Research article

Nutritional and Cost-Benefit Analysis of Some Traditional Thai Foods and Beverages Prepared from Sacred Lotus

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Abstract In Thailand, the sacred lotus (*Nelumbo nucifera* Gaertn.) is used as an ingredient for healthy food and beverage production and plays a role in Buddhist rituals. In particular, dried lotus petal tea and jasmine rice wrapped in lotus leaves are a staple of traditional food menus, but detailed nutritional information on these products is lacking. Hence, the objective of this research was to standardize some traditional value-added Thai foods and beverages made from lotus and assess their nutritional value. First, a recipe for rice mixed with lotus seed, shrimp, and chicken wrapped in lotus leaves was standardized as a main course, to be served along with lotus petal tea. Subsequently, a nutritional analysis of the two products was carried out for the purpose of nutritional information labeling. The estimated nutritional values in both products were assessed according to the criteria of Percentage of Thai Recommended Daily Intakes for population over 6 years of age (% Thai RDI) with a 2,000-kcal diet. The results showed that the nutritional value of rice wrapped in lotus leaves per net weight of 180 g as a percentage of RDI (excluding a nutritional analysis of the lotus leaves) was 390 kcal (20%) of total energy, 14 g (22%) of total fat, 285 mg (95%) of cholesterol, 18 g of protein, 48 g (16%) of total carbohydrate, 620 mg (31%) of sodium, and vitamin A, B1, and B2. For the nutrition value of a lotus petal teacup per 100 g net weight, only 20 mg (1%) of sodium was found. Lastly, the preliminary results of this study were evaluated based on a value index over five years. The findings revelated that the value addition of sacred lotus represented 8,859 Thai Baht of net present value (NPV), a benefit-cost ratio (BCR) of 1.34, and 8.1% of internal rate of return (IRR), and showed the break-even value of the project budget. Therefore, the result findings are expected to enhance development of sacred lotus products oriented towards green production.

Keywords lotus, traditional food, nutrition information, Thai RDI, green product

INTRODUCTION

Lotus (*Nelumbo nucifera* Gaertn.), commonly known as the sacred lotus, belongs to the Nelumbonaceae family and is a significant aquatic economic plant (Pal and Day, 2013). This species holds religious importance in Southeast Asia, including Thailand, where various parts of the lotus plant, such as the flower, seed, leaf, and rhizome, are utilized as food ingredients and traditional herbs (Dhanarasu and Al-Hazimi, 2013; On-nom et al., 2023). The lotus has been extensively studied for its nutritional composition. For instance, lotus seeds are a rich source of lipids (0.22-3.68%), proteins (10.60-28.19%), carbohydrates (61.3-70.1%), vitamins (0.13-4.6 mg/kg of B1, B2, B6, C, and E), minerals, and bioactive compounds (Shin et al., 1999; Zheng et al., 2003; Indrayan et al., 2005; Wu et al., 2007; Bhat and Sridhar, 2008; Zeng et al., 2011; Luo et al., 2016; Shahzad et al., 2021; Bangar et al., 2022). In Thailand, lotus seeds are commonly used in various food products, such as stir-fried lotus seeds with dried chili paste, lotus seed flour, lotus seed butter, lotus seed cream, and lotus seed milk (Punnaterkoon et al., 2016; Petcharat et al., 2009). For the local people in Pathum Thani province, the sacred lotus holds significance as they utilize it to craft lotus flower and stamen tea. Additionally, the fragrant aromas of its petals and leaves make them suitable for wrapping food (Meesuk, 2001; Changthom, 2021; Ridhowati et al., 2023). Some examples include rice wrapped in lotus leaves, herb appetizers wrapped in sacred lotus petals (Miang Kham), spicy sacred lotus petal salad (Yam), and fried crispy sacred lotus petals. This reflects the cost-effective utilization of different parts of the sacred lotus. However, the products derived from the sacred lotus still lack credibility in terms of quality and have limited reach among consumers. Therefore, there is a need to develop community products that enhance consumer awareness through food analysis, nutrition labeling, and environmentally friendly production.

