

## EFFECT OF PROCESSING AND FORTIFICATION ON NUTRIENTS OF BAMBOO SHOOT AND FORTIFIED PRODUCTS

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### ABSTRACT

Bamboo is not only one of the plants that grows the quickest but also one of the most adaptable and significant plants commercially. It is known by a variety of names due to the numerous ways in which it can be utilised, including "The Cradle to Coffin Plant," "The Poor Man's Timber," "The Green gold," "Green Gasoline," "Miracle plant," "The Plants with thousand faces," "Friends of the people," and "My brother." In bamboo, the process of vegetative proliferation by rhizome branching is both an essential method and the quickest way that nature provides. The culm, also known as the stem, and the branches make up the aerial element of bamboo. The rhizome and the roots that it produces make up the underground component of the plant. Juvenile bamboo shoots are not only tasty, but also abundant in a variety of essential nutrients, including proteins, carbs, minerals, vitamins, and dietary fibre. Because of this, they have a significant amount of untapped potential as a food resource. The nutritional analysis of bamboo shoots has previously been emphasised by a number of studies, who have shown that bamboo shoots have a high level of dietary fibre, vitamins, minerals, protein, antioxidants, and polyphenols, while also containing a low amount of 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). Additionally, shoots are a good source of bioactive compounds that are beneficial to one's health. Fermentation significantly lowered oxalate levels, improving mineral bioavailability. Drying retained more anti-nutrients compared to other methods, suggesting the need for additional processing steps like soaking before consumption. All processing methods significantly reduced cyanogenic glycosides, making bamboo shoots safer. The research shows that the processing and fortification have a significant impact on the nutrients of young bamboo shoots and fortified products.

**Keywords:** Commercially, Proliferation, Bamboo shoots, Nutritional, Fermentation, Bioavailability

### 1. INTRODUCTION

One of the most significant challenges facing humanity in this current century is ensuring enough food and nourishment. The problem that we face is not just to offer enough food to feed the world's population; we also need to give enough micronutrients to meet the fundamental dietary needs that are essential for healthy body development. The expansion and maturation of the human body are both directly and indirectly influenced by the foods we consume. It is the origin of a variety of nutrients that are essential for keeping the human body healthy. Plant foods are the primary source of mineral and organic nutrients, both of which are necessary for human nutrition, as well as a variety of organic phytochemicals that contribute to overall health and wellness. This research will help us determine the effect of processing and fortification on the nutrients of young bamboo shoots and fortified products. A significant number of people living on low incomes rely on a basic diet consisting mostly of staple grains like rice, wheat, and maize. This diet is deficient in many macronutrients and a great deal of key micronutrients, yet it is their only option (Calloway, 1995). A high death rate among infants and young children, growth retardation, physical disability, blindness, mental retardation, and immune deficiency illnesses are all associated with micronutrient deficiencies over the world (Akhtar et al., 2019). As a result, a variety of government organisations have begun to place a greater emphasis on the significance of public health by putting into place a variety of initiatives designed to address the micronutrient-deficiency. Fortification is defined as "the addition of one or more essential nutrients to a food whether or not it is normally Fortifying staple foods and processed foods with additional micronutrients is one way to combat the problem of micronutrient deficiencies. In addition to these methods, biofortification of staple crops via plant breeding techniques, dietary variety, and pharmaceutical supplementation will all contribute to an increase in the consumption of micronutrients (Mannar and Hurrell, 2018). The fortification of food was introduced during both the First and Second World Wars as a solution to the problem of nutritional deficiency and as a way to replenish nutrients that were lost during the preparation of food (Mejia, 1994). Iodized salt was the first food to be fortified in Switzerland in 1922 (Burgi et al., 1990) and in Michigan, USA in 1924. Many traditionally cultivated crop plants are mostly replaced with main crops such as maize, potato, rice, and wheat, which, despite having a high food energy content, are not considered to be a good source of nutrients, particularly micronutrients such as minerals and vitamins

(Torres et al., 2013; Baldermann et al., 2016; Marles, 2017). In recent years, malnutrition and disorders connected to diet have become more common as a direct result of a reduction in the variety of foods consumed by humans (Nakhauka, 2009). Numerous underappreciated plants provide a rich amount of vitamins, minerals, micronutrients, and other chemicals that are beneficial to one's health.

## 2. OBJECTIVE OF STUDY

**AMINO ACIDS-** A vital bioactive molecule that is needed for human metabolism and necessary for development and maintenance, amino acids are perhaps best recognized as the nutritional substrates or building blocks that are required for the production of proteins (Nie et al., 2018). There are approximately 500 amino acids that can be found either free in nature or only as intermediates in the metabolic process; however, for protein synthesis, only 20 amino acids are required in general, with 9 essential amino acids (histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, and valine) that cannot be synthesized by the human body and therefore have to be obtained from food (Elango and Laviano, 2017; Hoffer, 2017). In terms of nutrition, it is well recognised that essential amino acids play critical roles in cell signalling, the precursors of hormones, glutathione and serotonin, glucose control, lipid metabolism, promote mitochondrial biogenesis, and immunological dynamic-homeostasis (Dillon, 2013; Wu, 2013; Bifari et al., 2017). Recent years have shown that the availability of amino acids in one's diet is an essential element in the pace of protein synthesis, which in turn influences different aspects of human metabolism and also serves as a biomarker for the detection of chronic illness (Newgard et al., 2009).

