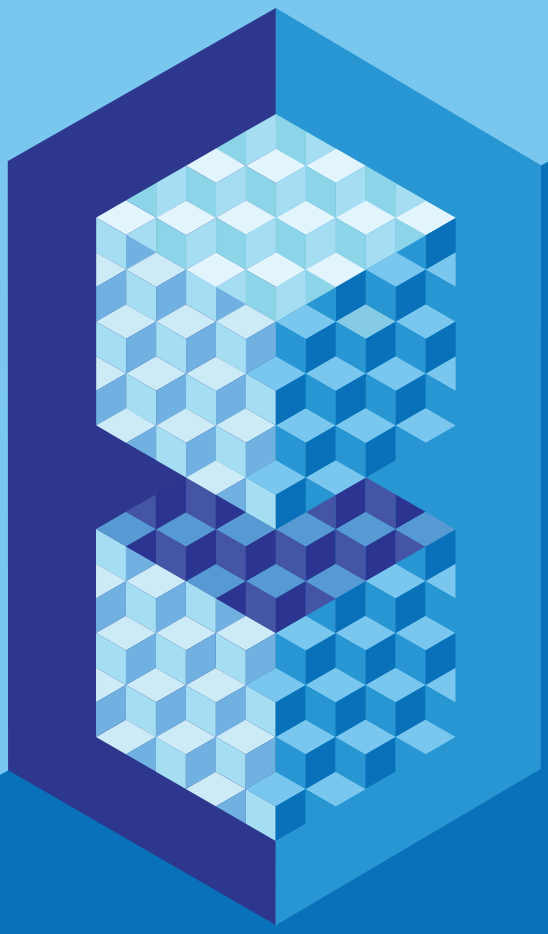

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HUMAN PERCEPTION AND GRAPHIC INDUSTRY

Paper as a printing substrate

STRENGTH PROPERTIES OF NEWSPRINT FROM RECOVERED PAPER IN ADMIXURE WITH WHEAT PULP

Ivana Plazonić, Željka Barbarić-Mikočević, Irena Bates
University of Zagreb, Faculty of Graphic Arts, Zagreb, Croatia

Abstract: *For papermakers throughout the world recovered paper that is repulped and made into new paper has become an important complement to virgin fibre. However, it should be noted that the maintenance of the fibre cycle relies on the feed of a certain amount of virgin fibres to ensure the strength and other properties of the paper to be produced. Therefore, along used papers and paperboards less expensive sources of virgin fibres such as non-wood fibres, especially agricultural waste, could be interesting alternative for pulp and paper industry. As newsprints are not high quality papers according to its optical, mechanical and chemical characteristics, in this research the possibility of using wheat semichemical pulp mixed with recycled pulp for making newsprint was studied at laboratory scale. For that purpose the tensile strength, tear resistance, bursting strength and surface strength (wax picking test) of laboratory made papers were determined according to TAPPI standards and compared to each other. Results indicated that addition of 10 to 30% wheat pulp to recycled pulp did not significantly changed the sheet strength of the laboratory newsprint compared with the control sheet (100% repulped recovered paper). Overall, the results showed that wheat straw as cheap, abundant and renewable agricultural residue of annual crops is valuable raw material which can be used as a lignocellulosic fibre for making newsprint in combination with recycled fibres.*

