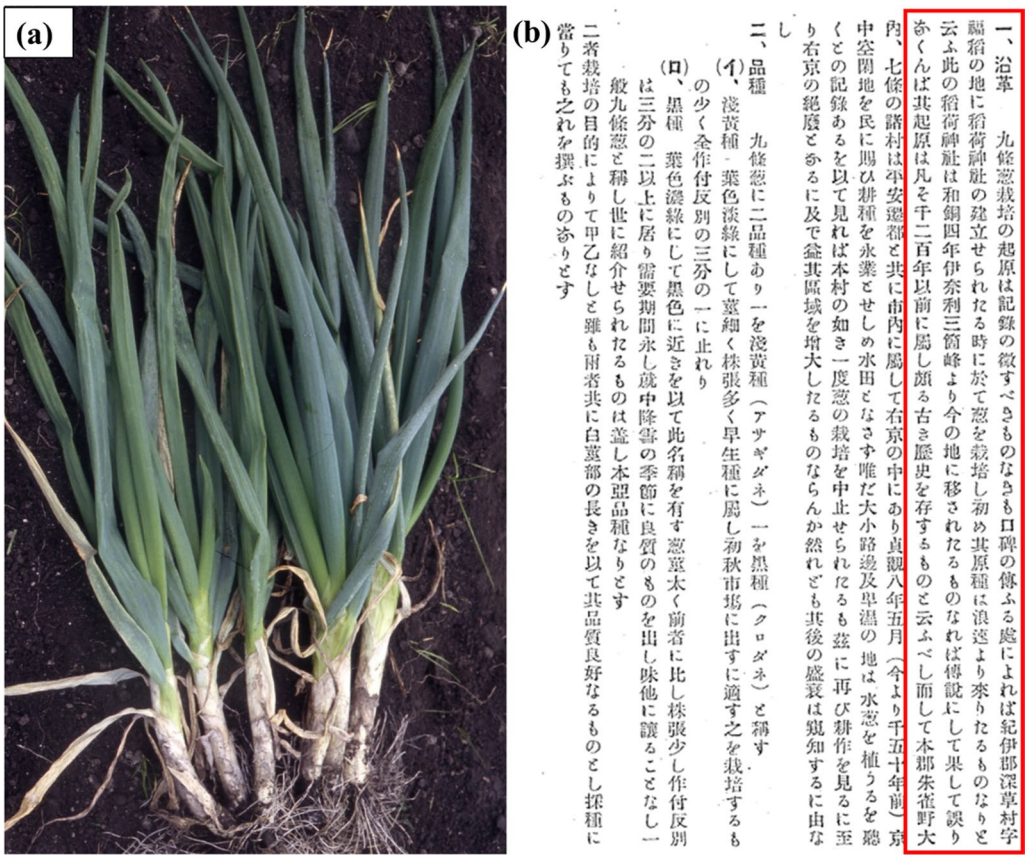

Fig. 4 Harvested *Kujo-negi* and the literature explaining the origin. **a** *Kujo-negi* and **b** Section explaining the origin of *Kujo-negi* cultivation in the Kyoto Gardening Handbook (*Kyotofu-Engeiyokan*), published in 1909; the area circled in red explains the origin. *Source* Photo **a** by KAFF. Photo **b** is part of reference [20], stored at KAFF

Fig. 5 Harvested *Kintoki* Carrots grown in Kamitoba, Minami Ward, Kyoto City. *Source* Photos by KAFF

(*Moso-chiku* in Japanese) was popular until the end of the seventeenth century in Kyoto because of its higher yield and better quality than other types of bamboo. Growers in Kyoto have practiced special techniques and improved the ground's physical properties by spreading straw in the bamboo groves and add 3 to 5 cm of soil on top of it every year. This makes it easier for underground stems to grow and increases the softer part of the bamboo shoots because of the deeper position of the underground stems. Bamboo shoots are harvested after they appear on the surface of the ground, resulting in a darker peel. However, in Kyoto, the soft soil is dug up when the surface swells or cracks before the shoots emerge at the surface, resulting in the entire harvest being softened, and the peel being light yellow. For this reason, the former is called *Kuroko* (black one) and the latter *Shiroko* (white one) in Kyoto, and the latter is sold at a higher price [37].

Hanana is a Brassicaceae vegetable whose flower buds are harvested in early spring and is characterized by its bitter taste.

Fruit vegetables Cucumber was introduced to Japan a long time ago. However, until the late Edo era, it was not popular in Kyoto. It has a bitter taste and a spine on the fruit peel. Another cucurbitaceous plant, the oriental pickling melon was popular in Kyoto at that time [38].

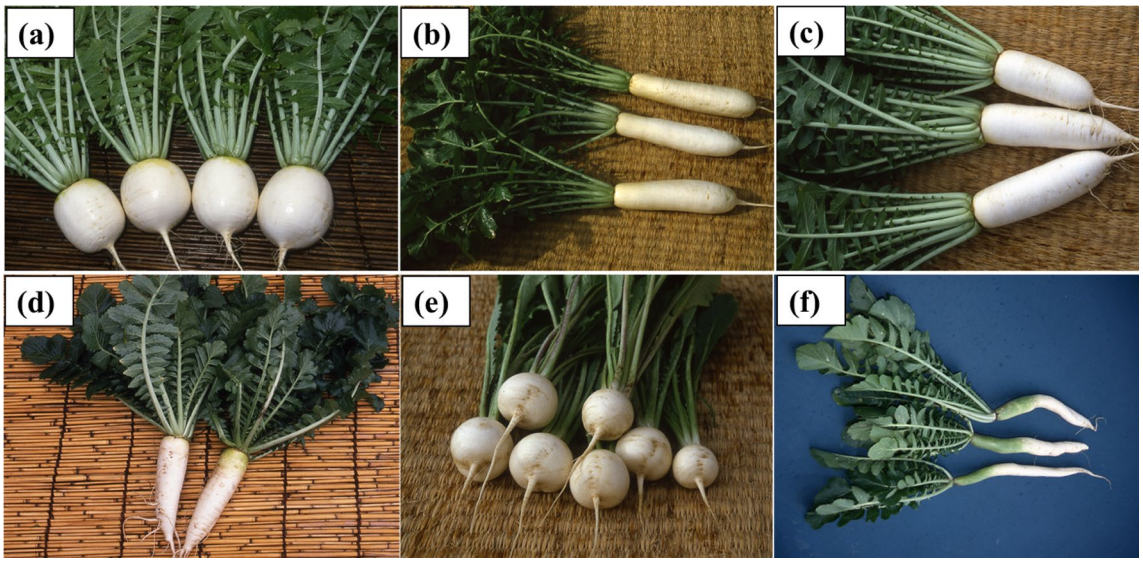

Fig. 6 Japanese radish of *Kyo-yasai*. **a** *Shogoin-daikon*; **b** *Kuki-daikon*; **c** *Momoyama-daikon*; **d** *Sabaga-daikon*; **e** *Karami-daikon*; **f** *Aomi-daikon*. *Source* Photos by KAFF

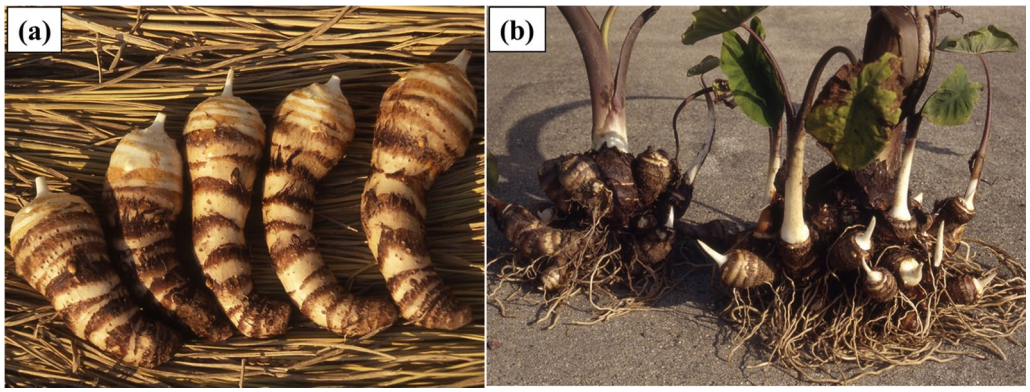

Fig. 7 **a** The typical shape of *Ebi-imo* harvests and **b** *Ebi-imo* individuals dug out from the ground. *Source* Photos by KAFF

Nevertheless, cucumber was used in forcing culture in Shogoin village in Kyoto in the late Edo era (Fig. 1).

