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Food Fortification Using Bamboo Shoot- A Review

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Abstract - The availability of sufficient food and adequate nutrition is one of the most important challenges facing the human race in the twenty-first century. Fortifying meals with additional nutrients is one way to address micronutrient deficiencies. Recent studies have shown the nutritional value of bamboo shoots, in addition to its many health benefits. The purpose of this research was to investigate the nutritional value of bamboo foods. The use of bamboo shoots in the process of fortification is an effective strategy for alleviating the widespread micronutrient deficiency that exists in our country.

Keywords - Bamboo Shoots, Food Fortification, Micronutrient, Nutritional Value

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INTRODUCTION

Providing adequate food and sustenance for everybody is one of the greatest issues mankind has in the twenty-first century. It is estimated that by 2023 the world's population will have reached 8 billion, and it is forecast to reach 10 billion by 2050, both of which portend a worldwide food shortage in the not-too-distant future (United Nations, 2017). Around 11% of the global population could not get enough food to meet their nutritional energy demands between 2014 and 2016, according the Food and Agriculture Organization of the United Nations (2018). To ensure that there is a balance between the demand for food and the available supply, a network of governmental and corporate sectors came up with the Green revolution in recent years. This revolution increases production of some of the primary food crops. It's not enough to provide enough calories to sustain the world's population; we also need to ensure that everyone has access to the micronutrients they need to grow and thrive. Due to people all over the globe depending on the same few crops for sustenance, agricultural diversification has decreased and food supplies have shrunk. As a result, individuals of all ages in both industrialized and developing nations may suffer from "hidden hunger," which is the result of insufficient intakes of certain essential micronutrients. In 2016, 11% of the world's population was undernourished, 22.9% of children were stunted, and 33.3% of women were reproductively anaemic due to hidden hunger.

Foods have both direct and indirect effects on the growth and development of the human body. It is where many vital minerals for human health have their genesis. Plant foods are rich in a wide range of organic phytochemicals that contribute to general health and wellbeing, and they are also the major source of mineral and organic nutrients essential to human nutrition. On the other hand, not all plant-based meals supply enough of each essential element per serving to meet the recommended daily allowances. The case is much stronger with plant-based foods. Many individuals on limited budgets depend on a diet dominated by staple grains like rice, wheat, and corn. Their only choice is this diet, which is severely lacking in several essential macronutrients and other micronutrients (Calloway, 1995). Worldwide, micronutrient deficiencies are linked to a high baby and early child mortality rate as well as growth retardation, physical impairment, blindness, mental retardation, and immune deficiency disorders (Akhtar et al., 2019). Therefore, many government agencies have started to give public health more of a priority, and have implemented several programmes to combat the widespread problem of micronutrient insufficiency.

Recently, the demand for a sustainable and long-term vitamin deficiency remedy has grown. This emphasis promotes nutrition-agricultural and food system innovation (Black et al., 2013). Due to fast lifestyle changes, non-communicable diseases are becoming more common in this century, necessitating integrated food sector strategies (Roos et al., 2019). Non-communicable diseases hinder public health and socioeconomic development in developing countries. According to a 2010 World Health Organization report (WHO, 2010), a rapidly changing lifestyle that included a limited selection of high-nutrient foods and other factors increased the risk of non-communicable diseases like cardiovascular diseases, obesity,

diabetes, osteoporosis, cancer, gastrointestinal diseases, and respiratory diseases. Thus, consumer choice has shifted away from nutritious meals and toward food that prevents nutrition-related disorders and enhances consumers' physical and mental health, leading to the creation of contemporary functional foods. This trend has transformed food industry. Functional foods may improve health when eaten regularly as part of a varied diet. Functional foods include whole and fortified, enhanced, or improved foods (Crowe and Francis, 2013).

