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Study of Morphological and Chemical Composition of Fibers from Iranian Sugarcane Bagasse

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Abstract: This research was down with aim of chemical and anatomical properties of used sugarcane bagasse used in pars paper industries. Wet method depithed sugarcane bagasse of pars Paper Company in Khuzestan province was used in this research. TAPPI standard was used for study of sugarcane bagasse fiber chemical and anatomical properties. Average length, diameter of cellular cavity and thickness of cellular layer of sugarcane bagasse fiber were calculated as 1590, 20.96, 9.719 and 5.64 µm. The slenderness ratio, flexibility ratio and Runkel ratio were of sugarcane bagasse were calculated as 75.86, 46.37%, 1.16. In addition measuring chemical properties showed that Cellulose proportion was 55.75%, lignin 20.5%, Extractives 3.25% and ash 1.85% measurement of sugarcane bagasse properties shows that the dimensional properties of fibers and chemical property of fibers are very suitable for use in paper making industries of the country and is better than hard woods and other nonwood herbals.

Key words: Sugarcane bagasse · Length · Cellulose · Slenderness ratio · Flexibility ratio · Runkel ratio

INTRODUCTION

Sugarcane bagasse, the sugarcane residue after sugar extraction, is one of the most available papermaking lignocellulosic fiber resources in some developing countries, e.g., Iran. Approximately 4.3 million tons of sugarcane bagasse is produced annually in Iran and the production is mainly centered in the southwestern province of Khuzestan [1]. About 54 million tons of sugarcane bagasse is produced annually throughout the world. In general, sugar factories generate approximately 270 kg of sugarcane bagasse (50% moisture) per metric ton of sugarcane [2]. A specific knowledge of the fibrous raw materials, especially of nonwood plants, is useful to predict its behavior during transformation processes, for instance pulp and paper production. In this paper sugarcane bagasse is particularly studied which is one of the most important raw materials for paper pulp production in Iran [3] and other countries like India, where almost 20% of India's paper production is from sugarcane bagasse. This country is the largest sugarcane producer and sugarcane bagasse supply is plentiful [4]. Sugarcane bagasse is a residue from the refining process of sugarcane. This product represents a great morphological heterogeneity. As the pith content of sugarcane bagasse causes serious problems in pulp and papermaking, it should have been removed as far as possible from the sugarcane bagasse raw material [5]. In particular pith increases the chemicals consumption of the pulping and bleaching process. It causes filtration difficulties in brown stock washers as well as in the bleach plant washers and finally it causes drainage problems on the paper machine [6]. Sugarcane bagasse short fibers have attracted attention as a potential nonwood raw material for the pulp and paper making and many researchers has studied the possibility of making pulps from sugarcane bagasse [7-8]. Depithing operations are not able to remove the whole pith fraction from the fibers, but it contributes to an enrichment of fibers in the pulp. In commercial scale depithing increases the fiber content of a sugarcane bagasse pulp from 60 to 80%. As a consequence of pith removal a by-product is generated

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which in most cases is used for steam generation. The objectives of this study were to examine chemical properties and morphological characteristics of sugarcane bagasse.

MATERIALS AND METHODS

Raw Material: Depithed sugarcane bagasse was collected from a local pulp and paper mill (Pars Paper Co. Haft Tapeh. Iran).

Methods

Measurement of Fiber Biometry Characteristics: The pieces of sugarcane bagasse were defibrated using the technique developed by Franklin (1954) [9] and then the fiber length, fiber diameter and lumen width were measured with a microscope equipped with a Leica Image Analysis System (Quantimeta 100+). The fiber wall thickness was calculated as a difference of fiber diameter and lumen width divided in half. For dimensions of 120 fibers were randomly measured. From these data, the average fiber dimensions were calculated and then the following derived indexes were determined [10]:

$$\text{Runkel ratio} = 2 \times (\text{Wall thickness}/\text{Lumen width}) \quad (1)$$

$$\text{Flexibility ratio} = (\text{Lumen width of fiber}/\text{Diameter of fiber}) \times 100 \quad (2)$$

$$\text{Slenderness ratio} = (\text{Length of fiber}/\text{Diameter of fiber}) \quad (3)$$

Chemical Composition: The proportions of the chemical constituent in the sugarcane bagasse fibers were determined according to TAPPI Test Methods. Lignin, ash and ethanol/acetone extractable of sugarcane bagasse fiber were determined according to TAPPI T222 om-97, T203 cm-99, T267 om-85 and T207 om-97, respectively [11-15]. The cellulose content of sugarcane bagasse was determined according to the nitric acid (Rowell and Young 1997) method [16]. All measurements were repeated three times.

