Theme: 3.2. Food and Pharmaceuticals

Bamboo Shoot as a Potential Source of Dietary Fiber for Food fortification

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Abstract

Within the last few years the intake of dietary fiber in our diet is decreasing, particularly in the population of developed nations like Japan, United States, United Kingdom, France, etc. The main reason for this decrease in dietary fiber consumption is dependence on processed food items. Dietary fiber is basically non-digestible and non absorptive parts of plants which are discarded out by alimentary canal. Plants are the only source of dietary fiber in our diets. The major health benefits of dietary are proper and regular bowel movement, prevention of constipation, diarrhea, diverticulitis, hemorrhoids, cardiac diseases and cancer. Now food products are being fortified with dietary fiber to provide its adequate amount in the diet. Bamboo shoot, a delicacy and medicinal food of East and South-East Asian countries is one the best and cheapest source for dietary fiber. Bamboo shoots are nutrient rich, possess several bioactive compounds and have less calories and fat and are considered as one of the best health food. The total dietary fiber in bamboo shoots ranges from 2.23 to 4.20 g/100 g fresh weight of shoots. Bamboo shoots are consumed as fresh, dried, canned, fermented and provide dietary fiber in all forms. Dietary fiber from bamboo shoots in the form of powder and paste is also being used for the fortification of various food products as it increases food quality as well as organoleptic properties. In the present study, young shoots of *Dendrocalamus hamiltonii* were processed and used as a fiber source for the preparation of two fortified products namely sweet biscuits and salty snacks (namkeen). The addition of bamboo shoots in the products, biscuits and salty snacks increased the dietary fiber content. In the fortified biscuit, the increase in neutral detergent fiber (NDF) was 36.97% (63.21g/100g) and acid detergent fiber (ADF) was 82.11% (3.46g/100g) as compared to control biscuit content of NDF (46.15g/100g) and ADF (1.90g/100g). Similarly lignin, hemicellulose and cellulose contents also increased in the fortified products. Bamboo shoot dietary fiber is now even available in pure powder, pills and capsules forms as nutraceuticals.

Keyword: Dietary fiber, bamboo shoot dietary fiber, fortification, health benefits

Introduction

Dietary fiber, also referred as roughage, bulk or blast, is the edible parts of plants that our digestive system cannot break or digest and absorb it while passing through digestive track and almost remains undigested. However, in the process of digestion of food, dietary fiber keep our digestive system clean and healthy, make bowel movement easy and absorbs cholesterol and other harmful carcinogens and flushes out those. The term dietary fiber (DF) was first coined by Hipsley (1953) for non-digestible plants and later it was defined in many ways. As for botanists dietary fiber is plant part, for chemical analysts it is a group of chemical compounds and for consumers it is a material of health benefits. Kay (1982) defined dietary fiber as ubiquitous components of plant foods resistant to the action of human alimentary enzymes. Now the accepted definition of dietary fiber is, "remnants of plant cells resistant to digestion by the alimentary enzymes of man" (Trowell et al. 1985). The American Association of Cereal Chemists (AACC) broadened this definition a bit (AACC 2001). According to their definition, dietary fiber is, "edible parts of plant or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine with complete or partial fermentation in the large intestine". Over the past decades, dietary fibre (DF) has been well studied with abundant evidence on its health benefits. Advances in nutritional studies always lead the way followed by the food applications. Food scientists and technologists then explored the applications of dietary fibers in a variety of food products through examination and utilization of fibres from various conventional and uncommon sources including agro-food processing by-products. Although the dietary fiber research was initiated by human nutritionists and physicians, with the early work focusing more on its biomedical aspect, the topic has quickly attracted the attention from a wider range of scientific fields, including plant chemistry, food chemistry, food processing technology, nutritional biochemistry and pharmaceuticals.

