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Nutritional Value of Lily Scales in *Lilium lancifolium* and *Lilium davidii*

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ABSTRACT

Wild lilies in Korea are classified into 2 groups (Asiatic and Martagon) and there are about 10 species. Their scales and leaves are edible ingredients that have been used since early times; however, there have been no food nutritive studies on wild lilies in Korea. So, scales of *L. lancifolium* (domestic wild lily in Korea) and *L. davidii* (Chinese edible lily) were analyzed for their use as nutritional edible wild lilies. They have a moisture content of 68.54-82.98% and are composed of 2.32-5.48% crude protein, 0.08-0.34% crude fat, 19-24% total carbohydrate and 1.15-2.58% crude ash. In particular, *L. lancifolium* and *L. davidii* were analyzed for their carbohydrate content, being composed of 5.8-6.8% starch, 6.5-8.3% free sugar and 4.7-6.8% non-starch polysaccharide. The non-starch polysaccharide was fractionated into two groups, an acidic and a neutral fraction at a 63:37 ratio by DEAE-cellulose absorption. The non-starch polysaccharides of *Lilium* spp. scales mainly consist of glucose, mannose and mannuronic acid. We conclude that *L. lancifolium* and *L. davidii* are worthy as nutritional edible foods because they have high polysaccharide and protein contents. Furthermore, they are easily propagated by twin-scaling, are disease-tolerant and firmly integrated into Korean economy and culture.

Keywords: carbohydrate, domestic wild lily, edible food ingredient, non-starch polysaccharide, nutrient ingredient content

INTRODUCTION

Lily belongs to the genus *Lilium*, family *Liliaceae* and is a fall planting bulb, and a monocotyledonous, perennial plant. Approximately 130 species are distributed in the Northern Hemisphere (10° to 60°), mainly in Asia, North America and regions within Europe (Shimizu 1977). Lily is also classified according to its cross-compatibility into Asiatic, Oriental, Longiflorum, Martagon, Candidum, American and Trumpet groups. Hybrid lilies occupy a prominent place in horticulture as a cut flower, and pot and garden plant. Lily as a cut flower is presently ranked as the third or fourth most important crop in Korea. There are 7 species of wild lilies in the Asiatic group and 3 species in the Martagon group distributed in Korea. Most of them have been historically used as an edible and medicinal plant. In particular, *L. lancifolium* in the Asiatic group and *L. hansonii* in the Martagon group have recently been used in traditional food (Lee *et al*. 2004). Furthermore, many foods using the scales and leaves of lily are sold in China including distilled wine, tea, noodles, snacks, among others and in Japan such as mixed rice, croquettes, stew, mixed jelly, etc. In Chinese medicine, this plant is used to cure boils, frostbite, vomiting of blood, cough, bronchitis, laryngeal catarrh, nervous prostration, diabetes, pneumonia, etc. (Choi 2003). The RDA (2003) reported that lily bulbs contain medicinal ingredients such as *p*-coumaric acid, sinapic acid, etc. Lee (2002) found that linalool and isoeugenol, commonly used as natural antiseptic, skin-care products and resistance to disease agents, respectively, in the flower fragrance of Oriental hybrid lily 'Casa Blanca' and 'Le Reve'. For various reasons, we believe that lilies are worthy developing as a food ingredient.

Accordingly, this work was conducted to investigate the possibility of developing *L. lancifolium* and *L. davidii* as a new matter for nutritious foods by analyzing their general ingredients and the storage polysaccharides.

Fig. 1 ***Lilium lancifolium*** **(left) and** ***L. davidii*** **(right) flowers.**

MATERIALS AND METHODS

Sample preparation

The lilies used in this work were *L. lancifolium* and *L. davidii* (**Fig. 1**); they were cultivated in a non-heat vinyl house of the Taean Lily Experiment Station in 2004. The lily bulbs were planted 12 per plastic box (60 × 40 × 20 cm) filled with artificial medium (rice straw: vermiculite: cocopeat = 1: 1: 1) and solution drench developed by the National Horticultural Research Institute of Korea (Lee *et al*. 2005). Bulbs were harvested on October 20 and only clean scales, i.e. from which foreign matter such as disease rot etc. was eliminated, were used.

