REVIEW ARTICLE Open Access

ISSN 2278-1404

International Journal of Fundamental & Applied Sciences

Antioxidant and nutraceutical potential of bamboo: an overview

Arvind Kumar Goyal* and Birendra Kumar Brahma
Bamboo Technology, Department of Biotechnology, Bodoland University, Kokrajhar- 783370, B.T.A. D, Assam, India

Abstract

The mention of the traditional use of bamboo in Asian medicine dates back to the 6th century. Today people are switching over the use of herbal medicine instead of the synthetic drugs and bamboo, the 'Green gold' has voluminous nutraceutical properties and thus forms a core ingredient for research in many laboratory. Scientists from round the globe are exploring bamboo for establishing its pharmacological mechanism and also record the individual constituents responsible for it. This review summarizes published information on the historical uses, nutritional composition of various parts together with the antioxidative potential and the possible role and mechanism of action of these phytochemical components with regards to the antimicrobial, anti-diabetic, anti-cancer, anti-inflammatory, anti-obesity, anti-fatigue, anti-lipidemic effect along with effects on the cardiovascular diseases of this 'Green gold'.

Keywords: Anti-cancer, anti-diabetic, anti-inflammatory, antioxidants, bamboo, nutraceutical, phytochemical

1. Introduction

Bamboo is the name given altogether 1575 species[1] of perennial evergreen plants that belongs to the subfamily Bambusoideae of the true grass family Poaceae[2]. Bamboo is naturally distributed throughout the globe. Major species of bamboo is found in Asia Pacific and South America but much less in Africa[3]. India is a home for about 136 indigenous and exotic species that grow naturally and/or under cultivation[4]. Northeastern states like Assam, Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Sikkim along with the state of West Bengal (North Bengal, Himalaya) houses over 50% of the total bamboo species recorded in India[5]. Popular among the common people as "Poor man's timber" since ancient times, because of its innumerable applications has attained the status of "Green Gold of forests" [6,7]. Today bamboo constitutes one of the most important renewable natural resources of India. The use of bamboo is not only restricted as structural and building materials but with the advent of time has become an important component of the rural industries[8]. From ancient time bamboo has been an important ingredient of traditional Asian Medicines in general and Chinese medicine in particular. Modern scientific approaches are now used to validate the traditional uses and researchers from round the globe have been successful in isolating active chemical constituents from different parts of this green gold. They also provide an insight into the potential health benefits of bamboo parts. The present paper explores the bioactive components recorded in different bamboo species worldwide along with its nutraceutical potential.

Corresponding author
Full Address :
Bamboo Technology, Department of Biotechnology, Bodoland University, Kokrajhar- 783370, B.T.A.D, Assam, India
Phone no. +91-8256002212
E-mail: *arvindgoyal210883@gmail.com*

2. Historical uses of bamboo

Popularly known as "Poor man's timber", bamboo has been closely associated with Asia as an important resource. Today bamboo is globally recognized as an important asset in eradication of poverty, economic and environmental development and thus leading to change its image to "Green Gold". Throughout the globe bamboo meets the basic requirements of the common people. Bamboo is closely associated with indigenous culture and knowledge not only in Asia but also in Africa and Latin America. There are over 1500 documented uses of bamboo worldwide[9]. In fact bamboo is valuable from top to rhizomes. Bamboo has multifarious uses and serves as a superior material for constructions, utensils, weapons, fuel, fodder, food, firewood, furniture, mats, chop sticks, tooth picks, handicrafts, musical instruments and many more[10]. It is extensively used in the paper and pulp industries. With the development of science and technology, the uses of bamboo have also developed. Today bamboo is used in making hard boards, flooring, corrugated sheets etc.[11] and thus can serve as a replacement of wood. Apart from this the shoots of bamboo are used as delicacy because of their high nutritive values[12,13]. The shoots are used in many exquisite culinary preparations like pickle, vegetables, soup, salads, vinegar and several other forms in different countries[14].

3. Proximate Physicochemical composition/ Nutritional values of different parts of bamboo

3.1 Leaf: Studies conducted on bamboo leaf have shown that leaf is highly nutritive and contains important raw materials like crude protein, crude fiber, ash and other minerals. Leaves were found to be rich in calcium, magnesium, copper, and manganese; moderate in zinc, while poor in phosphorous, potassium and sodium[15].

3.2 Seeds: Bamboo seeds are rich in various nutrients. The seeds have a good profile of minerals like calcium, phosphorous, iron. These are good source of vitamin B_1, nicotinic acid, riboflavin, carotene. Seeds are rich in carbohydrates (73.4%), crude protein (12%), fiber (2.6%), ash (1.1%) and moisture (10%)[16].

3.3 Shoots: The shoots are rich in proteins, saccharides, amino acids, minerals, low in fat, inorganic salts and the water content may be as high as 90% (table I). Shoots are rich in dietary fiber and low in calories[17].

However, the quantification of many components such as vitamins, minerals, and other pharmacological properties has to be evaluated in detail.

Table I: Nutritive value of bamboo shoots (modified from Chongtham *et al.*[17] and Hu[74])

Constituents	Amount
Moisture	90 g
Protein	2.65 g
Fat	0.49 g
Saccharine	2.50 g
Soluble saccharine	1.53 g
Coarse fiber	0.58 g
Ash	0.88 g
Phosphorous	60 mg
Iron	0.8 mg
Calcium	12.8 mg

4. Bamboo and human health

The use of bamboo as traditional medicine by the Chinese dates back to some 2500 years. They used the bamboo leaves, branches, shoots, seeds, roots and juice to treat phlegm, cooling fever, laryngitis, rhinorrhagia (nose bleed) and vomiting. Thus it can safely be asserted that each part of bamboo is not only a treasure but also a medicine (figure I).

The use of bamboo is endless and because of this it is an indispensable resource for the rural people.