Dietary fiber constituents and Health benefits

The constituents of dietary fibers are non-starch polysaccharides, carbohydrates, lignin etc (Table 1). Dietary fibers based on solubility in water are divided as soluble and insoluble fibers (Dhingra et al. 2012; Hoy and Goldman 2014). Soluble dietary fibers form gum or mucilage type structure in water. It is found in the pulps of fruits, legumes greens, etc. (Singh and Singh 2015). Soluble dietary fibers are resistant to digestion and absorption in the small intestine and fermented partially or fully in large intestine or colon (Singh and Singh 2015). Soluble dietary fiber lowers total and LDL cholesterol and regulates bold sugar levels in diabetes (Singh and Singh 2015). Insoluble dietary fiber is made up of structural material of cell walls of plant foods which add bulk to the stool, softens the stool and increase the transit time through the intestinal tract (Singh and Singh 2015). The main function of insoluble dietary fiber is regulation of bowel movement and prevention of constipation, removal of toxins and prevention of long stay of microbes in the colon (Singh and Singh 2015; Dhingra et al. 2012). The components of dietary fibers are cellulose, non-cellulosic polysaccharides such as

hemicellulose, pectic substances, gums, mucilages and non-carbohydrate components like lignin and waxes, cutin and suberin (Dhingra et al 2012). Cellulose, hemicelluloses and lignin are not soluble in water, whereas pectins, gums and mucilages are soluble and become gummy in water (Dhingra et al. 2012; Singh and Singh 2015).

Table 1. Constituents of dietary fiber (AACC Report 2001)

Non-starch polysaccharides and resistant oligosaccharides 1. Cellulose 2. Hemicellulose: Arbinoxylans, Arabinogalactans 3. Polyfructoses: Inulin, Oligofuctans 4. Galactooligosaccharides 5. Gums 6. Mucilage 7. Pectins
Analogous carbohydrates 1. Indigestible dextrins: Resistant maltodestrins (from corn), resistant potato dextrins 2. Synthesized carbohydrate compounds: Polydextrose, methyl cellulose, hydroxypropylemethyl cellulose 3. Indigestible starches
Lignin
Substances associated with the non-starch polysaccharide and lignin complex in plants 1. Waxes 2. Phytate 3. Cutin 4. Saponins 5. Suberin 6. Tannins

Though dietary fiber is considered inert, non-digestible and non-absorptive in the digestive system but it has many health benefits (Table 2). There are three clear physiological impacts of insufficient dietary fiber, constipation, increased risk of coronary and heart disease and increased fluctuation of blood glucose and insulin level (AACC 2001). Regular and timely passing of bowel without any problem is the first sign of healthy life style. Proper and regular bowel movements prevent both constipation and diarrhea. Eating plenty of fibers can also reduce the risk of diverticulitis (inflammation of the intestine), hemorrhoids, gallstones, kidney stones and provide some relief for irritable bowel syndrome (IBS). Dietary fiber lowers serum cholesterol by reducing the absorption of dietary cholesterol and inhibiting cholesterol synthesis by hepatocytes. These dietary fibers also make complexes with the bile acids which are compounds manufactured by the liver from cholesterol that are necessary for the proper digestion of fat. After complexing with bile acids, the compounds are removed from circulation and do not make it back to the liver. As a result the liver must use additional

cholesterol to manufacture new bile acids, thereby reducing the serum cholesterol level. Bile acids are necessary for normal digestion of fat (Chen and Anderson 1979; Fernandez 2001). Due to this cholesterol lowering properties, dietary fibers have been linked with prevention of various cardiovascular diseases such as coronary heart disease, stroke and hypertension (Liu et al. 2000; Merchant et al. 2003; Anderson 2004). Dietary fibers greatly help in maintaining proper body weight by promoting a sense of fullness and satiety after meal which helps to prevent overeating and weight gain (Dhingra et al. 2012; Nirmala et al. 2017). Dietary fiber also helps in normalizing the blood sugar level and prevents or help in the treatment of type 2 diabetes (Zhao et al. 2002; Anderson and Conley 2007; Anderson 2008).