The country's Bio-Circular-Green (BCG) Economy and Sustainable Development Goals (SDGs) connect the bio-economic system to the cost-effective use of biological resources, generate value-added cultural food menus for community economies, and mitigate environmental problems stemming from food waste—one of the primary sources of GHG emissions from human activities. Estimates suggest that 8-10% of global greenhouse gas emissions are associated with unconsumed food. The UNEP Food Waste Index Report (2021) reveals a household food waste measure in Thailand of 79 kg/capita/year, equivalent to 5,478,532 tons/year. Moreover, the project's outcome and impact pathways are evaluated using the concept of social return assessment (SROI), incorporating techniques such as monetization, benefit transfer, and project cost-effectiveness measurement with the net present value, benefit-cost ratio, and internal rate of return indices. This assessment aims to maximize the cost-effectiveness of budget expenditures.

OBJECTIVE

The objective of this study was to examine the nutritional status and the cost-benefit value of traditional Thai foods and beverages prepared from sacred lotus.

METHODOLOGY

Examine the menus of local food and healthy beverages across all 77 provinces of Thailand. Choose a cultural menu from the sacred lotus that can evolve into a series of single-dish menus and a healthy drink, including rice wrapped in sacred lotus leaves and dried sacred lotus petal tea. Furthermore, these menus should be positioned for promotion as food and beverage options, contributing to the reduction of global warming by evaluating their carbon footprint in the future.

The process for preparing rice wrapped in sacred lotus petals involves the following steps: First, 6.44 mL of vegetable oil, 1.00 g of ground white pepper, 2.66 tsp oyster sauce, 1.44 g of caster sugar, and a 3.33 mL mixture of blac k and light soy sauces. Combine these with a 6.66 g mixture of lotus seeds, 4.44 g of shrimp, 4.44 g of mushrooms, and 37.77 g of steamed jasmine jasmine rice. Next, scoop this mixture onto the middle of sacred lotus leaves, arranging ingredients such as 10 g of pork Chinese sausage, 10 g of salted egg, and 22.22 g of chicken on the rice. Proceed to wrap the sacred

lotus leaves and steam the package for 30 minutes. Each package of rice wrapped in sacred lotus leaves has a net weight of 180 g. Preparing dried sacred lotus petal tea involves separating the sacred lotus flower components, with the stamen section completely dried indoors. Simultaneously, the petals are washed and cut into small pieces of 0.5 centimeters before being dried indoors as well. Each package of dried sacred lotus petal tea has a net weight of 100 g, primarily composed of 60% sacred lotus petals, 20% stamens, and 20% pandan leaves as main components. The product samples were randomly collected: fifteen packages of rice wrapped in sacred lotus leaves with a total weight of 2,700 g and ten packages of dried sacred lotus petal tea with a total weight of 1,000 g. Food analysis and nutritional labeling were done by the Foundation for Industrial Development National Food Institute, Thailand. The processes and analytical methods for food analysis are outlined in Table 1. The nutritional analysis data is utilized to calculate the values of energy, sugar, fat, and sodium in comparison to the corresponding nutrient content per unit package, as specified in Notification No. 182 (1998) of the Ministry of Public Health (2012).

