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Formulation and Sensory Evaluation of Granule and Tablet from Lotus Rhizome (*Nelumbo nucifera* Rhizome)

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Abstract - *Nelumbo nucifera* root (NNR) is used to clear summerheat (暑熱), bear Yang (陽) upwards and stop bleeding as mentioned in traditional Korean medicine. Also, it has been known that NNR is effective for lowering blood pressure and hyperlipidemia. The rhizome is considered to be nutritive, demulcent, diuretic and cholagogue and is used to treat piles, dyspepsia and diarrhea. An increasingly growing market for nutraceuticals and functional foods has triggered the study on natural sources for nutraceuticals, health foods and functional foods. But rhizome was inconvenient to formulate liquid dosage form (extract) by way of hot water because of its limited storage. Also the majority of the consumers have a complaint against the dosage. The purpose of this study was to develop the functional materials from NNR without side effects. We formulated the solid dosage form viz tablet and granule from the lotus root. Sensory evaluation was performed in terms of smell, taste, color and overall of lotus root and all colored forms (brown, dark brown, light green and yellow) of tablet and granule to evaluate the acceptability of the formulated tablets and granules. In sensory evaluation, among the formulated tablets and granules, light green granules obtained best score overall and yellow tablets showed the overall improved acceptability. In conclusion, lotus rhizome could be recommended as functional food. Further studies to clarify bioactive functions of *Nelumbo nucifera* in experimental animal model on atopic dermatitis are in progress.

Key words - NNR, Granule, Tablet, Sensory evalutation

Introduction

Sensory evaluation is defined as scientific discipline used to evoke measure, analyze and interpret reactions to the characteristics of foods and materials as they are perceived by the senses. Sensory evaluation encompasses all of the senses. It takes into account several different disciplines but emphasizes the behavioral basis of perception. It involves the measurement and evaluation of sensory properties of food and other materials. Human judges are used to measure the flavor or sensory characteristics of food. We need to understand variations in natural products but do not tolerate them in processed foods. Sensory evaluation is a critical tool for quality assurance personnel. It can be used to test for off-flavors, changes due to reformulation, the effects of changes in processing, the effects of storage under various conditions (shelf life studies), the effects of packaging, etc.

Nelumbo nucifera Gaertn. (Nymphaeaceae) is a large aquatic herb widely found in the native of India, China, Japan and Korea. Traditional medicinal systems advocate several different therapeutic effects of this herb. The lotus with red and white colored flower is common in Korea. The lotus rhizome is considered to maintain homeostasis and people consume it as foodstuff. The rhizome is considered to be nutritive, demulcent, diuretic and cholagogue and is used to treat piles, dyspepsia and diarrhoea (Kirtikar and Basu, 1975). Different pharmacological and antomicrobial activities of the methanol extract of the rhizomes, including antidiarrhoeal, psychopharmacological, diuretic, antipyretic, antibacterial and antifungal (Mukherjee *et al.*, 1996, 1995) potentials have been reported previously. An increasingly growing market for nutraceuticals and functional foods has triggered the study on natural sources for nutraceuticals, health foods and functional foods (Cevallos-Casals & Cisneros-Zevallos, 2003; Lachance, 2002; Lachance, Nakat, & Jeong, 2001). The rhizome was inconvenient to formulate liquid dosage form (extract) by way of hot water because of its limited storage. Also the majority of the consumers have a complaint against the dosage. Based on this information, we formulated solid dosage form using lotus root as raw material. The purpose of this study was to develop the functional materials from natural resource without side effects.

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Materials and Methods

Formulation of granules and tablets using lotus root as raw material

Ground lotus root was sieved. Then it was mixed with cremophore (corn starch and lactose) which was followed by the addition of disintegrants (starch sodium glycolic acid and crospovidone) and sweetner (aspartame). The mixture was again blended with binders (hydroxypropyl cellulose and polyethylene glycol 4000), colorants (no. 4 yellow lake or red oxidized steel or yellow oxidized steel or black oxidized steel) and solution (ethyl alcohol and distilled water). The different colorants with their different quantity were used to obtain the desired coloring effect. The mixture was then subjected to granulation followed by drying at 50℃ for 3 hours and blending. The mixture thus produced was again subjected to granulation to obtain the desired granules. Then, the tablets were produced by subjecting the granules into compression in the presence of lubricants (magnesium stearate). The contents used in the formulation of lotus root granule (1000㎎/granule) and lotus root tablet (510㎎/tablets) are as shown in Tables 1 and 2 respectively.