Chemical composition analysis of fresh scales

The proximate composition of *L. lancifolium* and *L. davidii* scales was determined by the Association of Official Analytical Chemists (1995). Moisture and ash content were determined gravimetrically by desiccation at 105°C and incineration at 550°C, respectively in

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Short Communication

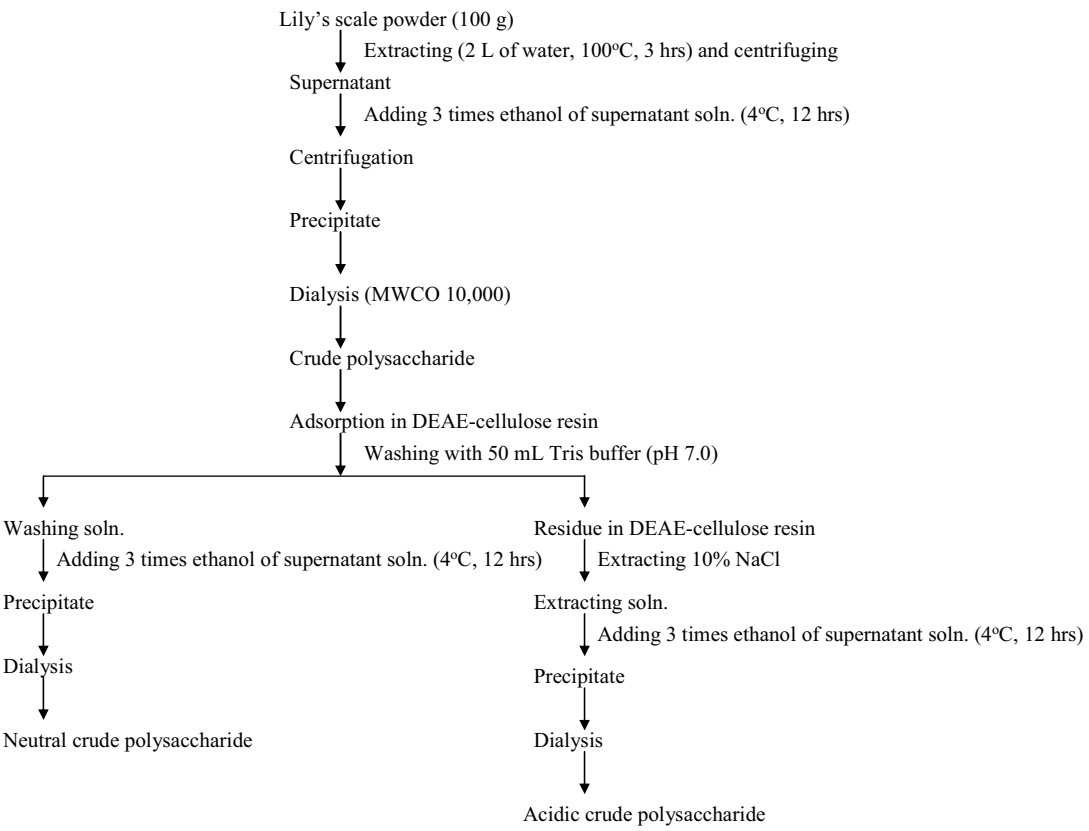

Fig. 2 Fractionation of crude polysaccharide from *Lilium* spp. scales.

a muffle furnace, and the crude protein content was obtained by the micro-Kjeldahl method (AOAC 1995). Lipids were extracted using a Soxhlet-extraction apparatus, and the content was determined gravimetrically. Carbohydrates were calculated by subtracted moisture, crude protein, crude lipid and crude ash from the total content.

Mineral composition analysis

Mineral composition of *L. lancifolium* and *L. davidii* scales was assessed by hydrolyzing them with nitric acid, perchloric acid and chloric acid in this order (Tsutagawa *et al*. 1994) and then analyzed by an Inductively Coupled Plasma Mass Spectrometer (ICP Analyzer, GBC integra XMP, made in Australia).

