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Variation of Mineral Compositions in the Regional, Varietal, and Seasonal Mulberry Leaves

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This study was carried out to investigate the mineral content in the regional, varietal and seasonal mulberry leaves. On average, mulberry leaf samples contained minerals in the order of potassium, phosphorus, calcium, magnesium, iron and so on (2.494 g/100 g, 2.255 g/100 g, 1.835 g/100 g, 0.627 g/100 g, 0.0245 g/100 g DW, respectively). Calcium content was 19-fold and 4-fold higher than that of green tea and spinach, respectively, suggesting that mulberry leaves appear to be a calcium-rich food source. In the comparison of geographic samples of Cheongilppong variety, calcium level was highest in Youngchun sample (2.477 g/100 g) and highest potassium level in Suwon sample (2.962 g/100 g). In the geographic samples of YK209 variety, Jinju-City sample was highest in calcium content (1.509 g/100 g). Among wild mulberry leaves collected from Cheju Island and Tsushima, potassium level was highest in Bongge-dong, Cheju City (3.865 g/100 g) and calcium level in Mitshshima Town, Tsushima (2.948 g/100 g). In the comparison of varietal samples collected in Suwon at the mulberry field of Dept. of Sericulture & entomology, Shinkwangppong variety was highest in the potassium level, although Keryangppong and Shinkwangppong were higher in calcium level. In the comparison of seasonal samples of Cheongilppong, there was a rough trend of increase in some minerals up to July (*e.g.*, calcium and potassium). Finding of the highest calcium and potassium contents in the wild mulberry (3.865 g/100 g and 2.948 g/100 g, respectively) rather than in the cultivated ones warrant that more focus should be paid to wild mulberry leaves to utilize their minerals efficiently.

Key words : Mulberry leaves, Minerals, Calcium

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Introduction

Researches on the feed value of mulberry leaves have thoroughly been performed, because mulberry leaves are the only natural food for domestic silkworm, *Bombyx mori*. With the rise of importance of the plant functionality in connection with technical improvement, however, mulberry leaves as well as other sericultural product became new research source in the course of shifting of traditional sericulture from silk production to functionality (Rural Development Administration, 2000).

It has been reported that sericultural product such as mulberry leaves, silkworm, Cordyceps ("winter-bug-summer-fungus"), silk, silkworm feces, silkworm urine, and mulberry root bark contains an abundant bio-active ingredient (Rural Development Administration, 2000), and their pharmacological effect is under investigation. Particularly, the capsulated, finely ground mulberry leaf powder is favored by my Korean peoples as a health subsidiary food after its blood glucose-lowering effect has been proved (Kim *et al.*, 1999b; Lee *et al.*, 1998). Furthermore, mulberry leaves are known to contain rutin and GABA (γ-aminobutyric acid), which exert blood vessel enhancement, blood pressure repression, and anti-bacterial, anti-oxidation, and anti-allergic effects (Bang *et al.*, 1998; Kim *et al.*, 1999a; Lee *et al.*, 1998). These aspects prompted for the utilization of mulberry leaves as an ingredient for functional foods such as ice cream, tea, noodle and so on.

Minerals are of significant to balance and metabolize our bodily functions. For example, calcium is the mineral in our body that makes up our bones and keeps them strong and iron is required for our blood and sulfur for our muscles. An aggregation of many other elements in balanced trace is required to ensure the proper function of our body (Christian and Greger, 1991; Eades, 1994).

Mulberry leaves contain about 50 kinds of inorganic ingredients and relatively large levels of potassium, iron, and, particularly, calcium (Kim, 1999). Ninety-nine percent of the calcium in human body is stored in the bones and teeth. The remaining 1% is present in the blood and soft tissues and is essential for life and health. Without this tiny 1% of calcium, human mussels wouldnt contract correctly, blood wouldnt clot, and nerves couldnt carry messages (Watson, 1997). Therefore, this 1% of calcium should be provided dairy through food to prevent the bone calcium from tearing down to fulfill body metabolism (Watson, 1997).

