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Some Trace Metals and their Ratios in Aloe (*Aloe vera* L.), Cucumber (*Cucumis sativus* L. var. *tuberculatus* Gabaj.) and Sponge-gourd (*Luffa cylindrica* L.) in Korea

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Abstract - Aloe (*Aloe vera* L.), cucumber (*Cucumis sativus* L. var. *tuberculatus* Gabaj.) and sponge-gourd (*Luffa cylindrica* L.) are well utilized in Asian countries as traditional medicines and cosmetics, or foods. And we carried out an experiment to see if there are some specific ratios among trace metals on the plants. Though the metal concentrations varied significantly depending on the sampling periods, aloe gel is high in iron (Fe) and calcium (Ca). Cucumber fruit juice is also high in iron (Fe) and potassium (K). Sponge-gourd sap contains a high amount of zinc (Zn) and calcium (Ca). The uses of the previous 3 plant parts are considered to have some relations to their different ratios and of their trace metals.

Key words - Fe/Zn, Iron, Manganese, Metals' ratio, Zinc, Zn/Mn

Introduction

Sponge-gourd (*Luffa cylindrica* L.) is well cultivated at home garden in Korea. And aloe (*Aloe vera* L.), cucumber (*Cucumis sativus* L. var. *tuberculatus* Gabaj.) and sponge-gourd are well utilized in Asian countries as traditional medicines and cosmetics, or foods (Schilling and Heiser, 1981). Aloe, known to have all-around healing property (Gjerstad and Riner, 1968; Bouchey and Gjerstad, 1969; Chang *et al*., 1993), sap and fruit juices of cucumber, and sponge-gourd have been used as sources of bio-cosmetics, health food, and folk medicines for asthma(Izawa, 1981). Effects of plant medicinal components might come from the interaction with metal components of the plants (Nakagomi *et al*., 1987).

Therefore, it is very interesting to know the composition of the metal elements. However, at the same time, the composition may differ from plants to plants, if they are raised under different soil and climate conditions (Park *et al*., 1996), and it will vary according to the sampling sites (Okusanya, 1983), and will not be stable with some analytical problems for the trace metals (Park *et al*., 2008). Until now a lot of studies on these useful components have been performed (Gjerstad and Riner, 1968; Bouchey and Gjerstad, 1969; Schilling and Heiser, 1981). But there is few on the ratios of trace metal concentrations of the above mentioned plants (Park *et al*., 1996).

We thought that the characteristic ratios of the trace metals have some relation to their usefulness of the previous 3 plant parts, and we carried out an experiment if there are some specific ratios among trace metals on the plants. The main objective of this study is to find out the relation among trace metals in the three types of plants: aloe, cucumber, and sponge-gourd. In Republic of Korea, aloe, cucumber, and sponge-gourd are usable for good effect on human health. Authors are interested to investigate "Are there ratios among some trace metals in such plants for the human health?", and to know from the present research "Which is more important,

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the higher metal contents itself or their ratio among the trace metal contents?" Besides we want to know whether the ratio itself changed between the growing seasons for some trace metals.

Materials and Methods

Aloe and sponge-gourd samples were prepared based on the methods of Chang *et al*. (1993). Sap sample of the cucumber was collected on September 16, 1991, and juice from the immature cucumber was taken two times, and they were kept at a low temperature or frozen for using as samples. Sponge-gourd plants were sampled twice each for the sap collection and the juice extraction for analysis. The first sap was collected by cutting the stem 15 days before the fruit harvest (October 24, 1991), and the second sap sampling was done 5 days after the harvest. For sampling the first fruit juice of the sponge-gourd plant, unripe fruits were pressed 15-30 days before harvest. Second fruit juice sample was collected by pressing the unripe fruit 5 days after the harvest.

Two hundred milligrams each of aloe parts and 10 ml each of sap and fruit juice of cucumber and sponge-gourd were used for potassium (K), calcium (Ca), and magnesium (Mg) analyses based on the atomic absorption spectrophotometric method (Baird, model Alpha-4, United Kingdom(UK)). Concentrations of iron (Fe), manganese (Mn), zinc (Zn), and copper (Cu) were determined using an another atomic absorption spectrophotometer (Varian, model Spectr AA-30)(*Norin Suisan-sho*, 1979).

Results

Metal concentrations of gel and skin parts of aloe plant

Table 1 shows the metal composition of aloe aged over 4 years old. On a dry matter basis, Fe, Mn, and Cu contents of the gel part were 2-fold higher than those of the skin parts. Potassium content of the skin part was two fold higher than those of gel part. The amounts of major and trace metals are Ca>K>Mg and Fe>Mn>Zn>Cu, respectively.