Food fortification

"Product fortification" is "the practise of purposely enhancing the level of micronutrients in a food to enhance the nutritional quality of the food supply and to give a public health benefit with low risk." The UN Food and Agriculture Organization defines this (WHO and FAO, 2006). Codex Alimentarius (1987) defines "fortification" as "enrichment." Enrichment is "the addition of one or more necessary nutrients to a diet regardless of whether or not it is ordinarily included in the food, with the aim of avoiding or correcting a demonstrable deficit in the population or particular population groups." "Adding one or more important nutrients to a food whether or not it is ordinarily fortified" is fortification. Micronutrient deficits may be addressed by fortifying basic and processed meals. Biofortification of staple crops by plant breeding, dietary diversity, and pharmaceutical supplementation will also boost micronutrient intake (Mannar and Hurrell, 2018).

Food Fortification Vehicle

Food fortification helps avoid micronutrient deficiencies. Fortification programmes depend heavily on food vehicle selection. To ensure the healthiness of the upper and lower limits, a comprehensive survey is needed to establish the appropriate nutritional intake and food consumption levels. The Food and Agriculture Organization (FAO, 1996) recommends considering many factors while choosing fortified food carriers. Other considerations include a variety of popular meals, quality control, a low price, bioavailability, sensory appeal, and storage stability. Food vehicles include wheat, rice, milk, salt, sugar, cooking oils, and sauces. Bread, biscuits, dairy goods, packaged cereals, flours, and ready-to-eat items are an excellent method for the public to receive micronutrients and comfort food.

Bamboo- A Wonder Grass

Bamboo is one of the fastest growing plants and also one of the most versatile and economically important plants. Numerous titles have been given to it because of its versatility: "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." They are all synonyms for the same plant (Bao, 2006; Nirmala et al., 2011). According to Guinness World Records, some types of bamboo may reach a daily growth rate of up to 91cm (35 inches) if allowed to continue at their current rate of development (2014). Some of bamboo's distinguishing features include its hollow internode stem, dispersed vascular bundles, lack of dicotyledonous woody xylem and secondary growth, spikelet inflorescence, and caryopsis fruit in which the seed coat is united to the fruit wall. Bamboo belongs to the subfamily Bambusoideae of the Poaceae family of plants. Most species of bamboo only produce a single, massive flowering once in their whole lifetime, and that is after they have spent many years producing many seeds. Vegetative propagation in bamboo is accomplished by rhizome branching, a process that is both important and the fastest technique nature gives. The aerial part of a bamboo plant consists of the culm (sometimes called the stem) and the branches. The rhizome and the roots it generates are the plant's subterranean structure. There are two distinct types of bamboo, distinguished by how their rhizomes branch: 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).

Scientificclassification	
Kingdom:	Plantae
Clade:	Angiosperms
Clade:	Monocots
Clade:	Commelinids
Order:	Poales
Family:	Poaceae
Subfamily:	Bambusoideae

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

Bamboo may attain its full height, produce all of its twigs and leaves, and complete the maturity of its culm tissue in a single growing season. The culms are fragile and easy to damage during the sprouting period, but they harden and become mature over the course of many years. Depending on the species, the time needed to grow bamboo to the point where it can be collected for use in construction or making bamboo-based products may vary from two to five years (Banik, 1993; Midmore et al., 1998).

Bamboo Shoot as Food:

Generations-old bamboo shoot delicacies are the rich man's treat. Bamboo shoots have been called poor man's lumber and wealthy man's delicacy (Nirmala et al., 2011; Satya et al., 2012). Collins and Keilar (2005) report that over 100 bamboo species are grown worldwide for edible young shoots. Most monsoons produce a juvenile bamboo branch from the rhizomes. These 20-30 cm shoots weigh around a pound and taper at one end. Their leaves are thick (Farrelly, 1984). Soups, stir-fries, appetisers, salads, fried rice, spring rolls, and other fried delicacies utilise bamboo stalk's crisp, crunchy flavour (Nirmala et al., 2011). Bamboo shoots are a staple vegetable in many Asian countries. Bamboo shoots are dried, fermented, pickled, and bottled in China, Japan, and India (Bashir, 2010; Nirmala et al., 2011). *Gulairebung and Sayurladeh* are bamboo-shoot-based Indonesian cuisines. Gulairebung uses thick coconut milk with spices, whereas Sayurladeh adds veggies (Bhatt et al., 2003). Chinese manufacture delicious ulanzi by fermenting fresh stalk sap during the rainy season (Qing et al., 2008). Bhutan and Nepal's eastern highlands ferment and eat mesu (Tamang, 2005). India harvests young bamboo shoots from *Bambusabambos, Dendrocalamusgiganteus, D. hamiltonii, D. membranaceus, and D. strictus* to make pickles and vegetables (Tripathi, 2011).

