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Post Harvest Traditional Bamboo Preservation Methods Practiced by the Bamboo Growers of Assam

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Abstract: ***Bamboo is a unique and versatile material used for variety of purposes. But, it has certain drawbacks like its easy susceptibility to biodegradation and low natural durability. Therefore, special treatments (chemical /non-chemical) are required before using this biomass. The rural people of Assam are not aware to use this valuable gift in a protected and prevented manner and only use some non chemical i.e. traditional method of preservation to protect bamboo from biodegradation. These methods are very popular among the rural masses because, these can be carried out without any special equipments and technical knowhow. This paper describes some traditional methods of bamboo preservation which are still practiced in rural Assam to protect bamboo from bio degradation.***

Keywords: Bamboo, biodegradation, preservation, durability

1. Introduction

Bamboo is one of the valuable gifts bestowed by nature on mankind. Its remarkable growth rate and versatile properties have made it one of the most sought after materials, especially in tropical countries. Bamboo, once considered the poor man's timber, in now a day's fast growing industry. It is cheap, abundantly available, possesses adequate strength, can be utilized readily for variety of purposes. In its adaptability to human needs it has few peers in the plant kingdom. There are as many as 75 genera and 1250 species distributed in Tropical sub- tropical and temperate zones of different parts of the Globe (Tewari, 1993). India endowed by 136 species of bamboo in 30 genera and majority of which are found in North-East India (Suri and Chouhan, 1984). The rural economy of this region is greatly dependent on bamboo where the state of Assam is not an exception. The rural people of the state use this gift of nature differently. It is a major building material for building houses, sheds, rafters, fencing, bridge making even for making traditional equipments of plough and fishing. Besides these, bamboo is also a major income source of the rural people of Assam. In Assam the lives of the both rural and urban area so intrinsically dependent upon bamboo and its variegated uses that it is hard to conceive the peoples plight without this useful commodity. They are sufficiently cheap and can meet varied needs of the human population from cradle to the bier. It is also an important fibrous raw material for pulp and paper industry. Easy workability, faster growing nature, high strength weight ratio, comparative cheapness together with availability in abundance and short period of maturity are the main purpose of its popularity. Bamboos are not only important from the point of improving the economy of the rural people and increasing revenues through industry, but also equally important in amelioration of the deteriorating environment.

Bamboo Diversity:

India is considered as one of the largest reserves of bamboos in the world (Tewari, 1993: Seethlakshmi and Kumar, 1998), which occupies 12.8% of the total forest area of the country. The distribution of bamboos in India differs according to the bio climatic regions. North eastern states of India *viz*. Arunachal Pradesh, Assam, West Bengal, Sikkim, Nagaland, Mizoram Manipur, Meghalaya and Tripura occupies more than 50% of the species reported from India. The recorded forest area of Assam is 26, 832 square km which works out to be 34.21% of its geographical area (FSI, 2015). The extent of bamboo bearing area in the forests is 7, 238 square km (FSI, 2011). The state Assam is having bamboo of 13 genera and 40 species (Baruah & Borthakur, 2003). But the number of genera and species of bamboo reported to be occurring in India have been reported differently by different workers. Humidity, precipitation and also development of complex and varied ecosystem of the region are the basic cause of enormous genetic diversity. Bamboo species which are available in Assam has been provided in Table-1

Table 1: Available Bamboo species found in Assam

S. No.	Scientific Name	Vernacular name	Locality	Uses
1.	*Bambusa arundinacea*	Kotoha banh, Kota banh	Nalbari	construction purposes, Fence making
2.	*Bambusa auriculata*	Kalia bans	Karimganj	
3.	*B. balcooa*	Bhaluka	Throughout the State.	Used mainly for construction purposes and house building
4.	*B. bambos*	Kotoha, Kotabanh	Throughout the State.	
5.	*B. cacharensis*	-	Lakimpur, Sultani-Cherra Village	Construction house hold articles, agricultural implement
6.	*B.jaintiana*	Beti banh	N.C.Hills, Karbi anglong dist.	
7.	*B. mastersii*	Deo banh	Lakhimpur, Dibrugarh	