Although mulberry leaves are known to possess an abundant amount of bio-active substances, which exert a diverse pharmacological effect, many of them are secondary metabolites, being affected by environmental factors such as climate and soil of the planted places. Particularly, mineral content of plant may be exclusively affected by genetic factor and environmental factors such as soil minerals of the planted places (Davis *et al.*, 1984), suggesting possible existence of regional and varietal difference in the mineral levels.

In the standpoint of the manufacturing company who purchases mulberry leaves from the sericultural farms and manufactures mulberry leaf powder and mulberry leaf-related product, an essential question of purchasing time and region is always remained for the production of highly qualified product. In the long run, an accumulation of the mulberry leaf data on the useful ingredients will be an important start point to grasp superiority of the domestic agricultural product.

In this study, we, therefore, analyzed the major mineral content of a few regional, varietal, and seasonal mulberry leaves to accumulate a basic information on the domestic mulberry leaves, which can be utilized for detailed investigation in the future.

Table 1. Collection information of the mulberry leaf samples

Sample number and variety	Collection locality	Date of collection
1. YK209	Kangwon Agricultural Technology & Extension Center, Yanggu-gun, Kangwon Province	2000. 5. 30
2. Wild mulberry	Shitomi Town, Shimo Agata County, Tsushima, Japan	2000. 6. 3
3. Cheongil	Wansan-dong, Youngchun City, Kyungsangbuk Province	2000. 6. 7
4. YK209	Kyungnam Agricultural Research and Extension services, Chojeon-dong, Jinju City, Kyungsangnam Province	2000. 6. 8
5. Cheongil	Kumsan-lee, Nakan-myon, Sunchon City, Chollanam Province	2000. 6. 9
6. Wild mulberry	Ara-dong, Cheju City, Cheju Province	2000. 6. 14
7. Wild mulberry	Bongke-dong, Cheju City, Cheju Province	2000. 6. 14
8. Keryang	Dept. of Sericulture and Entomology, Seodun-dong, NIAST, Suwon City, Kyunggi Province	2000. 6. 19
9. Cheongil	Dept. of Sericulture and Entomology, Seodun-dong, NIAST, Suwon City, Kyunggi Province	2000. 6. 19
10. Shinkwang	Dept. of Sericulture and Entomology, Seodun-dong, NIAST, Suwon City, Kyunggi Province	2000. 6. 19
11. Yongchun	Dept. of Sericulture and Entomology, Seodun-dong, Suwon City, Kyunggi Province	2000. 6. 19
12. YK209	Dept. of Sericulture and Entomology, Seodun-dong, NIAST, Suwon City, Kyunggi Province	2000. 6. 19
13. Cheongil	Dept. of Sericulture and Entomology, Seodun-dong, NIAST, Suwon City, Kyunggi Province	2000. 5. 31
14. Cheongil *	Dept. of Sericulture and Entomology, Seodun-dong, NIAST, Suwon City, Kyunggi Province	2000. 7. 20
15. Cheongil *	Dept. of Sericulture and Entomology, Seodun-dong, NIAST, Suwon City, Kyunggi Province	2000. 8. 24
16. Wild mulberry	Manjeki, Mitsushima Town, Shimo Agata County, Tsushima, Japan	2000. 6. 2

* Samples were collected after summer pruning.

Materials and Methods

Sample collection

Sixteen mulberry leaf samples were collected from May 30 to August 24, 2000 in the several localities in Korea and two in Tsushima, Japan. Collection information of the samples is listed in Table 1 and sampling location is depicted in Fig. 1. For the convenience of understanding and explaining data in the result and discussion section, the analyzed data were grouped into several categories, such as regions, varieties, and seasons (months), instead of explaining the categorical data in a single table. Thus, some samples were utilized more than once for better comparison of the data. Regional comparison of mineral content was made with each three geographic samples of Cheongilppong (sample number 3, 5, 9) and YK209 (sample number 1, 4, 12), and four of wild mulberry collected from Cheju Island and Tsushima (sample number 2, 6, 7, 16). Varietal comparison of mineral content was made among mulberry varieties of Keryangppong (SN 8), Cheongilppong (SN 9), Shinkwangppong (SN 10), Yongchunppong (SN 11), and YK209 (SN 12) collected in the mulberry field of the Department of Sericulture & Entomology, NIAST, RDA, Suwon (thereafter Suwon). For seasonal comparison of mineral content, Cheongilppong was collected on May 31 (SN 13), June 19 (SN 9), July 20 (SN 14), and August 24, 2000 (SN 15) in Suwon. Among

