

Bamboo shoots for fortification and novel food product development

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Abstract - One of the most significant challenges facing humanity in this current century is ensuring enough food and nourishment. Food fortification is one method that may be used to combat micronutrient deficiencies. Recent research has shown that bamboo shoots have a high nutritional content and a variety of positive effects on one's health. The purpose of this endeavour was to make bamboo shoot fortified biscuits, namkeen, and noodles as well as to establish ways for using the shoots of an edible bamboo species called *Dendrocalamushamiltonii* for food fortification. According to the findings of studies, the shoots are an abundant source of both macro- and micronutrients as well as bioactive compounds, and the product that was made making use of the shoots also showed an enrichment in the nutrients and bioactive compounds. Fortification with bamboo shoot is an excellent technique to combat the widespread micronutrient insufficiency that exists in our nation at the present time.

Keywords - *Dendrocalamushamiltonii*, Bamboo Shoot, Food Fortification, Micronutrients, Bioactive Compounds

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INTRODUCTION

One of the biggest challenges facing humanity in the twenty-first century is feeding the world's growing population. In the not-too-distant future, there will likely be a global food crisis once the world's population reaches 8 billion in 2023 and 10 billion in 2050, as projected (United Nations, 2017). The United Nations Food and Agriculture Organization estimates that between 2014 and 2016, almost 11% of the world's population was hungry due to a lack of food to fulfil their nutritional energy needs (2018). Recently, a network of government and business sectors came up with the Green revolution to guarantee that food supply meets demand. Some of the most essential food crops have seen a rise in output because to this revolution. It's not enough to just feed the world's population; we also need to provide them the micronutrients they need to develop normally and flourish. Reduced agricultural diversity and dwindling food supply are direct results of the widespread reliance on a small number of staple crops. Consequently, "hidden hunger," caused by low intakes of certain necessary micronutrients, may affect people of all ages in both developed and poor countries. In 2016, 11% of people worldwide were undernourished; 22.9% of children were stunted; and 33.3% of women were reproductively anaemic owing to hidden hunger.

Staple grains like rice, wheat, and maize make up a large part of the diets of many people who are on tight budgets. This is their sole option, and it drastically

lacks numerous macronutrients and other micronutrients (Calloway, 1995). Deficits in certain micronutrients have been related to a number of serious health problems, including low birth weight, stunted growth, impaired development, blindness, mental retardation, and immune system abnormalities all over the world (Akhtar et al., 2019). This widespread issue of micronutrient inadequacy has resulted in a number of government bodies giving public health a higher priority and launching various programmes to address the issue.

It has become more important to find a permanent solution to vitamin deficiencies. This focus encourages progress in the areas of nutrition, agriculture, and the food system (Black et al., 2013). Noncommunicable illnesses are on the rise in the 21st century due to rapid changes in lifestyle, calling for comprehensive plans to improve the nation's food supply (Roos et al., 2019). Public health and economic progress are stymied in low-income regions due to the prevalence of noncommunicable illnesses.

Fortification of food

Fortification of food products is defined as "the practise of intentionally increasing the amount of micronutrients in a food to improve the nutritional quality of the food supply and to provide a public health benefit with minimal risk." Organization for Food and Agriculture at the United Nations (WHO

and FAO, 2006). Fortification is defined as "enrichment" in the Codex Alimentarius (1987). Definition of enrichment: "the addition of one or more important nutrients to a diet, regardless of whether it is typically contained in the food, with the objective of preventing or correcting a proven shortfall in the population or certain population groups." Fortification is defined as the process of "adding one or more key nutrients to a food, whether or not it is typically fortified." Simple and processed foods might be fortified to help remedy micronutrient deficiencies. Increased consumption of micronutrients will also result from biofortification of staple foods via plant breeding, dietary diversification, and pharmaceutical supplementation (Mannar and Hurrell, 2018).