4.1 Antioxidant potential of bamboo

In the process of economic development, with the increase in income, human society tends to care more about their health. Therefore, demand for healthy herbal organic foods developed from various plants has also increased. Production of more efficient and productive food items by the researchers are on demand. One such plant with multiple qualities is bamboo.

Bamboo has been used over centuries by the humans both in daily life and for medicinal purpose in China and other Asian countries. The earliest scientific evidence of use of bamboo in traditional medicine dates back to 1963[18]. This marked the beginning of the use of bamboo as medicine which was followed by series of research carried out by different workers since then[19-31]. Bamboo has attracted attention world over due to its high antioxidant content and therapeutic effects on inflammation, fatigue, cancer, hyperlipidemia, diabetes, aging and hypertension.

Free radicals might occur either by the accidents of chemistry or due to specific metabolic purpose in the body. The free radicals produced by either way have different reactivity with some leading to damage to biomolecules such as DNA, lipids and proteins[32]. Antioxidants can react with free radicals during the oxidation process by acting as a reactive species scavenger and liberating catalysts, so antioxidants can be used to reduce the oxidative process[33] but they are not 100% effective. Mere large doses of diet-derived antibody was thought to be important to stay healthier for long time, but with the passage of time and development of science and technology the supply of 'pro-oxidants' is thought to be a better option[34]. Bioactive compounds like ascorbic acid, carotenoids, tocochromanols and phenols are antioxidants.

The bamboo leaf extract (BLE) is thought to be good source of natural antioxidants and also have great pharmaceutical potential[35-43]. BLE is mainly composed of flavonoids, lactones and phenolic acid. The flavonoids are represented mainly by the flavones C- glycosides which include homoorientin, isovitexin, orientin and vitexin. Apart from this quercetin, luteolin, rutin, caffeic acid, *p*-coumaric acid, chlorogenic acid and tricin are also present[44] (table II). The flavonoid content was recorded to be 3.44% in different bamboo leaves species[15].

4.2 Antimicrobial activity of bamboo

Plants are rich sources of various phytoconstituents which possess different medicinal properties against different microbes and bamboo is no exception. In 2010, Singh et al.[45] studied the antimicrobial activity of the aqueous and ethanolic leaf extracts of *Bamboosa arundinaceae* against *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aurenginosa* and *Bacillus* sp. The ethanolic extract was found to be more effective in inhibiting the microbes compared to aqueous extract against the standard penicillin. Later, Tanaka and his co-researchers[46] studied the antibacterial activity of *Phyllostachys pubescens* shoot skin (untreated and dicholormethane extract) against *Staphylococcus aureus*. They found that both the extracts could inhibit the growth of *S. aureus* and thus possess antibacterial activity. In 2012, Mulyono et al.[47] evaluated the antibacterial activity of *Dendrocalamus asper* against *E. coli*. They found that of the three different extract types (ethanolic, methanolic and methanol-ethanolic) ethanolic and methanol-ethanolic proved to be potential source of antimicrobial drugs. Recently in 2013, Mulyono and his team[48] also studied the antibacterial activity of *Gigantochloa apus* against the diarrheagenic *E. coli*. As per their results, they noted that *E. coli* was sensitive to both the ethanolic and methanolic extracts but in a concentration dependant manner.

4.3 Validated nutraceutical potential of bamboo

4.3.1 Anti-diabetic effect:

Diabetes Mellitus (DM) is prevalent among almost 200 million

people worldwide, which is thought to increase exponentially to 300 million in the next two decades, type 2 being common [49].

In the study conducted by Ding and his coworkers[50] with moso bamboo leaves on 50 diabetic rats, they evaluated that different doses of polysaccharide were found to possess good hypoglycemic effect. Hyun and Hyeon-Skoog[51] in their experiment with *Sasa borealis* leaf extract found that when substituted for meat in patty the leaf extract significantly lowered plasma glucose indicating anti diabetic activity of BLE. The anti diabetic activity of *Sasa borealis* leaf extract was also studied by Choi and his co workers[52]. The inhibitory effect of the leaves of *Pseudosasa japonica* was evaluated on high fat diet induced obesity and diabetes in C57BL/6J mice. All the mice had access to high fat diet for a week and then switched over to either the bamboo extract diet or control diet. The mice were regularly monitored for their daily intake of food and weight gained. Though the food intake of mice assigned to bamboo extract was found to be slightly higher than the control, but the weight gain was however restricted in mice on bamboo extract compared to control[53]. In 2011, Senthilkumar and others[54] made an attempt to scientifically prove the anti-diabetic activity of the petroleum extract of the leaf of *Bambusa vulgaris* in streptozotocin induced diabetic rats. They found that oral administration of the extract for a period of 15 days was effective in significantly reducing the blood glucose level in a dose dependant manner when compared to the standard drug glibenclamide. Nam and his team[55], recently in 2013, reestablished the exact mechanism by which the leaves of *Sasa borealis* exhibit the anti-diabetic activity. In their experiment they found administration of *S. borealis* extract in STZ-induced diabetic mice increased insulin signaling together with phosphorylation of AMP-activated protein kinase (AMPK) in HepG2 cells. In addition to this the extract also increased glucose uptake and suppressed the expression of gluconeogenic genes. They thus inferred that *S. borealis* extract exerted the anti-diabetic effect through the activation of AMPK and improvement of insulin signaling.

