Introducing molasses as a new additive in papermaking

TAMER Y.A. FAHMY

ABSTRACT: This study introduced, for the first time worldwide, molasses as an additive in papermaking. The introduction of molasses as an additive in papermaking resulted in paper composites with greater breaking length and remarkably higher water retention value (WRV), compared with paper that does not have molasses as an additive. Previous studies have shown that incorporating the cell wall microstructure of cellulose fibers with sucrose greatly enhanced the breaking length and WRV. It is well established in the literature that using gums (including starch) as additives in papermaking enhances paper strength. Molasses, which contains sucrose and gums (including starch) is a byproduct of the sugar industry and is cheaper than sucrose. Mercerization of pulp fibers before loading them with molasses was shown to greatly enhance the positive effects produced by loading with molasses.

Application: Paper composites produced using molasses as an additive are useful as specialty absorbent paper.

Molasses is an important byproduct of the sugar extraction process. The liquid discharged by the centrifugals in the last stage of sugarcane juice processing, after no more sugar can be separated from the sugarcane juice by usual factory methods, is called final molasses. Molasses contains sucrose, which cannot be recovered by economic methods. Sucrose (lost in molasses) represents the highest proportion of the losses incurred in the processing of sugarcane. This loss may reach approximately 9% of the total sucrose and is the principal reason for the studies that have been conducted on the profitable use of this valuable byproduct. The sucrose content in molasses may range from approximately 32% to 44%. Other reducing sugars are present in molasses, namely glucose and fructose. The content of reducing sugars ranges from approximately 10% to 15%. The principal value of molasses as an industrial raw material lies in its content of fermentable sugars, which amounts to approximately 50% by weight. Gums (including starch) are also present in molasses and range from 3% to 5% by weight [1].

Previous studies have shown that incorporating the cell wall microstructure of cellulose fibers with sucrose or reducing sugars (as glucose and fructose) greatly enhanced the breaking length and water uptake (WRV) of paper [2–7]. The literature also shows that using gums (including starch) as additives in papermaking enhances paper strength [8].

Molasses has several advantages as a paper additive. It contains sucrose and gums (including starch), and, as a byproduct of the sugar industry, it is cheaper than sucrose. Molasses contains much of the sucrose lost in the sugar industry. For these reasons, molasses was chosen as a new additive to study.

Moisture content %	5.41
Ash content %	0.24
Alphacellulose %	98.00
Degree of polymerization (DP)	973
Water retention value (WRV) air-dried %	57.90

I. Analysis, physical properties of Egyptian cotton linters.

Also, previous studies have shown that mercerization of pulp fibers, before incorporating them with the desired substance, greatly enhances the incorporation capacity of cell wall microstructure of cellulose fibers and has a positive influence on paper properties [2, 9–12]. Therefore, we also studied the effect of mercerization of pulp fibers before treatment with molasses.

EXPERIMENTAL

Cotton linters pulp is the basic specialty agricultural residue pulp possessing the highest alpha cellulose content. The Egyptian cotton linters used in this work were provided by Abo-Zabel Mill, Cairo, Egypt. The cotton linters were provided air-dried, in loose form. **Table I** shows the results of the chemical and physical analyses we conducted for these cotton linters.

RESULTS AND DISCUSSION

Effect of loading air-dried cotton linters with molasses

The air-dried cotton linters were first beaten until 30ºSR (55 min.). The beaten linters were put in the mixer and impregnated with molasses solutions at concentrations of 5%, 10%, 15%, and 20% w/w and stirred for 15 min. [2–5]. Paper sheets were prepared using the SCA-model sheet former (Lorentzen & Wettre, Kista, Sweden). Properties of the obtained paper are shown in **Table II**. Water retention values were determined according to the modified German Standard Method [13, 14].

