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Influence of Irrigation System on Characteristics of Pulp and Paper Manufactured from Sunflower Stalks

Fadl elmoula Abd alla Idris , Sabah Osman, Safa Idris, Mohammed Alfa
University of Gezira, Faculty of Textile
P.O. Box: 20, Wed Medani. Sudan.

ABSTRACT

Sunflower mainly cultivated for oil production, was evaluated as raw material for pulp and paper making. The irrigated and rain fed sunflower stalks were used to determine the effect of irrigating system on pulp and paper characteristics. The soda-anthraquinone pulping process was used in this study. The study confirms the feasibility of producing pulp and paper from two sunflower stalks been used. Differences in chemical compositions and physical properties of paper manufactured from both stalk were noticed. The cellulose, lignin, ash, 1%NaoH extractive and hot water extractive has been determined for both stalks, furthermore the paper manufactured were subjected to physical properties tests. The tests carried such as burst index, tearing, breaking length and bulk. The results obtained showed that, the pulp produced from irrigated stalks recorded higher values of hot water extractive, 1%NaoH extractive, cellulose, ash contents and yield percentage comparable with same contents obtained from rain fed stalks. On the other hand the physical properties showed slightly differences in burst index (3.26,3.24)for irrigated and rain fed stalks respectively, the tearing resistance it seem to be higher (4.32) for product of irrigated stalks compared with (3.19) value obtained for rain fed stalks.

Keywords: *Sunflower stalks, Pulping process, chemical compositions, physical properties, soda-anthraquinone*

1. INTRODUCTION

Pulp and paper industry is facing ever-increasing demand of quality paper and paper board that is causing search for new hitherto unexploited sources of cellulosic fibers. Out of nearly 600 known species, less than a dozen are in commercial use for pulp production. (Kharistova et al, 2006). Agriculture residues are an excellent alternative to using virgin wood fiber for many reasons aside from their abundance and renewability. Using agriculture residues will benefit farmer, industry and the environment. There are numerous types of agricultural cropping residues, for pulp and paper purposes, only those with cellulose fiber content are of real interest (internet, 2009). Non- wood pulp capacity was estimated at 5% of total paper making capacity in 2004 (SCA and WRI, 2007). A convergence of environmental concerns and wood fiber shortage constraints has led to an increase in non-wood fiber production even in seemingly forest rich regions like Canada and USA (Kissinger et al., 2006). Non-wood plants offer several advantages including short growth cycles, Moderate irrigation and fertilization requirements and low lignin content reduced energy and chemicals use during pulping (Hurter and Riccio, 1998). Sunflowers are an alternative for cereal crops the seed/stalks ratio for this crop is 2:3 (Jimenez et al, 1997).

The soda-AQ pulping makes pulping of sunflower much more attractive and feasible once the other technical constrains such as the high pith content are overcome by employing recent techniques developed for other agricultural residues. As reported by (Kristova et al, 1998). The paper characteristics produced from plants residues mainly depend on chemical compositions of the plant used. Seth and Page (1988) reported that under certain conditions tearing resistance property depends strongly on fiber length. The paper strength also depends on the lignin and cellulose content of plant materials the tensile strength is directly proportional to cellulose content (Madakkadze et al, 1999). The chemical compositions is varies from the plant to plant and also varies within the plant it self. The (ververis et al, 2004) showed that, there is a general tendency for decrease in cellulose, lignin and ash content as we move from the base of the stalks or branches to the top. It has been found by Nishimura et al, (2002) the higher lignin content in the middle parts of kenaf stem, the same result was reported for cellulose by (Neto et al, 1996). The higher content of lignin in coir fiber made the fiber tougher and stiffer compared to other fibres, to protect the carbohydrates from chemical and physical damage (Saheb and Jog, 1999).

2. MATERIALS AND METHODS

For this work two varieties of sunflower stalks cultivated in Sudan were collected form Gezira scheme farm (irrigated) and from Gedarif farm (rain fed).The stem were cut into pieces .the raw material were analyzed for cellulose, lignin, ash, ethanol benzene ,hot and cold water extractable and % caustic soda soluble .