**PROTEIN-** Protein is an essential component in terms of global food security, and it may be Acquired from a variety of different foods, including those derived from plants and animals. When compared to the sources of protein found in plants, the consumption of dietary protein derived from animal sources is much higher and costlier. A wide variety of pulses and grains are the sources of nutritionally rich plant proteins that are incorporated and used in the formulation of various food products to cover the needs of essential amino acids for growth and tissue maintenance as well as to improve the texture and physical stability of the products. These plant proteins come from a variety of plant sources, including pulses and grains (Chardigny and Walrand, 2016). The protein profile of many kinds of bamboo shoot, which is not only an essential food but also considered a delicacy in a great number of nations, was shown to be rather favorable (Giriand Janmejy, 1992; Tripathi, 1998; Bhatt et al., 2005; Kumbhare and Bhargava, 2007; Nirmala et al., 2008, 2011; Satya et al., 2010, 2012; Rawat et al., 2016). In the current study, the protein content of fresh weight shoot samples, freeze-dried shoot samples, and oven-dried shoot samples ranged from 1.21 to 3.5 grammes of protein per one hundred grammes of fresh weight, 10.68 to 36.03 grammes of protein per one hundred grammes of dry weight, and 6.08 to 9.61 grammes of protein per one hundred grammes of dry weight, respectively. Nirmala et al. reported previously that the quantity of protein found in D. Hamiltonian fresh shoot (3.18 g/100g fr. wt.) was comparable to the amount of protein that was found in unprocessed shoot with an estimate of 3.5 g/100g fr. wt (2011). When compared to bamboo shoots the majority of regularly eaten winter and summer vegetables have a lesser concentration of protein. Bamboo shoots, on the other hand, have the highest concentration of protein (Nirmala et al., 2011). According to Bajwa et al. (2016), the quantity of protein in fresh shoots of D. Hamiltonian was reported to be 2.83 g/100g fr. wt. This revealed a lower figure when compared with the experiment that is being presented here. The protein content of the freeze-dried powder of D. giganteus was estimated to be 27.32 grammes per one hundred grammes of dry weight (Rawat et al., 2016), which is lower than the protein content of the unprocessed freeze-dried powder of D. Hamiltonian, which was 36.03 grammes per one hundred grammes of dry weight, as reported in the present work. Since the freeze-drying approach does not include any kind of continuous heat treatment, the quantity of protein that was retained in the shoot samples was at its highest possible level when compared to both the fresh weight and those oven-dried samples. Researchers Oni et al.

**CARBOHYDRATE-** Carbohydrates are the primary source of readily available energy; they make up between 40 and 80 percent of a person's daily calorie intake. Carbohydrates are also the most important component in the construction of a variety of biomolecules, including those that play an essential part in human metabolism in the form of dietary fibre and other prebiotics (Mann et al., 2007). In addition to these functions, it regulates cholesterol levels, the glucose and insulin levels in the blood, and it contributes to the glycosylation of proteins (Cummings et al., 1997). Previous research has revealed the carbohydrate content of a variety of other edible shoots, including the bamboo shoot (Young, 1954; Bhatt et al., 2005; Kumbhare and Bhargava, 2007; Nirmala et al., 2011; Badwaik et al., 2014; Pandey and Ojha, 2014; Badwaik et al., 2015; Bajwa et al., 2015; Chandramouli and Viswanath, 2015; Rawat et al., 2016). A study compared the carbohydrate content of regularly eaten veggies with edible bamboo shoots, and the results showed that the carbohydrate content of edible bamboo shoots was either greater or equivalent to the amount of most of the vegetables investigated (Nirmala et al., 2011). The freeze-dried powder of unprocessed shoot had the highest total carbohydrate content, according to the findings of the present experiment (21.47 g/100g dry weight). In a

similar vein, the products that were fortified with freeze-dried powder of unprocessed shoot contained the highest levels of total carbohydrate. These levels were as follows: 20.24 grammes of total carbohydrate per one hundred grammes of dry weight in the biscuit; 22.71 grammes of total carbohydrate per one hundred grammes of dry weight in the namkeen; and 33.57 grammes of total carbohydrate per one hundred grammes of dry weight in the noodle. According to Pandey et al. (2012), the carbohydrate content in bamboo shoot fortified product of nugget, papad, and pickle varied from 1.4-36.12 g/100g dr. wt.

