



## Ethnomedicinal uses, Pharmacological and Phytochemical Studies of *Bambusa arundinacea* Retz (A Review)

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### ABSTRACT

Medicinal plants are a source of different types of natural products which are used in different illness. *Bambusa arundinacea*, commonly known as Bamboo belongs to family Poaceae (*Gramineae*). In folk medicine, it has been utilized for various inflammatory disorder, strangury, wounds, piles, dislodgement of worms, cirrhosis, hard tumour and *Diabetes mellitus*. This plant possess antiinflammatory, antidiabetic, antimicrobial, antioxidant, anticancer, antiglycation, laxative, antifertility, antihelminthic, insecticidal, antiarthritic and neuroprotective activities. *B. arundinacea* extract has also been utilized in the synthesis of nanoparticles which have enhanced the biological activities such as anticancer, antidiabetic, antimicrobial and antiglycation. The phytochemical analysis of this plant has afforded important classes of natural products such as terpenoids, steroids, flavonoids, phenols and glycosides, etc. These natural products have been reported for various pharmacological activities which may be responsible for the different biological activities of this plant. Although, this plant has not been explored much scientifically, very few reports are available on this plant. However, this plant is gaining interest in nanomedicine field as the nanoparticles synthesized using this plant extract have shown enhancement in antidiabetic, anticancer and antimicrobial activities. The present review article will help the readers to explore more on this plant in various filed of nanotechnology, biotechnology and phytochemistry as it contains promising bioactive molecules. Moreover, some phytoconstituents especially flavonoids may be used for semisynthetic modification for development of lead molecules.

**Keywords:** *Bambusa arundinacea*, Pharmacology, Ethnomedicinal, Phytochemistry.

### INTRODUCTION

*Bambusa arundinacea*, commonly known as Bamboo belongs to family Poaceae (*Gramineae*). It is known by various names as Bnah in Assamese, Spanish bamboo in English, Wans in Gujarati, Kanta bans in Hindi, Bansa in Urdu, Vansa in Sanskrit and Bilawar in Kashmiri<sup>1</sup>. It is situated upto height of 1250 m on the hills of Andhra Pradesh, Tamil Nadu, Karnataka in India,

Peru, China, Sri Lanka, Bangladesh, and Malaysia<sup>2,3</sup>. The plant consists of hard stem with internode and solid node that gives strength to this plant. The nodes bears many buds from which branches evolve, this makes Bamboo different from other grass family. The plant stems are thorny tufted on a stout rootstock, with a height of 240-280 cm and diameter of 150-170 mm. It has elongated and lanceolate leaves and flowers are in the form of panicles<sup>4</sup>.



*Bambusa arundinacea* has been reported to possess important pharmacological activities such as antiinflammatory<sup>5</sup>, antidiabetic<sup>6</sup>, antioxidant<sup>7</sup>, antimicrobial<sup>8</sup>, insecticidal<sup>9</sup>, antihelmintic<sup>10</sup>, anticancer<sup>11</sup>, protective effect<sup>12</sup>, antiarthritis<sup>13</sup>, etc. Muniappan *et al.*,<sup>5</sup> reported that the methanolic leaves extract exhibited promising antiinflammatory activity on carrageenan and immunologically induced paw edema in Albino wistar rats<sup>14</sup>. *B. arundinacea* has been found to possess antimicrobial activity against a number of bacterial and fungal strains hence it could be a possible source to obtain new and effective compound to treat bacterial and fungal infections. Zubair *et al.*,<sup>14</sup> reported that n-hexane and chloroform extract displayed significant antimicrobial activity against the tested pathogens while acetone, methanol and butanol extract were found to be inactive. Thamizarasan *et al.*,<sup>8</sup> reported that hexane, acetone and hydroethanolic extract of this plant seeds have significant antimicrobial effect against various microorganisms. Jayarambabu *et al.*,<sup>15</sup> reported the antimicrobial activity of ZnO nanoparticles using *Bambusa arundinacea* extract by Agar disc diffusion method against *S. aureus* and *B. subtilis*. The ethanolic extract of tender shoots of the plant possess antifertility effect as reported by Vanithakumari *et al.*,<sup>16</sup>

*B. arundinacea* is endowed with antihyperglycemic potential. Joshi *et al.*,<sup>17</sup> reported the aqueous ethanolic extract of leaves of *B. arundinacea* to possess hypoglycemic activity, Nazreen *et al.*,<sup>6</sup> reported the hypoglycemic effect of *B. arundinacea* leaves three fractions viz. ethanolic petroleum ether, chloroform in STZ induced diabetic rats. Kumar *et al.*,<sup>23</sup> reported that roots ethanolic extract of this plant displayed lowering in the blood glucose level in normal and hyperglycemic rats in alloxan and OGTT methods. Macharla *et al.*,<sup>18</sup> reported that the aqueous ethanolic stem extract (200 mg/kg) of *Bambusa arundinaceae* showed decrease in glucose level in alloxan induced diabetic rats. Jayarambabu *et al.*,<sup>15</sup> reported the antidiabetic effect of *Bambusa arundinaceae* (BA) extract and its ZnO nanoparticles in normal and STZ induced rats. *B. arundinacea* has been reported to possess insecticidal<sup>9</sup> and antihelmintic<sup>10</sup> properties. *B. arundinacea* has been used for the treatment of rheumatoid arthritis. Anti-arthritic effect against complete Freund's Adjuvant (CFA) induced arthritis in female rat were investigated by Rathod

*et al.*<sup>13</sup>. *B. arundinacea* has been found to possess protecting properties as well as anti-plasmin activity in cortical neuron which were induced by N-methylaspartate and fibrinogen and fibrin degradation (FDPs) assay, respectively as reported by Hong *et al.*,<sup>12</sup>. *B. arundinacea* is a rich source of antioxidants. Chauhan *et al.*,<sup>7</sup> reported that the methanolic extract and different fractions of young shoots of *Bambusa arundinacea* have prominent antioxidant property. *B. arundinacea* synthesized nanoparticles further enhanced the biological activities. For example, Kalaiarasi *et al.*,<sup>11</sup> have synthesized the silver nanoparticles (AgNPs) using *B. arundinacea* leaf extract which showed enhanced cytotoxicity on PC-3 (lung cancer) and Vero normal cell lines. Jayarambabu *et al.*,<sup>15</sup> prepared zinc oxide nanoparticles (ZnO NPs) of BA extract exhibited strong anticancer activity against MCF-7 cell line. Patel *et al.*,<sup>19</sup> reported antiglycation potential of zinc oxide nanoparticles utilizing *B. arundinacea* leaf extract, inhibited the formation of AGEs, decreased the level of fructosamine and formation of glycosylated Hb.

