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PULPING AND PAPER MAKING POTENTIALS OF STEM OF TITHONIA DIVERSIFOLIA

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ABSTRACT: *The stems of matured Tithonia diversifolia were harvested from their natural habitat along the sides of roads where it is often considered as weeds. Samples of the stem were prepared for maceration and thereafter, the fibers obtained were observed with the aid of the microscope and measurements of their morphological and anatomical features were carried out in micrometers using the system consisting of Leica DMLS microscope and a camera. A total of 800 fibers were measured to enhance accuracy of results. The data obtained were used to derive the Runkel ratio, flexibility coefficient and slenderness ratio/felting power of the fibers which were 0.85 ± 0.21, 54.75 ± 5.96 and 46.86 ± 10.09 respectively. Based on the results obtained, it was suggested that the matured stem of Tithonia diversifolia be henceforth harnessed as alternative source of raw material for pulp and paper production in consisting of fibres with Runkel ratio of less than 1, flexibility coefficient of 54.75 ± 5.96 which made it to be classified among the group of elastic fibers and slenderness ratio/felting power of more than 33. Consequently, it was further suggested that controlled and large scale cultivation of the plant be encouraged to meet the demand of the pulp and paper making industry. The results obtained in the present study were discussed alongside with the reports and assertions of previous researchers within the same context.*

KEYWORDS: Fibers, Stem, Runkel Ratio, Flexibility Coefficient, Slenderness Ratio/Felting Power, Pulp, Paper Making

INTRODUCTION

Tithonia diversifolia (Hemsl.) A. Gray (Asteraceae) is native to North America. It was probably introduced into West Africa as an ornamental plant (Akobundu and Agyakwa, 1998). According to Liasu and Ogunkunle (2007*)*, *Tithonia diversifolia* has become a problem weed of fieldcrops, wastelands and roadsides especially in South Western Nigeria. Akobundu and Agyakwa (1998) vividly described the vegetative morphology of *Tithonia diversifolia* as a bushy, many-branched perennial weed that grows up to 2.5m high and reproduces from seeds and vegetative regrowth of basal stem when the plant is cut. The stem is quadrangular, spirally-ridged, pubescent below and glabrous above. The leaves are simple and alternate with 3 to 5 deep lobes, obovate, 5-15cm long and 3.5-6cm wide, dark green, rough to the touch above, pubescent below, toothed, acute and wedge-shaped at the base. The petiole is winged. The inflorescence is a solitary capitulum on a peduncle 7-15cm long with large orange–yellow florets 5-10cm across. The fruit is a compressed and awned achene about 6mm long.

The Nigeria *Tithonia diversifolia* is a fast growing, water-loving annual weed that becomes woody at maturity. The fast growing habit of this weed puts it at an advantage over most other weeds which are eventually over-powered by *T. diversifolia* when growing together.

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The wood of older stem may have a potential application in wood-based industries for making pulp and paper, match splints and tooth picks while the bast could be found useful in rope making and carpet weeving (Liasu and Ogunkunle, 2007).

According to Marcia and Claudia (2012) the aerial parts of *T. diversifolia* are of value for the treatment of diabetes (Hui *et. al*, 2009), malaria (Njoroge and Bussman, 2006a) and infectious diseases in folk medicine (Heinrich *et. al.*, 1998; Njoroge, Bussman, 2006a; Maregesi *et al*., 2007). The species is of particular interest for phytomedical and health care research since it has shown diverse pharmacological activities, such as antiplasmodial (Goffin *et. al*., 2002; Madureira *et. al*., 2002), antiamoebic (Tona *et. al*., 2000), antiviral (Cos *et. al*., 2002; Chiang *et. al*., 2004), anti-inflammatory (Owoyele *et. al*., 2004).

Although many studies on *T. diversifolia* have been carried out in different research fields, there are a few reports on its botanical investigation (Marcia and Claudia, 2012). The studies available focused on trichome aspects (Sasikala and Narayanan, 1998) and the secondary thickening pattern of the stem, occurrence of persistent epidermis, angular collenchyma and collateral vascular bundles with a strip of cambial cells. (Liasu and Ogunkunle, 2007). Marcia and Claudia (2012) reported amphistomatous leaf with predominantly anomocytic stomata, uniseriate epidermis whose cell walls are sinuous in surface view, dorsiventral mesophyll and collateral vascular bundles in *T. diversifolia* which are in concordance with the general aspects of Asteraceae. *Tithonia diversifolia* showed a biconvex midrib, in transverse section and various vascular bundles in circular arrangement.

Consequent on the above, it suffices to point out that the morphology and structure of fibers in the stem of *Tithonia diversifolia* had not attracted the interest of researchers in the recent time. The present study therefore, focuses on determination of the value of the Runkel ratio for the fibers in the stem of *Tithonia diversifolia* with a view to recommending it for paper production.

MATERIALS AND METHODS

COLLECTION OF MATERIALS: The stem cuttings of *Tithonia diversifolia* were collected from its natural habitat in the bush along the road to Ekiti State University student village between the months of August and November, 2017.