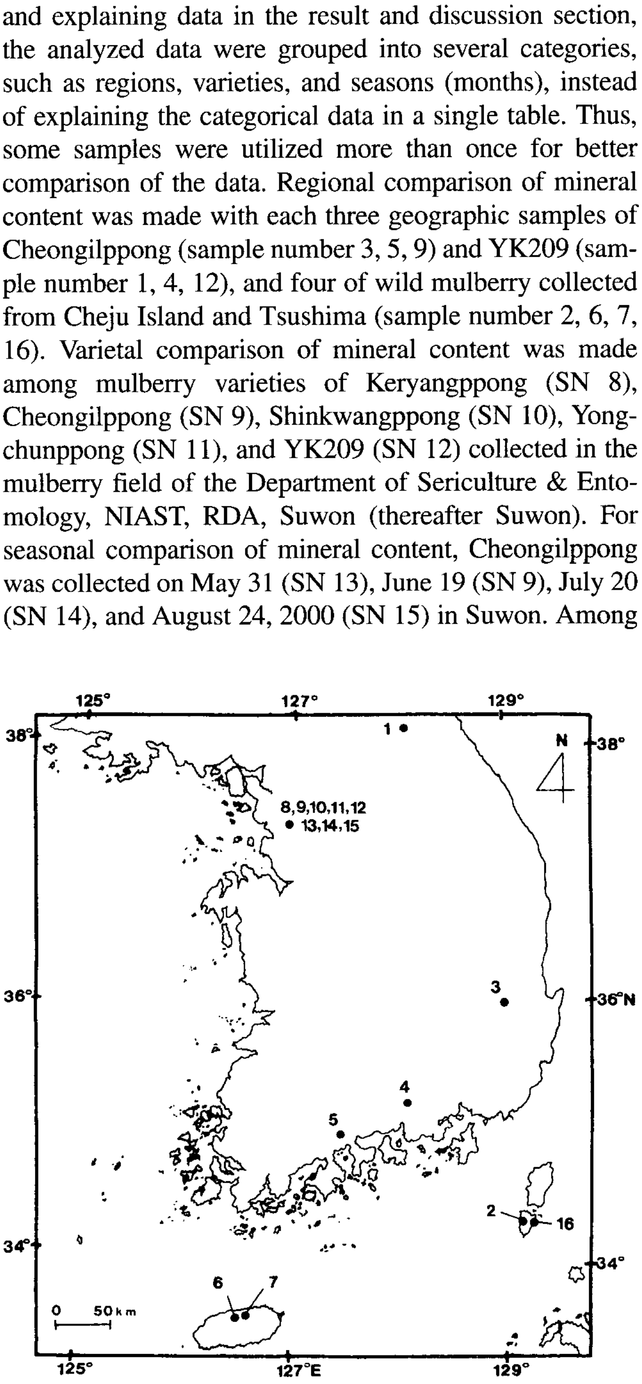

Fig. 1. A map showing sampling locations of mulberry leaves. General locality names are listed in Table 1.

these, last two samples were collected after summer pruning on June 22, 2000.

Mulberry leaves were taken from the branches at the upper part of trunk and weighed. To minimize "sampling error" and exaggeration of the data from paucity of sample into the whole locality and variety, mulberry leaves were collected from the trees as many as possible. For example, mulberry leaves were taken from at lest 20 trees to obtain 20 g of mulberry leaves in most cases. The collected leaves were deposited on ice while transportation to the Department and preserved in -70°C until use.

