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Chemical Composition of Petals of *Chrysanthemum* spp.

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Abstract

Chemical compositions of petals of *Chrysanthemum* spp. were determined to renew its interest as a food material. The moisture contents of wild *Chrysanthemum boreale* and holticulturized *Chrysanthemum morifolium* were 11.7% and 11.0%. The proximate chemical compositions were 6.1% and 11.7% in protein, 3.7% and 5.2% in ash, 11.1% and 12.8% in reducing sugar, of *C. boreale* and *C. morifolium*, respectively. Free sugars were mainly composed of fructose, glucose and sucrose. In fatty acid composition, the ratios of saturated to unsaturated fatty acids were 1.2:1 and 3.0:1, respectively. The amino acids determined were found 0.18 and 0.26 in the ratio of essential to total amino acids in each sample. Major elements of Chrysanthemum petals were Ca, K, Fe, Mg and Na, but the contents of Ca and Fe were more than twice higher in *C. boreale* than *C. morifolium*. Major volatile flavor components were 28.22% of epi-bicyclophellandrene and 24.55% of camphor in *C. boreale*, and 14.24% of 4-methyl-1-(1-methylethyl)-3-cyclohexen-1-ol, 10.74% of camphor and 7.64% of 1,8-cineol in *C. morifolium*.

Key words: *Chrysanthemum boreale*, *Chrysanthemum morifolium*, petals, chemical constituents

INTRODUCTION

Chrysanthemum was native to China but now grown all over the world. Chrysanthemum has been used for a natural medicine or food as well as a gardening flower from the ancient times. As a kind of natural medicines and health foods. chrysanthemums are divided into two groups, wild mums(*Chrysanthemum boreale*)(1) and holticulturized mums(*Chrysanthemum morifolium*)(2). Both *Chrysanthemum* spp. have yellow petals in flowering season and the harvested petals have several uses as a flavoring material for traditional foods as well as a natural medicine. In particular, wild *Chrysanthemum boreale* is known to have several biological actions, such as central-nerve sedation. blood-pressure reduction(3), and the growth control of *Bacilli* and various viruses(4). A lot of studies were made on petals of *Chrysanthemum* spp. in terms of pharmacological aspects. Nam and Yang(5,6) reported antibacterial activity of the extract of *C. boreale* M. and isolated the substances with cytotoxic activities from *C. boreale* M. Uchio et al.(7) determined constituents of essential oils from three tetraploid species of chrysanthemum. However, few literatures are available to evaluate compositional properties of petals of *Chrysanthemum* spp.

Associated with the flower-eating culture in the oriental world, Konta(8) reviewed its history and a research trend. Teutonico and Knorr(9) indicated *Amarnath*'s value as a rediscovered food crop by reporting its composition, properities, and applications. Kwon et al.(10) reported the chemical composition of Korean acacia petals. Kwon and Yoon(11) investigated the functional properties of acacia flower protein concentrate(AFPC) and its nutritive values by comparing with other plant protein concentrates.

In this work, some chemical compositions and volatile flavor constiuents of wild and holticulturized chrysanthemum petals were determined for the purpose of renewing interest in flowers as food.

MATERIALS AND METHODS

Materials

Petals of *C. boreale* and *C. morifolium* were collected in the suburbs of Youngcheon in October 1996. Fresh petals picked immediately before the fullbloom stage, were dried in the shade and then frozen until used.

Proximate composition and reducing sugar

Proximate composition of chrysanthemum petals was determined according to standard AOAC methods(12). Measurement for reducing sugar was based upon the modified Somogyi method(13).

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Free sugars

Free sugars were extracted with 70% ethanol and analyzed by high-performance liquid chromatography (HPLC)(14). HPLC was performed by Waters 400E system equipped with a refractive index detector and Sugars-pak I column(30cm × 3.9mm) by using mobile phase made up of 50mg Ca-EDTA/1L H_2O.

