Production and Marketing Reports

Prescreening Consumer Acceptance for Edible Lotus Rhizome

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ADDITIONAL INDEX WORDS. *Nelumbo nucifera*, testing, consumer preferences, market development

SUMMARY. Lotus (*Nelumbo nucifera* Gaertn.) is an underused edible aquatic perennial vegetable currently evaluated as a potential functional food source and promoted in the southeastern United States as a rich source of phytonutrients. There is a paucity of information concerning consumer acceptance and willingness to purchase edible, value-added lotus products in the southeastern United States. The purpose of this exploratory study was to evaluate the potential demand and consumer preference for fresh lotus rhizomes and value-added products namely lotus salad, baked lotus chips, and lotus stir-fry. Results of two taste panels indicated that lotus stir-fry was the most preferred value-added product with 77% of participants strongly liking stir-fry, whereas 92% of the participants were willing to recommend this preparation. Results suggest socioeconomic characteristics such as gender ($P = 0.014$), age ($P = 0.005$), income ($P = 0.043$), education ($P = 0.003$), shopping habits ($P = 0.013$), and type of meal purchased ($P = 0.004$) are the factors affecting consumer choice and willingness to recommend lotus stir-fry. Results provide information on consumer acceptance of fresh lotus rhizomes and value-added products. Findings of this case study will assist in analyzing consumer behavior and development of sustainable niche markets for locally cultivated fresh edible lotus rhizomes.

Lotus is an aquatic perennial vegetable native to many subtropical and temperate zones, and cultivated extensively throughout Asia (Huang et al., 2003). Rhizomes, stems, flowers, seeds, and young leaves of lotus are in great demand and considered a dietary vegetable staple in many Asian cultures because of their high content of protein, amino acids, dietary fiber, carbohydrates, vitamins C, B₁, B₂, and E, carotenoids, phenolic compounds, and macro/micronutrients (Gong et al., 2008; Hertog, 1994; Sridhar and Bhat, 2007). Appeal for fresh edible lotus and value-added products is favored by persons of Asian

descent because of its crispy texture, and distinctive aroma and taste. Lotus rhizomes are used extensively in culinary preparations such as soups, salads, desserts, and stir-fried food in China, Japan, India, Vietnam, and Australia (Wu, 1987).

Lotus is valued and used extensively for various medicinal and pharmacological purposes familiar to Asian and Native American cultures such as the Osage Indians of Oklahoma that consume large quantities of lotus as a medicinal plant (Swan, 2010). Lotus has traditionally been used as a diuretic and anthelmintic, in the treatment of strangury, leprosy, tissue inflammation, skin diseases,

certain forms of cancer, nervous exhaustion, and as a poison antidote. In addition, lotus rhizomes have been used for pharyngopathy, pectoralgia, spermatorrhea, leukoderma, small pox, diarrhea, dysentery, and as a cough suppressant (Mehta et al., 2013). Leaves are used as an effective drug for hematemesis, epistaxis, hemoptysis, hematuria, hyperlipidemia, and metrorrhagia (Ou, 1989). Lotus has extensively been screened for potential pharmacological activities associated with anticancer, antiobesity, antioxidant, anti-inflammatory, and antiviral activity, as well as to fight neurodegenerative diseases and enhance cardiovascular activity (Mehta et al., 2013). Although lotus is indigenous in many areas in Alabama and the United States, the prospect of cultivating lotus commercially presents several questions concerning its sustainability as a specialty vegetable crop in Alabama and the United States. However, concerns of potential heavy metal contamination of imported fresh and minimally processed lotus rhizomes provide justification for domestic production of this highly valued aquatic vegetable (Khan et al., 2008; Liu et al., 2005; Xiong et al., 2013; Zhuang et al., 2009).