#### Ethnomedicinal uses

*Bambusa arundinacea* are arboreous grasses known to mankind since a long time and is utilized as a food and shelter by native people<sup>20,21</sup>. It is used in various application such as making traditional and musical instruments, boat rafts, construction, furnitures and flooring, fencing and fodder for cattles, utensils for cooking, and in management of waste water<sup>22</sup>.

In folk medicine, *Bambusa arundinacea* is used for the treatment of many inflammatory disorders<sup>23</sup>. The plant stem and leaves are acidic and used as a laxative, in blood diseases, kapha, inflammation, piles and bile disorders<sup>24</sup>. It is also used in constringent and kidney disorders in Ayurveda. The extract of leaves bud is used in menstrual discharge, leaves infusion for eye wash and used internally for bronchitis, gonorrhoea and fever<sup>9</sup>. The acrid seed are used for liver dysfunction and urinary discharges<sup>2</sup>. The root ointment is a remedy for liver cirrhosis and tumors<sup>1</sup>. The leaves are emmenagogue and used for sciatica, fibrositis, gastic and liver diseases, lung bronchitis, and gonorrhoea whereas flower juices is used in deafness and ear pain. The bark is used as a cure for eruptions<sup>25</sup>. The manna is sweet, acrid, tonic which is used for blood

diseases, lung diseases such as asthma, bronchitis and tuberculosis. Besides this, it is also used for fever, haemoglobin deficient anaemia, hepatitis and leprosy. Tabasheer (dried bamboo sap) containing 97% silicon dioxide is used as a tonic for cough and asthma. The leaves of this plant are used by tribal women in Madras for abortion of a child by chewing it two times a day<sup>26</sup>. In Kanyakumari Kani tribes, the seeds of this plant increase the fertility and therefore it is in large demands for the improvement of fertility in this area<sup>27</sup>. The leaf juice is used for osteoarthritis, osteoporosis for making the cartilage and bones strong, for strengthening arterial walls, teeth and nails and reduces psoriasis and dermatitis. Traditional practitioner's uses 2-3 cups of *B. arundinacea* Retz. leaf decoction three times a day for months to treat diabetes mellitus<sup>5</sup>.

### Pharmacology

*Bambusa arundinacea* has been reported to exhibit important pharmacological activities viz. antiinflammatory, antidiabetic, anticancer, antifertility, antihelminthic, insecticidal, antimicrobial, etc. (Fig. 1). These activities are discussed below.

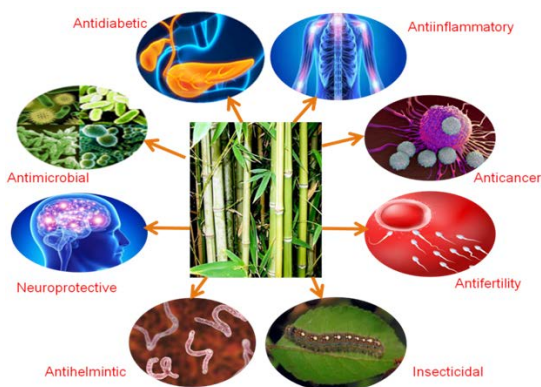


Fig. 1. Biological activities exhibited by *B. arundinacea*

### Antiinflammatory, analgesic and antiulcer activity

*B. arundinacea* is reported for the treatment of many inflammatory conditions. It has been found that the methanolic leaves extract exhibited antiinflammatory activity on carrageenan and immunologically induced paw edema in Albino wistar rats<sup>5</sup>. The effect was found to be significant, compared to positive control, phenylbutazone. However, amalgamation of extract and phenylbutazone when administered orally in *Albino rats* resulted in enhanced antiinflammatory activity experimentally

without any ulcerogenic effect. Therefore, the amalgamation of extract of this plant with modern medication could produce antiinflammatory drugs that could be of advantage in treating inflammatory problems such as rheumatoid and osteoarthritis. *B. arundinacea* ethanolic and hydroalcoholic extract displayed *in vitro* anti-inflammatory activity with  $IC_{50}$  of 700 and 212  $\mu\text{g/mL}$ , respectively whereas ibuprofen displayed  $IC_{50}$  of 118.33  $\mu\text{g/mL}$ <sup>28</sup>. Also, the ethanolic leaves extract at 100 mg/kg and 200 mg/kg exhibited promising analgesic and antipyretic effect in dose dependent manner<sup>29</sup>. These results indicate that *B. arundinacea* has the potential to reduce inflammation with less side effects.

### Antimicrobial effect

*B. arundinacea* could be a possible source to obtain new and effective compound to treat bacterial and fungal infections. *B. arundinacea* has been found to possess antimicrobial activity against a number of bacterial and fungal strains. 2,6 dimethoxy-p-benzoquinone isolated from bamboo extract inhibits the growth of *Candida albicans*, *Trichophyton interdigitale*, *Microsporum gypseum*, *Penicillium chrysogenum*, *Staphylococcus aureus*, *Bacillus subtilis*, and *P. aeruginosa*<sup>30</sup>.

Zubair *et al.*,<sup>14</sup> reported that *n*-hexane and chloroform extract displayed significant antimicrobial activity against the tested pathogens while acetone, methanol and butanol extract were found to be inactive. Table 1 showed that *n*-hexane extract showed good inhibitory activity against *E. coli*, *P. multocida*, and *B. subtilis* with MIC 3.81  $\mu\text{g/mL}$ , 5.28  $\mu\text{g/mL}$  and 5.26  $\mu\text{g/mL}$ , respectively whereas it was inactive on tested fungal strains. Chloroform extract displayed moderate inhibition on *S. aureus* and *B. subtilis* with MIC 15.5  $\mu\text{g/mL}$  and 10.7  $\mu\text{g/mL}$ , respectively while it was inactive against *E. coli*. Acetone extract was found to be active against *G. lucidum* with MIC = 4.00  $\mu\text{g/mL}$  only while it did not show any inhibitory activity against *A. alternata*, *E. coli*, and *S. aureus*.