Eggplants are popular in South and East Asia. The colors of eggplants were purple, white, and green. In Japan, they have spread to most regions and been differentiated into various local varieties, even during the Edo era. During that time, there were two major shape types of eggplants: one with elongated fruit and the other round. *Yamashina-nasu* and *Kamo-nasu* in Kyoto are examples of the former and latter type, respectively. There is also a variety called *Mogi-nasu* which can be harvested early, with each fruit weighing about 20 g (Fig. 10).

Pickling melon was cultivated in Soraku-gun, southern Kyoto prefecture, approximately 1000 years ago. It was cultivated in Katsura village in Kyoto in the late Edo era, and the production area extended to neighboring villages before World War II.

Several pepper varieties were introduced to Japan in the sixteenth century. It became popular in the early seventeenth century as a condiment. Most varieties exhibit pungency, however, an almost non-pungent variety called *Fushimi-ama* emerged in the Fushimi ward of Kyoto [39] (Fig. 1). It is used as a vegetable. *Manganji* is another sweet pepper variety which was cultivated in Maizuru City, Kyoto prefecture around 100 years ago. It was sold exclusively in Maizuru City until 1982 [40], after which it grew in popularity across the country.

Pumpkin was introduced to Japan in a manner similar to pepper. There are three major pumpkin species, *Cucurbita maxima*, *C. moschata*, and *C. pepo*. The old Japanese pumpkin varieties were all *Cucurbita moschata* species. In Kyoto, a gourd-shaped pumpkin variety *Shishigatani* was drawn in a picture named 'Kaso-Nehanzu' by

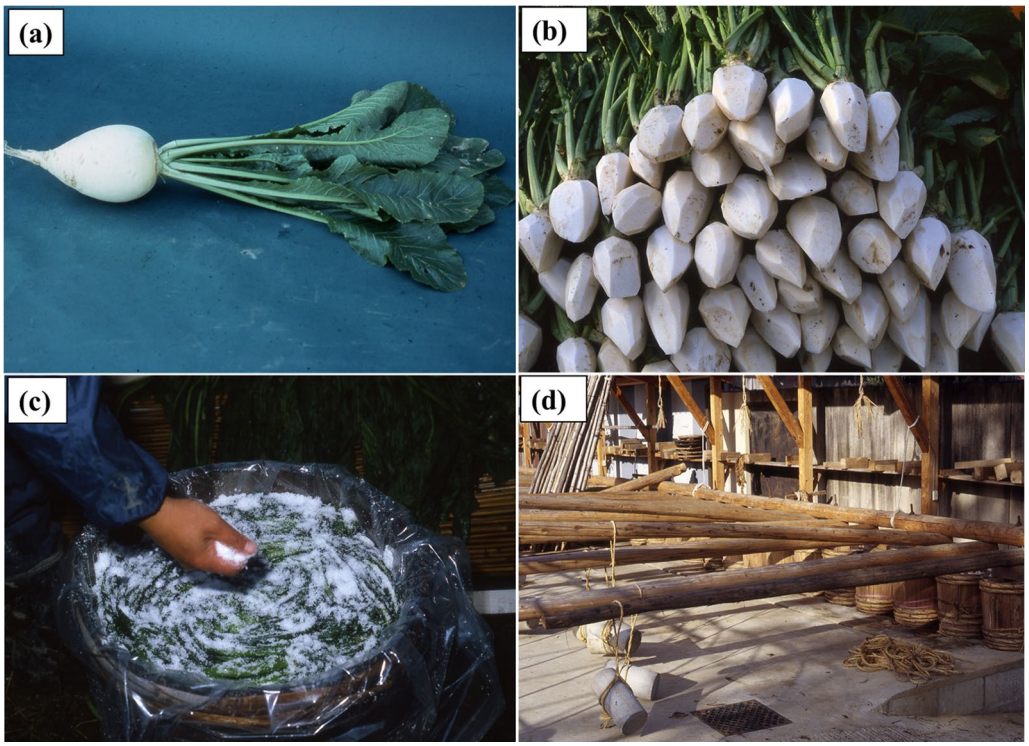

Fig. 8 *Suguki* plant and the production of pickles using it. **a** *Suguki* plant; **b** *Suguki* after pretreatment; **c** salt treatment; **d** pickling process in barrels (right) with load (left). *Source* Photos by KAFF

Fig. 9 **a** *Matsugasaki-ukinakabu*; **b** *Uguisuna*; **c** *Maizuru-kabu*. *Source* Photos by KAFF

Fig. 10 Four varieties of eggplant and one pepper variety of *Kyo-yasai*. *Yamashina-nasu*(right), *Kamo-nasu* (center), *Mogi-nasu* (lower left), *Manganji* pepper (Upper left). *Source* Photos by KAFF

a famous painter Jakuchu Ito in the eighteenth century [41] (Fig. 11).

Vegetable beans Cowpea, or *Sasage*, originated in Africa [42], but has spread and is widely cultivated as a legume variety across the world. Previously this was a well-established cereal crop, used over many centuries. However, a local variety *Hiiragino-sasage* has soft pods in its imma-

Fig. 11 Kyoto vegetables of the Edo period depicted in the painting of '*Kaso-Nehanzu*.' This painting was depicted by Jakuchu Ito (1716–1800); The area enclosed in red is *Shishigatani* pumpkin

ture stage and started to be used as a vegetable around 300 years ago.

Edamame is a preparation of immature soybeans in the pod, found in cuisines with origins in East Asia. The pods are boiled or steamed and may be served with salt or other condiments. The earliest documented reference to the term *edamame* dates from the year 1275 when the Japanese monk Nichiren mentioned it [43].

The rise *of hybrid* vegetable cultivars and the decline of heirloom vegetables after World War II, followed by efforts to revive *Kyo-yasai* in recent decades

According to a survey conducted by the Ministry of Agriculture, Forestry, and Fisheries (MAFF) between 1970 and 1980, 1214 local vegetable varieties were identified in 65 crops throughout Japan, and Kyoto prefecture had the largest number of local varieties out of all the prefectures in Japan [44, 45]. However, in 1948, Takii seed (Kyoto) sold its first domestic F_1 tomato seeds. Since then, the development of crossbred F_1 cultivars of vegetables has progressed, and F_1 vegetable cultivars have become prevalent in the seed market thanks to several advantages, such as high productivity, suitability for distribution, and vigorous, uniform, and stable traits [1].

In contrast, both the quantity and variety of heirloom vegetables decreased during the same period [2]. The work of people who prioritize food quality, genetic diversity, and tradition, as well as the support of public organizations led to a concerted effort to preserve heirloom vegetables.

Dr. Shiro Takashima of Kyoto Prefectural University conducted research on vegetables before and after World War II. With the cooperation of municipalities, agricultural organizations, and growers in Kyoto, he devoted himself to the preservation of seeds, while referring to the literature, and conducting research on their history and morphology.

Movements by local governments to preserve *Kyo-yasai*

The Kyoto City municipal office also started a project in 1962 to promote the preservation of 10 varieties of vegetables by setting up a Special Vegetable Preservation Field (*Kyoto-shi-Tokusan-Sosai-Hozonho*).

The Department of Agriculture in the Kyoto prefectural government compiled a list of heirloom vegetables and fruits in the prefecture that should be preserved in 1960. The list includes 50 vegetable varieties from 15 vegetable species (Table 3; Fig. 12).

In 1974, the Department of Agriculture started the "Project for the Establishment of Traditional Vegetable Seedling Hoards (*Dentoyasai-Gensyuho-Secchijigyo*)" and the Prefectural Institute of Agriculture (merged and renamed as Kyoto Prefectural Agriculture, Forestry and Fisheries Technology Center (KAFF) in 2009) interviewed production farmers about their cultivation methods, received seed and seedling donations along with their records, and preserved their original seeds [46–48], work which still continues in the present day [49].

As the Kyoto prefectural government promoted the production of *Kyo-yasai*, it became necessary to differentiate *Kyo-yasai* varieties from other vegetable cultivars. Therefore, in 1987, the Department of Agriculture defined and organized the 'traditional *Kyo-yasai*' under the guidance of Dr. Takashima.

The definition of 'traditional *Kyo-yasai*' is the vegetables in Kyoto prefecture with a pre-Meiji history. The category of vegetables includes bamboo shoots but not wild vegetables, mushrooms, or ferns, and is limited to those with differentiated varieties or unique cultivation methods.