Stability evaluation

Condition and state, disintegration, loss on drying and size were the parameters used to evaluate the stability of granule under the room temperature and accelerated condition (40℃ and relative humidity of 75%). Similarly, condition and state, hardness, disintegration and mean weight were used to evaluate the stability of tablet under the room temperature and accelerated condition (40℃ and relative humidity of 75%). Also, condition and state, loss on drying (120℃ for 3 minutes) and residue on ignition (500℃ for 3 hours) were the parameters used to evaluate the stability of raw material i.e lotus root.

a) Disintegration of tablets and granules

Disintegration was carried out in a relatively simple apparatus which consisted of a basket rack holding plastic tubes open at the top and bottom. The bottom was covered with 18 mesh screen. The rack was immersed in water at 37℃. The tablets or granules were put into each tube and the rack was moved up and down at a specified rate of 32 per minute. The time to disintegrate and fall through the screen was noted.

b) Hardness of tablet

Hardness of tablet was carried out using hardness tester. The tablet was placed between two jaws of the hardness tester. The force that just broke the tablet was noted.

c) Loss on drying

Tablets or granules were placed in the crucible and the combined

Table 1. Contents of lotus root granule (1000㎎/granule)

Section	Light green		Yellow	Dark brown	Brown
Main component	Lotus root	500㎎	500㎎	500㎎	500㎎
Cremophores	Cornstarch	255㎎	240㎎	245.8㎎	230㎎
	Lactose(milk sugar)	50㎎	50㎎	50㎎	50㎎
Disintegrants	Starch sodium glycolic acid	20㎎	20㎎	20㎎	20㎎
	Crospovidone	100㎎	100㎎	100㎎	100㎎
Sweetener	Aspartame	10㎎	10㎎	10㎎	10㎎
Binders	Hydroxypropyl cellulose (HPC)	40㎎	40㎎	40㎎	40㎎
	Polyethylene glycol 4000 (PGE4000)	5㎎	5㎎	5㎎	5㎎
Colorants	No. 4 yellow lake	0	15㎎	0	0
	Red oxidized steel	0	0	4㎎	10㎎
	Yellow oxidized steel	0	0	1.4㎎	4㎎
	Black oxidized steel	0	0	3.8㎎	11㎎
Flavorants	Orange cotton	20㎎	20㎎	20㎎	20㎎
Solutions	Ethyl alcohol	0.85ml	0.85ml	0.85ml	0.85ml
	Distilled water	0.3ml	0.3ml	0.3ml	0.3ml
Total		1000㎎	1000㎎	1000㎎	1000㎎

Table 2. Contents of lotus root tablet (510mg/tablet)

Section		Light green	Yellow	Dark brown	Brown
Main component	Lotus root	250mg	250mg	250mg	250mg
Cremophores	Cornstarch	127.5mg	120mg	122.9mg	115mg
	Lactose(milk sugar)	25mg	25mg	25mg	25mg
Disintegrants	Starch sodium glycolic acid	10mg	10mg	10mg	10mg
	Crospovidone	50mg	50mg	50mg	50mg
Sweetener	Aspartame	5mg	5mg	5mg	5mg
Binders	Hydroxypropyl cellulose (HPC)	20mg	20mg	20mg	20mg
	Polyethylene glycol 4000 (PGE4000)	2.5mg	2.5mg	2.5mg	2.5mg
Colorants	No. 4 yellow lake	0	7.5mg	0	0
	Red oxidized steel	0	0	2mg	5mg
	Yellow oxidized steel	0	0	0.7mg	2mg
	Black oxidized steel	0	0	1.9mg	5.5mg
Flavorants	Orange cotton	10mg	10mg	10mg	10mg
Lubricants	Magnesium Stearate	10mg	10mg	10mg	10mg
Solutions	Ethyl alcohol	0.425ml	0.425ml	0.425ml	0.425ml
	Distilled water	0.15ml	0.15ml	0.15ml	0.15ml
	Sum	510mg	510mg	510mg	510mg

mass was taken. The sample was dried at 120℃ for 3 minutes. The final weight was taken. The difference between two weights yielded the water content or loss on drying.

d) Residue on ignition

Sample was placed in crucible and the combined mass was taken. The sample was dried at 500℃ for 3 hours. The difference between the weights yielded the organic content of lotus root.

