XV WORLD FORESTRY CONGRESS
Building a Green, Healthy and Resilient Future with Forests
2–6 May 2022 | Coex, Seoul, Republic of Korea

Trema orientalis: A potential bioresource in Bangladesh

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Abstract

Trema orientalis L. is a fast growing tree in tropic and sub-tropic region. Traditionally, leaf, bark and root extract of *T. orientalis* is being used in therapeutic purpose in different part of the world. Leaf, root and bark extract of *T. orientalis* also shows antioxidant and antibacterial activity. *T. orientalis* bark contains 22% tannin material and suitable for leather tanning. Tannin from bark also can be used in in biobased resin preparation. Wood from *T. orientalis* had good amount of α–cellulose (45-50%) and moderate amount of (20-25%). Many researches were carried out research on *T. orientalis* pulping. In the chemical pulping processes, the pulp yield was about 50% with kappa number around 18-25. The papermaking properties of *T. orientalis* pulp were comparable to tropical hardwood pulp. Dissolving grade pulp with high purity could also be produced from this species. This species can be a good alternative for pulpwood production in tropical countries. A complete utilization of tree in biobased products development is possible through *T. orientalis*.

Keywords: *Trema orientalis*; Leaf and bark extract; Pharmacological properties; Pulping

Introduction, scope and main objectives

The forest resources in most of the developing countries are scarce, consequently development of biobased products from wood resources are therefore, challenging. Paper, a wood-based product being one of the major consumer products is constantly contributing to the decreased world forestland which has declined from 31.625% in 1990 to 30.716% in 2015 (Worldbank, 2021). In tropical regions, the widely used fast-growing hardwoods are eucalyptus, acacia, poplar and others. There are many other wood species grown locally in different regions which grow faster than the commonly used pulpwood. These faster-growing wood species are continually being investigated for pulpwood to get a higher yield as well as to minimize deforestation.

Trema orientalis is a native and underutilized fast-growing species in Bangladesh. *T. orientalis* could be mature for pulpwood within 3-4 years (Jahan and Mun 2003, 2004; Jahan et al. 2010).

The first step of wood processing for the purpose of pulpwood production is debarking. The unwanted bark in pulpwood would be a purpose of the bark biorefinery to upgrade the different constituents present in bark into multiple value-added bio-based products. Dimo et al. (2006) used aqueous stem bark extract of *T. orientalis* to lower the glucose level efficacy diabetic rats.

On the other hand, leaf littering plays an important role in nutrient cycling in forest ecosystem through the organic and inorganic nutrients present in leaf. In developing countries, the local people normally use leaves as a source of fuel. *T. orientalis* leaf is being used in different countries in traditional medicine (Adinortey et al., 2013).

Therefore, the objective of this paper is to review the published articles on traditional use of medicinal, pharmacological studies on leaf, bark of *T. orientalis* and data published on its wood pulping. This was done with a purpose of complete biorefinery exploring its biomaterials, biochemical and therapeutic potential for future research opportunities. The concept of this review is illustrated in Fig. 1.

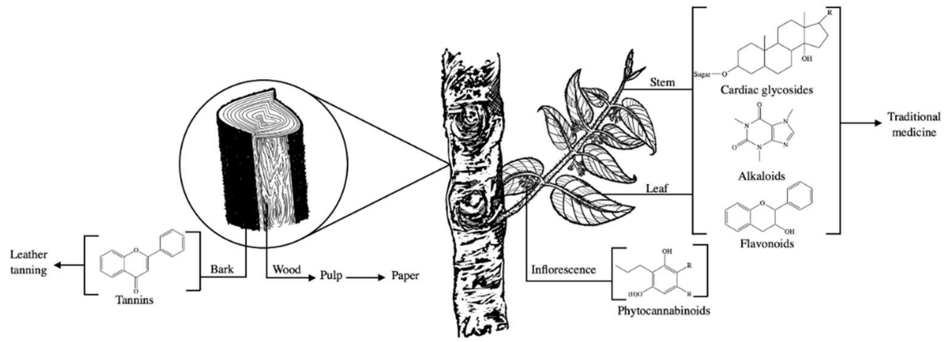

Fig. 1: *Trema orientalis* as a potential bioresource

Chemical and pharmacological properties of *T. orientalis*

T. orientalis L. has traditionally been used as a remedy against headache, pains, diarrhoea, fever and hypertension. The young leaves of *T. orientalis* are eaten as spinach by the Zulus in South Africa, who also use the roots and stem bark as traditional medicine (Coates, 1977). A mixture of *T. orientalis leaves*, *Bidens pilosa, Citrus aurantifolia*, and peels of boiled unripe pineapple are used in the treatment of jaundice (Katende, 1995). Phytochemical analysis has revealed important evaluation of the bioactive compounds present within these plants.

