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# Manufacturing Paper Sheets from Olive Wood by Soda, Sulphite and Kraft Pulping

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**Abstract:**Paper sheets from Iranian olive tree produced by soda, sulphite and kraft pulping.Then the influence of pulp beating on properties of paper sheets was studied. Kraft pulp exhibited the highest holocellulose/yield $\alpha$-cellulose/yield ratios and the sulphite pulp the soda pulp the highest lignin/yield ratio. Paper sheets from kraft with the breaking length 5851 m, stretch 4.61%, Burst index 4.48 KN/g and tear index 2.03 $mNm^2/g$, exhibited the highest resistance. Sulphite pulp showed the highest brightness (41%). The brightness difference between Kraft and soda pulp was not significant. Soda pulp required more intensive beating than did kraft or sulphite pulps; in fact, the PFI beater had be operated at about 50% higher number of beating revolutions to obtain soda pulp with 80-85° SR.

**Key words:** Yield · Pulping · Soda · Sulphite · Kraft · Beating

## INTRODUCTION

Papermaking (defined as being made of pulped cellulose) was invented from nonwoodmaterials in China almost 2000 years ago. Textile rags, cereal straw, reeds, grasses andsugar cane bagasse have been used in pulping and papermaking ever since, especially inAsia. The invention of industrial printing in the 15th century implied a rapid increase indemand for paper. Yet, it was not until 400 years later, that the use of wood to make pulphad been invented in Germany by Friedrich Gottlob Keller in 1840. The annualproduction of paper from wood pulp has grown since to a multi-billion dollar industry,concentrated mostly in a few industrialized countries. Today, about 90 percent of allpulps are being produced from wood [1]. Non-wood materials are also significant because they can help offset the growing shortage of forest wood resources.

The world production of this type of pulp has grown at a higher pace than that of wood pulp over the past two decades. Production figures are bound to rise even further in the coming years in response to the increasing demand in highly populated countries that produce vast amounts of agricultural cropping residues and fast growing plants [2]. This type of pulp is used as such or mixed with othersfrom wood or old paper to obtain a variety of products including paper, board and other lignocellulosic derivatives.In recent years, the pulping potential of various nonwood materials has been examined. Agricultural cropping residues are highly Iran. It is believed that the olive tree originated in the Mediterranean in prehistoric times. Iran lies in the Eastern Mediterranean - a part of the world that has been cradle of ancient civilizations and has been implicated as a possible place of birth for the olive tree.

The early history of olive tree in Iran has been shrouded in uncertainty but we know that olive was mentioned in ancient Iranian religious hymns of two thousand years ago. The history ofolive implantation in the major olive-growing region of the country (Roodbar) has been documented for the past nine hundred years. Today, Iran,with an olive crop area of 35,000 hectares and an olive oil production of 3,000 tons peryear, is one of the olive-growing countries of the world. Olive cultivars aredistributed in provinces of Gilan, Zanjan and Golestan in the North and Khozestan andFars in the South. Certain regions of Gilan province (Loshan, Manjil, Rodbar, Aliabad, Jodaky, Vakhman, Bahramabad, Kalashtar, Koshk, Rostamabad and Ganjeh) are the most important olive-growing areas in the country [3]. The olive gene pool of Iran constitutes a potentially important subset of the olive gene pool in the world.One of the references to

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the use of olive tree wood for pulping appear to be those of Camacho *et al*. [4], who studied this material in relation to the kinetics of the kraft process.In another study, paper sheets from olive tree wood pulp were obtained by soda, sulphite or kraft pulping were studied to examine the influence of pulp beating on properties of the paper sheets [5, 6]. Jimenez *et al*. investigated the influence of process variables on the properties of pulp and paper sheets obtained by sulphite pulping of olive tree wood [7].

In this work, the efficiencies of the soda, sulphite and kraft pulping processes as applied to Iranian olive tree wood were compared. The influence of pulp beating on the drainability (Shopper-Riegler index) and the properties of the paper sheets obtained from the pulps (breaking length, stretch, burst index and tear index) were examined.

## MATERIALS AND METHODS

**Raw Materials:** We used olive tree wood trimmings containing 62.4% holocellulose, 36.3% α-cellulose and 19.1% lignin by dry matter weight. The deviations of these contents from their respective means were all less than 2%. The material, free of young stalks and branches and also of leaves, was sun-dried and ground to pieces 10-20 mm long. The bark was not stripped off as it was very thin and difficult to remove.

