

# Bamboo and value addition: a boon for industrial development

## Abstract

Bamboo has been increasingly used as a substitute for tropical timber in the International market. Value-added bamboo products are becoming popular due to their characteristics of durability and strength, which resemble the qualities of tropical wood while providing an equally sustainable alternative. Bamboo is considered a grass with rapid growth. As it is a colony plant, it produces new canes (culms) every year from the root system. After 3 to 5 years, culms are ready for harvest, depending on the species. Every year, 5–6 culms can be harvested (from the species that are growing in clumps). Due to this feature, *bamboos are mostly used in the rural and semi-urban areas to make houses and so is known as 'poor man's timber'*. Bamboo shows a very significant part in day-to-day survives (lodging, service, revenue, gasoline, etc.). Lately, bamboo has also found more uses in the manufacturing areas as well as in transitory assemblies. Moreover, being a vital section of cottage and rural business, it is also utilized in some dedicated different usages such as bamboo wood, bamboo based-laminates, floor tiling, strengthening in cement material etc. Pulp and paper, Gasoline (charcoal), Fixtures and Handcrafts (picnic basket, jewellery, ball-points, cycles etc.), Building (houses, channels framework, armoured, barriers, concrete, boats), Harmonious Gadgets, Customary drugs, Food (shoots, wine) and silage. Separately from the varied usages of bamboo, the tender sprouts, being little in fat, rich in dietary fibre and mineral content, decent source of potassium, calcium, manganese, zinc, chromium, copper, iron and lesser quantity of phosphorus and selenium. The sprouts are eaten due to their unusual palate, flavour, medicinal and nourishing importance. Diverse value added foodstuffs such as nuggets, pickle and biscuit can be prepared from new bamboo sprouts. Anti-carcinogenic ingredients existing in sprouts marks them a regular portion of regime. It is assumed that bamboo extract offer anti-inflammatory *effects*. Thus, this paper discusses about the bamboo and its value addition via bamboo-based products industry's future.

**Keywords:** bamboo, value addition, industrial applications, food and agro-processing, handicrafts

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## Introduction

Bamboo is a dialect word cast-off for fellows of subfamily Bambusoideae of family Poaceae, the grasses. Bamboos make a measure of living variety intermixed with natural life, ritual and ethos of ethnic folks from period centuries old. Early Chinese underway to usage bamboos 7000 ages back. It is recognized from 'Vedas' as a basis of ardor (5000 ages back); 'Ancient Medicinal Text' as clinical tools; 'Arthashastra of Kautilya' as a foundation of returns (300 B.C.). Ancient Periodicals "Colloquies on the Simples and Drugs of India" printed (Garcia da Orta, 1568) specifies 'Tabasheer' a medicine (Oxalate crystal/ liquid existing in few bamboos). The initial printed text in which bamboos have been incorporated is the Hortus Malabaricus – by van Rheede 1675.<sup>1</sup>

Bamboo is innate to maximum tropical and subtropical nations round the equator (such as Ecuador and Colombia), but it is also grown in nations such as China, Japan, Chile, Mexico, New Zealand, etc. *Bamboos are big tree-like grasses that largely develop in the tropical, subtropical, and temperate East and South-East Asia areas. Bamboo can also be found in some of the islands of the Pacific and Indian oceans.* Around 14 million hectare of the globe exterior is roofed by bamboo forestry with 80% in Asia. They are equally fine signified in all the nations excluding Europe. There are about 75 genera of which 14 are common to the Asian region. Total number of species is about 1300. Nearly all of the 75 genera and 1250 species of bamboo are wooded and wild developing. They range from the dimension of greensward to colossuses of 40 meter in height and 30 cm in width. Bamboos raise at the sea level in tropics to an altitude of 4000 meters

in temperate areas.<sup>2</sup> They are dispersed mainly in the tropics, though they are found naturally in all subtropical and temperate regions excluding Europe. Bamboos are maximum plentiful in cyclical monsoon forestry and have a preference dispersed environments, in which they often develop weedy. Bamboo is a traditional piece of South-east Asia. No nation in the South East Asian area is deprived of native bamboo plants. Bamboos have been conventionally used in building as centuries old. It is also one of the utmost adaptable material in forestry goods employment and used as a raw material in big scales for pulp and paper.<sup>3,4</sup>

### Three main bamboo mounting ecological areas are recognized in the domain:

1. Asia-Pacific (42°S-51°N): Chief bamboo emergent nations in these areas are China, India, Myanmar, Thailand, Cambodia, Japan, etc.
2. American (47°S-40°N): It ranges athwart south and north Americas, Mexico, Guatemala, Honduras, Columbia, Venezuela, the Amazon valley in Brazil are the chief centres of bamboo dispersal in this area.
3. African (22° S-16° N): The southern Mozambique and eastern Sudan from south to north. The chief areas are Senegal, Guinea, Liberia, Ivory Coast, Nigeria, Congo, Zaire and Madagascar Island.