Table 3 The proposal for a preservation list of Kyo-yasai by the Kyoto prefecture government in 1960

Plant name	Botanical name	Varieties
Brassicaceae leaf (Tukena)	*Brassica rapa* L.	Tanbana, Banseinamana, Nakate-Mibuna*, Chudoji-Mibuna*
Cowpea	*Vigna unguiculata* (L.) Walp	Hiiragino-sasage*
Cucumber	*Cucumis sativus* L.	Shogoin-fushinari*
Eggplant (Aubergine, Brinjal)	*Solanum melogena* L.	Kamo-nasu*, Yamashina-nasu*, Mogi-nasu*, Saiin-kuronasu, Honjyo-nasu
Husk tomato	*Alkekengi officinarum* Moench	Tanba-Daihozuki, Tanba-Shohozuki
Hyacinth bean	*Lablab purpureus* L.	Momoyama-shu
Japanese Radish (Daikon)	*Raphanus sativus* L.	Aomi-daikon*, Karami-daion*, Toushichi-daikon*, Momoyama-daikon*, Chudoji-daikon*, Sabaga-daikon*, Shogoin-daikon*,Kori-daikon*, Oshimana
Mioga Ginger	*Zingiber mioga* (Thunb.) Roscoe	Natsuko, Akiko (Both varieties are called 'Kyo-mioga*' as a general)
Pickling Melon	*Cucumis melo* L. var. *conomon*	Katsura-uri*, Yarimochi
Pumpkin	*Cucurbita moschata* Duchesne	Shishigatani-kabocha *
Sweet Pepper	*Capsicum annuum* L.	Fushimi-togarashi*, Tanaka-togarashi*
Turnip	*Brassica rapa* L. var. *rapa*	Haji-kabu, Matsugasaki-ukinakabu*, Uguisuna*, Sabaga-kabu*, Sugukina*, Toji-kabu*, Kerikoyoshi-kabu, Maizuru-kabu*
Udo ginseng	*Aralia cordata* Thumb	Edomachiwase, Yozaemon, Fushiaka, Kuwana, Shobeishiro, Maiko, Hansa, Oniaka, Takemaeshiro, Tambashikanoko (These are called 'Kyo-udo*' as a general)
Water dropwort	*Oenanthe javanica* (BL.) DC	Chosen (Kyo-zeri*)
Welsh Onion	*Allium fistulosum* L.	Asagi (Kujo-negi*)

*Later, these varieties were registered as Traditional *Kyoto-yasai in 1987*

Based on this definition, 37 types of vegetables were selected as traditional *Kyo-yasai* [44, 50]. Three types that are newer to cultivation but essential for market distribution were added as equivalent to *Kyo-yasai*, for a total of 40 types of vegetables selected as traditional *Kyo-yasai* (Table 4) [51].

Some of the traditional *Kyo-yasai* were also used for sales promotion by a semi-governmental institution named 'the Kyo-Branded Products Association,' which was established in 1989, a move that once again drew the attention of the public [50]. In response, scientific research on the cultivation, culture, functionality, and history of *Kyo-yasai* has flourished. Additionally, the Kyoto Prefectural Institute of Agriculture has been conducting breeding programs aimed at improving the cultivation suitability, productivity, and quality of *Kyo-yasai* while maintaining their characteristics.

Modern *Kyo-yasai* promotion policy

The Kyo-Branded Products Association designated Kyoto brand products to promote sales of *Kyo-yasai*. Currently, there are 20 vegetable items designated as Kyoto brand products, 15 of which are traditional *Kyo-yasai* (Table 4) [44]. Since its establishment, *Mizuna* has been the leading product in sales promotions. The use of *Mizuna* in small bunches, the establishment of cultivation techniques, and the expansion of sales channels have increased the recognition of *Kyo-yasai* [52]. However, after expanding its sales channels nationwide, *Mizuna* has become recognized as a common vegetable, and Ibaraki Prefecture (Fig. 1), which is adjacent to Tokyo, now accounts for half the domestic production of *Mizuna*. In addition, the expansion of sales channels for *Kujo-negi* has stimulated the consumption of leaf onions in eastern Japan, which is also becoming a common vegetable, and this has the paradox that the mass sales of one commodity make the item less attractive as a 'local' product [53, 54]. Moreover, the popularity of *Mizuna* and *Kujo-negi* also expanded the seed market. It resulted in private seed companies quickly developing new F_1 and mix-breed cultivars that did not resemble *Kyo-yasai*. So, these gradations of new cultivars prompted the need to define the traits of *Mizuna* and *Kujo-negi* in detail. Contrary to private seed companies, the KAFF has been promoting the improvement of varieties in pursuit of better productivity and quality, while conserving the characteristics of *Kyo-yasai*. Additionally, *Kyo-yasai* often has superior functional components to common vegetable cultivars [55–57], and efforts are being made to utilize these components [58].

Breeding program and technology development—*Edamame*, Pepper, and Taro (*Ebi-imo*)

The production of some *Kyo-yasai* has increased thanks to promotional work. However, there is strong competition between modern cultivars of the same species. Therefore, KAFF has been improving some crops, such as *edamame* (Fig. 13), pepper, and *Ebi-imo*.

（秘秀）　京都の園芸品種保存案　そ菜の部　（昭和35年8月）

種類	第一次保存品目		第二次保存品目	
	品種名	現存場所	品種名	現存場所
だいこん	辛味だいこん	農試山城支場	中堂寺だいこん	京都市内種苗商
	青味だいこん	〃	佐波賀だいこん	農試丹後支場
	聖護院だいこん	不名	聖護院山城2号	農試山城支場
	藤七だいこん	京都南区九条の種苗商	老人菜（オオシマナ）	宮島野生
	桃山だいこん	伏見区桃山の農家		
かぶ	波路かぶ	宮津市波路の農家	東寺かぶ	南区九条の種苗商
	松ケ崎浮菜かぶ	高山種苗	けりこよしかぶ	〃
	蔦菜	農試山城支場	鉾鶴かぶ	鉾鶴農家
	佐波賀かぶ	農試本場		
	酸茎菜の原種	左京区上賀茂の農家		
うど	江戸町早生（早生白）	農試山城支場		
	与左エ門	〃		
	節赤	〃		
	衆名	伏見区桃山の農家		
	庄兵衛白（中生白）	農試山城支場		
	錨3	伏見区桃山の農家		
	半左	農試山城支場		
	鬼赤	〃		
	竹前白	〃		
	丹波鹿の子	亀岡市篠町の農家		
みようが	夏子	伏見区桃山の農家	秋子	伏見区桃山の農家
せり			朝鮮	南区九条の農家
きゅうり	聖護院節成	タキイ種苗		
なす	挑なす	府立大学		
	西院黒なす	タキイ，高山種苗		
	ほんじょうなす	南区久世の農家		
	鴨なす	左京区上賀茂の農家		
	山科なす	南区淀の農家		
とうがらし	伏見とうがらし	タキイ，高山種苗		
	田中（中獅子）	〃		
ほおずき	丹波大ほおずき	亀岡市篠町の農家		
	丹波小ほおずき	〃		
つけな	丹波菜	タキイ種苗	中生壬生菜	南区九条の種苗商
	晩生生菜	南九条の種苗商	中堂寺壬生菜	〃
ねぎ			浅黄（赤）（九条葱）	〃
かぼちゃ	鹿ケ谷（西京）	府立大学		
しろうり	やりもち（早生小白）	南区森本種苗		
	桂うり	向日町小林種店		
ささげ	松原紅豆	北区松野の農家		
ふじまめ	桃山種（褐色花）	伏見区桃山の農家		

Fig. 12 The proposal for a preservation list of Kyo-yasai by the Kyoto prefecture government in 1960

Table 4 List of heirloom vegetables (*Kyo-yasai*) registered as traditional *Kyo-yasai*

