Physical and Strength Properties of Paper Manufactured from Straw of Different Sudanese Sorghum Varieties

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ABSTRACT

The physical and strength properties of papers manufactured from different Sudanese sorghum straws were investigated. Pulp was manufactured from straws of five different sorghum varieties namely Wad Ahmed, Hegein, Tabbat, Feterita and Hemacy. The hand sheets were produced from each variety according to the American standard and subjected to physical tests including specific volume, breaking length, tensile strength, burst index and folding endurance. The effect of beating time on these properties was these varieties showed that the also taken into accounts. The results obtained from produced papers differed from one to another according to the variety from which it was produced. It has been noticed that, the increased beating times were substantially improved the properties of paper manufactured from these straws. For comparison purposes properties of these papers, were compared with properties of the printing paper size (A4). Although the latter was chemically treated with tilling and other improving materials, the results of comparison showed that, the paper produced from sorghum straws, were good and very much like the standard one (A4).

Key words: Paper Manufactured, Sorghum Straw, Physical and Strength Properties

INTODUCTION

Sorghum is a genus of numerous species of grasses, some of which are raised for grain and many of them were used as fodder plants. The plants are cultivated in warmer climates worldwide. Sorghum species are important food crop in Africa, Central America

and South Asia. It is one of the five top cereal crops in the world along with wheat, oats, corn and barley. (Internet, 2010).

Plant waste fibers can be described as lignocellulosics, i.e. resources comprised primarily of celluloses, hemicelluloses and lignin. Lignocellulosics include wood, agricultural residues, water plants, grasses and other plant substances (Rowell *et al*., 2000).

Plant waste fibers have the composition, properties and structure that make them suitable for uses such as composite, textile, pulp and paper manufacture. The organic plant waste such as oil palm, pineapple, banana and coconut fibers are annually renewable, available in abundance and of limited value at present. These byproducts could be a principal source for fibers and other industrial products (Reddy and Yang, 2005).

Non-wood fibers have long history as raw material for papermaking. Currently China produces about one-half of the world non-wood pulp, while, Europe and North America are relatively small contributors (FAO, 1995). Environmental and population growth pressures are contributing to long range changes in the forest land management's practices, which reduce harvest of wood for wood product and for pulp and paper manufacture (Bruenner, 1994). At the same time, cereal grain crop production in the world generates tremendous quantities of straw. Only 0.5 tons of straw per acre are required to maintain on the soil surface for erosion control. Therefore, straw may represent a significant fiber substitution opportunity (Misra, 1987). Straw pulps which are usually short fiber pulp, can be readily used for the production of writing and printing papers. In fact, the fibers will form very uniform sheets, give good printability and smoothness and in some cases improve opacity (Huter, 1998).

Properties of papermaking fibers from wood or from annual crops can be influenced by both growing conditions and genetic manipulation. Many studies showed that wood morphology and chemical composition vary with location, genetics and growth condition

(Beadle *et al*, 1996). Rice straw has also been found to vary with the growing location (Kuo and Shen, 1992). Preliminary tests indicated that unbleached spartina pulp had very low basic physical strengths. Spartina pulp could be used, possibly up to 30% for blending with bleached old corrugatedcontainer pulp, in the manufa-cture of high quality printing paper (Wong and Chen, 2001). The strength properties of red fescue pulp were found to be comparable to those of classical blend of 75% hardwood kraft and 25% softwood kraft pulps. This finding provides an opportunity to use the red fescue pulp for manufacture of uncoated offset printing paper (Wong and Chen, 2001). For papermaking purposes, hemp bast fiber is used interchangeably with flax bast fiber, both hemp bast fiber and hemp hurds (core) have been used for the manufacture of papermaking pulp despite its low lignin content (Al Wong and Chen, 1995). The yield of pulp from fibers is dependent mainly on the specificcookingprocedureandthequality of the fiber raw material. (Alfred, 2000). Straw pulps are well known to exhibit excellent textile strength properties, similar to hardwood pulps, but are deficient in tear strength (Watson and Bicho, 1998)

The objectives of this work is to study the physical properties of paper manufactured from straws of different Sudanese sorghum varieties, and to determine the effect of beating time on such properties.

