

Food Functionality of *Opuntia ficus-indica* var. Cultivated at Jeju Island

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INTRODUCTION

Opuntia is the largest group of Cacti in the world. This group also includes several edible kinds. The plant is commonly known as prickly pear, tuna, indian fig, bunny ears, cholla, and barbary fig. *Opuntia* is native to North America but it has spread to Central South America, North Africa, Europe, Mediterranean countries, the Middle East, and Korea (1,2). *Opuntia* is considered of fundamental economic importance in many arid and semi-arid areas of the world. Jeju island in Korea has over 200 ha under commercial cultivation, with an annual production of approximately 250 tons (3). *Opuntia ficus-indica* has been appointed as the Natural Monument number 429 by Bukjeju-gun province (Fig. 1). *Opuntia ficus-indica* is grown in commercial quantities as the food and medicinal plants in Jeju island. *Opuntia ficus-indica* employed for the treatments of inflammation, burned wound, and edema as folk medicinal plant at Jeju island. Ground or pureed young pads can be used in first aid similar to the aloe vera plant. Simply cut off a portion of a pad, crush it, and squeeze the juice onto a cut, burn, or inflammation. In this paper we review the characteristics including variety, compositions, food functionality, and pharmacological effects of *Opuntia ficus-indica* collected in Jeju island based on our published and unpublished literatures.

What is *Opuntia*

Opuntia is usually separated into two groups. The first group is *Platyopuntia*; those belonging to this group have round flattened joints, called pads. They are commonly known as prickly pears because they produce the spiny, usually edible, fruits. Some are grown for their edible pads called nopales or nopalitos. The spines of these

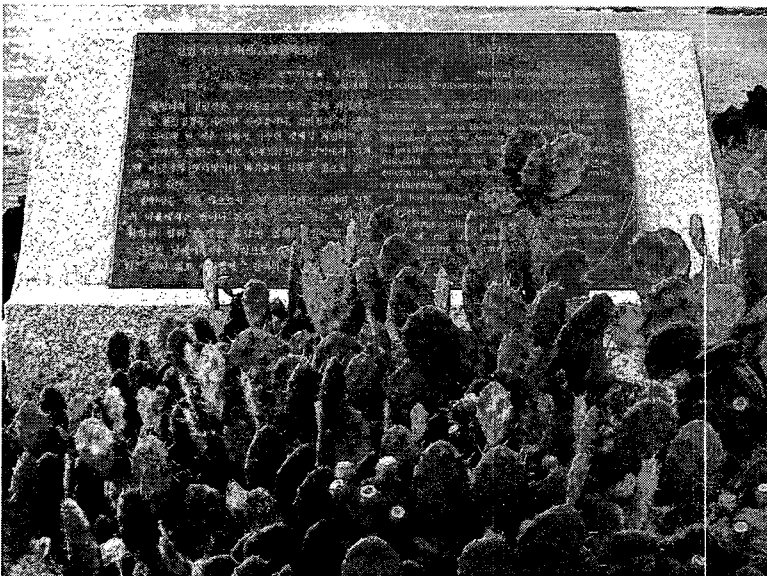


Fig. 1. *Opuntia ficus-indica* appointed as the Natural Monument number 429 by Bukjeju-gun province. Location: Seaside of Weollyeong-ri, Hallim-eup, Bukjeju-gun province, Jeju island, Republic of Korea.

pads must be singed off before they can be prepared for eating. The second group is *Cylindropuntia*; those belonging to this group have long, cylindrical joints and are commonly called chollas. The sizes of *Opuntias* vary. They can be just a few inches and spreading, or grow 100 feet high and tree-like. Most kinds of these plants are covered with sharp, barbed spines that are difficult to remove without lacerating the skin.

Four characteristics distinguish *Opuntia* from other cactus: firstly, they have jointed segments (though unlike chollas, the segments grow in flat pads). Secondly the areoles (roundish pads which produce spines) have minute barbed spines called glochids that are easily detachable. Thirdly rudimentary leaves are present on new joints. Fourthly, their seeds have a pale covering called an aril.