Plant name	Botanical name	Varieties	Other names
(Existing traditional ones) arrowhead	*Sagittaria trifolia* L.	Kuwai*	
Brassicaceae leaf (*Tsukena*)	*Brassica rapa* L.	Hatakena	
		Mibuna*	
		Mizuna*	Kyona
Bamboo shoot	*Phyllostachys pubescens* Mazel	Kyo-takenoko*	
Burdock	*Arctium lappa* L.	Horikawa-gobo*	Juraku-gobo
Cowpea	*Vigna unguiculata* (L.) Walp	Hiiragino-sasage	Sanjyaku-sasage
Cucumber	*Cucumis sativus* L.	Shogoin-fushinari	
Eggplant	*Solanum melongena* L.	Kamo-nasu*	Oserikawa-nasu
		Mogi-nasu	Yoshidamogi-nasu
		Yamashina-nasu*	
Japanese Radish	*Raphanus sativus* L.	Aomi-daikon	Aomi-rafuku, Mibu-daikon
		Karami-daikon	
		Kuki-daikon	Chudoji-daikon
		Momoyama-daikon	Okamedani-daikon, Nezumi-daikon
		Sabaga-daikon	
		Shogoin-daikon *	
		Tokinashi-daikon	Toushichi-daikon
Mioga Ginger	*Zingiber mioga* (Thunb.) Roscoe	Kyo-mioga	Momoyama-mioga, Mioga-take
Pickling Melon	*Cucumis melo* var. *conomon*	Katsura-uri	Saikyo-uri, Kyoto-uri
Pumpkin	*Cucurbita moschata* Duchesne	Shishigatani-kabocha *	
Sweet Pepper	*Capsicum annuum* L.	Fushimi-togarashi *	Fushimi-amanaga
		Tanaka-togarashi	Chujishi, Shishito
Taro	*Colocasia esculenta* L.	Ebi-imo*	
Turnip	*Brassica rapa* L. var. *rapa*	Maizuru-kabu	
		Matsugasakiukina-kabu	Yatsugashira, Ha-kabu
		Ohuchi-kabu	
		Sbaga-kabu	Tenjin-kabu
		Sugukina	Suguki
		Syogoin-kabu*	
		Uguisuna	
Udo	*Aralia cordata* Thumb	Kyo-udo	Momoyama-udo
Water Dropwort	*Oenanthe javanica* (BL.) DC	Kyo-zeri	Kyo-mizuseri
Water Shield	*Brasenia schreberi* J.F. Gmel	Junsai	
Welsh Onion	*Allium fistulosum* L	Kujo-negi *	
(Extinct vegetables) Japanese Radish	*Raphanus sativus* L.	Kori-daikon	
Turnip	*Brassica rapa* L. var. *rapa*	Toji-kabu	
(Vegetables conforming to traditional ones) Hanana	*Brassica rapa* L. var. *oleifera* DC	Fushimi-Kanzaki-natane *	
Sweet Pepper	*Capsicum annuum* L.	Manganji-togarashi *	Manganji-amato
		Takagamine-togarashi	

Items designated only as Kyoto brand vegetables include 'Kyonatsu-Zukin' and 'Murasaki-Zukin' edamame, 'Kintoki' carrots, 'Kyo-Kokabu' immature turnips, and Japanese yam (*Dioscorea japonica*)

*These varieties are also registered as Kyoto Brand vegetables

With *edamame*, some traits have been intensively improved, such as expanding the harvesting season, and developing resistance to soybean mosaic virus (SMV).

In 1975, cultivar *Shin-Tambaguro* seeds were irradiated with 10KR γ-rays, and mutant individuals were fixed and selected. One of the lines was registered in March 1993 as the edamame cultivar *Murasaki-Zukin* because of excellent traits, similar to those of *edamame*, and potential for early harvesting [59]. *Murasaki-Zukin* can be harvested in late September or early October, whereas

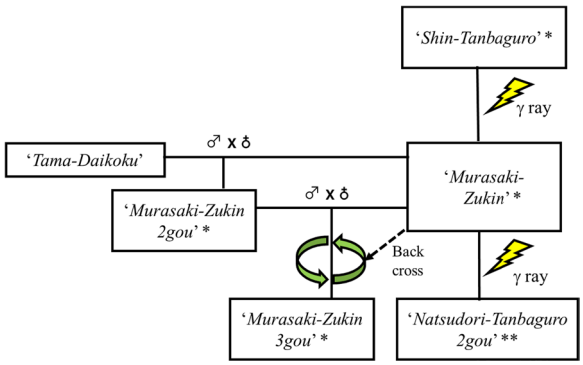

Fig. 13 Genealogy of the cultivars that make up the product brand names '*Murasaki-Zukin*' and '*Kyonatsu-Zukin*'. '*Murasaki-Zukin*': Four cultivars marked with * were harvested and shipped in the relay. '*Kyonatsu-Zukin*': One cultivar marked with ** was harvested and shipped under the trade name

Shin-Tambaguro can be harvested in mid-to-late October. The number of main stem nodes was more than three less than that of *Shin-Tambaguro*, and the main stem length was approximately 15 cm shorter.

To make *Murasaki-Zukin* early-maturing and SMV-resistant, KAFF developed a post-hybrid generation, then proceeded with fixation and selection using accelerated generation techniques. It applied for the cultivar registration of '*Murasaki-Zukin 2gou*' in April 2006 [60]. This cultivar can be harvested in early to mid-September and has a slightly shorter and more compact main stem.

To develop a variety that can be shipped in the summer season when the demand for *edamame* is high, *Murasaki-Zukin* was irradiated with γ-rays (dose 100 Gy), and the mutant plants were fixed and selected. This cultivar was registered as '*Natsudori-Tambakuro 2gou*' in April 2010 [61] and was harvested in August.

To provide SMV resistance to *Murasaki-Zukin*, it was crossed with *Murasaki-Zukin 2gou*. Subsequently, KAFF backcrossed *Murasaki-Zukin* to the BC_2 generation for fixation and selection and then applied for cultivar registration as '*Murasaki-Zukin 3gou*' in February 2015 [62]. Growth characteristics such as flowering time, harvest time, and main stem length were comparable to those of the recurrent backcross parent, *Murasaki-Zukin*.

KAFF has also completed a breeding program for a new cultivar to replace '*Natsudori-Tambakuro 2gou*' to prevent the early yellowing of pods and SMV infection [63].

Regarding pepper, sales promotion of *Manganji* began in the 1990s. Although it is sold as a traditional *Kyo-yasai* sweet pepper (Fig. 4), the variety sometimes generates pungency. Therefore, KAFF first selects extremely low-pungency lines and pure breeds them with another culture. The line was registered as the cultivar 'Kyoto Manganji No.1 (*Kyoto manganji-ichigou*)' [64]. To achieve a completely non-pungent pepper and eliminate some unfavorable traits from Kyoto Manganji No.1, Kyoto Manganji No.2 was bred using backcross breeding with marker-assisted selection of the non-pungent recessive gene. In the new cultivar, pungent fruits were completely eliminated, and other undesirable fruit characteristics (anthocyanin accumulation in the pericarp and short fruit length) were found at very low frequencies compared to Kyoto Manganji No.1 [65]. The Japan Agricultural Cooperatives, 'JA Ninokuni,' in Chutan adopted this cultivar and registered the area and the brand name 'Manganji-amato' as a Japan's geographical indicator (GI) starting in 2017 [66].

KAFF has also developed DNA markers and linkage maps necessary for conferring various traits of pepper, such as resistance to phytophthora and bacterial wilt, fruit shape, removal of fruit pungency, and capsanthin pigment content in the fruit [67–74]. Additionally, it bred pepper F_1 lines using cytoplasmic male-sterile lines [75].

Ebi-imo is very popular as a delicious taro, and it is sold at approximately three times the price of ordinary taro. However, as it is a late-growing variety with a low yield, and soil filling and harvesting are difficult, this has resulted in a decline in the cultivation area.

Therefore, KAFF-selected lines were intended to create an early maturing, high-yielding, egg-shaped cultivar with many tubers. A new early maturing, high-yielding cultivar with 50% more tubers than the local lines due to its large tubers was then bred. It also produces egg-shaped secondary tubers, which are suitable for '*Koebi-chan*' shipment (30–70 g tubers). The new cultivar was subsequently released as '*Kyoto Ebi-imo 1gou*' [76]. The cultivar was then used to generate variations during culture de-differentiation and further improve its yielding ability. The selected line is called '*Kyoto Ebi-imo 2gou*.'

Production of *Kyo-yasai* and their functionality

Among the traditional or branded *Kyo-yasai*, the six that are most widely distributed outside of the prefecture are, in descending order of production volume, *Kujo-negi* (8223t), *Kyo-takenoko* (3178t), *Shogoin-kabu* (918t), *Mizuna* (799t), *Manganji* pepper (789t), *Suguki* (608t), and *Shogoin-daikon* (407t). *Mibuna* (287t), *Kamo-nasu* (214t), *Hanana* (150t), *Fushimi* pepper (136t), *Murasaki-zukin* edamame (127t), *Kintoki* carrot (86t), and *Ebi-imo* (82t) also have relatively wide distributions (Table 4). However, only limited distribution or seed collection is practiced for other items. In addition to the organizations mentioned before, the promotion of Kyoto vegetable production and distribution involves agricultural improvement and extension centers, local promotion bureaus, agricultural cooperatives, and

Table 5 Food functionality of some vegetable species which include traditional *Kyo-yasai*