From 1990 to 2010, the Asian population in the United States increased from 2.8% to 4.8%. The U.S. Hispanic/Latin population in 2012 was 53 million, nearly six times the population in 1970 (U.S. Census Bureau, 2013). The associated increase of these segments of the population has a concurrent rise in demand for fresh fruit and vegetables familiar to these demographic segments of the population. In recognition of the changing American palate, vegetable producers must continually identify new and emerging underused horticultural commodities that are economically viable and unique to their region. Currently, there is an abundance of lotus products available in Asian supermarkets in the United States; however, increasingly, there remains an opportunity to expand the supply of fresh and/or minimally processed lotus. Research efforts addressing domestic niche market development in regard to fresh lotus rhizome production were conducted to assess the potential economic (Tian et al., 2006) and sustainability of lotus

rhizomes as an alternative functional food for the southeastern United States (Orozco-Obando, 2012; Tian, 2008; Tian et al., 2008, 2009a, 2009b; Wang, 2014). Several studies indicate consumer willingness to pay a premium for functional foods with expectations of potential health benefits (Niva, 2007; Sibbel, 2007; Sloan, 2000). Lotus offers unique marketing advantages as a functional food and as a medicinal plant due to phytonutrient content that particularly appeal to Asian and Latin American populations. These characteristics could be used for marketing lotus and eventual establishment and commercialization of lotus as a functional food and specialty vegetable crop in the United States.

Telephone interviews conducted with produce managers familiar with the diversity of lotus products at various international markets within Alabama and Georgia (Sand et al., 2012) indicate seasonal unavailability of imported fresh lotus rhizomes from China during summer. Consequently, the majority of the lotus rhizomes sold at these international markets from May to August is minimally processed and not fresh. Interestingly, the lack of fresh lotus rhizome availability will offer commercial opportunities for domestic production (all international markets were interested in buying locally grown fresh lotus rhizomes). Lotus rhizomes are highly perishable and have a limited shelf life due to microbial spoilage (Guo, 2008; Jiang et al., 2012). Refrigerated storage is the primary means of extending shelf life of both fresh and minimally processed

rhizomes. Maintaining freshness, appearance, and nutritional quality of lotus rhizomes is of paramount importance to consumers. According to telephone interviews (Sand et al., 2012), all produce managers surveyed were willing to purchase fresh locally cultivated lotus weekly to satisfy local market demand. The apparent demand and willingness to purchase fresh lotus suggests potential niche market for locally cultivated lotus rhizomes.

In consideration of changing ethnic demographics within the United States, the global objective of the present exploratory study was to evaluate consumer preference for three different preparations of fresh lotus rhizomes and value-added products (U.S. Census Bureau, 2013). In addition, if exploitation of this nutritionally underused aquatic vegetable crop is to be achieved, there are educational needs for the general public on its potential beneficial health properties. To the best of our knowledge, this is the first consumer taste panel conducted and reported in the southeastern United States for fresh lotus rhizomes. Information gained through this exploratory case study will assist lotus producers in developing marketing strategies to stimulate commercialization and market demand of locally cultivated lotus rhizomes. To achieve this goal, an exploratory consumer taste panel was assembled to evaluate consumer preference for diverse lotus preparations.

Materials and methods

SITE AND PANEL SELECTION, PROCUREMENT, AND PREPARATION OF LOTUS. Consumer taste panels were assembled in Auburn University's Department of Nutrition Dietetics and Hospitality Management (AUNDHM, Auburn, AL) and Amsterdam Café (Auburn, AL), a locally owned restaurant specializing in international cuisine using locally produced products. The current project was given approval to proceed as per the Auburn University Institutional Review Board for Research Involving Human Subjects (study no. 11-217-EX 1107), and participants provided their informed consent. The first taste panel was conducted in the AUNDHM consumer sensory laboratory facility that contained fluorescent lighting, temperature control, and individualized seating with partitions to accurately

reflect conducive simulated controlled laboratory conditions. A total of 27 panelists recruited through the use of on-campus e-mails, flyers, phone calls, and campus class announcements participated in the AUNDHM taste panel. Fresh lotus for this exploratory study was purchased at Buford Highway International Farmers Market in Atlanta, GA, the day before the consumer taste panel determination. Lotus rhizomes were rinsed and care was taken to minimize bruising before further food preparation. Lotus rhizomes are particularly susceptible to enzymatic browning as the result of mechanical wounding. Lotus preparations were served to taste panel participants by horticulture and agricultural economics and rural sociology technical assistants, and participants were asked to drink water and consume unsalted crackers between preparations to cleanse their palates. Participants were asked to refrain from discussing their findings with each other.