The genus *Opuntia* is the largest of the family comprising more than 300 species. Major varieties of genus *Opuntia* were *O. compressa*, *O. arenaria*, *O. fragilis*, *O. imbricate*, *O. phaeacantha*, *O. polyacantha*, *O. invicta*, *O. lindheimeri*, *O. tunicate*, *O. vestita*, *O. aurantiaca*, *O. basilaris*, *O. cylindrical*, *O. dillenii*, *O. ficus-indica*, *O. leucotricha*, *O. pentlandii* (boliviana), *O. pottsii* (filipendula), *O. spinosissima*, *O. whipplei*, *O. neoargentina* (tree opuntia), and *O. paraguayensis* (riverina Pear). Among these, *Opuntia ficus-indica*, *O. amyclaea*, *O. streptacantha*, *O. megacantha*, and *O. inermis* were cultivated as fruit plants. *Opuntia ficus-indica*, one of those, was considered as the important cactus. The most popular variety, *Opuntia ficus-indica* var. was cultivated in Jeju island.

Prickly pear cactus, form *Opuntia*, is considered to be an important nutrient and food source in many parts of the world. Mexico, Chile, Italy, and a number of areas in the USA farm prickly pear for commercial purpose. The fruits are called prickly pears and cactus pears at southwestern United States, or “tunas” at Latin America, ficodindia or fig of India at Italy, Tzabba at Israel, and Sabar at Arab nations around the Mediterranean Sea. At Jeju island in Korea, *Opuntia ficus-indica*, is called as Sonbadag cactus (mean: hand-like) or Baeknyuncho (mean: plant lives for hundred years). The pads are “cladodes” or “nopales” when they’re whole, and “nopalitos” when they’re diced.

Processed Foods

Opuntia Ficus-Indica is cultivated as foods and medicinal materials. The pads and the fruit are harvested for many different food dishes and processed foods.

The pads of *Opuntia ficus-indica* have been grown as a traditional vegetable in Central Mexico. Nopalitos (sliced or cubed pads) have been used as food materials such as omelettes, jelly, bread, and cookie. They taste something like green beans. Today, the pads are available in this country throughout the year in specialty produce sections. The smaller young pads in the early spring are the most succulent, delicate in flavor, and have the fewest spines. Fresh pads are full of water and should be bright green and firm. To prepare the pad, simply hold its base and scrape the skin on both sides with a blunt knife until all the spines are removed. Then peel the pads and cut them into shoestring strips or dice them according to the needs of the recipe. They can be eaten raw in salads, boiled and fried like eggplant, pickled with spices, or cooked with shellfish, pork, chilies, tomatoes, eggs, coriander, garlic, and onions. In jeju island, the crushed pads were dried by freezed dryer and ground into flour (180~200 mesh) as food materials for noodle, drink, jam, tea, baking, and tablet (4,5).

Fruits (tuna or prickly pear) has been used as appetizers, soups, salads, vegetable dishes, and breads to desserts, beverages, and candies in the world. The flavor of a ripe prickly pear cactus fruit depends on the variety but include strawberries, watermelons, honeydew melons, figs, bananas, and citrus. They can be cooked into jams and preserves or cooked down into a syrup as a base for jelly and candy, “cactus candy” in some Mexican food stores and “neck candy” in some Korean food store. The crushed fruits (usually a purple red colors) were also

dried by freeze-dryer and ground into flour (180~200 mesh) as food materials for noodle, drink, jam, tea, baking, yogurt, and tablet in Jeju island. The fruit pulp also extracted by the boiling water and then packed into retort pouch for drink (4,5).

Characteristics of *Opuntia ficus-indica* Cultivated in Jeju Island

Opuntia ficus-indica cultivated at Jeju island is considered as one of *Opuntia* varieties. Authors have thought the taxonomy of the group to be confusing, no doubt due to the asexual propagation of interspecific hybrid swarms, as well as its propagation as a crop in so many arid and semiarid regions. Usually, *Opuntia ficus-indica* was cultivated at stony soil in Jeju island. As shown in Fig. 2, *Opuntia ficus-indica* grown in well organized plantation for fruit production at Jeju island. The pads sprouted newly from early spring through late summer in Jeju island. As shown in Table 1, flower bloomed from late spring through early summer and fruits matured for winter season (5). Fruits are best for eating fresh ripen through December (5).