Transportation Means for Vitamin-Fortified Food

Micronutrient deficits may be avoided by food fortification. Selecting appropriate food vehicles is crucial to the success of fortification projects. A thorough survey is required to determine the optimal levels of nutritional intake and food consumption in order to assure the healthiness of the upper and lower limits. Many aspects should be taken into account while selecting fortified food carriers, as suggested by the Food and Agriculture Organization (FAO, 1996). Other factors include a wide selection of popular dishes, stringent quality assurance, competitive pricing, high bioavailability, high sensory appeal, and good storage stability. The wheat, rice, milk, salt, sugar, cooking oils, and sauces may all be used as vehicles in the kitchen. The distribution of baked goods, biscuits, dairy products, packaged cereals, flours, and other ready-to-eat foods is a great way to provide the people with comfort food and micronutrients.

The Amazing Bamboo Plant

Bamboo is not only one of the most rapidly growing plants but also one of the most adaptable and financially significant. Numerous names have been bestowed upon it as a result of its adaptability, including "Cradle to Coffin Plant," "Poor Man's Timber," "Green gold," "Green Gasoline," "Miracle plant," "The Plants with thousand faces," "Friends of the people," and "My brother." All of these names refer to the same plant under different circumstances (Bao, 2006; Nirmala et al., 2011). Certain species of bamboo have the potential to grow up to 91 centimetres (35 inches) a day if permitted to continue at their present rate of development, as stated by Guinness World Records (2014).

There are a number of characteristics that set bamboo apart from other plants, including its hollow internode stem, scattered vascular bundles, absence of dicotyledonous woody xylem and secondary development, spikelet inflorescence, and caryopsis fruit in which the seed coat is attached to the fruit wall. A member of the grass family Poaceae, bamboo is specifically part of the subfamily Bambusoideae. Only after many years of growing and generating seeds do

most bamboo species achieve a single, huge blooming. Rhizome branching is the most essential and rapid method nature provides for vegetative proliferation in bamboo. The culm (also known as the stem) and the branches make up a bamboo plant's aerial parts. The underground structure of a plant is made up of its rhizome and the roots it produces. It is possible to classify bamboo into two groups based on the way their rhizomes develop: i) leptomorph or monopodial, in which the rhizome grows horizontally and new shoots emerge from the nodal buds; and ii) pachymorph or sympodial, in which the rhizome develops only from lateral buds and new shoots emerge from pseudo-rhizome (Hidalgo-Lopez, 2003).

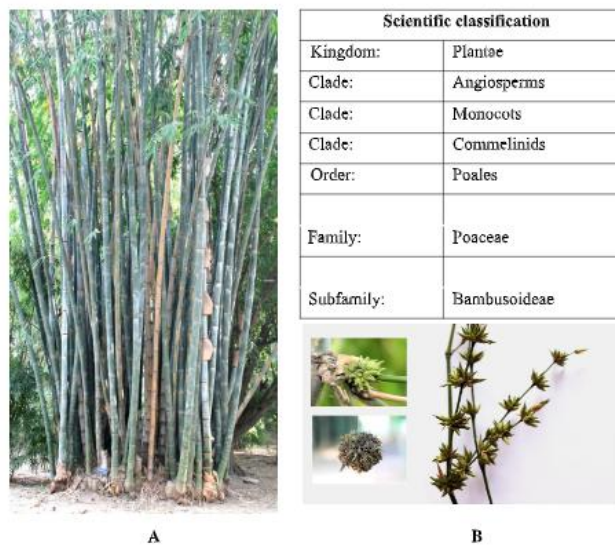


Figure 1: Bamboo: A) a group of bamboo stalks B) a bamboo flower

Eat Bamboo Shoots:

Rich people enjoy generations-old bamboo shoot delicacies. Bamboo shoots are poor man's lumber and rich man's delicacy (Nirmala et al., 2011; Satya et al., 2012). Collins and Keilar (2005) say around 100 bamboo species are farmed for delicious young shoots. Rhizomes grow bamboo shoots throughout most monsoons. One-pound 20-30 cm shoots taper at one end. Thicker leaves (Farrelly, 1984). Soups, stir-fries, appetisers, salads, fried rice, spring rolls, and other fried foods use bamboo stalk's crisp, crispy flavour (Nirmala et al., 2011).