**Characterization of Raw Materials, Pulps and Paper Sheets:** The starting materials and the products obtained from them were characterized according to the following norms: holocellulose [8]; α-cellulose [9], lignin [9], Schopper-Riegler index [10], brightness [10], breaking length [10], stretch [10], burst index [10] and tear index [10].

**Pulping:** Cellulose pulps were obtained by using the soda, sulphite and kraft processes in a 15 L digester wrapped in an electrically heated jacket. The system was rotated by a motor for agitating the digester. The control unit included the appropriate instruments for measuring and controlling the heating temperature.

**Soda Pulping Process:** An amount of wood was placed in the digester and supplied with the amounts of soda and water required to obtain a soda concentration of 8% (as Na2O) and a liquid/solid ratio of 6:1. The mixture was completed with 0.5% of anthraquinone.Following heating at 175°C for 45 min in the digester, the cooked material was washed with water and passed through a wet shredder. Next, the pulp was subjected to mechanical treatment on a Sprout-Waldron refiner. Finally, fibers and uncooked material were discarded and the pulp was washed in a fiber scavenger with water. The resulting pulp was processed on a PFI beater under different operating conditions in order to obtain various drainability levels as Tappi 248CM-85 standard [9].

**Kraft Pulping Process:** The procedure was similar to the previous one except that it used sodium sulphite, soda and water in the proportion required to obtain an active alkali concentration of 10% (as $Na_2O$), a sulphidity of 16% and a liquid/solid ratio of 6:1. The mixture was cooked at 165°C for 60 min.

**Sulphite Pulping Process:** The sulphite procedure was similar to the previous two but used sodium carbonate, sodium sulphite and water in appropriate amounts to ensure a sulphite concentration of 12.5% (as $Na_2O$) and a liquid/solid ratio of 6:1. The mixture was supplied with 0.5% anthraquinone and cooked at 165°C for 120 min.

**Sheet Making:** Paper sheets were obtained by using an ENJO-F- 39.71 sheet former according to UNE 57042-74 [10].

## RESULTS AND DISCUSSIONS

Table 1 gives the mean values for the yield and brightness obtained, as well as the holocellulose, α-cellulose and lignin contents in the olive tree wood pulps provided by the soda, sulphite and kraft processes (five experiments in each process). The deviations of these parameters from their respective means were all less than 8%. As can be seen, pulp yield ranged from 43 to 46%. Soda pulp exhibited the lowest holocellulose and α-cellulose contents and the highest lignin content.

On the other hand, kraft pulp exhibited the highest holocellulose/ yield and a-cellulose/yield ratios and the soda pulp the lowest lignin/yield ratio. Based on these results, kraft pulp would provide the strongest paper sheets and sulphite pulp the brightest ones.

Table 2 gives mean values (for 8 experiments in each parameter) of the drainability (Shopper-Riegler index) and the properties of the paper sheets (breaking length, stretch, burst index and tear index) made from beaten soda, kraft and sulphite pulps. The deviations of these parameters from their respective means were all less than 6-8%. As can be seen (Table 2), the values of the drainability increased less markedly with increasing

Table 1: Yield, holocellulose, a-cellulose, lignin contents and brightness of pulp from olive tree wood obtained by the soda, kraft or sulphite processes.

| Pulp | Yield (%) | Holocellulose (%) | H [1]/Y [2] Ratio | α-Cellulose (%) | α-C [3]/Y Ratio | Lignin (%) | Lignin/Y Ratio | Brightness (%) |
|---|---|---|---|---|---|---|---|---|
| Soda | 46.1 | 74.0 | 1.61 | 61.0 | 1.32 | 22.5 | 0.49 | 19.5 |
| Kraft | 43.3 | 80.1 | 1.85 | 66.4 | 1.53 | 19.2 | 0.44 | 23.7 |
| Sulphite | 44.5 | 81.2 | 1.82 | 64.0 | 1.44 | 16.1 | 0.36 | 41.0 |