Analysis of mineral content

Water content of the samples was obtained by subtracting the lyophilized weight of the samples from original weight of collection. Crude protein was analyzed according to the method of Bradford (1976). That is, to the 0.1 g of freeze-dried leaves, 1ml of potassium phosphate buffer was added, centrifuged for 40 min at 13,000 rpm, and supernatant was obtained. Ten micro-liter of supernatant was mixed with 200 μl of coloring reagent and 790 μl of ddH_2O. Absorbency was measured at 596 nm using spectrophotometer, and protein content was estimated from the standard curve. Mineral content was analyzed by AOAC method (1980): 0.2 g of freeze-dried leaves was pulverized and burnt at 600°C for 4 h for the analysis of ash content. For the other mineral analyses, 10 ml of 3N HCl was added to the ash and incubated at 100°C for 10~20 min for complete digestion. The digested samples were then filtered with Whatman No. 2 filter paper and diluted to 100 ml with ddH_2O. Mineral content was analyzed by atomic absorption spectroscopy (AAnalyst 300, Perkin Elmer, USA). Phosphorus content was determined by colorimetric method, which utilizes ammonium molybdate, hydroquinone, and sodium sulfate (AOAC, 1980).

Conversion of numerical value, statistical analysis

Correction values, 1.2046, 1.3993, and 1.6583, respectively, were multiplied to each numerical value, K, Ca, and Mg, respectively, to obtain its actual content present in the plant. Using SAS program, Duncans multiple range test ($p<0.05$) was performed to test if any significant difference exists in the mineral content among samples of Cheongilppong, YK209, and wild mulberry.

Results and Discussion

Water content

Water content ranged from 75.4~89.3% among 16 samples (Table 2). The minimum water content was observed in the Cheongilppong collected in Suwon (SN 9; 75.4%).

Table 2. Contents of minerals in the 16 mulberry leaf samples (g/100 g, DW)

Sample number	Water content (%)	Crude ash	K	P	Ca	Mg	Na	Fe	Mn	Cu	Zn	Crude protein
1	80.9	11.5	2.527	3.927	1.380	0.379	0.0285	0.0575	0.0100	0.0060	0.0050	3.170
2	84.6	19.5	2.287	0.746	1.516	0.323	0.0200	0.0380	0.0075	0.0015	0.0015	2.625
3	79.5	10.0	2.408	0.183	2.477	0.902	0.0260	0.0320	0.0130	0.0025	0.0025	3.475
4	82.3	9.50	2.768	3.613	1.509	0.417	0.0280	0.0180	0.0065	0.0010	0.0010	5.825
5	81.8	10.0	2.224	0.484	1.971	0.717	0.0295	0.0210	0.0195	0.0002	0.0065	1.845
6	81.2	13.5	1.951	1.414	2.701	0.674	0.0280	0.0250	0.0110	0.0000	0.0020	1.880
7	89.3	18.0	3.865	0.602	1.705	0.659	0.0340	0.0275	0.0075	0.0000	0.0035	1.375
8	76.9	32.0	3.235	3.442	1.743	0.761	0.0150	0.0290	0.0065	0.0000	0.0020	1.550
9	75.4	12.0	2.962	3.927	1.716	0.56	0.0360	0.0325	0.0070	0.0000	0.0015	1.425
10	84.7	16.0	3.347	2.827	1.737	0.857	0.0300	0.0105	0.0070	0.0000	0.0020	3.500
11	76.0	5.00	1.480	3.665	1.331	0.932	0.0315	0.0220	0.0070	0.0000	0.0020	3.470
12	78.3	12.5	1.542	2.696	1.065	0.538	0.0505	0.0245	0.0060	0.0000	0.0070	1.610
13	77.3	7.50	2.441	2.291	1.159	0.505	0.0300	0.0150	0.0065	0.0000	0.0010	1.490
14	86.0	1.50	2.795	2.094	1.812	0.691	0.0350	0.0110	0.0085	0.0000	0.0015	4.100
15	81.4	14.5	1.168	1.990	2.592	0.701	0.0315	0.0120	0.0090	0.0000	0.0010	1.440
16	85.2	10.0	2.906	2.186	2.948	0.410	0.0225	0.0160	0.0085	0.0000	0.0010	2.225
Mean	81.3	12.7	2.494	2.255	1.835	0.627	0.0298	0.0245	0.0088	0.0007	0.0026	2.563
Minimum	75.4	1.50	1.168	0.183	1.065	0.323	0.0150	0.0105	0.0060	0.0000	0.0010	1.375
Maximum	89.3	32.0	3.865	3.927	2.948	0.932	0.0505	0.0575	0.0195	0.0060	0.0070	5.825

On the other hand, the maximum water content was observed in the wild mulberry leaves collected in Cheju Island (SN 7; 89.3%). Mean water content was 81.3% in 16 samples.

