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CHARACTERIZATION OF A.SEYAL VAR. SEYAL DEL. (TALH) AS A RAW MATERIAL FOR PULP PRODUCTION

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ABSTRACT

In this study the morphological properties and chemical composition of A.seyal were determined and compared to other wood and non-wood materials, commonly used for pulp production, with the aim of assessing its potentials as a suitable raw material for pulp and paper production. Fiber length, Fiber width, lumen width and cell wall thickness of A.seyal were measured as 1.20 mm, 19.0µm, 13.8µm and 2.5µm, respectively. The value of Runkel ratio (0.91) was within the acceptable values (<1) suitable for pulp and paper production. Fiber of A.seyal gave flexibility coefficient of 52.39 %, which classified them as elastic fibber and within the acceptable values for pulp production. Slenderness and rigidity values for A.seyal were calculated as, 122.8 and 0.47, respectively. The chemical analysis of A.seyal revealed the holocellulose as 76.8%, α-cellulose 47.25%, lignin 20.32%, and ash 1.80%. Based on the analysis of the morphological and chemical characteristics of A.seyal the fibbers of this species could be considered as suitable for pulp and paper production in Sudan.

Keywords: A.seyal, fiber morphology, chemical composition, pulp.

INTRODUCTION

Wood is a highly variable and complex material with different anatomical, physical and chemical properties. A good understanding of the characteristics of wood is a key in evaluating its suitability for a particular end use. The fiber characteristics and chemical composition of wood are important parameters in evaluating its suitability for pulp and paper production (Riki *et al.,* 2019). The holocellulose, α-cellulose and lignin contents are mainly related to pulping behavior (Panshin and de Zeeuw 1980). Fibers morphology and their derived indices are fundamental factors of influence in estimating pulp quality of any fiber material (Dinwoodie 1965; Amidon, 1981; Ogunwusi, 2001). Fiber length is one of the quality parameters for pulpwood (Hudson *et al.,* 1995; Wimmer, et al.2002). Long fiber lengths are preferable for manufacture of paper (Dutt and Tyagi 2011). Fiber length generally influences the tearing strength of paper, the greater the fiber length, the higher will be the tearing resistance of paper (Fardim and Duran, 2004; Oluwadare and Ashimiyu 2007).The Runkel ratio is a primary parameter in assessing the suitability of any raw material for pulp and paper. The acceptable values for this ratio must be ≤ (Sadiku, N. A. and Abdukareem, K. A., 2019Enayati et al. 2006). Coefficient of flexibility gives the bonding strength of individual fiber. Based on flexibility Coefficient Bektas (1999) classified fiber into: high elastic fiber having flexibility> 75%, elastic fiber with flexibility 50-75%, rigid fibers with flexibility 30-50% and high rigid fibers with flexibility < 30% A.seyal (Talh), of family Fabaceae, is widely distributed in North Africa, in the Sahelian zone from Senegal to Chad, across Sudan in Eastern Africa, from Egypt Southward to Somalia, Kenya, Mozambique and Namibia (Thirakul, 1984; Badi al et., 1989; Vogt, 1995). In Sudan, it has a wide geographical distribution; it extends from the desert to the moist savanna with over 800 mm of rainfall. In the desert areas the species is restricted to the wettest sites, such as river banks (El Amin, 1990).The tree is the most abundantly naturally occurring in Sudan. However its utilization has been limited to fuel wood, forage and gum.

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The increasing demand for paper and pulp boards products in Sudan, due to increase in population and development arise the need for exploration of suitable resources for pulp and paper. However only few previous studies are available on characterization and evaluation of Sudanese wood species for pulp production. Khristova *et al.* (2006) studied four Eucalyptus species, Elzaki et al (2012) worked on A. niloticaand Albezia lebeck and Saeed et al. (2017) studied Zizphus spinachristi, A.seyal and Tamarindus indica. The objective of this study therefore, was to make available data on A.seyal and assess its suitability of for pulp and paper making based on their chemical and fiber properties and the derived morphological indices. These values were then compared to conventional raw material for pulp and paper making.

MATERIALS AND METHODS

Wood samples

Wood samples were obtained from three normal, randomly selected, A.seyal trees from Blue Nile State south Khartoum(Lat. 11˚ 16' N, long. 34˚ 4' E).10 Discs of 2.5 thick were cut down from the trees and were then taken to the laboratory. . Chips were cut out from the discs. A representative part of the prepared chips was ground into powder in a laboratory Wiley midland the fraction of 40 – 60 mesh was used for chemical analysis.

