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Original Article

ANALYSIS OF COMPLETE NUTRITIONAL PROFILE OF *AMORPHOPHALLUS CAMPANULATUS* TUBER CULTIVATED IN HOWRAH DISTRICT OF WEST BENGAL, INDIA

SUBHASHREE BASU[1], MOUMITA DAS[1], ANURUPA SEN[1], UTPAL ROY CHOUDHURY[2] AND GOURIPROSAD DATTA*[1]

[1]Department of Physiology, Rammohan College, 85A, Raja Rammohan Sarani, Kolkata: 700009, West Bengal, India. [2]National Test House (ER) Block-CP, Sector V, Salt Lake City, Kolkata: 700091, West Bengal, India.
E-mail: dattagp@yahoo.co.in

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ABSTRACT

Objective: This work aims to analyze the proximate composition, minerals and vitamins content in the popularly consumed tuber of West Bengal, *Amorphophallus campanulatus*.

Methods: The plant species were collected from farmers of Santragachhi, Howrah district and authenticated by Botanical Survey of India, Howrah district, West Bengal, India. Fresh tubers were analyzed for their content of crude proteins, total carbohydrate, soluble carbohydrate, fat, fibre, ash, moisture, carotenoids and vitamins. Mineral content was detected from the ash using Inductively Coupled Plasma Atomic Spectrophotometer.

Results: The study reveals that the tuber of *Amorphophallus campanulatus* has high crude protein, moisture, fibre, ash, vitamin E and C content. Besides, the tuber is rich in almost all the essential macro and micro-nutrients. The tuber is interestingly an important source of potassium, calcium and sodium. Moreover, the tuber also lacks the presence of heavy metals like mercury, cadmium, lead and arsenic.

Conclusion: Thus the results of the study form an important contribution to the knowledge about the complete nutritional profile of this tuber, which can lead to enhancement of its consumption for maintenance of healthy lifestyle and focus on its therapeutic approach as future perspective.

Keywords: *Amorphophallus campanulatus*, Macro Micro-Nutrient, Nutritional Profile, Proximate Composition

INTRODUCTION

A serious challenge to human survival, particularly in the developing world, is the ever growing gap between human population and food supply. Research and development which is focused on the lesser known edible plants could assist in narrowing the gap between population growth and food deficiency, currently escalating in developing countries. Growing and using wild vegetables is an opportunity that has never been adequately prospected to alleviate malnutrition and ameliorate food insecurity.

Vegetables are the edible parts of plant that are consumed wholly or in parts, raw or cooked as part of main dish or salad. A vegetable includes leaves, stems, roots, flowers, seeds, fruits, bulbs, tubers and fungi [1, 2]. Vegetables are good sources of oil, carbohydrates, minerals and vitamins depending on the vegetable consumed [3]. Vegetables, specially leafy and tuberous, are important items of diet in Indian kitchens. Apart from the variety which they add to the menu, vegetables are valuable sources of nutrients especially in rural areas where they contribute substantially to protein, minerals, vitamins, fibers and other nutrients which are usually in short supply in daily diets [4]. It is worthwhile to note that consumption of numerous types of edible plants as sources of food could be beneficial to nutritionally marginal population particularly in developing countries where poverty and climate do cause havoc to the rural populace. In such countries the supply of minerals is inadequate to meet the mineral requirements of farm animals and rapidly growing population. Minerals cannot be synthesized by animals and must be provided from plants or mineral-rich water [5].

Elephant foot yams (*Amorphophallus campanulatus*) are aroids belonging to the family Araceae. It is mainly cultivated in Asia, Africa and Pacific as well as Caribbean Islands. Not only so, the tubers are also cultivated in almost all the states of India. Tuber crops are the third important food crops after cereals and legumes. World production of the crop is estimated to be 5.5 million tons annually and provides about one third of food intake of more than 400 million people in the tropics. The starch root crops are marginal to poor in protein content, but they contain wide variety of minerals and trace elements, including relatively substantial quantities of iron and calcium, as well as potassium and magnesium [6]. Elephant foot yam is a popular tuber crop in Eastern India especially, West Bengal. Corms and cormels of this tuber are consumed as vegetable after boiling and baking. Value added products like elephant foot yam pickles are very popular in Eastern India.