The second taste panel was conducted at Amsterdam Café where 42 panelists were recruited through the use of the restaurant's website and Facebook pages as well as by e-mails sent throughout Auburn University campus. The chef at the restaurant was able to procure fresh lotus rhizomes from his local Sysco™ (Houston, TX) supplier. Lotus was served to the panel in three different preparations namely lotus salad, lotus stir-fry, and lotus chips (oven baked) in authentic consumer environment (Table 1).

SURVEY INSTRUMENT. The questionnaire consisted of two sections. The first section included three statements: 1) I would eat this preparation again, 2) I would recommend this preparation to others, and 3) I did enjoy the taste of the preparation. Participants rated each statement from 1 to 5, with 5 being strongly agreeing with the statement, 1 being strongly disagreeing with the statement, and 3 being neither agreeing nor disagreeing with the statement. Likert scale questions are very commonly used in studies to gauge potential demand and acceptance of different foods (House et al., 2004; Lusk and Coble, 2005; Lusk and Parker, 2009). The second section included demographic questions concerning participants' gender,

This work was supported by the Alabama Agricultural Experiment Station.

We gratefully acknowledge the technical assistance of David Bancroft of Amsterdam Café, Megan Johnson, Martin O'Neill from Department of Nutrition, Dietetics and Hospitality Management, Shannon Sand, Patricia Duffy, Norbert Wilson from Department of Agricultural Economics and Rural Sociology, Bernice Fischman, from Horticulture Department, Tung-Shi Huang, from Poultry Science and Auburn University Alabama Agricultural Experiment Station.

Mention of commercial vendor citing is not an endorsement.

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doi: 10.21273/HORTTECH03298-16

Table 1. List of ingredients contained in Asian salad, stir-fried, and chip lotus rhizome preparations and method of preparation used in a prescreening consumer taste panel study of lotus acceptance at Auburn, AL, in 2012.

Preparation served	Supplemental ingredients used	Method of preparation
Asian salad	Soy sauce, white vinegar, sesame oil, chopped cilantro, and sesame seeds	Asian salad was prepared by parboiling the lotus rhizomes in water for 20 min. The lotus rhizomes were then tossed in vinaigrette of soy sauce, sesame oil, white vinegar, and chopped cilantro.
Stir-fry	Fresh button mushrooms, salt, peanut oil, garlic, onion, snow peas, sugar, soy sauce, chicken broth, and sesame oil	Stir-fry was prepared by stir-frying lotus rhizomes in sugar, soy sauce, chicken broth, and sesame oil in peanut oil for 20–30 min or until tender and then adding in, fresh button mushroom, salt, garlic, onion, snow peas in the last 5–10 min before serving.
Chips (oven baked)	Rice vinegar, garlic salt, and olive oil	Lotus chips were prepared by thinly slicing lotus rhizomes and tossing them in rice vinegar, garlic salt, and olive oil. The chips were baked at 350 °F (176.7 °C) for 60 min flipping the chips every 15 min.

ethnicity, income, fruit and vegetable eating habits, the type of meal most often eaten away from home, how often they ate away from home, and whether they were the primary grocery shopper in the household. Strongly agree and agree (5 and 4) were combined to analyze positive responses. Disagree and strongly disagree (2 and 1) were combined to analyze negative responses. Neither agree nor disagree (3) was not used due to the lack of response (data not shown). Data were analyzed using descriptive statistics and analysis of variance with the SAS software package (version 9.3; SAS Institute, Cary, NC).

Results

DEMOGRAPHICS. Demographic information indicated 76% of the participants were Caucasian, 16% Asian, and 8% African American (Table 2). About 54% of the participants were male and were between 18 and 35 years of age (70%). About 54% of the participants had at least obtained one college degree; 54% had income less than \$40,000, and 62% were primary shoppers.

Concerning participants' eating behaviors, most participants (69%) stated that they consumed/purchased fruits and vegetables every day, 27% consumed fruits and vegetables at least once every week, and the remaining 4% consumed fruits and vegetables at least once per month. When asked how many times they dine out per week, half of the participants indicated one to three times, whereas 27% indicated four to five times, 19% indicated less than once per week, and 4% indicated that they dined out every day. Almost 44% of the participants typically purchased dinner, 36% of

Table 2. Demographic information concerning consumers participating in a prescreening taste panel study of lotus acceptance at Auburn, AL, in 2012. A total of 27 consumers participated at Auburn University's Department of Nutrition Dietetics and Hospitality Management taste panel and 42 at Amsterdam Café taste panel.