4.3.2 Bamboo in cardiovascular diseases:

With modernization and industrialization the number of death and disability due to chronic heart diseases such as cardiovascular disease, diabetes etc has surpassed the death and disability due to nutritional deficiencies and infectious diseases [56]. Fu and his co researchers[57] experimentally proved that when the high cholesterol mice were treated with different concentrations of BLE, there was great reduction in the serum cholesterol. *Phyllostachys pubescens* leaves proved to have protective effect against palmitic acid induced lipo apoptosis [53]. Experiments conducted on rats showed that flavonoids rich bamboo beer could significantly lower the blood triglycerides and cholesterol. Apart from this the beer could elevate HDL-cholesterol and reduce LDL- cholesterol in a dose dependant

Figure I: Principal therapeutic effect of bamboo

manner[58]. The cardioprotective potential of flavone C-glucosides i.e. Orientin obtained from the leaves of *Phyllostachys nigra* has been proved by Fu and his co workers[59]. They also stated that it could also inhibit apoptosis by blocking the mitochondrial apoptotic pathway.

4.3.3 Anti-cancerous effect:

The leaves of *Sasa senanensis* (popularly known as Kumaizasa) have been used in Eastern Asia as a potential source of natural drug since hundreds of years. The alkaline extract prepared from the leaves (in hot water at 100ºC) of *S. senanensis* is popularly known as "Sasa health". Tsunoda et al.[21] from their experiment on mammary tumor strain of SHN virgin mice proved that oral administration of Sasa health for 12 days could significantly inhibit both the development and growth of mammary tumor in experimental models. In 2008, Seki and his team[30] also made an attempt to prove the anti-tumor activity of Sasa health. They used three different temperatures (100ºC, 121ºC and 196ºC) to prepare the Sasa health to evaluate the anti -tumor potential in three mouse tumor models (S-180, C38 and Meth-A). Oral administration of the extract a concentration of 0.05% or more was found to be effective in suppressing tumor growth in mouse models S-180 and C38. The extract also accelerated immunostimulating activity, which in turn activated the macrophages and human natural killer (NK) cells in tumor models and thus suppress the tumor. Panee[53] conducted experiment to test the effect of leaves of *Pseudosasa japonica* on the development of DMBA (7,12-Dimethylbenz[a] anthracene) induce breast cancer in SD (Sprague-Dawley) rats. He found that oral administration of bamboo extract for 3 weeks prior to DMBA injection could delay the onset of breast cancer by one week as compared to the control. Moreover, the bamboo extract also showed the potential of decreasing the incidence of occurrence of tumor by 44% and restricting the growth rate of the tumor by 67% after 11weeks of DMBA treatment. In 2010, Seki and Maeda (2010), Seki et al. (2010) and Lu et al. (2010) studied the anti cancer/tumor activity of *Kumaizasa* bamboo, *Sasa senanensis* and *Caulis bamfusae*. In their study, Seki and Maeda (2010) tested the cancer preventive effect of aqueous extract of *Kumaizasa* bamboo both prior to tumor implantation and also after inducing of carcinogenesis using DMBA in experimental mouse. They found that the *Kumaizasa* bamboo was effective against both the cases and could significantly suppress the incidence of tumor growth and enhanced survival rate on one hand and the extract at the rate of 0.03% fed for two weeks could significantly suppress the cancer. In the same year, the anti tumor activity of *Sasa senanensis* leaf extract was experimented using three different mouse tumor models *viz*. S-180, C38 and Meth-A by Seki and his team[60]. Oral administration of the extract at a concentration of 0.05% or more was found to significantly reduce the tumor growth in mouse models S-180 and C38 and also prolonged the survival rate compared to the control. Lu and his co-researchers [61] were successful in establishing that the savings of *Caulis bamfusae* had the potential to inhibit the growth of cancer cell lines (P388 and A549) and also notably inhibit the tumor growth on sarcoma-loaded mice model S180 compared to standard cyclophosphamide. Apart from this they also isolated a compound named friedelin and proved its efficacy as anti tumor compound against cancer lines, A375, L929, Hela and THP-1. Recently in 2013, the ethanolic leaf extract of *Sasa quelpaertensis* has also been reported to exert potent cytotoxicity activity against human colon cancer HCT116 cells by Kim et al.[62].

4.3.4 Anti-fatigue effect:

Leaf extract of *Phyllosatchys nigra* var henonis have been reported to enhance the anti-fatigue capacity in mice[63]. You and his coworkers[64] found that oral administration of 80% ethanol extract of *Pseudosasa japonica* leaf for 18 days could drastically increase the swimming time in experimental mice up to one and half folds and simultaneously reduce the blood lactate and elevate the removal of lactate suggesting its potential to reduce fatigue compared to the control group. In 2006, an attempt was also made to study the anti-fatigue activity of *Bambusa tuldoides* using BALB/c mice models by Zhang and his team[65]. They found that the extract at an appropriate concentration mot only could prolong the weight-loaded swimming and climbing time but also exerted active effect on the serum urea nitrogen, hepatic glycogen and blood lactic acid level in BALB/c mice thus personified its anti-fatigue activity.

4.3.5 Anti-inflammatory effect:

In 2003, Muniappan and Sundararaj[66] validated that the methanol extract of *Bambusa arundinacea* was effective against both carrageenin induced and immunologically induced paw oedema in albino rats compared to standard drugs. They also proved that the extract in combination with phenybutazone (a non-steroidal antiiflammatory agent) was more effective in comparison to when used individually. They thus concluded that the natural product together with modern medicine can result in the development of the most suited anti-inflammatory drug.

Hwang and his co-researchers[67], provided scientific evidence to the traditional use of *Sasa quelpaertensis* leaves for the treatment of inflammation related diseases. They documented the hot water extract of *S. quelpaertensis* could ameliorate inflammation related diseases by suppressing nitric oxide production in pathological event.

Methanol extract of the leaves of *Bambusa vulgaris* have been shown to possess anti-inflammatory activity against the various anti-inflammatory tests performed which includes formaldehyde induced rat paw edema, acetic acid induced vascular permeability test, carrageenan induced peritonitis and cotton pellet granuloma in albino rats[68].