Bamboo Shoot Significance:

Juvenile bamboo shoots taste good and include protein, carbs, minerals, vitamins, and fibre. Their food potential is high. Bamboo shoots are abundant in fibre, vitamins, minerals, protein, antioxidants, and polyphenols and low in fat, according to research (Bhargava et al., 1996; Chen et al., 1999; Bhatt et al., 2005; Kumbhare and Bhargava, 2007; Nirmala et al., 2007, 2008; Satya et al., 2010; Choudhury et al., 2012). Shoots have health-promoting bioactives. Phytosterols, flavonoids, and phenolic acids lower

blood pressure and cholesterol, boost appetite, and combat cancer and diabetes. Bamboo shoots are high in fibre, which may lower the risk of cardiovascular disease, hypertension, obesity, cancer, and gastrointestinal disorders

Bamboo shoot lignans combat cancer, germs, and viruses (Fujimura et al., 2005). Bamboo shoot's high cellulose content speeds stomach peristaltic action, improving digestion (Fujimura et al., 2005; Shi and Yang, 1992). Ayurvedic, Chinese, Indo-Persian, and Tibetan medicine use tabasheer, a bamboo internode-based siliceous substance. Bamboo was useful in ancient Tibetan, Chinese, and Indo-Persian medicine (Nirmala and Bisht, 2017). 10,000 years ago, Indian Ayurveda employed tabasheer in Chyawanprash, a youth, beauty, and longevity tonic (Nirmala et al., 2018). Bamboo shoots have treated chicken pox, skin ailments, infections, ulcers, and more for millennia (Burkill, 1935; Sangtam et al., 2012). In the Ming Dynasty (1368-1644) Compendium of Materia Medica, bamboo shoots were medicinal. Liquid circulatory system advantages are highlighted (Yuming and Jiru, 1999). Bamboo is medicinal, according to recent research. Bamboo shoot is popular in nutritional, nutraceutical, cosmeceutical, and medicinal products due to its health advantages.

Bamboo Shoot Processing:

Due to their nutritious and bioactive chemical composition, bamboo shoots are healthful and fortifying. Fresh bamboo shoots are only accessible during monsoon season and spoil quickly. They are perishable due to their high moisture content. Two to three days after harvesting, the material browns, lignifies, and decays at room temperature (Badwaik et al., 2014; Zeng et al., 2015). Cyanogenic glycosides make the shoot poisonous and tasteless before processing. Before eating or fortifying, bamboo stalks must be harvested, prepared, and stored. Keep and consume them. For nutritional benefits, bamboo shoots have been boiled, soaked, dried, fermented, and canned (Kumbhare and Bhargava, 2007; Nirmala et al., 2007, 2008).

But most bamboo shoot-based dishes are created locally. Use the shoot to prepare everyday recipes to use this healthful vegetable year-round. This does both. Bakeries employ healthy ingredients. Bakeries contain fibre. Wheat, oat, rice, and barley bran; powdered apple, lemon, and mango peel; maize and fenugreek flour; coconut meal; legumes; and mushrooms. Bamboo shoots are functional foods (Nirmala and Bisht, 2017). Food fortification with minerals and bioactive substances has lowered nutritional insufficiency-related disorders for a century. Rickets, pellagra, goitre, and beriberi (Dwyer et al., 2015). It restores nutrients lost during cooking and enhances nutrient intake for a healthy diet. Fortification used to prevent nutritional illnesses, but today it solves nutritional concerns. Malignancies, cardiovascular disease, ischemic stroke, diabetes, and nutrition-

related disorders are rising globally, according to the Global Health Organization (2002).