MATERIALS AND METHODS

The sorghum straws were collected from Gezira scheme, their leaves and trashes were removed manually and then were cut into small pieces ranging from (1-1.5 inches). Moisture test was carried out for each straw type. The 18.06% of cooking liquor was used for cooking the straw in order to separate the cellulose fibers and the instrument used for cooking, is called Digester. An amount of 709 grams was taken from each sorghum straw added to 124.4 grams of caustic soda (the amount of caustic soda is mainly depend on the purity of caustic and dry weight of straw) and the amount was dissolved in 3.370 liter of water, the liquor ratio of water to straw is 1 : 5. The digester is secured tightly at pressure

of 10 bars and 170 ^{0} C temperature for 45 minutes. Different interval times of beating were used (0, 5, and 10 minute) to assure better separation of fibers. The fibers obtained were washed several times to remove lignin and other materials. Then 400 ml of paper paste was taken, added to 4800 ml of water, and placed into paper making device. These processes were repeated several time to produce different samples of paper. The samples were left to dry under normal light, the dried papers were placed under a compressor working at 1-2 bar for 15 minutes, then they were removed and placed on a circular metal sheet to dry completely. The paper manufactured was subjected to several physical tests to determine their properties. The tests, which has been carried out, are thickness, tensile strength, burst index, specific volume and folding tests. Each test was repeated five times and the average of these tests was used to determine the properties.

RESULTS AND DISCUSSION

The results on Table (1), showed the tensile strength of paper manufactured from five sorghum straws. The tensile strength of the papers manufactured from Wad Ahmed straw were of higher value 57.7 Nm/g, while the tensile strength of papers manufactured from other straws (Hagein, Tabbat, Hemecy and Feterita) gave less values (46.8, 44.8, 43.3, 32.8 , respectively).

Table (1) Physical and Strength Properties of Paper Manufactured from Straws of Five Sudanese Sorghum Varieties and A4 printer paper

Sorghum straw	Specific volume(cm/g)	Breaking Length(km)	Tensile Strength(Nm/g)	Burst Pressure	Folding
Hegein	2.24	4.77	46.8	0.9	1
Wad Ahmed	2.19	5.88	57.7	1.4	1
Feterita	2.33	3.34	32.8	1.2	0

Tabbat	2.27	4.57	44.8	1.0	0.8
Hemacy	2.3	4.41	43.3	0.7	1
A4 paper	17.61	8.17	80.2	4.3	1

Table (2). Presented the specific volume of paper manufactured from the sorghum straws. The results obtained showed that, the higher value of specific volume was obtained from papers manufactured from Feterita 2.33 followed by Hemacy straw 2.3, Tabbat 2.27, Hegein 2.24, and the lower value of specific volume was obtained from Wad Ahmed straw 2.19.

Table (2) Specific volume of paper manufactured from sorghum straw with respect to beating times

Varieties / Time(min)	0	5	10
Hagein	2.39	2.24	1.98
Wad Ahamed	2.58	2.19	1.64
Feterita	2.61	2.33	1.88
Tabbat	2.82	2.27	1.91
Hemacy	2.75	2.3	2.12

On the other hand Table (3), showed the breaking length of the papers manufactured from the sorghum straws. It was found that, the paper manufactured from Wad Ahmed straw has the highest value 5.88, comparable with values obtained for other sorghum straws (Hegein, Tabbat, Hemacy and Feterita), which have the following values, respectively (4.77, 4.57, 4.41, 3.34).

The results of the burst index test are illustrated on Table (4). The results showed that the highest value for burst index was found for Wad Ahmed straw1.4 Nm/g, followed by Feterita straw 1.2. The values recorded for the other straws (Tabbat, Hegein and

Hemacy), were as follows (1, 0.9, and 0.7, respectively). The Table also showed, that the paper manufactured from Hegein, Wad A hmed, and Hemacy obtained an equal value, followed by paper manufactured from Tabbat, while the folding test of paper manufactured from Feterita straw showed the lowest value.