T. orientalis has recently been studied for its phytocannabinoid contents as well. Napiroon et al., (2021) conducted a study on some natively grown plant samples and used inflorescence fractions to quantify the cannabinoids. Along with CBN, trace amounts of THC and CBD were also found in lipophilic extracts of the plant. These extracts were also found to have antimicrobial activities against MDR bacteria at varying concentrations. Comparative studies regarding the cannabinoid content within the Bangladeshi species has yet to be explored as it is presumed that geographical factors, biotic and abiotic stressors may induce cannabinoid production within this species. The investigations provided pharmacological evidence that the use of this plant extract in traditional medicine for different disease and justified the traditional use of this plant. Despite their approved efficacy there are little scientific data available on their biological potential, need more scientific research in this area. The many pharmacological and therapeutic effects associated with this plant opens new avenues to conduct research on the isolation of the specific compounds that might be responsible for such activities.

Tannin from bark of *T. orientalis*

The bark is separated from the wood at the first step of processing of pulp from wood. Like lignin, wood bark is a by-product from the pulp industry (Consonni et al., 2009). Bark is composed of high amount of tannins materials. Chemically tannins are polyphenolic which has many industrial applications. The total annual tannin production was 200,000 MT worldwide (Pizzi, 2006). Tannins are being used in the leather industry as prime chemical from the very past for hide treatment and convert it to leather (Kemppainen et al., 2014). Tannins are used for water treatment as coagulants and flocculants (Wang et al., 2019). Because of its antioxidant properties, it is used in cosmetics and pharmaceuticals (Pizzi, 1994). Since tannins are phenolic compounds, it has potential applications as wood adhesive (Pizzi, 2006). Among the many other applications are insulating foams (Tondi et al., 2009), mineral industry, wine production industry, animal nutrition, oil industry (Pizzi, 2006) and protecting metal from corrosion (Luo et al., 2019).

The extracted tannin from the barks of *T. orientalis* had a phenolic and tannin content were 266.13 mg Gallic acid equivalent/ gm of dry extract and 30.12 % respectively (Chowdhury et al., 2021). It also exhibited excellent crosslinking capability with hide powder similar to the commercial mimosa & amp; quebracho tannins. The research results showed that the bark from *T. orientalis* a potential source of tannin for leather tanning.

Chemical, Morphological and Physical properties of *T. orientalis* wood

The chemical, morphological and physical analyses were studied in relation to its age (Jahan and Mun, 2003), sites and stem and branch (Jahan et al., 2010). The α-cellulose content in *T. orientalis* was varied from 43 to 45% for stem and 41 to 43% for brunch (Jahan et al., 2010) and also it is higher than that in *Acacia auriculiformis* (Haque et al., 2019). The average Klason lignin content in *T. orientalis* was 24%, which is very close to that obtained by Ku et al., (1987). The pentosan content in *T. orientalis* is about 21-24% depending on site, stem and branch. The α-cellulose, total lignin and holocellulose content in *T. orientalis* increased from pith to bark (Jahan and Mun, 2003).

Fiber length influences the paper strength, particularly, tear and paper machine runability. The fiber length of *T. orientalis* was varied from 0.83 to 1.34 mm for stem and from 0.73 to1.0 mm for stem (Jahan et al., 2010), which was in the range of tropical hardwoods (0.7-1.5 mm).

Pulping

Paper grade pulp

A paper grade bleached pulp with a final yield of 46.0-49.8% was obtained from *T. orientalis* by sulfate process (Bhat and Jaspal, 1953). Bhat and Singh (1954) studied *T. orientalis* as a promising raw material for high yield pulp. Chung et al. (1966) investigated four semi-chemical pulping processes, that included compounds such as, neutral Na-sulfite, cold soda, sulfate, and soda. Cold soda pulp had the highest yield and lowest cost.

Witayapanyanonta et al. (1973) had studied the kraft pulping and bleaching of *T. orientalis* that was found to yield 52.9% pulp which was further bleached by the CEH sequence that resulted in a yield of 93.9%. Although the *T. orientalis* pulp showed deficient tearing resistance due to the short fibre length of the pulps, the pulp showed acceptable strength properties for wrapping paper.