Fatty acids

Fatty acid esters were obtained by methylesterification of the purified lipids using BF_3-methanol following hydrolysis by 0.5N sodium hydroxide(15) and analyzed with a gas chromatograph(GC) equipped with a flame ionization detector. Supercowax 10 column(length 60m × inside diameter 0.25mm × film thickness 0.25μm) was used for methyl ester separation. The column oven temperature was programmed linearly from 150°C(5min) to 240°C (20min) at an increasing rate of 4°C per min. Flow rate of the nitrogen carrier gas was 0.5ml per min.

Amino acids and minerals

Analyses of total amino acids were carried out after HCl hydrolysis by amino acid analyzer(16). Eight selected elements were analyzed by using atomic absorption spectrophotometer(Stectra 200 MTI, USA) following estabilished dry-digestion procedures(17).

Volatile flavor components

Volatile flavor components were extracted with simultaneous distillation extraction(SDE) apparatus. The extracts of diethyl ether were separated by Supelcowax 10 fused silica capillary column(length 60m × inside diameter 0.32mm × film thickness 0.25μm) on a Hewlett-Packard 5880 gas chromatograph equipped with a FID detector. The operating conditions of GC were as follows: oven temperature was held at 50°C for 5min, then programmed to increase at 2°C/min to 230°C and maintained for 30min. Injector and detector temperatures were 220°C and 230°C, respectively. Nitrogen carrier gas was operated at a flow rate of 1.8ml/min. Identification were carried by the condition of GC-MSD(HP5890 & HP5970, Hewlett-Packard, USA). Operation conditions were helium as a carrier gas, an ionization electron energy of 70 eV, and an ion source temperature of 220~250°C(18,19) Flavor compounds were identified by computer matching of the mass spectra with those of standardized reference compounds and by confirmation of the GC retention times.

RESULTS AND DISCUSSION

Proximate composition

Proximate chemical compositions of petals of chrysanthemums are shown in Table 1. *C. boreale* and *C. morifolium* containing about 11.7% and 11.0% of moisture showed a similar pattern in their chemical composition. Crude protein was higher in *C. morifolium*(11.7%) than in *C. boreale* (6.1%). Crude fat and crude fiber were similar each other in their contents. Crude ash contents were higher in *C. morifolium*(5.2%) than in *C. boreale*(3.7%). The results showed that petals were mainly composed of nitrogen-free extracts, 68~75% on a dry basis, which is very similar to acacia flower(10). But crude protein and ash were apparently higher in acacia(24.6%, 8.5%) than chrysanthemums(13.1%, 5.8%).

Free sugars

Free sugar contents analyzed by HPLC were given in Table 2. Free sugars of petals of *C. boreale* and *C. morifolium* were primarily composed of fructose (43.41mg/g, 17.43mg/g), glucose(9.50mg/g, 4.59mg/g) and sucrose(2.42mg/g, 5.26 mg/g). This compositional profile of petals of chrysanthemums was a little different from those of acacia petals(10) and chestnut flower(20), that were the highest in fructose, followed by sucrose and glucose in the former, and sucrose, fructose and glucose in the latter, respectively.

Table 2. Free sugar composition of chrysanthemum petals(mg/g, dry basis)

Sample	Fructose	Glucose	Sucrose	Fructose/Glucose
C. boreale	43.41	9.50	2.42	4.57
C. morifolum	17.43	4.59	5.26	3.79

Table 1. Proximate composition of chrysanthemum petals (unit : %)

Sample	Moisture	Crude protein	Crude fat	Crude ash	Reducing sugar	Crude fiber	N[1)]
C. boreale	11.7	6.1	2.7	3.7	11.1	9.8	66.0
C. morifolium	11.0	11.7	2.6	5.2	12.8	9.1	60.4

[1)]Nitrogen free extracts

Table 3. Fatty acid composition of chrysanthemum petals (unit : rel.%[1)])