**Table 1: Antimicrobial activity in terms of inhibition zones and minimum inhibitory concentration of *B. arundinaceae* leaves against selected bacterial and fungal strains**

Different organic extracts	Tested microorganisms (Diameter of inhibition Zone (IZ), mm)					
	<i>B. subtilis</i>	<i>P. multocida</i>	<i>S. aureus</i>	<i>E. coli</i>	<i>A. alternata</i>	<i>G. lucidum</i>
n-hexane	17.0±0.81 <sup>b</sup>	19.0±0.70 <sup>b</sup>	15.5±1.11 <sup>d</sup>	22.2±1.47 <sup>b</sup>	n.d	n.d
Chloroform	17.0±0.70 <sup>b</sup>	16.0±1.80 <sup>d</sup>	19.0±0.70 <sup>c</sup>	n.d	8.5±1.23 <sup>c</sup>	9.0±1.11 <sup>c</sup>
Ethyl acetate	22.7±2.27 <sup>b</sup>	18.0±0.70 <sup>b</sup> <sup>c</sup>	n.d	n.d	n.d	n.d
Acetone	18.5±0.5 <sup>b</sup>	16.2±1.47 <sup>cd</sup>	n.d	n.d	n.d	24.2±5.26 <sup>a</sup>
n-butanol	n.d	n.d	19.5±1.08 <sup>c</sup>	22.0±3.11 <sup>b</sup>	6.5±0.03 <sup>d</sup>	6.5±1.11 <sup>b</sup>
Absolute Methanol	n.d	n.d	n.d	n.d	11±1 <sup>b</sup>	8.5±0.02 <sup>b</sup>
(0.5:9.5) water: methanol	17.7±0.82 <sup>b</sup>	n.d	22.0±1.82 <sup>b</sup>	n.d	7.75±1.47 <sup>cd</sup>	8.5±1.11 <sup>b</sup>
(1:9) water: methanol	n.d	n.d	n.d	n.d	6.0±1.58 <sup>d</sup>	n.d
Control	29.0±1.08 <sup>a</sup>	34±1.08 <sup>a</sup>	28.5±0.82 <sup>a</sup>	28.5±1.08 <sup>a</sup>	26.0±5.71 <sup>a</sup>	

Minimum inhibitory concentration (MIC) mg/mL.

Extracts	<i>B. subtilis</i>	<i>P. multocida</i>	<i>S. aureus</i>	<i>E. coli</i>	<i>A. alternata</i>	<i>G. lucidum</i>
n-hexane	5.62±0.12	5.28±0.16	22.4±0.32	3.81±0.5	n.d	n.d
Chloroform	10.7±0.07	12.5±0.21	15.5±0.21	n.d	10.6±0.38	10.5±0.40
Ethyl acetate	3.02±0.25	6.48±0.29	n.d	n.d	n.d	n.d
Acetone	12.4±0.11	12.1±0.12	n.d	n.d	n.d	4.00±0.36
n-butanol	n.d	n.d	15.8±0.22	2.81±0.23	18.4	15.0±0.04
Absolute Methanol	n.d	n.d	n.d	n.d	7.4±0.40	11.4±0.04
(0.5:9.5) water: methanol	10.4±0.17	n.d	5.89±0.10	n.d	11.8±0.07	11.4±0.46
(1:9) water: methanol	n.d	n.d	n.d	n.d	18.4±0.36	n.d
Control	2.04±0.32	2.04±0.32	2.14±0.32	2.04±0.32	3.05±0.04	3.05±0.04

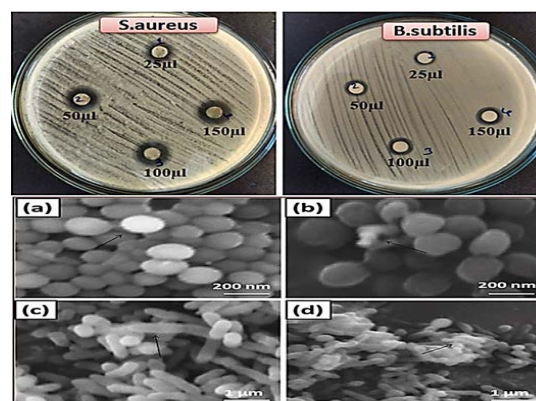
Data are expressed as the mean ± standard deviation; values having different letters differ significantly (p <0.05). n.d= not detected. Rifampicin and Fluconazole used as control for bacterial and fungal strains respectively

The hexane, acetone and hydroethanolic extract of this plant seeds have shown significant antimicrobial effect against various microorganisms<sup>9</sup>. Jayarambabu *et al.*,<sup>15</sup> reported the antimicrobial activity of ZnO nanoparticles using *Bambusa arundinacea* extract by Agar disc diffusion method against *S. aureus* and *B. subtilis*. As observed from Fig. 2, the synthesized ZnO nanoparticles showed enhanced zone of inhibition of 14, 16, 17, 19 mm and 12, 14, 15, 17 mm against *S. aureus* and *B. subtilis*, respectively. The ZnO NPs interaction between *S. aureus* and *B. Subtilis* was studied by SEM to observe the morphology changes of bacteria and under ZnO NPs treatment. The normal *S. aureus* and *B. subtilis* shows spherical and rod shape with smooth surface area, but ZnO NPs treated bacteria displayed irregular morphology and ruptured bacterial cell walls which indicate the interaction of bacteria and ZnO NPs, leading to demolition of bacterial cells.

**Antifertility effect**

The ethanolic extract of tender shoots of the plant exhibits antifertility effect<sup>16</sup>. The administration

of plant extract at 300 mg/kg in male rats for 7 days caused a fertility reduction in male rats and the reduction was 15% for control rats and 23% for tested rats after a seven day recovery period. The protein serum as well as effect of oxaloacetic and pyruvic transaminase was non toxic on the rats.



**Fig. 2. Antimicrobial activity of *Bambusa Arundinacea* mediated ZnO NPs against *S. aureus* and *B.subtilis* and SEM images of a) Control *S. aureus* b) ZnO NPs treated c) Control *B. subtilis* and d) ZnO NPs treated**

**Antidiabetic effect**

*B. arundinacea* is endowed with antihyperglycemic potential. The aqueous ethanolic extract of leaves of *B. arundinacea* have been found to possess hypoglycemic activity. Joshi *et al.*,<sup>17</sup> reported that BA leaves aqueous extract at 1000 mg/kg produced a promising decrease in blood glucose level to 260 mg/dL at 3 h in STZ induced diabetic rats. Whereas in OGTT method, the extract increased blood glucose significantly at 30 min as shown Fig. 3.