4.3.6 Anti-obesity effect:

Obesity, characterized by the deposition of excessive fats in the adipocytes is considered to be a major obstacle in efforts to improve human health[69].

Yang et al.[70] studied the effect of *Sasa borealis* leaf extract (SBE) on inflammatory cytokines and insulin resistance in high fat diet (HFD) induced obese mice. They found that the *S. borealis* leaf extract was effective at just 5% when administered for 12 weeks. After 12 weeks treatment they recorded that the body weight and the adipose tissue deposition were decreased significantly compared to untreated HFD mice. They also found decrease in glucose, insulin, IAUC, HOMA-IR, TNF-α, IL-6 and leptin levels. These results justified that SBE contains anti-obesity compounds. It was in 2012 that Kang and his

researchers[71] made an attempt to explore the anti-obesity effect of *Sasa quelpaertensis* leaf extract (SQE) in high fat diet (HFD) induced obese mice and mature adipocytes. They noted that the administration of SQE for 70 days to HFD mice not only decreased the body weight, adipose tissue weight, serum cholesterol and triglycerides but also reduced the serum levels of several enzymes along with deposition of lipid droplets in the liver when compared to untreated mice. They finally concluded that the anti obesity effect of SQE is mediated by the activation of AMPK in adipose tissue.

4.3.7 Anti-hyperlipidemic effect:

Alterations in lipid profile are one of the most common complications in diabetes mellitus and affects 40% of all diabetic patients[72]. The study was carried out by Ding and his team[73] to elucidate the anti-hyperlipidemic effect of polysaccharides from Moso bamboo leaves (PMBL). Mice were fed with high fat food to induce hyperlipidemia and then treated with PMBL in a dose dependant manner. The result revealed significant decrease in total cholesterol, tri-glyceride and low- density lipoprotein in serum together with decrease in crude fat in liver concluding PMBL exhibited could improve hepatic function in mice and possesses antihyperlipidemic

Table II: List of chemical compounds and their structure isolated from different bamboo species

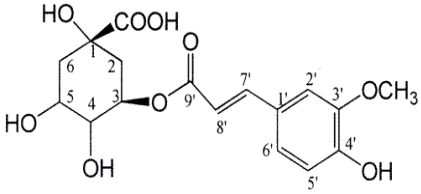
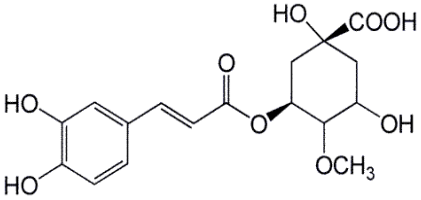
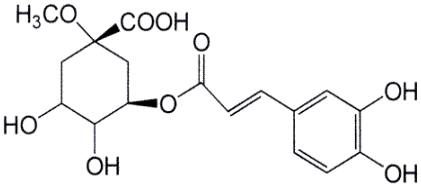
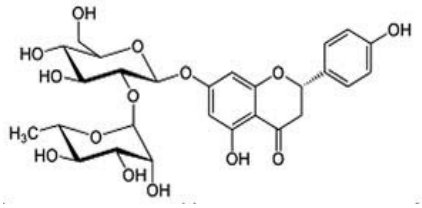
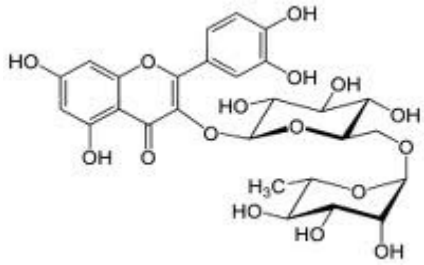
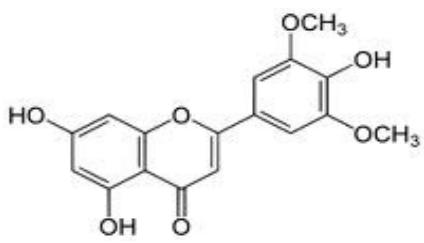
Plant name	Chemical compound	Chemical structure	References
Phyllostachys edulis	3-*O*-(3'-methylcaffeoyl) quinic acid		Kweon et al.[23]
	5-*O*-caffeoyl-4-methylquinic acid		
	3-*O*-caffeoyl-1-methylquinic acid		
Phyllostachys nigra var. henonis	naringin-7-rhamnoglucoside		Lu et al.[27]
	Rutin		
	Tricin		