Proximate compositions (6) of *Opuntia ficus-indica* are presented in Table 2. The major components of the freeze-dried *Opuntia ficus-indica* in proximate compositions were nitrogen free extract, 58.02~69.20%. Components of the pad and fruit are 9.30~5.94% water, 1.20~1.35 crude fat, 8.52~4.24% crude protein, 20.05~12.12% crude ash, and 3.79~6.27% crude fiber, respectively. The fibrousness of the fruits increased as the fruits mature and nitrogen free extracts related to dietary fiber contents (7).

Mineral compositions of *Opuntia ficus-indica* are presented in Table 3. The contents of calcium were relatively high compared to the other tested minerals. The calcium contents (4391.2~2086.9 mg%) were considerably higher than that of the commonly consumed fruits such as citrus, strawberry, jujube, persimmon, and apple (8). Calcium was related to bone formation. The major minerals were Ca (4391.2~2086.9 mg%), K (1932.1~2608.7 mg%),



Fig. 2. The prickly pear *Opuntia ficus-indica* grown in well-organized plantations at stony soil in Jeju island.

Table 1. Seasons of growing stages of *Opuntia ficus-indica* var. in Jeju island

Sprouting			Blooming stage		Fruiting stage	
First	Second	Third	Beginning	Completion	Beginning	Completion
20 May ± 2 ¹⁾	1 July ± 2	23 Aug ± 3	10 June ± 4	1 July ± 5	1 Nov ± 5	5 Dec ± 10

¹⁾Day Month ± Day

Table 2. Proximate compositions of *Opuntia ficus-indica* var. in Jeju island (unit: %)

Samples	Moisture	Crude fat	Crude protein	Crude ash	Crude fiber	Nitrogen free extract
Pad	5.94	1.20	8.52	20.05	6.27	58.02
Fruit	9.30	1.35	4.24	12.12	3.79	69.20

Table 3. Mineral compositions of *Opuntia ficus-indica* var. in Jeju island (unit: dry basis, mg%)

Minerals	Pad	Fruit
Ca	4391.2	2086.9
Mg	1984.8	800.6
Na	985.4	539.7
K	1932.1	2608.7
Fe	11.3	12.9
Mn	1.4	2.2
P	93.0	99.6
Total	9399.2	6150.6

and Mg (800.6~1984.8 mg%), respectively. Total mineral contents of pad and fruit of *Opuntia ficus-indica* were 9399.2, and 6150.6 mg%, respectively.

Information on the amino acid content of a food protein provides a useful indication of its nutritive value when compared to others of known high quality. Compositions of total amino acid of *Opuntia ficus-indica* showed Table 4. The major amino acids in fruit and pad were glutamic acid and their contents were 16.3% and 25.2%, respectively. The contents of glutamic acid, arginine, asparatic acid, leucine, and proline were relatively high compared to the other tested amino acids (6).

Compositions of free sugars of *Opuntia ficus-indica* are presented in Table 5. The major free sugar in pad was fructose, but the major free sugar in fruit was sucrose (6). Fructose contents was 40.8% in pad and 18.0% in fruit,

Table 4. Compositions of total amino acid of *Opuntia ficus-indica* var. in Jeju island (unit: dry basis mg%)

Amino acids	Pad (%)	Fruit (%)
Asp	453.742 (7.4)	258.424 (7.0)
Glu	1543.155 (25.2)	605.788 (16.3)
Ser	219.817 (3.6)	118.790 (3.2)
Gly	245.066 (4.0)	128.105 (3.5)
His	188.540 (3.1)	150.896 (4.1)
Arg	361.728 (5.9)	306.088 (8.3)
Thr	199.319 (3.3)	97.791 (2.6)
Ala	163.310 (2.7)	93.668 (2.5)
Pro	294.235 (4.8)	242.270 (6.5)
Tyr	228.108 (3.7)	314.067 (8.5)
Val	264.000 (4.3)	104.887 (2.8)
Met	24.075 (0.4)	5.432 (0.15)
Cys	55.394 (0.9)	57.636 (1.6)
Ile	249.127 (4.1)	131.149 (3.5)
Leu	373.521 (6.1)	121.220 (3.3)
Phe	276.887 (4.5)	153.856 (4.2)
Lys	281.268 (4.6)	108.269 (2.9)
Total	6130.047 (100)	3706.449 (100)

Table 5. Contents of free sugar of *Opuntia ficus-indica* var. in Jeju island (Unit: dry basis, mg)

Free sugars	Pad (%)	Fruit (%)
Fructose	4327.639 (40.8)	7359.003 (18.0)
Glucose	2722.767 (25.7)	5243.173 (12.8)
Sucrose	3364.785 (31.8)	28101.118 (68.7)
Mannose	180.481 (1.7)	208.286 (0.5)
Total	10595.672 (100)	40911.61 (100)

while scurose contents was 31.8% in pad and 68.7% in fruit, respectively. Mannose existed only below 2%. Sawaya et al. (9) have been reported that the sugars of prickly pear consisted of mainly glucose and fructose (60:40).