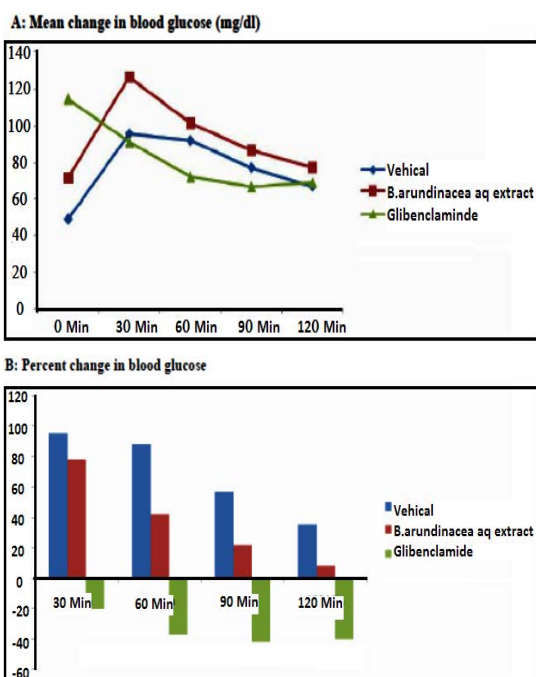


Fig. 3. OGTT in euglycemic rats treated with *Bambusa arundinacea* extract

Nazreen *et al.*,<sup>6</sup> reported the hypoglycemic effect of *B. arundinacea* leaves three fractions viz. ethanolic petroleum ether, chloroform in STZ induced diabetic rats showed that chloroform was the most potent in lowering the blood glucose at 150 mg/kg b.w., compared to glibenclamide, positive control. Also, this fraction did not cause any ulceration, decreased GSH level and increased LPO, AST and ALP enzymes Fig. 4.

Kumar *et al.*,<sup>31</sup> reported that roots ethanolic extract of this plant displayed lowering in the blood glucose level in normal and hyperglycemic rats in alloxan and OGTT methods. Macharla *et al.*,<sup>18</sup> reported that the aqueous ethanolic stem extract (200mg/kg) of *Bambusa arundinaceae* showed decrease in glucose level in alloxan induced diabetic

rats. As observed from Fig. 5, Group II, III, IV, V and VII showed suppression of blood glucose level at 6 h significantly ( $p < 0.01$ ) compared to zero hour to its respective group.

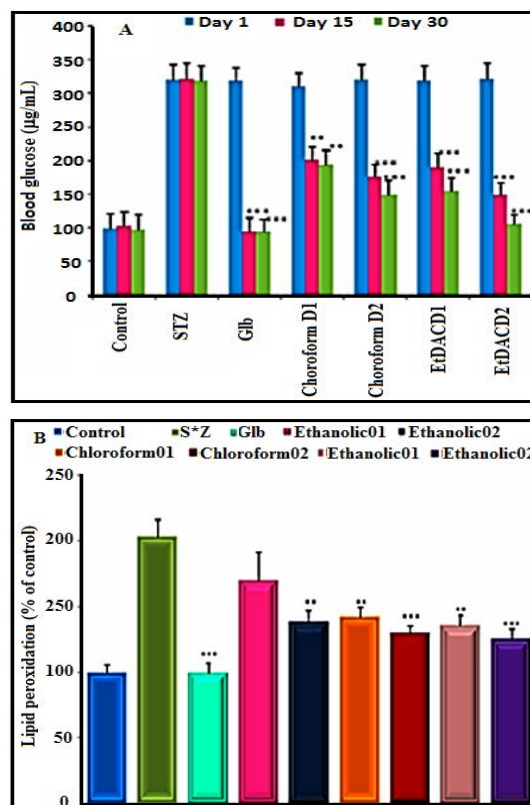


Fig. 4. Effect of chloroform fractions and ethyl acetate fraction of *Bambusa* on blood glucose levels of diabetic rats (A). Effect of fractions on lipid peroxidation (B)

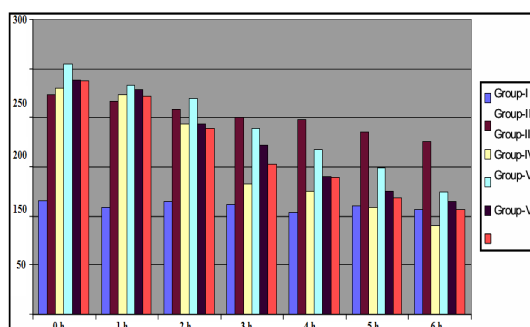


Fig. 5. Antidiabetic activity of aqueous ethanolic *Bambusa arundinaceae* stem extracts. GI: Normal rats; GII: alloxan control; GIII: glibenclamide; GIV: BA stem extract (50 mg/kg); GV: BA stem extract (100 mg/kg); GVI: BA stem extract (200 mg/kg)

Jayarambabu *et al.*,<sup>15</sup> reported the antidiabetic effect of *Bambusa arundinaceae* (BA) extract and its ZnO nanoparticles. As shown in Fig. 6, BA extract and ZnO-NPs did not produce reduction in



blood glucose levels in normal rats. Whereas in STZ induced diabetic rats, ZnO NPs significantly dropped the blood glucose levels at 200 mg/kg after 14 days of oral administration than BA extract. Moreover, the histopathology of liver after treatment with BA extract and ZnO-NPs displayed normal architecture, and the hepatocytes were observed Fig. 7.

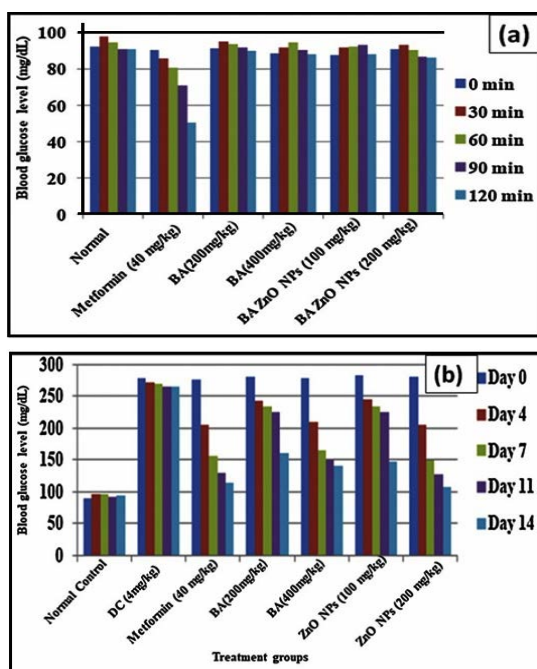


Fig. 6. (a) Effect of *Bambusa arundinacea* and ZnO NPs on fasted normal Wister rats, (b) Effect of *Bambusa arundinacea* and ZnO NPs on blood glucose levels in STZ induced diabetic Wister rats

