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Analysis of the Pattern of Complex Carbohydrates of Bamboo Shoot and Plantain Stem with Special Emphasis on its Impact on Metabolic Disorders

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Abstract

Total carbohydrate, starch, amylose, amylopectin, crude fibre, moisture and ash content of Bamboo shoot *(Bambusa vulgaris*) and Plantain Stem (*Musa paradisiaca*) were estimated quantitatively using standard protocols involving spectrophotometric and gravimetric principles. Scientific literature revealing its ethno medicinal and pharmacological properties was also studied. The Bamboo Shoot contained 7.2%, 3.24%, 2.0 %, 1.24%, 0.3%, 79.02%, 2.0 % and Plantain stem contained 9.3%, 4.32%, 3.2%, 1.12 %, 0.8%, 72.56%, 3.83% of total carbohydrate, starch, amylose, amylopectin, crude fibre, moisture, ash respectively. The higher content of complex carbohydrates and amylose were suggestive of its lower glycaemic index. The phytochemicals present in them in varying proportions can play a significant role in the prevention of many metabolic ailments and degenerative diseases.

Keywords:

Bamboo Shoot;
Plantain Stem;
Carbohydrates;
Metabolic Disorder;
Nutrients.

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1. Introduction

Dating back to Indian civilizations and Indian old literature, namely Bhagavadgita, Ramayana, and Manusmriti, every community that lived in India had a clear and separate food belief system [1]. Plants have always been part of human life. Historically, human knowledge and use of plants has been guided by practical needs and cultural predilections [2]. Traditional wisdom about processing of food, its preservation techniques, and their therapeutic effects has been established for many generations in India. Food systems can deliver numerous biological functions through dietary components in the human body. Indian traditional foods are also recognized as functional foods because of the presence of functional components such as body-healing chemicals, antioxidants, dietary fibers, and probiotics. These functional molecules help in weight management, blood sugar level balance and support immunity of the body [3].

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It has been estimated that there are around 27 thousand plant species with food potential in the world [4]. Prescott-Allen and Prescott-Allen estimated that 103 plant species are responsible for 90% of the world food supply. Although this number is underestimated and does not reflect the number of species that are actually used, since it is very likely that there is a large number of species with restricted distributions, whose uses are localized or have become neglected [5].Bamboo Shoot and Plantain stem are two significant food commodities with diverse functions [6], [7].

Bamboo is intricately associated with humans from times immemorial. Popularly known for their industrial use, a lesser known fact of bamboos is the usage of its young shoots as a food that can be consumed fresh, fermented, or canned. The juvenile shoots are not only delicious but are rich in nutrient components, mainly proteins, carbohydrates, minerals, and fiber and are low in fat and sugars. In addition, they contain phytosterols and a high amount of fiber that can be labeled as nutraceuticals or natural medicines that are attracting the attention of health advocates and scientists alike. The shoots are free from residual toxicity and grow without the application of fertilizers [8]. Bamboo shoots have a long history of being used as a source of both food and medicine in China and Southeast Asia [9].In Japan, the bamboo shoot is called the "King of Forest Vegetables." In China, knowing the nutritional value and delicious taste, people considered bamboo shoots a treasure dish in the Tang Dynasty and there was a saying that "there is no banquet without bamboo"[10]. The shoots have a good profile of minerals, consisting mainly of potassium (K), calcium (Ca), manganese, zinc, chromium, copper, iron (Fe), plus lower amounts of phosphorus (P), and selenium[11],[12]. Fresh shoots are a good source of thiamine, niacin, vitamin A, vitamin B6, and vitamin E [11], [13].

Banana is the second largest produced fruit after citrus, contributing about 16% of the world's total fruit production [14].India is largest producer of banana, contributing to 27% of world's banana production[15].

Banana pith from the pseudostem has long been eaten as vegetables in some parts of the world such as India, Sri Lanka, and Malaysia [16], [17]. The stem juices from *Musa paradisiaca L.* were investigated for the presence of phytochemicals with anti-diabetic potency. p-Hydroxybenzoiac and gallic acids, ferulic acid were the analytes found in stem juice. It also exhibited inhibitory activity against α-glucosidase and α-amylase [18]. The sap of the pseudostem from the banana tree (*Musa cavendish*) showed low content of solids, consisting primarily of sugars and minerals [19]. Banana pseudostem (*Musa acuminata*) is a commonly available agricultural waste to be used as lignocellulosic substrate and it is also used as a source for bioethanol production from the sugars released due to different chemical and biological pretreatment [20].

Aims and Objectives:

a. Quantitative estimation of the total carbohydrate, starch, amylose, amylopectin, crude fibre, moisture and ash content of Bamboo shoot and Plantain Stem.

b. To study the physiological, therapeutic, pharmacological properties by reviewing the literature of the commodities.

c. Correlating the results of the present study with its functional properties as obtained from the literature survey.

