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BIOCHEMICAL, ORGANOLEPTIC AND ANTI-MICROBIAL ASSESSMENT OF LOTUS STEM (*Nelumbo nucifera*)

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ABSTRACT

Lotus stem is an indigenous vegetable confined to selective cuisines of South East Asia. Lotus stem is a nutritionally balanced food-low in fat but high in protein, minerals and vitamins. Exploration of the nutritional and therapeutic profile of lotus stem is a popular topic of scientific research. The benefits of lotus stem are unexplored by majority of the culinary populations of the world. In many ethnic dishes, lotus stem is usually consumed fried. In this paper, the proximate analysis of raw lotus stem and fried lotus stem were carried out for establishing the comparative nutritional profiles of raw lotus stem and fried lotus stem. Also, the antimicrobial activity of lotus stem extract was ascertained against certain bacterial and fungal species. In addition, an edible product using lotus stem was developed and it was subjected to semi-trained panelists for sensory evaluation. The data obtained from the detailed questionnaire was analyzed statistically. This helped in ascertaining the acceptability of lotus stem among the populace. Future prospects include assessment of lotus stem in the dietary management of various diseases, development of new edible products, characterization of lotus stem starch and standardization of lotus stem alkaloids as potential therapeutic nutraceuticals.

Keywords: Lotus Stem, Fried Lotus Stem, Sensory Evaluation, Nutrition, Food Science.

INTRODUCTION

"We are what we eat" is the fundamental quote in nutrition and health sciences. Healthy food when consumed ensures a healthy population. Demanding schedules and workaholic cultures have dwindled our ability to think clearly about our food choices. Due to sedentary lifestyles, the spectrum of nutrition is moving from balanced diets to more convenient, but imbalanced diets. This is affecting human health and well-being at large. Therefore, emphasis on quality nutrition is need of the hour.

One aspect of serving this need would be to identify food sources that are nutritionally balanced, versatile while cooking, and can be consumed by all. One of the most unexplored food ingredients, which satisfy all the above criteria, is lotus stem. Lotus stem is an underwater vegetable whose consumption is confined indigenously to the cuisines of South-east Asia. People familiar with lotus stem consume it because of its mild sweet flavor, for its novelty as a vegetable or as part of their cultural food habits. A large proportion of people also consume lotus stem in their food (raw or fried) or as lotus tea for its therapeutic properties. One of the major reasons why people do not harness the benefits of lotus stem is its rare availability, as it is available in few selected markets.

The health benefits of lotus stem are that it is rich in proteins, iron, calcium omega-3 and omega-6 fats and potassium and low in sugars. In addition, the alkaloids present in lotus stem have proven nutraceutical properties. Lotus stem is beneficial in the treatment of various disorders like anemia, osteoporosis, bowel diseases, fungal and viral infections, various degenerative diseases and also fever. Thus, because of its diverse therapeutic qualities, lotus stem is one of the main ingredients in various traditional Indian and Chinese treatment regimens. Therefore, the present study was undertaken to create awareness about lotus stem and to further explore its nutritional benefits.

MATERIALS AND METHODS

The study on lotus stem was carried out in the following manner:

1. PROCUREMENT OF SAMPLES

Locally available lotus stem procured from the market was used for analysis. A portion of the fresh sample was deep fried and finely powdered for analysis.

2. PROCESSING OF SAMPLES FOR ANALYSIS

For estimation of macronutrients, a 2% aqueous extract of raw lotus stem and fried lotus stem was made. For estimation of minerals, an ash solution was prepared by incinerating dried samples at 800°C until a white ash was obtained. The ash obtained was extracted with 2.5 ml

of 1:1 HCl and diluted with distilled water to 50 ml.

3. PROXIMATE PRINCIPLES ANALYSIS

This section of the study involved using standardized biochemical methods for estimation of various nutrients in raw lotus stem and fried lotus stem respectively. The following proximate principles were estimated from raw lotus stem and fried lotus stem:

MACRONUTRIENTS

a. Determination of moisture content.
b. Determination of ash content.
c. Estimation of Carbohydrates by Anthrone method.
d. Estimation of Protein by Folin-Lowry method.
e. Estimation of Lipids by Solvent extraction method
f. Estimation of reducing sugars by Benedict's method.
g. Estimation of dietary fiber by Ashing method.