Bamboo Shoot and its Significance:

Juvenile bamboo shoots are pleasant and packed with protein, carbohydrates, minerals, vitamins, and fibre. Because of this, they have great food potential. Studies have shown that bamboo shoots are high in dietary fibre, vitamins, minerals, protein, antioxidants, and polyphenols and low in fat (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 contain health-promoting bioactive substances. Phytosterols, flavonoids, and phenolic acids decrease blood pressure and cholesterol, increase hunger, and fight cancer and diabetes (Park and Jhon, 2009; Hong et al., 2010; Koide et al., 2011; Nirmala et al., 2011; Singhal et al., 2013). Bamboo shoots are abundant in dietary fibre, which may reduce the risk of cardiovascular disease, hypertension, obesity, cancer, and several gastrointestinal issues (Anderson et al., 2009; Lattimer and Haub, 2010; Brennan et al., 2012). It also controls blood sugar, prevents constipation, lowers cholesterol, and helps manage weight (Behall, 1997). Shoots include a good amount of potassium, calcium, manganese, zinc, chromium, copper, iron, phosphorus, and selenium, according to Shi and Yang (1992). Fresh bamboo shoots include thiamine, niacin, vitamin A, vitamin B6, and vitamin E. (Visuphaka, 1985; Xia, 1989; Shi and Yang, 1992). Shoots contain 17 amino acids, 8 of which humans need (Qiu, 1992; Ferreira et al., 1995). The water content is at least 90%, substantially greater than the fat content (0.26% to 0.94%) and total sugar content (2.5% on average), which are lower than those of other vegetables (Nirmala et al., 2011).

Bamboo shoot lignans fight cancer, bacteria, and viruses (Fujimura et al., 2005). Bamboo shoot's high cellulose content accelerates gut peristaltic activity, aiding digestion (Fujimura et al., 2005; Shi and Yang, 1992). Ayurvedic, Chinese, Indo-Persian, and Tibetan medicine employ tabasheer, a siliceous material made from bamboo internodes. In ancient Tibetan, Chinese, and Indo-Persian medicine, bamboo was beneficial (Nirmala and Bisht, 2017). Indian Ayurveda used tabasheer in Chyawanprash, a health tonic that promotes youth, beauty, and longevity, 10,000 years ago (Nirmala et al., 2018). Bamboo shoots have been used for centuries to treat chicken pox, skin diseases, infections, ulcers, and more (Burkill, 1935; Sangtam et al., 2012). Bamboo shoots were medicinally documented in the Ming Dynasty (1368-1644) book Compendium of MateriaMedica. The text emphasises liquid circulatory system benefits (Yuming and Jiru, 1999). Recent scientific study has verified the medicinal benefits of bamboo. Due to its health benefits, bamboo shoot is gaining popularity as a dietary, nutraceutical, cosmeceutical, and pharmaceutical component.

Processing and Fortification of Bamboo Shoot:

Bamboo shoots are good for a healthy diet and fortification due to their high nutritional and bioactive chemical content. Fresh bamboo shoots are only available during monsoon season and have a short shelf life. Their high moisture content renders them perishable and prone to microbiological, mechanical, and physical damage. At room temperature, the material will brown, lignify, and decay two to three days after harvesting (Badwaik et al., 2014; Zeng et al., 2015). The shoot tastes bad and may be toxic due to cyanogenic glycosides, making it unfit for consumption before processing. Bamboo shoots must be gathered, processed, and preserved before they may be eaten or fortified. They may then be kept and eaten. Boiling, soaking, drying, fermenting, and canning bamboo shoots have been studied for their nutritional effects (Kumbhare and Bhargava, 2007; Nirmala et al., 2007, 2008).