Table 2: Physiological effects and health benefits of dietary fiber (Dhingra et al. 2012;Nirmala et al. 2017; AACC 2001)

Functions	Benefits
Positive nutrition-improved body function and increased overall body comfort	Reduce appetite and weight
Absorbs lot of water and turns to gel and mucilage. Traps carbohydrates, LDL cholesterols and carcingens	Reduces the risk of heart diseases and cancers
Increase in fecal bulk, reduce transit time, of fecal material through colon, increased frequency of defecation, reduced hardness of stool	Regulates proper bowel movement and prevents constipation and diarrhea, prevents diverticulitis, irritable bowel syndrome and hemorrhoids
Balances intestinal pH and stimulates intestinal fermentation, stimulates the proliferation of intestinal flora, production of short chain fatty acids	An increase and change in intestinal microflora populations and distributions
Dietary fiber slowing the breakdown of carbohydrates and absorption of sugars	Control of blood sugar level and type diabetes

Plants as a source of dietary fiber include beans, whole grains, brown rice, nuts, fruits, lentils, vegetables, isphagula husks, guar gum etc. (Table 3). However, there are many plant food items which are good source of dietary fibers but not recognized by many people. One such plant food item is bamboo shoot. Bamboo shoot is a delicacy in countries like China, Japan, Korea, India and other many East and South-East Asian countries and consumed as fresh, dried and fermented (Bao 2006; Nirmala et al. 2011; Tamang and Tamang 2009; Jeyaram et al. 2009). Besides other nutrient elements bamboo shoots are also reported as a rich source of dietary fiber (Nirmala et al. 2009, 2011).

Table 3: Amount of dietary fibers in various food items (Singh and Singh 2015)

Food items	Dietary fiber (g/100 g)
Rice (unpolished)	4.11
Wheat flour (whole)	12.48

Rye flour	12.9
Oatmeal	9.4
Cornflakes	2.4
Potato with peals	1.3
Japanese radish	1.4
Cabbage	2.8
Cauliflower	3.7
Squash	2.8
Lotus roots	2.0
Carrot	2.7
Green soya bean	5
Tomato	1
Bell pepper (green)	2.3
Brinjal	6.3
Celery	1.5
Spinach	2.8
Cucumber	1.1
Parsley	6.8
Dried Japanese persimmon	14
Dried fig	10.9
Dried prune	7.2
Avocado	5.3
Banana	1.1
Grape	0.5
Apple	1.5
Pear	0.9
Water melon	0.3
Straw berry	1.4
Dried pea	17.4
Dried soya beans	17.1
Dried kidney beans	19.3
Bamboo shoots	4.5

Bamboo shoots as source of dietary fiber

There are more than 1250 species of bamboo around the world and 100 to 120 species are preferred for shoots as food, particularly in East and South-East Asian countries (Nirmala et al. 2017; Midmore 1998; Collins and Keilar 2005). Species like *Phyllostachys pubescence*, *Bambusa balcooa*, *Dendrocalamus hamiltonii*, *Thyrsostachys siamensis*, etc are the most preferred for shoots. Bamboo shoots are low in calories but rich in dietary fiber and in various mineral nutrient elements (Nirmala et al. 2009, 2011, 2017). In bamboo shoots the amount of dietary fiber ranges from 2.23 to 4.23 g/100 g of fresh weight of shoots. Nirmala et al (2009) analyzed dietary fiber in more than sixteen species of bamboos from North-East of India and reported very high amount of fiber content (Table 4). It was observed that dietary fiber in bamboo species was much than many of the common vegetables that people consume daily (Nirmala et al. 2011). The fiber content in bamboo shoots can be classified

accordingly as neutral detergent fiber (NDF) which determines the indigestible component of the plant material consisting of hemicelluloses, cellulose and lignin and acid detergent fiber (ADF) primarily representing cellulose and lignin (Table 1). Young tender shoots have low dietary fiber content which increases according to age and finally shoots become fibrous and very hard unfit for consumption after 3 to 4 days of their emergence above ground. The dietary fiber in bamboo is also affected by processing of shoots with is essential for making the shoots fit for consumption. In case of *Dendrocalamus giganteus*, it has been reported that fermentation and canning both enhanced the fiber content in the shoots (Nirmala et al. 2008).