Sensory evaluation of tablets and granules

A sensorial evaluation performed by 58 non trained volunteers (age between 20 to 60 years) evaluated color, smell, taste and overall of different color samples. A nine-point hedonic scale was used for the analysis.

Results

The respective photographs of the formulated granules and tablets used in the sensory evaluation are as shown in Fig. 1.

Stability evaluation

Stability evaluation of lotus root as a raw material, formulated solid dosage forms granules and tablets are as shown in Tables 3, 4 and 5 respectively. When the granules and tablets were formulated, the peculiar flavor of lotus raw material was changed to feeble orange because of the incorporation of orange cotton as flavoring agent during formulation. The disintegration of granule was within 1 minute while that of tablet was within 3minutes, both in room temperature and accelerated condition. The grain size of all forms of granules was 0.85 ㎛. The brown colored tablet showed the maximum hardness which was 3.7KP in room temperature and 3KP under accelerated condition.

Sensory evaluation

Sensory evaluation of formulated solid dosage forms granules and tablets against the lotus root as raw material are shown in Tables 6 and 7 respectively. The graphical representation of sensory evaluation of formulated solid dosage forms granules and tablets against lotus root as raw material are shown in figures 2 and 3 respectively. Sensory evaluation was performed in terms of color, smell, taste and overall of lotus root and solid dosage forms granules and tablets. The color of light green and yellow granules were more accepted and scored 7.0 ± 1.1 and 7.3 ± 1.3 respectively which possessed $P < 0.001$ against the color of raw material. Similarly, the color of light green tablet was more accepted and

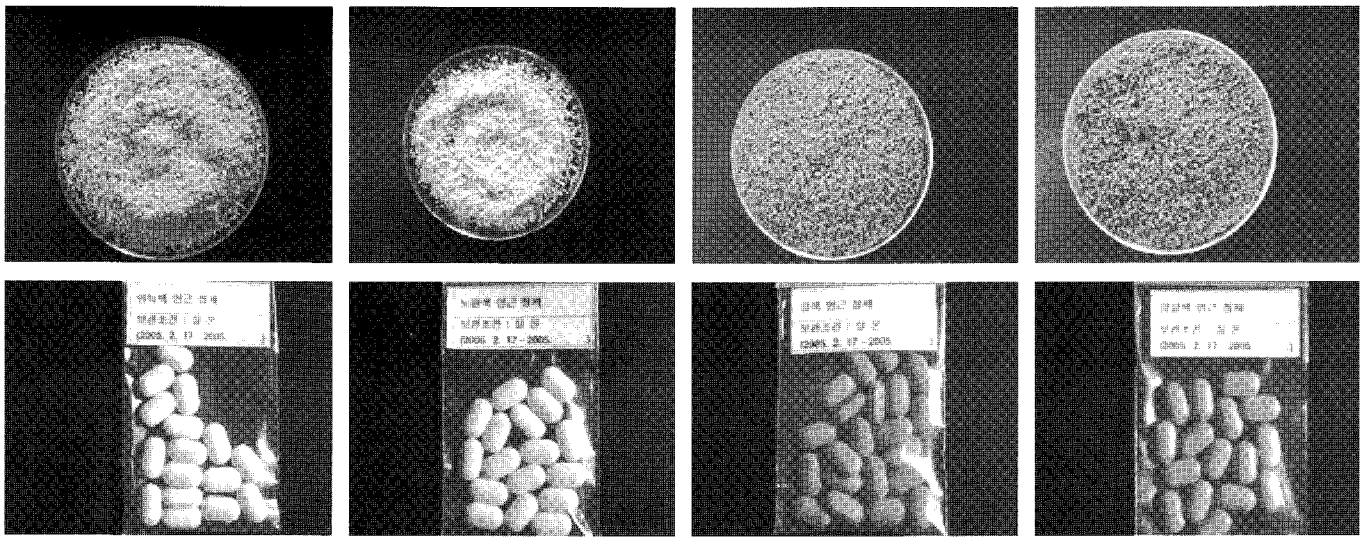

Fig. 1. Photography of solid dosage forms (granules and tablets) for sensory evaluation to lotus raw materials. Panels stand light green (left), yellow, brown and dark brown (right) (from right to left). Upper panels shown are granules and lower panels shown are tablets formulated from lotus root.