Table II continued to next page

Table II continued from previous page

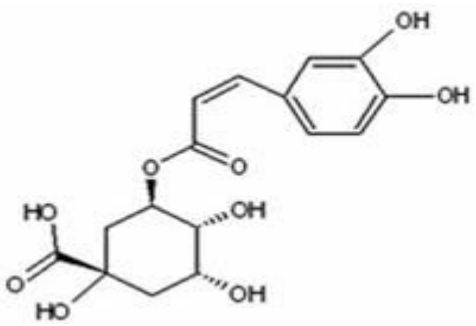
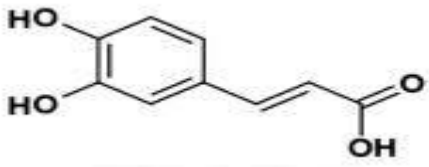
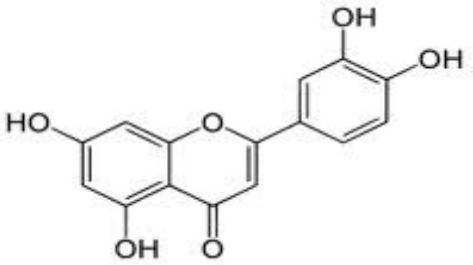
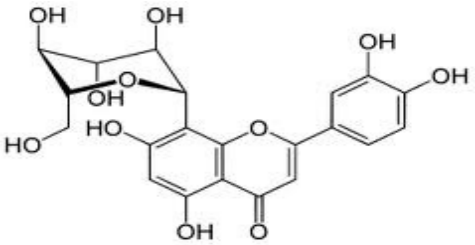
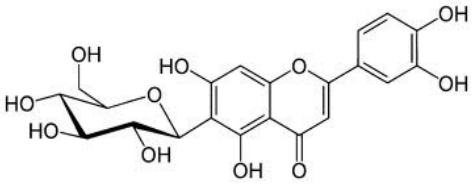
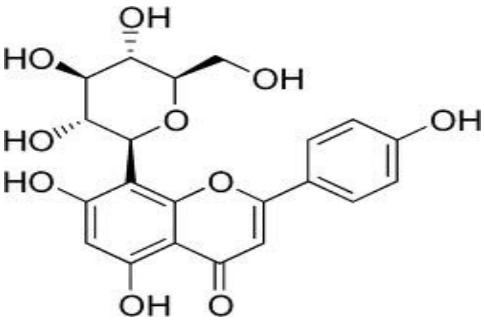
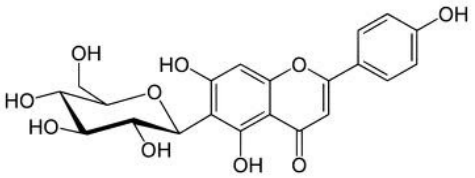
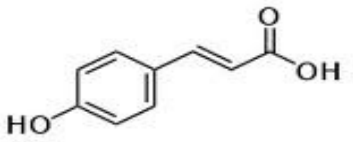
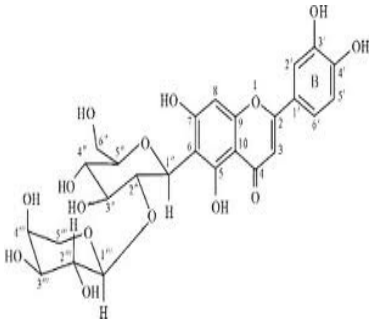
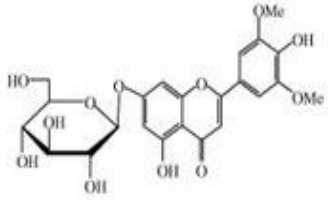
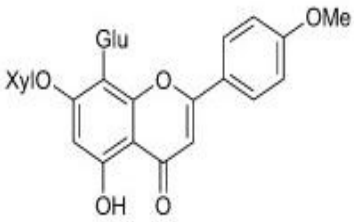
Plant name	Chemical compound	Chemical structure	References
Phyllostachys nigra var. henonis	Chlorogenic acid		
	Caffeic acid		
	Luteolin		
Phyllostachys nigra var. henonis	Orientin		Lu et al.[27]; Zhang et al.[75,76]
	Homoorientin		
	Vitexin		
	Isovitexin		

Table II continued to next page

Table II continued from previous page

Plant name	Chemical compound	Chemical structure	References
Phyllostachys nigra var. henonis	p-coumaric acid		Zhang et al.[76]
Sasa borealis	isoorientin 2"-O-c~-L-rhamnoside		Park et al.[29]
	tricin 7-O-13-D-glucopyranoside		
	apigenin 6-C-13-D-xylopyranosyl-8 -C-13-D-glucopyranoside		

activity.

4.3.8 Antihyperglycemic Activity

Middha and Usha (2012) reported *invitro* anti-diabetic study of bamboo species[77].

Conclusion

Leaves of different species of bamboo have been in use since long time not only as medicine but also as fodder. A number of studies have been done on animal models to judge the potentiality of bamboo leaf extract not only as food additive but also as medicine. The scientific validation and experiments clearly reveals that bamboo leaf is not only safe as food additive but also exhibit potential as raw materials to the pharmaceutical and nutraceutical industries. But a lot needs to be explored because the reports available are confined to some selected species of bamboo of the thousands that exists in nature.

Acknowledgements

The authors are thankful to the Agriculture Department, Bodoland Territorial Council Secretariat, Bodofa Nwgwr, Kokrajhar for providing the fund vide letter No. BTC/Agric-91/2013/15 dated 19th June, 2013. We are also obliged to Dr. Mohan Bhattacharya, Rector, Bodoland University for providing help and support.

Conflict of interest

The authors declare no conflict of interest.

References

1. Goyal AK, Kar P & Sen A, Advancement of bamboo taxonomy in the era of molecular biology: a review. In A Sen (eds) *Biology of useful plants and microbes*, Narosa publication house, New Delhi (2013), Pp197-208.
2. Watson L & Dallwitz M J, *The grass genera of the world* (revised edition) (Cambridge University Press) (1992).
3. Bystriakova N, Kapos V, Lysenko I & Stapleton CMA, Distribution and conservation status of forest bamboo biodiversity in the Asia-Pacific Region. *Biodiversity & Conservation*, **12(9)** (2003), 1833-1841.
4. Sharma, YML, Inventory and resources of bamboos. In: A.N. Rao, G. Dhanarajan and C.B. Sastry (Eds.) Recent Research on Bamboos. CAF, China and IDRC, Canada (1987), Pp 14-17.
5. FSI, *Forest and tree resources in States and Union territories* (Forest Survey of India) (2011), 241-246.
6. Goyal AK, Middha SK, Usha T, Chatterjee S, Bothra AK, Nagaveni MB & Sen A, Bamboo-infoline: A database for North Bengal bamboo's. *Bioinformation*, **5(4)**, (2010a), 184-185
7. Handique P, Rethy P, Dutta BK, Das A & Doley B, Role of bamboo resources in socio economic development of the Tribal people of Arunachal Pradesh with special reference to Nyishi tribe of Papum Pare District, *Journal of Biosciences Research*, **1(3)**, (2010), 216-226.