RESULTS AND DISCUSSION

The results in Table 1 represent an average of the dimensions of 120 cells of fiber sugarcane bagasse.

The results show that the sugarcane bagasse contained fibers with a mean length of 1590 µm. The sugarcane bagasse fibers are in the range of hardwoods and longer than wheat straw (1140 µm) [16] and aspen (960 µm) [17] and shorter than bamboo (2300 µm) [18].

On the other hand, cell wall thickness of sugarcane bagasse fibers is thicker than those of aspen (1.93 µm) [17] and reed (3.2 µm) [19]. More cell wall thickness of fibers causes more flexibility of fibers in pulp refining process. Increase of cell wall thickness has a direct effect on strength properties of fibers.

Therefore it is expected that with the resulting paper strength, properties can be met after refining. Consequently, the calculated Runkel ratio for sugarcane bagasse fibers (1.16) is higher than that of wheat straw (0.83) and aspen (0.23) fibers.

The slenderness ratio of sugarcane bagasse fibers is 75.85 and is higher than that of wheat straw (59) and aspen (46.15) fibers. Generally, the acceptable value for slenderness ratio of papermaking is more than 33, respectively [2]. But the flexibility coefficient of sugarcane bagasse fibers is less than both tobacco straw (60.82) and aspen (81.44). According to flexibility ratio there are 4 groups of fibers [20]: 1) High elastic fibers having elasticity coefficient greater than 75. 2) Elastic fibers having elasticity ratio between 50-75. 3) Rigid fibers having elasticity ratio between 30-50. 4) Highly rigid fibers having elasticity ratio less than 30. According to this classification, the flexibility coefficient of sugarcane bagasse fibers is 46.37, so it is included in the rigid fibers group.

The structure of the sugarcane bagasse fibers is very well suited for papermaking. It has a fairly high length, an acceptable wall thickness and small cell diameter. The ratio cell length to diameter is around 60 [21], which is good for an annual plant fiber and corresponds to data reported in the literature [22].

Table 1: Dimensional characteristics of fiber of sugarcane bagasse.

	Length (µm)		Cell Diameter (µm)		wall thickness (µm)		Lumen width (µm)		Runkel ratio	Slenderness ratio	Flexibility ratio (%)
	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	Mean	Mean
fiber	1590	0.21	20.96	0.24	5.64	0.33	9.72	0.29	1.16	75.86	46.37

Table 2: Chemical composition of sugarcane bagasse (% on OD basis)

Component	Value %
Cellulose	55.75±0.4
Lignin	20.5±1.7
Extractives soluble in alcohol - acetone	3.25±4.3
Ash content	1.85±3.7

The percentage of cellulose, lignin, extractive soluble in alcohol-acetone and ash are summarized in Table 2.

The cellulose content of sugarcane bagasse was found to be 55.81%, which is satisfactory for pulp production (close to or above 40%). The result obtained for the cellulose content of sugarcane bagasse was close to an earlier finding (52.42%) [23], whereas the cellulose content of sugarcane bagasse was higher than that of rice straw (41.20%) [24] and wheat straw (38.20%) [25]. According to Nieschlag *et al*. (1960) plant materials with cellulose of 34% and above are characterized to be suitable for pulp and paper manufacture [26]. The lignin content of sugarcane bagasse was found to be lower than that of rice straw (21.90%) and Egyptian cotton stalks (22.50%) [27]. the organic solvent extractive of sugarcane bagasse was found to be higher than those of rice straw (0.56%) and aspen (2.50%). The organic solvent extractive was lower than that of wheat straw (7.80%). The ash content of sugarcane bagasse was also low.

CONCLUSIONS

- The results of a biometrical study showed that sugarcane bagasse contained fibers with similar average biometrical properties to the hardwood fibers, except that the cell wall of sugarcane bagasse was thicker.
- Chemical compositional analysis showed that the lignin content of sugarcane bagasse was lower than other nonwood papermaking fiber resources. The cellulose content of sugarcane bagasse is higher than other nonwood papermaking resources. It was found that the sugarcane bagasse contained low amounts of ash.

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