The dietary fibers of bamboo shoots also have various health benefits which are totally ignored. The bamboo shoot fibers have the property to absorb very high amount of water (nearly more than six times than the original weight) and oil, so when consumed will absorb lot of water and fats in alimentary canal and swell, make fecal heavier and flush out. Park and Jhon (2009) have shown experimentally that diet with bamboo shoots was able to lower the cholesterol levels and improve the bowel movement in healthy young women. Bamboo shoots also have the antibacterial, antiviral and antifungal properties due to the presence of lignans, which is an important component of dietary fiber in shoots (Shi and Yang 1992). Bamboo shoots also have high content of hemicelluloses (Table 4). It is reported that the hemicelluloses exists in the form of polyxylose in shoots and on hydrolysis forms xylose that is hydrogenated to produce xylitol which is extensively used in the food and chemical industry (Nirmala et al. 2011). Eating bamboo shoots also make skin and hairs smooth and shiny due to the presence of high amount of silica in shoots.

Table 4: Dietary fiber in the shoots of some edible bamboo species (Nirmala et al. 2009)

Bamboo species	Dietary fiber (g/100 g fresh weight of shoot)
Bambusa bambos	3.54 ± 0.02
B. kingiana	4.5 ± 0.06
B. nutans	2.28 ± 0.01
B. polymorpha	3.82 ± 0.06
B. tulda	3.97 ± 0.02
B. vulgaris	4.24 ± 0.01
Dendrocalamus asper	3.54 ± 0.07
D. brandisii	4.03 ± 0.09
D. giganteus	2.65 ± 0.03
D. hamiltonii	3.90 ± 0.03
D. membranaceus	2.91 ± 0.06
D. strictus	2.26 ± 0.01
Gigantochloa albociliata	4.15 ± 0.11
G. rostrata	4.20 ± 0.09

Bamboo shoot dietary fiber as functional food

Bamboo is one such food item which is more for health benefits than for providing energy and nutrition for making a stronger and muscular body. Traditionally bamboo, particularly young juvenile shoots are consumed since centuries in many Asian cultures like Chinese, Japanese, Korean and Indian, however more as a medicine for good health and for curing some diseases rather than as food (Bao 2006; Midmore 1998; Collins and Keilar 2005; Bisht et al. 2012, 2015). According to old Chinese medicinal books such as, "Ben Chao Qui zheng", "Ben Jing Feng Yuan", "Yao Pin Hua Yi" and "Jing Yue", bamboo shoots are claimed to be beneficial for human health by promoting motion and peristalsis of the intestine, by helping digestion and by preventing and curing cardiovascular diseases and cancers (Nirmala et al. 2011). Similarly in old medical literature of India like Ayurveda, bamboo is also mentioned as "laxative, frigid seminal curative, palatable, bladder purifier full of astringent juice. It splits cough, subsides bile, and cures leprosy, bloody flux, wounds and swellings" (Tewari 1992; Shastri 2015). Banslochan, an amorphous substance collected in the internodes of some bamboo species is being used for making a health tonic called Chyawanprash in India for more than 5000 years.

On comparison with other food items, bamboo shoots are not so rich in calories and nutrients like proteins, carbohydrates and fats, rather it is richer in amino acids, vitamins, minerals, bioactive compounds like phenols and phytosterols and dietary fibers, which make it a natural health food or functional food (Table 5). Functional foods basically are those food items when consumed regularly provide a specific health effect beyond their nutritional properties (Diplock et al. 1999; Nirmala et al. 2017). Table 5 shows calories, protein, carbohydrates and fats in bamboo shoots and in some common daily food items. Due to properties like low calories, rich in bioactive compounds, minerals and dietary fiber bamboo shoots are projected as perfect health food or functional food for the modern society. In fact bamboo shoots are organic, one of the cheapest natural functional foods providing better health and curing various diseases even related to cancer and heart (Nirmala et al. 2017).