8. Nimachow G, Rawat JS & Dai O, Prospects of bamboo shoot processing in north-east India. *Current Science*, **98(3)**, (2010), 288–289.
9. Ogunwusi AA, Potentials of bamboo in Nigeria's Industrial Sector. *Journal of Research in Industrial Development*, **9(2)**, (2011), 136-146.
10. Goyal AK, Ghosh PK, Dubey AK & Sen A, Inventorying bamboo biodiversity of North Bengal: A case study. *International Journal of Fundamental and Applied Sciences*, **1 (1)**,(2012), 5-8
11. Pande SK & Pandey S, Bamboo for the 21st Century. *International Forestry Review*, **10(2)**, (2008), 134-146.
12. Choudhury D, Sahu JK & Sharma GD, Value addition to bamboo shoots: a review. *Journal of Food Science and Technology*, **49(4)**, (2012), 407-414.
13. Satya S, Singhal P, Bal LM & Sudhakar P, Bamboo shoot: a potential source of food security. *Mediterranean Journal of Nutrition and Metabolism*, **5(1)**, (2012), 1-10.
14. Christine R & Wetterwald MF. *Bamboos*. Oregon. USA, Timber Press Inc., 1992.
15. Singhal P, Satya S & Sudhakar P, Antioxidant and pharmaceutical potential of bamboo leaves. *Bamboo Science and Culture*, **24(1)**, (2011), 19-28.
16. Kiruba S, Jeeva S, Sam Manohar Das S & Kannan, Bamboo seeds as a means to sustenance of the indigenous community. *Indian Journal of Traditional Knowledge*, **6(1)**, (2007), 199-203.
17. Chongtham N, Bisht MS & Haorongbam S, Nutritional properties of bamboo shoots: potential and prospects for utilization as a health food. *Comprehensive Reviews in Food Science and Food Safety*, **10(3)**, (2011), 153-168.
18. Sakai S, Saito G, Sugayama J, Kamasuka T, Takada S & Takano T, On the Anticancer Action of Bamboo Extract. *Journal of Antibiotics, [B]* 16, (1963), 387-391.
19. Okabe S, Takeuchi K, Takagi K & Shibata M, Stimulatory effect of the water extract of bamboo grass (Folin solution) on gastric acid secretion in pylorus-ligated rats. *Japanese Journal of Pharmacology*, **25(5)**, (1975), 608.
20. Otani K, Yanaura S, Yuda Y, Kawaoto H, Kajita T, Hirano F & Inouye S, Histo-chemical studies on the anti-ulcer effect of bamboo grass in rats. *International Journal of Tissue Reactions*, **12(6)**, (1990), 319.
21. Tsunoda S, Yamamoto K, Sakamoto S, Inoue H & Nagasawa H, Effects of Sasa Health®, extract of bamboo grass leaves, on spontaneous mammary tumourigenesis in SHN mice. *Anticancer Research*, **18(1A)**, (1998), 153-158.
22. Hu C, Zhang Y & Kitts DD, Evaluation of antioxidant and prooxidant activities of bamboo *Phyllostachys nigra* var. Henonis leaf extract *in vitro*. *Journal of Agricultural and Food Chemistry*, **48(8)**, (2000), 3170-3176.
23. Kweon MH, Hwang HJ & Sung HC, Identification and antioxidant activity of novel chlorogenic acid derivatives from bamboo (*Phyllostachys edulis*). *Journal of Agricultural and Food Chemistry*, **49(10)**, (2001), 4646-4655.
24. Kim KK, Kawano Y & Yamazaki Y, A novel porphyrin photosensitizer from bamboo leaves that induces apoptosis in cancer cell lines. *Anticancer Research*, **23(3B)**, (2003), 2355.
25. Ren M, Reilly RT & Sacchi N, Sasa health exerts a protective effect on Her2/NeuN mammary tumorigenesis. *Anticancer research*, **24(5A)**, (2004), 2879-2884.
26. Kurokawa T, Itagaki S, Yamaji T, Nakata C, Noda T, Hirano T & Iseki K, Antioxidant activity of a novel extract from bamboo grass (AHSS) against ischemia-reperfusion injury in rat small intestine. *Biological and Pharmaceutical Bulletin*, **29 (11)**, (2006), 2301-2303.
27. Lu B, Wu X, Tie X, Zhang Y & Zhang Y, Toxicology and safety of anti-oxidant of bamboo leaves. Part 1: Acute and subchronic toxicity studies on anti-oxidant of bamboo leaves. *Food and Chemical Toxicology*, **43(5)**, (2005), 783-792.
28. Lu B, Wu X, Shi J, Dong Y & Zhang Y, Toxicology and safety of antioxidant of bamboo leaves. Part 2: Developmental toxicity test in rats with antioxidant of bamboo leaves. *Food and Chemical Toxicology*, **44(10)**, (2006), 1739-1743.
