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Some Chemical and Morphological Properties of Wheat Straw

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Abstract: In the present study, chemical and morphological properties of wheat straw fibers were investigated. Chemical properties including cellulose (49.78%), lignin (19.64%), ash (5.28%) and extractives (4.93%) contents were determined. Fiber length, diameter, lumen width and cell wall thickness were 1140, 19.32, 10.54 and 4.39 µm, respectively. The short length and thin-walled fibers may be expected to give relatively dense papers which are weak in tearing strength, but are superior in burst and tensile properties. Wheat straw has acceptable Runkel ratio and flexibility coefficient are in the range of nonwoods, respectively. In general, results based on chemical and morphological analysis indicated that wheat straw fibers are promising fibrous raw material for the paper production.

Key words: Cellulose % Lignin % Runkel ratio % Flexibility coefficient

INTRODUCTION

Nonwood raw materials account for 5-7% of the worldwide production of paper pulp [1]. Non-wood plants represent an important alternative fiber source for the pulp and paper industry. The role of agro-fiber biomass is particularly prominent in countries with limited wood resources. In some regions of Asia, Africa and Latin America, this is the only source of industrial papermaking fibers [2]. Plant waste fibers can be described as lignocellulosics, i.e. resources comprised primarily of cellulose, hemicellulose and Lignin. lignocellulosics include wood, agricultural residues, water plants, grasses and other plant substances [3]. In Iran, the main fibrous raw material resources available for Papermaking are short-fibred hardwoods and nonwood fibers especially agricultural wastes. Nonwood fibers are important raw material sources for Papermaking in many developing countries. Of all the Nonwood fibers used for Papermaking, straws or grasses such as wheat straw, rice straw, reed and sugar cane bagasse account for most of the total nonwood pulp capacity [4]. Wheat straw has better quality for papermaking compared to the other nonwood fibers such as sunflower stalks, vine shoots and cotton stalks due to its stronger breaking length of paper handsheets [5]. The objectives of this study were to examine some chemical properties and morphological characteristics of Wheat Straw.

MATERIALS AND METHODS

Raw Material Preparation: Wheat straw was collected from the field in Karaj city.

Chemical Composition: The ground meals were screened and the particles that were retained at BS 60 mesh (250 µm) sieve were used for determining the chemical components. The chemical compositions of wheat straw were determined following the standards outlined in the TAPPI Test Methods and the other published procedures where indicated. Cellulose was determined following the procedure of nitric acid (Rowell and Young 1997) [6] method. Lignin, ash and ethanol/acetone extractable of wheat straw fiber were determined according to TAPPI T222 om-97, T267 om-85 and T207 om-97, respectively.

Fiber Morphology Determination: The pieces of bagasse, Corn, sunflower, rice and Rapeseed residue were defibrated using the technique developed by Franklin (1954) [7] and then the fiber length, fiber diameter and lumen width were measured with a Leica Image Analysis System. The fiber wall thickness was calculated as a difference of fiber diameter and lumen width divided in half. For dimensions of 300 fibers were randomly measured. From these data, the average fiber dimensions were calculated and then the following derived indexes were determined:

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Slenderness ratio = (Length of fiber/Diameter of fiber)
Flexibility ratio = (Lumen width of fiber/Diameter of fiber) × 100
Runkel ratio = (Wall thickness/Lumen width)

RESULTS

The morphological properties of Wheat Straw and their comparison with common Papermaking fiber resources are Summarized in Table 1. The results show that the wheat straw contained short fibers with a mean length of 1.14 mm. The wheat straw fibers are as long as the short fibers of nonwood plant such as Bamboo, reed and corn stalk. However, they are longer than tobacco straw, cotton stalks and aspen and similar rye straw fibers. The fiber diameter and lumen width of wheat straw fibers are similar to those of cotton stalks and aspen fiber and thicker than bamboo and rye straw fiber and thinner than corn stalk and tobacco straw fibers. On the other hand, cell wall thickness of wheat straw fibers is thicker than bamboo, reed, cotton stalk and aspen fibers.

Consequently, the calculated Runkel ratio for wheat straw fibers (83.3) is higher than that of Tobacco straw, cotton stalk and aspen fibers. The slenderness ratio of wheat straw fibers is 59 and is comparable with that of corn stalk and aspen fibers and higher than that of tobacco straw and cotton stalk fibers. Generally, the acceptable values for slenderness ratio and Runkel ratio of Papermaking fibers are more 33 and less than 1, respectively [8]. Referring to this and morphological properties of wheat straw fibers, it can be deduced that the wheat straw fibers can be collapsed to form ribbon like structures in the paper and that the overall morphological properties of wheat straw fibers are satisfactory for papermaking, although they would be classified as short fibers.

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

The cellulose content of wheat straw was found to be 49.78%, which is satisfactory for pulp production (close to or above 40%). The result obtained for the cellulose content of Egyptian cotton stalk was close to an earlier finding (48.83%) [16], whereas the cellulose content of wheat straw was higher than that of rice straw (41.20%) [17] and wheat straw (38.20%) [18]. According to Nieschlag *et al*. (1960) plant materials with cellulose of 34% and above are characterized to be Suitable for pulp and paper manufacture [19]. The lignin content of wheat straw was found to be lower than that of rice straw (21.90%), egyptian cotton stalks (22.50%) [16] and bamboo (24.5%) [9]. the organic solvent extractive of wheat straw 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 wheat straw was also high.

Table 1: The mean values of wheat straw fiber dimensions and derived indexes, comparison with common papermaking fibers

Fiber Properties	Wheat straw[a]	Bamboo[b]	Rye straw[c]	Corn stalk[d]	Tobacco straw[e]	Reed[f]	Cotton stalk[g]	Aspen[h]
Length (mm)	1.14	2.30	1.15	1.32	1.07	1.39	0.83	0.96
Diameter (µm)	19.32	15.1	14.7	24.3	26.8	13.5	19.60	20.80
Lumen width	10.54	6.9	4.2	10.7	16.3	7.0	12.80	16.94
Cell wall thickness	4.39	4.17	4.6	6.8	5.3	3.2	3.40	1.93
Runkel ratio	0.83	1.21	2.19	1.27	0.65	0.91	0.53	0.23
Slenderness ratio	59	152.3	78.23	54.32	39.93	102.96	42.35	46.15
Flexibility coefficient	54.55	45.69	28.57	44.03	60.82	51.85	65.31	81.44

(a): Present study, (b): Deniz and Ates 2002 [9], (c): Usta and Eroglu 1987 [10], (d): Usta *et al*. 1990 [11], (e): Eroglu *et al*. 1992 [12], (f): Kirci *et al*. 1998 [13], (g): Ververis *et al*. 2004 [14], (h): Law and Jiang 2001 [15].

Table 2: Chemical Composition of Wheat straw (% on OD basis)

Component	Value %
Cellulose	49.78
Lignin	19.64
Extractives soluble in alcohol - acetone	4.93
Ash content	5.28

CONCLUSIONS

The results of morphological study showed that wheat straw contained short fibers with similar morphological properties to the common nonwood fibers. Chemical composition analysis showed that the lignin content of wheat straw was comparable to other Nonwood Papermaking fiber resources. It was found that the Wheat Straw contained high amounts of extractives and ash.

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