However, most bamboo shoot-based cuisine products are prepared according to local tastes. Using the shoot to make ordinary foods is a potential way to utilise this healthy vegetable year-round. This achieves both purposes. Bakeries often use nutritious ingredients. Researchers have added fibre to bakery products. These ingredients include wheat, oat, rice, and barley bran; powdered apple, lemon, and mango peel; maize and fenugreek flour; coconut meal; legumes; and mushrooms (Sudha et al., 2007; Vitali et al., 2009; Srivastava, 2010; Bisht et al., 2015). Functional foods and nutraceuticals may include bamboo shoots (Nirmala and Bisht, 2017).

Over the last century, food fortification with minerals and bioactive compounds has reduced nutritional

insufficiency-related diseases. Rickets, pellagra, goitre, and beriberi are examples (Dwyer et al., 2015). It replenishes nutrients lost during food preparation and boosts nutrient intake for a healthier diet. In the early 1920s, fortification was meant to eliminate diseases caused by nutritional inadequacies, but nowadays it addresses nutritional issues rather than diseases. The Global Health Organization (2002) reports an increase in malignancies, cardiovascular disease, ischemic stroke, diabetes, and other nutrition-related illnesses worldwide. These illnesses formerly only affected high-income countries. In recent years, chronic illnesses have skyrocketed worldwide owing to environmental causes, particularly lifestyle changes that alter diets. The rising costs of diet- and sedentary-related chronic diseases and an ageing population have elevated nutrition and health concerns (Malla et al., 2014).

Bamboo Shoot as Food and Medicine

Due to its potential as a health food, bamboo, a key plant taxon used in both traditional and modern civilization, is gaining appeal worldwide (Nirmala et al., 2011). China, Japan, and India use bamboo stalks for food and medicinal (Bao, 2006). Due to its flavour and nutritional benefits, it is called the "King of Forest Vegetables" in Japan. During the Tang Dynasty (618–907) in China, "there is no feast without bamboo" was a prized dish. "King of Forest Vegetables" in Japan (Nirmala et al., 2011). "It is slightly cool, pleasant, non-toxic, and it quenches thirst, enhances the liquid circulatory system, and may be offered as a daily meal," the Ming Dynasty (1368–1644) wrote about bamboo shoots (Yuming and Jiru, 1999). Traditional Tibetan, Chinese, Indo-Persian, and Tibetan medicine uses tabasheer, a siliceous material made from bamboo internodes. Ayurvedic, Chinese, and Indo-Persian medicine recognise bamboo's medicinal properties (Nirmala and Bisht, 2017).

Edible young bamboo shoots have been a favourite dish for decades (Satya et al., 2012). For almost 2,500 years, Chinese cuisine has used young bamboo shoots as a woodland vegetable. Bamboo shoots are generally eaten in northeastern India and a few hilly regions in the south, north, and west. Upscale stores and restaurants want bamboo shoots. Bamboo shoots are now "rich man's delicacy" rather than "poor man's lumber." Bamboo shoots are still overlooked by locals, although their deliciousness is in great demand (Nirmala et al., 2011). Young, frail bamboo shoots, available during the rainy season in many Asian countries, are utilised to make delicious dishes, either fresh, dried, tinned, or fermented. Fresh shoots provide a crisp, crunchy flavour to soups, stir-fries, snacks, salads, fried rice, spring rolls, and more (Nirmala et al., 2011). China, Japan, and India sell them dry, fermented, pickled, and canned (Bashir, 2010).