In India, bamboos form rich belts of flora in the well-drained parts of the monsoon area at the base of the Himalayas and down in peninsular India and alongside the Western Ghats or Sahayadri

ranges. Biosphere's biggest reserves of bamboos occur in India, which is signified by 136 species. There are over 136 species of bamboos developing in India but only little of them are only of commercial significance from practicality and application opinion of outlook. The present collecting of bamboo surpasses 3.2 million tons (5 million cum) a year, 50% of which is used for handicraft/structural purposes.<sup>5</sup> Further reserve of bamboo may be produced by accepting technically progressive performs like refining storing and preserving handling is about 1.1 million cum which stresses the alteration of innovative methods of bamboo treating. Prerequisite of timber (and bamboo) for solid wood and reconstructed timber produces was projected to be 25.72 million cum in India. Out of this, assessed demand for bamboos is about 2.5 million cum. In outlook of vast break between manufacture and intake of timber in India (of the order of 20 million cum), bamboos may be regarded as filling this gap up to some degree.<sup>2</sup> The main bamboo developing areas/states in India are given in Table 1.

**Table 1** Major bamboo growing regions / states

| Regions / States | Area (%) | Gross share |
|------------------|----------|-------------|
| North East       | 28.0     | 66          |
| Madhya Pradesh   | 20.3     | 12          |
| Maharashtra      | 9.9      | 5           |
| Orissa           | 8.7      | 7           |
| Andhra Pradesh   | 7.4      | 2           |
| Karnataka        | 5.5      | 3           |
| Other States     | 20.2     | 5           |

Value added bamboo goods are mostly created in China and picked up in Europe. Bamboo is progressively been cast-off as a substitute for hardwood, as it offers a naturally thorough suggestion. Bamboo is one of the ancient construction resources used by civilization. It has been conventionally in usage in building, lodging, framework, boundary support, porch stick, stepladders, channels, farm cart and agrarian equipment. Being a treasured regular source, it has variety of usages in cabinets, floorboards, many-types of handicraft objects, mush and newspaper, yachts, harmonious gadgets, charcoal, plywood and particleboard making etc. Further usages of bamboo are skyscraper framework, photo rules, gasolines; organic extractives from numerous parts of the plant have been used for hair and skin liniment, medication for asthma, eyewash. Bamboos is also used in water situation for the assemblies such as aquaculture farmstead, railing, rods and fishing nettings by Yang. As unprocessed bamboo culms are vulnerable to wood boring creatures, it wants protective action. Bamboo is also fetching gradually prevalent in the gardening business as an indoor plant. The rustic underprivileged are the main consumers of bamboo using more material than the pulp and paper businesses. Bamboos are used for production of great amount of value added things, cottage business rest on for its fresh material necessity and a huge number of jungle inhabitants hang on them for their living. Other than the above, as of its quicker development easy proliferation and soil tie things, bamboo is a perfect select for afforestation, soil maintenance and communal forestry programmes. Bamboos are widely established in nationwide afforestation programmes to encounter manufacturing and rustic necessities. In view of the diverse usages, investigation was done to create technical information on the morphology, leaf epidermal studies for identification, structure and fibre morphology, strength possessions, engineered usages, pulp sheet stuffs and value goods. Diverse factors for physical, assembly, thatching, fencing, roofing handicrafts, and unique substances and for pulp and paper as choice conditions, the species are accessible and used in the nation.<sup>6</sup>

Bamboo utilization in India, projected on definite making of 2.56 million ton has improved in latest years. Bamboo is in small stock in virtually all the states excluding Assam and Maharashtra. Forecast of necessity of bamboo/Ochlandra canes as a fresh material for the paper, paperboard and newsprint is more than 6.70 million tons. Amongst diverse bamboos, *Dendrocalamus strictus*, *B. arundinaceae* are broadly used. Some of the frugally significant bamboo kinds in India. Main groups of bamboos are *Arundinaria*, *Bambusa*, *Cephalostrachyum*, *Dendrocalamus*, *Gigantochloa*, *Melocanna*, *Ochlandra*, *Phyllostachis* and *Thysostachus*. Most of these are native to India. Amongst the many groups that have probable for many usages, *Bambusa bambos* and *Dendrocalamus strictus* which are copiously obtainable in India in general and South India in specific are selected from the fact of several produce expansions. Other vital bamboo classes are *B. nutans*, *B. pallida*, *Dendrocalamus hamiltonii*, *D. stocksii*, *D. strictus*, *Bambusa polymorpha*, *Dendrocalamus asper*, *B. tulda*, *Guadua angustifolia*, *B. vulgaris*, *Melocanna baccifera*, *B. balcooa*, *Ochlandra travancorica*, *Dendrocalamus brandisii*, *Schizostachyum dullooa*, *D. giganteus*, *Phyllostachys bambusoides*.<sup>7,8</sup>