29. Park HS, Lim JH, Kim HJ, Choi HJ & Lee IS, Antioxidant flavone glycosides from the leaves of Sasa borealis. *Archives of Pharmacal Research*, **30(2)**, (2007), 161-166.
30. Seki T, Kida K & Maeda H, Immunostimulation- Mediated Anti-tumor Activity of Bamboo (*Sasa senanensis*) Leaf Extracts Obtained Under 'Vigorous' Condition. *Evidence Based Complement & Alternative Medicine*, **7(4)**, (2008), 447-457.
31. Seki T & Maeda H, Cancer preventive effect of Kumaizasa bamboo leaf extracts administered prior to carcinogenesis or cancer inoculation. *Anticancer Research*, **30(1)**, (2010), 111-118.
32. Halliwell B, Free radicals and antioxidants: a personal view. *Nutrition reviews*, **52(8)**, (1994), 253-265.
33. Gülçin İ, Alici HA & Cesur M, Determination of *in vitro* antioxidant and radical scavenging activities of propofol. *Chemical and Pharmaceutical Bulletin*, **53(3)**, (2005), 281-285.
34. Halliwell B, Free radicals and antioxidants: updating a personal view. *Nutrition reviews*, **70(5)**, (2012), 257-265.
35. Goyal AK, Middha SK & Sen A, Evaluation of the DPPH radical scavenging activity, total phenols and antioxidant activities in Indian wild *Bambusa vulgaris* "Vittata" methanolic leaf extract. *Jounral of Natural Pharmaceuticals*, **1 (1)**, (2010a), 40-45.
36. Goyal AK, Middha SK & Sen A, *In vitro* Antioxidative Profiling of Different Fractions of *Dendrocalamus strictus* (Roxb.) Nees leaf Extracts. *Free Radicals and Antioxidants*, **1 (2)**, (2011) 42-48.
37. Ni Q, Xu G, Wang Z, Gao Q, Wang S & Zhang Y, Seasonal Variations of the Antioxidant Composition in Ground Bamboo *Sasa argenteastriatus* Leaves. *International journal of molecular sciences*, **13(2)**, (2012), 2249-2262.
38. Wang J, Yue YD, Tang F & Sun J, TLC Screening for Antioxidant Activity of Extracts from Fifteen Bamboo Species and Identification of Antioxidant Flavone Glycosides from Leaves of *Bambusa textilis* McClure. *Molecules*, **17(10)**, (2012), 12297-12311.
39. Liao HB, Hu CJ & Yuan K, Composition and Antioxidant Activity of the Volatile Oil of Bamboo Leaves from Different Provenances. *Applied Mechanics and Materials*, **108**, (2012), 320-325.
40. Naz SH, Zubair M, Rizwan K, Rasool N, Jamil M, Riaz M *et al.*, Phytochemical, Antioxidant and Cytotoxicity studies of *Bambusa arundinacea* leaves. *International Journal of Phytomedicine*, **4(2)**, (2012), 220-228.
41. Ibeh BO, Maxwell E & Bitrus HJ, Phytochemical constituents and in vitro antioxidant capacity of methanolic leaf extract of *Oxytenanthera abyssinica* (A. Rich Murno). *European Journal of Medicinal Plants*, **3(2)**, (2013), 206-217.
42. Mao JW, Yin J, Ge Q, Jiang ZL & Gong JY, In vitro antioxidant activities of polysaccharides extracted from Moso Bamboo-Leaf. *International Journal of Biological Macromolecules*, **55**, (2013), 1-5.
43. Goyal AK, Middha SK & Sen A. *Bambusa vulgaris* Schrad. ex J. C. Wendl. var. vittata Riviere & C. Riviere leaves attenuate oxidative stress- An *in vitro* biochemical assay . *Indian Journal of Natural Products and Resources,* **4(4)**, (2013), 436-440.
44. Zhang Y, Wu XQ & Yu ZY, Activity of the leaves of bamboo, *Phyllostachys nigra,* and *Ginkgo biloba*, *China Journal of Chinese Meteria Medica*, **27(4)**, (2002), 254–257.
45. Singh VK, Shukla R, Satish V, Kumar S, Gupta S & Mishra A. Antibacterial activity of leaves of bamboo. *International Journal of Pharma and Bio Sciences*, **6**, (2010),1-5.
46. Tanaka A, Kim HJ, Oda S, Shimizu K & Kondo R, Antibacterial activity of moso bamboo shoot skin (*Phyllostachys pubescens*) against *Staphylococcus aureus*. *Journal of Wood Science*, **57(6)**, (2011), 542-544.
47. Mulyono N, Antibacterial Activity of Petung Bamboo *Dendrocalamus asper* Leaf Extract Against Pathogenic Escherichia coli and Their Chemical