In addition, raw lotus stem was used exclusively for the following analysis:

h. Isolation of starch.
i. Characterization of lotus stem starch hydrolysate by Diphenylhydrazine test: A pinch of lotus stem starch was dissolved in hot water. 1ml of 2N HCl was added to it and the mixture was boiled in a water bath for 30 minutes to allow complete hydrolysis of the starch molecules. 2ml of the hydrolysate was then treated with 2ml of freshly prepared Diphenylhydrazine reagent and allowed to react in a water bath for 30 minutes. Osazones obtained were observed microscopically under 450X magnification.
j. Estimation of percent purity of lotus stems starch by Willstatter's method.

MICRONUTRIENTS

a. Estimation of Iron by Wong's method.
b. Estimation of Phosphorus by Fiske-Subbarow method.
c. Estimation of Calcium by EDTA method.
d. Estimation of Sodium by flame photometry.
e. Estimation of Potassium by flame photometry.
f. Estimation of Vitamin C by 2, 6-Dichlorophenol Indophenol blue method.

4. SENSORY EVALUATION

A payasam (jaggery-based dessert) was developed from lotus stem. A sensory evaluation of the developed product was carried out in presence of semi-trained panel consisting of 49 panelists wherein it was compared with rice flakes payasam. Products presented to the panelists were:

Figure 1-Sample A- Rice flakes payasam

Figure 2- Sample B- Lotus stem payasam

The panelists organoleptically assessed the products by answering a detailed questionnaire based on various sensory parameters. The questionnaire also emphasized on aspects like product marketability and VFM. The data obtained from the questionnaire was analyzed biostatistically to ascertain the acceptability of the lotus stem payasam.

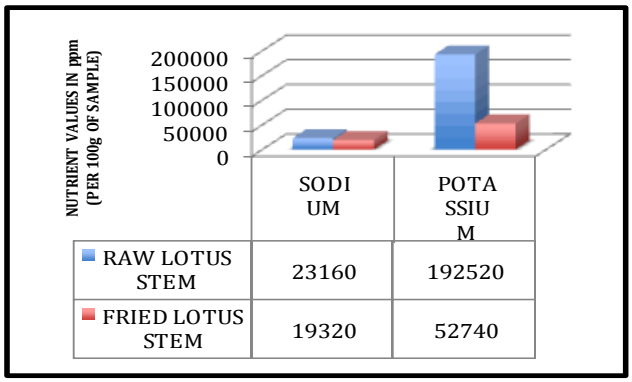
5. ANTIMICROBIAL ACTIVITY

Lotus stem aqueous extract was used to ascertain its antimicrobial activity. Sterile nutrient agar plates were seeded with the appropriate culture and allowed to absorb onto the plates for 15 minutes. Whattman No 1 paper discs of 8 mm diameter were soaked in the lotus stem extract and placed on the plates, which were then incubated for 24 hours at the optimum temperature of the test organism. The diameter of zone of inhibition was measured and the diameter of the paper disc was subtracted from it and reported as net zone of inhibition.

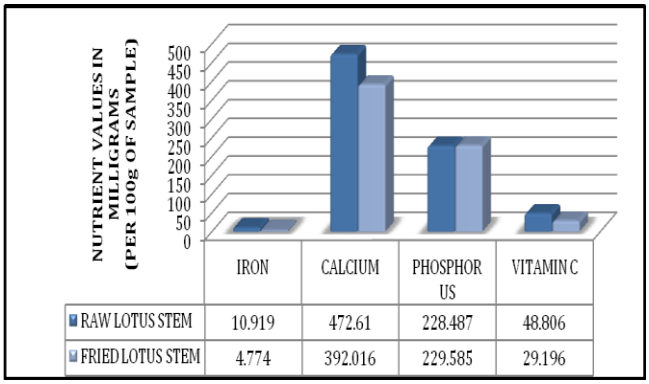
RESULTS AND DISCUSSION

A) PROXIMATE ANALYSIS

As determined by the standardized methods, the values of the various nutrients per 100g of the samples are as follows:



Graph1: Values of sodium and potassium in raw lotus stem and fried lotus stem respectively (In ppm per 100g of sample)