Variables	Frequency (%)
Ethnicity	
African American	8
Asian	16
Caucasian	76
Gender	
Male	54
Female	46
Age (years)	
18–24	50
25–35	23
55 and above	27
Education	
High-school graduate	8
Some college or trade/vocational school	38
College graduate	27
Advance degree	27
Income	
Less than \$40,000	57
\$40,000–\$99,999	31
\$100,000 and above	12
Primary household shopper	
Yes	62
No	38
Eating habits	
Consume/purchase fruits and vegetables every day	69
Consume/purchase fruits and vegetables once per week	27
Consume/purchase fruits and vegetables once per month	4
Go out to eat every day	4
Go out to eat four to five times per week	27
Go out to eat one to three times per week	50
Go out to eat less than once per week	19
Purchase lunch	36
Purchase dinner	44
Purchase snacks	20

them purchased lunch, whereas 20% purchased snacks.

LOTUS DISH PREFERENCES. According to the data, only 30% of

the participants had some knowledge about lotus rhizome, its health benefits, and its preparations (data not shown). Participants were asked

to provide a preference rating for each dish. Participants enjoyed lotus stir-fry the most, followed by baked lotus chips and lotus salad. About 77% of the participants stated they really like stir-fry compared with 52% for baked lotus chips and 47% for lotus salad (Table 3). Among respondents, 92% strongly agreed with the statement that they would buy/eat again lotus stir-fry, 62% for baked lotus chips, and 59% for lotus

salad. Moreover, 80% of the participants indicated that they would strongly recommend lotus stir-fry, whereas 39% were willing to recommend baked lotus chips, and 34% were willing to recommend lotus salad to their relatives.

Furthermore, data revealed that Asian panelists were more receptive to various lotus preparations, with 100% of them willing to recommend lotus salad or lotus stir-fry. This is likely

explained by their familiarity with these culinary choices. However, African American and Caucasian panelists seemed to appreciate lotus stir-fry with 100% of African American and 74% of Caucasian panelists willing to recommend lotus stir-fry. Panelists consuming fruit and vegetables daily (75%) indicated that they were willing to eat and/or recommend lotus salad again, whereas 36% of participants that consume fruit and vegetables each week were willing to recommend and/or eat lotus chips again.

CORRELATION ANALYSIS. Gender differences were observed in participants' willingness to pay and/or recommend lotus stir-fry ($P = 0.014$), with 54% of males willing to eat again or recommend lotus stir-fry vs. 45% of females (Table 4). More participants (42%) between 18 and 24 years of age vs. 27% of participants of 55 years or

Table 3. Percentage of participants' eating habits, recommendations, and enjoyment following consumption of three lotus rhizomes preparations in a prescreening taste panel study of lotus acceptance at Auburn, AL, in 2012. A total of 27 consumers participated at Auburn University's Department of Nutrition Dietetics and Hospitality Management taste panel and 42 at Amsterdam Café taste panel.

	Salad (%)	Stir-Fry (%)	Chips (%)
I would eat this again	59	92	62
I would recommend to others	34	80	39
I enjoyed the taste of this dish	59	92	62

Table 4. Analysis of variance of consumers demographic information concerning participant choice of three lotus rhizome preparations used in a prescreening taste panel study of lotus acceptance at Auburn, AL, in 2012. A total of 27 consumers participated at Auburn University's Department of Nutrition Dietetics and Hospitality Management taste panel and 42 at Amsterdam Café taste panel.