Shoots as Food and Medicine

Bamboo, a plant employed in both ancient and contemporary civilisation, is becoming popular globally as a health food (Nirmala et al., 2011). China, Japan, and India eat and medicate using bamboo stalks (Bao, 2006). Japan calls it the "King of Forest Vegetables" for its taste and nutrients. "There is no feast without bamboo" was a popular Tang Dynasty (618–907) dish. Japanese "Forest Vegetable King" (Nirmala et al., 2011). Bamboo shoots are "slightly chilly, pleasant, non-toxic, and it quenches thirst, increases the liquid circulatory system, and may be served as a daily meal," according to the Ming Dynasty (1368–1644). (Yuming and Jiru, 1999). Tabasheer, formed from bamboo internodes, is used in Tibetan, Chinese, Indo-Persian, and Tibetan medicine. Bamboo is medicinal in Ayurvedic, Chinese, and Indo-Persian medicine (Nirmala and Bisht, 2017).

Young bamboo stalks have long been a popular food (Satya et al., 2012). Chinese cuisine has employed young bamboo shoots as forest vegetables for approximately 2,500 years. Northeastern India and certain hilly areas in the south, north, and west consume bamboo stalks. Luxury retailers and restaurants seek bamboo shoots. Bamboo shoots are becoming "rich man's delicacy." Though popular, residents disregard bamboo shoots (Nirmala et al., 2011). Many Asian nations use young, weak bamboo shoots during the rainy season to prepare delectable foods, either fresh, dried, canned, or fermented. Fresh shoots provide snap to soups, stir-fries, appetisers, salads, fried rice, spring rolls, and more (Nirmala et al., 2011). China, Japan, and India offer them dry, fermented, pickled, and canned (Bashir, 2010).

Bamboo Shoot Nutrition

Many research has explored bamboo shoot nutrition. The US Bureau of Human Nutrition and Home Economics published a study on species' average food value in early 1953. (1954). Xia (1989) tested Guangdong's Moso bamboo, *Phyllostachys pubescens*, for lowering sugar, protein, crude fat, fatty acids, vitamins, minerals, and amino acids. Tripathi tested *Bambusa vulgaris*, *B. bambos*, and *Melocannabaccifera* edible shoots for nutrition (1998). *B. bambos* has the greatest moisture (88.8%), protein (3.9%), fat (0.5%), carbohydrates (5.7%), and minerals (1.1%). Fiber-rich juvenile shoots are low in calories. Shoots are low-calorie and healthy. In healthy proportions, bamboo stalks include potassium, calcium, manganese, zinc, chrome, copper, iron, phosphorus, and selenium. Fresh shoots are rich in thiamine, niacin, vitamins A, B6, and E. The body requires 17 amino acids, including methionine, serine, leucine, isoleucine, lysine, and

phenylalanine, but cannot produce them (Qiu, 1992; Ferreira et al., 1995). Phenylalanine, tyrosine, methionine, and glutamic acid changed throughout the shoot. Bamboo greatly decreased tyrosine. Glutamic acid and methionine were stable (Higuchi and Shimada, 1969).

Bamboo Shoot Preparation

Bamboo stalks are perishable at room temperature. Only during monsoon season does India and Southeast Asia sell it. Bamboo shoots' short shelf life necessitates immediate consumption or processing. Tissue lignification made the shoot firm quickly after harvest, but microbial deterioration and browning caused by various enzymatic and non-enzymatic activities reduced its quality. The shoot underwent enzymatic and non-enzymatic activities (Luo et al., 2008). Mechanical damage increases respiration and microorganisms, decaying bamboo shoots. Matsui et al. say phenylalanine ammonia-lyase affects shot texture during storage (2004). Temperature, humidity, microbial exposure, and storage reduce shoot shelf life without proper processing and preservation. Water keeps bamboo shoots fresh (Anonymous, 2009). To preserve their appearance, flavour, and scent, bamboo shoots are processed. Due to taxiphyllin, bamboo shoots must be treated before eating. Vital. Bamboo shoots can be preserved using traditional and modern methods. Boiling, soaking, fermenting, sun drying, roasting, canning, pickling, etc.