Plant name	Botanical name	Benefit	Key ingredients and/or function	References
Arrowhead	*Sagittaria trifolia* L.	Inhibitory effects on the histamine release	Four bioactive diterpene ketones	Yokota [79], Yoshikawa et al. [80] Wen et al. [81]
Bamboo shoots	*Phyllostachys pubescens* Mazel	Biological regulatory actions such as information transmission between cells for proliferation and differentiation, intercellular adhesion, and also for cell quality	Sialic acid, proteins, and fiber	Onodera et al. [82] Watanabe and Koketsu [83]
Burdock	*Arctium lappa* L.	Antioxidant activity, anti-inflammatory, and hypolipidemic properties, and gastric mucosal defense mechanisms	Prebiotic fibers, chlorogenic acids, cinnarine, lignans, and quercetin	Moro and Glerici [84]
Carrot 'Kintoki'	*Daucus carota* L.	Higher anti-radical activity than those of western carrot	Lycopene	Takahashi et al. [85] Leja et al. [86]
Cucumber	*Cucumis sativus* L.	Possibility to mitigate cancer by stopping cancer cells from reproducing	Cucurbitacin	Alghasham [87]
Japanese Butterbur	*Petasites japonicus* (Siebold et Zucc.) Maxim	Anti-allergic effect	Sesquiterpenoids, lignans, and flavonoids	Hiemori-Kondo [88]
Mioga ginger	*Zingiber mioga* (Thunb.) Roscoe	Increased nerve growth factor, improvement of learning and memory	Mioga ginger extract	Kim et al. [89]
Pepper	*Capsicum annuum* L	Antioxidant activity	Ascorbic acid, carotenoids, sialic acid	Onodera et al. [82]
Taro	*Colocasia esculenta* L.	Radical scavenging activity	At a stalk of taro, called 'Zuiki,' the red pigment was identified as cyanidin 3-rutinoside	Terasawa et al. [90]
Turnip	*Brassica rapa* L. var. *rapa*	Anticancer, antimicrobial, antimicrobial, antihyperoxia, antidiabetes, antioxidant, and renoprotective activities	Bioactive components, including glucosinolates, isothiocyanates, phenolic compounds, flavonoids, and organic acids	Cao et al. [91]
Udo ginseng	*Aralia cordata* Thumb	Mitigating diabetes, alleviating high blood pressure	Falcarinol renin inhibitory activity	Yoshida et al. [92] Takahashi et al. [93]
Water dropwort	*Oenanthe javanica* (BL.) DC	Biological activities such as hepatoprotective, anti-inflammatory, immune enhancement, ethanol elimination, antioxidant, antiviral, neuroprotective,anti-cancer, anticoagulant, anti-fatigue, hypoglycemic, cardiovascular protection, analgesic, and insecticidal activities	Sialic acid, coumarins, flavonoids, flavonoid glycosides, organic acids, polyphenols, and chlorogenic acid	Onodera et al. [82] Manaois et al. [94] Lu and Li [95]
Water shield	*Brasenia schreberi* J.F. Gmel	Antioxidant activities	Polysaccharides, quercetin-7-O-β-D-glucopyranoside and gallic acid	Kakuta and Misaki [15] Legault et al. [96] Xiao et al. [97]
Welsh Onion	*Allium fistulosum* L.	Augment immune functions	Secretes mucus in the cavities of its green leaves	Ueda et al. [98]

wholesale markets in each region in Kyoto prefecture. In terms of the functionality of *Kyo-yasai*, some have higher bio-antimutagenicity than common vegetables (Table 5) [56, 77]. Examples include eggplant, Japanese radish, pickling melon, and pumpkin [57, 78]. *Edamame* cultivars contain several unique ingredients. The production, composition, and functional properties of each variety of *Kyo-yasai* are detailed below:

Mizuna contains three aroma components, 3-butenyl isothiocyanate, 3-phenylpropionitrile, and phenylmethyl isothiocyanate, and the antimutagenic effects of these components were identified. However, year-round cultivation in vinyl greenhouses has revealed seasonal variations in the amount of these components, and traditional open-field cultivation is known to be more suitable when these components are desired [52].

The concentration of 4-methylthio-3-butenyl isothiocyanate (MTBITC) in *daikon* roots depends on local varieties and cultivars. Among domestic 38 accessions, *Karami-daikon* showed the highest content of MTBITC, reaching as much as 1735 μmol/100 ml [55]. Six traditional *Kyo-yasai daikon* varieties produce 2.0–11.5 times higher levels of MTBITC than the conventional variety *Aokubi* [99, 100]. MTBITC extracted from *Momoyama* and *Sabaga* may exert chemo-preventive effects against esophageal carcinogenesis in rats [101]. MTBITC complexes with α-cyclodextrin (αCD) in ground *daikon*. MTBITC-CD has anti-inflammatory and antioxidant effects that suppress lipid accumulation in epididymal adipose tissue and the liver [102].

The soybean cultivar *Murasaki-Zukin* is an immature black soybean grown in Kyoto. This cultivar is rich in oligosaccharides, such as raffinose and stachyose, compared to ordinary soybean cultivars. *Shin-Tanbaguro*, the parent cultivar of *Murasaki-Zukin*, also has the highest maltose content, and related cultivars such as *Murasaki-Zukin 2go* contain higher maltose than the typical *edamame* cultivar *Fuki* [103–105].

Eggplant contains acetylcholine, a neurotransmitter that is expected to be a functional food material. When 19 vegetables and fruits were analyzed for this component, the concentration in eggplant was 2900 times higher than the average value for vegetables and fruits [106]. In terms of bio-antimutagenicity, 'Kamo-nasu' showed higher levels than common eggplant based on their extracts against UV-induced mutation of *E. coli* [56].

Katsura-uri (pickling melon) contains the odorant compound 3-methylthiopropionic acid ethyl ester in its ripened fruit, suggesting its medical use [107]. As this ingredient has a melon-like aroma, it can also be used as a non-sugar beverage and dish [108–110]. Another compound, methylthioacetic acid, has been shown to improve glucose metabolism and acidification in skeletal muscles during exercise in both human and animal studies [111].

Pumpkin pulp has a high carotenoid content, especially lutein, which is the most abundant carotenoid in many varieties [112]. The profile of bioactive compounds in pumpkin pulp is considerably diverse. The literature has revealed that *Shishigatani-kabocha* contains the highest content of gallic acid and protocatechuic acid among the 15 cultivars [113]. Other studies have also reported that the protocatechuic acid content of the *Shishigatani* cultivar was second only to that of *Kogiku*, and for caffeic acid, it was the highest among the 20 cultivars in *Cucurbita* species [114].

The functionalities and ingredients of other vegetable species are summarized in Table 5.

Conclusion

Efforts such as the definition and selection of traditional *Kyo-yasai*, as well as sales promotion of the branded *Kyo-yasai* [115], have played a pioneering role in promoting regional vegetables across Japan [48] and increasing consumer interest in heirloom vegetables. As a result, efforts to rediscover heirloom vegetables in other regions have accelerated [116]. In recent years, the Ministry of Agriculture, Forestry, and Fisheries has also begun a survey of the production status of regional specialty vegetables since 2000 [117]. It is currently attempting to construct a database of heirloom varieties owned by local governments and municipalities through PGRAsia, a commissioned project conducted by NARO Genebank [118], thus encouraging the preservation and utilization of regional vegetables. To continue this work in the future, it is necessary to improve these heirloom varieties and popularize them further, while public institutions need to continue to preserve the seeds. Maintaining the character of these heirloom varieties without changing the taste, functional ingredients, and appearance of the vegetable will be considered as contributing to the diversity of species and food culture in general.

Acknowledgements
The author would like to express appreciation to all the staff, both past and present, who contributed to the promotion and research of *Kyo-yasai*. The author also would like to gratitude to Mr. Norihiro Uemura for valuable feedback in interview, and Mr. Andrew Tidmarsh for editing a draft of this manuscript.

Author contributions
YM designed the study, drafted the manuscript, and wrote the final version. The institute approved the manuscript.

Funding
Not applicable.

Availability of data and materials
Not applicable.

Declarations

Ethics approval and Consent to participate
Not applicable.

Consent for publication
The author agrees for this publication.

Competing interests
The author declares that he has no competing interests.