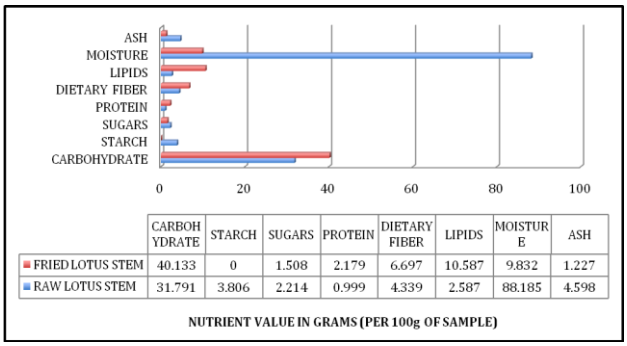


Graph 2: Values of micronutrients in raw lotus stem and fried lotus stem respectively (In mg per 100g of sample)

MICRONUTRIENTS

From the above figures, it is evident that nutrients like iron, calcium, phosphorus, sodium and Vitamin C were abundant in raw lotus stem as compared to fried lotus

stem. The value of these nutrients reduced on frying, as they being hydrophilic, are not extracted in the majorly hydrophobic environment of organic material in fried lotus stem during frying. However, during frying, about 5 times reduction in potassium content is observed. The low sodium to potassium ratio of raw lotus stem is significantly elevated in fried lotus stem. Thus, fried lotus tem is not optimally electrolytically balanced as compared to raw lotus stem.



	CARBOHYDRATE	STARCH	SUGARS	PROTEIN	DIETARY FIBER	LIPIDS	MOISTURE	ASH
FRIED LOTUS STEM	40.133	0	1.508	2.179	6.697	10.587	9.832	1.227
RAW LOTUS STEM	31.791	3.806	2.214	0.999	4.339	2.587	88.185	4.598

NUTRIENT VALUE IN GRAMS (PER 100g OF SAMPLE)

Graph 3: Values of macronutrients in raw lotus stem and fried lotus stem respectively (In g per 100g of sample)

MACRONUTRIENTS

Macronutrients like carbohydrates, protein, and dietary fiber are abundant in fried lotus stem than raw lotus stem. Significant increase in values of these in fried lotus stem is implicated due to the process of frying. Frying results in significant loss of water, thus concentrating the organic material in raw lotus stem, which raises levels of these nutrients. This makes fried lotus stem a more concentrated source of energy or a higher calorific value.

However at the same time, moisture content is significantly reduced in fried lotus stem. This occurs due to the displacement of water and subsequent dehydration of lotus stem during frying. Frying lotus stem also denatures starch. This is the reason why starch could not be isolated from fried lotus stem. The ash content; a crude estimate of mineral content also decreases on frying. The higher proportions of minerals are easily oxidized during incineration. Thus, the amount of residue is reduced significantly upon incineration leading to lower ash content. Thus, fried lotus stem exhibits a lower mineral content than raw lotus stem.

In addition, the percent purity of starch isolated from raw lotus stem is 87.25%. Lotus stem starch hydrolysate when subjected to diphenylhydrazine test yielded glucosazones when observed under 450X magnification. This ascertained that the isolated molecule from lotus stem is pure starch.