Nutritional Value of Bamboo Shoot

Many studies have examined the nutritional value of eating bamboo shoots. In early 1953, the US Bureau of Human Nutrition and Home Economics released a research on the average food value of various species. (1954). Xia (1989) examined Phyllostachyspubescens, known as Moso bamboo in Guangdong, China, for its reducing sugar, protein, crude fat, fatty acids, vitamins, minerals, and amino acids. Tripathi examined *Bambusa vulgaris, B. bambos, and Melocannabaccifera* edible shoots for nutritional content (1998). *B. bambos* contained the most moisture (88.8%), protein (3.9%), fat (0.5%), carbs (5.7%), and minerals (1.1%). Young juvenile shoots are high in fibre and low in calories. Because of their minimal calories, shoots are healthful food. The bamboo stalk includes potassium, calcium, manganese, zinc, chrome, copper, iron, phosphorus, and selenium in healthy amounts (Shi and Yang, 1992; Saini et al., 2017; Bajwa et al., 2019). Thiamine, niacin, vitamin A, B6, and E are abundant in fresh shoots (Visuphaka, 1985; Xia, 1989; Shi and Yang, 1992). It includes 17 amino acids, including methionine, serine, leucine, isoleucine, lysine, and phenylalanine, which the body needs but cannot generate (Qiu, 1992; Ferreira et al., 1995). Phenylalanine, tyrosine, methionine, and glutamic acid levels varied throughout the shoot. Bamboo growth largely reduced tyrosine. Methionine and glutamic acid levels were stable (Higuchi and Shimada, 1969). 57–67% of the shoot's amino acids are tyrosine. The amino acids, proteins, carbs, and fibre content of edible shoots of *Bambusaarundinacea, B. polymorpha, B. tulda, B. vulgaris, B. wamin, and Dendrocalamuscalostachys, D. giganteus, D. membranaceus, and D. strictus*were analysed. Protein content varied from 1.5 to 4.0 g/100g fresh. (2004). Yuming et al. (2004) examined 250 bamboo species in Yunnan, China. 100 bamboo species are edible, and 9 have high-quality shoots. Nine bamboo species are: *Dendrocalamushamiltonii, Qiongzhueatumidinoda, Fargesiayunnanensis, Chimnonocalamusfimbriatus*, D. lat. According to an investigation, the nutritionally valuable species has a high protein (15.23%), edible cellulose (6-8%), fat (2.4%), amino acids, trace elements, and vitamin content. *Bambusabalcooa, Bambusanutans, Bambusatulda, D. giganteus, D. hamiltonii, D. hookerii, D. longispathus, D. sikkimensis, Melocannabaccifera, Phyllostachysbambusoides, and Teinostachyumwightii* are 11 bamboo species with high market potential. The study also reported bamboo shoot food energy (14.6 - 16.9 MJ/kg), ash content (2.1 - 3.7%), crude fibre (23.1 -35.5%), fat (0.6 -1.0%), and carbohydrate (4.5 -5.2%). Ascorbic acid, tryptophan, and methionine are also found in the edible stem. Shoots include potassium, phosphorus, and magnesium. Five bamboo species—*Bambusabambos, Bambusatulda, Dendrocalamus asper, D. giganteus, and D. hamiltonii*—had their immature shoots and 10-day-old shoots analysed for nutritional changes (Nirmala et al., 2007). As they matured, all five species lost nutrients, vitamins, and minerals while gaining dietary fibre and moisture. Nirmala et al. (2011)

examined the nutritional value of fourteen bamboo species, including *Bambusa bamboo, B. kingiana, B. nutans, B. polymorpha, B. tulda, B. vulgaris, Dendrocalamus asper, D. brandisii, D. giganteus, D. hamiltonii, D. membranaceus, and D. strictus*. Fresh shoots have less fat than carbohydrates, proteins, and fibre. *B. tulda* has the most carbohydrate (6.92 g/100 g fresh weight). *D. hamiltonii* has 3.71% protein. B. vulgaris has 4.80 mg/100 g vitamin C. D. asper has 0.91 mg/100 g of vitamin E. Each species was studied. *B. tulda, B. bambos, D. asper, D. giganteus, and D. hamiltonii* are recommended for commercial bamboo shoot production due to their high nutritional content.