Jahan and Mun (2004) investigated the effect of maturity age of *T. orientalis* for pulping in the Soda-AQ process. *T. orientalis* gets well maturity as early as 3 years with the ability of producing a pulp yield of 48.9% with the kappa number of 21 under the conditions of 17% alkali charge, 120 min of cooking at 170^{o}C. Authors extensively studied the *T. orientalis* in the means to explore this highly potential fast growing wood species in the pulp industry. In the kraft process at the same condition of Soda-AQ process, the pulp yield was 47% with the kappa number of 20.1 (Jahan et al., 2008). In the alkaline-sulfite-anthraquinone-methanol (ASAM) process, the pulp yield was highest (51.7 %) with the lowest kappa number (13.4) under the conditions of 17% alkali charge at 180 ^{o}C for 120 min of cooking (Jahan et al., 2007). Not only the pulping processes but also the geographic location, and trunk and branch of *T. orientalis* were also investigated separately (Jahan et al., 2010). Effect of geographic location was least, however, the trunk produced better pulp than brunch. It can be said that *T. orientalis* can be an important pulpwood in tropical region. Pulping and papermaking properties of *T. orientalis* and *A. auriculiformis* are shown in Table 1.

Table 1. Comparison of *T. orientalis* and *Acacia auriculiformis* pulps

Wood species	Pulp yield (%)	Kappa number	^{0}SR	Tensile index (N.m/g)	Tear index (mN.m^2/g)	Ref
T. orientalis	50.0	21.0	30	58.8	7.6	Jahan and Mun 2004
Acacia auriculiformis	44.3	19.5	43	82.61	6.23	Haque et al. 2019

Dissolving pulp

Dissolving pulp is used for the production of regenerated cellulose and cellulose derivatives. The global demand of dissolving pulp has been increasing day by day. It has been projected that the dissolving pulp consumption will increase to 19.0 million tons by 2030 (Shen and Patel, 2010). The promising underutilized *T. orientalis* was studied for producing rayon grade pulp for the first-time using magnesium and calcium-based sulfite pulping processes. Dissolving pulp is typically produced by the pre-hydrolysis kraft (PHK) and acid sulfite (AS) pulping processes from wood. However, Jahan et al. (2007) produced dissolving pulp from *T. orientalis* by formic acid pulping process which yielded greater than 94 % α-cellulose. *T. orientalis* was investigated for dissolving pulp production by acid prehydrolysis followed by kraft (PHK) and soda-ethylenediamine pulping process as well (Jahan et al., 2008). The PHK process provided comparatively better-quality dissolving pulp with α-cellulose content of 91% with 0.25% H_2SO_4 pre-treatment for 1 hr followed by 18% active alkali with 25% sulfidity cooking for 1 hr at 170 °C. *T. orientalis*, thus can be considered a suitable raw material for dissolving pulp production as it is flexible in different processes.

Biorefinery

A biorefinery initiative was carried out by Jahan et al. (2011) on the pre-extraction of *T. orientalis* prior to producing paper grade pulp. The pre-extracted liquor (PHL) obtained by treatment at 150°C for 1 hour contained sugars (3.5%), lignin (1.9%) and acetic acid (1.9%). This followed by kraft pulping showed almost similar pulp yield, bleachability and papermaking properties with non-extracted *T. orientalis*. However, the amount of extracted biomass increased with increasing the pre-treatment temperature and time produced inferior quality of pulp in terms of yield and papermaking properties. The authors therefore, recommended pre-extraction at 170 °C for 1.5 hours for dissolving pulp production along with the utilization of pre-hydrolysis liquor for biofuel, biochemical and biomaterials (Jahan et al., 2008). A biorefinery concept based on the sodium carbonate pre-extraction of *T. orientalis* prior to pulping was studied by Jahan et al. (2015). The alkaline pre-extraction had a beneficial effect on delignification in the subsequent soda-AQ-pulping. In addition, the alkaline pre-extraction improved the pulp bleachability.

Conclusion

T. orientalis is a potential resource for green products, where all fractions like leaf, bark and wood would be efficiently utilized. The leaf and bark extracts of *T. orientalis* has beneficial therapeutic properties and has been used as herbal medicine in different countries. *T. orientalis* bark contains good amount of tannin and suitable for leather tanning.

T. orientalis is one of the fastest growing species, with acceptable chemical compositions and morphological properties to be used as the raw material for pulping. Pulping and papermaking properties are comparable to other hardwood species.

References

Adinortey MB, Galyuon IK, Asamoah NO. 2013. Trema orientalis Linn. Blume: A potential for prospecting for drugs for various uses. Pharmacogn Rev. 7: 67-72.

Bhat, R. V., Jaspal, N. S., 1953. Indigenous cellulosic raw materials for the production of pulp, paper and board. Part XIII. Chemical pulps and writing and printing papers from Trema orientalis, Blume. Indian For. 79, 69-76.