Metal concentrations in sap and fruit juice of the cucumber plant

Table 2 shows the metal compositions of sap and fruit juice of cucumber. Though other metals' concentrations differed, the value of Mg concentration was similar both in the sap and the fruit juice. Calcium concentration of the sap was two- to four fold higher than that of the fruit juice, while K concentration of the fruit juice was nearly tenfold higher than that of the plant sap.

Higher concentrations of Fe, Mn, Zn, and Cu were found in the fruit juice than in the sap of cucumber plant. Among the trace metals in the fruit juice of the plant concentrations of Fe and Mn tended to be higher in the first sampling period, while those of Zn and Cu did *vice versa*. And this tendency is similar to that of fruit juice of sponge-gourd plant (Table 3). From Table 2, the metal orders in the cucumber fruit juice were

Table 1. Metal composition of aloe (*Aloe vera* L.) [1] (mg/g DW [2])

Plant Part	K	Ca	Mg	Fe	Mn	Zn	Cu
Gel	21.4	142.0	9.6	2.08	0.46	0.09	0.02
Skin	39.1	101.0	7.1	0.94	0.13	0.06	0.01

[1] dried at the temperature of 80℃,
[2] dry matter basis.

Table 2. Metal composition in sap and fruit juice of cucumber (*Cucumis sativus L.* var. *tuberculatus* Gabaj.) (mg / L)

Plant Part	Period	K	Ca	Mg	Fe	Mn	Zn	Cu
Sap		152	339	114	3.8	0.8	1.4	0.4
Fruit juice	1st	1380	84	119	11.7	1.9	3.2	0.7
Fruit juice	2nd	2030	169	167	8.0	1.2	3.6	0.8

Table 3. Metal concentration in sap and in fruit juice of sponge-gourd (*Luffa cylindrica* L.) (mg / L)

Plant Part	Period	K	Ca	Mg	Fe	Mn	Zn	Cu
Sap	1st	19	232	15	0.9	0.2	1.0	0.2
Sap	2nd	15	20	16	1.9	0.4	1.7	0.2
Fruit juice	1st	1350	180	110	5.8	9.0	2.2	0.3
Fruit juice	2nd	960	84	94	3.6	1.9	3.2	0.6

K>Mg~Ca and Fe>Zn>Mn>Cu, respectively.

Metal concentrations of sap and fruit juice of sponge-gourd

Table 3 shows the metal concentrations of sap and fruit juice of sponge-gourd. Magnesium concentration in the sap of sponge-gourd was similar to that of K, but lower than Ca. The concentration of Ca was the highest among the metals in the sap of sponge-gourd. This tended similarly to the result in cucumber sap as shown previously (Table 2). And the element Ca seemed to be an important factor in the case of sponge-gourd sap. However, significant variation was observed in Ca concentration between the two sampling dates. Calcium concentration of the sap from the first sampling was ten fold higher than that from the second sampling. Potassium concentration of the fruit juice was the highest among the metals, and was 60-fold higher than that of the sap. This tendency is also similar to the result of cucumber fruit juice (Table 2).

From Table 3, the order of trace metals in the sap of sponge-gourd was Fe~Zn>Mn>Cu. The order in the fruit juice of sponge-gourd was Fe~Mn>Zn>Cu on the basis of the mean value. The amount of Mn and Zn content was much different between the sap and the fruit juice of the plant.

In detail, the Mn concentration, 9.0 (the first sampling), in the fruit juice was high. The concentrations of Zn and Cu in the fresh juice of the plant increased to higher values in the second sampling period, while the other elements were higher in the first period. The first sampling period was an unripe stage, even though the immature fruits were taken on all the sampling dates, and the difference of the plant maturity is considered to be a reason of the inconsistent metal concentration between the two sampling periods.

Tables 2 and 3 showed that fruit juice of cucumber had higher contents of major and trace metals (except Ca and Mn) than that of sponge-gourd in the present experiment. Cucumber sap had higher metal contents except Zn than the same part of sponge-gourd, and the concentrations of K and Mg in the cucumber sap were 7-fold higher than those in the sponge-gourd sap.

Discussion

From Table 2, it was considered in cucumber and in sponge-gourd plants that there were an antagonism between K and Ca contents (Foth, 1978). In Table 2, the Ca, K, and Mg contents of cucumber fruit juice in the second period were higher than those in the first period. This trend was similar with that of Iwahashi *et al*. (1982) who have reported that Ca accumulated steadily in cucumber plant during the whole experimental period, while it was opposite to the result of sponge-gourd fruit juice as was shown in Table 3. From Table 3, the concentrations of Fe, Mn, and Zn were higher in the second sampling period in the sap of sponge-gourd. Same result was obtained by Park *et al*. (1996).

