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The Influence of Axial Position on Fiber Features of Cotton Stems

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Abstract: In the present research, variations of fiber length, fiber diameter, cell-wall thickness, lumen diameter, Runkel ratio, flexibility coefficients and slenderness features of cotton stalks were investigated. Ten of cotton stalks were selected in Varamin site-Iran and three parts were cut along longitudinal position (25%, 50% and 75%) from base to up of the stem. For fiber separation of cotton stem were used from Franklin method. The analysis of variance indicated that the longitudinal position hadn't significant effect on fiber properties and morphological features of cotton stalks, whereas theses features along axial direction were decreased from base to up of stems. The average of fiber length in the present study is more than other residues such as rice and wheat residues and is less than bagasse stems. Results based on the biometry analysis indicated that cotton stalks fibers is promising fibrous raw material for the paper production.

Key words: Axial position · Fiber · Cotton Stem

INTRODUCTION

When paper making was invented, non-wood fibers were utilized as the main source of the raw material [1]. However, this situation did not last too long and very soon, wood fibers replaced non- wood fibers. However, not all countries in the world possess suitable and sufficient quantities of wood to fulfill their fiber requirements [2, 3]. Consequently, these countries are forced to use non-wood fibers and research on this aspect of pulping was foreseen and most efforts were concentrated on this issue [4]. Even though, the share of non-wood pulping is only 6.5% of the total pulp production, there is evidence that this rate will increase and more fibers from straw and bagasse will be used for pulp production [3]. Over the years, an increasing preoccupation and national use of forest and agricultural residues have occurred. This fact was mainly motivated by the increasing consumption of wood fiber-based products, such as panel, paper and boards [5]. Around 95-97% of all the raw materials used for this purpose are known collectively as 'non-wood' materials [6]. Non-wood fiber plants, with annual or biannual harvests that may be grown rapidly as agricultural crops, are receiving a renewed attention partly due to concerns on increasing wood consumption and raw-material availability for the pulp industry in some regions. Non-wood plants are important pulp fibers: they represented 6% of the world pulp production in 1991, with a 7% annual increase thousand tons in 1993, of which 92 thousand tons were imported [7]. Non-wood plants are an alternative to the increasingly scant forest wood as a source of pulp fiber [8]. One of the agricultural residues, cotton stalks are available in large quantities in several parts of the world and produced by former Egypt which have no forests; cotton stalks are one of the agricultural residues available for pulping and papermaking [9]. On the other hand, Turkey is the 7th cotton fiber producer in the world with an annual production of 997.000 tons which is about 4% of total world production. Estimated cotton stalks remaining in the field is around 4 million tons [10]. The aim of this study is some morphological properties of cotton stalks were determined.

MATERIALS AND METHODS

Three parts (25, 50 and 75%) were selected from ten cotton stalks in Varamin site–Iran. From Franklin method was used for fiber separation [11]. The fiber diameter, fiber length, lumen width and cell wall thickness were measured

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Table 1: Fiber features in cotton stalk

Variable	Fiber length (mm)	Fiber width (μm)	Lumen width (μm)	Single cell wall thickness (μm)
25%	0.96a	24.21a	16.48a	3.86a
50%.	0.93a	23.86a	16.06a	3.74a
75%	0.89a	23.59a	15.78a	3.68a
Average	0.926	23.88	16.10	3.78

Table 2: The fiber features in cotton stalks and other agricultural residues

Literature	Cell-wall thickness (μm)	Lumen width (μm)	Fiber width (μm)	Fiber length (mm)	Species
Current Study	3.78	16.1	23.88	0.926	Cotton
(Tutus et al., 2004) [13]	4.2	6.4	14.8	0.89	Rice
(Deniz et al., 2004) [14]	4.59	4.02	13.2	0.74	Wheat
(Hemmasi et al., 2011) [15]	5.64	9.72	20.96	1.59	Bagasse

Table 3: The biometry features of cotton stalks in three parts of stem

Variable	Flexibility ratio (%)	Slenderness ratio	Runkel ratio (%)
25%	68.07a	39.65a	46.84a
50%.	67.30a	38.97a	46.82a
75%	66.89a	37.72a	46.64a
Average	67.42	38.78	46.76

with a microscope equipped with a Leica Image Analysis System (Quantimeta 100+). For dimensions of 30 (in each of parts) fibers were randomly measured. From these data, the average fiber dimensions were calculated and then the following derived indexes were determined.

$$\text{Flexibility ratio} = (\text{Lumen width of fiber}/\text{Diameter of fiber}) \times 100 \quad (1)$$

$$\text{Slenderness ratio} = (\text{Length of fiber}/\text{Diameter of fiber}) \quad (2)$$

$$\text{Runkel ratio} = 2 \times (\text{Wall thickness}/\text{Lumen width}) \quad (3)$$

Statistical Analysis: In order to determine the relationship between the experimental variable (three parts of stem) and fiber features, all the data measured were subjected to an analysis of variance (ANOVA) and Duncan's mean separation test.

RESULTS

Fiber Dimensions: The average of fiber length, fiber diameter, cell-wall thickness and lumen diameter of cotton stalks are shown in Table 1. The analysis of variance indicated that the axial direction hadn't significant effect on the fiber features in cotton stalks. Overall, the values of fiber features were decreased along axial direction from base to the up of stems. The average fiber length, fiber diameter, lumen diameter and cell wall thickness varied between stems 0.86 to 0.96 mm, 23.59 to 24.21, 15.78 to 16.48 and 3.68 to 3.86 μm, respectively.

There results were compared with other agricultural residues such as rice, wheat and bagasse, which are presented in Table 2. The value of fiber diameter, cell wall thickness and lumen diameter is more than other residues, whereas the fiber length of cotton stalks is less than bagasse and is more than rice straw and wheat residues. In general, today, just as long fiber and short fiber pulp concepts are widely used in paper industry, measurement of fibers constituting pulp and accordingly relations between pulp properties also become important. For example, increase in fiber length affects resistance properties of the paper positively but causes to malformation on paper obtained [12].

The slenderness coefficient, flexibility ratio and Runkel ratio of cotton stalks are presented in Table 3. The analysis of variance (ANOVA) indicated that the axial direction hadn't significant effects on the above items. The values of biometry features were decreased along axial direction from base to the up of stems. In other hand, the biometry features in base stem is more than other part stems. The average of flexibility, slenderness and Runkel indexes were determine 67.42%, 38.78 and 46.76%.

CONCLUSIONS

In the present study, the fiber properties and biometry features of cotton stalks in three parts of stems were studied. The results indicated that the analysis of variance indicated that the effect of axial direction on the biometry features and fiber dimensions wasn't significant.

The values of studied items were decrease along axial position from base to the up of the stems. The fiber length value is similar to fiber length in hardwood species. Therefore, the cotton fibers can be mixed with other large fibers softwood for high paper quality production.

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