### Importance of bamboo

Bamboo is a very significant non-timber source that aids the life of folks in a countless means. These multipurpose grasses have the ability to yield supreme biomass per unit area and time related to numerous other forest plant life. Bamboo affords foodstuff, raw material, shelter, fodder and even medications in several portions of the world and has been said to be put to 4000 uses. About half of the sphere's populace is projected to be connected with Bamboo in over US\$ 7 billion trade and uses. In Asia, there are billions of persons who hang on it for part or total of their earnings. For instance, in India, it is projected that there are 2 million customary bamboo artistes. Their living hang completely on the collecting, treating and vending of bamboo and its products. The significance of bamboo, particularly to rustic societies in the rural area of bamboo growing nations can hardly be over strained. It plays a significant part in their day-to-day life in many means in as silage, foodstuff, medication, as material for household building, agrarian implements and kits, device grips, railing, spinning traps, bars etc. It creates large-scale countryside occupation, right from the supervision, collecting, assemblage, conveyance, storing treating and utilisation.<sup>9</sup>

### Bamboo as unconventional

Owing to the non-availability of the timber from the regular jungles and non-suitability of numerous plantation timbers, struggle has been faced by the Organization to endorse species necessary for diverse usage from the Indian criterions. The shortage of hard logs for particularly opens fresh views, bids possibility, and tosses test to discover potentiality of bamboo each in curved form or in laminates. The appropriateness of bamboo culms in curved form and as covered shields as a substitute as of intrinsic culm possessions and standby of timber are probable aspirants for survey. Bamboo a similarly robust material as wood is recognized as meagre man's wood. With the growing gaps in timber response and stock, a new curiosity has been produced to discover and use this material. Usage of hard bamboos has been asserted particularly for fixtures in place of solid wood as there is scarcity of timber and bamboo species are accessible. Government of India strategy is to boost the application of more and more bamboo in place of hard timber. Its surplus of vital usages has managed to the usage of languages such as "bamboo culture", "green gold", "poor man's timber", "bamboo-friend of the people" and "the cradle to coffin species". Bamboo alternates timber in numerous ways. The frightening speed of decline of tropical forestry

demand for limit on tree demolishing separately from conservational deliberations thus growing curiosity in cultivated area of fast growing species; collecting them at small cycles and using young woodlands as construction supplies. In outlook of weakening stock of timber from normal forestry, a lot of curiosity has been created on the better usages of bamboo.<sup>10</sup> With the progression of science and technology, novel techniques are required for handling of bamboo to style it into more sturdy and extra functional in the current world. Bamboos is widely utilized in curved and splitting form for range of uses like lodging, framework, passages, stepladders, agronomic equipment, instrument holders, twigs, barriers, bags, sporting possessions and many other usages also papermaking. Bamboo covers and other rebuilt bamboo produces have also been made and being used for diverse uses. A lot of investigation effort has been done on assessment of bodily, motorized and biochemical properties of diverse bamboo species and their connections with structural stuffs. The normal strength of bamboo is actual little (changing from 1 to 36 months dependent on species) for its fast and austere bio-deterioration owing to colour molds, decomposing mildews and bugs. This also is governed by upon the classes and weather situations. Splitting bamboos are devastated more quickly than curved bamboo. Modest and low-cost means of bamboo protection have also been described in the texts. The Institution of Wood science and Technology, Bangalore has been intricate in the bamboo exploitation and upgrading work for value culms for the last 30 years. Organization has also been leading consistent drills to bamboo artistes for technical operation of bamboo. The Institution has a well-equipped research laboratory to perform elementary and practical work linked to estimation of properties and treating. Separately from these, the Institution also has rudimentary workspace to work on solid wood, and bamboos.<sup>11</sup>

### Marketplace information on this commerce

During 2019, the Bamboos marketplace's worth is 72.10 billion USD, and it is anticipated to touch a total income of 98.30 billion USD. The business of bamboo will raise at a CAGR of 5 percent. Its trade has seen substantial progress in the spell age of 2014 to 2019 and their business has bagged 20 percent of the total marketplace portion. It is estimated that until 2025, Central Eastern and African nations are projected to be the topmost manufacturers of bamboo and bamboo-based goods.

### Significant features of bamboo

Bamboo, the underprivileged man's wood is a robust, multipurpose and renewable wooded material having diverse usages in both countryside and city sector. It has been a vital portion of India's' ethnic, communal and commercial customs. Masses of folks rest on it for their living and for domestic and practical uses. It is the nature's greatest treasured gift to humankind particularly to countryside persons. For its easy workability and little prices, bamboo has been beneficial to the overall population. The culm progress is quicker and develops within 3 to 4 years. The distinctive assets of bamboo such as its power, straightness, and evenness, robustness, easy to cut and divide, easy to transfer have made it valuable to the village dweller in practically every necessity of lifespan. One of the significant features of bamboo is its rubbery construction. The filaments are lengthier in comparison to wood strings. The metier assets are superior than many wooden types. The spherical and deep cross section of bamboo gives it a great strength-weight proportion. Bamboo is flexible in contrast to wood. The cross dividing wall at each node mark the bamboo as durable and firm to twist or disruption at junctions. It has a even and spotless exterior. It can be simply cut into requisite size and split-up into shreds with domestic implements. Bamboo culms can be

effortlessly stowed and conveyed. Normal means of seasoning and dealing such as plunging in water can upsurge its strength. Growing settings (area) may seemingly influence the alignment and construction of the tissue and thus may have some effect on the total bodily and strength assets of bamboo. There are few distinctions amongst genera and species, partially associated to the kinds of vascular packets existing. The simple variances in the structural make-up must touch a number of assets like solidity, forte, winding behaviour, splitting and contraction.<sup>12</sup>