Comparison of mineral content among mulberry leaves, green tea, and spinach

Mineral content and crude protein content of the 16 samples and their mean values are shown in Table 2. The major minerals in the mulberry leaves were K (2.494 g/100 g DW), P (2.255 g/100 g), and Ca (1.835 g/100 g), and minor ones were Mg (0.627 g/100 g), Na (0.0298 g/100 g), and Fe (0.0245 g/100 g). Kim (1999) reported 3.101 g of K, 2.699 g of Ca, and 0.044 g of Fe per100 g of dry matter and Lee *et al.* (1999) also reported 3.800 g of K, 0.45 g of Ca, and 0.0131 g of Fe per 100 g of dry matter in the mulberry leaves. Considering these reports, mineral contents were overall lower than those of others, even though some samples showed higher level of mineral content (Table 2).

Table 3 shows mineral content in mulberry leaves, powdery green tea, and spinach, adopted from Food Composition Table excluding data on the mulberry leaves (1996). Mulberry leaves contained 4-fold more calcium than spinach (1.835 g vs. 0.448 g) and 19-fold more calcium than powdery green tea (1.835 g vs. 0.095 g), confirming that mulberry leaves are a high calcium-containing food. In case of potassium, spinach contained significantly high amount than both mulberry leaves and powdery green tea (6.197 g vs. 2.494 g and 1.528 g), but it was slightly higher in mulberry leaves than powdery green tea. Mulberry leaves also contained relatively abundant amount of iron than powdery green tea, although the level was similar between mulberry leaves and spinach (Table 3).

Variation in mineral content in the regional mulberry leaves

Comparison of mineral content in the Cheongilppong mulberry leaves collected from Youngchun City (SN 3), Sunchon City (SN 5), and Suwon (SN 9) showed that Suwon sample was highest in potassium, phosphorus, and iron (2.962 g, 3.927 g, and 0.0325 g, respectively) and calcium were highest in the Youngchun City sample (2.477 g) (Table 4).

In the comparison of geographic samples of YK209, Jinju-City sample (SN 4) contained the highest amount of K, Ca and Mg (2.768 g, 1.509 g, and 0.417 g, respectively) (Table 5). However, Fe and P content were highest in the Yanggu-gun sample (SN 1) (0.0575 g and 3.927 g, respectively), showing variable mineral content depending on geographic location of the samples even in an identical mulberry variety.

Table 3. Content comparison of minerals among mulberry leaves, green tea, and spinach (g/100 g, DW)

Minerals	Mulberry leaves*	Powdery green tea**	Spinach***
Crude ash	12.7	5.88	11.5
K	2.494	1.528	6.198
P	2.255	0.515	0.104
Ca	1.835	0.095	0.448
Mg	0.627	NA	0.729
Na	0.0298	0.0032	0.7500
Fe	0.0245	0.0073	0.0260
Mn	0.0088	NA	0.0000
Cu	0.0007	NA	0.0019
Zn	0.0026	NA	0.0083
Crude protein	2.563	34.66	29.17

NA, not available.
*The values listed are mean values of 16 samples adapted from Table 1.
**The data were adopted from Food composition table: 5th revision, published by National Rural Living Science Institute, RDA, Korea (1996). Because the original values in the table were based on 95.2% of dry matter (4.8% of moisture), they were converted into g/100 g, DW, using the equation, the value =(A×100)÷95.2, where A is the value at the 95.2% of dry matter.
***The spinach was cultivated in the vinyl house, and the data were adopted from Food composition table: 5th revision, published by National Rural Living Science Institute, RDA, Korea (1996). Because the original values in the table were based on 9.6% of dry matter (90.4% of moisture), they were converted into g/100 g, DW, using the equation, the value=(A×100)÷9.6, where A is the value at the 9.6% of dry matter.

