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Compositional Properties of Mulberry (*Morus bombycis* Koids) Fruit and Mulberry Leaf

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뽕나무(*Morus bombycis* Koids)의 오디와 잎의 조성 특성

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국문요약

오디와 뽕잎을 이용하여 새로운 건강기능성 식품을 개발하기 위하여 전라남도 화순군에서 생산되고 동결건조된 원료의 영양성분들과 항산화활성을 분석, 비교하였다. 오디는 7.70%의 수분, 2.58%의 조지방, 6.55%의 단백질, 1.32%의 회분, 30.39%의 식이섬유를 포함한 81.50%의 당질을 함유하고 있었다. 한편, 뽕잎은 수분 5.86%, 조지방 1.62%, 단백질 18.74%, 회분 6.90%, 그리고 43.29%의 식이섬유를 포함한 66.88%의 당질을 함유하는 것으로 분석되었다. 오디는 100 g 당 387.0 mg의 Ca, 153.3 mg의 Mg, 1,344.0 mg의 K, 4.0 mg의 Fe, 1.7 mg의 Zn, 5.5 mg의 Mn, 1.3 mg의 Na, 0.4 mg의 Cu와 274.2 mg의 P를 각각 함유하고 있었다. 한편, 뽕잎은 100 g 당 Ca 1698.0 mg, Mg 314.8 mg, K 1896.0 mg, Fe 10.0 mg, Zn 7.0 mg, Mn 6.6 mg, Na 3.2 mg, Cu 3.0 mg 그리고 P 369.8 mg을 각각 함유하는 것으로 분석되었다. 오디 100 g 당 주요 유기산 함량은 10.87 g의 구연산, 2.29 g의 사과산, 그리고 1.09 g의 호박산 등이었으며 뽕잎 100 g 중에는 구연산 0.32 g, 사과산 0.11 g, 그리고 호박산

0.07 g으로 분석되었다. 항산화활성은 오디의 경우 68.21%이었고, 뽕잎의 경우에는 58.69%로 나타났다. 시료 g 당 총 페놀함량은 오디에서 8.48 mg이었고, 뽕잎에서는 4.56 mg으로 분석되었다.

Key words : mulberry fruit(오디), mulberry leaf(뽕잎), compositional property(조성특성)

Ⅰ. Introduction

Mulberry fruit (*Morus bombycis* Koids) and mulberry tree leaf have been used as traditional medicine and food since B. C 200 years (1). Mulberry fruit is fruit of mulberry has nutritionally significant flavonoids, which are known as antioxidant and anti-aging substances (2). Mulberry fruit contains anthocyanins with red pigment, which is used as herbal supplement against anemia, cancer, and neurological diseases. Mulberry fruit is applied for making jam, wine, juice, beverage, and other food products (3, 4). Mulberry fruit also contains anti-bacterial such as albafuran and anti-inflammatory material as bergapten, anti-diabetic and antioxidant cyaniding-3-glucoside (5-7). Mulberry leaf contains protein, vitamin, minerals, fibers, flavones, steroids and triterpenes and shows various functional properties (8, 9). Mulberry leaves have been applied to treat for anti-diabetics, anti-hyperlipidemia, antioxidant, and anti-heavy metals as well (7, 10-13). The blood sugar reducing 1-deoxynojirimycin (DNJ), the blood pressure reducing gamma-aminobutyric acid (GABA) and the antioxidant flavonoids are known as biological active substances (8). Mulberry leaves are as the sole food source of the silkworm, the pupa or cocoon of which is used to make silk (3).

In this study, we tried to make powder of mulberry fruit and mulberry leaf, and analyzed their compositional properties for using food ingredients.

Ⅱ. Materials and Methods

2.1. Materials

Good ripened mulberry fruit and fresh harvested mulberry leaf were purchased from Hwasun-Gun, Jeollanam-Do Province, Korea, mulberry farm on the beginning of June and August 2008, respectively.

Analytical-grade of hydrochloric acid (HCl), sodium hydroxide (NaOH), standard organic acids, i.e., citric acid, malic acid, succinic acid, fumaric acid, oxalic acid, lactic acid, and acetic acid were purchased from Sigma Chemical Co. (St. Louis, MO, USA).

2.2. Methods

2.2.1. Preparation of samples and measurement of composition

Mulberry fruit and mulberry leaf were dried with a freeze-dryer (Bondiro DC1316, Ilshin Lab Co, Seoul, Korea) in a frozen state under high vacuum, ground with Hanil Grinder (FM-681C, Seoul, Korea), and screened with a 50 mesh sieve.

The contents of water, carbohydrates, crude protein, crude fat, ash, and total dietary fiber of powdered mulberry fruit and mulberry leaf were analyzed by AOAC method (14).

Water content was measured with dry method at normal pressure, ash was measured by ashing in a electric oven at 550 °C, protein was measured by micro-Kjeldahl, and crude fat was analysed by Soxhlet method.

