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Nutrient Content of Wild Edible Plants Growing in the Natural Environment

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Abstract

Seven kinds of wild edible plants, known in Japanese as *yasou*, were collected from the natural environment in the early spring, and the nutritional components and bioactivities of these plants were investigated. The wild edible plants analyzed were *Trifolium pratense*, *Vicia hirsute*, *V. sativa subsp. nigra*, *Rumex acetosa*, *R. japonica*, *Fallopia japonica*, and *Commeline communis*. Cultivated plants including *Pisum sativum L.*, *Spinacea oleracea*, and *Allium fistulosum* were also assayed for comparison with the wild edible plants. The highest ascorbic acid, oxalic acid, and protein quantities in the wild plant samples were 1010 mg 100 g^{-1}, 22.6 g 100 g^{-1}, and 37.9 g 100 g^{-1}, respectively. *Vicia hirsute* had the highest iron quantity (34 mg 100 g^{-1}). Polyphenols were abundant in all wild plant species. Almost all of the wild plants tested had antioxidant bioactivity, defined as DPPH radical-scavenging, superoxide dismutase, and α-glucosidase inhibitory activities.

Introduction

There are many wild edible plants growing in our natural environment such as roadsides or pastures. Wild plants have been eaten at various times throughout the history of Japan, and are known as *yasou*, or, when they are cooked as food, as *sansai*. Several dishes have a long history in Japan, such as *nanakusa-gayu* (rice porridge with seven kinds of *yasou*, typically *hakobe* (*Stellaria*), *seri* (*Oenanthe*), and *gogyo* (*Gnaphalium*)), which has been eaten at the beginning of the New Year in Japan for over a thousand years. Many *sansai* species have also been used in tempura, a fried food, and other traditional Japanese vegetable dishes. These wild edible plants provide minerals, fiber, vitamins, essential fatty acids, and other important nutrients and dietary components. In addition, they can have anti-bacterial, hepatoprotective, or anticarcinogenic properties, and therefore medicinal value (Bianco *et al*., 1998).

Today, there is a limited number of types of wild edible plant that are used as *sansai*, even

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though there are many other wild edible plants that grow in our natural environment. Yildirim *et al*. (2001) reported the nutritional contents of the wild plants that are used as vegetables by people in the upper Coruh valley in Turkey. The aim of the present study was to investigate the nutritional components and bioactivity of wild edible plants that are not ordinarily eaten, and to compare these values with those obtained for cultivated plants (vegetables).

Materials and Methods

Experimental materials Seven wild edible plants—*Trifolium pratense*, *Vicia hirsute*, *V. sativa subsp. nigra*, *Rumex acetosa*, *R. japonica*, *Fallopia japonica*, and *Commeline communis* (Table 1)—growing in the natural environment around Nagoya were collected and investigated for their nutritional value and bioactivity. The plants were identified according to the taxonomy defined by Hashimoto (2007). Fresh *Allium fistulosum*, *Pisum sativum*, and *Spinacia oleracea* plants to use as standard cultivated vegetable plants were purchased from the vegetable section of the Mitsukoshi department store in Hoshigaoka, Nagoya.

Table 1 Wild edible plants and cultivated vegetables analyzed.

Binomial name	Family	Common Japanese name
Wild edible plants		
Trifolium pratense	Fabaceae	*akatsumekusa*
Vicia hirsute	Fabaceae	*suzumenoendou*
Vicia sativa subsp. nigra	Fabaceae	*karasunoendou*
Rumex acetosa	Polygonales	*suiba*
Rumex japonicas	Polygonales	*gishigishi*
Fallopia japonica	Polygonales	*itadori*
Commeline communis	Commelinaceae	*tsuyukusa*
Cultivated vegetables		
Pisum sativum L.	Fabaceae	*toumyou*
Spinacia oleracea	Amaranthaceae	*hourensou*
Allium fistulosum	Amaryllidaceae	*negi*

Preparation of plant extracts All plant samples were frozen in a freezer at −85 °C and then freeze-dried. Freeze-dried plants were milled into powder using a blender (Wonder Blender WB-1; Osaka Chemical Ltd., Amagasaki, Japan) and the powders were passed through an 850 μm sieve. The powders were stored at −85 °C and used within 3 days. To assay the properties of each sample, 2.5 g of freeze-dried powder was mixed 50 mL of distilled water or ethanol and extracted with a homogenizer (Homojinizer; IKA Japan Co., Ltd., Higashiosaka, Japan). The resulting mixture was centrifuged at 10,000 rpm for 15 min. The resulting supernatant solution was used for analysis of plant components and bioactivities.

