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Application of Soda Anthraquinone Pulping to Sudanese *Albizia amara* (Arad) Wood

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Abstract: This study was carried out to determine the applicability of soda and soda anthraquinone cooking method for *Albizia amara* (Arad) wood (branches) to add new value of this tree in addition as source of traditional medicines. Most of the applied methods were done according to Technical Association of Pulp and Paper (TAPPI standards). The chemical composition of the wood reflected high amount of cellulose (51.6%), lignin (26%), with low amounts of extractives. The fiber properties of *Albizia amara* (Arad) wood resemble most of tropical hardwood trees, fire length was 0.915 mm, fiber diameter 40.2 µm and lumen diameter 23.5 µm. Soda with anthraquinone methods produced pulp with higher screened yield and paper properties.

Key words: *Albizia amara* (Arad) · Chemical Constituents · Fiber Dimensions · Soda Cooking · Pulp Properties

INTRODUCTION

Albizia amara (Arad) belongs to *Fabaceae* family, occur in the whole world except in north and south poles, in Africa, distributed in Sudan, Ethiopia, Zimbabwe, Botswana and the Shetu [1], Khuddus *et al*. [2], Abdel Karim *et al*., [3], Abdurrahman *et al*. [4] and Rajkumar and Sinha [5]. The different parts of *Albizia amara* widely used for treatments of different diseases and aliments in local communities such as coughs [2] piles and diarrhea [3-6] bone fracture [4], hair fall, dandruff and cools the body [7] skin diseases and poisonous bites [8] asthma, arthritis, antiseptic, burns, antidysentric and allergic rhinitis [9] boils, eruptions, swellings, emetic, coughs and ulcer [10] malaria [11] vomiting and wounds [12] pneumonia [13]. Trypanosoma *brucei rhodesiense* [14] breast cancer [15] Cervical cancer [16].

The general features of *Albizia amara* is tree of 1.5-1.8 m long, branched deciduous, non-climbing, drought tolerant tree with dark brown green, smooth and scaly bark (Figure 1) [17-22]. Wood of *Albizia amara* is utilized in building, furniture, firewood and production of charcoal especially in remote areas [23, 24].

Fig. 1: General features *Albizia amara* tree

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The production of high alpha cellulose had been studied by Guha and coworkers to produce viscose rayon and nitrocellulose [25]. It seemed more research done on pulping of *Albizia lebbeck* and take more attention compared to *Albizia amara*. However soda and soda anthraquinone pulping looks the suitable method for production of pulp and paper from tropical hardwood trees.

The objective of the current study is to investigate the suitability of *Albizia amara* stems for pulping with soda and soda anthraquine methods and this include determination of chemical components and fiber morphology.

MATERIALS AND METHODS

About fifteen branches of *Albizia amara* were felled and collected from forest near Aljonina city in western part of Sudan in October 2018. The area is characterized with mud sandy soil, depending on annual rains ranges between 200-800 mm. The branches were cut into discs packaged in plastic bags and transported to Khartoum in central Sudan by bus stored in National Centre of Research for further treatments according to TAPPI standards 2000 [26]. Other parts of the tree such as leaves, flowers and fruits with photos were brought for identification in Medicinal and Aromatics Plants Research institute (National Centre for Research).

Fiber dimension evaluation was done accordingly, maceration with a mixture of 30% hydrogen peroxide and acetic acid (1:1), measured microscopically at 300x and 400x magnifications of 40 fibers after staining with aqueous safranin according to (TAPPI-232cm-01), morphological indices were calculated.

Table 1: Pulping Conditions of *Albizia amara* (Arad) wood

Cooking conditions	Soda	Soda	Soda-AQ
Cooking code	Al1	Al2	Al3
Active alkali charge as NaOH %	15	17	15
Anthraquinone, %	0	0	0.05
Liquor to *Albizia amara* (Arad) wood. ratio 4 4 4 Maximum temperature, °C	170	170	170
Time to maximum temperature, min	60	60	60
Time at maximum temperature, min	90	90	90

Most of cooking parameters were kept constant except the active alkali charge as NaOH and addition of anthraquinone in very small amount as 0.05% of oven dry wood.