Table 1 Test methods for nutritional analysis

Items	Test methods
Ash	AOAC (2019) 945.38C
Calcium	In-house method T9152 based on AOAC (2019) 984.27
Calories from fat	Methods of analysis for nutrition labeling 1993, chapter 1,5
Cholesterol	In-house method T992 based on the J. of AOAC International, Vol. 76, No.4, 1993
Dietary fiber	In-house method T995 based on AOAC (2019) 985.29
Iron	In-house method T9152 based on AOAC (2019) 984.27
Moisture	AOAC (2019) 945.38B
Protein (N x 6.25)	In-house method T927 based on AOAC (2019) 991.20
Saturated fat	In-house method T974 based on AOAC (2019) 996.06
Sodium	In-house method T9152 based on AOAC (2019) 984.27
Total carbohydrate	Methods of analysis for nutrition labeling 1993, chapter 1,5
Total calories	Methods of analysis for nutrition labeling 1993, chapter 1,5
Total fat	AOAC (2019) 945.38F
Total sugars	In-house method T997 based on AOAC (2019) 982.14
Vitamin A	In-house method T969 based on AOAC (2019) 992.06
Vitamin B1	In-house method T970 based on AOAC (2019) 942.23
Vitamin B2	In-house method T971 based on AOAC (2019) 970.65

The research project at Valaya Alongkorn Rajabhat University under the Royal Patronage Pathum Thani Province has received budget allocation and obtianed the profit from sales at the university market. The study aims to evaluate economic impact through a benefit-cost analysis method, utilizing the ex-ante evaluation model for an additional 5 years. This extended assessment is conducted while the project is ongoing, measuring the investment value with quantitative indices such as Net Percent Value (NPV), Benefit-Cost Ratio (BCR), and Internal Rate of Return (IRR).The assessment data is gathered through participant interviews, employing instruments designed to evaluate project cost-effectiveness (Wongjinda, 2021; Jaijit et al., 2017), as represented in Eqs. (1-3).

$$NPV = \sum_{t=0}^{n} (B_t - C_t) / (1+r)^t \quad (1)$$

$$BCR = \sum_{t=0}^{n} B_t / (1+r)^t / \sum_{t=0}^{n} C_t / (1+r)^t \quad (2)$$

$$IRR = \sum_{t=0}^{n} (B_t - C_t) / (1+r)^t = 0 \quad (3)$$

These equations involve variables t (project duration in years), B_t (project benefit in year t in baht per year), C_t (project research cost in year t in Thai baht per year), and r (discount rate in percentage).

Before initiating the research project, the researcher sought certification from the Human Research Ethics Committee of Valaya Alongkorn Rajabhat University under the Royal Patronage Pathum Thani Province. This certification aligns with the ethical guidelines for research involving

human subjects, meeting international standards outlined in COA No. 0049/ 2566 and REC No. 0049/2566.

RESULTS AND DISCUSSION

The results of the nutritional analysis for rice wrapped in sacred lotus leaves and dried sacred lotus petal tea are presented in Table 2.

Table 2 The results of nutritional analysis

Test items	Rice wrapped in sacred lotus leaves					Dried lotus petal tea				
	Amount (per 100 g)		1 pack (per 180 g)		Thai RDI (%)	Amount (per 100 g)		1 glass (250 ml, 5 g)		Thai RDI (%)
Total energy			390.00	kcal				0.00	kcal	
Calories from fat			130.00	kcal						
Total calories	220.00	kcal				1.00	kcal			
Total fate	8.00	g	14.00	g	22			0.00	g	0.00
Saturated fat	2.60	g	4.50	g	23					
Cholesterol	157.00	mg	285.00	mg	95					
Protein	10.20	g	18.00	g		Not detected		0.00	g	0.00
Total carbohydrate	26.70	g	48.00	g	16	0.20	g	< 1.00	g	0.00
Dietary fiber	1.70	g	3.00	g						
Sugar	3.80	g	7.00	g		Not detected		0.00	g	0.00
Sodium	346.00	mg	620.00	mg	31			20.00	mg	1.00
Iron	1.18	mg	2.12	mg	15					
Calcium	57.00	mg	102.60	mg	15	< 9.62	mg			
Vitamin A	51.00	µg	91.80	µg	10					
Vitamin B1	0.05	g	0.09	mg	6					
Vitamin B2	0.13	g	0.23	mg	15	0.10	g			
Ash	1.57	g	2.83	mg		Not detected				
Moisture	53.56	g	96.41	g		99.72	g			