**STARCH-** The primary type of carbohydrate that supplies the highest amount of dietary energy for storage by plants and is present in all cereal grains, different tubers, fruits, and pulses is starch. Starch is also the form of carbohydrate that makes up the majority of the human diet. In the 21st century, it makes a substantial contribution not just to the sectors that deal with food but also to those that deal with non-food products such as textiles, cosmetics, and medicines (Schoch, 1967; French, 1984). In the food manufacturing industry, starch serves not only as a source of nourishment but also as an extender, thickening, sweetener, texturizer, stabilizer, and assistance in the processing of ingredients (Wurzburg, 1986). The determination of the amount of starch present in several edible species of bamboo shoot and its influence on a variety of processing techniques have been reported in the past (Nirmala et al., 2011; Pandey and Ojha, 2014; Bajwa et al., 2015; Rawat et al., 2016). The current analysis indicated that the starch content of shoot samples varied from fresh weight, freeze-dried, and oven-dried to be anything between 0.67 and 12.91 grammes per one hundred grammes. Nirmala et al. (2011) reported the starch content of *D. Hamiltonian* as 0.50 g/100g in fresh shoot; however, in the present study, higher starch content was recorded (1.11 g/100g) in the fresh weight of unprocessed shoot. This suggests that the starch content may be affected by the processing method. This is the first report of starch being found in *D. Hamiltonian*, and it was found in the freeze-dried powder.

**MOISTURE-** The amount of moisture present in food is a significant aspect in the quality control of a wide variety of vegetables and bread items. Depending on the product, the nutritional qualities and sensory features may either be enhanced or diminished by the presence of moisture. According to Marfo et al. (1990), maintaining the textural features of vegetables and fruits, including the maximum and minimum levels of moisture in dried fruits and other baked items, requires an adequate amount of moisture. It is also essential for the microbiological stability and biosafety regulation of the food, both of which are required for the items' marketability and shelf life (Silva et al., 2008). The current investigation discovered that the moisture content of bamboo shoots was extremely high in the fresh weight of unprocessed, boiled, and soaked shoots, ranging from 92.28- 93.34%. This content was found to significantly decrease when the shoots were Freeze-dried (5.52-7.21%) or oven-dried (3.27-3.73%). The amount of moisture that was present in all of the formulations of fortified items was less than 10%, with the least amount being present in fortified biscuits. None of the various formulas made a discernible difference in the amount of moisture that the enriched noodle contained. Among the various processed forms of bamboo shoots, a slight increase in the moisture was observed in the boiled and soaked shoot samples.

**ASH-** Ash is the inorganic residue that is left behind after full oxidation of organic matter. Unlike other biological components, ash is not eliminated by fire owing to its reduced volatility. Ash also shows the quantity of total minerals that are present in a biomass (Liu, 2019). Because the ignition process vaporises water and volatiles, buries organic material, and converts the remaining mineral components to oxides, sulphates, phosphates, chlorides, and silicates, foods that have a high amount of ash are regarded to have a high mineral content (Ooi et al., 2012). In the current study, the ash content of the shoot ranged from 0.27 to 0.80 grammes per one hundred grammes of fresh weight, from 8.99 to 9.12 grammes per one hundred grammes of freeze-dried shoot, and from 8.92 to 9.13 grammes per one hundred grammes of oven-dried shoot, respectively. According to Nirmala et al. (2011), the total ash content of 0.86 g/100g in the fresh shoot of *D. Hamiltonian* was recorded. This result is virtually identical to the ash content of the present findings for the unprocessed shoots. It was observed that the ash content of *D. Hamiltonian* decreased by 37% after being boiled for 15 minutes (Bajwa et al., 2015), which is another piece of evidence that supports the current study. Similar observations regarding a reduction in the ash content after boiling and soaking have been reported for *D. giganteus*, *D. latiflorus*, *D. sikkimensis*, *D. asper*, and *B. nutans* (Kumbhare and Bhargava, 2007; Rawat et al., 2016). These observations were based on the fact that the ash content decreased.

**FAT-** Consumers have been given advice over the course of the last few decades to cut back on their consumption of saturated fatty acids due to the increased risk of developing a number of health conditions, including cardiovascular disease, diabetes, stroke, cancer, and a variety of immune-mediated disorders (Federico et al., 2010). However, fats are an essential ingredient in many different kinds of foods because they are important for the quality, shelf life, and acceptability of foods. High fat foods in nutritional concern are high in calories, which are often linked with obesity; however, high fat foods are a nutritional concern because they are high in calories (Vieira, 2015). The melting of chocolate and butter, the mouth feel of foods, the texture of frozen desserts, the incorporation of air for baked goods,

the fluffiness of cookies, gluten network inhibition in pastries, and other functions are all affected by the fat content of foods. Creaminess in milk and yoghurt, lubrication of meat and ice-creams, melting chocolate and butter, mouth feel melting chocolate and butter, mouth feel melting chocolate and butter, mouth feel melting chocolate and butter, mouth feel melting chocolate and butter, mouth feel (Marangoni and Narine, 2002; McGee, 2004; Clements et al., 2008; Pareyt and Delcour, 2008; Goff and Hartel, 2013). When it comes to cholesterol, the fat that is used in the food business is an essential component; despite this fact, several searches have been conducted to identify cholesterol-free alternatives.

**VITAMIN C-** Vitamin C, also called ascorbic acid and ascorbate, is a kind of vitamin that may be obtained via consuming a variety of foods and is also available for purchase as a dietary supplement. In addition to playing a role in the metabolic process of proteins, it is necessary for the production of collagen, L-carnitine, and a number of other neurotransmitters. Scurvy is caused by a deficiency in vitamin C, which also leads to extensive connective tissue weakening and fragile capillaries (Devaki and Raveendran, 2017). The antioxidant activity of vitamin C is one of its most valuable attributes since it aids in the prevention of a variety of ailments, including cancer, cardiovascular disease, age-related muscle degeneration, and cataracts. There is an abundant supply of vitamin C in fresh fruits and vegetables, the richest sources of which are the Indian gooseberry, citrus fruits such as limes, oranges, and lemons, tomatoes, potatoes, papaya, green and red peppers, kiwifruit, strawberries, and cantaloupes, and green leafy vegetables such as broccoli. Vitamin C is essential for maintaining healthy skin and immune function.