Besides the various forms in which this tuberous vegetable is consumed, it also has its mention in India's one of the most traditional system of medicine, *Ayurveda*. The root extract of *Amorphophallus campanulatus* have been used in the treatment of piles and dysentery. The fresh root acts as an acrid stimulant and expectorant, and in India it is much used in the treatment of acute rheumatism. Especially in Ayurveda, it is used in arthralgia, elephantiasis, tumors, inflammations, hemorrhoids, hemorrhages, vomiting, cough, bronchitis, asthma, dyspepsia, colic, constipation, hepato-splenopathies, amenorrhea, dysmenorrhea, seminal weakness, fatigue and general debility. Recent studies have also shown that extracts of *Amorphophallus campanulatus* possesses anti-inflammatory [7], anti-microbial [8], hepatoprotective [9] and in vitro antioxidant property [10].

Consumption of underutilized edible plants, vegetables in particular, has often been looked upon as a sign of poverty; largely a reflection of lack of knowledge on their nutritional benefits. Fast regeneration of most vegetables under limited soil moisture and availability of the perennial species all year round, makes them capable of bridging the gap during food shortages and famine situations experienced by rural communities [11-16]. *Amorphophallus campanulatus* is very popular, wildly cultivated and greatly consumed by rural as well as urban population in West Bengal. Report regarding the proximate composition and nutritional profile of this tuber, specially the cultivated variety grown in West Bengal, is currently lacking. So the objective of the current study is to evaluate the thorough nutritional profile of this very popular tuber of West Bengal.

MATERIALS AND METHODS

Plant materials

Fresh tubers of *Amorphophallus campanulatus* (*AC*) were purchased from the farmers of Santragachhi village of Howrah district, West Bengal, India, from the month of May to October. Authentication was done primarily by Dr. Krishnendu Sarkar, Associate Professor, Department of Botany, Rammohan College under University of Calcutta, West Bengal, India and finally by the Botanical Survey of India (BSI). A herbarium of the specimen was maintained in the institute library bearing the number RMC/PHY/SB/03/14.

Preparation of tissue homogenate

1 g of fresh tissue was crushed and homogenized with 10 ml of 1 M phosphate buffer (pH 7.4). The homogenate was centrifuged at 10,000 × g for 30 min at 4°C and the supernatant was collected, for analysis.

Estimation of protein and soluble carbohydrate

Protein and soluble carbohydrate was estimated from the supernatant. Protein content was determined following the method of Lowry et al. 1951 [17] and soluble carbohydrate by dinitrosalicylic acid (DNS) method [18].

Estimation of total carbohydrate

For estimation of total carbohydrate, fresh thallus sample (1 g) was ground in mortar with 5 ml of 1 M phosphate buffer (pH 7.4). Then 5 ml of 2.5 (N) HCl was added to it and hydrolysed by keeping it in water bath for 3 h, cooled and neutralized with solid sodium carbonate [19]. The quantity of carbohydrate was determined after centrifugation according to DNS method [18].

Estimation of crude fibre

For estimation of crude fibre, 2gm of dried tissue was boiled in 200ml of sulphuric acid (1.25% w/v) for 30 min. Then it was filtered through muslin and washed with boiling water until the filtrate was no longer acidic, further boiled with 200 ml of sodium hydroxide (1.25% w/v) solution for 30 min, filtered through muslin, washed with 25 ml of boiled 1.25% w/v sulphuric acid, then washed thrice with water and finally with 25 ml absolute alcohol. The residue was then transferred into pre weighed ashing dish and dried for 2 hours at 130±2°C. The dry weight was taken and the residue was ignited for 30 min at 660±15°C cooled in a dissector and reweighed. The crude fibre was calculated according to the method of Maynard, 1970 [20].

Estimation of moisture:

Initially an amount (10 gm) of fresh tissue sample was taken. The amount of moisture in the tissue material was taken determined by drying the tissue in an over drier at about 60°C for 72 hours. The dried sample was weighed again after 72 h and the moisture percentage (M %) was calculated as following way.

M% = (Fresh Wt-Dry wt /Fresh wt) x 100

Estimation of fat

Fat was estimated by homogenizing tissue in 20 ml chloroform: methanol (2:1 v/v) mixture for 10 min in a tissue homogenizer. After vigorous shaking and filtering, the residue was again stripped with 25 ml chloroform: methanol mixture for 30 min. This combined filtrate was then shaken with 0.9 % sodium chloride to remove not fat contaminant [21]. The solvent layer was dried in vacuum and the total amount of fat was weighed according to the method of Itoch and Koneko, 1974 [22].

Analysis of mineral content

5gm of dry sample of *AC* was weighed carefully in clean porcelain crucibles and placed inside muffle furnace for incineration at temperature not more than 550 ºC to obtain carbon free ash. The ash thus obtained was dissolved in 0.1 (N) hydrochloric acid and the resulted acid soluble ash solution was fed into Inductively Coupled Plasma Atomic Spectrophotometer (ICP-AS, M/S Ametek Spectro Analytical Instruments GmbH, Germany) for detection of elemental content in the sample. The measured element intensities were evaluated by the Smart Analyzer Software.