Table 4. Content variation of minerals in Cheongilppong leaves collected at three localities in Korea (g/100 g, DW)

Minerals	3. Yeongchun City	5. Sunchon City	9. Suwon	Mean
Crude ash	10.0	10.0	12.0	10.7
K	2.408	2.224	2.962	2.531
P	0.183	0.484	3.927	1.531
Ca	2.477	1.971	1.716	2.055
Mg	0.902	0.717	0.560	0.726
Na	0.0260	0.0295	0.0360	0.0305
Fe	0.0320	0.0210	0.0325	0.0285
Mn	0.0130	0.0195	0.0070	0.0132
Cu	0.0025	0.0002	0.0000	0.0009
Zn	0.0025	0.0065	0.0015	0.0035
Crude protein	3.475	1.845	1.425	2.248

Table 5. Content variation of minerals in YK209 leaves collected at three localities in Korea (g/100 g, DW)

Minerals	1. Yanggu-gun	4. Jinju City	12. Suwon	Mean
Crude ash	11.5	9.50	12.5	11.2
K	2.527	2.768	1.542	2.279
P	3.927	3.613	2.696	3.411
Ca	1.380	1.509	1.065	1.318
Mg	0.379	0.417	0.538	0.445
Na	0.0285	0.0280	0.0505	0.0357
Fe	0.0575	0.0180	0.0245	0.0333
Mn	0.0100	0.0065	0.0060	0.0075
Cu	0.0060	0.0010	0.0000	0.0023
Zn	0.0050	0.0010	0.0070	0.0043
Crude protein	3.170	5.825	1.610	3.535

Table 6. Content variation of mineral in the wild mulberry leaves collected at four localities in Korea and Japan (g/100 g, DW)

Minerals	2. Shitomi Town, Tsushima	6. Ara-dong, Cheju City	7. Bongke-dong, Cheju City	16. Mitsushima Town, Tsushima	Mean
Crude ash	19.5	13.5	18.0	10.0	15.3
K	2.287	1.951	3.865	2.906	2.752
P	0.746	1.414	0.602	2.186	1.237
Ca	1.516	2.701	1.705	2.948	2.218
Mg	0.323	0.674	0.659	0.410	0.517
Na	0.0200	0.0280	0.0340	0.0225	0.0261
Fe	0.0380	0.0250	0.0275	0.0160	0.0266
Mn	0.0075	0.0110	0.0075	0.0085	0.0086
Cu	0.0015	0.0000	0.0000	0.0000	0.0003
Zn	0.0015	0.0020	0.0035	0.0010	0.0020
Crude protein	2.625	1.880	1.375	2.225	2.026

In the wild mulberry leaves, Bongke-dong sample in Cheju Island (SN 7) contained the highest amount of potassium in all 16 samples used in this study (3.865 g) (Table 6). Mitshshima town sample (SN 16) was highest in the calcium and phosphorus content (2.948 g and 2.186 g, respectively). This calcium level was also highest in all samples used in this study (Table 6). When mean estimates of K, P, and Ca content of the four wild mulberry samples (2.752 g, 1.237 g, and 2.218 g, respectively) were compared with those of total samples (2.494 g, 2,255 and 1.835 g, respectively), it was obvious that wild mulberry leaves contain substantially more K and Ca than average mulberry leaves (0.268 g/100 g, DW, in K and 0.383 g/100 g, DW, in Ca), although the content was somewhat lower in P content (Tables 2 and 6).