It is clear from Table II that the addition of molasses solutions during stock preparation and sheet making improved the properties of the final sheets. The WRV of the loaded paper sheets increased as the concentration of the molasses solutions increased. The percentage increase in WRV reached a maximum of approximately 29% when the loading molasses solution concentration was 20 w/w. The breaking length also slightly increased in a progressive manner, with the highest percentage increase of approximately 10%. The wet breaking length also increased progressively, with the highest percentage increase of approximately 7%.

Concentrations of the molasses solutions % w/w	0	5	10	15	20
Breaking length in meters	1733	1803	1901	1911	1914
% increase in breaking length	----	4.04	9.69	10.27	10.44
Wet breaking length in meters	287	295	304	308	305
% increase in wet breaking length	----	2.78	5.92	7.31	6.27
WRV of paper sheets %	54.16	59.12	65.34	69.31	70.14
% increase in WRV	----	9.15	20.38	27.97	29.50

II. Properties of paper made from air-dried cotton linters before and after loading with molasses.

Concentrations of the molasses solutions % w/w	0	5	10	15	20
Breaking length in meters	1679	1968	2197	2467	2473
% increase in breaking length	----	17.21	30.85	46.93	47.29
Wet breaking length in meters	284	300	307	349	347
% increase in wet breaking length	----	5.63	8.09	22.88	22.88
WRV of paper sheets %	77.93	93.71	102.67	112.27	113.18
% increase in WRV	----	20.24	31.74	44.06	45.23

III. Properties of paper made from mercerized wet cotton linters loaded with molasses

Effect of mercerization of cotton linters

In these experiments, the air-dried cotton linters were subjected to mercerization using sodium hydroxide solution (17.5 w/w) at 20ºC for 35 min., then washed with water until neutral pH conditions were reached and kept wet for further processing. The WRV of the mercerized non-dried linters fibers was 118.69%. The mercerized non-dried cotton linters were beaten in a Jokro beater until 30ºSR (45 min.). Each prepared molasses solution was added to the mercerized beaten cotton linters in the mixer and stirred for 15 min. Paper hand sheets were made from the pulp suspensions in the molasses solutions. Paper properties using mercerized wet cotton linters are shown in **Table III**.

It is clear from Table III that mercerization of cotton linters, before loading them with molasses, greatly enhanced the WRV and the wet and dry strengths of the prepared paper composites, compared with unmercerized cotton linters.

The WRV of the paper sheets, prepared from mercerized non-dried molasses-loaded linters, increased as the molasses solution concentrations in-

creased. The WRV of the molasses-loaded paper sheets reached a maximum of approximately 113% at molasses concentration 20% w/w. The breaking length also increased progressively, reaching its maximum at molasses concentration 20% w/w. The highest percentage increase in breaking length was approximately 47%. The wet breaking length also increased progressively and reached its maximum, approximately 23%, at molasses concentration of 15% w/w.

CONCLUSIONS

For the first time, molasses, a byproduct of the sugar industry that is cheaper than sucrose, was used as an additive in papermaking. The resulting paper composites exhibit greater dry and wet breaking length, and remarkably higher WRV, compared with paper that does not have molasses as an additive. Mercerization greatly enhances the positive effects produced by loading with molasses. Paper composites produced in this work are useful as specialty absorbent paper. This work shows that the benefits of using molasses are close to the benefits of using the more expensive additive sucrose. **TJ**

Received: September 8, 2006
Accepted: March 23, 2007

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INSIGHTS FROM THE AUTHORS

Sucrose has shown promise as an additive in papermaking. Molasses, a byproduct of the sugar industry, is a cheaper alternative that yields benefits comparable with the more expensive additive sucrose.

One difficulty with the research was determining how to greatly enhance the positive effects produced by loading with molasses. Mercerization of pulp fibers before loading with the molasses addressed the problem.

Mills could benefit from this study by introducing molasses as an alternative to sucrose as an additive in papermaking. The next step is to transfer the research from the lab to a pilot scale.

Fahmy

Fahmy is with the Cellulose and Paper Department, National Research Center, Sh. El-Tahrir, Dokki, Cairo, Egypt; email Fahmy at drtamer_y_a@yahoo.com.