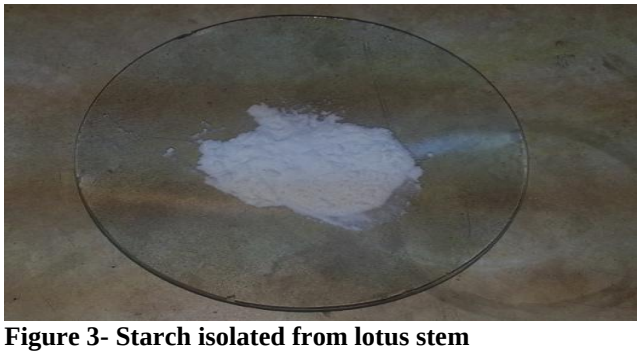


Figure 3- Starch isolated from lotus stem

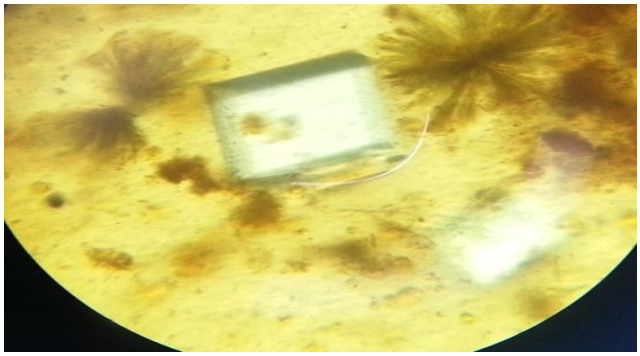
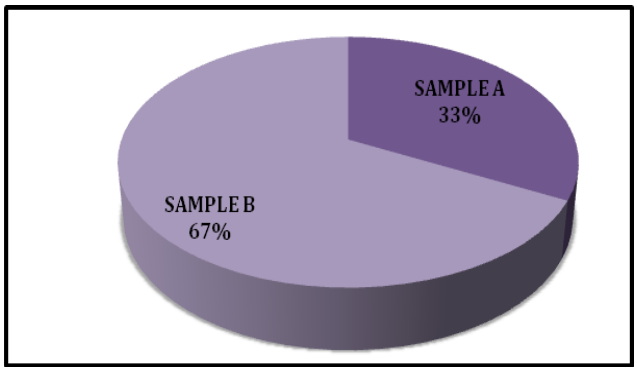


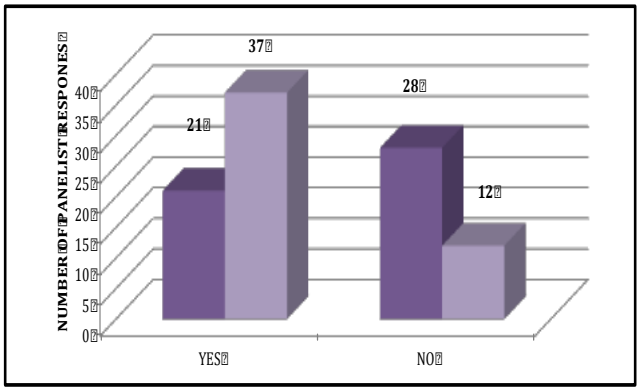
Figure 4- The glucosazones obtained when lotus stem starch hydrolysate is treated with diphenylhydrazine reagent

B) SENSORY EVALUATION

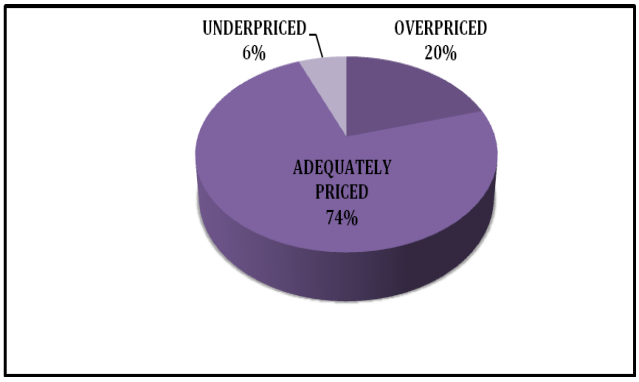
After thorough biostatistical analysis of the questionnaire filled by the 49 semi-trained panelists during the sensory evaluation procedure, the following results were obtained:



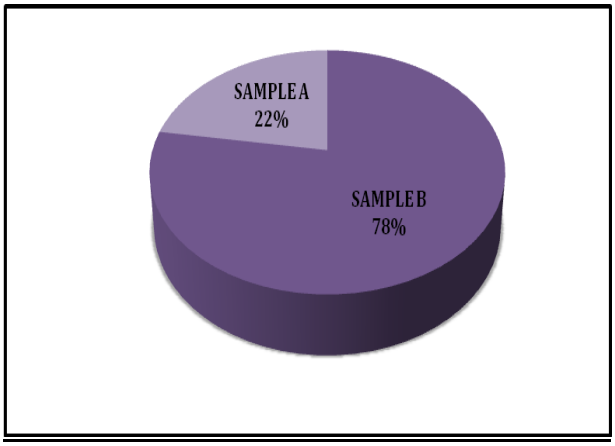
Graph 4- Panelist opinions on the marketability of the two samples



Graph 5-Panelist opinions on which sample will they prefer if the products were commercially available



Graph 6-Panelist opinions on the pricing of the product



Graph 7- Panelist opinions on their overall preference between the two samples

The sensory evaluation involving the semi-trained panelists exhibited high organoleptic acceptability for the product developed from lotus stem. Also, VFM aspects of the product were evaluated, and the product developed ascertained high VFM. Manufacturers thus need to exploit the dual benefits of versatility and balanced nutrition of lotus stem and try to incorporate lotus stemmore frequently in their products. The findings were also reported by Nazni and Shalini, 2010.