To further confirm whether wild mulberry leaves contain more minerals than cultivated ones or not, statistical analysis was performed (Table 7) after the wild mulberry leaf samples collected from Cheju Island and Tsushima (SNs 2, 6, 7, and 16) were grouped as one, geographic

Table 7. Comparison of mineral content among geographic mulberry leaf samples of Cheongilppong, YK209 and wild mulberry (g/100 g, DW)

Samples	Crude ash	K	P	Ca	Mg	Na	Fe	Mn	Cu	Zn	Crude protein
Cheongil											
3	10.0	2.408	0.183	2.477	0.902	0.0260	0.0320	0.0130	0.0025	0.0025	3.475
5	10.0	2.224	0.484	1.971	0.717	0.0295	0.0210	0.0195	0.0002	0.0065	1.845
9	12.0	2.962	3.927	1.716	0.560	0.0360	0.0325	0.0070	0.0000	0.0015	1.425
Mean	10.7[a]	2.531[a]	1.531[a]	2.055[a]	0.726[a]	0.0305[a]	0.0285[a]	0.0132[a]	0.0009[a]	0.0035[a]	2.248[a]
YK209											
1	11.5	2.527	3.927	1.38	0.379	0.0285	0.0575	0.0100	0.0060	0.0050	3.170
4	9.50	2.768	3.613	1.509	0.417	0.0280	0.0180	0.0065	0.0010	0.0010	5.825
12	12.5	1.542	2.696	1.065	0.538	0.0505	0.0245	0.0060	0.0000	0.0070	1.610
Mean	11.2[a]	2.279[a]	3.412[a]	1.318[a]	0.445[a]	0.0357[a]	0.0333[a]	0.0075[a]	0.0023[a]	0.0043[a]	3.535[a]
Wild mulberry											
2	19.5	2.287	0.746	1.516	0.323	0.0200	0.0380	0.0075	0.0015	0.0015	2.625
6	13.5	1.951	1.414	2.701	0.674	0.0280	0.0250	0.0110	0.0000	0.0020	1.880
7	18.0	3.865	0.602	1.705	0.659	0.0340	0.0275	0.0075	0.0000	0.0035	1.375
16	10.0	2.906	2.186	2.948	0.410	0.0225	0.0160	0.0085	0.0000	0.0010	2.225
Mean	15.3[a]	2.752[a]	1.237[a]	2.218[a]	0.517[a]	0.0261[a]	0.0266[a]	0.0086[a]	0.0004[a]	0.0020[a]	2.026[a]

Means with different superscripts indicate significant difference at the level of $p<0.05$.

samples of Cheongilppong as another (SNs 3, 5, and 9), and YK209 samples as the other (SNs 1, 4, and 12). Although wild mulberry leaves were higher in the K and Ca, the estimates were not statistically significant at the level of $p<0.05$. Although it is not equivalent, higher content of GABA in the wild mulberry rather than cultivated ones also was reported for mulberry fruit, syncarp, collected in the field of Hwengsung in Kangwon Province (Kim *et al.*, 1999), rendering to pay attention to wild mulberry. Generally speaking, difference in mineral composition is expected according to culture area and variety, because mineral composition is known to be controlled both by genetic factor and environmental factors at the culture area (Davis *et al.*, 1984; Peterson *et al.*, 1983). Thus, our finding of somewhat high levels of some minerals are not clear whether the result was stemmed from "wildness" or environmental factors, such as high temperature and soil composition in the field of both islands. This is because, the wild mulberry leaves utilized in this study were both collected at the places of higher average annual temperature than that of any other localities (≥ 15°C). Thus, further study with a detailed scheme will provide us a better understanding on this issue.

Variation of mineral content in the varietal mulberry leaves

Mineral content among mulberry varieties planted in Suwon was analyzed (Table 8). Mulberry leaves of Keryangppong (SN 8), Cheongilppong (SN 9), Shinkwangppong (SN 10), Yongchunppong (SN 11), and YK209 (SN 12) were collected on the same day, June 19, 2000. Substantially high level of calcium was observed in Shinkwangppong and Keryangppong (3.347 g and 3.235 g, respectively), and Cheongilppong also was somewhat similar to the estimates of those varieties (2.962 g). It is noteworthy that the estimates of Shinkwangppong and Keryangppong ranked the second and third following a wild mulberry sample collected at a locality in Cheju Island (SN 7). In case of phosphorus, Cheongilppong was highest in its content (3.927 g) and this estimate was highest together with that of YK209 collected in Yanggu-gun (SN 1). In case of calcium, although Keryangppong (SN 8), Cheongilppong (SN 9), and Shinkwangppong (SN 10) showed almost similar estimates (1.743 g, 1.737 g, and 1.716 g), these were lower than the mean value of 16 samples (1.835 g). Although the varietal comparison in this study was made using the samples collected only at a time of a locality for the equivalent comparison of environmental condition, a prolonged collection over a longer period would provide a confident conclusion on the characteristics of mulberry varieties.