8.	*B.nutans*	Deobanh, Jotia Makal	Throughout the State	Basket making, Mat making, Ornamental
9.	*B. pallida*	Bijuli, Jowa	Throughout the State	House hold articles, agricultural implement
10.	*B.polymorpha*	Betua, Jama	Cachar, Dholai, Kakicherra, Silchar	Fishing implements, Musical instruments
11.	*B. pseudopallida*	Nangal banh, Deo banh	-Throughout the State	construction purposes and house building
12.	*Bambusa Sp.*	Bhaluki makal, Paura	Kamrup, Gohpur	Basket making, Mat making,
13.	*Bambusa teres*	Bhaluki makal, paura	Chariduar, Darrag, Kamrup, Sibsagar.	Basket making
14.	*B. tulda*	Jati, Nal banh	Throughout the State.	construction purposes, Pulp & paper, rural huts, agricultural implements
15.	*B. vulgaris*	Tansti banh, Ketura	Karimganj.	Pulp & paper, rural huts, agricultural implements
16.	*Dendrocalamus giganteus*	Ketura,	N. Lakhimpur, Upper Dihing	Musical instruments, Costruction, pulp&paper
17.	*D.hamiltonii*	Pahari Kako, Kekowa	NC Hill., K. Anglong, Nagaon Cachar etc.	Costruction purposes, Basket making, Mat making
18.	*D. longispathus*	Khang, Lota kasundi	NC Hills, Kamrup, Dholai Block, Hovaithung	Construction purposes, rural huts,
19.	*D. strictus*	Karail, Jati, Rupahi banh	Deopani river bank, Cachar, NC Hills, Bhuban Hills.	construction purposes, Pulp & paper making and other industrial use
20.	*Dinochloa compactiflora.*	Karail, Jati	Karimganj N.C.Hills	cottage industry
21.	*D. gracilis*	-	Karimganj.	crafts and in cottage industry
22.	*D. india*	Dalu banh	Hathikhali, Kamrup, Kulsi	
23.	*D. mclellandii.*	Lota Kalisundi	Common in hill Dist.	Fodder
24.	*Gigantochloa macrostachys*	Nah banh, Tek serah	-	Basket making, Mat making
25.	*Melocanna baccifera (M.bambusoides)*	Muli banh	Common in hilly areas and in Upper Assam.	Furniture, crafts and in cottage industry
26.	*Phyllostachys assamica*	Tarai banh	Sibsagar & Dibrugarh.	Furniture, crafts and in cottage industry
27.	*Schizostachyum dullooa*	Dalu banh		Furniture, crafts and in cottage industry
28.	*S. griffithii*	Beti banh	Dibrugarh, NC Hills.	Fishing implements, musical instrument, ornamental
29.	*S. pergracile*	Madang banh	Barduar, Batasipur, Darrang	Fencing, hedge, live fencing etc.
30.	*S. polymorphum*	Bajal banh, bajah banh.	R.F. Garampani, Makum forest Narduar, Joypur etc.	Furniture, crafts and in cottage industry

Source: State Forest Research institute, Itanagar, Draft Assam Bamboo and Rattan Policy 2003

Bio Deterioration of Bamboo

Bamboo, being a biological material is liable to be destroyed by various destroying agencies, which degrade bamboo singly or in combination. It has very low resistance to biological degrading agents as compared to timbers. Bio-deterioration in bamboo is known to be caused by different types of microbiological destroying organisms (Kumar et al, 1994; Srivastava, 1990). Majority of bio intruders like molds and staining fungi do not attack directly the wood/bamboo structure but derive their nutrition's mainly from cell lumen content. The degree of bio deterioration of bamboo depends on the climatic condition such as temperature, rainfall, moisture, humidity, soil condition and other environmental conditions in which the bamboo species grow and also put to test (Liese and Kumar 2003). Moisture and soluble sugars present in bamboo plays an important role in its degradation as well as durability. In bamboos soluble sugars are the principal nutrients for parasites. Bamboo with depleted carbohydrates becomes reasonably resistant to the attack of borers. The greatest damages are done by fungi and to relative minor extent, bacteria. Decay is by far, the most serious kind of microbiological damage cause structural failure. Due to the lack of any toxic constituents, bamboo forms a ready food source for variety of organism.