Determination of ascorbic acid:

Ascorbic acid content was determined by the well established method of Riemschneider, 1976 [23] using 2, 4- dinitrophenyl hydrazine. 1gm fresh tissue was homogenized in 5% metaphosphoric acid and drops of bromine water were added to it. After some time, the bromine was removed by bubbling air through the solution and 0.5 ml of this solution was used to estimate the ascorbic acid content. Ascorbic acid was calculated from the calibration curve prepared with L-ascorbic acid.

Determination of α-tocopherol

Vitamin E was determined by method of Baker and Frank, 1988 [24]. 2.5 gm fresh tissue was weighed and homogenized in 0.1 (N) H_2SO_4 and kept overnight to digest out the fibrous plant materials. The day following, the homogenate was filtered and used for estimation of α-tocopherol. Vitamin-E reduce ferric to ferrous ions, which then form a red colored complex with α,α′ dipyridyl. Tocopherols and carotenes are first extracted into xylene and the absorbance was read at 460 nm to measure the carotenes. A correction for the carotenes was made after adding ferric chloride and reading at 520 nm using UV–Vis spectrophotometer at 517 nm (Systronics, India UV–Vis 118). α-tocopherol was calculated from the calibration curve prepared with α-tocopherol acetate.

β-Carotene and lycopene determination

β –Carotene and lycopene were determined according to the method of Nagata and Yamashita, 1992 [25]. 1gm of fresh tissue was vigorously shaken and homogenized with 10 mL of acetone-hexane mixture (4:6) and filtered through Whatman No. 4 filter paper. The absorbance of the filtrate was measured at 453, 505, 645 and 663 nm. Contents of β -carotene and lycopene were calculated according to the following equations:

Lycopene (mg/100ml) = $-0.0458A_{663} + 0.204A_{645} + 0.372A_{505} - 0.0806A_{453}$

β-carotene (mg/100ml) = $0.216A_{663} - 1.22A_{645} - 0.304A_{505} + 0.452A_{453}$

Statistical Analysis

Results were subjected to statistical analysis using SPSS version 20.0. In all the cases, results are the mean ± SD of at least three individual experimental data, each in triplicate.

RESULTS

Proximate Composition

Table 1: Represents the Proximate composition of the tuber of *Amorphophallus campanulatus*

Serial No.	Proximate composition	*Amorphophallus campanulatus* (g/100g dry weight)
1.	Protein	9.81 ± 2.5
2.	Soluble carbohydrate	6.67 ± 1.65
3.	Total carbohydrate	25.54 ± 6.52
4.	Fat	1.414 ± 0.79
5.	Fibre	5.7 ± 1.2
6.	Moisture	66.08 ± 1.98
7.	Ash	4.83 ± 0.54

All values are expressed as MEAN ± SD, of triplicate set of values for each parameter

Table 1 presents the proximate composition of *AC.* High ash content in *AC* reflects the presence of greater amount of minerals in *AC.* In this study, it was found that the tuber of *AC* show proportionately more of carbohydrate than that of protein content. Moderate quantity of protein content in *AC* can be beneficial for consumption by the poor, rural population to fight out the threats of malnutrition. Besides the protein content, the amount of total and soluble carbohydrate is also high in tubers of *AC*. The study shows that the tuber has very low fat content and moderately high crude fiber content.

Vitamin Content

Table 2: Represents the ascorbic acid, alpha-tocopherol, β-carotene and lycopene content in the tuber of *Amorphophallus campanulatus*

Vitamins	***Amorphophallus campanulatus* (mg/100g dry weight)**
Ascorbic Acid	76.65 ± 10.5
Alpha Tocopherol	900.00 ± 15.54
Beta Carotene	0.19 ± 0.05
Lycopene	2.03 ± 0.58

AC shows the presence of two most common antioxidant vitamins- ascorbic acid and alpha-tocopherol. None the less *AC* tubers are to some extent sources of vitamin A precursors, β-carotene and lycopene. Table 2 represents the ascorbic acid, alpha-tocopherol, β-carotene and lycopene content in *AC*.