Fatty acids	*Chrysanthemum boreale*	*Chrysanthemum morifolium*
$C_{12:0}$	0.20	0.91
$C_{14:0}$	1.76	10.91
$C_{14:1}$	0.52	0.19
$C_{16:0}$	17.40	44.36
$C_{16:1}$	0.37	0.61
$C_{17:0}$	4.01	0.66
$C_{18:0}$	4.51	10.12
$C_{18:1}$	11.93	10.33
$C_{18:2}$	23.22	8.99
$C_{18:3}$	8.00	4.43
$C_{20:0}$	1.69	0.79
$C_{20:1}$	0.30	2.27
$C_{22:0}$	23.98	5.03
$C_{22:2}$	2.11	0.40
TSFA[2)]	53.55	75.05
TUFA[3)]	46.45	24.95

[1)]Relative %
[2)]Total saturated fatty acids
[3)]Total unsaturated fatty acids

Table 4. Total amino acid of chrysanthemum petals (unit : g/100g, dry basis)

Amino acids	*Chrysanthemum boreale*	*Chrysanthemum morifolium*
Isoleucine	0.9	2.5
Leucine	2.3	6.9
Lysine	2.4	2.5
Methionine	0.5	0.9
Phenylalanine	1.2	2.0
Threonine	1.6	1.8
Valine	0	6.0
Aspartic acid	3.7	7.4
Serine	2.0	1.5
Glutamic acid	3.9	5.1
Proline	19.8	38.8
Glycine	5.2	1.1
Alanine	1.5	3.9
Cystine	0	2.3
Tyrosine	0.7	1.8
Histidine	0.8	0.9
Arginine	0.3	0.3
Total amino acid	46.8	87.7
Total essential amino acid	8.9	22.6

Fatty acids

Percent compositions of fourteen different fatty acids were given in Table 3. The major fatty acids in *C. boreale* were behenic acid(23.98%), linoleic acid(23.22%), palmitic acid(17.40%) and oleic acid(11.93%), while *C. morifolium* contained palmitic acid(44.36%), myristic acid (10.91%), oleic acid(10.33%) and stearic acid(10.12%). The ratios of unsaturated to saturated fatty acids were remarkably different between both samples, 0.87 in *C. boreale* and 0.33 in *C. morifolium*. The compositional profile of fatty acids was similar to that of acacia petals which had palmitic acid(44.4%) and linoleic acid(19.3%) from the results of Kwon et al.(10).

Amino acids

Eighteen amino acids were determined for petals of chrysanthemums and their contents are presented in Table 4. Major amino acids were proline(19.8mg/g), glycine (5.2mg/g), glutamic acid(3.9mg/g) and aspartic acid(3.7mg /g) in *C. boreale*, while proline(28.8mg/g), aspartic acid (5.4mg/g), leucine(4.9mg/g) and glutamic acid(3.9mg/g) were focused in *C. morifolium*. These findings were generally different from the results of the amino acid profile of AFPC reported by Kwon and Yoon(11), and also different from major amino acids in the postbloomed chestnut flower(20) that were mainly contained aspartic acid and glutamic acid.

Minerals

Table 5 represents the mineral composition of petals of chrysanthemum. Major elements of petals of chrysanthemums were Ca(558.9mg/g), K(67.7mg/g), Fe(44.5mg/g), Mg(15.7mg/g) and Na(14.3mg/g), but the contents of Ca(242.7mg/g) and Fe(13.7mg/g) were more than twice higher in *C. boreale* than *C. morifolium*. This tendency was similar to the mineral compositions of acacia flower by Kwon and Yoon(11). Chang et al.(21) reported that calcium, magnesium and phosphorus were found in high concentration than iron, copper, zinc and manganes in acacia honey and chesnut honey. Chestnut honey had a greater quantity of minerals than acacia honey, with a lower value of sodium/potassium ratio.