C) ANTIMICROBIAL ACTIVITY

Results as tabulated below:

Table 1-Antimicrobial activities of lotus stem aqueous extract

Serial Number	Test organism	Net Zone of inhibition (mm)	Remarks	Nature of activity
1.	*E. coli*	---	No activity	Antibacterial
2.	*K. pneumoniae*	---	No activity	Antibacterial
3.	*S. aureus*	14	Moderate activity	Antibacterial
4.	*B. subtilis*	8	Negligible activity	Antibacterial
5.	*C. albicans*	10	Moderate activity	Antifungal
6.	*Asp. niger*	----	No activity	Antifungal

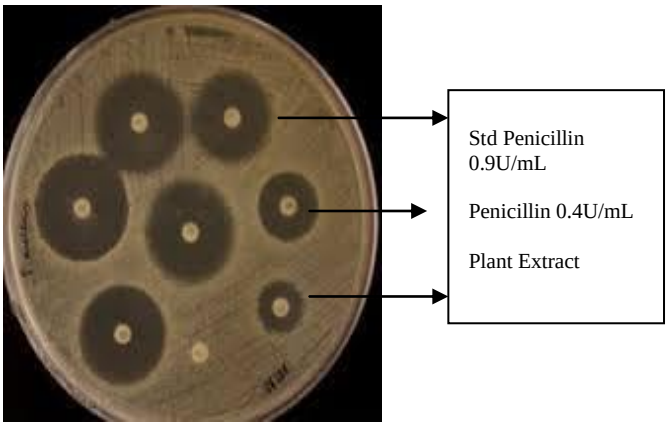


Figure 5- Antibacterial activity of Lotus stem aqueous extract

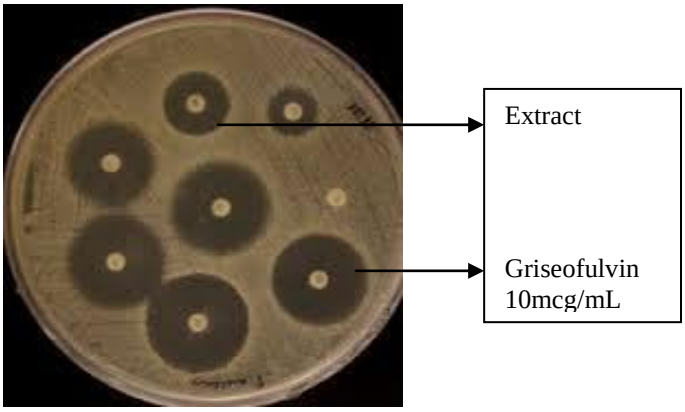


Figure 6- Antifungal activity of Lotus stem aqueous extract

Thus lotus stem exhibited moderate activity against *S. aureus* and *C. albicans*_and negligible activity against *B. subtilis*. This activity is exhibited by the aqueous extract, which reaffirms the efficacy of lotus stem in combatting pathogenic strains when consumed through the diet. Lotus stem extracts could be standardized and developed into formulations, which alleviate the holistic positive effect of lotus stem on human well-being. The same was found by Dharmalingam and Nazni, 2013 and Nazni and Dharmaligam, 2013.

CONCLUSION

From the results it is certain that lotus stem is a nutritionally balanced vegetable. The results of sensory evaluation prove the fact that lotus stem is a versatile ingredient which can be consumed in most recipes. Thus, lotus stem can be processed and marketed in the form of various recipes for maximum utilization of its health benefits by the general population. Consumption of lotus stem is thus recommended for optimizing the biochemistry of the individual.

From this study, it is clear that lotus stem is a dynamic, multi-faceted topic of research. The proximate principles assessed ascertain that the nutritional benefits of lotus stem are retained but reduced on frying. The anti-microbial activity of lotus stem ascertains that this vegetable could be standardized to be used as a nutraceutical. It shows promising activity as a nutraceutical to treat opportunistic infections caused by *Candida* sp.; observed in various secondary immunodeficiency disorders.

Future prospects include characterization of lotus stem starch and its optimization to be used as a coating for sustained release formulations. Also, isolation and characterization of lotus stem alkaloids can be carried out. These alkaloids can then be standardized to yield nutraceuticals, which can be safer alternatives to traditional drugs used in the prophylactic care of most diseases.

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