The chief characteristics of bamboo are obtainability in diverse dimensions, straightness of the culm, agility of the material, decent physical and mechanical assets, usual solidity & low reduction, decent flexural assets, great stretchable forte, very decent mass to forte relation, heaviness tolerance (>3600 kg/cm<sup>2</sup>), stress-free to holder with artless implements and renewable fresh material. Thus, bamboo is well suitable to substitute wood in numerous uses.<sup>13</sup> Table 2 shows a contrast of metier factors among diverse resources.

**Table 2** Comparison of strength parameters among different materials

| Property (kN/cm <sup>2</sup> ) | Wood      | Bamboo    | Steel |
|--------------------------------|-----------|-----------|-------|
| Elastic modulus                | 1100-1500 | 1800-2200 | 21000 |
| Bending strength               | 7-12      | 8 - 28    | 14    |
| Compressive strength           | 4-6       | 6-9       | 14    |
| Tensile strength               | 9-12      | 15-38     | 16    |
| Shearing strength              | 1-2       | 2-3       | 9     |

### Development of bamboo-based technology & value added products

Bamboos undertake distinct implication, mainly due to succeeding reasons-: bamboo is the wildest developing among the wooded classes, achieving harvestable development in fewer than five years and plantation know-how for far-reaching farming of bamboo is well known. While normal practices have been established with culm clippings, tissue culture is acquiring recognition as a material, matured bamboo positions theoretically greater than immature timber having less changeability in organization and more stuffs favourable for creating reconstructed board goods in spite of its dynamic and aggressive growing routine. It is "ecologically welcoming" in contrast to several foreign species being developed in the nation.<sup>14</sup>

The bamboo is in its magnitude, nimbleness and forte an exciting creation of Mother Nature. It is steady and due to its holes an extreme light and flexible construction material. The strengthening by diaphragms and its bodily situations reason its massive advantage related to additional construction ingredients. Bamboo has a very effective natural physical design; due to its emptiness and the strings in longitudinal way, low solid quantity is required than in case of resources with a huge segment, e.g., wood. In terms of load-bearing build, as with all tube-like rudiments, bamboo tasks as an I-shaped cross-section, in individual way it is laden, while additional cross-sections are best effective in one or two ways. Owing to the favourable motorized possessions, the high suppleness, the fast developing speed, the low weight and the cost effectiveness, bamboo is one of the most significant construction resources with many prospects. It can be used in many areas; from very customary handcraft (e.g., baskets) to stuffs that are totally commercial (e.g., parquetry and boards). Some bamboo species can very finely be used in subsidiary structures as the very tall bamboo frameworks against Eastern skyscrapers reveal. Particularly for the fewer rich people in tropical zones, bamboo shows a very significant part in day-to-day survives (lodging, service, revenue, gasoline, etc.). Lately, bamboo has also found more

uses in the manufacturing areas as well as in transitory assemblies. Moreover, being a vital section of cottage and rural business, bamboo is also found to be utilized in some dedicated different usages such bamboo wood, bamboo based-laminates; bamboo laminated floor tiling, strengthening in cement material etc. Pulp and paper, Gasoline (charcoal), Fixtures and Handcrafts (picnic basket, jewellery, ball-points, cycles etc.), Building (houses, channels framework, armoured, barriers, concrete, boats), Harmonious Gadgets, Customary drugs, Food (shoots, wine) and silage.<sup>15</sup>

As defined above, bamboo can be utilized for many diverse purposes. Often only, some species are apt or favoured usages, however other species are ignored or even omitted. It is normally recognized that limitations in treating and consumption are often linked to inappropriate stuffs. Hence, a detailed understanding of the associations amongst constructions, goods, behaviour in treating and produce makings is required for endorsing the exploitation of bamboo. Luckily, bamboo is much humbler created than wood and the alterations among the about 700 species seem comparatively minor. The lignifying cell structure of the bamboo sense and its applied conditions are very alike to the unique feel of wood. Although wood has a firm centre and becomes feebler near the exterior parts, the bamboo is in its external parts hard and in its internal parts feeble, what origins a much more steady building. Linking the diverse outcomes of study of the strength assets of bamboo, there is a great variation of the consequences, though they all tried the similar types of bamboo. Nonetheless, a complete investigation of the associations amongst assembly and assets does barely occur so far. The threads donate 60-70% by bulk of the whole culm tissue. Some bamboo species have smaller threads and the fibre length displays substantial differences within a culm. As, fiber length effects compactness and power assets, exhaustive readings seem to be worthwhile. The existence and dissemination of thick- and thin- walled fibers disturb handling abilities and certain other assets, thorough studies with technical bigger and lesser bamboo species will be very valuable.<sup>16</sup>