Characteristics	Salad			Stir-fry			Chips		
	Frequency (%)	F	P	Frequency (%)	F	P	Frequency (%)	F	P
Gender		3.1	0.186		24.5	0.014*		0.233	0.805
Male	58			54			37		
Female	42			45			63		
Age (years)		0.861	0.47		13.72	0.005*		0.619	0.57
18–24	25			45			55		
25–35	17			18			18		
55 and above	42			27			18		
Income		0.47	0.645		5.509	0.043*		0.23	0.80
Less than \$40,000	54			92			77		
\$40,000–\$99,999	71			100			86		
\$100,000 and more	66			100			66		
Ethnicity		0.225	0.804		2.24	0.187		0.057	0.945
Asian	100			100			75		
African American	50			100			23		
Caucasian	37			74			53		
Education		0.877	0.449		11.433	0.003*		0.112	0.894
High school	30			100			57		
Some college degree	22			70			70		
College graduate	50			71			28		
Advance degree	71			100			14		
Primary household shopper		0.816	0.521		24.5	0.013*		0.184	0.84
Yes	37			75			50		
No	50			90			20		
Fruit and vegetable consumption		0.333	0.729		1.777	0.248		0.088	0.917
Every week	17			18			36		
Every day	75			73			55		
Meal purchased		1.042	0.41		15.35	0.004*		0.108	0.81
Lunch	33			36			36		
Dinner	33			36			36		
Both	17			18			9		

*Statistically significant at $P \leq 0.05$.

above and 18% of participants between 25 and 35 years of age were willing to eat and/or recommend lotus stir-fry ($P = 0.005$). For income distribution groups, results showed 92% of participants earning less than \$40,000, 100% of participants earning between \$40,000 and \$99,999, and 100% of participants earning between \$100,000 or more were willing to recommend or eat lotus stir-fry ($P = 0.043$). In addition, differences in education levels ($P = 0.003$) were significant with 100% of high-school participants, 70% of some college/vocational degree holders, 71% of college graduates, and 100% of participants having an advance degree willing to eat again or recommend eating lotus stir-fry. Differences between primary household shoppers ($P = 0.013$) were found significant with 75% of primary household shoppers and 90% of nonprimary household shoppers willing to eat again or recommend eating lotus stir-fry. Finally, 36% of participants that purchase either lunch or dinner, and 18% of participants that typically purchase both lunch and dinner were willing to recommend and eat lotus stir-fry again ($P = 0.004$).

Discussion

Although there is an abundance of web-based information regarding culinary preparations of lotus, there is limited information pertaining to consumer preference and palatability of fresh lotus rhizomes with regard to domestic consumer preferences. To the best of the authors' knowledge, there is limited research reported on consumer acceptance of fresh lotus products consumed in the southeast United States. This exploratory study albeit is not a "typical consumer socio-demographic study" with a large sample size; however, due to the lack of information in this regard, the present case study using a limited representative sample of lotus recipes/dishes provides benchmark information concerning lotus consumer attitudes and potential demand. Results suggest that participant's choice of lotus preparation was correlated with gender, age, income, education level, shopping habits, and meal purchased. On the basis of the results from two taste panels, lotus stir-fry was the favored dish among the majority of participants, followed by lotus

chips and lotus salad. According to the U.S. Department of Agriculture, from 1977 to 2012, the average American household budget spent on food away from home increased from 30% to 43%, and represented about one-third of all calories consumed (USDA, 2013). These results indicate consumer purchasing potential and appeal for lotus as a restaurant menu item. This study provides benchmark information concerning culinary meal preference and nuance of fresh lotus rhizome as an appealing functional food.

Conclusions

There is a paucity of information concerning consumer acceptance and willingness to purchase edible lotus and value-added products in the southeastern United States. Results of this exploratory case study indicate potential demand for fresh lotus rhizomes particularly among individuals who are health conscious and are the primary household shoppers. Understanding consumer behavior and preferences can aid in the development of potentially sustainable niche markets of locally cultivated fresh nutritious edible lotus rhizomes. In terms of domestic market development of lotus rhizomes, in general, panelists were not familiar with this underused aquatic vegetable. Results of this study suggest that continued research and outreach efforts with appropriate dissemination of ongoing research findings of potential health benefits should stimulate further interest, consumer demand, consumption, and subsequent local production of fresh lotus rhizomes.

Benchmark information concerning consumer preference and appeal for lotus rhizomes and the potential health benefits of this unique aquatic vegetable was provided. Further research is needed to understand the characteristics that motivate purchase and consumption of lotus rhizomes (i.e., appearance, aroma, flavor, texture, color, and health benefit) as well as expanded sociodemographic variables, and consumer behavior toward this aquatic vegetable.

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