Table 5: Comparison of nutrients in bamboo with other food items

Food items (100 g)	Calories	Protein (g)	Carbohydrates (g)	Fat (g)	Dietary fiber g
Bamboo shoots	27	2.6	5	0.3	2.23-4.23
Wheat	339	14	71	2.5	12.48
Rice	111	2.6	28	0.9	4.11
Corn	365	9	74	4.7	
Potato	77	2	17	0.1	
Chicken	239	20		1	0
Pork	242	27		14	0
Lamb	249	25		21	0
Beef	250	26		15	0

In this age of very efficient processing and purification technique of food, dietary fiber is totally missing from our daily diet. During processing most of the non-digestible parts from food which includes dietary fibers also are removed. Like in fine wheat flour and polished rice, all dietary fibers present on the surface of the seeds are removed. Food items like bread, pizzas, noodles and fruit juices

are in purest form are kept on the shelves of departmental stores, may be rich in nutrients and proteins but lack in dietary fibers. The changing life style is compelling people to have well processed and cooked ready to eat food items. In developed countries like Japan United States, United Kingdom and France people are now taking very less dietary fiber in their daily diet (Nakaji et al. 2002; Fukuda et al. 2007). With the result general population in these countries are suffering with various health problems associated with insufficient dietary fiber intake in the diet (Table 6). Looking into the problems of insufficient dietary fiber in the daily diet, food items are being now fortified with dietary fibers. To compensate the dietary fiber deficiency even people are going for pure form of it in the form capsules, tablets and pills.

Table 6: Present intake of dietary fibre per day by the population (25 g/day or more is the recommended dietary fiber in general for the population, Nakaji et al. 2002)

Countries	Daily dietary fiber intake at present
Japan	11.4 g
United States	15 g
France	16 g
Sweden	22.1 g
Finland	16.7 g
Germany	21 g
Netherlands	20 – 25 g
Switzerland	30 – 33 g
United Kingdom	14.2 g
India	39 – 43 g

Though bamboo shoots are the best source of dietary fiber, shoot remains as an underutilized seasonable vegetable in many countries including in India. Due to reasons like non-availability of shoots, difficulty in processing and cooking or old traditional food, new generation in Indian and many other parts of the region are avoiding bamboo shoots in their daily diet. It is countries like China, Taiwan and Thailand which have exploited bamboo shoots as food. China is having around 75 per cent of the bamboo shoot market of the world followed by Taiwan and Thailand. It is time to develop new ways of processing bamboo shoots to make it a popular food. Bamboo shoots are now available in the form of paste and powder as well.

Bamboo shoots in food fortification

Food fortification is used to enrich food products by incorporating nutritionally rich entities. It is known that bamboo shoots are rich in various mineral elements, bioactive compounds and dietary fibers and at the same time are less in calories, fats and protein. Fortification of food with bamboo shoots is the best way of enriching food with bioactive compounds, mineral elements and dietary fiber

present in bamboo shoots. Another reason of processing and keeping bamboo shoots in usable form is very short harvesting period and post harvesting time. Bamboo shoots grow very fast and within short time of two to three days of appearing on the ground shoots become hard and unfit for food. After harvesting also bamboo shoots need immediate processing otherwise spoiled. Bamboo shoots are either vacuum packed, stored in water or brine solution, dried or fermented. Now bamboo shoots are being converted into chunks, powder and paste for long term usage also (Fig. 1). Fortification of food products with bamboo shoots is another best option of using it immediately and then transporting it long distances for consumption. But during fortification, it should also strictly be kept in mind that the sensorial characteristics of the food are not hampered much (Akhtar et al. 2008). In recent years, attention is being paid to the foods that have valuable amounts of minerals, vitamins, micronutrients, and other bioactive compounds such as fiber and antioxidants. Bamboo shoots, with their high nutritive and therapeutic value hold a great promise for utilization as a health food. Recipes such as chutney, pulao, halwa, curry, and bhaji with bamboo shoots have been standardized by Engineering Resource Group, Bangalore (NMBA, 2009). Bamboo shoot-based products commercially available in China, Japan, Thailand, and Malaysia include canned bamboo shoots, fermented bamboo shoots, bamboo shoot pickle, bamboo shoot powder, and bamboo shoot juice. Several other value-added products such as candies, nuggets, crackers, chutney, chips, cookies, chappaties, and buns have now been prepared from bamboo shoots (Bisht et al. 2012; Sood et al. 2013; Das et al. 2013). These novel products have also been analyzed for their sensory and nutritional qualities. Farris, and Piergiovanni (2008) prepared a popular Italian food namely, 'Amaretti cookies' using bamboo fiber as an ingredient. Incorporation of bamboo fiber imparted a characteristic flavor, texture and taste to the cookies. Sood et al. (2013) also prepared some edible products such as candy, chutney, nuggets, cracker and chukh using juvenile shoots of *D. hamiltonii*. Using of paste from bamboo shoots for the fortification of food products is very convenient and can be stored in the refrigerator (Bisht et al. 2015). Fortification with bamboo shoot paste and powder led to improved nutritional and organoleptic qualities of the food products. Similarly, other products such as, pork nuggets, chicken nuggets, pork pickle, chips, and cookies have been prepared, using fresh or fermented shoots of different bamboo species. These products when analyzed for their nutritional and organoleptic qualities, revealed significantly higher mean sensory scores in terms of flavor, texture, juiciness and overall acceptability. Dietary fiber from bamboo shoots also improved the functional properties of many food products including water-holding, oil holding capacity, foaming capacity, emulsification and gel formation (Zhang et al. 2017).