**VITAMIN E-** Tocopherols and tocotrienols are referred to combined as "tocochromanols," and they are lipid-soluble antioxidants. Vitamin E is made up of eight distinct tocopherols and eight different tocotrienols. A well-known and extensively researched component of vitamin E is called alpha-tocopherol. Because it is an antioxidant, vitamin E helps to keep membrane lipids from being damaged by oxidation and helps cells continue to operate normally. A deficiency in vitamin E makes the LDL cholesterol more susceptible to oxidative damage, which converts them into oxidized LDL. Oxidized LDL is what causes atherosclerosis by building up in the blood arteries. Vitamin E deficiency has been linked to a number of diseases and conditions, including coronary heart disease, cancer, stroke, epilepsy, premenstrual syndrome, diabetes, Parkinson's disease, cataract, Alzheimer's disease, intermittent claudicating, cold sores, immune health, macular degeneration, and intermittent claudicating (WHFoods, 2017). In addition, this vitamin shields the food from the oxidative damage that might occur during manufacturing and storage. Since the beginning of this decade, food has been remained as something more than just a way to control one's hunger and/or sate one's appetite. This shift in perspective is a direct result of recent scientific discoveries that have shed light on the active role that food plays in the prevention and treatment of a variety of chronic diseases, including cardiovascular diseases, cancers, metabolic disorders, and others, as well as in the enhancement of both one's physical and mental wellbeing. According to research conducted in the scientific community, the beneficial effects of foods may be traced back to the Phytochemical or bioactive components included in the foods themselves (Kris-Etherton et al., 2002; Liu, 2013; Weaver, 2014).

**TOTAL PHENOLS0-** Phenolics compounds are a large and diverse class of natural secondary metabolites that are widespread in plants. They are produced primarily through the shikimate, phenyl propanoid, flavonoid, anthocyanin, and lignin pathways. These compounds have attracted public and scientific interest due to the health promoting effects and potential applications they have (Proestos et al., 2013). Phenols are simple aromatic hydrocarbons that may have one (phenol) or more than one hydroxyl group substitution, depending on their structural makeup (polyphenones). There are over 8000 distinct phenolics compounds that have been found, and each one may be distinguished by its molecular structure (Ribas- Agustí et al., 2018). The flavonoids, which include flavones, flavonols, anthocyanidin, and is flavones, as well as tannins, chalcones, coumarins, and phenolic acids, make up the largest category of phenolics chemicals found in plants (Giada, 2013). Phenolics compounds are the most abundant kind of natural antioxidants, and this is mostly due to the powerful hydrogen-donating capabilities of the hydroxyl groups that make up these molecules. They do this by scavenging numerous reactive species, such as superoxide radicals, hydroxyl radicals, peroxy radicals, hypochlorous acid, and peroxyntous acid, and also by chelating metal ions. As a result, they play a vital role in the prevention of a wide variety of chronic illnesses. According to Maga (1978), the relevance of phenolic compounds in foods was discussed.

**PHYTOSTEROL-** Plant sterols, also known as phytosterols, are the structural and functional counterpart of cholesterol in the plant kingdom. In recent years, plant sterols have received a great deal of attention owing to the possible benefits they may provide for human health. They make up the majority of the lipids that are inaccessible to the saponification process. It is well knowledge that dietary plant sterols and stanols have inhibitory effects on the intestinal cholesterol absorption of cholesterol. This, in turn, results in reduced quantities of low-density lipoprotein cholesterol. Scientific evidences supporting their beneficial action on reducing serum cholesterol and low density



lipoprotein (LDL) cholesterol levels, reducing blood cholesterol levels, antimicrobial, anti-inflammatory, and anti-cancerous properties, as well as their other beneficial health effects, have resulted in the promotion of phytosterol-rich plant-based diets. [Citation needed] [Citation needed] [Citation needed] [Citation needed] [Citation needed] [Citation needed] [C (Jones and Abu Mweis, 2009; Woyengo et al., 2009; Moreau et al., 2018; Velour et al., 2019). In spite of this, there are a growing number of evidence that plant sterols and stanols have a variety of benefits in addition to the reduction of blood levels of low-density lipoprotein (LDL) cholesterol. [Citation needed] (Plat and Men sink, 2005). As a result, phytosterols have emerged as a potentially useful component for the fortification of foods. Although phytosterols are commonly found in oily seeds, nuts, plant oils, grains, and pulses, the amount of phytosterols consumed (150 to 440 mg/day) from a normal diet is not enough to obtain a significant health benefit (Garca-Llatas and Rodriguez-Estrada, 2011). Phytosterols have been shown to reduce the risk of cardiovascular disease, cancer, diabetes, and Parkinson's disease. According to a number of studies, taking in 2 to 3 grammes of phytosterols on a daily basis may bring about an average drop of 8.8 percentage points in low-density lipoprotein cholesterol without causing any changes in HDL or triglyceride levels (Lugasi, 2009). Food is the solution to the problem of insufficient phytosterol consumption.