Table 3. Stability evaluation of lotus raw materials in room temperature

Section	Initial	After one month	After two months	Reference
Condition and state	Citrine powders of peculiar smell	Citrine powders of peculiar smell	Citrine powders of peculiar smell	Vinyl packing
Reduce the quantity of drying (120℃, 3 min)	2.32%	4.72%	8.03%	
Residue on ignition (500℃, 3 h)	6.47%	6.45%	6.48%	

Table 4. Stability evaluation of lotus root granules in room and accelerated conditions (40℃, relative humidity 75%)

Section		Room temperature		Acceleration	
		Initial	After one month	Initial	After one month
Light green	Condition and state	Feeble orange	Feeble orange	Feeble orange	Feeble orange
	disintegration	Within one minute	Within one minute	Within one minute	Within one minute
	Reduce the quantity of drying	5.01%	5.31%	5.01%	6.98%
	Grain size	More than 0.85㎛	More than 0.85㎛	More than 0.85㎛	More than 0.85㎛
Yellow	Condition and state	Feeble orange	Feeble orange	Feeble orange	Feeble orange
	disintegration	Within one minute	Within one minute	Within one minute	Within one minute
	Reduce the quantity of drying	4.1%	4.5%	4.1%	6.04%
	Grain size	More than 0.85㎛	More than 0.85㎛	More than 0.85㎛	More than 0.85㎛
Dark brown	Condition and state	Feeble orange	Feeble orange	Feeble orange	Feeble orange
	disintegration	Within one minute	Within one minute	Within one minute	Within one minute
	Reduce the quantity of drying	4.9%	5.12%	4.9%	6.81%
	Grain size	More than 0.85㎛	More than 0.85㎛	More than 0.85㎛	More than 0.85㎛
Brown	Condition and state	Feeble orange	Feeble orange	Feeble orange	Feeble orange
	disintegration	Within one minute	Within one minute	Within one minute	Within one minute
	Reduce the quantity of drying	4.1%	4.44%	4.1%	6.12%
	Grain size	More than 0.85㎛	More than 0.85㎛	More than 0.85㎛	More than 0.85㎛

Table 5. Stability evaluation of lotus root tablets in room temperature and accelerated conditions (40℃, relative humidity 75%)

Section		Room temperature		Acceleration	
		Initial (050211)	After one month	Initial (050212)	After one month
Light green	Condition and state	Feeble orange	Feeble orange	Feeble orange	Feeble orange
	disintegration	Within three minute	Within three minute	Within three minute	Within three minute
	Mean weight	605㎎	507㎎	506㎎	507㎎
	hardness	2KP	2KP	2KP	1.7KP
Yellow	Condition and state	Feeble orange	Feeble orange	Feeble orange	Feeble orange
	disintegration	Within three minute	Within three minute	Within three minute	Within three minute
	Mean weight	507㎎	506㎎	507㎎	513㎎
	hardness	2.7KP	2.5KP	2.7KP	2.3KP
Dark brown	Condition and state	Feeble orange	Feeble orange	Feeble orange	Feeble orange
	disintegration	Within three minute	Within three minute	Within three minute	Within three minute
	Mean weight	502㎎	503㎎	502㎎	508㎎
	hardness	2KP	2KP	2KP	1.6KP
Brown	Condition and state	Feeble orange	Feeble orange	Feeble orange	Feeble orange
	disintegration	Within three minute	Within three minute	Within three minute	Within three minute
	Mean weight	509㎎	512㎎	509㎎	515㎎
	hardness	3.7KP	3.5KP	3.7KP	3KP

Table 6. Sensory evaluation of lotus root granules

Group	Color	Smell	Taste	Overall
Raw materials	6.0±1.0	4.6±1.1	5.3±1.3	5.3±1.3
Brown	5.9±1.2	5.2±1.1*	6.6±1.5***	5.9±1.4
Dark brown	5.7±1.3	5.2±1.2*	6.3±1.6**	5.7±1.5
Light green	7.3±1.3***	5.2±1.0**	6.5±1.3***	6.3±1.5
Yellow	6.9±1.6**	5.2±0.8**	6.2± 1.3**	6.1±1.4

Statistical significances: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ vs. raw material values.
Nine-point hedonic scale rating : 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely.

Table 7. Sensory evaluation of lotus root tablets

Group	Color	Smell	Taste	Overall
Raw materials	6.0±1.0	4.6±1.1	5.3±1.3	5.3±1.3
Brown	6.0±1.1	6.8±1.1***	5.6±1.5	6.2±1.3
Dark brown	5.8±1.2	6.3±1.2***	5.5±1.4	5.9±1.3
Light green	7.0±1.1***	6.1±1.2***	5.7±1.3	6.3±1.3
Yellow	7.3±1.3***	6.5±1.2***	5.6±1.5	6.5±1.5

Statistical significances: *** $p < 0.001$ vs. raw material values.
Nine-point hedonic scale rating : 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely.