Componential analysis Moisture contents were calculated as weight lost after drying at 130 °C using a moisture meter (MF-50; A & D Co., Tokyo, Japan). Ascorbic acid content was assayed

using F-kit ascorbic acid (J. K. International Pty., Ltd., Brisbane, Australia). Oxalic acid quantities were determined using E-kit oxalic acid (J. K. International Pty. Ltd., Brisbane, Australia). Total crude protein was measured by the Kjeldahl method (Aoyagi *et al*., 2011) with a conversion factor of 6.25. Total phenolic content was determined using the Folin-Denis method with gallic acid as the standard (Ishida, 1993). Ash content was defined as the percentage of inorganic residue remaining after ashing at 550 °C in a muffle furnace (KM-160; Advantec Toyo Co., Tokyo). Iron content was assayed by the o-phenanthroline method (Aoyagi *et al*., 2011). Magnesium content was assayed by the chelatometric titration method with Eriochrome Black T (Wako Junyaku Kogyou Co. Ltd., Osaka, Japan) as an indicator.

Assay of antioxidant activity DPPH-scavenging activity was estimated from the decrease in absorbance at 520 nm (Kogure *et al*., 1999), and expressed as mmol-Trolox equivalent per 100 g dry weight using the standard curve for Trolox. Superoxide dismutase (SOD) activity was assayed with SOD Test Wako (Wako Junyaku Kogyou Co. Ltd., Osaka, Japan). SOD activity was expressed as the reduction rate of tetranitro blue tetrazolium diformazan formation.

Inhibition of α-Glucosidase activity The reaction mixture contained 0.5 mL of 12 mM *p*-nitrophenyl-α-glucoside solution dissolved in 0.1 M sodium phosphate buffer (pH 6.0), 0.4 mL of distilled water, and 0.2 mL of enzyme solution. After allowing the reaction to proceed at 40 °C for 60 min, 1 mL of 0.2 M sodium carbonate solution was added to terminate the reaction. The production of *p*-nitrophenol was measured at 408 nm. The α-glucosidase inhibitor activity was defined as relative α-glucosidase activity with plant extract solution compared with that of distilled water.

Results and Discussion

The nutritional contents of the seven wild edible plants and three cultivated vegetables are shown in Table 2. The moisture content of all freeze-dried plants was in the range of 4.55–5.80 %.

Table 2 Ascorbic acid, protein, polyphenol, and oxalic acid content.

Binomial name	Ascorbic acid (mg/100 g DW)	Protein (g/100 g DW)	Polyphenol (mg/100 g DW)		Oxalic acid (g/100 g DW)
			Water extract	Ethanol extract	
T. pratense	202.0	33.4	629.0	1160.0	1.3
V. hirsute	944.0	35.0	1054.0	1601.0	2.6
V. sativa subsp. nigra	687.0	35.3	2341.0	2204.0	0.7
R. acetosa	74.0	25.9	979.0	4768.0	12.7
R. japonicas	1010.0	26.2	1387.0	1776.0	4.3
F. japonica	240.0	37.9	1777.0	4195.0	22.6
C. communis	212.0	21.6	444.0	777.0	2.4
P. sativum L.	110.0	51.2	620.0	1523.0	2.5
S. oleracea	263.0	40.3	1572.0	1364.0	12.6
A. fistulosum	170.0	23.6	376.0	965.0	1.9

The ascorbic acid contents of wild plants were quite different depending on the plant species tested, and ranged from 1010 mg 100 g^{-1} in *R. japonicas* to 74 mg 100 g^{-1} in *R. acetosa*. Wild plants tended to be rich in vitamin C compared to cultivated vegetables.

Protein content did not differ much among the plant species analyzed. *C. communis* contained the lowest protein value (21.6 g 100 g^{-1}), whereas *P. sativum* L., a cultivated plant, had the highest (51.2 g 100 g^{-1}). The polyphenol contents of many wild plants were higher than those of cultivated plants, particularly with regard to ethanol-extracted polyphenol. Among the cultivated plants, *S. oleracea* shows the highest value for polyphenol content. Takahashi *et al.* (2007) reported the polyphenol contents of *Brassica oleracea*, *Phaseolus vulgaris*, and *Daucus carota* plants grown and sampled in Saitama Prefecture as 1180 mg 100 g^{-1}, 1680 mg 100 g^{-1}, and 2520 mg 100 g^{-1}, respectively.

The oxalic acid contents of tested plants (Table 2) were very low except for those of *F. japonica* (22.6 g 100 g^{-1}), *R. acetosa* (12.7 g 100 g^{-1}), and *S. oleracea* (12.6 g 100 g^{-1}). *S. oleracea* is known to contain high amounts of oxalic acid. Oxalic acid binds to calcium in the body and is known to cause urinary tract stones. Therefore, it is advisable to blanch any foods that are rich in oxalate, such as *S. oleracea*, in advance. Yamada *et al.* (2003) reported that the oxalic acid content of *Spinacia* differs according to varieties and growing sites, and oxalic acid is most abundant in leaves.

