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Physico-chemical properties of the lotus (*Nelumbo nucifera*) rhizome

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Abstract
Lotus was acquainted in Asia around 7,000 years back, and grown as food crop for its seeds and rhizomes. The objective of this research work was carried out to determine the physico-chemical properties of 50 selected lotus rhizomes. The average value of the total weight of the sample, edible portion weight, length (node-node distance) was found to be 113.47 gm, 84.91 gm, 319.80 mm respectively. The average values of the diameter of unpeeled lotus rhizome at top, middle and bottom were 26.5, 23.43 and 27.03 mm respectively and for peeled lotus rhizome, the average values of the diameter rhizome at top, middle and bottom were 24.74, 22.11 and 25.59 mm respectively. The proximate analysis of lotus rhizome was evaluated. The moisture content, ash, protein, fat, fibre,carbohydrate content of the lotus rhizome varies from 80.714-81.292%, 4.423-4.825%, 1.730-1.750%, 1.050-1.143%, 4.901-5.124%, 17.234-18.416% respectively.

Keywords: Physico-chemical properties, lotus rhizomes, proximate analysis

Introduction
Lotus (*Nelumbo nucifera*), belongs to the Nelumbonaceae family, is also called as sacred or Indian lotus and recognised as aquatic perennial vegetable which is used for medicinal and nutritional purpose. It is widely distributed in South-East Asia. In India it can be found in all parts from Kashmir to Kanyakumari (Sheikh, 2014) [1].

Lotus is one of the most established plants on the planet. It was acquainted in Asia around 7,000 years back, and grown for its rhizomes and seeds as a food crop. Lotus is developed in numerous nations on the planet, particularly in India, Japan, China, Russia, Korea, South East Asia, and a few nations in Africa. (Nguyen, 2001) [2]. Lotus plant parts like flowers, buds, stamens, anthers, stalks, leaves, rhizomes and roots have been utilized as herbal medicines for the treatment of numerous deceases including depression, cancer, diarrhea, heart problems, hypertension and insomnia (Sheikh, 2014) [1].

Kamala and Padma are two common names of lotus in India. *Pundarika* or *Sveta Kamala* (which has white flowers) and *Rakta Kamala (which has* pink or reddish-pink flowers*)* are two varieties of Kamala (Mehta *et al.*, 2013) [6]. Lotus plant can grow up to 150 cm height with the horizontal spread of 3 m. The diameter of the leaves is about 60 cm (Dhanarasu *et al.*, 2013) [5]. Harvesting of Lotus generally starts in July and ends in September but some late varieties harvested from October March after complete draining of ponds. Mature stage of Lotus rhizomes for eating is around 6 to 9 months.

The external part of the Lotus rhizome root is enclosed with a peel which is in white or reddish brown colour. The internal part this root is in white colour with sweet flesh and water chestnut like flavour. The cut section of root contains air canals traversing along the length of the root (Syed *et al.*, 2012) [8]. The length of the rhizomes is ranging from 60 to 140 cm and diameter ranging from 0.5 to 2.5 cm (Dhanarasu *et al.*, 2013) [5].

Lotus rhizome contains a plentiful amount of starch, dietary fiber, protein, amino acids, lipids, sugars, vitamins, minerals, phenolic compounds, and antioxidants. They are nutritious and easily digested food for all ages (Wang *et al.*, 2011) [9].

In India lotus is utilized for various purposes like in pickles making and cooking. The flour of lotus root can be utilized in the making of various value added products. The starch is Main component of the lotus root. The fresh root contains about 15% of starch. Starch as a crude material has different applications in the making of products like thickeners, stabilizers and gelling agent (Syed *et al*., 2012) [8]. In Kashmir lotus is utilized as lotus stem (Nadru) and lotus stem kabab, yogurt curry, lotus stem rogan josh, lotus stem-fish, lotus stem pickles, lotus stem-Palakh etc (Sheik, 2014).

Materials and Methods

Selection Raw Material

A matured and fresh lotus rhizome was purchased at local markets of Raipur.

Physical properties of lotus rhizomes

Weight of the lotus rhizome

The weight of the individual lotus rhizome was measured of an electric balance. At first, the balance adjusted to zero mark. The lotus rhizome was cleaned and weighed in gram (g) by keeping it on the balance chamber. The weight of fifty matured rhizomes was noted and average weight of rhizome was recorded (Fig.1).