Contents of vitamin C, total polyphenols, and flavonoids of *Opuntia ficus-indica* were presented in Table 6. Vitamin C contents of pad and fruit were 71.2 and 163.8 mg%. Vitamin A was not presented in pad and fruit. Total polyphenols of fruit were higher than those of pad. Total flavonoids of fruit were similiar to those of pad. However, Lee et al. (6) have been reported that the contents of total polyphenols and flavonoids were changed by extraction solvent and temperature. From the methanol extract of the fruits, two dihydroflavonols were isolated and identified as (+)-trans-dihydrokaempferol and (+)-trans-dihydroquercetin by spectroscopic methods (10). Kuit (11) also identified conjugated flavonoids (quercetin, kaempferol, and isorhamnetin) in extracts from cactus (*Opuntia* species) fruits. Polyphenolic flavonoids are metabolic products widely distributed in foods of plant origin and they have numerous biological and pharmacological properties. Also they could potentially afford protection against chronic diseases. The results indicate that fruit and pad of *Opuntia ficus-indica* are rich sources of flavonoids and polyphenols (6). Therefore, their components also may be attributed to food functionalities such as antioxidant, biological and pharmacological effects.

Table 6. Contents of vitamin C, total polyphenols, and flavonoids of *Opuntia ficus-indica*

Vitamic C (mg%)		Polyphenols (mg/g)		Flavonoids (mg/g)	
Pad	Fruit	Pad	Fruit	Pad	Fruit
71.2	163.8	1.858	4.976	1.290	1.590

Pharmacological Efficacy

Serum biochemical and hematological parameters

The activities of serum biochemical and hematological parameters were not affected by rats orally treated for 4 weeks (5). Hematological values such as white blood cell (WBC), red blood cell (RBC) and hemoglobin (Hb) showed no significance in the experimental rats intaraperitoneally treated with the fruit and pad of the *Opuntia ficus-indica* (Table 7). It also showed no significance in SDH, ALT, AST, GGT, ALT, T.Pro, uric acid and creatine (Data not shown. Refer to Ref. No 5). On the other hand, in the acute toxicity, both of the fruit and pad of the *Opuntia ficus-indica* were not affected by rats orally treated for 4 weeks. All rats did not die for experimental period (Data not shown. Refer to Ref. No 5). The results indicated that the fruit and pad of the *Opuntia ficus-indica* are considered to be the good sources of food materials.

As shown in Table 8, serum lipid components were not also effected on the normal rats (5). Hepatic lipid peroxide content, superoxide dismutase and glutathion peroxidase activities were not affected significantly by the treatment of the fruit and pad of the *Opuntia ficus-indica*.

Table 7. Hematological values of rats intraperitoneally treated with fruit and pad of *Opuntia ficus-indica*

Samples	Parameter \ Dose (mg/kg)	0	500	1000	1500	2000
Fruit	WBC ($\times 10^3$ μ L)	13.7 \pm 2.1	14.3 \pm 2.0	13.5 \pm 3.2	15.2 \pm 4.0	15.7 \pm 2.7
	RBC ($\times 10^3$ μ L)	7.6 \pm 0.2	7.7 \pm 0.3	7.5 \pm 0.4	7.5 \pm 0.3	7.8 \pm 0.3
	Hb ($\times 10^3$ μ L)	14.9 \pm 0.6	15.3 \pm 0.5	14.2 \pm 0.6	14.7 \pm 0.3	15.2 \pm 0.6
Pad	WBC ($\times 10^3$ μ L)	14.6 \pm 3.7	15.2 \pm 3.0	14.6 \pm 2.3	15.6 \pm 4.0	15.9 \pm 2.6
	RBC ($\times 10^3$ μ L)	7.8 \pm 0.7	7.6 \pm 0.3	7.8 \pm 0.4	7.5 \pm 0.5	7.7 \pm 0.5
	Hb ($\times 10^3$ μ L)	15.0 \pm 0.7	14.9 \pm 0.6	15.2 \pm 0.5	15.3 \pm 0.6	14.9 \pm 0.5