2. Research Method

2.1. Sample selection and preparation:

The two samples namely Bamboo Shoot *(Bambusa vulgaris)* and Plantain Stem (*Musa paradisiaca*) were collected from local markets of Harishchok, Khanakul, Hoogly, West Bengal, India. The culm sheath and the unwanted portion of the bamboo shoot and the outer covering of the plantain stem were also removed to get the soft edible portions which were used for the analysis.

Figure1: Bamboo Shoot

Figure2: Plantain Stem

2.2. Sample Analysis:

The samples were analysed in triplicates.

2.2.1. Total Carbohydrates [21].

100 mg of the sample was weighed into a boiling tube. It was then hydrolysed in a boiling water bath for 3 hours with 5 ml of 2.5N HCL and cooled to room temperature. It was then neutralised with sodium carbonate until the effervescence ceases and the volume was made upto 100 ml. It was centrifuged, supernatant was collected and 1ml aliquot was taken for analysis.

Standard glucose Stock was prepared by dissolving 100mg in 100 ml water. Working standard was prepared by mixing 10 ml of stock solution with 100 ml of distilled water. The standards were prepared by taking 0, 0.2, 0.4, 0.6, 0.8 and 1 mL of the working standard; 0 served as blank. The volumes of all the test tubes were made upto the volume of 1 ml including the sample tubes by adding distilled water. Then 4ml of anthrone reagent (200mg anthrone was dissolved in 100 mL of ice-cold 95% H2SO4) was added to all the test tubes which were followed by heating for 8 minutes in a boiling water bath. It was then cooled rapidly and the green to dark green colour was read at 630 nm.

2.2.2. Starch [21], [22].

0.5 g of the sample was homogenised in hot 80% ethanol to remove sugars.Centrifuged and the residue was retained. The residue was repeatedly washed with hot 80% ethanol till the washings do not give colour with anthrone reagent.The residue was dried well over a water bath. 5.0 mL of water and 6.5 mL of 52% perchloric acid was added to the residue. It was then centrifuged at 0°C for 20 min. Supernatant was collected. The extraction was repeated using fresh perchoric acid and the volume was made upto 100 mL. 0.1 ml of the supernatant was pipetted and the volume was made upto to 1 mL with water. The standards were prepared by taking 0.2, 0.4, 0.6, 0.8 and 1 mL of the working standard and the volume to was made upto 1 mL in each tube with water. 4 ml of anthrone reagent was added to each tube and heated for eight minutes in a boiling water bath. It was then cooled rapidly and the intensity of green to dark green colour was measured at 630 nm. The glucose content in the sample was estimated using the standard graph. The obtained value is multiplied by a factor 0.9 to get the starch content.

2.2.3. Amylose and Amylopectin [22]-[24].

100 mg of the powdered sample was weighed and 1 mL of distilled ethanol was added. Then 10 mL of 1 N NaOH was added and heated for 10 minutes in boiling water bath. The volume was made upto 100 mL. 2.5 mL of the extract was taken and 20 mL distilled water was added followed by the addition of three drops of phenolphthalein. 0.1 N HCl was added drop by drop until the pink colour just disappeared. 1 mL of iodine reagent was added and the volume was made upto 50 mL and the colour was read the colour at 590 nm. 0.2, 0.4, 0.6, 0.8 and 1 mL of the standard amylose solutions were taken and the color was allowed to develop and develop as in the case of sample.The amount of amylose was calculated using the standard graph. The amylose solution was prepared by dissolving 100 mg of amylose in 10 mL 1 N NaOH and the volume was made up to 100 mL with water.

1 mL of iodine reagent (1 g iodine and 10 g KI was dissolved in water and the volume was made upto 500ml) was diluted to 50 mL with distilled water for a blank.

Calculation:

Absorbance corresponds to 2.5 mL of the test solution =X mg amylose

100 mL contains=X/2.5 ×100 mg amylose = % amylose

The amount of amylopectin was obtained by subtracting the amylose content from that of starch.

2.2.4. Moisture [25].

The crucible was washed and dried up. Then the weight of crucible was taken. The sample weight along with crucible was also taken together. The sample was then placed in an oven at 104-105°Cfor 4 hrs and was cooled in a desiccator. The process was repeated for several times until the constant weight was reached.

$$\% \text{ moisture} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Sample weight}} \times 100$$

2.2.5. Crude Fibre [26].

2 g of dried material was boiled with 200 mL of sulphuric acid for 30 min with bumping chips. It was then filtered through muslin and washed with boiling water until washings were no longer acidic. It was then boiled with 200 mL of 1.25 % sodium hydroxide solution for 30 min. It was filtered through muslin cloth again and washed with 25 mL of boiling 1.25% H2SO4, three 50 mL portions of water and 25 mL alcohol.The residue was removed and transfered to ashing dish (preweighed dish W1).The residue was dried for 2 h at 130 ± 2°C. The dish was cooled in a desiccator and weighed (W2).It was then ignited for 30 min at 600 ± 15°C. Cooled in a desiccator and reweighed (W3).