Variation of mineral content in the seasonal mulberry leaves

Seasonal mineral content in the Cheongilppong mulberry leaves collected in Suwon is shown in Table 9. In case of the mulberry leaves collected before summer pruning, most minerals were higher in the June sample than those of the May sample. This may suggest that mineral content increase with an initiation of leaf formation on May. In a comparison between May and June samples, overall mineral content was increased in the June sample. For example, potassium content was increased from 2.692 g in June to 2.795 g in July and calcium content was increased from 1.717 g in June to 1.812 g in July. However, calcium content still increased to 2.592 g in August, although potassium content dropped sharply in August. Thus, further research with a shorter time interval may illustrate more detailed picture of mineral metabolism.

Summarized, it was evident that mulberry leaves con-

Table 8. Content variation of minerals in the mulberry leaves from several varieties (g/100 g, DW)

Minerals	8. Keryang-ppong	9. Cheongil-ppong	10. Shinkwang-ppong	11. Yongchun-ppong	12. YK209	Mean
Crude ash	32.0	12.0	16.0	5.00	12.5	15.5
K	3.235	2.962	3.347	1.480	1.542	2.513
P	3.442	3.927	2.827	3.665	2.696	3.312
Ca	1.743	1.716	1.737	1.331	1.065	1.518
Mg	0.761	0.560	0.857	0.932	0.538	0.730
Na	0.0150	0.0360	0.0300	0.0315	0.0505	0.0326
Fe	0.0290	0.0325	0.0105	0.0220	0.0245	0.0237
Mn	0.0065	0.0070	0.0070	0.0070	0.0060	0.0067
Cu	0.0000	0.0000	0.0000	0.000	0.0000	0.0000
Zn	0.0020	0.0015	0.0020	0.0020	0.0070	0.0029
Crude protein	1.550	1.425	3.500	3.470	1.610	2.311

Table 9. Content variation of minerals in Cheongilppong leaves collected at different seasons in the field of Department of Sericulture & Entomology, NIAST, Suwon, Korea (g/100 g, DW)

Minerals	13. May 31	9. June 19	14. July 20*	15. August 24*	Mean
Crude ash	7.50	12.0	1.50	14.5	8.88
K	2.441	2.692	2.795	1.168	2.274
P	2.291	3.927	2.094	1.990	2.575
Ca	1.159	1.716	1.812	2.592	1.820
Mg	0.505	0.560	0.691	0.701	0.614
Na	0.0300	0.0360	0.0350	0.0315	0.0331
Fe	0.0150	0.0325	0.0110	0.0120	0.0176
Mn	0.0065	0.0070	0.0085	0.0090	0.0078
Cu	0.0000	0.0000	0.0000	0.0000	0.0000
Zn	0.0010	0.0015	0.0015	0.0010	0.0013
Crude protein	1.490	1.425	4.100	1.440	2.114

* Samples were collected after summer pruning.

tain substantially high amount of calcium compared with green tea and spinach. Overall high calcium content was observed in the wild mulberry leaves than cultivated ones. Varietal comparison on the mineral content was variable depending on the variety, suggesting an extensive sampling over longer period may provide further obvious conclusion. In the comparison among seasonal mulberry leaves, there was a trend of increase in the mineral content as weather gets warmer, but an experiment with shorter interval is required. Because the major purpose of this study was focused to utilize the result for the basis of further analysis, aiming to understand the regional, varietal and seasonal variation of the mineral content, not much detailed information is available at this point. Nevertheless, we hope this study would provide a direction for further mineral research.

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