The total dietary fiber content was analysed by AOAC method (14) and calculated with the formula as follows.

Total dietary fiber level (%) = [(weight residue - weight of protein - weight of ash - weight of blank)/ weight of sample] × 100

2.2.2. Analysis of mineral and organic acid content

Mineral contents were measured by inductively coupled plasma-atomic emission spectrometer (ICP-AES) of Perkin Elmer Co. (USA).

Organic acid content was analyzed by HPLC of Shimadzu (LC-20AD, Japan). The column was Aminex® HPX-8711 300*7.8 mm of Bio-Rad (USA), mobile phase was 0.004M H_2SO_4, flow rate was 0.6 ml/min, and detector was UV (210 nm), SPD-20A. The separation column temperature was 37 ℃ and injection volume was 20 μL.

2.2.3. Measurement of 1,1-diphenyl-2-picrylhydrazyl (DPPH) free radical quenching activity of total phenolic content

Free radical quenching activity of DPPH was analyzed by the method of Blois (15). 0.8 mL of 0.4 mM DPPH was added to 0.2 mL of ethanol extracted sample and mixed for 30 sec, and then reacted in dark place for 30 min. The absorption was measured by U-2800A spectrophotometer (Hitachi, Japan) and the electron donating ability (EDA) was calculated as follows.

EDA (%) = (1-A/B) × 100

Where A is absorbance of sample at 525 nm, B is absorbance of blank at 525 nm.

Total phenol content of sample was analysed using Folin-Ciocalteu method by Gutifinger (16).

2.2.4. Statistics

All measurements were performed triplicate and calculated mean value and standard deviation. The statistical analysis was performed by SPSS package (Version 14.0) using Duncan multiple test.

Ⅲ. Results and Discussion

3.1. Composition of samples

Approximate composition of freeze-dried mulberry fruit and mulberry leaf is shown as Table 1.

The water contents of mulberry fruit powder and mulberry leaf powder were 7.70% and 5.86%, respectively. The carbohydrate contents of mulberry fruit powder and mulberry leaf powder were 81.85% and 66.88%, respectively.

The crude fat contents of mulberry fruit powder and mulberry leaf powder were 2.58% and 1.62%, respectively. The Turkish mulberry fruit contained 0.85-1.10% of fat (17). The approximate crude protein contents of mulberry fruit powder and mulberry leaf powder were 6.55% and 18.74%, respectively. It was reported that mulberry leaf has much protein second to soy (18).

Table 1. Approximate compositions of freeze-dried powder of mulberry fruit and mulberry leaf

	Mulberry fruit (%)	Mulberry leaf (%)
	values are mean±standard deviation	
Moisture	7.70±0.09	5.86±0.03
Carbohydrate	81.85±0.18	66.88±0.07
Crude fat	2.58±0.12	1.62±0.03
Crude protein	6.55±0.03	18.74±0.07
Ash	1.32±0.02	6.90±0.01
Dietary fiber	30.39±1.32	43.29±0.91

Approximate total dietary fiber contents of mulberry fruit and mulberry leaf are 30.39% and 43.29%, respectively as shown in the Table 1. The dietary fiber of mulberry leaf delays absorption of sugars in small intestine, protects rapid increasing of insulin level, absorbs and secrets toxicants in human intestine, and helps weight control and constipation (7, 10).

3.2. Mineral content

The approximate mineral contents of mulberry fruit and mulberry leaf were as shown in Table 2.

The mulberry fruit contained 387.0 mg of Ca, 153.3 mg of Mg, 1,344.0 mg of K, 4.0 mg of Fe, 1.7 mg of Zn, 5.5 mg of Mn, 1.3 mg of Na, 0.4 mg of Cu and 274.2 mg of P, respectively per 100g of sample. The mulberry leaf contained 1,698.0 mg of Ca, 314.8 mg of Mg, 1,896.0 mg of K, 10.0 mg of Fe, 7.0 mg of Zn, 6.6 mg of Mn, 3.2 mg of Na, 3.0. mg of Cu and 369.8 mg of P, respectively per 100g of sample.

The mulberry fruit showed high content of Ca, P, Mg, Mn, Fe, Zn, Na, Cu in the order, while the mulberry leaf showed high content K, Ca, P, Mg, Fe, Zn, Mn, Cu in the order. Overall, mulberry leaf contained higher quantity of minerals than mulberry fruit. Ercisli and Orhan (17) reported the different cultivars of Turkish mulberry fruits contained 139 mg of Ca, 109 mg of Mg, 1,141 mg of K, 4.3 mg of Fe, 3.1 mg of Zn, 4.0 mg of Mn, 60 mg of Na, 0.4. mg of Cu and 235 mg of P, respectively per 100g of sample.