### Value added eatable yields from bamboo shoots

Separately from the varied usages of bamboo, the tender sprouts, being little in fat, rich in dietary fibre and mineral content, decent source of potassium, calcium, manganese, zinc, chromium, copper, iron and lesser quantity of phosphorus and selenium;<sup>17</sup> have been disbursed conventionally by the people. Vitamin A, B1, B3, B and E are also present in new shoots. Sprouts also contain flavonoids, phenols and phenolic acids that retain antioxidant activity.<sup>18,19</sup> They also comprise fatal concentration of the anti-nutrient (cyanogen).<sup>20</sup> The sprouts are eaten due to their unusual palate, flavour, medicinal and nourishing importance. Bamboo sprouts are obtainable for restricted period and have a small keeping quality, thus they must be treated and consumed instantly after harvest. Diverse value added foodstuffs such as nuggets, pickle and biscuit can be prepared from new bamboo sprouts. Anti-carcinogenic ingredients existing in sprouts marks them a regular portion of regime. It is assumed that bamboo extract offer anti-inflammatory effects.<sup>21</sup> The diverse eatable species of bamboo are *Dendrocalamus strictus*, *D. asper*, *Bambusa bambos* and *Bambusa tulda* originate in central India. These species have a good prospective for eatable sprout manufacture in central India. Bamboo derivative pyrolysates own antimicrobial and antifungal activities, which shield neurons from oxidative stress.<sup>22,23</sup> Bamboo sprouts are also a decent basis of phytosterols that are the originators of numerous pharmaceutically active steroids originate in plants<sup>24</sup> and function as nutraceuticals.<sup>25</sup> Bamboo sprout sap has protease action, which supports in absorption of proteins.<sup>26</sup> In Java, juice from inside the sprouts of *B. vulgaris* is used for remedial

jaundice.<sup>27</sup> The sprouts are utilized as foodstuff in numerous means and forms such as garden-fresh, desiccated, preserved, shredded or pickled. Furthermore, they are used as an extender as they take on the flavour of the constituents they are prepared with. Diverse kinds of preparations like bamboo shoot curry, chutney, bamboo sweetie, pickle, fried shoots, pulav, keema, manchurian, broth, bamboo tinned sap and bamboo cocktail are prepared from bamboo sprouts. They are also utilized as biofertilizer, bioinsecticide and as medication for abdominal ailments.<sup>28</sup> Sap of fermented sprouts or bamboo vinegar kept for around 50-60 days is utilized for flavouring vegetables.<sup>29</sup>

The sprouts are utilized as food in numerous means and forms such as new, desiccated, preserved, shredded or cured. Furthermore, they are utilized as an extender as they take on the flavour of the components they are prepared with. Diverse kinds of preparations like bamboo sprout curry, chutney, bamboo toffy, pickle, fried sprouts, pulav, keema, manchurian, soup, bamboo canned juice and bamboo beer are prepared from bamboo shoots. They are also utilized as biofertilizer, bio-insecticide and as drug for abdominal illnesses.<sup>28</sup> Sap of fermented sprouts or bamboo vinegar, kept for about 50-60 days is used for flavouring vegetables.<sup>29,30</sup>

### Fermented food items from bamboo

The varied diversity of fermented bamboo food products are quite normally used up by tribal folks living in sub Himalayan regions, Nepal and Bhutan.<sup>6,31,32</sup> For example, mesu, a customary fermented bamboo sprout produce of the eastern hills of Nepal and Bhutan is consumed as a pickle and as a base in curries is a conservative dish among the Nepalis, Bhutias and the Lepchas of the Darjeeling hills and Sikkim.<sup>33</sup> Some supplementary leading delicacies in Indian foods contain ushoi, soidon, soibum, soijim, iromba, ekung, eup, hiring lung-siej and syrwa.<sup>32,34</sup> Ushoi, a fresh bamboo sprout, is unique of the prevalent foodstuffs amongst the Manipuris and Apa Tanis of Arunachal Pradesh. Soibum, a fermented bamboo sprout, is a remarkable dish of the Meities of Manipur, consumed as pickle and curry assorted with fermented fish. Alike fermented bamboo sprout produce called naw-mai-dong or nor-maidong is eaten in Thailand. Soidon is additional fermented bamboo sprout produce in Manipur, prepared from the tip of ripened bamboo sprouts and eaten together as a curry and as pickle. Soijim is an additional kind of fermented bamboo sprout produce prepared by submerged fermentation in Manipur. Iromba is a fermented or poached bamboo sprout consumed with fish and other vegetables by Khasi communities in Meghalaya.<sup>35</sup> The juice of young straws collected during the wet period is fermented to make ulanzi (a sweet wine), which is used by Chinese as a delightful alcohol.<sup>36</sup> In central India, the new sprouts are grated and fermented to make kardi or amil, a tangy vegetable broth. In the province, the bamboo sprouts are fermented, dehydrated, crushed into fine particles and used as an enhancer called hendua, which is frequently favored alcohol amongst the ethnic folks.<sup>37</sup> In Nepal, bamboo sprouts are fermented with turmeric and oil and then cooked with potatoes to prepare 'alu tama'.<sup>32</sup>