Two kilograms of chips were grinded in star mill for chemical analysis, passed through mesh fraction of 40X60 and used for determination of chemical constituents of wood. The preparation was done according to (TAPPI-264-cm-97), testing for moisture (TAPPI-210cm-93), cellulose Kurshner and Hoffer method, according to Obolenskaya *et al.* [27], lignin (TAPPI-222), hot water soluble (TAPPI-T- 207), 1% NaOH (T 212 om-98), solvent extractives (TAPPI 204 cm-97) and ash (TAPPI-212).

The cooking conditions and pulping parameters were controlled as mentioned in Table 1. Most the authors agreed these conditions after reviewing the chemical components of *Albizia amara* wood, the decided final products, availability of chemicals and apparatus s well as the tropical hardwood pulping conditions. Figure 2 showed the branches of *Albizia amara* and the soda - AQ pulps.

The studied pulps were washed after cooking to remove the dirt, residual lignin in form of black liquor, after screening, the reject were determined as well as screened yield on oven dry basis, disintegrator was used to separate the fibers at 1200 rpm for 30 min. the

Fig. 2: a/ Felled branches of *Albizia amara* b/ pulps produced from *Albizia amara* wood.

pulps of the three trials were treated with Valley beater at intervals zero, 5 and 10 min to investigate the quality of beating on studied pulps, according to (TAPPI200-sp-01). Physical testing of pulp sheets (TAPPI-220-sp-01), conditioning of testing atmosphere (TAPPI-402-sp-98), apparent density (TAPPI T 410 om-98), burst strength (TAPPI403om-97), tensile and breaking length (TAPP-404-cm-92). The Kappa number was determined according to (TAPPI-236 om-99). The statistical analysis used was ANOVA.

RESULTS AND DISCUSSION

Although the fiber length of *Albizia amara* (Arad) wood was less than one millimeter equal to 0.915 mm (Table 2) which typical to tropical hardwood trees, the fiber seemed flexible reflected with comparatively wide fiber diameter (40.2 µm) lumen diameter (23.5 µm) and relatively thin wall (8.5 µm), this supported further by morphological indices where the Runkel ratio was less than one unit (0.72), flexibility coefficient 58.46% and slenderness ratio was 22.76%, from mentioned readings the fiber expected to collapse easily during beating and produce pulp with acceptable strength properties as shown in Table 2.

The chemical constituents of *Albizia amara* wood (Table 3) revealed that high percentage of lignin and cellulose as Kurchner-Hoffer and were 26% and 51.6% respectively with low amount of extractives thus hot water extractives were 1.6%, cold water, 3.0% with negligible amount of ethanol cyclohexane extractives with normal amount of ash as recorded for tropical hardwood trees especially of fast growing ones, indicating normal cooking conditions.

The cooking results of *Albizia amara* chips, indicating the superiority of soda -AQ pulping compared to soda pulping as appeared in Figure 3. When reducing the chemical as NaOH, by 2% compared to soda pulp cooked with 17%, the soda -AQ cooked with 15% gave higher screened yield, higher total yield and lower percentage of rejects at more or less similar Kappa number. On the other hand when increasing the soda to 17% and compared to soda 15%, the screened yield increased with decreased rejects at more or less Kappa number. From the mentioned results it seemed the increase of chemical as NaOH will not potentially improve the pulping properties as addition of AQ even in small amounts as 0.05 on oven dry wood, with keeping the percentage of NaOH constant.