Table 1: Products fortified using Bamboo Shoots:

Sr. No.	Fortified products	Bamboo Species	Processed form
1	Amaretti cookies	Not mentioned	Bamboo fiber
2	Crackers, Nugget, Pickle	<i>Bambusa bambos</i> , <i>B. tulda</i> , <i>Dendrocalamus asper</i> , <i>D. strictus</i>	Brine treated boiled shoot
3	Chicken nuggets	<i>B. auriculata</i>	Shoot fermented for two months
4	Candy, Chutney, Chukh, Cracker, Nugget	<i>D. hamiltonii</i>	Boiled shoot
5	Pork Nuggets	<i>B. polymorpha</i>	Brine treated boiled and fermented for 6 months

6	Biscuit	<i>B. balcooa</i>	Boiled, dried and powdered
7	Chips	<i>B. vulgans</i>	Shoot boiled for two hours
8	Pork Pickles	Not mentioned	Minced shoot exposed to sun and fermented for 21 days, dried and powdered
9	Candies	Not mentioned	Boiled shoot
10	Cookies	Not mentioned	Boiled shoot, dried and powdered
11	Pork Nuggets	<i>B. polymorpha</i>	Brine treated boiled shoot extract
12	Battered and breaded fish balls	Not mentioned	Bamboo shoot fiber of Hubei Ruifa Biological Engineering Co., Ltd.
13	Fried potato chips	<i>Bambusa balcooa</i>	Bamboo shoot powder and bamboo shoot extract
14	Frozen dough	Not mentioned	Bamboo shoot fiber of Zhejiang Geng Sheng Tang Ecological Agriculture, Co., Ltd.
15	Milk pudding	<i>D. latiflorus</i>	Shoot fiber extracted with cellulase and papain enzyme method

16	Biscuit	<i>D. hamiltonii</i>	Freeze-dried powder of fresh, boiled and soaked shoots
17	Biscuit	<i>D. hamiltonii</i>	Fresh, boiled and soaked shoot paste
18	Cookies	<i>D. asper</i>	Bamboo culm treated with meta-bisulphite, dried and powdered

MATERIAL AND METHODS

- **Selection of Bamboo Species:** The *Dendrocalamushamiltonii* Nees & Arn. ex Munro bamboo is one of India's most popular Himalayan *Dendrocalamus* species. It's also crucial. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura are among the north-eastern states where the species is found. North-eastern Indians collect *D. hamiltonii* for its edible shoots on a big scale. The inquiry focused on *D. hamiltonii* shoots.
- **Selection of Study Site:** Natives in all of India's north-eastern states eat the shoots of the *D. hamiltonii* plant, one of the most prevalent fermented species. The Garo Market in Shillong, Meghalaya is the only North-Eastern Indian market with substantial numbers of *D. hamiltonii* shoots.
- **Procurement of Plant Material:** *Dendrocalamushamiltonii* Nees & Arn. ex Munro juvenile shoots were acquired at the local Garo market in Shillong, Meghalaya, India during the peak season from June to September for three years (2016-2018). Shillong is 25.5 degrees north and 91.89 degrees east. The gathered shoots were wrapped in blotting paper, labelled with the right species name and date, and put in an airbag with dry ice before being transported to the Panjab University Department of Botany in Chandigarh (India).
- **Preparation and Processing of Bamboo Shoot Samples:** The recovered shoots were washed and the external culm sheets peeled off at the Panjab University Department of Botany laboratory in Chandigarh. The edible part of the peeled shoots was chopped into small pieces and put on blotting paper to remove excess water.