Ratio of the major and trace metal compositions of aloe, cucumber and sponge-gourd

Table 4 shows the ratio of the major and trace metal components of aloe, cucumber, and sponge-gourd per Mg and Zn, respectively. Through Tables 1, 2 and 3, Mg concentration was comparatively stable and lower than Ca or K concentrations, and it was utilized as a basis for comparing the major metal contents in the table.

Aloe gel, cucumber fruit juice, and sponge-gourd sap are known to be useful for human being's health. Shimazu H. (2006) reported that all foods have a unique finger print. Several metals concentrations differed and therefore they might be fingerprints of the three plants.

At first for major metals, the Ca ratio in aloe gel, K in cucumber fruit juice, and Ca in sponge-gourd sap per Mg was the highest with the value of 14.7, 11.9, and 8.4, respectively. The aloe gel has a higher Ca/Mg ratio of 14.7 with a lower K/Mg value of 2.2, and in the plant Ca might act a more important effect among the major metals. The trend in the cucumber fruit juice was opposite to that of the aloe plant; higher value was K/Mg of 11.9 with a lower Ca/Mg value of 0.88. Result showed that K had an important role. And the ratio of Ca/Mg of sponge-gourd sap was 8.4. On the other hand for the trace metals, the ratio in aloe gel was 23.1 Fe and 5.1 Mn per Zn. And the ratio of sponge-gourd sap 0.23 Mn, it means that the value of Zn/Mn is larger than 4. And it can be said that Fe and Mn seemed to be important for aloe, and Zn for sponge-gourd sap, respectively.

Characteristics of metals composition of aloe, cucumber and sponge-gourd

Table 5 shows the ratios of K/Mg (or Ca/Mg) and Zn/Mn of cucumber and sponge-gourd plants depending on sampling period. The value of Zn/Mn in this table is controversial figure to that Mn/Zn shown in the previous Table 4.

The Zn/Mn ratio varied significantly on a different period in cucumber plant, while Ca/Mg did in sponge-gourd plant. Here, the value of its sap was 15.4 on the first period, and Zn/Mn for cucumber fruit- juice was larger on the second sampling period, and the value was 3.0. It can be said that the Ca in sponge-gourd sap was effective on an earlier period, and that Zn in cucumber fruit- juice did on a later period. Therefore, it might be said that Zn is effective for cucumber plant and that Ca is effective for sponge-gourd sap.

As a result, it is concluded that aloe gel contains very high Fe/Zn, high Ca/Mg, and high Mn/Zn; cucumber fruit juice does very high K/Mg and high Zn/Mn depending on sampling period; and sponge-gourd sap does very high Zn/Mn and high Ca/Mg depending on period.

Calcium is poorly absorbed in the human intestinal tract, and the rate of Fe absorption is extremely slow (Guyton, 1981). Due to high Ca concentration ratios among the major metals in aloe gel and in the sap of sponge-gourd and high Fe

Table 4. Ratio of major and trace metal components of aloe (*Aloe vera* L.), cucumber (*Cucumis sativus* L. var. *tuberculatus* Gabaj.) and sponge-gourd (*Luffa cylindrica* L.) per magnesium and zinc, respectively

Species	Plant part	K/Mg	Ca/Mg	Fe/Zn	Mn/Zn	Cu/Zn
Aloe	Gel	2.2	14.7	23.1	5.1	0.22
Aloe	Skin	5.5	14.2	15.6	2.1	0.16
Cucumber	Sap	1.3	2.9	2.7	0.57	0.28
Cucumber	Fruit juice	11.9	0.88	2.8	0.44	0.20
Sponge-gourd	Sap	1.1	8.4 [1)]	1.0	0.23	0.15
Sponge-gourd	Fruit juice	11.3	1.2	1.7	2.0	0.14

[1)] between the two sampling dates, there was a big difference in Ca concentrations around 10 times.

Table 5. The ratios of K/Mg (or Ca/Mg) and Zn/Mn of cucumber (*Cucumis sativus* L. var. *tuberculatus* Gabaj.) and sponge-gourd (*Luffa cylindrica* L.) plants depending on sampling period [1)]

Sampling Period	Cucumber Plant Part	K/Mg	Zn/Mn
1st	Fruit juice	**11.5**	1.6
2nd	Fruit juice	**12.1**	**3.0**
Sampling Period	**Sponge-gourd Plant Part**	**Ca/Mg**	**Zn/Mn**
1st	Sap	**15.4**	**5.0**
2nd	Sap	1.2	**4.2**

[1)] The figures appeared in bold type show the meaningful values.

concentration ratio among trace ones in aloe gel (Tables 4 to 5), the two elements seem to be easily absorbed into the body. In addition, metal elements, present as metallic ions in solution, are readily absorbed in animal body (McDonald *et al*., 1985). With Zn treatment, appetite improved, taste became normal, and catch up growth occurred (Berkow *et al*., 1992), whereas manganese (Mn) is a component of several enzyme systems and is essential for normal bone structure (Berkow *et al*., 1992).