Table 8. Effects of fruit and pad of *Opuntia ficus-indica* on the lipid peroxidation, superoxide dismutase (SOD) and glutathion peroxidase (GP) activities in normal rats

Samples	Dose (mg/kg) \ Parameters	Lipid peroxidation ¹⁾	SOD activity	Glutathion peroxidase
Fruit	0	16.8 \pm 0.8	9.6 \pm 0.2	120.9 \pm 16.7
	250	20.2 \pm 2.1	9.7 \pm 0.4	140.8 \pm 23.2
	500	21.9 \pm 4.2	9.9 \pm 0.5	138.7 \pm 20.4
	1000	18.9 \pm 0.9	10.3 \pm 0.4	129.6 \pm 18.4
Pad	0	18.3 \pm 1.2	10.1 \pm 0.5	123.7 \pm 20.4
	100	21.4 \pm 2.7	9.8 \pm 0.6	139.4 \pm 19.6
	250	20.6 \pm 3.1	9.7 \pm 0.4	119.6 \pm 18.7
	500	22.9 \pm 4.1	9.7 \pm 0.4	140.3 \pm 35.4

¹⁾Lipid peroxidation unit: MDA nmole/g of tissue.

Blood circulatory system

Both of the fruit and pad extracts of the *Opuntia ficus-indica* also not influenced the normal mean blood pressure in anesthetized rat (Table 9). Samples were given orally to 3 rats. This results showed no significant actions on blood circulatory system, which imply to no toxic effects to animal (5).

Autonomic nervous system

The fruit and pad extracts of the *Opuntia ficus-indica*, acetylcholine and histamine showed the measurable non-contractility on the isolated rat ileum (Table 10 and 11). Each 15 μ L/mL of extracts were added to isolated organ after cumulative addition of acetylcholine and histamine and then washing. They showed no significant differences each other. This results showed no significant actions on autonomic nervous system (5,12).

When we measured phenobarbital-induced sleeping time, locomoter activity, rotarod test, body temperature,

Table 9. Effects of fruit and pad of *Opuntia ficus-indica* on blood pressure in rat

Time (min)	Mean blood pressure (mmHg)					
	Fruits			Pad		
	Control	15 mg/kg	30 mg/kg	Control	15 mg/kg	30 mg/kg
0	119 \pm 2.6	115 \pm 1.2	112 \pm 3.1	113 \pm 3.8	115 \pm 3.2	112 \pm 3.1
5	106 \pm 3.1	108 \pm 9.1	116 \pm 4.2	103 \pm 3.2	108 \pm 5.1	111 \pm 3.4
10	107 \pm 2.4	111 \pm 8.7	107 \pm 3.4	115 \pm 6.7	113 \pm 4.7	110 \pm 3.5
30	114 \pm 3.1	104 \pm 4.5	113 \pm 3.9	114 \pm 1.4	114 \pm 3.2	112 \pm 4.2
60	108 \pm 3.1	113 \pm 9.4	118 \pm 2.1	113 \pm 5.4	102 \pm 3.9	106 \pm 5.3
90	115 \pm 2.9	118 \pm 4.2	117 \pm 5.3	99 \pm 2.7	101 \pm 5.4	108 \pm 3.5
120	117 \pm 1.4	109 \pm 3.1	108 \pm 5.2	101 \pm 2.4	105 \pm 4.1	112 \pm 2.6

Table 10. Effects of fruit and pad of *Opuntia ficus-indica* and acetylcholine of isolated rat ileum

Acetylcholine concentration (M)	% of contraction			
	Ach	Fruit+Ach	Ach	Pad+Ach
10 ⁻⁹	7.3±1.3	1.4±0.0	7.4±2.1	2.1±0.1
2×10 ⁻⁹	15.2±1.7	5.8±3.2	7.4±2.1	6.2±2.2
5×10 ⁻⁹	17.9±1.8	15.7±2.3	18.2±2.0	19.3±2.4
10 ⁻⁸	28.3±1.4	43.0±7.5	30.4±1.4	40.2±8.5
2×10 ⁻⁸	81.6±3.5	80.8±1.4	89.2±2.2	84.3±2.2
5×10 ⁻⁸	98.8±0.3	99.3±0.3	100.0±0.0	99.1±0.4