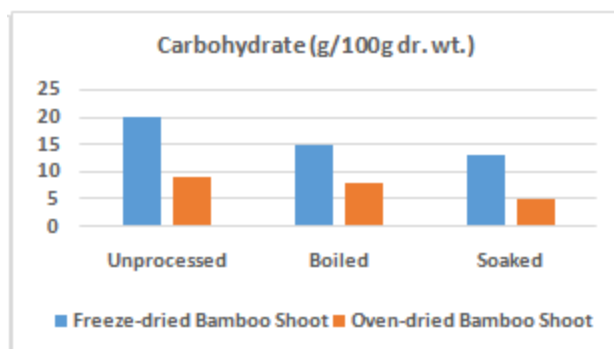
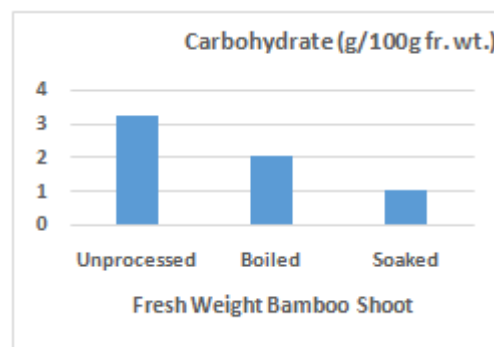
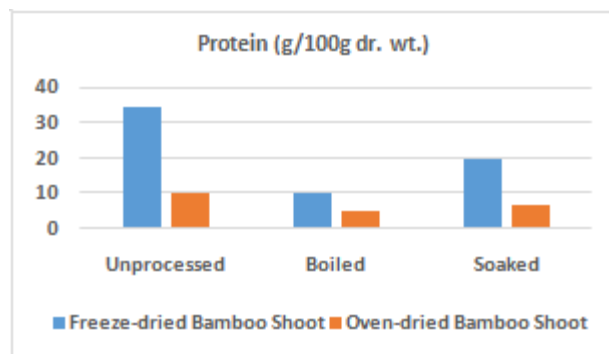
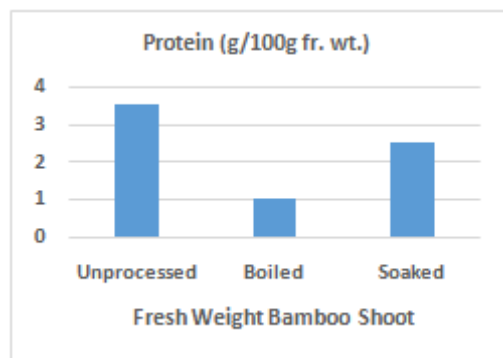
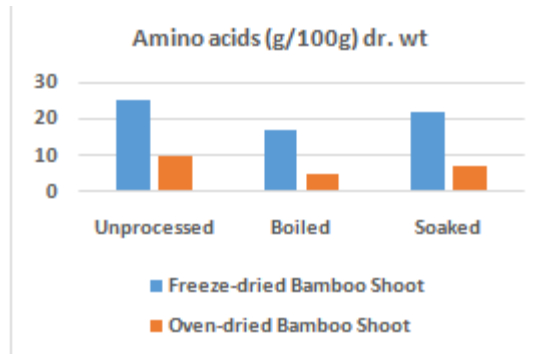
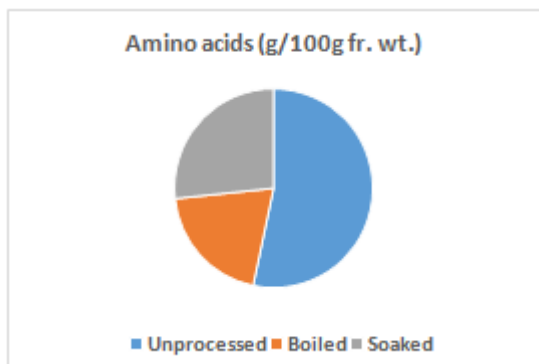
- **Preparation of Bamboo Shoot Fortified Products:** Baking, deep frying, and mixing dough were only some of the preparation procedures that were used in the process of creating items that had bamboo shoots as an ingredient. There are ten different recipes for each of the three different types of products that are produced, which include biscuits, namkeen, and noodles.
- **Equipments/Instruments used:** The Department of Botany's laboratory was used in various ways to complete many procedures to reach the desired results.
- **Biochemical Analysis:**