The sap of sponge-gourd exists as liquid, and aloe gel is in near liquid condition (99% of water content); therefore, the metals might have higher availability in the body. Thus, Fe, Ca and Mn in aloe gel might be absorbed by the human body at a high rate, and in cucumber fruit juice, K and Zn depending on sampling period, and also in sponge-gourd sap, Zn and Ca depending on period might be absorbed efficiently, respectively.

It is considered that aloe gel contains very high Fe/Zn, high Ca/Mg, and high Mn/Zn; cucumber fruit juice does very high K/Mg and high Zn/Mn depending on sampling period; and sponge-gourd sap does very high Zn/Mn and high Ca/Mg depending on period. It is necessary to study the different ratios of the trace metals in detail, for example, with respect to the utilization as traditional medicines and cosmetics, or foods (Schilling and Heiser, 1981).

Future study on what kind of ratio in trace metals on the different seasons will have an favorable effect (or effects) on the human health.

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Literature Cited

Berkow, R. *et al*. (Merck Research Laboratories). 1992. The Merck Manual of Diagnosis and Therapy. 16th edn: Rahway, Merck & Co., Inc.

Bouchey, G.D. and G. Gjerstad. 1969. Chemical studies of *Aloe vera* inorganic ingredients. Quart. J. Crude Drug Res., 9: 1445-1453.

Chang, K.W., J.S. Park, G.C. Jang and Y.G. Nam. 1993. Fatty and organic acids and barbaloin in various parts of Aloe species dried at different drying temperatures. J. Korean Agric. Chem. Soc., 36: 244-248.

Foth, H.D. 1978. Fundamentals of Soil Science. 6th edn: New York., John Wiley & Sons. pp. 359-375.

Gjerstad, G. and T.D. Riner. 1968. Current status of aloe as a cure all. American J. Pharmacy., 1968 (March-April): 58-64.

Guyton, A.C. 1981. Textbook of Medical Physiology. 6th edn: Philadelphia, W.B. Saunders Company. pp. 61-973.

Iwahashi, M., Y. Tachibana and Y. Ohta. 1982. Accumulation of calcium, magnesium, potassium and sodium with growth of individual leaves, petioles and stems of cucumber plants. Soil Sci. Plant Nutr., 28: 441-449.

Izawa, B. 1981. Illustrated Cyclopedia of Medicinal Plants of Japan: Tokyo (Japan), Seibundo-Shinkosha Publishing Co. (in Japanese)

McDonald, P., R. A. Edwards and J. F. D. Greenhalgh. 1985. Animal Nutrition. 3rd edn: London and New York, Longman Group Ltd. pp. 199-200.

Nakagomi, K., M. Yamamoto, H. Tanaka , N. Tomizuka, T. Masui, H. Nakazawa. 1987. Inhibition by aloenin and barbaloin of histamine release from rat peritoneal mast cells. Agric. Biol. Chem., 51: 1723-1724.

Norin Suisan-sho, *Nosan-ka* (Japanese ministry of agriculture, fishery and forest, Division of agricultural products). 1979. Analytical methods of soil, water and crop on the fundamental survey of soil environment. *Dojohozen Chosa Jigyo Zenkoku Kyogikai*. (in Japanese)

Okusanya, O.T. 1983. The mineral nutrition of *Luffa aegyptica*. Can. J. Bot., 61: 2124-2132.

Park, B.H., I.S. Choi, E.Y. Kim, E.M. Lee, H.J. Lee, S.C. Lee, J.W. Park, S.M. Yoo and S.A. Kim. 2008. Effect of water treatment Sludge (WTS) on trace metals content in Sorghum

(*Sorghum bicolor* (L.) Moench). II. Measuring of nickel content of the forage. J. Kor. Grassl. Forage Sci., 28: 19-28.

Park, J.S., K.W. Chang and J.I. Lee. 1996. Inorganic components and some physical properties of sap from sponge-gourd (*Luffa cylindrica* L.) as affected by collection time. Agricultural Chemistry and Biotechnology, 39: 67-69. (in Korean)

Schilling, E.E. and C.B. Heiser Jr. 1981. Flavonoids and the systematics of Luffa. Biochemical Systematics and Ecology, 9: 263-265.

Shimazu, H. 2006. Japanese introduce mechanical sommelier. In: Seoul, 4 September 2006, The Korea Herald (Newspaper), p. 9.

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