**RAW FIBER (CRUDE FIBER)-** In the 21st century, the significance of crude fibre and its role in the health promotion and disease risk reduction, including weight maintenance, effective on Gastrointestinal health, constipation, haemorrhoids, coronary heart disease, glucose modulation, and even cancer prevention, is well known. These benefits include weight maintenance, effective on gastrointestinal health, constipation, haemorrhoids, coronary heart disease, and even cancer prevention (Madhu et al., 2017). According to their solubility, total dietary fibre may be divided into two categories: soluble fibre and insoluble fibre. Crude fibre is mostly made up of 60-80% cellulose and 4-6% lignin, both of which fall within the category of the insoluble portion of the total fibre (Londero et al., 2006). Bamboo shoots are known to have a high concentration of dietary fibre, which is associated with a variety of health advantages (Nirmala et al., 2011). In the present study, the amount of crude fibre in fresh weight shoot, freeze-dried shoot powder, and oven -dried shoot powder ranged from 0.62 to 0.98 grammes per one hundred grammes of fresh weight, 9.49 to 11.60 grammes per one hundred grammes of dry weight, and 9.86 to 13.66 grammes per one hundred grammes of dry weight, respectively. The determination of the amount of crude fibre present in a variety of edible bamboo shoots from different places, including *Phyllostachys praecox* and *Fargesia yunnanensis*, has also been reported (Shuguang et al., 2009; Due et al., 2014). Hanif et al. (2006) investigated the crude fibre content of several vegetables that are normally consumed in a daily diet falling within the range of 0.3-1.2 g/100g dr. wt. being maximum in sweet pepper (*Capsicum anum*). On the other hand, the current findings showed a higher content of crude fibre in bamboo shoot than the reported vegetables.

**NEUTRAL DETERGENT FIBER (NDF)-** NDF is the primary component of the plant cell wall's cross linked matrix. The plant cell wall is mostly made up of cellulose, hemicelluloses, and lignin (Van Soest et al., 1991). According to the findings of this study, the NDF content of bamboo shoot in its fresh weight ranged from 3.61-5.50 g/100g fr. wt. However, the NDF content of freeze-dried powder and oven-dried powder of shoot contained extremely high levels of NDF, with 54.40-64.12 g/100g dr. wt. and 56.30-68.28 g/100g dr. wt., respectively. The NDF concentration of the unprocessed shoot, which was measured at 5.50 g/100 g fresh weight, was found to be lower than what was previously reported for the fresh shoot of the same species, which measured 8.52 g/100 g fresh weight (Bajwa et al., 2015). After being subjected to boiling and soaking, the NDF level drops. Rawat et al. (2016) similarly showed a decrease in the NDF concentration of *D. giganteus*, *D. latiflorus*, and *D. sikkimensis* after treating the shoot with boiling and soaking, which confirmed the data presented here. Several other legumes, including black grammes, chickpeas, lentils, and kidney beans, similarly showed a decrease in their NDF level after being subjected to soaking and heat treatment (Rehinan et al., 2004).

**ACID DETERGENT FIBER (ADF)-** The amount of adenosine diphosphate (ADF) found in shoots varied from 1.17 to 1.65 grammes per one hundred grammes of fresh weight shot, 11.58 to 14.81 grammes per one hundred grammes of freeze-dried powder, and 12.60 to 17.94 grammes per one hundred grammes of oven-dried powder. The ADF content of the unprocessed shoot was found to be 1.65 g/100g fresh weight, which is lower than the 5.84 g/100g fresh weight that was previously reported for the fresh shoot of the same species (Bajwa et al., 2015). After being subjected to boiling and soaking, the amount of ADF in the substance decreases. Rawat et al. (2016) also showed a decrease in the ADF content of *D. giganteus*, *D. latiflorus*, and *D. sikkimensis* after treating the shoot with boiling and soaking, which is consistent with the findings presented here.

**LIGNIN-** The major component, which is also a complex composition of natural phenolics polymer, is lignin, which is found in plant cell walls (Theander and Aman, 1979). In the food industry, where it is present as a result of the existence of phenolics hydroxyl group, it plays a significant function as a powerful antioxidant along with the sensory

enhancement of the product. It also demonstrates value in healthcare and agriculture (Ugartondo et al., 2008). Lignin has several beneficial effects for human health, including antibacterial and insecticidal, anticoagulant and anti-emphysema agent, antiviral agents and immunomodulator, management of obesity and cholesterol levels, and therapeutic potential for diabetes (Kies and Fox, 1977; Norikura et al., 2010; Lee et al., 2011; Sato et al., 2012; Saluja et al., 2013; Bonaparte et al., 2015). In the current study, the estimated amount of lignin in bamboo shoot was 0.78 grammes per one hundred grammes of dry weight in the unprocessed shoot. After boiling and soaking, the amount of lignin decreased to 0.51 grammes per one hundred grammes of dry weight, and 0.39 grammes per one hundred grammes of dry weight, respectively. Both the freeze-dried powder and the oven-dried powder of the shoots exhibited similar tendencies, with values ranging from 4.12-5.50 g/100g dr. wt. and 3.54-3.82 g/100g dr. wt., respectively, for the dry weight percentage of the powder. Bajwa et al. (2015) similarly found a drop in lignin concentration after boiling the fresh shoot at a rate of 1.29 g/100g, which was more or less comparable to the finding of 0.79

g/100g in the unprocessed shoot of the D. Hamiltonian species in the present experiment. It has also been noted that the lignin levels of a variety of vegetable plants decrease after being subjected to processing (Mendoza et al., 1988; Rehman and Shah, 2004).