Table (3) Breaking length of paper manufactured from sorghum straw with respect tobeating time

Varieties / Time(min)	0	5	10
Hagein	3.46	4.77	6.26
Wad Ahamed	2.97	5.88	7.71
Feterita	2.42	3.34	4.57
Tabbat	3.3	4.57	6.17
Hemacy	3.24	4.41	5.32

Table (4) Burst index of paper manufactured from sorghum straw with respect to beating time.

Varieties / Time(min)	0	5	10
Hagein	0.7	0.9	1.3
Wad Ahamed	1.2	1.4	2.2
Feterita	0.8	1.2	2
Tabbat	0.8	1	1.3
Hemacy	0.6	0.7	1.5

Results displayed on Table (5) showed that the increase of beating time has rapidly improved the tensile strength of the paper manufactured from the sorghum straws, at least for the beating time tested. However, Table (6) showed that the folding properties of the papers manufactured from some sorghum varieties such as Hagein, Tabbat and Hemacy

was improved with increasing of the beating time, while the rest of varieties (Wad Ahmed and Feterita), were not affected.

Table (5).Tensile strength of paper manufactured from sorghum straw with respect tobeating times (min).

Varieties / Time(min)	0	5	10
Hagein	33.9	46.8	61.4
Wad Ahamed	29.2	57.7	75.6
Feterita	23.7	32.8	44.8
Tabbat	32.4	44.8	60.6.
Hemacy	31.8	43.3	52.2

Table (6). Folding of paper manufactured from sorghum straw with respect to beating time.

Varieties / Time(min)	0	5	10
Hagein	0.3	1	1
Wad Ahamed	1	1	1
Feterita	0	0	0
Tabbat	0	0.8	1
Hemacy	0	1	1

CONCLUSSIONS

The tremendous agricultural residues, in general, and sorghum straw, in particular, can be successfully considered as an alternative, replacing the pulp produced from wood

fibers. It has been noticed from this study that the paper manufactured from different Sudanese sorghum straws, were quite different in their physical properties. These results agreed with the studies recorded by Beadle *et al* (1996), which confirmed that, the properties of papermaking from wood or from annual crops can be influenced by both growing conditions and genetic manipulation. Wong and Chen (2001) showed that wood morphology and chemical composition vary with location, genetics and growth condition. The results of the present study also showed that, the increasing of beating time has substantial effect on the physical properties of paper manufactured from sorghum straws. The tensile strength, burst index and breaking length properties were increased with increasing of the beating time. On the other hand the specific volume decreased with increasing of the beating time.

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الخلاصة

تم في هذا البحث دراسة الخواص الفيزيائية والمتانة للورق المنتج من أصناف الذرة الرفيعة المزروعة في السودان. و تم إنتاج لب الورق من سيقان خمسة أصناف من الذرة الرفيعة وهي وداحمد والهجين والفتيريته وطابت والحيميسي. وتم تصنيع عينات من الورق من كل صنف من سيقان الذرة وفقا للطريقة القياسية الأمريكية الموصي بها لتصنيع الورق. واجريت عليها بعض الاختبارات الفيزيائية مثل الحجم النوعي والاستطالة وقوة الشد ومعامل الانفجار والثني . وقد اخذ قي الاعتبار تاثير زمن الطرق علي هذه الخواص . وقد أظهرت النتائج المتحصل عليها، ان خواص الورق المنتج يختلف باختلاف نوعية سيقان الذرة المستخدم، كما لوحظ ان الزيادة في زمن الطرق قد ساهمت في تحسين خواص الورق المنتج. ولغرض المقارنة فقد تمت مقارنة تلك الخواص مع ذات الخواص لورق الطباعة. هذا وقد أظهرت نتائج المقارنة ان الورق المنتج يماثل لحد كبير ورق الطباعة في الخواص ، بالرغم من ان ورق الطباعة قد تمت معالجته ببعض المواد الكيميائية لتحسين خواصه.