Table 2. Mineral content of freeze-dried powder from mulberry fruit and mulberry leaf

Mineral	Mulberry fruit (mg/100g)	Mulberry leaf (mg/100g)
Ca	387.0	1,698.0
Mg	153.3	314.8
K	1,344.0	1896.0
Fe	4.0	10.0
Zn	1.7	7.0
Mn	5.5	6.6
Na	1.3	3.2
Cu	0.4	3.0
P	274.2	369.8

3.3. Organic acid content

Organic acids contents of mulberry fruit and mulberry leaf were as shown in Table 3.

The differences could be dependent on cultivar, harvest time, and analytic method (19).

Table 3. Organic acid content of freeze-dried powder from mulberry fruit and mulberry leaf

Organic acid	Organic acid contents (mg/100g)	
	Mulberry fruit	Mulberry leaf
Citric acid	10,873.5	317.9
Malic acid	2,288.3	110.1
Succinic acid	1,085.3	70.2
Fumaric acid	nd*	nd
Oxalic acid	nd	nd
Lactic acid	nd	nd
Acetic acid	nd	nd

*nd means not detected

3.4. DPPH free radical quenching activity

DPPH free radical quenching activities of mulberry fruit and mulberry leaf were 68.21% and

Table 4. Radical DPPH scavenging activity of mulberry fruit and mulberry leaf

Sample	Electron donating ability (%)
Mulberry fruit	68.21±0.27
Mulberry leaf	58.69±0.07

*values are mean±standard deviation.

58.69%, respectively as shown in Table 4.

Bae and Suh (20) reported that the DPPH scavenging ability of the ethanolic extracted from mulberry fruit was 60.0%. The mechanism of antioxidant activity is due to suppress the oxidation reaction, quenching the active oxygen, and control the antioxidants by protecting free radical forming enzymes or by chelating trace elements (21). Some flavonoids like rutin, quercitrin, isoquercitrin, guaijaverin were isolated and identified from the mulberry and mulberry leaf (17).

3.5. Phenolic content

Total phenolic contents of mulberry fruit and mulberry leaf were 8.48 mg and 4.56 mg per g of sample, respectively as shown in Table 5.

The antioxidant activity increased as the phenolic compounds increased. Total phenolic content showed astringency and antioxidative activity. Polyphenolics in plants had phenolic hydroxyl group which bound to proteins, enzymes, divalent metal ions, and macromolecules and showed antioxidant and anti-microbiological effects (22). Cho, Chun & Cha (23) reported that phenolics from mulberry fruits could use as natural antioxidant and the source of anti-hypertension and anti-gout.

According to a report of Isabelle, Lee, Ong, Liu & Huang (24), good correlations were observed among the phenolic, anthocyanin, and proanthocyanidin contents and the radical scavenging capacities of mulberry fruits.

Table 5. Total phenolic contents of mulberry fruit and mulberry leaf

Sample	Total phenolic contents (mg/g)
Mulberry fruit	8.48±0.35
Mulberry leaf	4.56±0.01

* values are mean±standard deviation.

In summary, powdered mulberry fruit contained more crude carbohydrate, crude lipid, organic acid, radical DPPH scavenging activity, and total phenolic compounds than mulberry leaf, while powdered mulberry leaf had more crude protein, ash (minerals), and dietary fiber than mulberry fruit.

Abstract

In order to develop a new functional foods using mulberry fruit and mulberry leaf which were cultivated and freeze-dried in Hwasun-Gun, Jeollanam-Do Province, Korea, some nutritional compositions and antioxidant activity were analyzed and compared. The mulberry fruit contained 7.70% of moisture, 2.58% of lipid, 6.55% of protein, 1.32% of ash, 81.85% of carbohydrates including 30.39% of total dietary fiber. The mulberry leaf contained 5.86% of moisture, 1.62% of lipid, 18.74% of protein, 6.90% of ash, 66.88% of carbohydrate including 43.29% of total dietary fiber. The mulberry fruit contained 387.0 mg of Ca, 153.3 mg of Mg, 1,344.0 mg of K, 4.0 mg of Fe, 1.7 mg of Zn, 5.5 mg of Mn, 1.3 mg of Na, 0.4 mg of Cu and 274.2 mg of P, respectively per 100g of sample. The mulberry leaf contained 1,698.0 mg of Ca, 314.8 mg of Mg, 1,896.0 mg of K, 10.0 mg of Fe, 7.0 mg of Zn, 6.6 mg of Mn, 3.2 mg of Na, 3.0. mg of Cu and 369.8 mg of P, respectively per 100 g of sample. The detected principal organic acids of mulberry fruit were 10.87 g of citric acid, 2.29 g of malic acid, and 1.09 g succinic acid per 100 g, respectively. The detected principal organic acids of mulberry leaf were 0.32 g of citric acid, 0.11 g of malic acid, and 0.07 g of succinic acid per 100 g, respectively. The antioxidant activity (DPPH) of mulberry fruit and mulberry leaf were 68.21% and

58.69%, respectively. The total phenolic content of the mulberry fruit and mulberry leaf were 8.48 mg and 4.56 mg per g of sample, respectively.

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