Identification. *International Journal of Pharmaceutical & Biological Archive*, **3(4)**, (2012), 770-778.
48. Mulyono N, Lay BW, Ocktreya L & Rahayu S, Antidiarrheal activity of Apus bamboo (*Gigantochloa apus*) leaf extract and its bioactive compounds. *American Journal of Microbiology*, **4(1)**, (2013), 1-8.
49. Alberti, Sir George, *Type 2 Diabetes, Practical Targets and Treatments* - Asian - Pacific Type 2 Diabetes Policy Group, Third Edition; (2002), 2.
50. Ding HX, Gao YY, Chao HJ & Xia DH, Study on Hypoglycemic Effect of Polysaccharide from Moso Bamboo Leaves. *Food Science*, **28(12)**, (2007), 446-449.
51. Hyun KO & Hyeon-Sook L, Effects of hamburger patties with bamboo leaf (*Sasa borealis*) extract or sea tangle (*Laminaria japonica*) powder on plasma glucose and lipid profiles. *FASEB Journal*, (2009), Meeting Abstract Supplement 563.17.
52. Choi YJ, Lim HS, Choi JS, Shin SY, Bae JY, Kang SW & Kang YH, Blockade of Chronic High Glucose–Induced Endothelial Apoptosis by *Sasa borealis* Bamboo Extract. *Experimental Biology and Medicine*, **233(5)**, (2008), 580-591.
53. Panee J, Bamboo extract in the prevention of diabetes and breast cancer. *Watson RR (ed.), Complementary and Alternative Therapies and the Aging Population: An Evidence-Based Approach. San Diego: Elsevier*, (2008), Pp 159-177.
54. Senthilkumar MK, Sivakumar P, Changanakkattil F, Rajesh V & Perumal P, Evaluation of anti-diabetic activity of Bambusa vulgaris leaves in streptozotocin induced diabetic rats. *International Journal of Pharmaceutical Sciences and Drug Research*, **3(3)**, (2011), 208-210.
55. Nam JS, Chung HJ, Jang MK, Jung IA, Park SH, Cho SI & Jung MH, *Sasa borealis* extract exerts an antidiabetic effect via activation of the AMP-activated protein kinase. *Nutrition research and practice*, **7(1)**, (2013), 15-21.
56. Yusuf S, Reddy S, Ôunpuu S & Anand S, Global burden of cardiovascular diseases. *Circulation*, **104(23)**, (2001), 2855-2864.
57. Fu X, Wang M, Li S & Li Y, The effect of bamboo leaves extract on hemorheology of normal rats. *Zhong yao cai Zhongyaocai Journal of Chinese Medicinal Materials*, **28(2)**, (2005), 130-132.
58. Ying Z, Lei F, Xia C, XiaoQing W & Jian, Bamboo beer-a new kind of healthy beer. *Journal of Bamboo Research*, **19(1)**, (2000), 33-37.
59. Fu XC, Wang MW, Li SP & Wang HL, Anti-apoptotic effect and the mechanism of orientin on ischaemic/reperfused myocardium. *Journal of Asian Natural Products Research*, **8 (3)**, (2006), 265-272.
60. Seki T, Kida K & Maeda H, Immunostimulation-mediated anti -tumor activity of bamboo (Sasa senanensis) leaf extracts obtained under 'Vigorous' condition. *Evidence-Based Complementary and Alternative Medicine*, **7(4)**, (2010), 447-457.
61. Lu B, Liu L, Zhen X, Wu X & Zhang Y, Anti-tumor activity of triterpenoid-rich extract from bamboo shavings (*Caulis bamfusae* in Taeniam). *African Journal of Biotechnology*, **9 (38)**, (2010), 6430-6436.
62. Kim JY, Kim JH, Byun JH, Kim JH, Lee YJ, Im SJ *et al*, Antioxidant and anticancer activities of water and ethanol extracts obtained from *Sasa quelpaertensis* Nakai. *Life Science Journal*, **10(1)**, (2013), 1250-1254.
63. Zhang Y & Tang L, Experimental studies on anti-aging effect of the leaf-extract of *P. nigra* var. Henonis. *Journal of Bamboo Research*, **16(4)**, (1997), 62-67.
64. You Y, Kim K, Heo H, Lee K, Lee J, Shim S & Jun W, Stimulatory effects of *Pseudosasa japonica* leaves on exercise performance. *Bioscience, Biotechnology, and Biochemistry*, **70 (10)**, (2006), 2532-2535.
65. Zhang Y, Yao X, Bao B & Zhang Y, Anti-fatigue activity of a triterpenoid rich extract from Chinese bamboo shavings (*Caulis bamfusae* in taeniam). *Phytotherapy Research*, **20(10)**, (2006), 872-876.
66. Muniappan M & Sundararaj T, Antiinflammatory and antiulcer activities of *Bambusa arundinacea*. *Journal of Ethnopharmacology*, **88(2)**, (2003), 161-167.
67. Hwang Joon-Ho HJH, Choi Soo-Yoon CSY, Ko, Hee-Chul KHC, Jang Mi-Gyeong JMG, Jin Young-Jon JYJ, Kang Seong -Il KSI *et al.*, Anti-inflammatory effect of the hot water extract from *Sasa quelpaertensis* leaves. *Food Science and Biotechnology*, **16(5)**, (2007), 728-733.
68. Carey WM, Dasi JM, Rao NV & Gottumukkala KM, Anti-inflammatory activity of methanolic extract of *Bambusa vulgaris* leaves. *International Journal of Green Pharmacy*, **3 (3)**, (2009), 234.
69. Frühbeck G, Gómez-Ambrosi J, Muruzábal FJ & Burrell MA, The adipocyte: a model for integration of endocrine and metabolic signaling in energy metabolism regulation. *American Journal of Physiology-Endocrinology and Metabolism*, **280(6)**, (2001), E827-E847.
70. Yang JH, Lim HS & Heo YR, *Sasa borealis* leaves extract improves insulin resistance by modulating inflammatory cytokine secretion in high fat diet-induced obese C57/BL6J mice. *Nutrition research and practice*, **4(2)**, (2010), 99-105.
71. Kang SI, Shin HS, Kim HM, Hong YS, Yoon SA, Kang SW *et al.*, Anti-Obesity Properties of a Sasa quelpaertensis Extract in High-Fat Diet-Induced Obese Mice. *Bioscience, Biotechnology and Biochemistry*, **76(4)**, (2012), 755-761.
72. Middha SK, Bhattacharjee B, Saini D, Baliga MS, Nagaveni MB & Usha T, Protective role of *Trigonella foenum* graceum extract against oxidative stress in hyperglycemic rats," *European Review forMedical and Pharmacological Sciences*, **15(4)**, (2011), 427–435.
73. Ding HX, Gao YY, Chao HJ & Xia DH, Effect of Polysaccharide from Moso Bamboo Leaves on Blood Lipid of Mice with Hyperlipemia. *Food Science*, **9**, (2010), 60.
74. Hu CZ, Nutrients in Bamboo Shoot. *Journal of Zhejiang Forestry College*, **1(1)**, (1984), 1-13.
75. Zhang Y, Jiao J, Liu C, Wu X & Zhang Y, Isolation and purification of four flavone C-glycosides from antioxidant of bamboo leaves by macroporous resin column chromatography and preparative high-performance liquid chromatography. *Food Chemistry*, **107(3)**, (2008), 1326-1336.
76. Zhang Y, Tie X, Bao B, Wu X & Zhang Y, Metabolism of flavone C-glucosides and p-coumaric acid from antioxidant of bamboo leaves (AOB) in rats. *British Journal of Nutrition*, **97 (03)**, (2007), 484-494.
77. SK Middha, & T Usha An in vitro new vista to identify hypoglycemic activity. *Int J Fund Applied Sci,* **1 (2)**, (2012), 27-29.