% crude fibre in ground sample

=Loss in weight on ignition (W2-W1) - (W3-W1)/ Weight of the sample×100

2.2.6. Ash [25]

5 gram of grounded sample was weighed in a crucible and was gently heated over a flame until the mass was charred. Then the crucible was transferred to muffle furnace and ignited at 600°C. Cooled in a dessicator and weighed. The process was repeated until a constant weight was obtained.
% of ash= weight of ash/ weight of sample × 100

3. Results and Analysis

Constituents (g/100g)	**Bamboo Shoot** (*Bambusa vulgaris*)	**Plantain Stem** (*Musa paradisiaca*)
Total Carbohydrate	7.20±2.13	9.30±2.62
Starch	3.24±1.10	4.32±1.82
Amylose	2.00±0.50	3.20±0.71
Amylopectin	1.24±0.50	1.12±0.71
Crude Fibre	0.30± 0.10	0.80±0.17
Ash	2.00±1.02	3.83± 1.50
Moisture	79.02±5.5	72.56± 4.30

Table 1: Composition of Constituents in Bamboo Shoot and Plantain Stem
[Results are presented as mean ± Standard Deviation].

In the present study Bamboo Shoot and Plantain Stem were found to contain significant quantity of Starch (complex carbohydrate) which is about about 45% and 46% of total carbohydrates respectively. Starch is comprised of two polymers, amylose and amylopectin. Amylose is essentially linear (long linear chains) formed by α-(1,4) linked glucose units ; while amylopectin, with high molecular weight and highly branched structures, consists of α-(1,4) and α-(1,6) glycosidic linkages[27]. The amylose/amylopectin ratio has an effect on the functionality of starch [27], [28]. Amylose/amylopectin ratio also affects the nutritional quality of starch gauged by its digestion rate and resultant glycemic response, which is represented by the glycemic index (GI) and used as an indicator of carbohydrate quality [29]. Evidence shows that amylose slows digestion and insulin response time, providing a lower glycaemic index [30] and slow release of reducing sugars is desirable in diabetics [31]. Starchy foods that are rich in amylose content are associated with lower blood glucose levels and slower emptying of human gastrointestinal tract compared to those with low levels of amylose [32]-[34].

The results of this study clearly showed that amylose/ amylopectin ratio is high i.e., the proportion of amylose is more in comparision to amylopectin in both the samples. In case of Bamboo shoot amylose is about 62% of the total starch. The amylose content of Plantain stem was found to be 74% of starch.
Retrogradation rate and formation of resistant starch can be increased by high amylose amylopectin ratio [35]. RS (Resistant Starch) content has been found to positively correlate with amylose content in cereal crops [36] - [38]. A number of physiological effects have been ascribed to RS [39], which have been proved to be beneficial for health. There is ample justification that RS behaves physiologically like fiber. RS exhibits a level of slow digestibility and can be used as a vehicle for the slow release of glucose. Also, like soluble fiber, it has a positive impact on colonic health by increasing the crypt cell production rate, or decreasing the colonic epithelial atrophy in comparison with no-fiber diets. There is indication that RS like guar, a soluble fiber, influences tumorigenesis, and reduces serum cholesterol and triglycerides [40]. Significant changes in fecal pH and bulking as well as greater production of Short Chain Fatty Acid in the cecum of rats fed RS preparations have been reported [41]. RS has been suggested for use in probiotic compositions to promote the growth of such beneficial microorganisms as Bifidobacterium [42]. RS have a positive effect on intestinal calcium and iron absorption [43].

Bamboo Shoot and Plantain Stem are also good sources of crude fibre and moisture. As a result it can be used in the prevention and treatment of obesity, constipation, diabetes mellitus etc [44].
High content of ash suggests the presence of significant quantity of minerals which can boost up the overall metabolism [45].

Inspite of being a potential source of nutreints they also contains antinutritional factors. Bamboo contains a cynogenic glycoside called taxiphyllin which can be very harmful [46]-[48]. Tannin content is high in plantain stem [49]. These antinutrients can be removed considerably by proper heating, washing and processing [50].

4. Conclusion

Food unavailability is a major conundrum especially in developing countries with meagre resources. The understanding of the rich flora and its sustainable utilisation can serve as panacea. Bamboo Shoot and Plantain stem are unconventional and underutilized plant materials which can serve as a potential source of nutrients. High amylose to amylopectin ratio made it very advantageous for the patients suffering from

Glucose Intolerance and Diabetes mellitus. The results are suggestive that these complex carbohydrates and its interaction with minerals not only determine the glycaemic index of the food commodities but also regulate its digestibility and utility. These plant fragments also serves as prebiotics and plays a significant role in the prevention of many metabolic ailments and degenerative diseases. Several dishes can be developed from these plant products having greater nutritional contribution and enormous therapeutic efficacy.

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