Note: Percent Thai Recommended Daily Intakes for the population over 6 years of age (% Thai RDI) are based on a 2000 kcal diet. Serving size 1 glass (250 ml, 5 g of dried lotus petal tea) and serving size 1 pack (180 g of rice wrapped in lotus leaves)

The findings indicate that rice wrapped in sacred lotus leaves, with a net weight of 180 g, provides a total of 390 kcal. of energy and contains five macronutrient groups for Thai people: 18 g of protein, 14 g (22%) of total fat, 48 g (16%) of total carbohydrate, and minerals: 102.60 mg (15%) of calcium and 1.18 mg (15%) of iron. Additionally, it includes vitamins A, B1, and B2. The product also offers nutrients beneficial to the gastrointestinal tract, such as dietary fiber, while monitoring against overeating includes cholesterol, sodium, saturated fat, and sugar (Surakarnkul, 2011). These monitored nutrients are reported on the Guideline Daily Amounts (GDA) nutritional label, with the maximum daily consumption recommended at 20% of total energy, 11% of sugar, 22% of fat, and 31% of sodium. Regarding the nutrition value of a cup of dried sacred lotus petal tea per net weight of 100 g, only 20 mg (1%) of sodium was found. Both products' nutritional values meet the percentage of Thai recommended daily intakes for the population over 6 years of age (% Thai RDI) based on a 2,000-kcal diet (Ministry of Public Health, 2012). The results suggest that both products can be integrated into food and beverage businesses. In addition to providing nutritional information, they exhibit similar nutrient content to popular Thai foods, such as chicken pad Thai with rice noodles (energy: 159 kcal/100 g, protein: 6.36 g/100 g, total fat: 3.53 g/100 g, total carbohydrate: 24.7 g/100 g) (USDA, 2021). Moreover, the standard recipe developed from jasmine rice wrapped in sacred lotus leaves into a single-dish menu served with dried sacred lotus petal tea can incorporate environmentally friendly ingredients and cater to a diverse consumer base, including Islam, vegetarians, and health enthusiasts. This development can potentially upgrade products from the sacred lotus toward green products in the next phase of the carbon footprint assessment.

The project's results, focused on creating value-added traditional Thai food and healthy drinks from the sacred lotus to green products, initially considered economic returns (income) and evaluated the value index for the next 5 years. The creation of value-added dried sacred lotus petal tea and rice wrapped in sacred lotus leaves demonstrated that the return from this project exceeds the investment, making the investment worthwhile. Specifically, there is a NPV of 8,859 Thai Baht, an IRR of 8.1%, and a BCR of 1.34, indicating that for every 1 Thai Baht invested, 1.34 baht is returned. According to the criteria for measuring the value of capital (NPV > 0, BCR > 0, and IRR > the interest rate of the source of investment (5%) (Vijitsrikamol, 2021)), the evaluation results affirm the value of spending the project budget. However, in the future, at the end of the project, a Social Return on Investment (SROI) evaluation for the sustainable development of the Thai traditional food and beverage from the sacred lotus project should be conducted.

CONCLUSION

In the initial phase of the research project, the goal was to transform jasmine rice wrapped in sacred lotus leaves into a single dish, served with royal lobster tea, with a focus on standardizing the recipe. This standardized recipe can be adapted to incorporate local, environmentally friendly ingredients and cater to a diverse range of consumer groups. The product includes a nutritional information label adhering to GDA and Thai RDI criteria. Additionally, it boasts a nutrient content comparable to popular Thai dishes, contributing to the acceptance and creation of value-added traditional Thai menus and healthy drinks from the sacred lotus over the next five years. This represents the outcome of the cost-effectiveness evaluation of the budget expenditure, yielding indices of NPV, IRR, and BCR. In conclusion, it is essential to conduct a SROI evaluation. This evaluation should further extend to green products through a carbon footprint assessment. Products obtained from using lotus plant components do not create food waste and can generate income for the community. This linkage aims to connect the bio-economy system and reduce GHG emissions from food production.

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