Length of the lotus rhizome

Length of the lotus rhizome was measured by measuring scale in centimetre (cm). The length of fifty matured rhizomes was noted and average length of rhizome was recorded.

Diameter of lotus rhizome

The diameter of the lotus rhizome is unequal throughout the length. The top, middle and bottom diameter of the lotus rhizome was measure by using vernier calliper in millimetre (mm). The diameter of fifty matured rhizomes was noted and average diameter of rhizome was recorded.

Shape and Size of lotus rhizome

Shape and size of rhizome was determined by estimating the length and diameter of rhizome.

Weight of skin of lotus rhizome

The outer layer of the lotus rhizome was peeled by peeler and weight of this lotus skin was measured by an electrical weighing balance. The outer layer of the fifty individual lotus rhizomes was estimated in gram and average weight was recorded.

Fig 1: Physical properties of lotus rhizome

Weight of the edible portion of the lotus rhizome

The weight of the edible portion of the rhizome was measured in gram by using electrical balance after peeling off rhizome outer layer.

Weight of non-edible portion of lotus rhizome

By subtracting the edible portion weight from total turmeric weight the weight of the non-edible portion of rhizome was measured in gram.

Hardness of lotus rhizome

The hardness of lotus rhizomes was determined by using TA. HD. Plus-C texture analyzer. The probe depth was set to 50% of each rhizome's diameter and pre and post speed was set to 10 mm/sec. A test probe went into a position in the rhizome at a speed of 1mm/sec, and then returned to the point where pre-load was reached on the first cycle.

Proximate analysis of lotus rhizome

Moisture, Ash, Fat, Protein, Crude fibre and Carbohydrate was analyzed by following the AOAC (2000) methods.

Results and Discussion

Physical properties of lotus rhizome

The results of study conducted for determination of physical properties lotus rhizome *viz.*, weight, edible portion of rhizome, length (node-node distance) and diameter (before and peeling) have been presented in this section.

Weight and length of lotus rhizome

The average values of weight and length of lotus rhizome has been presented in Table 1.

Table 1: Weight and Length of lotus rhizome

Parameter	Range	Average	Standard Deviation	CV
Total weight of sample, gm	51.4-221.40	113.47	32.45	28.60
Weight of edible portion, gm	36.2-177.60	84.91	26.15	30.79
Length (node-node distance), mm	180-490	319.8	72.22	225.83

Diameter of lotus rhizome

The average value of diameter (before and after peeling) of lotus rhizome has been presented in Table 2 a & b.

Table 2a: Diameter of lotus rhizome before peeling

Diameter	Average (mm) Range(mm)		Standard Deviation	CV
Top	26.5	20.25-33.98	2.84	10.86
Middle	23.43	18.89-30.39	3.10	11.45
Bottom	27.03	19.64-36.15	2.55	10.89

Table 2b: Diameter of lotus rhizome after peeling

Diameter	Average (mm) Range(mm)		Standard Deviation	CV
Top	24.74	19.52-31.05	2.74	11.07
Middle	22.11	17.89-28.75	2.88	11.25
Bottom	25.59	19.2-33.15	2.54	11.48

Hardness of lotus rhizome

The average value of the hardness of the sample was found to be 28.14 kg and it was ranges from 23.78 to 33.65 kg with standard deviation of 3.915 and 13.911% coefficient of variation.

Proximate analysis of lotus rhizome

The Proximate analysis of lotus rhizome was shown in Table 3. The data presented in the table 3 indicates that the average values of the moisture, ash, fat, protein, fibre, carbohydrate content of lotus rhizome.

Table 3: Proximate analysis of lotus rhizome

Principle	Range	Average	SD	CV
Moisture content (%)	79.812-80.245	80.064	0.194	0.243
Ash content (%)	0.846-0.912	0.910	0.057	6.311
Protein content (%)	1.645-1.782	1.710	0.056	3.303
Fat content (%)	0.823-0.947	0.895	0.038	4.219
Fibre content (%)	3.347-3.437	3.395	0.039	1.138
Carbohydrates (%)	12.947-13.145	13.026	0.084	0.647

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