Received: 30 March 2023 Accepted: 24 May 2024
Published online: 06 August 2024

References

1. Yamashita T. Origin of new varieties of vegetable crops (*Yasairui-no-Shinhinshu-no-Oitachi*). J Integr Stud Diet Habits. 1996;7:16–23 (**in Japanese**).
2. Takashima S. Kyo-yasai. Kyoto: Tankosha; 1982. (**in Japanese**).
3. Fujime Y. Introduction to some indigenous vegetables in Japan. HortScience. 2012;47:831–4.
4. Sugiyama N. Brief history of horticulture in Japan. In: Sci JSH, editor. Horticulture in Japan 2006. Kyoto: Shoukadoh Publication; 2006. p. 1–4.
5. Chandler T. Four thousand years of urban growth: an historical census. Lewiston: The Edwin Mellen Press; 1987.
6. Takashima S. Traditional and seasonal vegetables from Kyoto (*Kyo-no-Dentoyasai-to-Syunyasai*). Osaka: Tombo Shuppan; 2003. (**in Japanese**).
7. Fukuzaki H. Meals described in the tea-ceremony classics (part 1) Nanboroku. J Home Econ Jpn. 1980;31:69–74 (**in Japanese**).
8. Fukuzaki H. Meals described in the tea-ceremony classics (part 2) Nanboroku. J Home Econ Jpn. 1985;36:770–8 (**in Japanese**).
9. Hayashi Y. Factor analysis of the location transition of specialty vegetable crops in the suburbs of Kyoto City (*Kyotoshikinko-Tokusansosai-Sakuricchihensen-no-Yoinbunseki*). J Rural Probl. 1973;9:91–100 (**in Japanese**).
10. de St. Maurice G. Everything but the taste: Kyoto's Shishigatani squash as culinary heritage. Food Cult Soc. 2017;20:281–301.
11. de St. Maurice G, Miller T. Less palatable still valuable taste crop agrobiodiversity and culinary heritage. Food Cult Soc. 2017;20:193–200.
12. Hayashi Y. Study of cropping systems in the suburbs of Kyoto [pre-World War II] (*Kyotoshikinko-niokeru-Sakutsuketaikei-no-Kenkyu* [*Senzenhen*]). Kyoto-Sakutsuketaikei-Kenkyukai; 1981 (**in Japanese**)
13. Iwamoto Y. Breeding of Japanese butterbur (*Petasites japonicus*) by using flowerhead culture. Plant Biotech. 2009;26:189–96.
14. Misaki A, Smith F. Food plant polysaccharides, structure of the polysaccharide of the Japanese water-plant, *Brasenia schreberi* J. F. Gmel. composition of the polysaccharide and isolation of 2-O-(β-D-glucopyranosyluronic acid)-D-mannose. J Agric Food Chem. 1962;10:104–8.
15. Kakuta M, Misaki A. The polysaccharide of "Junsai (*Brasenia schreberi* J. F. Gmel)" mucilage; fragmentation analysis by successive Smith degradations and partial acid hydrolysis. Agric Biol Chem. 1979;43:1269–76.
16. Kimura S, Kawakatsu Y. Evolutionary history of leaf shape diversification found in Mizuna and Mibuna. Acta Numanistica Sci Univ Sangio Kyotiensis. 2016;49:161–81 (**in Japanese**).
17. Kawakatsu Y, Sakamoto T, Nakayama H, Kaminoyama K, Igarashi K, Yasugi M, et al. Combination of genetic analysis and ancient literature survey reveals the divergence of traditional *Brassica rapa* varieties from Kyoto. Jpn Hortic Res. 2021. https://doi.org/10.1038/s41438-021-00569-0.
18. Sato S, Kubo N. Omikabuno Sosenshuto Kodaishuno Keifu 'Omikabura' ha Shogoinkabuno Sosenshuka? Agric Hortic. 2019;94:849–56 (**in Japanese**).
19. Wako T, Tsukazaki H, Ohara T, Yoshida M, et al. Verification of variety classification of bunching onion based on principal component analysis of morphological traits and growth habits. Bull Natl Inst Vege Tea Sci. 2009;8:121–30.
20. Kyotofunokai. Kyoto gardening handbook (Kyoto-fu-Engeiyokan). 1909. https://doi.org/10.11501/840101.
21. Yamazawa K, Kato K, Yamauchi R, Ueno Y. Bitter principle of tubers of *Sagittaria trifolia* (Kuwai). Agric Biol Chem. 1986;50:3179.
22. Chan YS, Cheng LN, Wu JH, Chan E, Kwan YW, et al. A review of the pharmacological effects of *Arctium lappa* (burdock). Inflammopharmacol. 2011;19:245–54.
23. Banga O. Origin of the European cultivated carrot. Euphytica. 1957;6:54–76.
24. Iorizzo M, Senalik D, Ellison S, Grzebelus D, Cavagnaro P, Allender C, et al. Genetic structure and domestication of carrot. Am J Bot. 2013;100:930–8.
25. Kubo N, Yamashita R, Tani M, Ozaki K, Fujiwara T, Mimura Y. Classification of 'Kintoki ninjin' and other groups of carrot based on simple sequence repeat markers. Breed Sci. 2019;69:688–95.
26. Hayashi D. *Tashikihen*. 1631. https://doi.org/10.20730/100271677 (**in classical Chinese**)
27. Terashima R. *Wakansansai-Zue*. 1712. (**in classical Chinese**)
28. Akatsuki K. *Settsu-Meisyo-Zue-Taisei*. 1855. (in Japanese)
29. Kyoto City Hall. Kyoto city agriculture and forestry handbook (*Kyotoshi-Norin-yoran*). Kyoto: Kinki-Nichinichi-Shinbunsha-Insatsubu; 1938. (**in Japanese**).
30. Yamagishi H, Yamashita Y. Origin of local radish variety, 'Sabaka', in Kyoto prefecture inferred by analyses of genes for cytoplasmic male-sterility and fertility restoration. Hort Res J. 2009;8:1–6 (**in Japanese**).
31. Shibutani S, Okamura T. On the classification of turnips in Japan with regard to the types of epidermal layers of the seed. J Jpn Soc Hort Sci. 1954;22:235–8.
32. Aoba T. Studies on the classification and 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 Jpn Soc Hort Sci. 1961;30:147–52.
33. Aoba T. 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 northwestern part of central Japan. J Jpn Soc Hort Sci. 1961;30:318–24.
34. Takahashi Y, Yokoi S, Takahata Y. Genetic divergence of turnip inferred from simple sequence repeats in chloroplast and nuclear genomes and morphology. Genet Resour Crop Evol. 2016;63:869–79.
35. Kubo N, Ueoka H, Satoh S. Genetic relationships of heirloom turnip cultivars in Shiga prefecture and other regions of Japan. Hortic J. 2019;88:471–80.
36. Takashima S, Narita M. The difference of *Brassica rapa* Linn. Var. *neosuguki* Kitamura strain from the morphological point of view II. Sci Rep Kyoto Prefect Univ. 1971;23:29–33.
37. Ueda H. Useful bamboo and bamboo shoots, New cultivation techniques (*Yuyotake-to-Takenoko, Saibai-no-Shingijyutsu*). Tokyo: Hakuyusha; 1963. (**in Japanese**).
38. Kaibara H. *Shosaifu*. 1704. https://doi.org/10.20730/100344829. (**in Japanese**)
39. Kurokawa D. *Youshufushi*. 1684. https://doi.org/10.20730/200017530. (**in classical Chinese**)
40. Mimura Y, Minamiyama Y, Kubo N. Parentage analysis of pepper cultivar "Manganji" (*Capsicum annuum* L.) characterized by SSR markers. Bull Agric For Technol Dep Kyoto Prefect Agric For Fish Technol Center Agric Sect. 2017;39:1–7.
41. Ito N. On the fruit and vegetable Nirvana and the vegetables and fruits depicted in it. (*'Kasonehanzu'-to-Egakareta-Yasai-Kudamono-nitsuite*). Stud Lang Cult (Nagoya Univ). 2008;30:3–24.
42. Xiong H, Shi A, Mou B, Qin J, Motes D, Lu W, et al. Genetic diversity and population structure of Cowpea. PLoS ONE. 2016. https://doi.org/10.1371/journal.pone.0160941.
43. Nichiren (Ed. Hori N.). *Nichiren-Daishonin-Gosho-Zenshu*. Tokyo: Seikyoshinbunsya Shuppankyoku; 1952. (**in Japanese**)
44. Rath EC. New meanings for old vegetables in Kyoto. Food Cult Soc. 2014;17:203–23.
45. Ashizawa M. Compendium of local vegetables by prefecture (*Todoufuken-betsu-Chiho-Yasai-Taizen*). Tokyo: Rural Culture Association Japan; 2002. (**in Japanese**).