1 Holocellulose
2 Yields
3 α-Cellulose

Table 2: Variations of drainability and properties of paper sheets made from soda, kraft or sulphite pulps obtained from olive tree wood, as a function of the number of PFI beating revolutions

| Pulp | Number of PFI beating | Drainability (SR) | Breaking length (m) | Stretch (%) | Burst index (kN/g) | Tear index ($mNm^2/g$) |
|---|---|---|---|---|---|---|
| Soda | 0 | 20.5 | 497 | 0.9 | 0.25 | 1.18 |
| | 2000 | 37.8 | 2148 | 1.42 | 1.04 | 1.2 |
| | 3500 | 56.7 | 3143 | 2.28 | 1.63 | 1.31 |
| | 6500 | 73.3 | 4263 | 2.72 | 2.5 | 1.52 |
| | 7500 | 81 | 4298 | 2.79 | 2.74 | 1.73 |
| | 9000 | 85.8 | 5118 | 3.74 | 3.09 | 1.91 |
| Kraft | 0 | 22.1 | 1673 | 1.16 | 0.7 | 1.43 |
| | 2000 | 49.4 | 3922 | 2.6 | 2.33 | 1.81 |
| | 3500 | 68.3 | 4590 | 3.49 | 3.21 | 1.91 |
| | 4500 | 74.7 | 5323 | 4.13 | 3.67 | 1.99 |
| | 5000 | 81.3 | 5241 | 4.15 | 4.26 | 2.03 |
| | 6500 | 86.3 | 5851 | 4.61 | 4.48 | 2.03 |
| Sulphite | 0 | 14.7 | 576 | 0.74 | 0.26 | 1.63 |
| | 2000 | 44.1 | 3526 | 2.04 | 1.98 | 1.78 |
| | 3500 | 70.4 | 4672 | 3.01 | 2.86 | 2 |
| | 4500 | 78.8 | 5035 | 3.02 | 3.3 | 2.17 |
| | 5000 | 82 | 5121 | 3.14 | 3.66 | 2.29 |
| | 6500 | 87.2 | 5995 | 3.38 | 4.13 | 1.99 |

beating of the soda pulp than of the other pulps (kraft and sulphite); this suggests that soda pulp requires more refining energy than do kraft and sulphite pulps to reach a given drainability level. On the other hand, the values of all four properties of the paper sheetsincreased with increased beating, the effect being less marked for the tear index than for breaking length, stretch and the burst index.A comparison of the breaking length and burst index for the soda, kraft and sulphite pulps revealed very similar values for unbeaten soda and sulphite pulps and somewhat greater values for kraft pulp. On the other hand, the properties of paper sheets from beaten sulphiteand kraft pulps had similar values that exceeded those of paper from soda pulp. On equal beating, soda pulp gives the paper sheets with the smallest breaking length ± the other two types of pulp are similar to each other in this respect [6]. As regards stretch, paper sheets from kraft pulp exhibited the largest values and those from soda pulp the smallest. Also, the increase in stretch with increasing beating was more marked in paper from kraft pulp than in that from soda pulp. As with stretch, the burst factor was greater and increased more markedly with increasing beating in paper from kraft pulp than in sheets from the other two pulp types (particularly soda pulp).

Finally, paper from soda pulp exhibited smaller tear index values than did sheets from the sulphite and kraft pulps beaten to an identical extent. Also, the variations were less even than those for the other properties studied, shown by the much narrower range spanned by the tear index values which varied little with beating.

## CONCLUSIONS

The contents in holocellulose per yield unit of pulps from olive tree wood subjected to the kraft and sulphite processes exceed that of soda pulp by 15.2% and 13.7% respectively. The α-cellulose/yield ratio of kraft and sulphite pulps is 15.9 and 8.7% higher, respectively, than that of soda pulp. On the other hand, the lignin/yield ratio of soda pulp is 11.4% and 36.1% more than that of kraft and sulphite respectively. All this reflects in increased resistance of paper sheets from kraft and sulphite pulps (Table 2) and in higher brightness in the sulphite pulp (Table 1).

Soda pulp requires more intensive beating than do kraft and sulphite pulps; the PFI beater must be operated at a 50% higher number of beating revolutions to obtain pulp with 80-85°SR. On similar beating, kraft and sulphite pulps from olive tree wood provide paper sheets with greater breaking length, stretch, burst index and tear index than does soda pulp from the same material [11]. In fact, the breaking length, stretch, burst index and tear index of paper from kraft pulp beaten to a Schopper-Riegler index of 80-85°SR exceed those of sheets from soda pulp beaten to the same extent by 14-22%, 23-48%, 45- 55% and 7-17%, respectively.

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