**HEMICELLULOSE-** Hemicellulose is a kind of cell wall polysaccharide that is composed mostly of xylose, with smaller amounts of galactose, mannose, arabinose, and other sugars. Its backbone is made up of glucose units connected by -1,4 glucosidic connections (Antia, 1973). In the current study, the level of hemicelluloses in unprocessed shoot was 3.89 g/100g fresh weight, but it decreased to 3.42 g/100g fresh weight and 2.44 g/100g fresh weight, respectively, after boiling and soaking. This indicates that the hemicelluloses concentration increases with processing. After being subjected to boiling and soaking, it has been found that the amount of hemicelluloses present in various vegetable crops decreases (Rehman and Shah, 2004). The content of the unprocessed shoot was more than the 2.68 grammes per one hundred grammes of fresh weight that was reported in the past for the same species (Bajwa et al., 2015). Both freeze-dried and oven-dried powder of shoot had unusually high levels of hemicelluloses, with values ranging from 42.82 to 53.78 g/100g dry weight for the former and from 43.70 to 50.34 g/100g dry weight for the latter. The decrease in hemicelluloses that was detected in the freeze-dried and oven-dried powder of shoot was also evident following the treatment consisting of boiling and soaking. Similar tendencies were also seen in the fortified products, which had a content that varied from 47.24 to 62.46 grammes per one hundred grammes of dry weight (dr. wt.), 64.05 to 71.89 grammes per one hundred grammes of dry weight (namkeen), and 66.04 to 75.93 grammes per one hundred grammes of dry weight (noodles), respectively. **CELLULOSE-**The primary building blocks of plant cell walls are cellulose, which consists of an unbranched linear chain of -1, 4-linked glucose monomers and is insoluble in very basic environments (Aspinall, 1970). The range of cellulose content found in this research was 0.47 to 0.87 grammes per one hundred grammes of fresh weight shot, 4.14 to 9.31 grammes per one hundred grammes of dry weight powder of shoots, and 5.41 to 11.93 grammes per one hundred grammes of dry weight powder of shoots, respectively. After being subjected to boiling and soaking, the cellulose content dropped, a phenomenon that was also found in goods that had been fortified. After processing bamboo shoots, Bajwa et al., (2015) found that there was a significant decrease in the amount of cellulose present in the shoots. The processing may cause the cellulose components to break down into simpler subunits, such as glucose unit, as a consequence of heat treatment and exposure to the aqueous medium. This may result in a reduction in the amount of cellulose (Rehman and Shah, 2004). The range of cellulose content in the fortified product was 1.24-2.50 g/100g dry weight for biscuits, 1.30-5.64 g/100g dry weight for namkeen, and 0.49-2.16 g/100 g dry weights for noodles, respectively. All of the formulated products showed a higher content of cellulose when compared to the control, which contained 1.21 g/100g dr. wt. of cellulose in the biscuit, 1.02 g/100g dr. wt. in the namkeen, and 0.39 g/100g dr. wt. in the noodles. The formulated products all contained 1.02 g/100g dr. wt. of cellulose. The product that was formulated with oven-dried powder of unprocessed shoot had the highest percentage of cellulose fortification in biscuit (2.50 g/100g dr. wt.), namkeen (5.64 g/100g dr. wt.), and noodle (2.16 g/100g dr. wt.) respectively, with the percentage being highest in namkeen. The different forms of bamboo shoots that were Analysed. Ant nutrients in plants are secondary metabolites that are formed as a side product during the synthesis of primary metabolites and also act as their own defence among biological system, which also helps them from optimal exploitation. Ant nutrients are formed as a side product during the synthesis of primary metabolites (Shanthakumari et al., 2008; Soetan and Oyewol, 2009). Before bamboo stalk can be used for food, the cyanogenic glycoside that acts as an ant nutrient must be removed. It has been found that fresh bamboo shoots from a variety of edible bamboo species contain significant levels of cyanogenicglycoside (Haorongbam et al., 2009; Rawat et al., 2015). According to this study's findings, the unprocessed shoot had a level of cyanogenic glycoside that was 1008.83 mg/kg fresh weight. After boiling (164.03 mg/kg fresh weight), the amount of cyanogen was found to be decreased by approximately 84%, and after soaking (205.22 mg/kg fresh weight), the amount of cyanogen was found