Table 2: Fiber dimensions and morphological indices of *Albizia amara* (Arad) wood

Hardwood	*Albizia amara* (Arad) wood
Fiber dimension	
Average fiber length, mm	0.915±0.14
Average fiber diameter, µm	40.2±0.76
Average lumen diameter, µm	23.5±0.46
Average wall thickness, µm	8.5±0.44
Morphological indices	
Runkel ratio	0.72
Flexibility coefficient, %	58.46
Wall fraction, %	21.14
Felting power (slenderness ratio)	22.76

Table 3: Chemical components of *Albizia amara* (Arad) wood

Chemical composition, %	*Albizia amara* (Arad) wood
Ash	1±0.08
Solubility in	
Hot water	1.6 ±0.23
Cold water	3.0±0.33
Ethanol: Cyclohexane (1:2)	0.2±0.12
1% NaOH	16.5±0.32
Kurchner-Hoffer cellulose	51.6±0.22
Lignin	26.0±0.35
Total extractives	5.51 N/A
Cellulose to lignin ratio	1.98 N/A

N/A= Not available

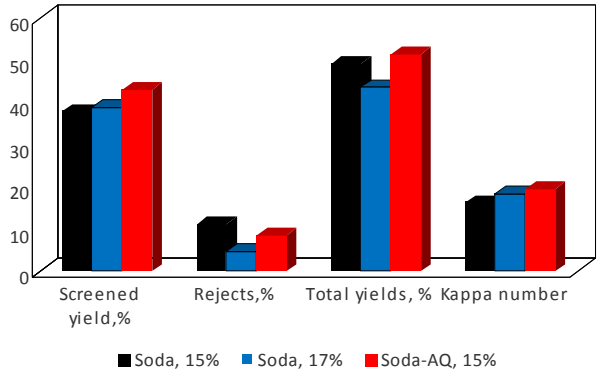

Fig. 3: Screened yield, rejects and total yield of *Albizia amara* (Arad) pulps under different chemical charge as NaOH

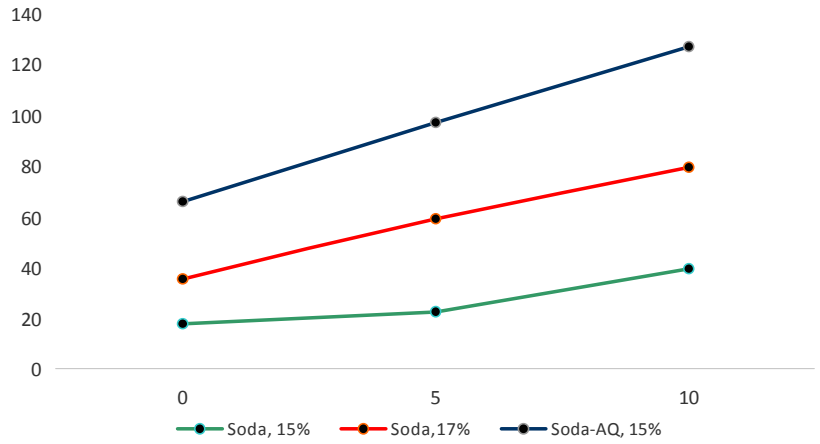

Fig. 4: Tensile index, (Nmg^{-1}) vs. beating time (min) of unbleached *Albizia amara* (Arad) pulps

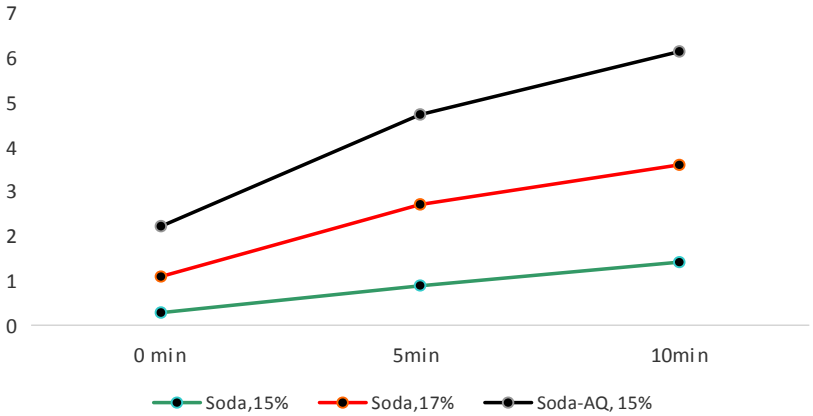

Fig. 5: Burst index, (K Pa m^2 g^{-1}) vs. beating time (min) of unbleached *Albizia amara* (Arad) pulps