Bamboo consists of 50 – 70% hemicelluloses, 30% pentosans and 20 -25% lignin (Tamolang *et al*., 1980; Chen *et al*., 1985). Bamboo is known to be rich in silica (0.5 -4%), but the entire silica is located in the outer layer (1mm), with hardly any silica in the rest of the wall epidermis layers. Limited amount of resins, wax and tannins are present in bamboo, but it does not have enough toxicity to improve its natural durability. The large amount of starch present in bamboo makes it highly attractive to mold and fungi, termites and powder-post beetles. They cause much damage during drying, storage, and subsequent use. Tests have also shown that bamboo is more prone to soft rot and white rot attack than to brown rot.

Without any protective treatment, most bamboo species have an average durability of less than two (2) years in soil contact and stored under cover without soil contact may last 2-6 years (Tewari, 1993). The lower portion of the bamboo culms is considered more durable, while the soft inner part of the wall deteriorates faster than the outer harder portion. This is related to the anatomical and chemical nature of the woody cells. These variations in bamboo durability strongly depend on the species, age of the culm, thickness of the wall and also the time of harvesting. The quality of bamboo material obtained from different species is variable; there is notable difference in the properties between culms of different age classes within a species and within the different portions of the same culm (Osorio *et.al*. 2011). Some of the parameters of this variation which have direct bearing on bamboo utilization include culm /inter nodal length and diameter, density and strength properties, moisture content, shrinkage, permeability, anatomical structure and so on.

Much of this variation is inherent to bamboo and cannot be artificially controlled (Liese and Kumar, 2003). However, the only aspect that can be manipulated is the variation with respect to culm age and this can be achieved by harvesting bamboo at suitable age. It is observed that most of the physical and mechanical properties and machining quality of bamboo material also change with increasing culm age (Liese, 1992; 1995; 1998; Liese and Weiner, 1996; Hidalgo, 2003). There are several publications highlighting the effect of age on technical properties and processing quality of bamboo (Abdul Latif, 1992; 1993; 1995; Abdul Latif and Zin, 1992; Abdul Latif *et al*., 1990; 1993; Espiloy, 1994; Sattar *et al*., 1994).The assessment of culm age in the field requires some experience and understanding of a few basic principles of clump and culm morphology. Generally in clump forming bamboos, the older culms lie at the center and the newly formed culms at the periphery of the clump. There can also be a difference in inter nodal length and diameter of the older and recently formed culms. However, the most useful features that are widely employed for judging the culm maturity are the morphological features such as sheath characteristics, culm surface, texture and colour, branches and leaf scars. These features are also variable depending on the species and a few studies have been made to elucidate the changes in morphological features in relation to age in different species. However, the technique of using morphological features has not so far been perfected for all the bamboo species to facilitate the accurate age determination of culms.

Durability (Need for Protection):

The natural durability of bamboo is very low which depends on species, climatic conditions and type of use. The lifetime of untreated bamboo in ground contact, last only 1-3 years, under cover 2-6 years, without ground contact, undercover and not in a very humid climate is 10-15 years (Tewari, 1981). It has very low resistance to biological degrading agents as compared to timbers. Due to the void of toxic constituents, bamboo forms a ready food source for variety of organism, in contrast to timber. Bamboo culm consists of about 40 % parenchyma cells which are filled with nutritious starch, even in older culms. Only in flowering bamboo, the starch is used up for the seed production. Bamboo in ground contact rapidly colonized by a large range of microorganisms mainly fungi. Invaders like molds and staining fungi do not attack directly to the wood structure; they derive their nutrition mainly from cell lumen contents. Soft rot fungi may produce relatively small amounts of decay in bamboo after a few weeks on ground, the more destroying *Basidiomycete* usually attack bamboo only after few months. More than 40% volume of bamboo is destroyed due to these biological agents during use and storage in untreated condition (Mohanan, 1997). There are however, variations in the degree of deterioration depending upon factors such as altitude, soil, rainfall, temperature and other environmental condition. Fungal decay can be prevented by architectonic and constructive details that keep the bamboo dry and insect attack can be avoided efficiently only by using suitable chemical preservative treatment (Liese, 1980). Some important biodegrading agents have been enlisted in Table 2 and 3.