Table 11. Effects of fruit and pad of *Opuntia ficus-indica* and histamine of isolated rat ileum

Histamine concentration (M)	% of contraction			
	Histamine	Fruit+His	Histamine	Pad+His
5×10 ⁻⁸	4.9±0.5	6.3±1.4	5.1±0.4	6.2±1.3
10 ⁻⁷	9.1±0.9	16.8±1.8	10.2±1.2	15.3±2.8
2×10 ⁻⁷	48.0±4.0	47.2±4.0	52.3±5.2	48.2±6.0
5×10 ⁻⁷	83.7±9.2	77.8±5.2	88.2±8.3	79.2±7.2
10 ⁻⁶	87.6±3.4	90.7±1.9	87.4±7.2	90.2±2.4
2×10 ⁻⁶	100±0.0	95.7±0.5	99.2±0.2	98.8±0.4

MES-induced seizure, strychnine-induced seizure and pentylenetetrazol-induced seizure which influence CNS, it was found that they were not effected by treatment of the fruit and pad extracts of *Opuntia ficus-indica* (data not shown. Refer to Ref. No 5 and 12). On the basis of above results, *Opuntia ficus-indica* showed no significant actions on central and autonomic nervous, and blood systems, which imply no toxic effects to animals. The results indicated that fruit and pad of the *Opuntia ficus-indica* are considered to be the good sources of food materials.

Anti-inflammatory

Carrageenin-induced hind paw edema in rat was utilized as animal models to search anti-inflammatory (5,12). As shown in Table 12, the cactus fruit and pad were administered to ten rats orally 30 mins prior to carrageenin injection. The treatment of the cactus fruit (500, 1000 mg/kg) and pad (100, 250, 500 mg/kg) showed an inhibitory effect on carrageenin-induced paw edema, indicating that both of the cactus fruit and pad exhibited the anti-

Table 12. Effects of fruit and pad of *Opuntia ficus-indica* on the carrageenin-induced hind paw edema in rat

Treatments	Dose (mg/kg, p.o)	Time (hr) course of swelling percent (%)			
		0.5	1	2	3
Control	0	67.0±7.2	63.7±5.7	76.6±4.2	79.0±7.8
	250	60.9±3.2	59.8±3.6	61.3±6.2	72.3±4.9
	500	51.8±4.3	49.9±5.3	53.6±4.7	67.4±5.5
	1000	45.3±2.4	43.4±3.6	50.8±5.5	70.3±6.2
Indomethacin	20	39.7±6.2	37.3±5.0	47.3±6.6	54.3±6.4
Control	0	66.0±5.7	68.9±6.2	78.8±5.2	81.3±6.2
	100	52.3±2.3	54.0±3.4	58.4±4.2	69.8±5.3
	250	50.8±8.6	48.6±3.5	55.9±3.6	71.3±6.2
	500	43.7±3.9	42.7±5.2	51.6±3.7	68.8±4.2
Indomethacin	20	37.3±3.3	36.7±4.0	40.7±3.4	53.9±4.3

inflammatory activity. Moreover, Park et al. (13) demonstrated that the ethanol extracts of *Opuntia ficus-indica* suppressed the release of glucuronidase, a lysosomal enzyme in rat neutrophils. It was also noted that the ethanol extracts showed the protective effect on gastric mucosal layers. From the results it is suggested that the ethanol extracts of *Opuntia ficus-indica* cultivated at Jeju island contain anti-inflammatory action having protective effect against gastric lesions.

Analgesic activity

Author and coworkers (5,12) found that of *Opuntia ficus-indica* showed the anti-inflammatory and analgesic activities. Hot plate and acetic acid induced writhing tests in mice were utilized as animal models to search analgesic activity (Table 13 and 14). The cactus fruit and pad were administered orally 30 mins prior to the intraperitoneal injection of 0.7% acetic acid-saline (0.1 μ L/10 g) to ten ICR mice according to Whittle's method. The treatment of the cactus fruit (250, 500, 1000 mg/kg) and pad (100, 250, 500 mg/kg) showed the inhibitory effects on acetic acid-induced writhing and hot-plate tests. The results indicating that both of the cactus fruit and pad inhibited the analgesic activity. The activity of pad showed stronger than that of fruit.

