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Investigation of Instant Soluble Herb Tea Production from Lotus (*Nelumbo Nucifera*) Rhizome

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Abstract.

Rhizome of *Nelumbo nucifera* is known to contain different bioactive phytochemical constituents. The rhizomes are used as popular health food. Lotus rhizomes are composed of proteins, fats, carbohydrates and minerals and are good source of energy. The lotus rhizomes are popularly used as vegetables. The lotus rhizomes need to be exploited for the development of value added products. We investigated a production of instant soluble herb tea from lotus root by investigating the raw lotus root, method of extraction and spray drying to get an optimal processing protocol for herb tea production. Our results showed that raw lotus root should be chopped and freeze-dried to 8% moisture; solvent for extraction of lotus root herb tea should be 30% ethanol: 1% acetic acid; ratio of solvent to material should be 8:1 in 24 hours at 70^{o}C by deep soaking. Spray drying conditions to get herb tea powder should be 6% maltodextrin as carrier; 140^{o}C as drying temperature; 250 ml/h as volumn of input feeding for spraying, 8% of isomalt as supplementation.

Keywords: *Lotus rhizome, herb tea powder, extraction, spraying, maltodextrin, isomalt*

1. INTRODUCTION

Lotus (*Nelumbo nucifera*) is an aquatic perennial plant belonging to family *Nelumbonaceae.* It is an aquatic plant that grows naturally in the South of Vietnam. Its roots remain fixed within the muddy bottom of the water bodies and the leaves as large as 60 cm in diameter float over the surface of water. *The lotus plant* grows by extending a creeping rhizome through anaerobic sediments at the bottom of the water body. The petioles and the rhizome bear gas canals which channel air from the leaves throughout the petioles and rhizomes.[1] Its rhizome, petal, and leaf have been consumed as common food ingredients. It is also extensively used as a traditional herb medicine.[2, 3] Lotus rhizome contains several biological active compounds such as polyphenolic compounds (kaempferol, quercetin, and isoquercetin) and oligomeric procyanidines. It contains abundant dietary fiber consisting of non-carbohydrate components.[4, 5] Moreover, lotus rhizome has been reported to have multiple physiological efficacies, including hypolipemic, anti-inflammatory, antipyretic, antioxidaive, anti-obesity and anti-hypercholesterolemia activities. [6, 7, 8, 9, 10] Rhizome extract of N.nucifera showed potential antimicrobial activity against both Gram-positive and Gram-negative bacteria.[11] It was used in the treatment of diarrhea, tissue inflammation, and homeostasis.[12] The extract improved glucose tolerance and potentiated the action of exogenously injected insulin.[13] It has a potential activity improving learning and memory functions.[14] Lotus root extract is considered to contain novel substance(s) protecting glial cells against the iron-induced oxidative insults.[15]

Lotus rhizome powder, an antioxidant dietary fiber, could be used as an effective natural ingredient in meat products for the development of healthier and functional food.[16] Extract of lotus root (*Nelumbo nucifera* rhizome) caused necrotic damage to human colorectal cancer cells in culture.[14] There was a significant difference in total phenolic content and antioxidant activity between any two of four parts of lotus rhizome. The order of total phenolic content and antioxidant activity in different parts of lotus rhizome was as follows: peel of old lotus rhizome > peel of young lotus rhizome > flesh of old lotus rhizome > flesh of young lotus rhizome.[17]

In order to improve the added value of this vegetable, we investigated a production of one functional instant soluble herb tea from lotus root by investigating the raw lotus root, method of extraction and spray drying to get an optimal processing protocol for instant herb tea powder.

2. MATERIAL & METHOD

2.1 Material

We collected lotus root fruits from the Dong Thap province, Vietnam. Lotus root fruits should be cultivated following Vietnamese Good Agriculture Practices (VietGAP) to ensure food safety.

Figure 1. Lotus (*Nelumbo nucifera*) rhizome

2.2 Research method

2.2.1 Investigation of raw material storage

We monitored the flavonoid content in lotus root fruits in two conditions: normal room temperature, cooling to 10^{o}C.

2.2.2 Investigation of sun drying for raw material

Our experiment focused on three groups: normal sun drying, conventional drying at 60-80^{o}C and freeze drying to 8% moisture content. After treatment, we tested these samples in 2 days periodically regarding to flavonoid content.

2.2.3 Investigation of solvent extraction

We investigated the effect of solvent extraction (30% ethanol: 1% acetic acid) in 3 groups: soaking with solvent, deep soaking with solvent and Soxhlet. After treatment, we analyzed flavonoid recovery in these samples.