Table 2: Fungal group/ species causing deterioration in storage bamboos

S. No.	Category of damage	Causal organism	Host bamboo species
1.	White rot	*Daldinia concetrica, Trametes lactinea, lactinea sp., Pycnoporus sanguineus, gloeophyllum sapiarium, G. subferruginosum, Trametes cervinogilvus, Haploporus ljubarsky.*	*Bambusa sp.*
2.	Soft rot	*Xylaris Sp., chaetomium globosum*	*Phyllostachys Sp.*
3.	Brown rot	*Fomitopsis pinicola, Favolus sp., Schozophyllus commune*	*Bambusa sp.*
4.	Stain fungi	*Penicillum sp., Aspergillus Sp., Trichoderma sp.*	*Bambusa blumeana, B. vulgaris*

Table 3: Insect group/species causing deterioration in stored bamboos

S. No.	Category of damage	Causal organism	Host bamboo species
1.	Borers	*Chlorophorus annularis, Stromatium barbatum, Niphona hookeri, Dinoderus minutes, D. ocellaris, D. brevis, Lictus afticanus, Heterobostrychus aequalis*	*Dendrocalamus strictus, D, giganteus, D. hamiltonii, Bambusa bamboos, B polymorpha, B. arundinaceae, B. vulgaris, Phyllostachys pubescens etc.*
2.	Termites	*Coptotermes heimi, Cryptotermes dudleyi, Microtermes flacheri, Microtermes heimi*	Almost all bamboo in storage.

Protection Measures

The service life of bamboos can be increased many times by adopting proper preservation technology. This can be achieved by using non chemical and chemical methods of preservation. Chemical Preservative treatments give adequate protection against biodegrading agencies and normally a service life of at least 15 years can be expected from bamboos even under severe condition of use (Anon 2). The chemicals used for research aspect as well as industry include copper chrome arsenic (CCA), copper chrome boron (CCB), sodium pentachlorophenol, boric acid-borax, Cu/Zn naphenates/ abietates, tebuconazole, IPBC (3-iodo 2-propanyl butyl carbamate), chlorothalonil, isothiozolones, and synthetic pyrethroides (Kumar *et al*, 1994). A lot of work has been done on chemical preservation of bamboos by different researchers (Dev *et al*, 1997**;** Kumar *et.al*., 1998 **;** Kumar *et al*., 1981). Treatment of three species of bamboo with creosote: fuel oil mixture was investigated (Kumar *et.al*., 1998) and reported that creosote: fuel oil mixture can be used for enhancing the service life of bamboo. A formulation containing 0.5% sodium pentachlorophenol (NaPCP), 1% boric acid and 1% borax was used for protection of bamboo pulps during storage and found effective (Kumar et al 1985). Similar combination of 0.5% NaPCP and 1.5% borax was used to control the sap stain and decay and NaPCP exhibited protection against termites at 2% concentration. However, these combinations have some disadvantages as they have a tendency to leach out due to rain. To overcome this disadvantages, various blends of

copper chrome arsenic (CCA) with sodium PCP was used against termites and sap stain and reported that formulation containing 2% CCA and 0.2% NaPCP was suitable to prevent both sap stain and insect attack (Jain, 1998). A study was conducted by using an eco friendly preservative zinc borate and reported that treatment of lignocellulosic with borax followed by zinc chloride protect the lignocellulosic from termite attack (Dev *et al*, 1997).