Determination of total phenolics

The Prussian blue method (Price *et al*. 1997) was used to determine total phenolics. A fresh sample (5 g) was extracted with 100 mL of 70% ethyl alcohol. To the extracted solution, 3 volumes of 0.1 M $FeCL_3$ and 0.008M $K_3Fe(CN)_6$ were added. The mixture was kept at room temperature for 10 min, and then the absorbance at 730 nm was measured. A calibration curve was constructed from the absorbance of various dilutions of tannic acid (0.01-0.1 mM; Sigma Chemical Co.).

Determination of organic acid

A fresh sample (5 g) was extracted with 100 mL of distilled water. To the extracted solution, total acidity was analyzed by titration with 0.1 N sodium hydroxide in accordance with the AOAC method and then content of total acid was expressed as milligrams per 100 g citric acid.

Determination of starch

An exact amount (5 g) of dried lily scale powder was mixed with 90% dimethyl sulfoxide (DMSO) solution (50 mL). The mixture was refluxed for 3 hrs. The suspensions were centrifuged for 30 min at 8,000 × *g*, and solid residues were treated a second time with 90% DMSO solution. Starch was precipitated by 3 volumes of ethyl alcohol from the supernatant collected after extraction. The insoluble residues remaining after precipitation with ethyl alcohol were solubilized in 0.1 N hydroxide and then determined by the phenol-sulfuric acid method (Saha *et al*. 1994).

Fractionation of non-starch polysaccharide

An exact amount (100 g) of dried lily scale powder was mixed with 20 parts of hot water. The mixture was refluxed for 3 hrs at 100°C and then the next procedure was as indicated in **Fig. 2**.

Analysis of sugar composition

The sugar composition of non-starch polysaccharide in *Lilium* spp. was determined by gas chromatography (GC) analysis of their alditol acetates (Choi *et al*. 2004). Samples were hydrolyzed with 2 M trifluoroacetic acid for 1.5 hr at 121°C, converted into the corresponding alditol acetates, and analyzed by GC at 60°C for 1 min, 60→220°C (30/min), 220°C for 12 min, 220°C→250°C (8°C/min), and 250°C for 15 min, using a Hewlett-Packard HP 6890 GC equipped with an SP-2330 capillary column (0.25 μm film thickness, 0.32 mm I.d. × 30 m, Supelco) and was detected by a flame ionization detector (FID).

Statisical analysis

Results were expressed as the mean ± SD from the average of three experiments. Statistical analysis was performed by analysis of variance with Duncan's multiple range test using the SAS program. The level of significance was set at $P<0.05$.

RESULTS AND DISCUSSION

Chemical composition analysis of fresh *L. lancifolium* and *L. davidii*

The proximate composition of *L. lancifolium* and *L. davidii* on the basis of fresh weight is presented in **Table 1**. The moisture contents for *L. lancifolium* and *L. davidii* scales were 70.58 ± 1.31 and 74.13 ± 1.22%, respectively. The crude protein, crude fat and ash contents were 5.21 ± 0.41, 0.15 ± 0.04 and 2.16 ± 0.12% in *L. lancifolium* scales, and 4.31 ± 1.22, 0.16 ± 0.02 and 2.00 ± 0.15% in *L. davidii*

Table 1 Proximate composition (%) of *L. lancifolium* and *L. davidii* scales.

Species	Moisture	Crude protein	Crude fat	Crude ash	Carbohydrate	Total phenolic	Organic acid
L. lancifolium	70.58 ± 1.31 [a]	5.21 ± 0.41 [b]	0.15 ± 0.04	2.16 ± 0.12 [b]	21.90 ± 1.34 [b]	0.08 ± 0.01	0.54 ± 0.02 [a]
L. davidii	74.13 ± 1.22 [b]	4.31 ± 0.21 [a]	0.16 ± 0.02	2.00 ± 0.15 [a]	19.40 ± 1.32 [a]	0.07 ± 0.01	0.59 ± 0.01 [b]

Values presented as the mean ± SD. Different superscripts indicate significant difference among groups by Duncan's multiple range test ($p<0.05$).