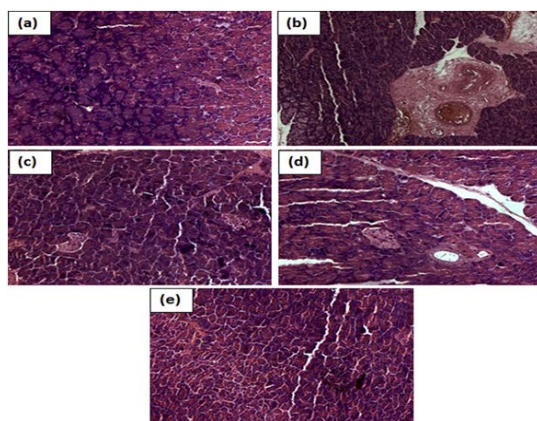


Fig. 7. (a) Normal control, (b) Diabetic control, (c) Metformin standard, (d) *Bambusa arundinacea* group, (e) Zinc oxide nanoparticles group

**Insecticidal activity**

*B. arundinacea* has been reported to possess insecticidal property. The young shoots

contain 0.03% hydrogen cyanide, benzene carboxylic acid and cyanogenic glucosides viz. taxiphyllin which are reported to be fatal on mosquito larvae. Bamboo shoots can resist insects, laterites, pH and hemp thus they have antiseptic and antilarval properties<sup>9</sup>.

**Antiarthritic activity**

*B. arundinacea* has been used for the treatment of rheumatoid arthritis. Anti-arthritis effect against complete Freund's Adjuvant (CFA) induced arthritis in female rat were investigated<sup>13</sup>. The methanolic plant extract at 100, 200 and 300 mg/kg b.w. for 21 days displayed dose dependent reduction in erosion of bone and enlargement of spleen, compared to control, But the reduction was not as significant as dexamethasone (5 mg/kg i.p.)

**Anthelmintic Activity**

*B. arundinacea* root ethanolic extract has been endowed with anthelmintic property. The anthelmintic activity of the extract has been investigated in *Pheretima posthuma*. It has been observed that the extract at 10, 20 and 50 mg/mL were found to be lethal for *Pheretima posthuma*. The anthelmintic effect was comparable to Albendazole, (10 mg/mL) and Piperazine citrate (15 mg/mL) positive control<sup>10</sup>.

**Protective effects**

*B. arundinacea* has been found to possess protecting properties as well as anti-plasmin activity in cortical neuron which were induced by N-methyl-d-aspartate and fibrinogen and fibrin degradation (FDPs) assay, respectively<sup>12</sup>. It has been observed that *B. arundinacea* pyrolyzates treated neuronal cells increases the cell viability, compared to untreated cells. Furthermore, *B. arundinacea* pyrolyzates treated cortical neurons when stained by Hoechst 33342 showed decline in apoptosis following NMDA exposure. Besides this, pyrolyzates of *B. arundinacea* showed anti-plasmin activity. Pyrolyzate isolated from bamboo have antiapoptotic effect and it can be used for ischemic injury treatment as the amalgamation of NMDA receptor antagonists, GABAergic drugs, glucocorticosteroids, and heparin are used for delay in post ischemic injury.

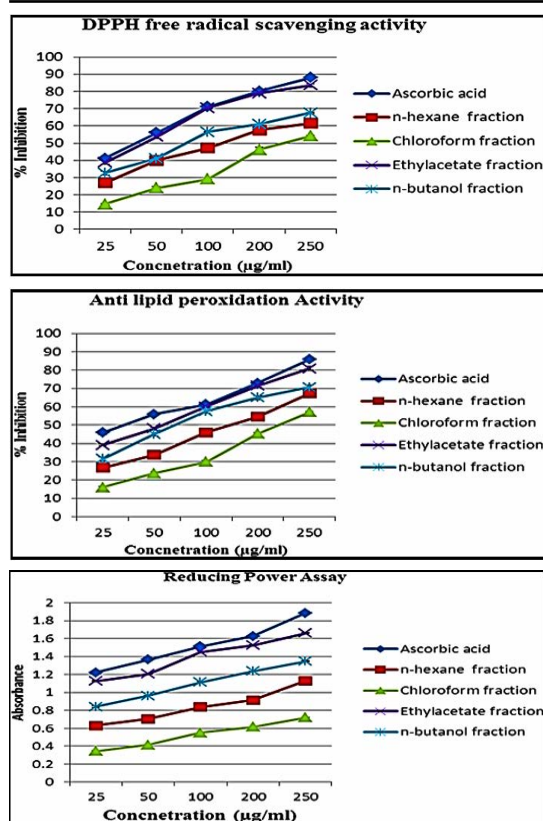
**Antioxidant property**

Chauhan *et al.*,<sup>7</sup> reported that the methanolic extract and different fractions of young shoots of

*Bambusa arundinaceae* have prominent antioxidant property. Among the tested fractions (Table 2), *n*-butanol fraction contained highest phenolic (56.6±2.4 mg gallic acid equivalent (GAE)/g DW) and ethylacetate fraction contain highest flavanoid (47±2.6 mg Quercetin equivalent/g DW) content. From the DPPH scavenging activity as shown in Fig. 8, Ethylacetate fraction displayed highest scavenging with  $IC_{50}$ =40.33±0.63  $\mu$ M, compared to ascorbic acid ( $IC_{50}$ =30.69±2.1  $\mu$ M. Also, this fraction showed superior anti-lipid peroxidation ( $IC_{50}$ = 61.89±0.44  $\mu$ M and reducing power as shown in Fig. 8.

**Table 2: Total Phenolic and Flavonoid content of different fractions of young shoots of *Bambusa arundinaceae* by Chauhan *et al.*,**

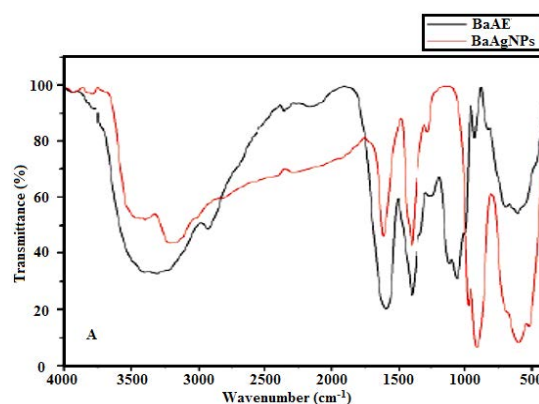
	Phenolic content mg Gallic acid equivalent/g DW	Flavonoid content mg Quercetin equivalent/g DW
<i>n</i> -hexane fraction	3.5±1.4	9.5±1.1
Chloroform fraction	10.2±1.8	8.5±0.7
Ethyl acetate fraction	30.8±1.5	47±2.6
<i>n</i> -butanol fraction	56.6±2.4	20±1.6



**Fig. 8.** DPPH free radical scavenging, antilipid peroxidation and reducing power of different fractions of young shoots of *Bambusa arundinaceae* and Ascorbic acid. Data are represented as mean ± SD (n=3).