Table 5. Mineral composition of chrysanthemum petals (unit : mg/g, dry basis)

Sample	K	Ca	Na	Mg	Zn	Mn	Fe	Cu
C. boreale	67.72	558.90	14.28	15.69	3.69	2.19	44.51	1.28
C. morifolium	64.64	242.68	19.68	17.56	8.24	3.24	13.72	1.41

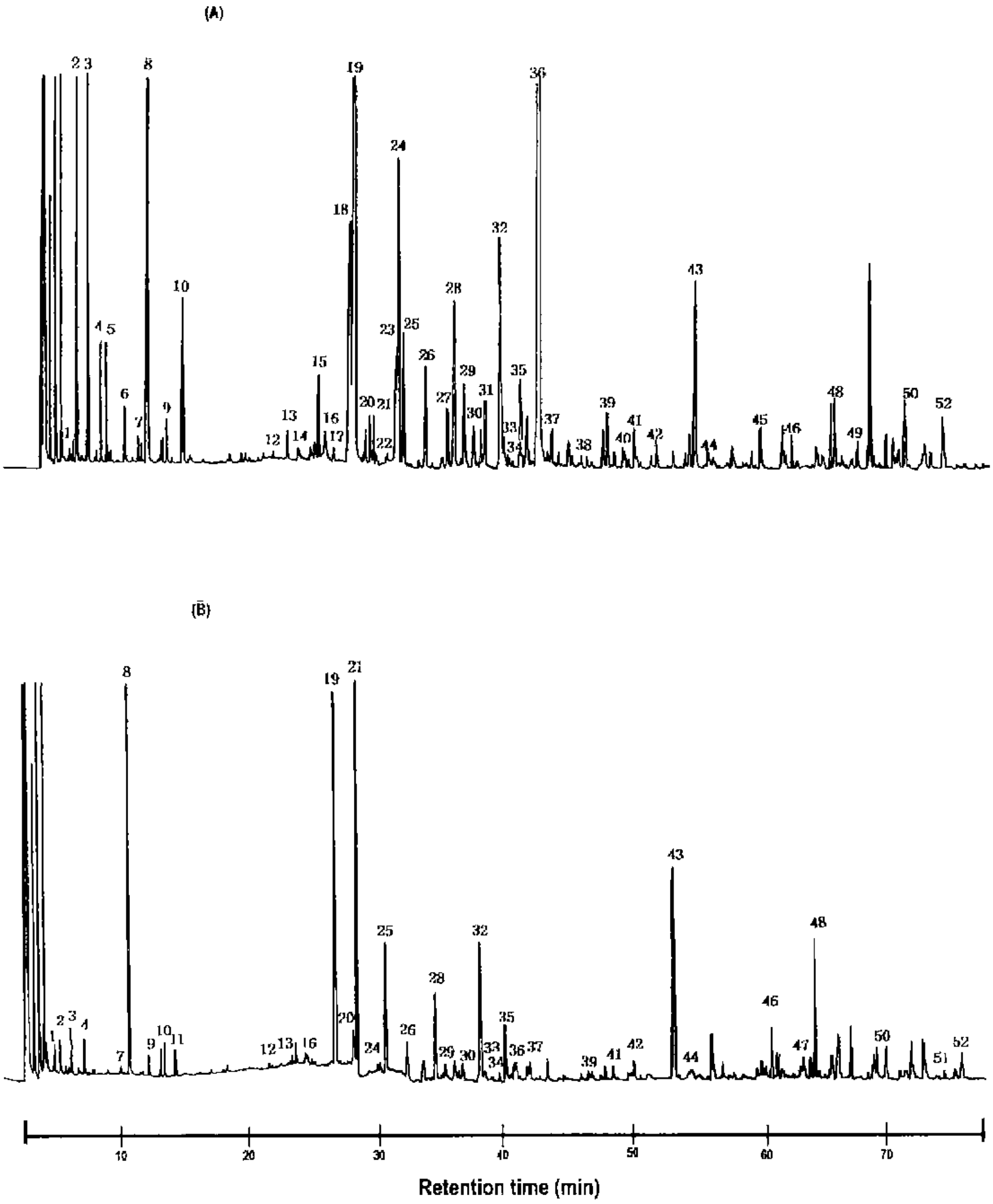

Fig. 1. GC chromatograms of volatile compounds in petals of *Chrysanthumum boreale*(A) and *Chrysanthumum morifolium*(B).