Table 13. Effects of fruit and pad of *Opuntia ficus-indica* on acetic acid-induced writhing syndrome in mice

Treatments	Dose (mg/kg)	Fruit		Pad	
		Writhing lag (sec)	Writhing syndrome (sec)	Writhing lag (sec)	Writhing syndrome (sec)
Control	0	220.4 \pm 16.5	18.4 \pm 1.8	230.6 \pm 17.4	19.4 \pm 1.6
<i>Opuntia ficus-indica</i>	100	243.6 \pm 17.9	16.4 \pm 1.7	260.7 \pm 18.9	15.1 \pm 1.8
	250	307.4 \pm 22.7	10.7 \pm 2.2	310.9 \pm 24.4	10.3 \pm 2.5
	500	324.9 \pm 30.1	9.8 \pm 1.9	330.4 \pm 29.8	8.7 \pm 1.6
Aminopyrine	100	398.9 \pm 39.4	5.3 \pm 0.7	404.2 \pm 41.2	4.8 \pm 1.2

Table 14. Effects of fruit and pad of *Opuntia ficus-indica* on hot-plate test in mice

Treatment	Dose (mg/kg)	Onset time (sec)
<i>Opuntia ficus-indica</i> fruit	0	15.4 \pm 0.1
	250	18.7 \pm 0.1
	500	25.4 \pm 0.2
	1000	30.6 \pm 0.3
Aminopyrine	100	50.2 \pm 0.5
<i>Opuntia ficus-indica</i> pad	0	16.5 \pm 0.2
	100	20.3 \pm 0.2
	250	30.7 \pm 0.3
	500	33.6 \pm 0.4
Aminopyrine	100	49.8 \pm 0.4

Anti-diabetic activity

Diabetes mellitus is chiefly classified as two categories: type 1 (insulin-dependent diabetes mellitus, IDDM) usually characterized chronic disorder that results from autoimmune destruction of the insulin-producing pancreatic beta-cell and type 2 (non-insulin-dependent diabetes mellitus, NIDDM), of which a major metabolic abnormality is the impairment of insulin action (insulin resistance). There are several kinds of a microvascular and macrovascular complications in diabetics. There is an evidence that the hyperglycemia acts through a common mechanism to

cause the early functional alterations in a peripheral nerve, kidney, and retina that antedate the development of characteristic diabetic pathology. Anti-diabetic activity (in vitro alpha-glucosidase inhibitory and reducing activities of blood glucose level on alloxan-induced streptozotocin-induced diabetic *db/db* mice) of *Opuntia ficus-indica* was investigated by author and coworkers (14). We exhibited the only urinary total glucose and blood total glucose in *db/db* mice (Table 15 and 16). The other results were omitted in this review. *Opuntia ficus-indica* was administered with the diet for 5 weeks on *db/db* diabetic mice. The pads of *Opuntia ficus-indica* inhibited the glucose elevation in blood and urine. The results suggest that *Opuntia ficus-indica* could reduce the postprandial blood glucose level in normal and diabetics. Also, the results seem to be able to prevent various symptoms of diabetics and other diseases originated from hyperglycemia. *Opuntia ficus-indica* pads could be more effective than fruit on insulin-independent diabetic mellitus type 2.

The other activity

In order to isolate pharmacologically active constituents from *Opuntia ficus-indica*, author and coworkers (15) screened several bioassays including antithrombotic, anticoagulant, dopamine beta-hydroxylase and monoamine oxidase (MAO) activities. Among these, it was found that the fruit and pad of *Opuntia ficus-indica* inhibited MAO activity. The isolation of well known but not previously reported in this plant-origin acid methylester showed inhibitory activity against MAO-B from the extract of fruit. Citric acid methylesters, particularly dimethylester, are major components in the MAO fraction found in the fruit. Trimethyl citrate has been reported in other plant, but 1,3-dimethyl citrate and 1-monomethyl citrate have not been previously reported. In addition to, some Korean

Table 15. Change of urinary total glucose in *db/db* mice treated by fruit and pad of *Opuntia ficus-indica*