FIBER MORPHOLOGICAL ANALYSIS: This was carried out following (San *et. al.*, 2016). A small piece from the side of samples were cut and prepared for macerations. Maceration solution consisted of 30% **hydrogen peroxide** and glacial acetic acid in a 1:1 ratio. The prepared reagent was applied to wood samples (fragmented to the size of the matches) in the glass tubes, after which the tubes were corked. The material in test tubes was transformed into pulp in the oven at a temperature of 65°C for the period of 24 h. After rinsing with distilled water and shaking individual cells of xylem tissue suitable for measuring were obtained. Macerated wood fragments are transported to the glass slide with a dissecting needle and they are observed under microscope. Fiber length, thickness of cell walls and lumen diameters were measured using the system consisting of Leica DMLS microscope and a camera: Leica DC 300 supported by Leica IM 1000 software which enabled digital recording of prepared preparations and very precise electronic measurement of the mentioned anatomical elements. A total of 800 fibers were measured to achieve the accuracy of

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properties evaluated. From the data, the average fiber dimensions were calculated and then the following derived indexes were determined:

$$\text{Runkel ratio} = \frac{2 \times \text{Wall thickness}}{\text{Lumen Width}}$$

$$\text{Flexibility coefficient} = \frac{\text{Lumen Width of Fiber}}{\text{Diameter of Fiber}} \times 100$$

$$\text{Slenderness ratio} = \frac{\text{Length of Fiber}}{\text{Diameter of Fiber}}$$

RESULTS AND DISCUSSIONS

The anatomical and morphological properties of the stem of matured *Tithonia diversifolia* have been summarised in Table 1.

The mean length and diameter of the fibers in the stem of this spp were 1.14 ± 0.18 and 25.21 ± 5.58 respectively while the lumen width and cell wall thickness were 13.84 ± 3.59 and 5.69 ± 1.42 (Table 1).

On the other hand, the mean and standard deviations for the derived indexes such as Runkel ratio, flexibility coefficient and Felting power were 0.85 ± 0.21, 54.75 ± 5.96 and 46.86 ± 10.09 respectively (Table 1).

TABLE 1: ANATOMICAL AND MORPHOLOGICAL PROPERTIES OF THE STEM OF TITHONIA DIVERSIFOLIA

Properties	Means and Standard Deviation
Fiber length (µm)	1.14 ± 0.18
Fiber diameter (µm)	25.21 ± 5.58
Lumen width (µm)	13.84 ± 3.59
Cell wall thickness (µm)	5.69 ± 1.42
Runkel ratio	0.85 ± 0.21
Flexibility coefficient (%)	54.75 ± 5.96
Slenderness ratio/Felting power	46.86 ± 10.09

According to San *et. al.* (2016) wood fibers are usually cellulosic elements that are extracted from trees and used in the manufacture of pulp and paper or fiber board. The fiber morphological characteristics are important because it determines the suitability of the lignocellulosic material before proceeding to production. Runkel ratio is usually used to determine the suitability of a fibrous material for pulp and paper production. If a wood species has a Runkel ratio more than 1, its fiber will be stiff, less flexible and with poor bonding ability. Whereas, fibers with low ratio (< 1) produce good quality pulp and paper.

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Similarly, Jang and Seth (1998) reported that materials having a runkel value less than 1 would be suitable for paper making because they collapse(become ribbon like) and provide a large surface area for bonding (San *et. al.*, 2016). Consequently, results obtained in the present study showed that the stem of *Tithonia diversifolia* is suitable for pulp and paper production by having Runkel ratio of less than 1(Table 1). This assertion further corroborates the earlier reports of Sharma *et. al.*, (2013) on some group of weeds as being suitable for paper making.

On the other hand, the slenderness ratio or felting power of *Tithonia diversifolia* as shown in Table 1 was 46.86 ± 10.09. According to San *et. al.* (2016) the acceptable value for slenderness ratio of fibres for paper production is more than 33. Hence, *Tithonia diversifolia* having a value of 46.86 ± 10.09 will produce better forming and well bonded paper. Another derived anatomical parameter that influences the selection of fibers suitable for pulp and paper production is the flexibility coefficient. Flexibility coefficient gives the bonding strength of individual fiber and by extension the tensile strength and bursting properties (San *et. al.*, 2016).

Consequently, flexibility coefficient of this species was 54.75%. This places it among the plants with elastic fibers according to the ranges of flexibility coefficient of fibers reported in Samariha *et. al.* (2011). The groups are (i) High elastic fibers having elasticity coefficient greater than 75 (ii) Elastic fibers having elasticity ratio of between 50 -75. (iii) Rigid fibers having elasticity ratio of between 30 -50. (iv) Highly rigid fibers having elasticity ratio of less than 30.

In conclusion, *Tithonia diversifolia* grows naturally and massively to maturity as weeds on the sides of most Nigerian roads without being extracted for any meaningful end-use but are suddenly cleared off and considered as waste. Given the present report about the stem of this plant, it suffices to suggest that it be harnessed as alternative source of raw materials for pulp and paper production and controlled large scale cultivation of this same plant be encouraged for the same purpose.

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