2.1 Pulping process

The Sodium antherquinone method was used for pulping process. Pulping was carried out in eclectically heated rotary digester associated with temperature control device, after completion of pulping process the pressure maintain to atmospheric pressure. The pulp was washed, mixed into mixer and screen by using a No ram pulp screen with slotted plate. The kappa number for the two varieties were found according to T236 cm-85 ,the kappa number used for washing the pulp made from irrigated and rain fed stalk were found (5.39,6.31) respectively, hand sheet of unbleached pulp of gram mage(61.3,59.8) for sheets obtained from rain fed and irrigated stalk respectively were carried in accordance to TAPPI (T272 om-92).

2.2 Statistical Analysis

Data obtained was subjected to analysis of variance (ANOVA, $P< 0.05$) using appropriate statistical software (Origin pro 8.1). Mean and standard deviation were tested using one way analysis of variance.

3. RESULTS AND DISCUSSION

3.1 Characterization of Chemical compositions of sunflower stalks

Results illustrated on Table (1) shows the chemical properties of two sunflower stalks used for pulp and papers manufacturing (irrigated and rain fed) comparable with fibers from some annual plant. It has been noticed from the table (1) that the lignin contents of sunflower for both irrigated (18.36) and rain fed (18.66) were lower indicating that these stalks were easier to pulp than wood with a lignin content of 26 - 30% (Moore, 1996) but still these values were greater when comparable with lignin for wheat straw (22), corn stalks (17.4) and baggase (23.9). However the amount of lignin obtained from both sunflower (irrigated and rain fed) it seem to be similar. This result was agreed with lignin content (18.3) available for sunflower stalks reported by Khristova et al (1998). These content was also found at satisfactory levels (<30%) which indicate this material to undergo bleaching more easily with used of small amount of chemical according to study conducted by Vervris et al (2004). The cellulose obtained for irrigated sunflower stalks was (44.42) is found to be higher when comparable with cellulose of rain fed sunflower (42.03). However the amount of cellulose of both sunflowers was greater than wheat, corn stalks and baggase (38.2, 35.6 and 28.9 respectively). It was also reported that the plant with 34% and over cellulose content was characterized as promising for pulp and paper making form chemical composition point of view (ververis et al, 2004). Base on this report the two types of sunflower stalks can be used as source for pulp and paper manufacturing. The rain fed and irrigated sunflower stalks obtained the following values of hot water soluble (16.77, 17.83),1% Noah (24.03,31.11) and ash content (8.60,9.17%) respectively .

Table1: Chemical Composition of Sunflower S Stalks Fiber Verses Commonly Used Non Wood Fiber

Chemical composition	Wheat straw%	Corn stalk%	Bagasse %	Irrigated sunflower%	Rain fed sunflower%	Sunflower 1	Sunflower 2
Cold water extractive	6.5		2.8	15.05	17.33	-	-
Hot water extractive	23	14.8	5.9	17.83	16.77	22.0	23
1%naoH extractive	40	47.1	32	31.11	24.03	44.9	48.0
lignin	22	17.4	23.9	18.36	18.66	16.2	15.0
cellulose	38.2	35.6	28.9	44.42	42.03	40.6	42.1
Ash	4.7	7.5	-	9.17	8.60	-	-

Sunflower 1-data available from Sudan sunflower stalks, Sunflower 2-data available from Spain sunflower stalks .Source :(Lopez et al, 2005).

3.2 Characterization of pulp and paper making from sunflower stalks

Results on Table (3) presented the pulp conditioning and physical properties of papers produced from irrigated and rain fed sunflower stalks. The cooking conditions for the stalks were kept constant. The kappa number is higher for rain fed sunflower stalks (19.32) comparable with kappa number used for irrigated sunflower stalk (18.13). However the Kappa number of two sunflower stalks were less than value obtained by Khristova et al (1998) using the same residue. The yield of irrigated sunflower stalks (46.80) are found higher than yield of rain fed type (38.1). One-way ANOVA at 95% (α=0.05) confidence level was carried out to determine the significant difference in yield of pulp between irrigated and rain fed sunflower. The results of One-way ANOVA are given in table (8) shows that there is no significant difference in the yield between irrigated and rain fed sunflower at 95% confidence level. Therefore it can be concluded that irrigating systems used does not deteriorate the pulp yield of sunflower.