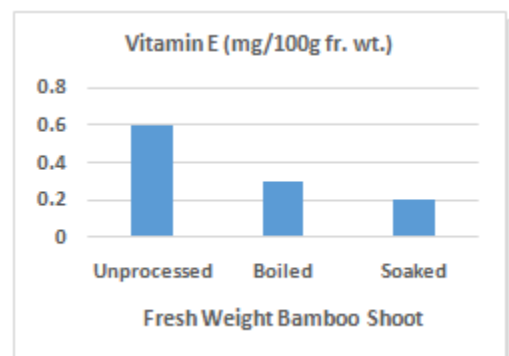
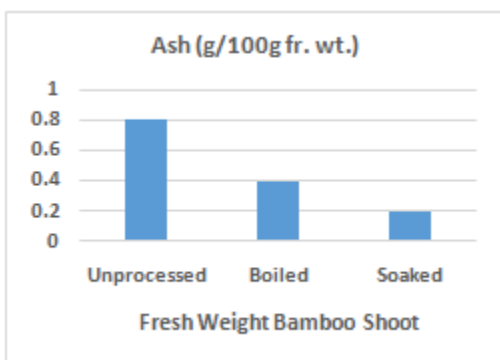
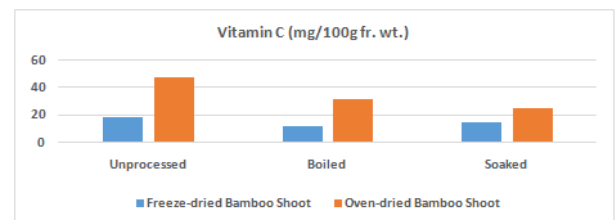
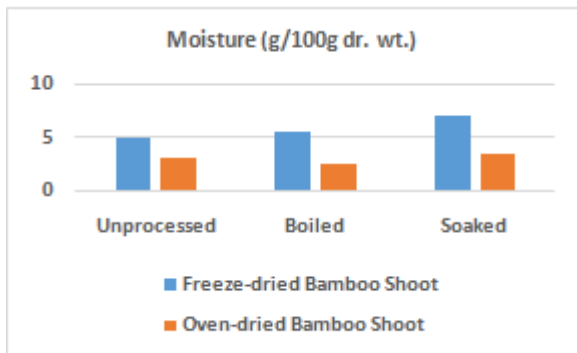
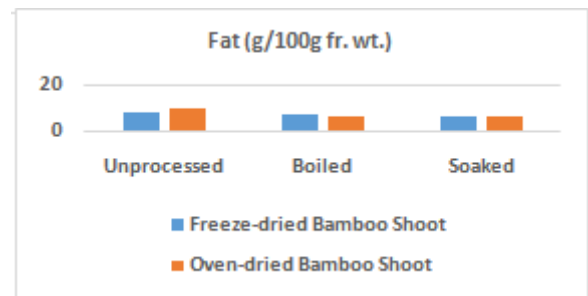
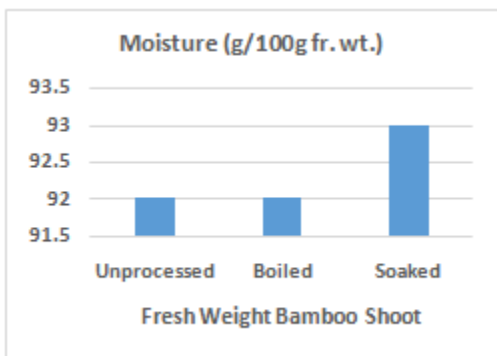
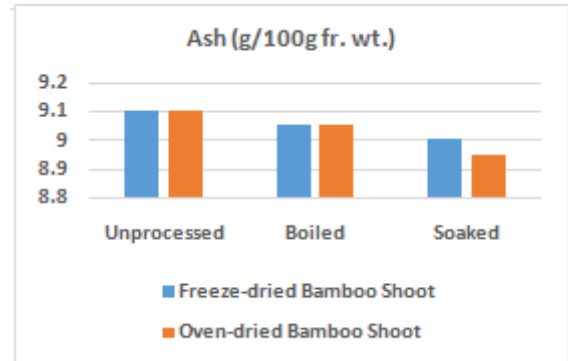
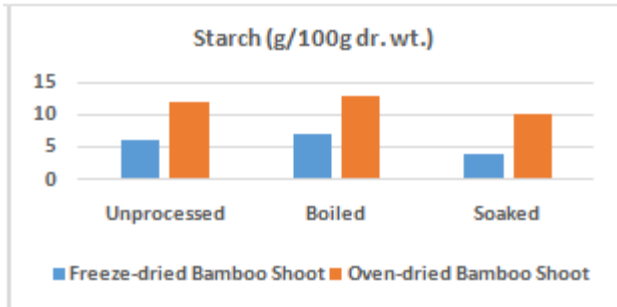
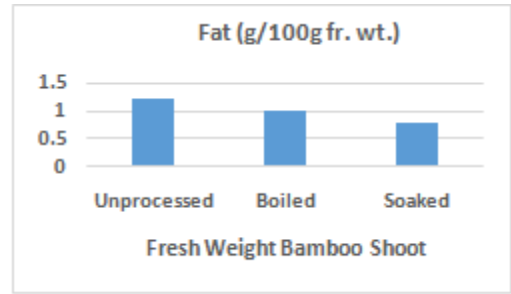
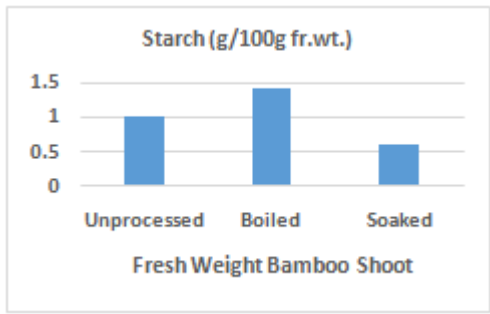
Table 2. Methods used for biochemical estimation of various parameters.