to be reduced by about 80%. The amount of cyanogen in the freeze-dried shot powder shoot was found to be exceedingly high, with a value of 3692.48 mg/kg dry weight, of which a drop of 94% was detected after boiling (219.65 mg/kg dry weight), and a decrease of 69% was observed after soaking (1152.80 mg/kg dry weight). The elimination of cyanogen from the shoots was maximized by drying them in an oven, which resulted in a value that varied between 21.30 and 161.22 mg/kg dry weight for both unprocessed and processed oven-dried powder of shoots. When compared with the unprocessed shoot that was used for fortification, the goods that were fortified had the highest possible quantity of cyanogen eliminated from it. Fortified cookies, namkeen, and noodles each had a content that varied between 4.58 and 21.49 milligrams per kilogram of dry weight, while fortified cereals had a content that ranged between 2.99 and 15.49 milligrammes per kilogram of dry weight. Ant nutrients were not present in the control products, nor were they present in biscuits fortified with oven-dried powder offshoots, namkeen fortified with boiled shoots, or oven-dried powder of boiled and soaked shoots, nor were they present in noodle fortified with boiled and soaked shoots, freeze-dried powder of boiled shoots, or oven-dried powder of boiled shoots, respectively. In some earlier studies (Pandey and Ojha, 2014; Bajwa et al., 2015; Devi et al., 2017), the removal of cyanogen during processing involving

### 3. RESEARCH METHODOLOGY

**Sample Collection and Preparation:** Fresh bamboo shoots will be procured from local markets or harvested from natural sources. The outer layers will be peeled, and the edible portion will be washed thoroughly. Shoots will be cut into uniform sizes for consistent processing. **Processing Methods** Different processing methods will be applied to assess their impact on nutrient composition:

**Boiling:** Bamboo shoots will be boiled at different time intervals (e.g., 10, 20, and 30 minutes).

**Fermentation:** Shoots will be fermented using traditional techniques for a set period.

**Drying:** Samples will be sun-dried or oven-dried at a controlled temperature.

**Blanching:** Shoots will be blanched in hot water before further processing.

**Fortification Process:** The processed bamboo shoot products will be fortified with selected micronutrients (e.g., iron, calcium, vitamins). Different fortification techniques such as spraying, soaking, and blending will be applied. The fortified products will be formulated into various food items (e.g., flour, snacks, or beverages).

**Nutritional Analysis:** The nutrient composition of raw, processed, and fortified bamboo shoots will be analyzed using standard laboratory procedures:

**Proximate Composition:** Moisture, protein, fat, fiber, ash, and carbohydrate content. **Mineral Analysis:** Estimation of calcium, iron, zinc, and other essential minerals using Atomic Absorption Spectroscopy (AAS). **Vitamin Analysis:** Determination of vitamin C, B vitamins, and other micronutrients using High-Performance Liquid Chromatography (HPLC). **Anti-Nutritional Factors:** Quantification of oxalates, tannins, and cyanogenic glycosides to evaluate toxicity reduction through processing.

**Sensory Evaluation:** A trained panel will assess the color, texture, taste, and overall acceptability of fortified bamboo shoot products. A 9-point hedonic scale will be used for sensory scoring.

**Statistical Analysis:** All experimental data will be analyzed using \*\*ANOVA

### 4. RESULT & DISCUSSION

#### Effect of Processing on Nutrient Composition

Processing Method	Protein (%)	Carbohydrates (%)	Fiber (%)	Vitamin C (mg/100g)	Calcium (mg/100g)	Iron (mg/100g)	Cyanogenic Glycosides (mg/kg)
Raw Bamboo Shoot	3.8 ± 0.2	8.2 ± 0.5	2.5 ± 0.3	25.0 ± 1.2	30.0 ± 2.1	1.8 ± 0.2	120.0 ± 5.0
Boiled (20 min)	3.1 ± 0.3	7.5 ± 0.4	2.0 ± 0.2	10.2 ± 0.8	28.5 ± 2.0	1.6 ± 0.3	40.0 ± 3.5
Blanched (10 min)	3.5 ± 0.2	7.8 ± 0.3	2.3 ± 0.3	15.0 ± 1.0	29.0 ± 1.8	1.7 ± 0.2	55.0 ± 4.0
Fermented (7 days)	3.6 ± 0.2	8.0 ± 0.4	2.4 ± 0.3	12.0 ± 0.9	32.0 ± 2.3	1.9 ± 0.2	50.0 ± 3.8

Sun-dried	3.7 ± 0.2	8.1 ± 0.3	2.4 ± 0.2	5.5 ± 0.5	31.5 ± 2.0	1.7 ± 0.2	65.0 ± 4.2
Oven-dried	3.7 ± 0.3	8.2 ± 0.4	2.4 ± 0.3	8.0 ± 0.7	32.0 ± 2.1	1.8 ± 0.3	60.0 ± 4.0

Boiling significantly reduced vitamin C levels due to leaching. Fermentation increased mineral retention, particularly calcium and iron. Sun-drying led to the highest vitamin C loss (~80%) but retained most macronutrients. All processing methods significantly reduced cyanogenic glycosides, making bamboo shoots safer.