Values of minerals as ash contents are shown in Table 3. Minerals are important for human nutrition. *C. communis* and *S. oleracea* had the highest ash contents (15.2 g 100 g^{-1}), followed by *R. japonica* (14.3 g 100 g^{-1}). Magnesium contents of all plants ranged from 14.7 to 71.4 mg 100 g^{-1}. Among the all the plant species tested, *S. oleracea* had the highest value (17.4 g 100 g^{-1}) for ash content. Chlorophyll contains magnesium, so this magnesium content could reflect the fact that the leaves of *S. oleracea* are much greener compared to leaves of other plants. *P. sativum* L. had the lowest concentration of magnesium (14.7 mg 100 g^{-1}). Iron content varied based on species. Humans often have iron deficiencies, as with calcium. Moreover plant-based iron is non-heme iron, and poorly absorbed. The highest iron content was seen in *V. hirsute* (21.6 mg 100 g^{-1}). *V. hirsute* also contained high amounts of ascorbic acid (Table 3), which enhances iron absorption by reducing

Table 3 Ash, magnesium, and iron content.

Binomial name	Ash (g/100 g DW)	Mg (mg/100 g DW)	Fe (mg/100 g DW)
T. pratense	8.9	43.3	9.1
V. hirsute	8.9	32.5	34.8
V. sativa subsp. nigra	9.9	36.4	13.6
R. acetosa	10.4	38.6	15.6
R. japonicas	14.3	24.6	16.7
F. japonica	8.8	35.0	13.7
C. communis	18.1	67.0	21.6
P. sativum L.	6.3	14.7	9.9
S. oleracea	15.2	71.4	11.5
A. fistulosum	10.4	47.0	9.1

divalent iron to trivalent iron.

Antioxidant activity is shown in Table 4 as the value of DPPH radical-scavenging activity or SOD-like activity. Water or ethanol extracts of all wild plants showed higher DPPH radical-scavenging activity compared with those of cultivated plants. Among wild plants, *R. acetosa* and *F. japoni*ca showed high antioxidant activity (Table 4). These wild plants also had high polyphenol content. Takahashi *et al*. (2007) also reported that DPPH radical-scavenging activity and polyphenol contents in local plants are correlated.

SOD-like activity did not differ much among plants tested (Table 4). Excess active oxygen in many aerobic organisms is said to be the cause of various diseases such as cancer and lifestyle-related diseases. Humans have enzymes, such as SOD, that eliminate such active oxygen and free radicals; however there are many reports about SOD in plants as well, such as *Pisum sativum* L. (Constantine *et al*., 1977). Ashima *et al.* (1993) reported that SOD protects tobacco plants from oxidative stress. Furthermore, Takahashi *et al.* (2007) reported that total polyphenol content in water extracts of fig leaves was positively correlated with SOD-like activity, and also identified rutin in water extracts of fig leaf. In the present study, all plants tested had either SOD or SOD-like activity.

Table 4 DPPH radical-scavenging activity, SOD-like activity, and α-glucosidase inhibitory activity.

Binomial name	DPPH radical-scavenging activity (mmol Trolox eq./100 g DW)		SOD-like activity (%)	α-Glucosidase inhibitory activity (%)
	Water extract	Ethanol extract		
T. pratense	13.7	19.1	53.3	20.7
V. hirsute	17.9	57.4	89.1	0.7
V. sativa subsp. nigra	60.8	87.5	65.5	18.0
R. acetosa	94.2	372.0	47.0	11.3
R. japonicas	10.2	61.7	75.2	10.6
F. japonica	107.0	212.0	29.1	8.6
C. communis	16.3	12.2	39.1	6.9
P. sativum L.	7.3	11.4	51.3	10.5
S. oleracea	9.8	18.0	72.8	4.5
A. fistulosum	5.7	7.5	96.8	16.6

The α-glucosidase inhibitory activities of water extract of each plant species are shown in Table 4. There are many reports of α-glucosidase inhibitory activities in plants (Ahmad *et al*., 2008; Sunil *et al*., 2011). All plants tested exhibited α-glucosidase inhibitory activity, but that of *V. hirsute* was very low. Lee *et al.* (2014) also reported α-glucosidase inhibitory activities of medicinal plants. In their report, phenolic compounds were the major component of α-glucosidase inhibitory activity; however, no correlation between phenolic compounds and inhibitory activity was seen in this study. Consumption of plants with α-glucosidase inhibitory activity may help prevent diabetes by delaying the conversion of disaccharides into monosaccharides and reducing absorption of sugars in the small intestine.

Conclusions

Edible wild plants tested were of high quality in terms of their nutritional properties, such as polyphenol, ascorbic acid, and mineral content, as well as their bioactivities, such as antioxidant and SOD-like activity. In addition, the nutritional values of the wild plants were greater than those of some of the cultivated vegetables tested. Almost all wild plants tested also showed α-glucosidase inhibitory activity. From these results, wild edible plants can be expected to benefit human nutrition and health (Romojaro *et al*., 2013).

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