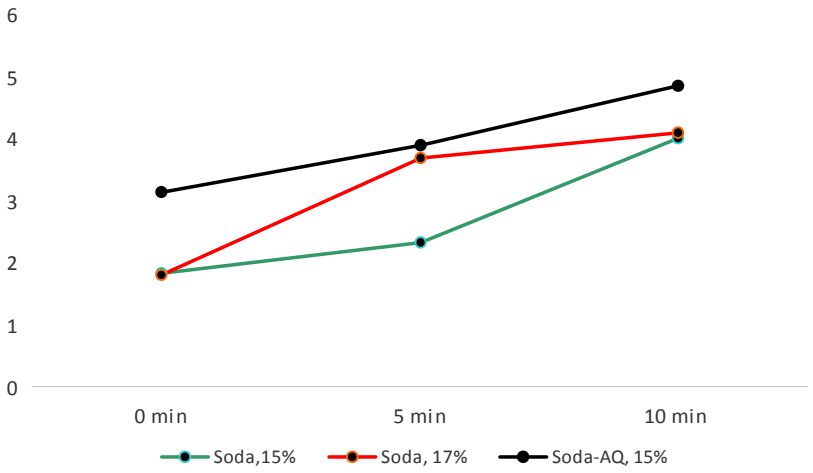

Fig. 6: Breaking length, (Km) vs. beating time (min) of unbleached *Albizia amara* (Arad) pulps

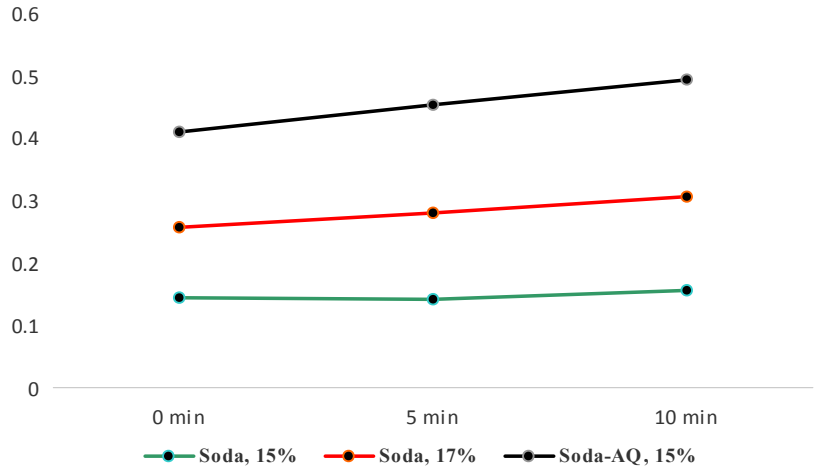

Fig. 7: Apparent density, (g cm^{-3}) vs. beating time (min) of unbleached *Albizia amara* (Arad) pulps

Fig. 8: Prepared hand sheet from pulp of *Albizia amara* (Arad) pulps for physical properties evaluation

The physical pulp properties for soda and Soda-AQ for *Albizia amara* wood are reflected in Figures 4-7. The superiority of Soda-AQ pulps was obvious compared to soda pulps supported literature results [28-32] in tensile index (Figure 4), burst index (Figure 5), breaking length (Figure 6) and apparent density (Figure 7).

It appeared that due to the low amount of extractives in *Albizia amara* (Arad), produced pulps with light color for all soda and soda-AQ sheets, although of relatively high Kappa number produced (residual lignin),as shown in Figure 8.

CONCLUSION

The plantation of *Albizia amara* (Arad) in different areas especially in Sudan is attractive idea, thus the multiple uses of this tree as source of medicinal plant and production of fire wood may activated by production of pulp and paper of the pruned branches of this tree specifically in rural areas which will improve the economic conditions. The application of soda-AQ method to produce pulp of *Albizia amara* (Arad) wood will be smart opinion where the screened and total yields gave high percentages compared to soda pulping methods at the same Kappa number. The chemical constituents and fiber properties were at the range of tropical hardwoods.