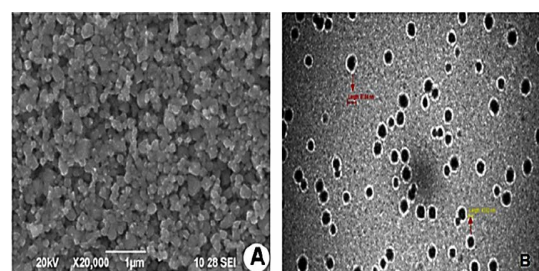
**Anticancer activity**

Kalaiarasi *et al.*,<sup>11</sup> have synthesized the silver nanoparticles (AgNPs) using *B. arundinaceae* leaf extract and screened for cytotoxicity on PC-3 (lung cancer) and Vero normal cell lines. The AgNPs were characterized by FTIR, TEM and SEM. The FTIR spectra of BaAgNPs showed intense peaks at 3396  $cm^{-1}$ , 3211  $cm^{-1}$ , 2286  $cm^{-1}$ , 1402  $cm^{-1}$  for NH stretching, S–H stretching, C=C stretching (alkenes) and C=C stretching Fig. 9.



**Fig. 9.** FT IR of AgNPs of *Bambusa arundinaceae* extract

SEM analysis confirmed the synthesis of AgNPs in the reaction mixture. SEM images of BaAgNPs is shown in Fig. 10A. The size of the synthesized AgNPs obtained ranged between 32 to 46.65 nm. TEM images for the biosynthesized AgNPs showed that the particles were spherically shaped with an average size ranging from 30 nm to 90 nm for AgNPs Fig. 10B.



**Fig. 10.** SEM (A) and TEM (B) of synthesized AgNPs of *Bambusa arundinaceae* extract

The synthesized silver nanoparticles showed  $IC_{50}$  values of the PC3 cells and Vero cells were 73.57 and 84.88  $\mu$ g/mL and 93.58 and 96.41  $\mu$ g/mL for BaAgNPs. The effect of NPs on the growth of normal cell lines (Vero) did not exhibit significant cytotoxicity at their lower concentrations (Fig. 11). The percentages of the apoptotic bodies by AO/EtBr staining were found to be 76% and 62% for BaAgNPs and BnAgNPs, respectively Fig. 12.

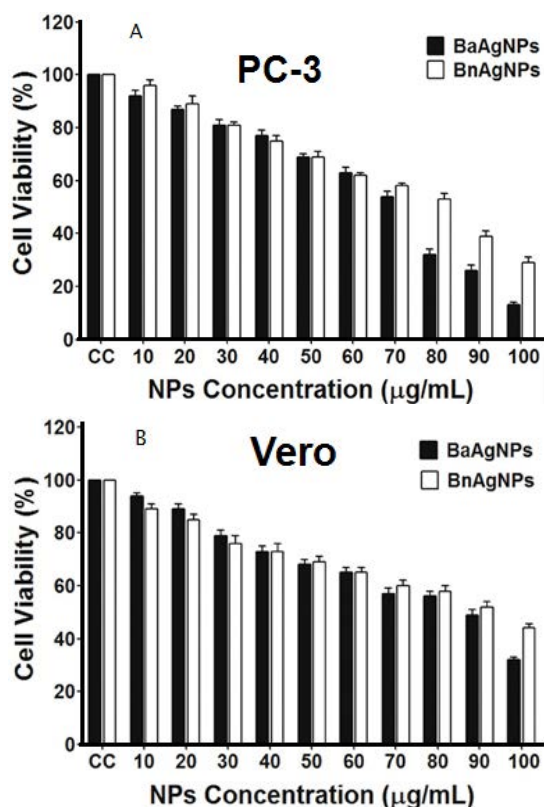


Fig. 11. Cytotoxicity of synthesized AgNPs of *Bambusa arundinaceae* extract on PC-3 and Vero cell lines

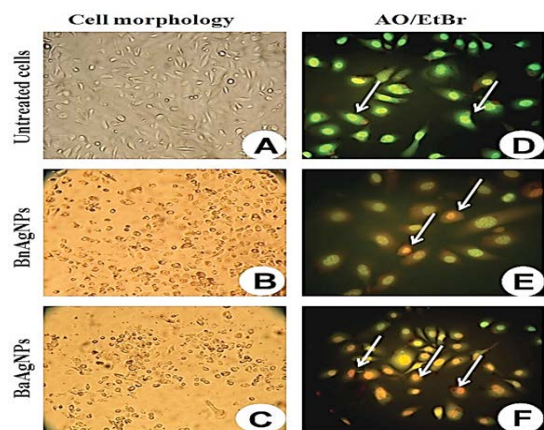


Fig. 12. Bright field and fluorescence microscopy image of IC<sub>50</sub> concentration of AgNPs and *in vitro* leaf extracts of *B. arundinaceae* and *B. nutans* applied to PC3 cell lines and incubated at 37°C with 5% CO<sub>2</sub> for 48 hour. Cytotoxicity observed from bright field microscopy: (A) untreated, (B) BnAgNP-treated, and (C) BaAgNP- treated PC3 cell lines. Fluorescence microscopy study of AO/EtBr-stained untreated control and treated PC3 cell lines, respectively. The cell lines in (D), (E), and (F) denoted by the arrows are live cells (green color), apoptotic cells (orange color), and necrotic cells (red color), respectively

Jayarambabu *et al.*,<sup>15</sup> prepared zinc oxide nanoparticles (ZnO NPs) of BA extract exhibited strong anticancer activity against MCF-7 cell line. As shown in Fig. 13 (a,b), SEM images of the obtained nanoparticles were agglomerated, and most of them are in spherical. From TEM Fig. 13 (c,d), the sizes of the particles were observed in the range of ~7-20 nm.