Fiber dimensions and derived indices

The wood chips were macerated by heating them in 60% nitric acid. The cook was allowed to heat in a water bath for ten minutes then the acid was removed and the fibers were washed thoroughly by water. The macerated fibers were stained with aqueous solution of safranin for five minutes and were then washed first by alcohol followed by water several times. The stained fibers were mounted on glass slides using Canada Balsam. After drying they were examined under an electronic reflecting microscope to measure fiber length, fiber diameter and lumen width. The derived indices values calculated were Runkel ratio (2× cell wall thickness/lumen diameter), coefficient of flexibility (lumen diameter/fiber diameter ×100), coefficient of

rigidity (double cell wall thickness/fiber diameter) and slenderness ratio (fiber length/fiber diameter

Chemical composition

The standards and methods used for the chemical analysis are given in table 1

Table 1. Standards and methods used for chemical analysis

Analysis	Standard or method, reference	Extractive-free
Ash content	TAPPI T 211 om-93	No
Solubility in:-		
Hot water	TAPPI T 207 cm-99	No
Alcohol/benzene	TAPPI T 204 cm-97	No
1% NaOH	TAPPI T 212 om-98	No
Holocellulose	Wise et.al 1945	Yes
α-cellulose	TAPPI T 203 om-99	Yes
Lignin	Khristova and Gabir, 1984	Yes

RESULTS AND DISCUSSION

Fiber dimensions

Table 2 presents the values of fiber dimensions of A.seyal as compared to other fibrous materials (poplar, E.grandis, wheat straw, bamboo and cotton stalks). The average fiber length of A.seyal (1.57 mm) is in the range (1.0 – 1.8 mm) of hardwood fibers (Hurter 1997) and is longer than that of poplar, E.grandis, wheat straw and cotton stalks (1.01, 1.06, 0.74 and 0.83 mm, respectively), but shorter than that of bamboo (3.49 mm).A near value (1.45 mm) of fiber length was given by Mohammed (2019) for A. seyal from Darfur State. However, a lower fiber length of 0.77 mm for A.seyal from western Sudan was reported by Saeed et al. (2017).The fiber width of A.seyal (12.94µm) is lower than that of E. grand is, bamboo and cotton stalks, (19.21, 17.7 and 19.6µm, respectively, but comparable to that of poplar and wheat straw. Lumen width of A.seyal was measured as 6.7µm which is lower than that of poplar (11.7µm) E. grand is (12.2µm) and cotton stalks (12.8µm), but higher than that of wheat straw (4.0µm).Cell wall thickness of A.seyal (3.08µm)is near to that of E. grand is and cotton stalks, and thinner than of wheat straw (4.6µm) and bamboo (5.0µm).Mohammed (2019) reported near values for lumen width and cell wall thickness of 14.97µm and 6.12µm, respectively, for A.seyal from Darfur State. This result indicated that fibers of A.seyal are comparatively long and wide and have thin cell wall.

Table 2. Fiber dimensions of acacia seyal as compared to other pulp raw materials.

Fiber property	*A.seyal*	poplar	*Eucalyptus grandis*	Wheat straw[3]	bamboo	Cotton stalks
Fiber length(mm)	1.57	1.01	1.06	0.74	3.49	0.83
Fiber width (µm)	12.94	15.20	19.21	13.20	17.7	19.6
Lumen width(µm)	6.78	11.70	12.2	4.00	7.7	12.8
Cell wall thickness(µm)	3.08	2.20	3.2	4.60	5.0	3.4

Source:[1,5] Enayati et.al (2009);[2]Ates et.al. (2008); [3]Deniz *et al.,* (2004); 4Lwin et al (2001)

Derived morphological indices

The results of the derived morphological indices of A.seyal and their comparison with other common pulp fibers are presented in Table 3.Runkel ratio of A.seyal (0.91) is lower than that of wheat straw (2.3) and bamboo (1.3), but higher than that of poplar, E. grand is and cotton stalks (0.23, 0.52and 0.53,) respectively. Runkel ratio is an important property that affects the suitability of fiber for pulp production. Pulp yield and strength properties are influenced by Runkel ratio (Emerhi, 2012). The fibers with Runkel ratio less than 1.0 are considered suitable for pulp and paper production, and good quality paper is usually obtained when Runkel ratio is less than 1.0 (Kpikpi, 1992;Dutt and Tyagi,2011;Enayati et al. 2006).).Good tensile, bursting and folding endurance properties are associated with low Runkel ratio (Riki *et al.,* 2019).With increase in Runkel ratio the quality of the produced paper decreases with Runkel ratio less than 1 being the best (Ademiluyi and Okeke, 1977). The Flexibility coefficient of A.seyal was calculated as 52.39% which is lower than that of poplar, E. grand is and cotton stalks but higher than that of wheat straw (30.0%) and bamboo (43.0%).Fiber with flexibility coefficient≥ 50 tend to produce paper with good strength properties (Ajala and Noah2019). According to Bektas et al. (1999) who classified fibers based on flexibility ratio, A.seyal falls in the class of elastic fibers (Flexibility coefficient 50-75%).Slenderness ratio of A.seyal (122.8) is higher that of poplar, E. grand is, wheat straw and cotton stalks. The acceptable values for slenderness values are > 33 (Xu et al. 2006). Coefficient of rigidity of A.seyal (0.47) is higher than that of E. Grand is, wheat straw and bamboo (0.33, 0.35 and 0.2), respectively The overall results on morphological properties of A.seyal, favorably compared to other wood and non-wood pulp raw materials, indicating the suitability of this wood species for pulp and paper production.