Volatile flavor components

The GC profiles of volatile compounds are illustrated in Fig. 1. Table 6 summarizes the composition of identified volatile components. Identification was accomplished by comparing the mass spectra of their components with the published mass spectral data, and their GC retention time with authentic samples(18,19). GC chromatogram(A) showed 31 individual compound peaks in *C. boreale*, which were mainly composed of epi- bicyclophellandren(28.22%), camphor(24.55%) and 1,8-cineol(4.04%). On the other hand, 26 peaks were identified in *C. morifolium*, showing the major volatile components such as 4-methyl-1-(1-methylethyl)-3-cyclohexen-1-ol(14.2%), camphor(10.74%) and 1,8-cineol(7.64%).

In the study on volatile constituents of essential oils from *Chrysanthemum indicum*, Uchio et al.(7) reported that total monoterpenoids of germacrene-D, α-seline, myrcene, γ-cadinene and β-farnesene were relatively high in their contents, and that their characteristic flavors were sweet and floral. Also the major components

Table 6. Volatile compounds in petals of *Chrysanthumum boreale* and *Chrysanthemum morifolium*

Peak No.[1)]	Compounds	Relative peak area(%)	
		C boreale	*C. morifolium*
1	α-thujene	0.86	-[2)]
2	α-pinene	3.63	0.22
3	camphene	2.04	0 71
4	β-pinene	0.48	0.51
5	sabıne	0.53	-
6	myrcene	0.27	-
7	α-phellandrene	0.14	0 15
8	1.8-cineol	4.04	7.64
9	γ-terpinene	0 23	0 40
10	*p*-cymene	0 92	0 73
11	α-terpinene	-	0.56
12	tetradecane	0.05	0.21
13	α-thujone	0.22	0.16
14	β-thujone	0.16	-
15	α-ylangene	0.73	-
16	linalool oxıde	0 49	0 24
17	α-copaene	0.11	-
18	trans-chrysanthenyl acetate	3.25	-
19	camphor	24.55	10 74
20	β-ylangene	0 42	0.43
21	4-methyl-1-(1-methylethyl)-3 -cyclohexen-1-ol	0 21	14.23
22	β-terpıneol	0.17	-
23	β-elemene	0.72	-
24	*cıs*-chrysanthenyl acetate	2.51	0.33
25	bornyl acetate	0.93	3.58
26	myrtenal	0.77	0 94
27	aromandenarene	0.46	-
28	chrysanthenone(T)	1.32	2.42
29	pinocarveol	0.64	0.36
30	α-humulene	0.29	0 46
31	*trans*-β-farnesene	0.56	-
32	α-terpineol	2.36	4 37
33	borneol	0.36	0.49
34	heptadecane	-	0.27
35	*cis, cis*-α- farnesene	1.01	-
36	epi-bicyclophellandrene	28.22	-
37	curcumine	-	0.76
38	germacrene B	0.95	-
39	n-hexanoic acid	-	0.21
40	2-phenylethyl-2-methylbutyrate	0.16	-
41	benzyl alcohol	-	0.59
42	2-phenylethyl alcohol	-	0 48
43	caryophyllene epoxide	1.69	6.73
44	n-octanoic acid	-	0.50
45	nerolıdo	0.37	-
46	spathulenol	0.26	1.49
47	guaiol	0.51	0.55
48	carvacrol	0.54	3.33
49	docosane	0.10	-
50	tricosane	0.63	0 98
51	tetracosane	-	0.26
52	pentacosane	0 26	1 22

[1)]Peak number refers to Fig. 1
[2)]Not detected

in flower and leaves of *C. indicum* were known to be composed of terpene compounds like cucubene, elemene, iperitone and cymene. These findings were a little different from the result on the constituents of essential oils from three tetraploid species of chrysanthemums(7).

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