Chemical treatments of bamboo has been claimed to be an economical proposition and is widely regarded as necessary, but however it is seldom carried out, the reasons are the lack of knowledge about possible use of preservatives, the uncertainty about the advantage of bamboo preservation and the lack of market for the treated bamboos (Liese, 1980). In Assam, wider application of the bamboo preservation is rare. The rural people of Assam is still not aware the use of chemical preservation methods and the benefits of the application of chemical preservatives. This is mainly due to the fact that bamboo is a low-cost material and abundantly available in Assam. On the other hand chemical treatment would be more expensive and chemical required for the treatment is less accessible to the common masses (Liese, 1981). The rural masses still use the non chemical i.e. traditional method of preservation because these methods can be carried out without any special equipments and technical knowhow. These treatments are effective in improving the degree of resistance of the bamboo to some extent. These methods are generally practiced for controlling the soluble sugars, starch etc. as the bamboo with depleted carbohydrates become reasonably resistant to the attack of borers and staining fungi. This assumption however, remains to be proved ; because not much is known about the real effectiveness of this traditional method of preservation (Liese, 1985) and only few studies have been carried out (Sulthoni, 1988) in Java. It was reported that the Javanese traditional method of bamboo preservation is justified to some extent, only in the case of *Dendrocalamus asper* good results were obtained after water immersion. The susceptibility of bamboo to borer attacks depends on the species, its starch content, age of the culm, felling season and its physical properties itself (Purusotham *et al*, 1954). Further studies indicated that starch content in bamboo influences the susceptibility to borer and the damaged caused by the borer has been proportional to the starch content of the bamboo (Liese, 1985; Sulthoni 1984; Beeson, 1961; Moran, 2002), .

A long standing tradition exists to protect bamboo structures by constructional methods, are base supports by stones, preformed concrete footings etc. which prevent the access of moisture. The main principle of this method is to reduce the high moisture content and avoid any later uptake by rain or ground contact (Moran, 2002). Another widely adopted traditional method is the selection of the harvesting season. It is reported that bamboos harvested during summer are more rapidly destroyed than those felled in the winter season and the felling season as applied by the Javanese is recommendable (Sulthoni 1988). It is generally observed that most of the physical and mechanical properties of bamboo change with increasing culm age (Liese, 1992; 1995; 1998; Liese and Weiner, 1996; 1997; Hidalgo, 2003). The properties like basic density, moisture content, strength properties, machining quality, etc. are affected with increase in culm age and therefore, culm age is an important factor having direct bearing on bamboo utilization. There are several publications highlighting the effect of age on technical properties and processing quality of bamboo (Abdul Latif, 1992; 1993; 1995; Abdul Latif and Zin, 1992; Abdul Latif *et al*., 1990; Espiloy, 1994; Sattar *et al*., 1994). Flowered bamboo plants are more resistant to beetles because of starch depletion. Mishra and Thakur (1998) carried out some pioneering work on laboratory evaluation of natural resistance of 13 species of bamboo against the test termite ***Microceroterms beesoni.Synder*** and came to the conclusion that ***Bambusa nutans*** (wt.loss 23.40%), ***Dendrocalamus strictus*** (wt. loss 25.63%), ***Bambusa balcooa*** *Rox*. (wt. loss 27.42%), ***Dendrocalamus giganteus*** (wt. loss 28.66%) and ***Ochlanda travancorica*** (wt. loss 29.82%) are relatively more resistant as compared to other species.

Soaking in water is a commonly used traditional preservation method of bamboo and reported that soaking in water reduces the starch content of the parenchyma cell (Beeson 1961). It is therefore, less attractive and improving the resistance level against borers (Tamolang *et al*, 1985 ; Liese, 2003) . Baking or smoking the fresh bamboo over a fire place around 60^0C for 40-60 days is another traditional method for preservation of bamboo. This causes rapid drying of the outer shell and induces partial charring and decomposition of starch and other sugars which is not recognized by beetle and fungi. It was reported that during the drying process, the smoked culms acquire a higher dimensional stability and resistance against borers. These treatments costs nothing and can be carried out without any special equipment, hence it is more popular and suitable for the reasonably cheap and easily available raw materials.