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REFERENCES

1. Shetu, H.J., 2015. Phytochemical and Biological Evaluation of *Albizia richadiana* (Benth. *Fabaceae* family). A project ID 11346001 BRAC University Dhaka, Bangladesh.

2. Khuddus, G.A., S. Angothu, A. Mallam and S. Gurajala, 2013. Hypolipidemic Activity of *Albizia amara* (Roxb.) Boiv. (*Fabaceae*) Bark. International Journal of Phytopharmacology 4(1): 8-11.
3. Abdel Karim, M., S. Mongid and M.O. Mohamed, 2016. Isolation, Characterization and Antimicrobial Activity of a Flavanone from Sudanse *Albizia amara* (*Fabaceae*) leaves. Int. J. Adv. Res., 4(8): 1799-1805.
4. Abdurrahman, I., I. Omer, Y. Cai-Xia and H. Yu-Lai, 2017. Two New Phthalate Derivatives from Bark of *Albizia amara* (*Fabaceae*). Int. J. Pharm. Sci. Rev. Res., 42(1): 103-106.
5. Rajkumar, T. and B.N. Sinha, 2010. Chromatographic finger print analysis of budmunchiamines in *Albizia amara* by HPTLC technique. Int. J. Res. Pharm. Sci., 1(3): 313-316.
6. Karuppannan, K.A., D. Subramanian and S. Venygopal, 2014. Antioxidant, antibacterial and GC-MS analysis of *Albizia amara* leaves and seed extracts - A comparison. Indo American of Pharmaceutical Research, 4(4): 1928-1939.
7. Nivetha S., S. Padmini and S. Tamilselvi, 2017. A Review on Phytopharmacological Properties of Arappu. Int. Res. J. Pharm., 8(11): 28-32.
8. Indravathi, G. Sreekanth, R. Reddy and R.S. Babu, 2014. *Albizia amara* - A Potential Medicinal Plant: A Review. International Journal of Science and Research, 5(3): 621-627.
9. Kokila, K., S.D. Priyadharshini and V. Sujatha, 2013. Phytopharmacological Properties *Albizia* species: A review. International Journal of Pharmacy and Pharmaceutical Sciences, 5(3): 70-73.
10. Shubha, G., B. Govindaraju, N.D. Satyanarayan and K.S. Manjunatha, 2014. Antibacterial Activity of Different Solvents Extracts of *Albizia amara*. Indian J. Sci. Res., 5(2): 9-12.
11. Muthaura, C.N., G.M. Rukunga, S.C. Chhabara, G.M. Mungai and E.N.M. Njagi, 2007. Traditional Phototherapy of some Remedies Used in Treatment of Malaria in Meru District of Kenya. South African Journal of Botany, 73: 402-411.
12. Abdel Karim, M. and S. Munjed, 2016. Physiochemical Characterization and Biological Activity of a Dihydroflavonol from Sudanese *Albizia amara* (Roxb.)B. Biovin Leaves. Int. J. Adv. Res., 4(9): 1741-1746.
13. Karuppannan, K., S.D. Priyadharshini and V. Sujatha, 2014. Antioxidant, Antibacterial and GC-MS Analysis of *Albizia amara* Leaves and Seed Extracts - A Comparison. Indo American Journal of Pharmaceutical Research, 4:4(04): 1928-1939.
14. Abdalla, M.A. and H. Laatsch, 2012. Flavonoids from Sudanese *Albizia zygia* (Leguminosae, Subfamily Mimosoideae), a plant with Antibacterial Potency. Afr. J. Tradit. Complement Altern. Med., 9(1): 56-58.
15. Gopinath, P., S. D. Vadivel, S. Kamatchiammal and V. Saroja, 2013. Anti-Cancerous Activity of *Albizia amara* (Roxb.) Boivin using Human Breast Cancer Cells (MCF-7) by In Vitro Methods. International Journal of Pharma. Research & Review, 2(8): 23-32.
16. Balasubramani, G., R. Ramkumar, R.K. Raja, D. Aiswarya, C. Rajthilak and P. Perumal, 2016. *Albizia amara* Roxb. Mediated Gold Nanoparticles and Evaluation of Their Antioxidant, Antibacterial and Cytotoxic Properties. J. Clust. Sci. DOI 10.1007/s10876-016-1085-9
17. Tamilselvi, S., T. Dharani, S. Padmini, S. Nivetha, M. Sangeetha, Arunava Das and R. Balakrishnaraja, 2018. Gc-Ms Analysis of *Albizia amara* and Phyla Nodiflora Ethanolic Leaf Extracts. International Journal of Recent Technology and Engineering, 7(4): 466-473.
18. Banerjee, A.K., 1989. Shrubs in Tropical Forest Ecosystems Examples from India. World Bank Technical Paper, 103: 132.
19. Smith, R.L. and C.J. Payne, 2017. Consumption of the bark of *Albizia niopoides* (Mimosaceae) by Sapajus cay Illiger, 1815 (Cebidae: Primates) in the Atlantic Forest fragment of Rancho Laguna Blanca in Eastern Parag Mammalogy Notes, 4(1): 17-20.
20. Orwa, C., A. Mutua, R. Kindt, R. Jamnadass and S. Anthony, 2009. Agroforestry tree Database: a tree reference and selection guide version 4.0. World Agroforestry Centre, Kenya.
21. Baltazary, G. and C.M. Nshimo, 2010. *In vitro* antimicrobial activity of *Albizia amara* leaves from Lindi region, Tanzania. TaJONAS, 1(1): 35-42.
22. Nawinda, T., 2016. Antibacterial, Antioxidant and Phytochemical investigation of *Albizia anthelmintica* leaves, Root and Stem Bar. Master thesis in Industrial Biochemistry, University of Namibia.
23. Heuzé, V., H. Thiollet, G. Tran and F. Lebas, 2016. Albizia (*Albizia amara*). Feedipedia, a programme by INRA, CIRAD, AFZ and FAO. https://www.feedipedia.org/node/337