Dietary fiber content of bamboo shoot and wheat flour

Wheat is one of the staple food of the world population and eaten in various forms including bakery items like biscuits. Though total dietary fiber in wheat is quite high 12.48 g/ 100 g (Singh and Singh 2015) but during milling all dietary fiber is removed. Before fortification of biscuits with bamboo

shoot powder the wheat flour in the market was analyzed for nutrient detergent fiber (NDF) which determines the indigestible component of the plant material consisting of hemicelluloses, cellulose, lignin and acid detergent fiber (ADF) primarily representing cellulose and lignin. Harvested shoots were washed, peeled and cut into small chunks. Shoots were then boiled for 20 minutes in order to remove the anti-nutrients present in the shoots. Boiled shoots were dried in an oven at 60^0C for 24 hour, grounded to powder and used for dietary fiber analysis. Wheat flour for the analysis was procured from the local market of sector 14, Chandigarh, India. The analysis of neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin, hemicellulose and cellulose was done by using the method given by Goering and Van Soest (1970). The results (Table 7) show that 20 minute boiled oven dried bamboo shoot flour has higher content of NDF (58.98g/100g), ADF (14.68g/100g) compared to the wheat flour NDF (53.43g/100g), ADF (0.46g/100gm). Similarly bamboo shoot flour also showed higher content of lignin (3.66g/100g), hemicellulose (44.30g/100g) and cellulose (8.92g/100gm).

Table 7. Dietary fiber (g/100g) comparison for wheat flour and 20 min boiled oven dried *D. hamiltonii* shoot flour.

Parameter	Wheat flour	20 min boiled oven dried bamboo shoot flour
NDF	53.43 ± 0.04	58.98 ± 0.05
ADF	0.46±0.01	14.68 ± 0.01
Lignin	0.42±0.01	3.66 ± 0.01
Hemicellulose	52.97±0.04	44.30±0.06
Cellulose	0.04±0.01	8.92±0.05

Values reported are measurement replication means ± standard deviation (n = 03 replicates).