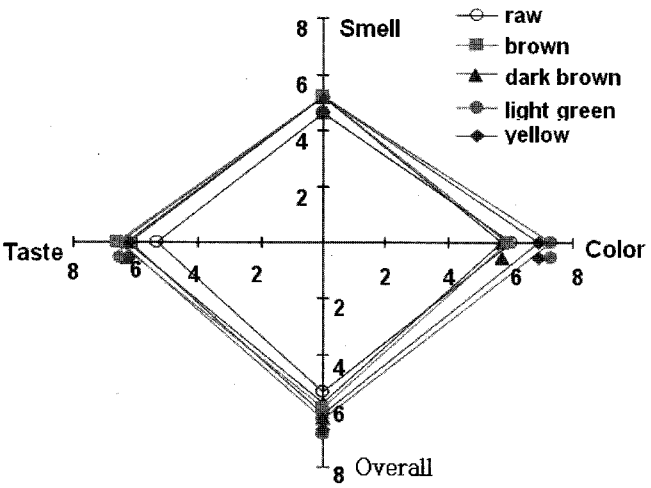

Fig. 2. Sensory evaluation of lotus root granules.

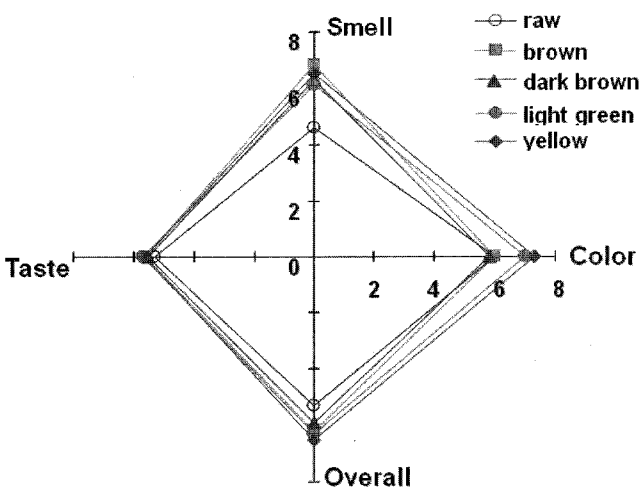

Fig. 3. Sensory evaluation of lotus root tablets.

scored 7.3 ± 1.3. The smell of all forms of granules was improved while the smell of light green and yellow colored tablets was accepted. There was no change in the taste of granules while light green and brown colored tablets showed the improved effects which were scored as 6.5 ± 1.3 and 6.6 ± 1.5 respectively ($P < 0.001$). Thus, light green and yellow colored tablets and granules showed the improved overall sensory evaluation.

Discussion

Nelumbo nucifera root possesses different pharmacological effect. Oral administration of the ethanolic extract of rhizomes of *Nelumbo nucifera* markedly reduced the blood sugar level of normal, glucose-fed hyperglycemic and streptozotocin-induced diabetic rats, when compared with control animals (Mukherjee *et al.*, 1997). The methanolic extract of the *Nelumbo nucifera* root showed antipyretic effect and psychopharmacological actions in rats and mice (Mukherjee *et al.*, 1996). In addition, we reported that lotus rhizome has inhibitory activities on smooth muscle cell proliferation related to the progression of atherosclerosis and cytotoxicity of liver cancer cells (Kim *et al.*, 2005). Although whole lotus plant is edible, the root is commonly consumed. Different food products have been developed from the flour of lotus root. So, lotus root has both pharmacological and nutritive value. But it is very important to consider the consumer acceptability which can be evaluated through sensory evaluation. The physical condition, state, hardness, weight, disintegration etc are the parameters of stability evaluation that should be considered while launching the product to the market. Without appropriate sensory analysis, there is a high risk of market failure. Sensory analysis is too frequently often overlooked as a requirement before product launch (Arazi and Kilcast, 2001). The incorporation of flavorants and sweetners during the formulation of tablets and granules from lotus root has made the granules and tablets more palatable, which helped to improve their acceptability. Moreover, the stability evaluation has aided to improve the acceptability of the products. In sensory evaluation, among the formulated tablets and granules, light green granules obtained best score overall and yellow tablets showed the overall improved acceptability.

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