24. Cox, Arthur, F., 1895. Madras District Manuals: North Arcot (North Arcot District Gazetteer). Madras: Government Press, pp: 25.
25. Guha, S.R.D., M.M. Singh and P.P. Bhola, 1976. Production of High Alpha Cellulose Pulp from *Albizia amara*, *Acacia planifrons* and Mixture of Hardwoods. Indian Forester, 102(3): 191-196.
26. TAPP1, 2002. Standards and suggested methods. TAPPI, New York
27. Obolenskaya, A.V.V.P., G.I. Tshegolov, N.C. Akim, N.L. Kossoviz and I.Z. Emelyannova, 1965. Practitcheshie Raboti po Himii Drevesinii Tzellulozi. Moscow, Lesporm. (In Russian) https://www.bloomberg.com
28. Khider, T.O., S. Omer and O. Taha, 2012. Alkaline pulping of *Typha domingensis* from Sudan. World Applied Sciences Journal, 16(3): 331-336.
29. Tarig Osman Khider, Safaa Omer, Osman Taha and Suhair Kamal Shomeina, 2012. Suitability of Sudanese Cotton Stalks for Alkaline Pulping with Additives. Iranica Journal of Energy & Environment, 3(2): 167-172.
30. Tarig Osman Khider, Safaa Hassan Omer and Osman Taha Elzaki, 2012. Pulping and Totally Chlorine Free (TCF) Bleaching of *Acacia mellifera* from Sudan. World Applied Sciences Journal, 16(9): 1256-1261.
31. Osman Taha Elzaki, Tarig Osman Khider and Safaa Hassan Omer, 2012. Pulp and papermaking characteristics of *Cajanus Cajan* from Sudan. American-Eurasian Journal of Agricultural and Environmental Science, 12(2): 159-163.
32. Khider, T.O., S. Omer and O. Taha, 2011. Alkaline Pulping with Additives of Southern Cattail Stems from Sudan. World Applied Sciences Journal, 15(10): 1449-1453.