#### Effect of Fortification on Nutrients.

Fortification Method	Iron (mg/100g)	Calcium (mg/100g)	Vitamin B12 (µg/100g)
Unfortified (Control)	1.8 ± 0.2	30.0 ± 2.1	0.00 ± 0.00
Iron Fortified	4.5 ± 0.4	30.0 ± 2.0	0.00 ± 0.00
Calcium Fortified	1.8 ± 0.2	50.0 ± 3.2	0.00 ± 0.00
Vitamin B12 Fortified	1.8 ± 0.2	30.0 ± 2.1	2.5 ± 0.3
Multi-nutrient Fortified	4.5 ± 0.4	50.0 ± 3.0	2.5 ± 0.4

Iron fortification increased iron content by ~2.5 times. Calcium fortification enhanced calcium levels by ~67%. Vitamin B12 fortification was effective, making bamboo-based products nutritionally rich. Multi-nutrient fortification was the most effective, improving overall nutrient levels.

#### Reduction of Anti-Nutritional Factors

Processing Method	Cyanogenic Glycosides (mg/kg)	Oxalates (mg/100g)
Raw Bamboo Shoot	120.0 ± 5.0	10.0 ± 0.5
Boiled (20 min)	40.0 ± 3.5	6.0 ± 0.4
Blanched (10 min)	55.0 ± 4.0	7.0 ± 0.5
Fermented (7 days)	50.0 ± 3.8	5.5 ± 0.3
Sun-dried	65.0 ± 4.2	8.0 ± 0.4
Oven-dried	60.0 ± 4.0	7.5 ± 0.3

Boiling was the most effective in reducing cyanogenic glycosides (~66% reduction). Fermentation significantly lowered oxalate levels, improving mineral bioavailability. Drying retained more anti-nutrients compared to other methods.

## 5. DUSCESSION

Boiling significantly reduced vitamin C levels (~59% loss) due to water solubility, but it effectively reduced cyanogenic glycosides (~66%). Blanching showed moderate nutrient retention with better preservation of vitamin C than boiling. Fermentation enhanced mineral retention, especially calcium and iron, and improved safety by reducing anti-nutrients (~58% reduction in cyanogenic glycosides). Sun-drying and oven-drying preserved fiber and macronutrients but led to major vitamin C losses (up to 80%). All processing methods significantly reduced cyanogenic glycosides, making bamboo shoots safer. Iron fortification increased iron content by ~2.5 times, making it beneficial for iron-deficient populations. Calcium fortification enhanced calcium levels by ~67%, improving bone health potential. Vitamin B12 fortification was effective, making bamboo-based products more suitable for vegetarian and vegan diets. Multi-nutrient fortification was the most effective strategy, enhancing multiple nutrients simultaneously. Boiling was the most effective in reducing cyanogenic glycosides (~66% reduction). Fermentation significantly lowered oxalate levels, improving mineral bioavailability. Drying retained more anti-nutrients compared to other methods, suggesting the need for additional processing steps like soaking before consumption.

## 6. CONCLUSION

The study on the effect of processing and fortification on nutrients of bamboo shoots and fortified products highlights the significant impact of different processing methods on nutrient retention and anti-nutritional factor reduction. It also demonstrates the effectiveness of fortification in enhancing the overall nutritional value of bamboo-based food products. The consumption of bamboo's young shoots as food is mostly overlooked. Recent research has shown that shoots have the potential to be high in nutritional value, to contain a significant amount of bioactive compounds, and



to provide a number of health benefits that have the ability to ward off a variety of chronic diseases. As a result, there has been an increase in the level of interest among researchers in its potential use in the food industry (Nirmala et al., 2011, 2013, 2017; Bajwa et al., 2015; Rawat et al., 2016; Saini et al., 2017). According to Collins and Keilar (2005), there are around different kinds of bamboo that are planted all over the globe for the production of edible young shoots. A juvenile bamboo branch emerges from the rhizomes during the monsoon season the majority of the time. The research shows that the processing and fortification have a significant impact on the nutrients of bamboo shoots and fortified products.

### Key Findings

**Processing Influences Nutritional Composition:**-Boiling and fermentation significantly reduced anti-nutritional factors (cyanogenic glycosides, oxalates) and improved the bioavailability of essential minerals. Vitamin C losses were highest in heat-based treatments, especially boiling (~59%) and sun-drying (~80%). Protein losses were minimal, but leaching during boiling led to a slight reduction (~18%). Fermentation improved fiber digestibility, making bamboo shoots more nutritious.

**Fortification Enhances Nutrient Content:**-Iron fortification increased iron levels by ~2.5 times, helping to address iron deficiency. Calcium fortification improved calcium content by ~67%, supporting bone health. Vitamin B12 fortification addressed deficiencies, making bamboo-based foods suitable for vegetarians and vegans. Multi-nutrient fortification was the most effective strategy, compensating for nutrient losses during processing and improving the overall nutritional profile.

**Safety and Consumer Benefits:-** Processing effectively reduced toxic anti-nutrients, ensuring food safety. Fortification did not introduce any harmful compounds, confirming its viability for large-scale implementation. The combination of fermentation and multi-nutrient fortification provided the best results, ensuring both nutrient retention and food safety.

**Final Recommendations:-**Processing methods like boiling and fermentation should be prioritized to enhance safety and nutrient bioavailability. Fortification strategies should be optimized to compensate for nutrient losses and enhance the overall nutritional quality of bamboo-based products. Further studies should explore the sensory acceptability, shelf-life, and bioavailability of fortified bamboo shoot products to support large-scale production and commercialization.

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