**Precooking processing:** Bamboo sprouts must be treated afore humanoid feeding. The technique established by Pandey and Ojha<sup>38</sup> was trailed for treating of bamboo sprouts to eliminate noxious constituents and hold ideal nourishing constituents. For *B. bambos*, sprouts were poached in five percent of sodium chloride solution for fifteen minutes, *B. tulda* in one percent sodium chloride solution for ten minutes, *D. asper* in one percent sodium chloride solution for fifteen minutes and for *D. strictus* in five percent of sodium chloride solution for ten minutes. The residual water is removed and stewed sprouts can then be utilized for creating several foodstuffs.<sup>14</sup>

## Product development

**Nuggets:** To prepare nuggets, two parts of boiled bamboo shoots are added in one part of saturated pulse gram chana, green gram, soybean and black gram; red chili powder, turmeric powder and salt is added as per taste. The mixture is then grounded to a coarse paste. Small identical sized balls are prepared from the paste and desiccated in oven for three days at 45-50°C. Dehydrated nuggets are then put in storage in airtight glass or poly-propylene vessel.<sup>14</sup>

**Pickle:** Bamboo shoots are cut into small portions, boiled and dried out in air for around one hour. One teaspoon red chilli powder, turmeric powder, salt as per taste, half table spoon roasted and ground fenugreek seeds, one tablespoon and ground mustard seeds, black cumin seeds and asafoetida were mixed in a vessel, bamboo shoots were then added and shifted to a sterilized glass vessel. Mustard oil is then heated till smoke comes, cool and transferred into the bowl. The pickle is stirred once a day and kept unopened for a week.<sup>14</sup>

**Cracker (Papad):** Papad is a thin, round in form, crunchy cracker like dish. To prepare bamboo papad, one part of boiled shoots is added with one part of boiled potatoes, red chilli powder, black pepper powder, cumin seeds and salt to taste. Mix is then distributed well and dough is made. Identical sized spheres are made from dough and rolled on a roiling board with the aid of rolling pins in spherical actions to make round papads. Papads are then dried in oven for two days at 45-50°C and kept in sealed bowl.<sup>14</sup>

**Bamboo sprout based powder:** Bamboo sprout, from its ingredients, shows that it comprises significant quantity of carbohydrate and dietary fibers. During boiling, the polysaccharides are hydrolysed into simple sugars and provides sweet taste to the sprouts.<sup>16</sup> The main benefits of using desiccated bamboo sprout residue is its little moistness content which may permit its straight usage into several dry food items, and making chutney and beverages. Other benefits of using desiccated bamboo sprout based powder may comprise free-flowing, easiness of usage and balancing, reduced storing space, ease of cleaning and hygienic features. In Japan, bamboo shoot-based powder is used as an essence in cookies and numerous new foodstuff. Japanese use bamboo powder in regular bread flour and endorses a 3-8% adding of the powder to any food products. In China, bamboo juice manufactured by pressure-cooking, is used to create drinks and specific alcohols, separately from medications.<sup>36</sup> With a distinctive bamboo smell and beer flavour, bamboo sap beers show a decent number of healthiness aids by dropping blood lipids and combat heart illnesses.<sup>39</sup>

Value addition refers to any action that augments the worth of product in the marketplace thus growing its usefulness and revenue. Value addition can be accomplished by producing diverse eatable foodstuffs; this will upsurge the use of bamboo sprouts and ultimately will lead to agriculture of bamboo sprouts by the agriculturalists and can be used to deliver living prospects for revenue generation to the indigenous inhabitants.

### Uses of bamboo in numerous trades

Bamboo has been utilized for several years as the material of numerous customer goods. The usage of bamboo in numerous businesses has affected the industrialized economy a lot. It is normally utilised as the raw material to make stuffs for customers. Bamboo is used as an auxiliary for wood typically. It is also used in the making of food, and many cottage industries rest on the bamboo. Hand-made objects are also prepared by consuming bamboo shreds. Most of these hand-made goods are generally used in the agronomic ground like

baskets and trays, jars, lampshades, mats, and a few other goods. The following is a list of products mass-produced from Bamboo.<sup>40</sup>

### Handiwork

Handiworks are generally ornamental goods prepared from bamboo canes by people only by means of hands, and in few cases, some petty implements are also used. It involves enormous hard work, endurance, and talents. This creation is mainly traded to the different parts of the globe and generally used for artistic drives.<sup>40</sup>