2.2.4 Investigation of temperature, solvent/material, and time of extraction

Our experiments implemented on the temperature, solvent/material and time of extraction to verify the optimal parameters. Solvent for extraction was selected as 30% ethanol:1% acetic acid. Temperature of extraction was demonstrated as 60^{o}C, 70^{o}C, 80^{o}C. Solvent/ material was demonstrated as ratio of 6:1, 8:1, 10:1. Time of extraction was demonstrated as 12 hours, 24 hours, 36 hours. After treatment, we analyzed flavonoid recovery in these samples.

2.2.5 Investigation of carrier, temperature, input feeding, and isomalt supplementation for spraying

Our experiments focused on testing optimal parameters for spraying such as maltodextrin carrier (4%, 6%, 8%), temperature (120^{o}C, 140^{o}C, 160^{o}C), input feeding (200 ml/h, 250 ml/h, 300ml/h) and isomalt supplementation (6%, 8%, 10%). We analyzed flavonoid content in tea powder.

2.2.6 Sampling method

We collected 1,000 gram in each sample from 3-5 pieces randomly.

2.2.7 Analytical method

Color of lotus root tea was measured by colorimeter (Minota); soluble dry matter was counted by refractometer; moisture content was analyzed by drying to constant weight; total flavonoids was measured by high performance liquid chromatography; yeast and mold were counted by Petrifilm (3M).

2.2.8 Sensory analysis

Sensory acceptance was evaluated by consumer satisfaction in score range from 1 to 9 (Hedomic) for the product color and taste.

2.2.9 Statistical analysis

Data were statistically summarized by Microsoft Excel.

3. RESULT & DISCUSSION

3.1 Determination of raw material storage

We monitored the weight change of lotus root fruits by time in two different storage conditions: normal room temperature and cooling to 10^{o}C. Our results were as follows:

Table 1. Weight loss of lotus root fruits by different storage condition

Days of preservation	Normal room temperature		Cooling to 10^{o}C	
	Weigh loss (%)	Flavonoid (g)	Weigh loss (%)	Flavonoid (g)
0	0^e	0.067±0.01^a	0^e	0.067±0.01^a
2	1.26±0.03^d	0.055±0.03^b	1.18±0.01^d	0.064±0.02^{ab}
4	2.43±0.02^c	0.051±0.02^c	2.30±0.02^c	0.060±0.01^b
6	3.42±0.01^b	0.047±0.01^{cd}	2.93±0.00^b	0.057±0.04^{bc}
8	4.34±0.02^a	0.044±0.02^d	3.14±0.03^a	0.053±0.02^c

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

From table 1, we noticed that keeping lotus root fruits in cooling temperature (10^{o}C) was better than keeping in normal one. Lotus roots have been found to be rich in dietary fiber, vitamin C, potassium, thiamin, riboflavin, vitamin B6, phosphorus, copper, and manganese, while very low in saturated fat.[18]

Table 2. Change of flavonoid in lotus root pellets by different drying methods

Days of preservation	Flavonoid (g) in lotus root pellets by different drying methods		
	Normal sun drying	Conventional drying	Freeze drying
0	0.067±0.01^a	0.067±0.01^a	0.067±0.01^a
2	0.060±0.03^b	0.063±0.02^a	0.062±0.01^{ab}
4	0.056±0.04^b	0.058±0.03^{ab}	0.061±0.03^a
6	0.049±0.01^b	0.053±0.02^{ab}	0.057±0.01^a
8	0.042±0.02^b	0.051±0.02^{ab}	0.053±0.02^a

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

3.2 Effect of sun drying for raw material

Our experiment focused on three groups: normal sun drying, conventional drying at 60-80^{o}C and freeze drying to 8% moisture content. Our results showed as table 2. We clearly found that freeze drying was the best option to maintain the flavonoid content in lotus root pellets.

Lotus rhizomes (Nelumbo nucifera Gaertn.) were pretreated using the following 4 treatments, blanching at 40°C, blanching at 90°C, soaking in 0.5% $CaCl_2$, and blanching at 40°C followed by immersion in 0.5% $CaCl_2$. The greatest hardness was obtained after blanching at 40 °C in $CaCl_2$.[19] Lotus root slices were dehydrated with polyethylene glycol. The PEG-treated samples had better results than those of freeze dried or hot-air dried samples in terms of rehydration ratio and color. The total phenolic content of the PEG-treated samples was higher than that of the freeze dried or hot-air dried sample. The microstructure of the PEG-treated samples was better than that of the freeze dried or hot-air dried one.[20]

3.3 Effect of solvent extraction

We investigated the effect of solvent extraction in 3 groups: soaking with solvent, deep soaking with solvent and Soxhlet. Temperature for extraction was kept at 70^{o}C. Our results showed as table 2. We clearly found that Sohxlet was the best choice to obtain as much as flavonoid. However, when applying in the industrial scale, Sohxlet will be not convenient so we believe deep soaking with solvent will be resonable.