Group ¹⁾	Change of urinary total glucose (mg/20 h)				
	0 w ²⁾	1 w	2 w	4 w	5 w
Lean	1.2 ± 0.4	2.5 ± 1.5	2.1 ± 1.0	1.3 ± 0.7	1.1 ± 0.7
Nontreated	286.8 ± 5.6	318.0 ± 4.6 [#]	572.0 ± 9.6 [#]	572.0 ± 5.3 [#]	586.8 ± 2.0 [#]
Acarbose	532.4 ± 2.6	499.0 ± 3.8	108.4 ± 4.2 [*]	108.4 ± 6.9 [*]	495.2 ± 5.2 [*]
Pad	444.0 ± 4.2	532.0 ± 7.6	452.4 ± 0.4 [*]	452.4 ± 6.4 [*]	488.0 ± 7.1 [*]
Fruit	342.0 ± 0.8	791.6 ± 3.7	521.6 ± 6.3 [*]	521.6 ± 4.4 [*]	506.4 ± 2.4 [*]

¹⁾Lean, C57BLKS/J-control group for *db/db*: Nontreated, group treated with normal diet on C57BLKS/J-m+/+Lepr^{db}; Acarbose, group treated with 0.1% acarbose-mixed diet on C57BLKS/J-m+/+Lepr^{db}; Pads, group treated with 1% the pad of cactus-mixed diet on C57BLKS/J-m+/+Lepr^{db}; Fruit, group treated with 1% the cactus fruit-mixed diet on C57BLKS/J-m+/+Lepr^{db}. ²⁾Week. [#]Significantly different from the lean group. ^{*}Significantly different from the nontreated group.

Table 16. Change of blood total glucose in *db/db* mice treated by fruit and pad of *Opuntia ficus-indica*

Group ¹⁾	Change of urinary total glucose (mg/20 h)				
	0 w ²⁾	1 w	2 w	4 w	5 w
Lean	47.5 ± 2.1	75.0 ± 21.1	64.0 ± 5.6	71.5 ± 10.6	80.0 ± 2.8
Nontreated	94.5 ± 22.5	161.5 ± 40.5 [#]	205.0 ± 34.0 [#]	258.0 ± 14.0 [#]	199.5 ± 45.5 [#]
Acarbose	134.5 ± 56.5	68.5 ± 4.5	244.5 ± 51.5 [*]	358.0 ± 43.0 [*]	230.5 ± 23.5 [*]
Pad	138.0 ± 41.2	65.0 ± 30.8	199.0 ± 37.1 [*]	178.0 ± 34.0 [*]	138.0 ± 23.8 [*]
Fruit	221.0 ± 44.0	123.5 ± 47.5	188.0 ± 26.0 [*]	171.0 ± 45.4 [*]	74.5 ± 2.5 [*]

¹⁾Lean, C57BLKS/J-control group for *db/db*: Nontreated, group treated with normal diet on C57BLKS/J-m+/+Lepr^{db}; Acarbose, group treated with 0.1% acarbose-mixed diet on C57BLKS/J-m+/+Lepr^{db}; Pad, group treated with 1% the pad of cactus-mixed diet on C57BLKS/J-m+/+Lepr^{db}; Fruit, group treated with 1% the cactus fruit-mixed diet on C57BLKS/J-m+/+Lepr^{db}. ²⁾Week. [#]Significantly different from the lean group. ^{*}Significantly different from the nontreated group.

researchers (16) studied effects of *Opuntia ficus-indica* on the dietary and alcoholic hyperlipidemia, the respiratory system, antigastic and anti-ulcerative actions.

CONCLUSION

Opuntia is the largest group of Cacti in the world. Jeju island in Korea has over 200 ha under commercial cultivation, with an annual production of approximately 250 tons. *Opuntia ficus-indica* is grown in commercial quantities as food and medicinal plants in jeju island. The crushed pads and fruits of *Opuntia ficus-indica* were dried by freeze-dryer and ground into flour (180~200 mesh) as food materials for noodle, drink, jam, tea, baking, beverages, candy, yogurt, and tablet in Korea. The results of pharmacological efficacy such as serum biochemical and hematological parameters, autonomic nervous system, anti-inflammatory, analgesic activity, anti-diabetic activity, antithrombotic, anticoagulant, dopamine beta-hydroxylase, monoamine oxidase (MAO) activity, hyperlipidemia, the respiratory system, antigastic and anti-ulcerative actions indicate that fruit and pad of the *Opuntia ficus-indica* are considered to be good sources of food materials

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