**Bamboo canes:** Bamboo is generally used in creating structures. In few portions of the world, typically in India, bamboo is used to create provisional assemblies for sacred rituals and is used in purificatory rites by the priests. 'Agarbatti,' which is used in Indian Pujas, mainly rest on the bamboo sticks.<sup>40</sup>

**Paper from bamboo:** Paper is utilized in numerous manufacturing fields in contemporary periods. Today, the making necessity of paper has enlarged a lot. Bamboo pulp made papers practically have the similar eminence matched to the paper made from wood. It only diverges in the toughness as it has lesser tensile stiffness than wood-made paper.<sup>40</sup>

**Bamboo furniture:** Several inns, cafeterias use bamboo furniture to beautify the inside. The use of bamboo furniture in households is very fewer. Bamboo furniture is very robust, as weather fluctuations do not distress the furniture.<sup>40</sup>

**Ply board and rug:** In the case of stylish households, occasionally bamboo is used as flooring material. Preparation and broadening of bamboo canes are done to create ply boards and mats. These flat canes are then hard-pressed together with the aid of gum to make the stated items.<sup>40</sup>

### Bamboo processing

Air seasoning of split or half round bamboo does not create considerable problematic but caution has to be taken to avoid fungal and insect occurrence during seasoning. Bamboo with poor early state on account of deterioration, borer hole etc. normally suffer more dehydrating damages. Green bamboo may comprise 50-150% of dampness. As in the case of wood, seasoning of bamboo is essential before its effective utilisation. Air seasoning of split or half curved bamboo does not pose great problem but precaution has to be taken to escape mycological and bug occurrence during seasoning. Speedy drying in open sun as usually adopted for several handiwork stuffs like bags, rugs, chicks, etc., can govern fungoid and bug outburst. Seasoning of round bamboo presents substantial difficulty. A research on seasoning behaviour of bamboo showed that young bamboo gets regularly distorted in cross section and heavy walled immature bamboo normally breakdown. Dense ripe bamboo be likely to crash on exterior with the crash initiating at the nodes and at rotten points. Reasonably thick juvenile and thin and moderately mature bamboo season with much fewer damage. Bamboo with reduced initial state due to deterioration, borer hole, etc. usually suffers more dehydrating damages. The curved bamboos should be placed in upright stand up place for air-drying.<sup>40</sup>

### Bamboo amalgams

Bamboo goods are finding growing usages in numerous uses such as floorboards, covering, handiworks, ornamental panels, athletic kit and additional structure supplies. Bamboo as raw material is used for mash, paper and sheet panel productions. Bamboos are used in several customary uses such as railing, water piping, fishing sticks,

canopy grips, harmonious gadgets and ornamental handiworks. Yet, currently the attention is on bamboos as organizational ingredients. The appropriateness of bamboos for mechanical goods is proved by its motorized and physical properties. Bamboo amalgams are usually used for structural goods rather than the raw bamboos. This is due to likely changeability of material goods along the longitudinal and circular instructions as well as physical magnitudes of the goods necessities. For load, carrying physical amalgamated goods, motorized assets such as ductile strength, compressive forte, shear power, flexural power and winding bounciness modulus are vital. For carpeting tiles and layers, through-the-thickness compressive power, firmness, scratch fight and slip-up struggle are vital. For structural assemblages, nail removal power is vital.<sup>40</sup>

### Development of bamboo based technology

Bamboo-based technologies spanning applications like polyhouses, electrical appliances, food, and fiber are bringing about improvements in the life and livelihood of people in the North East India. Several bamboo-based technologies and products like bathroom sanitary and electrical products, bamboo buildings and structures for reprieve and restoration in the stir of main catastrophes, laptop stand, photo frames, bamboo shoot processing, cane furniture, plyboards have been developed, and IPRs also filed on some of them. These have generated employment of the direction of 30 million person-days per year. Equipment finished with novel designs and contrived bamboo is gaining fame and attracting the attention of architects, designers, and interior decorators. Greater than 42 lakh sq. ft. area of engineered bamboo structures and constructions have been built for assistance and recuperation in the stir of main tragedies.<sup>40</sup> Bamboo-based board/ply/timber flattened board, veneer board, jute composites, plastic composites have been developed and commercialized. Around 576 schoolrooms were made of engineered bamboo house 20000 children in Chhattisgarh.

Under the Nationwide Task of Bamboo Solicitations, NECTAR has been generating a bamboo-based ecosystem and developing technologies, and promoting and commercializing them. These include bamboo disposable cutleries & bamboo bottle prototypes, bamboo-based bathroom sanitary, bamboo cricket bat and stamps and electrical products, etc. These, as well as the polyhouse technology, which uses minimum steel with bamboo connections eliminating the use of nuts and bolts, have been patented and are being commercialized now.