Methanol was more suited to the extraction of phenolics from lotus root than ethanol, acetone, ethyl acetate, dichloromethane, and petroleum ether. Total phenolics in their flesh, peel and nodes were 1.81, 4.30 and 7.35 mg gallic acid equivalents (GAE)/g fresh weight (FW), and those of total flavonoids were 3.35, 7.69 and 15.58 mg rutin equivalents/g FW.[21]

3.4 Effect of temperature, solvent/material, and time of extraction

Our experiments implemented on the temperature, solvent/material and time of extraction to verify the optimal parameters. Solvent for extraction was selected as 30% ethanol:1% acetic acid. Deep soaking was applied in this experiment. Temperature of extraction was demonstrated as 60^{o}C, 70^{o}C, 80^{o}C. Solvent/ material was demonstrated as ratio of 6:1, 8:1, 10:1. Time of extraction was demonstrated as 12 hours, 24 hours, 36 hours. After treatment, we analyzed flavonoid recovery in these samples. Our results depicted as in table 4.

Table 3. Recovery of flavonoid (%) in fluid by different extraction methods

Days of preservation	Recovery of flavonoid (%) in fluid by different extraction methods		
	Soaking with solvent	Deep soaking with solvent	Soxhlet
0	69.75±0.02^{c}	70.23±0.01^{b}	84.86±0.01^{a}
2	68.19±0.01^{c}	69.91±0.01^{b}	83.81±0.02^{a}
4	67.39±0.01^{c}	69.47±0.04^{b}	82.72±0.01^{a}
6	65.22±0.03^{c}	68.84±0.02^{b}	81.94±0.03^{a}
8	65.11±0.03^{c}	66.91±0.01^{b}	81.63±0.01^{a}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 4. Recovery of flavonoid (%) in fluid by temperature, solvent/material and time of extraction

Preservation days	Temperature of extraction			Solvent: material			Time of extraction		
	60^{o}C	70^{o}C	80^{o}C	6:1	8:1	10:1	12h	24h	36h
0	68.63 ±0.01^{b}	70.19 ±0.04^{a}	70.19 ±0.01^{a}	68.57 ±0.01^{b}	70.27 ±0.03^{a}	70.31 ±0.03^{a}	66.17 ±0.02^{b}	70.20 ±0.03^{a}	70.31 ±0.02^{a}
2	65.37 ±0.02^{b}	69.97 ±0.02^{a}	70.08 ±0.03^{a}	67.49 ±0.01^{b}	69.93 ±0.02^{ab}	70.11 ±0.04^{a}	65.91 ±0.01^{b}	70.08 ±0.02^{a}	70.29 ±0.01^{a}
4	64.20 ±0.03^{b}	69.49 ±0.01^{a}	69.57 ±0.04^{a}	65.25 ±0.02^{b}	69.49 ±0.01^{a}	69.59 ±0.02^{a}	64.37 ±0.02^{b}	69.61 ±0.01^{a}	70.11 ±0.01^{a}
6	63.11 ±0.01^{b}	68.93 ±0.03^{a}	68.96 ±0.05^{a}	64.84 ±0.01^{b}	68.77 ±0.02^{ab}	69.09 ±0.01^{a}	63.18 ±0.02^{b}	68.77 ±0.04^{ab}	69.19 ±0.03^{a}
8	62.67 ±0.03^{b}	67.14 ±0.02^{a}	67.17 ±0.01^{a}	63.21 ±0.03^{b}	67.93 ±0.01^{ab}	78.13 ±0.01^{a}	62.65 ±0.01^{b}	67.39 ±0.02^{ab}	68.13 ±0.03^{a}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 5. Recovery of flavonoid (%) in lotus root tea powder by different spraying parameters