Processing and Preservation of Bamboo Shoot

The bamboo stalk is a perishable food that lasts three to four days at room temperature. India and other South-East Asian countries sell it only during monsoon season. Bamboo shoots must be consumed or processed quickly after harvest due to their limited shelf life. Due to tissue lignification, the shoot's firmness rose fast after harvest, but microbial deterioration and browning induced by various enzymatic and non-enzymatic activities lowered its quality. The shoot was subjected to enzymatic and non-enzymatic activities (Luo et al., 2008). Mechanical damage may enhance respiration and microorganisms, decaying bamboo shoots. Phenylalanine ammonia-lyase affects shot texture during storage, according to Matsui et al. (2004). Without proper processing and preservation, temperature, humidity, microbial exposure, and storage conditions will reduce shoot shelf life. Bamboo shoots need moisture to stay fresh. Bamboo shoots are processed and preserved to maintain their look, flavour, and scent and delay their decomposition. Bamboo shoots must be treated before consumption due to their high antinutrient content, especially taxiphyllin. It's vital. Traditional and modern methods may process and preserve bamboo shoots. Boiling, soaking, fermenting, sun drying, roasting, canning, pickling, and more are examples.

Table 1: Products fortified using Bamboo Shoots:

Sr.No.	Fortifiedproducts	BambooSpecies	Processedform
1	Amaretti cookies	*Notmentioned*	Bamboofiber
2	Crackers,Nugget,Pickle	*Bambusabambos, B. tulda, Dendrocalamusasper,D.strictus*	BrinetreatedboiledShoot
3	Chicken nuggets	*B. auriculata*	Shoot fermented for two months
4	Candy, Chutney, Chukh, Cracker, Nugget	*D. hamiltonii*	Boiled shoot
5	Pork Nuggets	*B. polymorpha*	Brine treated boiled and fermented for 6 months
6	Biscuit	*B. balcooa*	Boiled, dried and powdered
7	Chips	*B. vulgaris*	Shoot boiled for two hours
8	Pork Pickles	*Not mentioned*	Minced shoot exposed to sun and fermented for 21 days, dried andpowdered
9	Candies	*Not mentioned*	Boiled shoot
10	Cookies	*Not mentioned*	Boiled shoot, dried and powdered
11	Pork Nuggets	*B. polymorpha*	Brine treated boiled shoot extract
12	Battered and breaded fish balls	*Not mentioned*	Bamboo shoot fiber of Hubei Ruifa Biological Engineering Co.,
13	Fried potato chips	*Bambusabalcooa*	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	*D. latiflorus*	Shoot fiber extracted with cellulase and papain enzyme method
16	Biscuit	*D. hamiltonii*	Freeze-dried powder of fresh, boiled and soaked shoots
17	Biscuit	*D. hamiltonii*	Fresh, boiled and soaked shoot paste
18	Cookies	*D. asper*	Bamboo culm treated with meta- bisulphite, dried and powdered

Fortified bamboo shoot products are promising health foods and sources of medicinal and nutraceutical compounds. Fortified goods have been studied less than shoot processing. Fortified goods should concentrate on the best processing method to remove antinutrients and retain nutrients. Bamboo shoot-fortified items such nuggets, crackers, papad, chips, and biscuits have been reported, however a nutritional profile comparison to a control sample to assess protein, carbs, and amino acids has not been done. Phenol, phytosterol, and dietary fibre are frequently used in manufacturing owing to their health benefits, but their addition to fortified products has not been studied until now. The bamboo stalk has significant mineral content, however there is untapped potential to increase those minerals in the product. This requires thorough processing and evaluation of bamboo shoot-enriched products' nutritional, bioactive, mineral, sensory, and antioxidant properties.

CONCLUSION

One of the most significant obstacles that the human race will have to overcome in the twenty-first century is finding a way to ensure that sufficient food and enough nourishment are readily available. Micronutrient deficits may be addressed in a number of ways, one of which is by adding more nutrients to meals. In addition to having numerous positive effects on one's health, recent research has shown that bamboo shoots also have a high nutritional value. The investigation of the nutritional content of meals made from bamboo was the focus of this particular piece of study. The use of bamboo shoots as part of the process of fortification is a productive method for addressing the widespread micronutrient shortage that is present in our nation.

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