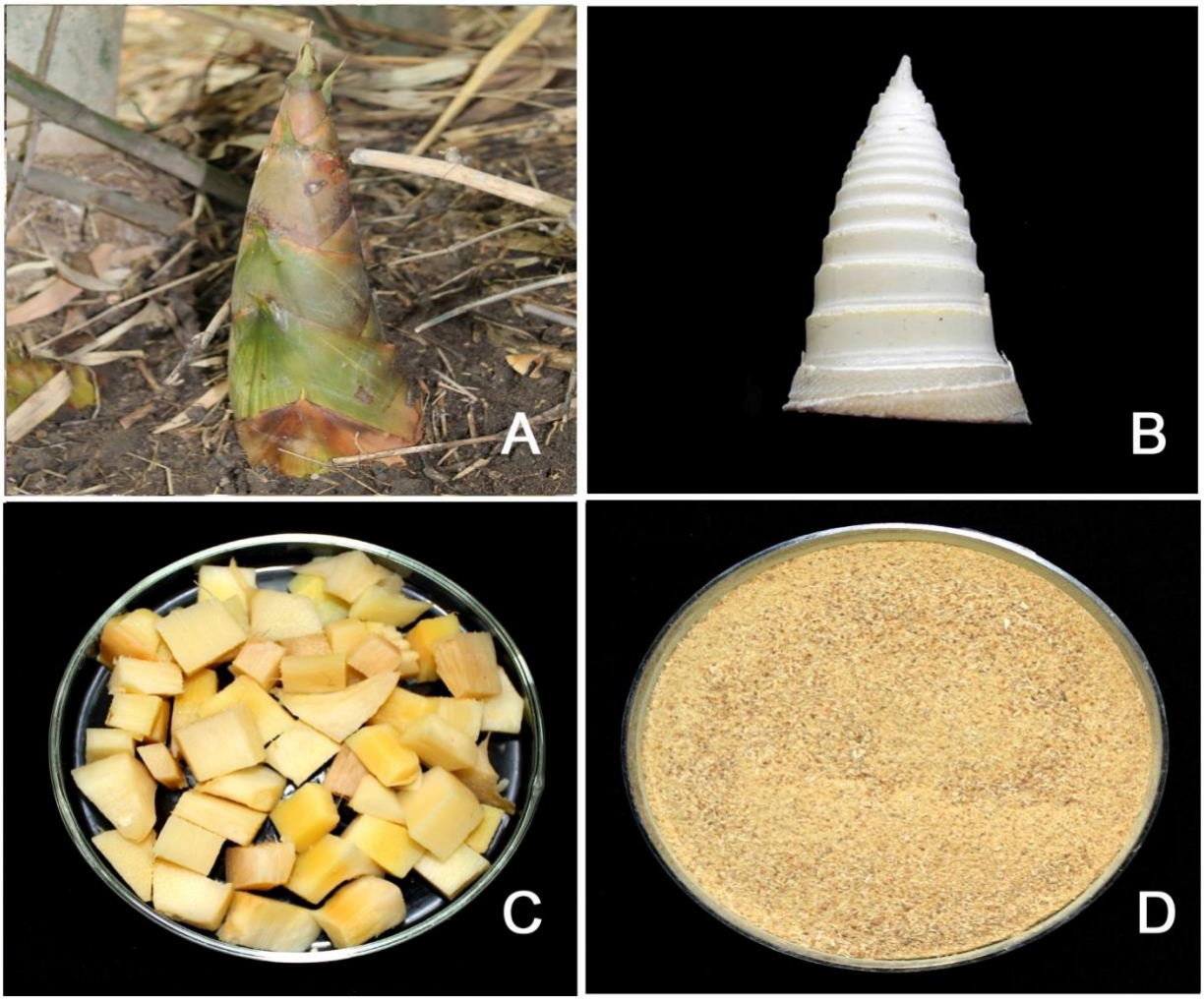

Figure 1. *Dendrocalamus hamiltonii* Nees & Arn. ex Munro, (A) Young shoots, (B) Peeled shoots, (C) 20 min boiled Chunks, (D) 20 min boiled oven dried bamboo shoot flour.

Dietary fiber content of bamboo shoot fortified sweet biscuits and salty snack (namkeen)

In India biscuits and salty snacks (namkeen) are very common ready to eat products enjoyed by people of all age groups (Fig 2). Both are prepared from well processed flour of wheat with very less or no dietary fibers (Gandhi et al. 2001). Most of the biscuits and salty namkeen are prepared from fine wheat flour where most of dietary fiber is removed while milling wheat into flour. We added bamboo shoot dietary fiber in these products in the form of powder to enrich the final product with dietary fiber. In the present study, biscuits and namkeen were fortified with 20% of 20 minute boiled oven dried bamboo shoot flour. Nutritional analysis for control and fortified products was performed using the established method given by Goering and Van Soest (1970). Both the products showed increment in NDF, ADF as well in the amount of lignin, cellulose and hemicelluloses by the fortification with bamboo shoot powder (Table 8). In biscuits, the NDF increased by 37 per cent

whereas in namkeen increment was by 9 per cent only. The ADF increment was very high in namkeen (around 257 per cent) than in biscuits (82 per cent). Similarly lignin, cellulose and hemicelluloses also increased in bamboo shoot dietary fiber fortified biscuits and salty namkeen (Table 8).