The major technologies that has been developed, tested, and commercialised include:

**Wood substitutes and composites:** including different types of bamboo boards like flatten, veneer, jute composite, corrugated sheets.

**Construction and structural applications:** Bamboo complexes have unlocked novel outlooks for frivolous, robust and artistic building for a range of uses, allowing informed selections for accommodation, communal, and practical constructions, including high-end construction for areas like Leh-Ladakh.

**Food and agro-processing:** Bamboo sprouts convey the prospective of value-added commercial action through community business initiatives in cultivation, processing, and packaging. Group level treating and packing expertise of bamboo sprouts is regularised for 7 days and were verified microbiologically, chemically and organoleptic ally.

**Processing machines and technology:** The Mission functioned with apparatus constructors to grow a variety of effective, robust, and cost

effective tooling and treating equipment apposite to Indian situations and classes, to lessen labour, improve output and minimize waste.

**Bamboo for energy:** The gasification of bamboo can yield clean and renewable electricity and a series of valued by-products like high-grade charcoal.

**Industrial products:** Bamboo treating ‘waste’ is a brilliant basis material for high-grade charcoal and stimulated carbon, which can function as a gasoline, absorbent, and conductor.

Activated carbon can be used as deodorizer, sanitizer, medication, agrarian biochemical, and absorbent of contamination and too much humidity. Technologies to enable the manufacture of bamboo charcoal and activated carbon have been established.

Along with supporting such technology development, value addition of products, and entrepreneurial ventures connected to bamboo, NECTAR has been supporting this sector by collating and disseminating information related to bamboo and its application in user-friendly formats. This initiative has completely changed the dynamics of people in NE to think an alternative option for better and sustainable livelihood.

### Bamboo as traditional remedies

Bamboo sprout has been in usage in medication, ever since period ancient by the ethnic folks in several areas. With diverse flavones, glycosides, bamboo sprouts have decent anti-oxidant, anti-free-radical and anti-aging agents, and can be extracted to prepare pills and medications.<sup>41</sup> In the customary scheme of Ayurveda, the silicious concretions originate in the bamboo sprouts is termed banslochan and in the Indo-Persian and Tibetan scheme of medication, it is named as bamboo manna and is known to be a good stimulant for breathing complaints. *Bambusa arundinacea* species is considered as the brilliant basis of bamboo manna. In China, bamboo shoots are used for handling contaminations. The liquid of hard-pressed bamboo sprouts owns protease action that aids in absorption of protein. The poached bamboo sprouts are used as starters. Decoction of the sprouts are used for washing injuries and worm infested wounds, sores etc. Bamboo sprouts, mixed with palm-Jaggery, are recognized to encourage parturition or abortion.<sup>42</sup> In Java, sap from inside the sprouts of *Bambusa vulgaris* is used for curative jaundice. Bamboo salt pills used in Korea are recognized to aid treat certain interior sicknesses. These are arranged by closing salt in bamboo sprouts by means of sterilized yellow clay and then blistering them eight times in a specifically planned heater. This permits the salt to engross greatly healing trace components plus Cu, Zn and Fe and also removes any contaminations and heavy metals from the salt that can cause any injury to the form. It helps as a normal cleansing means with a solid anti-microbial property and also delivers energy and nutrients to the body. Korea fairs a delightful bamboo sea salt, which is used as a substitute to table salt in culinary. Korea is even described of advertising bamboo shoot-based make-ups such as scrubbing agent called bamboo bath salts.<sup>14</sup>

### Prospect scenarios & conclusion

A blooming economy turns everywhere bamboo supply. Bamboo is well-placed to discourse the foodstuff safety through bamboo-based agro-forestry schemes by upholding the richness of adjacent agronomic plots, and as a direct nutrition basis like eatable bamboo sprouts. Bamboo sprouts grasp the vision of price supplementary financial actions at manufacturing and culture stages via farming, treating, packing and commercialization. Nonetheless, the preparation of many bamboo shoot-based food crops is customary, indigenous, chaotic and

built on the palate of the native folks. There is no consistent process expertise or technology for conservation of the fresh bamboo sprouts into many foodstuff. This appeals for the progress of suitable skills for conservation of bamboo sprouts in different formulas. In India, there is however neither foremost method for advancement of sprouts nor is there well thought-out marketplace or source series for the fresh or treated bamboo sprouts. Attention should be focused for subsequent features for supportable expansion of a bamboo sprout-based foodstuff business through documentation and collection of maximum suitable eatable classes such as *Dendrocalamus giganteus*, *Dendrocalamus asper*, *Bambusa balcooa* and *Dendrocalamus hamiltonii*; endorsement of suitable set of training for bamboo farming; suitable fermentation expertise of palatable bamboo sprouts; channel organization measures comprising plantation, upkeep, and collecting; materials processing such as grouping, scrubbing, and aeration; product development (tools, diets, jigs, colorants, dyes, lacquers) and promotion that comprises consumer documentation, circulation, commercials.

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## Conflicts of interest

Authors declare that there is no conflict of interest.

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