46. Takashima S. Crop variety name miscellaneous remarks, Kyoto specialty vegetables (*Sakumotsu-Hinshumei-Zakko, Kyoto Tokusanyasai*). Jpn Agri Sci. 1980;35:276–81 (**in Japanese**).
47. Uemura N. Traditional vegetables in Kyoto (*Kyoto-no-Dentoyasai*). Jpn Agri Sci. 1981;36:102–5 (**in Japanese**).
48. Uemura N. Traditional vegetables in Kyoto II (*Kyoto-no-Dentoyasai 2*). Jpn Agri Sci. 1981;36:169–71 (**in Japanese**).
49. Kusama H. Regional names and maps in traditional vegetables (*Dentoyasai-nimiru-Chiikimei-to-Chizu*). Chizujyouhou. 2014;34:8–10 (**in Japanese**).
50. de St. Maurice G. The movement to reinvigorate local food culture in Kyoto, Japan. Food Act. 2014. https://doi.org/10.5040/9781350042155.ch-006.
51. Kyoto prefectural government. Traditional vegetables in Kyoto and Kyoto brand products (*Kyo-no-Dentoyasai, Kyo-no-Burandsanpin*) [Internet]. 2023 [cited 2024 Feb 18]. Available from: https://www.pref.kyoto.jp/brand/brand1.html (**in Japanese**)
52. Nakamura T, Nakao A, Watanabe M, Ueda K, Matsuda T, Matsumoto S, et al. Nationwide distribution of *Kyo-yasai* (heirloom vegetables in Kyoto) and the advantages of traditional farming methods with importance of 'Syun': a case of mizuna. J Ethn Foods. 2022. https://doi.org/10.1186/s42779-022-00141-8.
53. Ikejima Y, Hsano S. Commodification of local resources and its paradox—a case of traditional vegetables in Kyoto. Yokohama J Soc Sci. 2012;16:441–5.
54. Zhou W, Sun P, Wang F, Qian X, Nakagami K. Study on current situation and issues of the regional brand building for "Kyoto Vegetables." Policy Sci (Ritsumeikan Univ). 2016;24:1–13 (**in Japanese**).
55. Okano K, Asano J, Ishii G. Contents of pungent principle in roots of Japanese radish cultivars. J Jpn Soc Hort Sci. 1990;59:551–8.
56. Nakamura Y, Suganuma E, Kuyama N, Sato K, Ohtsuki K. Comparative bio-antimutagenicity of common vegetables and traditional vegetables in Kyoto. Biosci Biotechnol Biochem. 1998;62:1161–5.
57. Nakamura Y, Matsuo T, Okamoto S, Izumi T, Mori T, Sato K, et al. Bioantimutagenicity of heirloom vegetables in Kyoto. Environ Mutagen Res. 2004;26:259–64.
58. Kyoto prefectural government. Eat! Healthy Kyoto vegetables (*Tabete, Kenko-Kyo-yasai*) [Internet]. 2023 [cited 2024 Feb 18]. Available from: https://www.pref.kyoto.jp/kenkyubrand/news/kyouyasaikinousei.html (**in Japanese**).
59. Kobayashi H. Breeding of the 'Murasaki Zukin' black soybean variety for edamame (*Edamame-you-Kurodaizu 'Murasaki-zukin' no-Ikusei*). Kinki Chugoku Chiikiniokeru Shingijyutsu. 1995;29:1–4 (**in Japanese**).
60. Mimura Y, Furutani N, Kosaka Y, Hayashi K. Characteristics of the Tamba black soybean variety 'Murasaki-zukin 2gou' for edamame (*Tamba-kurodaizukei-Edamame-Hinsyu 'Murazaki-zukin 2gou' no-tokusei*) [Internet]. 2006 [cited 2024 Feb 18]. Available from: https://www.naro.affrc.go.jp/org/warc/research_results/h18/05_yasai/p185/index.html (**in Japanese**).
61. Sugimoto M, Kawai T. The breeding of black-seeded soybean 'Tambaguro' varieties for edamame being harvested in summer 'Natsudori Tambaguro 1' and 'Natsudori Tanbaguro 2.' Bullet Agri Fores Tech Dept KAFF Agri Sec. 2011;34:1–8 (**in Japanese**).
62. Furutani N, Ogawa T, Mimura Y, Yamazaki M. Breeding of new green soybeans of Tamba black soybean varieties, 'Murasaki zukin 3gou.' Hort Res Jpn. 2015;14:403–8 (**in Japanese**).
63. Naito I. Genetic breeding of a new edamame line E17-10 with soybean tambaguro to inculcate resistance against soybean mosaic virus. AHC2023 The 4th Asian Horticultural Congress Abstract Book. 2023;129.
64. Minamayama Y, Inaba K. A new sweet pepper variety, 'Kyoto Manganji No.1', with very low frequency of pungent fruits. Kinki J Crop Sci Breed. 2007;52:21–4.
65. Minamiyama Y, Furutani N, Inaba K, Asai S, Nakazawa T. A new sweet variety, 'Kyoto Manganji No. 2', with non-pungent fruit. Hort Res Jpn. 2012;11:411–6.
66. Japan Geographical Indication Council. Information website on Japan's geographical indications (Manganji Amatou) [Internet]. 2017 June [cited 2024 Feb 18]. Available from: https://pd.jgic.jp/en/register/entry/37.html
67. Mimamiyama Y, Tsuro M, Kubo T, Hirai M. QTL analysis for resistance to *Phytophthora capsici* in pepper using a high density SSR-based map. Breed Sci. 2007;57:129–34.
68. Mimura Y, Yoshikawa M, Hirai M. Pepper accession LS2341 is highly resistant to *R. solanacearum* strains from Japan. Hort Sci. 2009;44:2038–40.
69. Mimura Y, Yoshikawa M, Hirai M. Kyoto-Manganji No.1 pepper cultivar as a standard for partial resistance to bacterial wilt disease. Trop Agr Dev. 2010;54:98–105.
70. Minamiyama S, Kinoshita S, Inaba K, Inoue M. Development of a cleaved amplified polymorphic sequence (CAPS) marker linked to pungency in pepper. Plant Breed. 2005;124:288–91.
71. Mimura Y, Kageyama T, Minamiyama Y, Hirai M. QTL analysis for resistance to *Ralstonia solanacearum* in Capsicum accession 'LS2341.' J Jpn Soc Hort Sci. 2009;78:307–13.
72. Mimura Y, Minamiyama Y, Sano H, Hirai M. Mapping for axillary shooting, flowering date, primary axis length, and number of leaves in pepper (*Capsicum annuum*). J Jpn Soc Hort Sci. 2010;79:56–63.
73. Mimura Y, Inoue T, Minamiyama Y, Kubo N. An SSR-based genetic map of pepper (*Capsicum annuum* L.) serves as an anchor for the alignment of major pepper maps. Breed Sci. 2012;62:93–8.
74. Konishi A, Furutani N, Minamiyama Y, Ohyama A. Detection of quantitative trait loci for capsanthin content in pepper at different fruit ripening stages. Breed Sci. 2019;69:30–9.
75. Konishi A, Ozaki K, Suetome N. Breeding of high capsanthin-containing red pepper 'DMSM188.' New Kinki Chugoku Shikoku Agri Res. 2019;2:20–5.
76. Inaba K, Tanaka D, Minamiyama Y. 'Kyoto Ebiimo 1gou' a new taro cultivar candidate for early maturing, high-yielding Ebiimo cultivation (*Wasetashu-na-Ebiimo-Saibaiyou-Satoimo-Shinhinshu-kouho 'Kyoto Ebiimo 1gou'*) [Internet]. 2003 [cited 2024 Feb 18]. https://www.naro.affrc.go.jp/org/warc/research_results/h15/08_yasai/251.html (**in Japanese**).
77. Nakamura Y, Itoi S, Fujii M, Nakamura T, Park EY, Sato K. The superiority of *kyo-yasai* over popular species in terms of food functionality and the creation of demand by exploiting this advantage (*Kyo-yasai-no-Shokuhin-Kinousei-ni-okeru-Fukyusyu-ni-taisuru-Yuisei-to-Sore-o-ikashita-Jyuyou-no-Soushutsu*). Prep Food Tech. 2012;18:141–9 (**in Japanese**).
78. Nakamura Y, Nakamura K, Asai Y, Wada T, Tanaka K, Tatsuo T, et al. Comparison of the glucosinolate–myrosinase systems among daikon varieties. J Agri Food Chem. 2008;56:2702–7.
79. Yokota M. Proteins and carotenoids contents in arrowhead. Jpn J Nutr Diet. 1995;53:49–55.
80. Yoshikawa M, Yoshizumi S, Murakami T, Matsuda H, Yamahara J, Murakami N. Medicinal foodstuffs II. On the bioactive constituents of the tuber of *Sagittaria trifolia* L. (Kuwai, Alismataceae): absolute stereostructures of trifoliones A, B, C, and D, sagittariosides a and b, and arabinothalictoside. Chem Pharm Bull. 1996;44:492–9.
81. Wen C, Zhang J, Zhou J, Duan Y, Zhang H, Ma H. Effects of slit divergent ultrasound and enzymatic treatment on the structure and antioxidant activity of arrowhead protein. Ultrason Sonochem. 2018;49:294–302.
82. Onodera K, Hirano S, Hayashi H. Sialic acid and related substances part IV sialic acid content of some biological materials. Agr Biol Chem. 1966;30:1170–2.
83. Watanabe T, Kotetsu M. Function of sialic acid. Food Process Ingr. 2018;53:59–63 (**in Japanese**).
84. Moro T, Clerici M. Burdock roots as a source of inulin-type fructans and other bioactive compounds: current knowledge and future perspectives for food and non-food applications. Food Res Int. 2020. https://doi.org/10.1016/j.foodres.2020.109889.
85. Takahashi K, Maeda T, Ikeura H, Kurauchi T, Zadrak WD, Osanai S, et al. Comparison of qualities commencing with volatile compounds and growth between western, oriental and intermediate carrot cultivars grown in Aomori Prefecture. Hort Res Jpn. 2020;19:391–8 (**in Japanese**).
86. Leja M, Kamińska I, Kramer M, Maksylewicz-Kaul A, Kammerer D, Carle R, et al. The content of phenolic compounds and radical scavenging activity varies with carrot origin and root color. Plant Foods Hum Nutr. 2013;68:163–70.
87. Alghasham A. Cucurbitacins—a promising target for cancer therapy. Int J Health Sci (Qassim Univ). 2013;7:77–89.