Table 8. Dietary fiber content of products fortified with 20 min boiled oven dried bamboo shoot flour (g/100g).

Parameter	Control biscuits	Biscuit	Control Namkeen	Namkeen
NDF	46.15 ± 0.23	63.21 ± 0.01	65.25 ± 0.02	71.25 ± 0.02
ADF	1.90±0.01	3.46 ± 0.01	1.47 ± 0.01	5.25 ± 0.01
Lignin	0.69±0.01	0.98±0.01	0.46±0.01	1.60±0.01
Hemicellulose	44.26±0.23	59.76 ± 0.01	63.77 ± 0.02	66.01 ± 0.02
Cellulose	1.21±0.01	2.48±0.01	1.02±0.01	4.10±0.01

Values reported are measurement replication means ± standard deviation (n = 03 replicates).

Figure. 2 A. Control biscuits, B. Bamboo shoot fortified biscuits

Figure. 3 A. Control namkeen, B. Bamboo shoot fortified namkeen

Organoleptic (Sensory) analysis of bamboo shoot dietary fiber fortified biscuits and namkeen

Biscuits and salty namkeen fortified with dietary bamboo shoot powder were subjected to sensory analysis (Fig. 2). Five parameters, colour, aroma, texture, taste and overall were selected to assess the sensory quality of both the products. It was interesting to observe that biscuits have better scores than salty namkeen in all the select sensory parameters (Table 10). Biscuits fortified with bamboo shoot powder even out performed than the control biscuits (Table 10). Overall, the bamboo shoot dietary fiber fortified biscuits were having 6.55 whereas control biscuits were having 6.20. In case of salty namkeen fortified with bamboo shoot powder having 4.90 (for aroma) to 5.80 (for taste) on the hedonic scale (Table 9). Both the products were having overall liking slightly (salty namkeen) to moderately (biscuits).

Table 9. Sensory analysis data of control and bamboo shoot fortifiedproductsusing 9-point Hedonic scale (1-Extremely dislike to 9- Extremely like).

Parameter	Control biscuits	Biscuit	Control Namkeen	Namkeen
Colour	5.45 ± 1.19	5.86±1.832	5.45±0.88	4.90±1.68
Aroma	6.00±0.92	6.25±1.234	6.00±1.03	5.10±1.71
Texture	5.55±1.73	6.17±1.743	6.10±0.97	5.70±1.75
Taste	5.90±1.99	6.310±1.747	6.45±1.28	5.80±2.07
Overall	6.20±1.51	6.55±1.373	6.25±0.97	5.75±2.01

Values reported are measurement replication means ± standard deviation (n = 20 replicates).

Conclusions

Dietary fibers have very important role in our health particularly in this modern age of high dependence on processed food. Regular and proper bowel movement is the first sign of a healthy life style which is possible only due to intake of sufficient amount of roughage in our daily food. In well processed ready to eat food, the dietary fiber is lost. Insufficient dietary fiber in our diet leads to

various problems like constipation, diarrhea, diverticulitis, hemorrhoids, cardio vascular diseases and cancer. Now in developed countries within last 50 years there is fifty to sixty per cent decrease in the intake of dietary fiber in the daily diet of the population. To overcome the problem of dietary fiber deficiency in the daily diet, food products like bakery, dairy and meat products are being fortified with dietary fiber from other sources, like oat, barley and other various vegetables and fruits. Bamboo shoots are rich and cheap source of dietary fiber, which are consumed a lot in East and South-East Asian countries. Bamboo shoots are also less in fats, calories, rich mineral elements and various bioactive compounds. Though bamboo shoots are consumed as fresh, dried, fermented and processed forms, but now various food products are being fortified with bamboo shoot dietary fiber or also consumed as medicine in the form pills, tablets and capsules. It is proven that bamboo shoot dietary fiber has same health benefits as dietary fibers from other sources have.

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