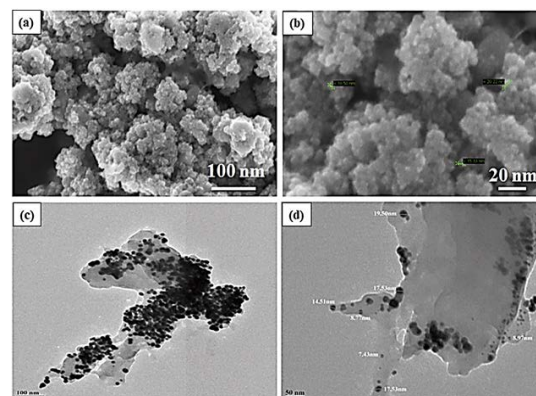


Fig. 13. FESEM images of the ZnO NPs biosynthesized with plant extract (a-b) low and high magnifications. (c-d) TEM images of ZnO NPs at different magnifications

Anticancer activity of *Bambusa arundinaceae* mediated ZnO NPs against the MCF-7 cell lines is depicted in Fig. 14. It was observed that with an increase in ZnO NPs concentration the cell viability levels decreased. These results indicate that biosynthesized ZnO NPs exhibit good anticancer activity.

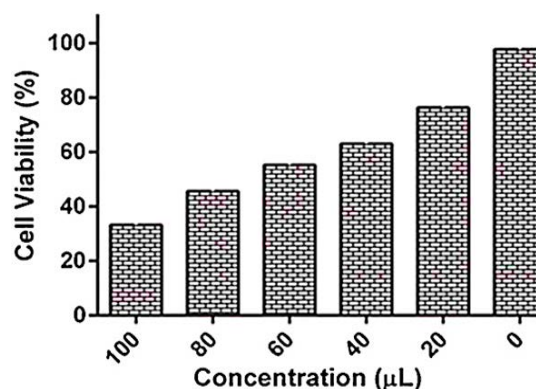


Fig. 14. Anticancer activity of *Bambusa arundinaceae* mediated ZnO NPs

### Miscellaneous

Zihad *et al.*,<sup>32</sup> carried out the laxative activity of the ethanolic extract of shoot of *B. arundinaceae* in mouse model. It was observed from Fig. 15 that the extract exhibited promising laxative potential by promoting watery faeces, increasing



gastrointestinal motility and the amount of intestinal content, when compared with a negative control. The maximum activity (47.92%) was observed at 2 h at the dose of 500 mg/kg b.w. Gastrointestinal transit at the dose of 250 and 500 mg/Kg was 67.18 and 60.03% respectively. This reports support the traditional use of shoot of *B. arundinacea* in constipation.

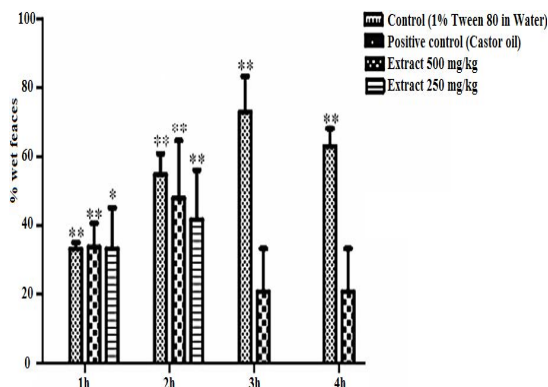


Fig. 15. Laxative activity of *Bambusa arundinacea* in mice

Patel *et al.*,<sup>19</sup> reported that zinc oxide nanoparticles (ZnO NPs) utilizing *B. arundinacea* leaf extract inhibited the formation of AGEs, decreased the level of fructosamine and formation of glycosylated Hb. The antiglycation potential of zinc oxide nanoparticles, ZnO NPs which was prepared from zinc acetate using sodium hydroxide were investigated. The synthesized ZnO nanoparticles were characterized by FTIR, and TEM analysis as shown in Fig. 16. The FT IR spectra of ZnO NPs showed a sharp and intense peak at 681 cm<sup>-1</sup> for Zn–O stretching, 1430 cm<sup>-1</sup> for C–C stretching, 1600 to 1800 cm<sup>-1</sup> for C=O, and 2854 cm<sup>-1</sup> for O–H stretching of carboxylic acid. The Result of TEM showed that ZnO NPs are spherical and some oval particles with an average size of 80 nm. The synthesized ZnO NPs were tested for degree of glycation of albumin by measuring fluorescence intensity. The increased fluorescent intensity in BSA/glucose reaction indicates the level of glycated BSA increased over a period of time. As observed from Fig. 17, ZnO-Nps showed significant inhibition on glycation reaction, compared to control. Also, ZnO NPs treated glycation of albumin and AG treated glycation of albumin showed significant inhibition of glycated albumin (43.41% and 55.19% respectively) when compared to the untreated glycated control. Moreover, these

nanoparticles inhibit the glycosylation of hemoglobin significantly when compared to the control (Fig. 18). Table 3 illustrates the preventive effect of green synthesized ZnO NPs on the formation of hemoglobin glycosylation. The study suggests biologically synthesized zinc nanoparticles showed the strong antiglycation potential and considered as a potential source of therapeutic agents for AGEs related disorder.

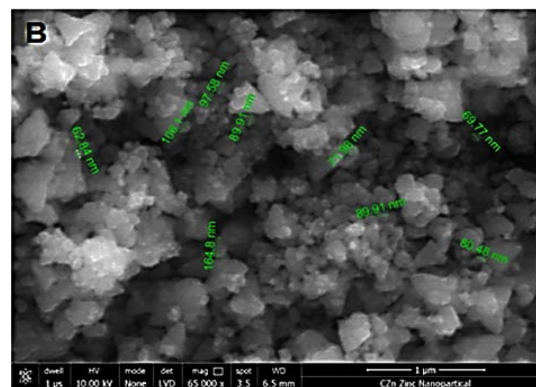
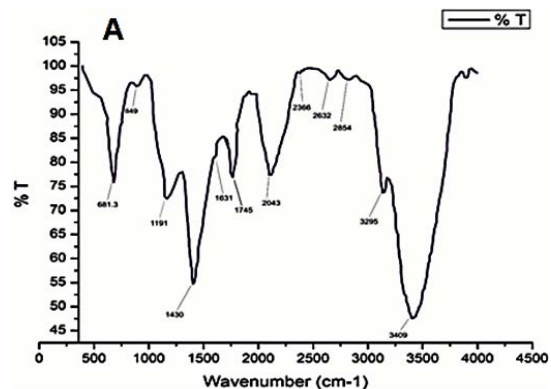


Fig. 16. (A) FT-IR spectrum of biologically synthesized ZnO NPs; (B) TEM images of ZnO NPs