Preservation days	Maltodextrin carrier (%)			Spraying temperature (^{o}C)			Input feeding for drying (ml/h)			Isomalt supplementation (%)		
	4	6	8	120	140	160	200	250	300	6	8	10
0	68.46 ±0.01^{b}	70.29 ±0.01^{ab}	70.34 ±0.03^{a}	68.97 ±0.02^{ab}	70.30 ±0.01^{ab}	70.35 ±0.02^{a}	68.55 ±0.03^{b}	70.27 ±0.01^{a}	70.32 ±0.02^{a}	68.67 ±0.02^{b}	70.35 ±0.00^{ab}	70.39 ±0.01^{a}
2	65.29 ±0.04^{b}	69.11 ±0.02^{ab}	70.15 ±0.01^{a}	65.40 ±0.03^{b}	70.11 ±0.02^{ab}	70.26 ±0.01^{a}	65.29 ±0.02^{c}	69.80 ±0.02^{b}	70.11 ±0.01^{a}	65.48 ±0.02^{b}	69.89 ±0.03^{ab}	70.11 ±0.02^{a}
4	64.49 ±0.02^{b}	69.37 ±0.01^{ab}	69.55 ±0.01^{a}	64.28 ±0.02^{b}	69.59 ±0.03^{ab}	69.69 ±0.02^{a}	64.27 ±0.01^{c}	69.55 ±0.00^{b}	69.60 ±0.02^{a}	64.31 ±0.01^{b}	69.47 ±0.02^{a}	69.64 ±0.03^{a}
6	63.20 ±0.01^{b}	68.79 ±0.02^{ab}	68.80 ±0.01^{a}	63.17 ±0.04^{b}	68.60 ±0.01^{ab}	69.14 ±0.02^{a}	63.49 ±0.02^{c}	68.79 ±0.00^{b}	68.97 ±0.00^{a}	63.22 ±0.00^{b}	68.75 ±0.02^{ab}	68.89 ±0.02^{a}
8	62.54 ±0.03^{b}	67.20 ±0.02^{ab}	67.39 ±0.02^{a}	62.44 ±0.04^{b}	67.27 ±0.03^{ab}	67.20 ±0.03^{a}	62.56 ±0.03^{c}	67.63 ±0.00^{b}	67.31 ±0.01^{a}	62.54 ±0.01^{b}	67.33 ±0.01^{a}	67.77 ±0.02^{a}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 6. Quality of lotus root herb tea powder

Criteria	Preservation days		
	1 month	6 months	12 months
Color value	0.94±0.01^{a}	0.91±0.02^{ab}	0.90±0.00^{b}
Consumer tastes (Hedonic)	8.23±0.03^{a}	8.21±0.00^{ab}	8.20±0.01^{b}
Soluble dry matter (%)	35±0.02^{a}	33±0.02^{ab}	31±0.01^{b}
Moisture (%)	8.0±0.02^{b}	8.2±0.00^{ab}	8.3±0.01^{a}
Flavonoid (g)	0.053±0.00^{a}	0.051±0.00^{ab}	0.050±0.00^{b}
Yeast and mold (cfu/g)	0	0	0

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Extraction at 80^{o}C gave us a little bit higher recovery of flavonoid to the extraction at 70^{o}C, however we consumped more energy for vapor. Solvent: material at 10:1 gave us a little bit higher recovery of flavonoid to the extraction at 10:1 however it's not benificial in economics. Similarly, extraction in 36 hours will obtain a little bit higher recovery of flavonoid to the extraction at 24 hours but it's too long. So we decided to choose 70^{o}C as extraction temperature, 8:1 as solvent: material extraction, and extraction as long as 24 hours.

3.5 Effect of carrier, temperature, input feeding, and isomalt supplementation for spraying

Our experiments focused on testing optimal parameters for spraying such as maltodextrin carrier (4%, 6%, 8%), temperature (120^{o}C, 140^{o}C, 160^{o}C), input feeding (200 ml/h, 250 ml/h, 300ml/h) and isomalt supplementation

(6%, 8%, 10%). After treatment, we analyzed flavonoid recovery in tea powder. Our results depicted as in table 5.
Spraying parameters were recorded with non-significant difference while comparing 6% and 8% maltodextrin as carrier; 140^{o}C and 160^{o}C as spraying temperature, 250 ml/ h and 300ml/h as input feeding, 8% isomalt and 10% isomalt as supplementation. So we decided to choose 6% maltodextrin as carrier, 140^{o}C as spraying temperature, 250 ml/ h as input feeding, 8% isomalt as supplementation.

3.6 Evaluation on sensory, physical, biological aspects of lotus root herb tea powder

Lotus root herb tea powder was evaluated color by colorimeter (Minota); consumer tastes by Hedonic scale; soluble dry matter by refractometer; moisture content by drying to constant weight; total flavonoids by high performance liquid chromatography; yeast and mold by Petrifilm (3M). Our results were all acquired TCVN 9740:2013 and ISO 11287:2011.
The variations in antioxidant activity and concentration of functional components in the ethanol extracts of lotus seeds and rhizomes based on the growing region and dryness were investigated. Free radical scavenging activity, total phenolic and flavonoid content, and concentration of several specific flavonoids and alkaloids in the ethanol extracts of lotus were measured. Antioxidant activity and its correlative total phenolic content varied characteristically depending on the growing region and dryness.[22]

4. CONCLUSION

Nelumbo nucifera is grown naturally in the lakes. *N. nucifera* have been used for various medicinal purposes in various systems of medicine. The bioactive constituents of lotus are mainly alkaloids and flavonoids. The rhizome extract was used as antidiabetic and anti-inflammatory properties due to the presence of asteroidal triterpenoid. We have successfully studied to produce one kind of instant soluble tea powder from lotus rhizome. In cultures where it occurs naturally it is known not only as a fragrant tea, but as having health and medicinal benefits as well. Lotus can be regarded as a potential nutraceutical source.

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