All values are expressed as MEAN ± SD, of triplicate set of values for each parameter

Mineral content

AC is found to be good source of all essential dietary minerals. Mean values for mineral content of nutritional importance in *AC* are presented in Table 3 along with the reference daily intake (RDI) based on older recommended dietary allowance (RDA) from 1968, Council for Responsible Nutrition, and biological importance of the respective elements. The tuber serve to be an important source for potassium, sodium and calcium, the most common among macroelements, the order decreasing from K>Ca>Na. The tuber also serves to be good source of microelements like iron, chromium, magnesium, manganese zinc boron etc. Besides, evaluating the different macro and microelements in the sample, screening for the presence of heavy metals were also achieved. It is noteworthy to mention that no detectable trace of toxic heavy metals like arsenic, cadmium, lead and mercury were found in both the tubers of *AC*.

Table 3: Mean values for mineral content of nutritional importance in the tubers of *Amorphophallus campanulatus* (AC) and Reference Daily Intake (RDI)

Serial No.	Name of Mineral	Quantity (mg/100g dry tissue) *Amorphophallus campanulatus*	RDI	Biological significance
1.	Sodium (Na)	14.2 ± 0.59	2400mg	Electrolyte balance, nerve tissue excitability.
2.	Potassium (K)	1208 ± 5.66	4700mg	Electrolyte balance, nerve tissue excitability.
3.	Calcium (Ca)	19.524 ± 2.66	1000mg	Essential role in blood clotting, muscle contraction, nerve transmission, and bone and tooth formation
4.	Magnesium (Mg)	81.98 ± 6.54	400mg	Cofactor for enzyme systems
5.	Manganese (Mn)	0.394 ± 0.25	2mg	Involved in the formation of bone, as well as in enzymes involved in amino acid, cholesterol, and carbohydrate metabolism
6.	Iron (Fe)	1.794 ± 0.57	18mg	Component of hemoglobin and numerous enzymes; prevents microcytic hypochromic anemia
7.	Cobalt (Co)	Nil	0.008mg	Act as cofactor and stimulates erythropoiesis
8.	Chromium (Cr)	0.012 ± 0.05	0.12mg	Helps to maintain normal blood glucose levels
9.	Zinc (Zn)	2.058 ± 0.48	0.015mg	Component of multiple enzymes and proteins; involved in the regulation of gene expression.
10.	Copper (Cu)	0.332 ± 0.09	0.7mg	Component of enzymes in iron Metabolism
11.	Boron (B)	0.37 ± 0.06	20 mg	Necessary for brain function, memory and alertness

All values are expressed as MEAN ± SD, of triplicate set of values for each parameter

DISCUSSION

The root and tuber crops have been an essential constituent of diet among the rural folk. Tuberous vegetables are generally more starchy and marginal in protein content. Though these vegetables are not considered as good protein source, this study however reports that the protein content in both the tubers are more likely comparable to that of cereal paddy crops. The quantity and quality of the protein in starchy staples are variable and relatively low on a fresh weight basis but compare favourably with some cereals on a dry weight basis. None the less, the tubers can serve to be a good source of calorie for their rich carbohydrate content, as well as beneficial, since carbohydrate constitutes a major class of naturally occurring organic compounds that are essential for the maintenance of plant and animal life and also provide raw materials for many industries [26].Impact of urbanization has shifted the focus of people from these carbohydrate rich food crops to more of cereal consumption. It is considered by many authorities that the increasing dependence in developing countries on imported cereals is unsustainable and the trend should be reversed by stimulating reliance on indigenous crops, in particular roots and tubers [27]. Besides, reports are available that *AC* tubers possess hypoglycemic property [28] and despite being tuberous crop it can be safely consumed by diabetic patients without the risk of their blood glucose getting elevated.

Low fat content of the tuber make it safe for consumption by mankind in the era where obesity possess a serious threat to health and life of people. It can therefore frequently be consumed by individuals on weight reduction. Simultaneously, another important finding of the study is that the tubers of *AC* shows significantly higher amount of crude fibre content. According to Gordon, 2002, [29] there is a "dietary fibre hypothesis" which suggests that fibre helps to prevent many diseases prevalent in affluent societies. Fibre has been shown to help prevent and manage cardiovascular disease by lowering total and low-density lipoprotein (LDL) cholesterol levels. It also helps regulate blood sugar levels [30] and is also nutritionally beneficial, since it has been reported that food fibre aids absorption of trace elements in the gut [31]. Low in fat and carbohydrate while rich in fibre and protein can make tubers of *AC* attractive and healthy food component to be consumed safely and securely by people.