Table 3. Derived morphological indices of A.seyal as compared to other pulp raw materials

Fiber property	*A.seyal*	Poplar[1]	*E.grandis*[2]	Wheat straw[3]	Bamboo[4]	Cotton stalks[5]
Runkel ratio	0.91	0.23	0.52	2.30	1.30	0.53
Flexibility coefficient	52.39	81.44	66.0	30.0	43.0	65.31
slenderness	122.8	46.16	55.18	56.1	197.1	42.35
Rigidity coefficient	0.47	-	0.33	0.35	0.28	-

Source: [1,5] Enayati et.al (2009); [2]Ates et.al. (2008); [3]Deniz *et al.,* (2004); [4]Lwin et al (2001)

Chemical composition

Table 4 shows the chemical composition of A.seyal and its comparison with other fibrous raw materials suitable for pulp and paper production. Holocellulose content of A.seyal (76.86%) is lower than that of E. globulus (80.48%), but similar to that of poplar(76.6%), wheat straw(74.5%) and bamboo (70.5%). On the other hand, α-cellulose content of A. seyal (47.25%) is higher than that of poplar (42.82) and wheat straw (38.3%)and near to that of cotton stalks (48 3%) and E, globules ((50.17%). The holocellulose content is a quantitative indication of fibrous raw material influencing consideration of its suability for pulp (Alen, 2000).

The lignin content of A.seyal (20.32%) is lower than that of bamboo(28.7%) and E. globules (23.3%), but it is higher than that of poplar (18.1%) and wheat straw (15.30%). However, this result is comparable with that of hardwoods (17-26) and lower than that for softwoods (25-32) (Ates, Ni, Algaland Tozluoglu, 2008). Hot water extractive content of A.seyal (5.25%) is lower than that of E. globules, wheat straw, bamboo and cotton stalks (9.91, 13.9, 8.0 and 10.77%), respectively, but higher than that of poplar (2.4%). Alcohol-benzene solubility of A.seyal (2.35%) is near to that of poplar (2.5%) and E. globules (3.29%), but lower than that wheat straw (7.8%) and bamboo (5.9%). 1%NaOH solubility of A.seyal (18.46%) is comparable to that of poplar (20.0%) and E. globules (23.56%), but twice less than that of wheat straw and cotton stalks (40.5% and 39.6%), respectively. Ash content of A.seyal (1.8%) is near to that of bamboo (1.4%) and cotton stalks (1.84%)and lower than that of wheat straw (4.7%), but higher than that of poplar (0.54) and E. globules(0.47) . The overall results on chemical analysis showed that the chemical composition of A.seyal compared favorably to other raw materials suitable for pulping , indicating the suitability of this species as a raw material for pulp and paper making.

Table 4. Chemical composition of A.seyal as compared to other pulp raw materials

Species Component%	*A.seyal*	*Poplar*[1]	*Eucalyptus globulus*[2]	wheat straw[3]	Bamboo[4]	Cotton stalks[5]
Holocellulose	76.86	76.6	80.48	74.5	76.3	--
α-cellulose	47.25	42.82	50.17	38.3	-	48.83
Lignin	20.32	18.10	23.30	15.3	28.7	22.50
1% NaOH	18.46	20.00	23.56	40.59	25.9	39.60
Hot water	5.25	2.40	9.91	13.99	8.0	10.77
Alcohol-benzene	2.35	2.50	3.29	7.8	5.90	0.56
Ash	1.80	0.54	0.47	4.7	1.40	1.84

Source:[1,5] Enayati et.al (2009); [2]Ates et.al. (2008); [3]Deniz *et al*.(2004); [4]Kamthai (2007).

CONCLUSION

The analysis of fiber dimensions showed that the fibers of A.seyal species have Runkel ratio of < 1acceptablefor pulp and paper production. The flexibility coefficient (> 50%) compared to some other pulp raw materials and are therefore classified as elastic fibers. Holocellulose, α-cellulose and lignin content of A.seyal were comparable to that of other fibrous materials suitable for pulp and paper production. The results of morphological and chemical characteristics of A.seyal compared favorably with other fibrous raw materials indicating the suitability of this wood species for pulp and paper making. However, this research covered only the properties of the wood, therefore, further investigations in pulping of the species are needed.

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