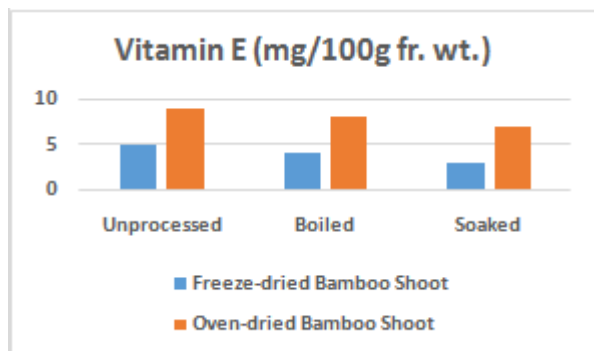
Parameters	MethodUsed
Nutrients	
AminoAcid	Leeand Takahashi (1966)
Protein	Bradford(1976)
Carbohydrate	Whistler(1971)
Starch	Mecreddy et al. (1958)
Moisture	ByOvenDryMethod
Ash	Harbers(1994)
TotalFat	AOAC(1990)
VitaminC	Riemschneider et al. (1976)
VitaminE	Baker et al. (1980)
Minerals	WavelengthdispersionX-rayfluorescence (WDXRF)

RESULTS

In both fresh weight shoots and processed freeze, the amount of total free amino acids, protein, carbs, starch, moisture, ash, and fat is measured in grams per 100 grams, while the amount of vitamin C and E is recorded in milligrams per 100 grams. - oven-dried and dried shoots.







CONCLUSION

Food and nutritional security is one of humanity's most pressing concerns in the twenty-first century. Micronutrient insufficiency may be remedied by fortifying foods. Recent research has shown bamboo shoots' nutritional worth and several health advantages. The objective of this study was to establish techniques for using the shoots of the edible bamboo *Dendrocalamushamiltonii* for food fortification and the formulation of bamboo shoot fortified cookie, namkeen, and noodle. According to studies, the shoots are a rich source of macronutrients, micronutrients, and bioactive compounds, and the product derived from the shoots also shown an increase in the nutrients and bioactive compounds. Utilizing bamboo shoot in fortification is an appropriate method for addressing the widespread micronutrient shortage in our nation.

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