Limited studies have been carried out in the North- Eastern region in this aspect. Rain Forest Research Institute carried out some preliminary work on traditional preservation methods such as submerging the bamboo in running water, stagnant water and mud submersion. Performance of the treated bamboo have been evaluated by putting them in graveyard test ie., in natural environmental condition of Jorhat, Assam during 2000 - 2004. Among these three traditional methods, submersion of bamboo in running water improves a little bit resistance against bamboo ghoon (Gurung *et al*.2009). There are several traditional methods of preservation which are very popular among the rural masses are described below:

Water Soaking of Bamboo

The traditional methods followed in rural areas for post-harvest protection of bamboo is the submersion of harvested culms in water for one to three months and was found effective in preventing borer damage. Water soaking of bamboo reduces the starch content of parenchyma cell (Beeson, 1961). It is therefore less attractive to borers and improves the resistance level of bamboo. Submersion causes degradation of storage starch in culm tissues due to the action of saprophytic microorganisms. In Assam this is an easy and widely followed practice for increasing the durability of bamboo. During soaking in water most of the

sap is bleached out. Some villagers have suggested that a soaking period of 4 to 12 weeks is sufficient.

Smoking

Smoking is a common method of preserving bamboo. Heat and toxic agents produced by smoke destroy the starch in bamboo making it immune to insect attack and also blackens the culms. The smoke from the kitchen (fireplace without chimney) spreads throughout the house and thus preserves the bamboo structure from any attack

Baking Over Open Fire

Baking over fire after applying oil on the surface is another traditional method for preservation of bamboos. This causes rapid drying of the outer shell and induces partial charring and decomposition of starch and other sugars. Baking is done over a gentle fire and the surfaces are rotated constantly. Moist heating balances the shrinkage due to moisture loss and thus stabilizes bamboo. This method is very suitable for straightening of bamboos in round form and used by the rural masses of Assam for preparing their agricultural implements.

Clump-curing

Sugar contents of bamboos can also be reduced by keeping culms upright or leaning them against tree for a few days. Parenchyma cells in plant continue to live for some time, even after felling. During this period, the stored food materials are utilized and thus, the sugar/ starch content in bamboo are lowered. The evaporation in the leaves also reduces the starch/sugar content of bamboo and consequently beetle attack. However, attack by rot and termites are not diminished.

Mud Submersion

This is another popular method of bamboo preservation in rural Assam. In this method freshly cut culms are soaked in muddy pond for 1-8 weeks and then slowly dried in the shade (Choudhury, 1993).

White washing

Harvested bamboo culms are painted with slaked lime, thereby prolonging their lifespan by delaying and reducing the absorption of moisture. White washing act as an insects repellent.

Believes

The rural masses of Assam are also accustomed with certain traditional believes at the time of felling bamboos. Though these believes are not scientifically proved yet it plays vital role among the rural masses. Some believes are:

1) Not to fell bamboo on Saturday and Tuesday. The general believe is that if bamboos are felled on these days, there will be bamboo flowering which is a symbol of disaster among the rural masses of Assam.
2) There is a strong belief among the rural masses of Assam not to fell bamboos on moonlight days. They believe that if they does it the bamboos will get beetle (ghoon) attack .

Though there is no any scientific evidence in support of these believes, yet the traditional knowledge of post harvest practices followed in rural areas of Assam cannot be underrate. Some traditional post harvest practices like curing treatments have been found to be effective for protection of bamboo. Most of these treatments particularly the submersion treatments and the 'clump curing' are reported to decrease the starch content stored in culm tissues. Smoking is believed to deposit toxic substances and destroy the starch in the culm tissue and thus offering resistance to degradation (Hidalgo, 2003).

2. Conclusion

Bamboo the tallest grass in the earth has numerous uses and abundantly found in the North East India in general and Assam in particular. It is the important source of livelihood especially the rural population of the state. The rural people of Assam use bamboo for different purposes but they never feel the need of scientific treatment of bamboo at the time of its use. They are only guided by traditional beliefs and only some traditional methods of preservation are used at the time of utilization of bamboo. Some of these traditional methods of preservation have some positive effects to reduce the beetle and fungal attack but these techniques fail to enhance the life span of bamboo. So it is the needs of the hour to popularize the chemical treatment among the rural mass which will enhance the service life of bamboo many folds and reduced the replacement cost as well as irrational felling of bamboo and protect the greenery of the region.

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