Table 2 Content (mg%) of mineral compositions of *L. lancifolium* and *L. davidii* scales.

Species	K	Mg	P	Ca	Na	Fe	Mn	Al	Zn	Cu
L. lancifolium	752.4 ± 30.1 [b]	29.1 ± 1.2 [b]	142.3 ± 8.1 [b]	17.2 ± 1.8 [b]	8.9 ± 2.5 [b]	2.1 ± 0.1 [b]	0.66 ± 0.01 [b]	0.82 ± 0.17 [a]	0.45 ± 0.25	0.20 ± 0.07
L. davidii	582.4 ± 22.0 [a]	22.9 ± 1.4 [a]	130.8 ± 10.1 [a]	15.1 ± 2.6 [a]	7.8 ± 2.6 [a]	1.9 ± 0.2 [a]	0.55 ± 0.03 [a]	1.13 ± 0.45 [b]	0.42 ± 0.26	0.19 ± 0.05

Values presented as the mean ± SD. Different superscripts indicate significant difference among groups by Duncan's multiple range test ($p<0.05$).

Table 3 Content (%) of polysaccharide from *L. lancifolium* and *L. davidii* scales.

Species	Starch	Non-starch polysaccharide
L. lancifolium	6.81 ± 0.62	7.06 ± 0.31 [b]
L. davidii	6.73 ± 0.55	5.85 ± 0.63 [a]

Values presented as the mean ± SD. Different superscripts indicate significant difference among groups by Duncan's multiple range test ($p<0.05$).

Table 4 Sugar compositions of crude non-starch polysaccharide from *L. lancifolium* scales.

Crude non-starch polysaccharide	Acidic polysaccharide	Neutral polysaccharide
Proportion of polysaccharide (%)	63	37
Composition of monosaccharide (%)	Glucose (42.3 ± 3.5)	Glucose (44.1 ± 4.2)
	Mannose (44.1 ± 6.1)	Mannose (55.9 ± 5.7)
	Mannuronic acid (1.8 ± 0.9)	

Values presented as the mean ± SD.

scales, respectively. Total phenolic and organic acid contents were 0.08 ± 0.01 and 0.54 ± 0.02% in *L. lancifolium* scales, and 0.07 ± 0.01 and 0.59 ± 0.01% in *L. davidii* scales, respectively. Generally, the moisture content in these scales were lower than those of burdock, lotus and onion which are other root and scale crops, whereas the carbohydrate and protein content in these scales were higher in comparison (Food Composition Table 7th, 2006).

Minerals

Mineral compositions are presented in **Table 2**. Mineral compositions of *L. lancifolium* and *L. davidii* were rich in K (582.4-752.4 mg%), P (130.8-142.3 mg%), and Mg (22.9-29.1 mg%). All the mineral portions measured in *L. lancifolium* and *L. davidii* scales, except for Al, were detected at a higher level in *L. lancifolium* than in *L. davidii*. K content in these scales was similar to that of garlic (Food Composition Table 7th, 2006), also a member of the *Liliaceae*, while P content was lower than that of garlic (173 mg%) and Ca content was higher than that of garlic (5 mg%).

Fractionation of non-starch polysaccharide and its sugar composition

The polysaccharides of *L. lancifolium* and *L. davidii* on the basis of fresh weight are presented in **Table 3**, being composed of starch (6.73-6.81%) and non-starch polysaccharide (5.85-7.06%). The contents of starch and non-starch polysaccharide were higher in *L. lancifolium* than in *L. davidii*. Non-starch polysaccharide was divided into acidic polysaccharide (63%) and neutral polysaccharide (37%); also, the carbohydrate was mainly composed of glucose, mannose and mannuronic acid (**Table 4**).

In this study, we found that *L. lancifolium* contained as many nutritive components such as non-starch polysaccharide, protein and minerals as *L. davidii*. This has particular pertinence since research on the physiological functionality of non-starch polysaccharides found in various foods is a hot topic. In this sense, *L. lancifolium* is worthwhile researching further. Based on these results, we are now carrying out research on the physiological function and development of processed *L. lancifolium* food to try and obtain the most out of *L. lancifolium*'s scales as food material.

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