88. Hiemori-Kondo M. Antioxidant compounds of *Petasites japonicus* and their preventive effects in chronic diseases: a review. J Clin Biochem Nutr. 2020;67:10–8.
89. Kim HG, Lim S, Hong J, Kim AJ, Oh MS. Effects of Myoga on memory and synaptic plasticity by regulating nerve growth factor-mediated signaling. Phytother Res. 2016;30:208–13.
90. Terasawa N, Saotome A, Tachimura Y, Mochizuki A, Ono H, Takenaka M, et al. Identification and some properties of anthocyanin isolated from Zuiki, stalk of *Colocasia esculenta*. J Agric Food Chem. 2007;55:4154–9.
91. Cao Q, Wang G, Peng Y. A critical review on phytochemical profile and biological effects of turnip (*Brassica rapa* L.). Front Nutr. 2021. https://doi.org/10.3389/fnut.2021.721733.
92. Yoshida J, Ito Y, Kimura K. Functional properties of GSK-3β inhibitors in wasabi, udo and parsley vegetables in relation to type 2 diabetes. New Food Ind. 2012;54:9–18 (**in Japanese**).
93. Takahashi S, Tokiwano T, Hata K, Hokari M, Yoshizawa Y, Gotoh T. Isolation and Identification of human renin inhibitor from *Aralia cordata* (Udo). J Biol Macromol. 2011;11:83–9.
94. Manaois RV, Oki T, Wakagi M, Takano-Ishikawa Y, et al. Antioxidant analysis and antioxidant composition of water dropwort (*Oenanthe javanica*). Philipp J Crop Sci. 2017;42(supplement 1):20.
95. Lu C, Li X. A review of *Oenanthe javanica* (Blume) DC. as traditional medicinal plant and its therapeutic potential. Evid Based Complement Altern Med. 2019. https://doi.org/10.1155/2019/6495819.
96. Legault J, Perron T, Mshvildadze V, Girard-Lalancette K, Perron S, Laprise C, et al. Antioxidant and anti-inflammatory activities of quercetin 7-*O*-β-D-glucopyranoside from the leaves of *Brasenia schreberi*. J Med Food. 2011. https://doi.org/10.1089/jmf.2010.0198.
97. Xiao H, Cai X, Fan Y, Luo A. Antioxidant activity of water-soluble polysaccharides from *Brasenia schreberi*. Pharmacogn Mag. 2016;12:193–7.
98. Ueda H, Takeuchi A, Wako T. Activation of immune responses in mice by an oral administration of bunching onion (*Allium fistulosum*) mucus. Biosci Biotechnol Biochem. 2013;77:1809–13.
99. Nakamura Y, Iwahashi T, Tanaka A, Koutani J, Matsuo T, Okamoto S, et al. 4-(Methylthio)-3-butenyl isothiocyanate, a principal antimutagen in daikon (*Raphanus sativus*; Japanese white radish). J Agri Food Chem. 2001;49:5755–60.
100. Nakamura Y, Matsuo T, Okamoto S, Nishikawa A, Imai T, Park EY, et al. Antimutagenic and anticarcinogenic properties of *Kyo-yasai*, heirloom vegetables in Kyoto. Genes Environ. 2008;30:41–7.
101. Suzuki I, Cho YM, Hirata T, Toyoda T, Akagi J, Nakamura Y, et al. 4-Methylthio-3-butenyl isothiocyanate (raphasatin) exerts chemopreventive effects against esophageal carcinogenesis in rats. J Toxicol Pathol. 2016;29:237–46.
102. Okamoto H, Ino S, Nihei N, Ikuta N, Ueno C, Itoi A, et al. Anti-obesity effects of α-cyclodextrin-stabilized 4-methylthio-3-butenyl isothiocyanate from daikon (*Raphanus sativus* var. *longipinnatus*) in mice. J Clin Biochem Nutr. 2019;65:99–108.
103. Nomura S, Furutani N, Ohtani K, Muramoto Y, Shibata M, Matsui M. Production of maltose in various cultivars of soybean vegetable, *Glycine max* (L.) Merr., after boiling. Food Sci Tech Res. 2014;20:401–7.
104. Rhee HK, Minamide T, Ohtani K. Water-soluble Oligosaccharides of Murasakizukin, immature black soybeans at different maturities, and changes of their oligosaccharides by boiling. Nippon Nogeikagaku Kaishi. 2000;74:501–4.
105. Ohtani K, Rhee HK, Minamide T. The contents of stachyose in 'Murasakizukin' one of Kyoto traditional vegetables. Trace Nutri Res. 2000;17:115–20.
106. Wang WH, Yamaguchi S, Koyama M, Tian S, Ino A, Miyatake K, et al. LC–MS/MS Analysis of choline compounds in Japanese-cultivated vegetables and fruits. 2020. Foods. https://doi.org/10.3390/foods9081029.
107. Nakamura Y, Nakayama Y, Ando H, Tanaka A, Matsuo T, Okamoto S, et al. 3-Methylthiopropionic acid ethyl ester, isolated from *Katsura-uri* enhanced differentiation in human colon cancer cells. J Agric Food Chem. 2008;56:2977–84.
108. Sasaki A, Nakamura Y, Kobayashi Y, Aoi W, Nakamura T, Shirota K, et al. A new strategy to protect *Katsura-uri* from extinction. J Ethn Foods. 2017;4:44–50.
109. Sasaki A, Nakamura Y, Kobayashi Y, Aoi W, Nakamura T, Shirota K, et al. Preparation of contemporary dishes and a functional drink using Japan's heirloom vegetable, *Katsura-uri*. J Ethn Foods. 2018;5:60–5.
110. Sasaki A, Nakamura Y, Kobayashi Y, Aoi W, Nakamura T, Shirota K, et al. Contribution of *Katsura-uri* (Japan's heirloom pickling melon, *Cucumis melo* var. *conomon*) at the completely ripe stage to diabetes control. J Nutr Sci Vitaminol. 2020;66:261–9.
111. Aoi W, Takeda K, Sasaki A, Hasegawa Y, Nakamura Y, Park EY, et al. The effect of Katsura-uri and its derived ingredient methylthioacetic acid. Springerplus. 2015. https://doi.org/10.1186/s40064-015-1144-y.
112. Kulczyński B, Sidor A, Gramza-Michalowska A. Antioxidant potential of phytochemicals in pumpkin varieties belonging to *Cucurbita moschata* and *Cucurbita pepo* species. CYTA J Food. 2020;18:472–84.
113. Kulczyński B, Gramza-Michałowska A. The profile of secondary metabolites and other bioactive compounds in *Cucurbita pepo* L. and *Cucurbita moschata* pumpkin cultivars. Molecules. 2019. https://doi.org/10.3390/molecules24162945.
114. Kostecka-Gugała A, Kruczek M, Ledwożyw-Smoleń I, Kaszycki P. Antioxidants and health-beneficial nutrients in fruits of eighteen *Cucurbita* cultivars: analysis of diversity and dietary implications. Molecules. 2020. https://doi.org/10.3390/molecules25081792.
115. Aotani M. Branding and marketing management of 'kyoyasai' (Kyoto vegetables). Review of living science. In: Journal of the Faculty of Human Sciences, Kobe Shoin Women's University. 2010;41:1–10 (**in Japanese**).
116. Imaizum A, Hisano S. Institutionalisation of genetic resource management with farmers: cases of traditional vegetables in Japan. J Agric Sci Tech. 2013;B3:399–413.
117. Ministry of Agriculture, Forestry and Fisheries. Survey of local speciality vegetable production (*Chiho-Tokusan-Yasai-Seisanjokyo-Chosa*) [Internet]. 2022 June [cited 2024 Feb 18]. Available from: https://www.maff.go.jp/j/tokei/kouhyou/tokusan_yasai/ (**in Japanese**).
118. Genebank Project, NARO. 9th PGRAsia Symposium [Internet]. 2022 Nov [cited 2024 Feb 18]. Available from: https://www.gene.affrc.go.jp/event-ws_20221116.php (**in Japanese**).

Publisher's Note