Table3: Characterization of Pulp Conditions and Properties of Paper Sheet Made from Irrigated and Rain Fed Sunflower Stalks

Parameter	Irrigated sunflower stalk	Rain fed sunflower stalk
Active alkali concentration%	15	15
Anthraquinone concentration%	0.1	0.1
Temperature(C)	170	170
Time at maximum temp/h	1.5	1.5
Liquor ratio	3/1	3/1
Yield (%)	46.80	38.1
Kappa number	18.13	19.32
Bulk(cmg)	0.1046	0.1026
Breaking length(km)		
Burst(kpa-mg)	3.26	3.24
Tear(mN-mg)	4.32	3.19
Fiber length(mm)	1.49	1.25

Table8: One –way ANOVA results for Yield data

	DF	Sum of Squares	Mean Square	F value	prob
Model	12	10.76733	0.26198	0.26198	0.94788
Error	2	6.86	3.425		
Total	14	17.61733			

DF-Degree of Freedom

3.3 Testing of physical properties

The physical properties presented on table (2) shows that the two varieties of sunflower stalks irrigated and rain fed obtained higher freeness value at CSF (181 and 183.5 respectively) comparable with Elephant grass pulp (139) .On other hand this values were lower than freeness of Switch grass (335) reported by Madakadze (2010). The close similarity between the freeness values of two varieties may be due to similarity of apparent density.

The characteristics of pulp and papers obtained for the irrigated and rain fed sunflower stalks were Presented on table (3).The results shows some differences in properties tested, the burst index of irrigated and rain fed were obtained (3.26 and 3.24 respectively). From the results of One-way ANOVA at 95% (α=0.05) confidence level, illustrated on table (5) probability value is found to be (0.03177 < 0.05) which mean that there is significant difference between the burst index of irrigated and rain fed sunflower at 95% confidence level. Results also show that the fiber length of two types of the stalks was (1.49 and 1.25 respectively). One-way ANOVA at 95% (α=0.05) confidence level was carried out to determine the significant difference in the fiber length between irrigated and rain fed sunflower stalks. The results of One-way ANOVA given in Table (7) shows that there is no significant difference between the fiber lengths of

irrigated and rain fed. Sunflower stalks. Difference was noticed for tearing resistance, the irrigated sunflower stalks obtained higher value (4.32) and the rain fed sunflower stalks recorded (3.19). According to the results of One-way ANOVA at 95% (α=0.05) confidence level, probability value of tearing resistance presented on table (6) is found to be (0.086 >0.05) which indicated that there is no significant difference between the tearing resistance of irrigated and rain fed sunflower at 95% confidence level. It has been documented that fiber length of material affected pulp and paper properties. The Horn and stetterholm (1990) found that the majority of variation in burst and tensile strength in hard wood used for pulp sheet could be accounted by fiber length and cell thickness. Also the study conducted by Horn (1978) reported that increase in fiber length enhances the tearing strength of hard wood pulp.

Table 2: Physical Properties for Irrigated and Rain Fed Stalks Vs. Switch and Elephant Grasses

Parameter	Irrigated	Rain fed	Switch grass	Elephant grass
CSF(ml)	181	183.5	335	139
Gramm age (g/m^2)	59.8	61.3	61.60	60.20
Apparent density (g/cm^2)	0.1046	0.1026	0.49	0.68
Specific density (cm^3/g)	9.56	9.74	2.03	1.47
Caliper(mm)	177	164	126.6	88.60

Table5.One- Way ANOVA Results For Burst Index Data

	DF	Sum of Squares	Mean Square	F value	Prob
Model	7	0.00624	8.91667E-4	7.92593	0.03177
Error	4	4.5E-4			
Total	11	0.00689			

Table 6: One –Way ANOVA Results for Tearing Strength Data

	DF	Sum of Squares	Mean Square	F value	Prob
Model	9	0.01723	0.00191	3.58889	0.08653
Error	5	0.00267	5.3333E-4		
Total	14	0.01989			

Table7: One Way ANOVA Results for Fiber Length Data

	DF	Sum of Squares	Mean Square	F value	Prob
Model	7	0.00439	6.27143E-4	0.46785	0.83118
Error	7	0.00938			
Total	14	0.01377			

3. CONCLUSION

The study confirms the possibility of producing pulp and paper sheet from both types of sunflower stalks (irrigated and rain fed). The amounts of cellulose contents for both stalks were above 40% which found to be satisfactory. The differences in chemical compositions, pulp and paper characteristic probably due to irrigating system applied. The amount of lignin content was agreed with lignin content available for sunflower stalks reported by (Kristova, 1999). However the yield found are higher for irrigated sunflower compared with yield from rain fed sunflower stalks. The chemical analysis obtained in general was slightly different from those obtained by (Eroglu et al, 1992) using oxygen pulping for the same plant residue.

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