Bhat RV, Singh MM. 1954. Indigenous Cellulosic Raw Materials for the Production of Pulp, Paper and Board. Part XXII-Wrapping Papers from Trema orientalis Blume. Indian For. 80: 453-465.

Chowdhury MJ, Razzaq MA, Md Biswas I, Quadery AH, Md Uddin T. 2021. Extracts of Trema Orientalis (L.) Stem Bark: A Potential Source of Environmentally Friendly tanning Agent for Leather industry. The Journal of the American Leather Chemists Association, Accepted.

Chung CS, Chieh LS. 1966. Comparisons of four semichemical processes on Taiwan hardwood pulping. Taiwan sheng Linye Shiyanso Baogao. 135: 11.

Consonni S, Katofsky RE, Larson ED. 2009. A gasification based biorefinery for pulp and paper industry. Chem. Eng. Res. Des. 87:1293–1317

Dimo T, Ngueguim FT, Kamtchouing P, Dongo E, Tan PV. 2006. Glucose lowering efficacy of the aqueous stem bark extract of Trema orientalis (Linn) Blume in normal and streptozotocin diabetic rats. Die Pharmazie: An International Journal of Pharmaceutical Sciences. 61: 233-236.

Haque MM, Aziz MI, Hossain MS, Quaiyyum MA, Alam MZ, Jahan M.S. 2019. Pulping of hybrid acacia planted in a social forestry program in Bangladesh. Cellul. Chem. Technol. 53: 739-745.

Jahan MS, Mun SP. 2003. Characterization of Nalita Wood (*Trema orientalis*) as a Source of Fiber for Papermaking (Part I): Anatomical, morphological and chemical properties. Journal of Korea Tappi. 35: 72-79.

Jahan MS, Mun SP. 2004. Effect of tree age on the soda-anthraquinone pulping of Nalita wood (Trema orientalis). Korean J. Ind. Engg. Chem. 10: 766-771.
Jahan MS, Rubaiyat A, Sabina R. 2007. Evaluation of cooking processes for *Trema orientalis* pulping. J. Sci. Ind. Res. 66: 853-859.
Jahan MS, Ahsan L, Noori A, Quaiyyum MA, 2008. Process for the production of dissolving pulp from *Trema orientalis* (Nalita) by prehydrolysis kraft and soda-ethylenediamine (EDA) process. BioRes. 3: 816-828.
Jahan MS, Chowdhury DAN, Ni Y. 2010. Effect of different locations on the morphological, chemical, pulping and papermaking properties of *Trema orientalis* (Nalita). Bioresour. Technol. 101: 1892-1898.
Jahan MS, Rahman M, Nuruddin M, Haque SA, Chowdhury A. 2011. Effect of pre-extraction on the pulping and paper making properties of short rotation *Trema orientalis*. Indian J. Ecol. 38: 35-40.
Jahan MS, Sarkar M, Rahman MM. 2015. Sodium carbonate pre-extraction of *Trema orientalis* in the production of paper grade pulp. Drewno. 58: 69-78.
Katende AB, Birnie A, Tengnäs BO. 1995. Useful trees and shrubs for Uganda: identification, propagation, and management for agricultural and pastoral communities (No. 10), Regional Soil Conservation Unit, Nairobi, Kenya.
Luo X, Bai R, Zhen D, Yang Z, Huang D, Mao H, Li X, Zou H, Xiang Y, Liu K, Wen Z. 2019. Response surface optimization of the enzyme-based ultrasound-assisted extraction of acorn tannins and their corrosion inhibition properties. Ind. Crops Prod. 129: 405-413.
Napiroon T, Tanruean K, Poolprasert P, Bacher M, Balslev, H, Poopath M, Santimaleeworagun W. 2021. Cannabinoids from inflorescences fractions of Trema orientalis (L.) Blume (Cannabaceae) against human pathogenic bacteria. Peer J, 9: e11446.
Pizzi A. 2006. Recent developments in eco-efficient bio-based adhesives for wood bonding: opportunities and issues. J. Adhes. Sci. Technol. 20: 829-846
Pizzi. A. 1994. Advance Wood Adhesives Technology. New York: Marcel Dekker.
Tondi G, Zhao W, Pizzi A, Du G, Fierro V, Celzard A. 2009. Tannin-based rigid foams: a survey of chemical and physical properties. Bioresour. Technol. 100: 5162-5169.
Wang G, Chen Y, Xu G, Pei Y. 2019. Effective removing of methylene blue from aqueous solution by tannins immobilized on cellulose microfibers. Int. J. Biol. Macromol. 129: 198-206.
Witayapanyanonta B, Tamolang FrN. 1973. Pulp and papermaking qualities of anabiong *Trema orientalis*. Araneta Research Journal. 20: 239-57.