It is also evident from the results that the tubers of *AC* are sources of antioxidant vitamins like the fat soluble vitamin α-tocopherol and the water soluble vitamin ascorbic acid. Both the vitamins act synergistically as potent antioxidants thus preventing cellular damage caused by free radicals and reactive oxygen species (ROS). Not only so, presence of β-carotene and lycopene add to the antioxidant property of the tubers. Natural antioxidants, today in the era of nutraceuticals, are considered to have valuable health benefits in combating various stress related disorders.

The tubers of *AC* are good sources of macro and micro elements. It shows high potassium content, suggesting that high dietary potassium in humans play a protective role against hypertension, stroke, cardiac dysfunctions, renal damage, hypercalciuria, kidney stones, and osteoporosis [32]. The ratio of sodium (Na) to potassium (K) in the body is of great concern for prevention of high blood pressure. Na/K ratio less than one is recommended. The tubers of AC has Na/K ratio less than one and therefore it would not promote high blood pressure [33]. Besides, high calcium (Ca) content of the tubers may be of therapeutic value in hypocalcaemic state like osteoporosis.

Consumption of this tuber for its sufficient amount of essential micronutrients can be considered as nutritionally valuable and healthy. These nutrients may not be strictly medicinal but could be valuable in preventing diseases that are related to malnutrition. It is estimated that 2 billion of the world's population (largely in developing countries) have marked iron deficiency anaemia [34]. This, in turn, limits work performance and impaired mental and motor functions in children. Thus use of this tuber, especially among rural populace, can limit chances of nutritional anaemia because of their sufficient iron content to meet the daily allowance. Similarly, the tuber can also offer good amounts of zinc, magnesium, manganese and boron. FAO/WHO (2001) reported that zinc (Zn) is an essential component of a large number (>300) of enzymes participating in the synthesis and degradation of carbohydrates, lipids, proteins, and nucleic acids, as well as in the metabolism of other micronutrients. Furthermore, zinc has an essential role in polynucleotide transcription and thus in the process of genetic expression. Zinc also plays a central role in the immune system, affecting a number of aspects of cellular and humoral immunity [35].

Magnesium (Mg) is required in the plasma and extracellular fluid, where it helps maintain osmotic equilibrium [36]. It is required in many enzyme catalysed reactions, especially those in which nucleotides participate, the reactive species is the magnesium salt, e.g. $MgATP^{2-}$. Lack of Mg is associated with abnormal irritability of muscle and convulsions and excess Mg with depression of the central nervous system [37-39].

Manganese (Mn) is cofactor for some enzymes; because it is found with lecithin, it is involved in the synthesis of fatty acids and cholesterol; strengthens nerves and thought processes; element in body linings and connective tissues; helps with eyesight; enhances body's recuperative abilities and resistance to disease [37, 40].

Boron (B) assists and improves retention of calcium, magnesium, and phosphorus; necessary for brain function, memory and alertness, as well as for the activation of vitamin D [37]. Presence of heavy metals in soil is an obvious outcome of geo-climatic conditions and environmental pollution. Their assimilation and accumulation in plants is obvious, as, together with other pollutants, heavy metals are discharged into the environment through industrial activity, automobile exhaust, heavy-duty electric power generators, municipal wastes, refuse burning and pesticides used in agriculture [41]. Lead, Cadmium, Mercury and Arsenic is not detected in the tuber sample. Hence their consumption can be considered safe without the hazard of mankind being exposed to heavy metal toxicity.

Medicinal plants are found to contain minerals and heavy metals which in turn play an important role in their usage. Minerals are the product of geological processes, very essential in the regulation of metabolic process of the body. On the other hand heavy metals are dangerous to the health. World Health Organization guidelines also claim that medicinal plants might be checked for the presence of heavy metals. Therefore, estimation of minerals and heavy metals acquire great importance with respect to the safe and correct use of the plant [42]. The tuber of *AC* thus has nutritional qualities which when used in the right proportions can be of tremendous benefit to the body. Further studies will concentrate more on the use of the extracts of this plant on laboratory animals in order to determine their metabolic effects. Thus research in medicinal plants with claimed folkloric use should therefore be viewed as a fruitful and logical research strategy in the search for new drugs with low toxicity profile [43].

CONCLUSION

The results of the study show that the tuber of *Amorphophallus campanulatus* is a good source of almost all essential macro and micro nutrients. Besides, it is low in fat content with high fibre and carbohydrate. The results offer important ground to rank the wild edibles on the basis of organoleptic properties provided by local participants, along with the chemical data, for integration of indigenous knowledge with chemical information. Therefore, most of these underutilized edibles can be used to mitigate micro- and macronutrient deficiency and improve food security. Roots and tubers are an analogous substitution of cereals and research on their chemical composition are an important contribution in the field of indigenous traditional system of food consumption.

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