Inhibit the formation of fluorescent AGEs

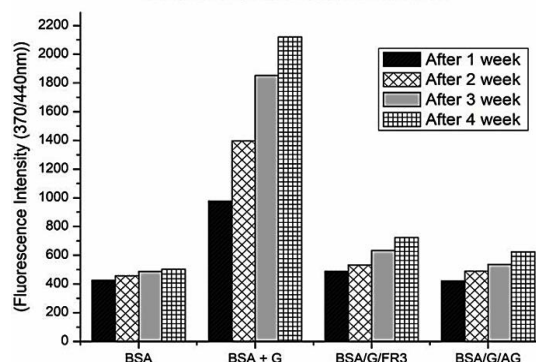


Fig. 17. Degree of glycation of albumin formed at different time interval measured relatively by measuring fluorescence intensity by using spectrofluorometry

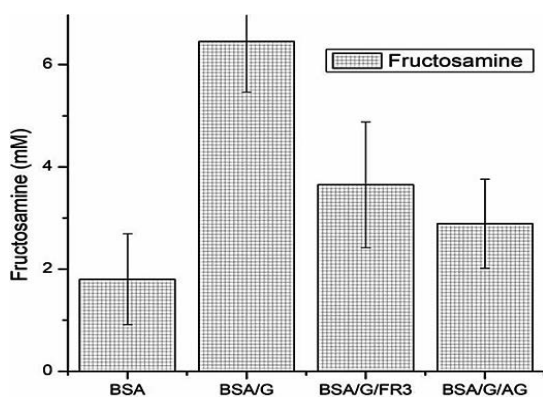


Fig. 18. Inhibitory effect of biosynthesized ZnO-NPs from bioactive fraction F3 obtained from crude *Bambusa arundinacea* leaf extract on glycosylated Hb

Table 3: Inhibitory effect of biologically synthesized ZnO NPs on the formation of glycosylated Hemoglobin expressed in percentage

No	Absorbance	Percentage of Inhibition
Control (Hb + glucose)	0.723 ± 0.051	0
In presence of ZnO NPs with Hb + glucose	0.448 ± 0.082	39.73%

### Phytochemistry

Phytochemical investigation of *B. arundinacea* Retz has afforded different type of chemical constituents (Fig. 19). Tabasheer (dried bamboo sap) is white, crystalline and sweet

siliceous matter near the shoots joint<sup>33,34</sup>. Shoot of the plant contain various substances such as ethanedioic acid, hydrogen cyanide, waxes, and benzene carboxylic acid<sup>35</sup>, feruloyl arabinose hexasaccharide and taxiphyllin (1)<sup>36</sup>. The seed of the plant contains various amino acids and other essential organic molecules such as phenylalanine, thiamine, lysine, leucine, histidine, aginine, cysteine, isoleucine, lysine, valine, methionine, tyrosine, riboflavin, niacin and thiamine. The leaves of the plant contains mainly gluteline, betain, methionine, cholin, lysine, nuclease, urease and proteolytic enzymes.<sup>37</sup>

Tanaka *et al.*,<sup>38</sup> have reported isoorientin(2), triclin glucoside(3), p-hydroxy cinnamic acid(4), lyoniresinol 3 $\alpha$ -O- $\beta$ D-glucopyranoside(5), 3, 4, 5-trimethoxyphenol- $\beta$ -D-glucopyranoside(6), koaburaside(7), 2, 6 dimethoxy-p-benzoquinone(8) and sinapic aldehyde(9) from the leaves of the plant. The plant also contains 3',3,6,7-tetramethoxy-4',5,8-trihydroxy flavones(10), p-anisidic acid(11), 4'-hydroxy 3-hydroxy flavane(12) and hemicelluloses<sup>39,40</sup>. Nazreen *et al.*, isolated 17, 20, 20-tri demethyl-20  $\alpha$ -isopranyl oleanane(13), eicosanyl dicarboxylic acid(14) stigmasterol(15), Stigmasterol glucopyranoside(16),  $\alpha$ -amyrin acetic acid(17) and ursolic glucopyranoside(18) from the chloroform fraction of this plant<sup>41</sup>.

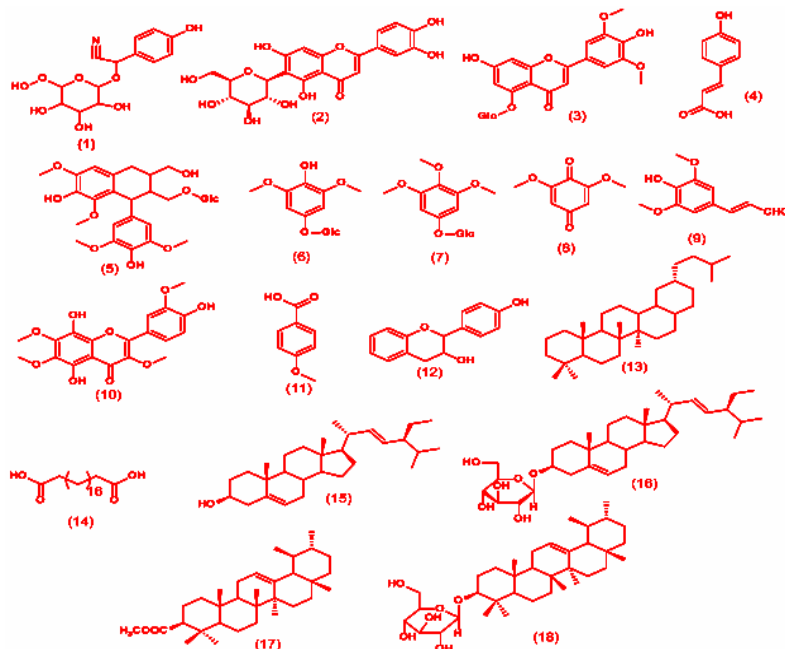


Fig. 19. Compounds isolated from *B. arundinacea*

## CONCLUSION

*Bambusa arundinacea* is endowed with important pharmacological activities such as antiinflammatory, antidiabetic, antioxidant, antimicrobial, insecticidal, antihelminthic, and anticancer. It is also rich in phenolic and flavonoid bioactive molecules. Moreover, the nanoparticles using this plant extract have shown remarkable enhancement in various biological activities. Although, this plant has not been explored much scientifically, very few reports are available on this plant. The present review

article will help the readers to explore more on this plant in various filed of nanotechnology, biotechnology and phytochemistry as it contains promising bioactive molecules.

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## Conflicts of Interest

No conflict of interest

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