Key words: wheat straw, semichemical pulp, newsprint, strength properties

1. INTRODUCTION

Although the recovered paper is important complement to virgin fibre, in pulp and paper industry fibres of cellulose pulp derived still predominantly from wood (Schott et al., 2003). In Europe, recovered paper has become a major raw material representing 51 % of the total volume of the raw materials used by the paper industry (Grossmann, 2009). However, it should be noted that the maintenance of the fibre cycle relies on the feed of a certain amount of virgin fibres to ensure the strength and other properties of the paper to be produced. Therefore during papermaking process from recycled pulp, definite percentage of virgin wood (softwood) pulp is added to provide the desired strength of paper. Worldwide in the last few decades' non-wood plants and agricultural residues as virgin fibre resources attracted renewed interest for paper products. Till now only about 2% of the raw materials involved in papermaking in USA and Europe are non-wood fibres (Grossmann, 2009). Studying on utilisation of suitable non-wood species was provoked with increased trend in need and consumption of wood for different purposes and consequently the shortage of conventional wood raw material for pulping industry. Based on numerous advantages which non-wood plants offer, including short growth cycles, abundant availability and low price, such sources of fibres are used mainly for cardboards and fluting papers as low quality paper (Schall et al., 2009., Sarkhosha et al. 2009). One of the most investigated agricultural residue as non-wood raw material for pulp and paper industry is wheat straw (Potůček et al., 2014). This is understandable considering that the wheat is the most widely cultivated crop in the world (Curtis) which consequently generates substantial quantities of residues of about 529 million tons worldwide every day (Govumoni et al., 2013.). Along lots of benefits which the utilization of wheat straw for pulp and paper production have, there are also some deficiencies such as low pulp yield and problems whit the recovery of spent puling liquors by soda pulping process (Veisi & Mahdavi, 2016). On a global scale so far wheat straw pulp, carried out by soda-anthraquinone process, based on its mechanical properties has proven as a good substitute to old corrugated cardboard (OCC) pulp for making fluting paper. Namely, blending of wheat straw soda – anthraquinone pulp with OCC pulp in different ratios significantly improved all the paper properties, except tear index, compared to 100% OCC pulp (Schall et al., 2009., Sarkhosha et al. 2009).
The aim of this research was to determine the potential value of wheat straw for pulp and papermaking based on strength properties of laboratory made newsprint from recovered paper in admixture with variable content of wheat pulp. As newsprint represents a lower grade paper along accepting four-color printing (CMYK), paper strength properties are the most important one.

2. METHODS

The experimental part of this research was divided into three stages: 1. obtaining wheat pulp; 2. forming laboratory papers with variable contents of wheat pulp; 3. analysing strength properties of laboratory made newsprint sheets

2.1 Obtaining wheat pulp

For this study wheat straw as an agricultural residue of wheat crop was used. After harvesting these winter crop, the straw was collected from the fields and was cut manually into 1- to 3-cm-long pieces before it was converted into semichemical pulp according to the soda method (Plazonic et al. 2016). Operating conditions of straw pulping are presented in Table 1.

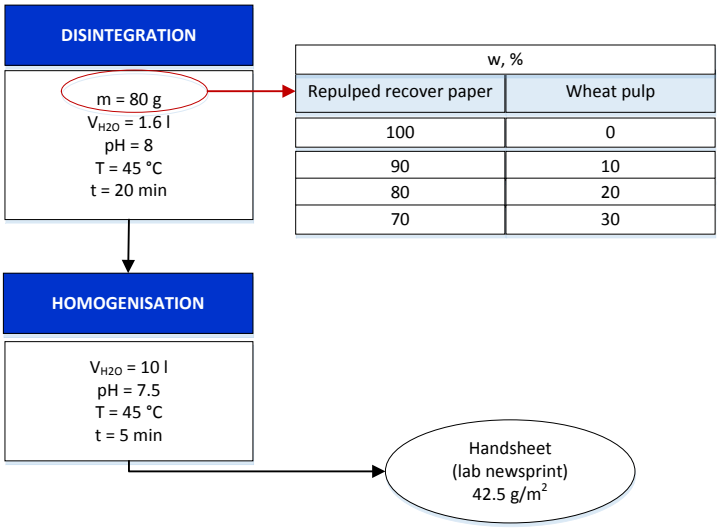
Table 1: Operating Conditions of Straw Pulping

Agricultural residues	Pulping method	Extraction conditions
Wheat straw	Soda pulping	Temperature of 120 °C, alkali level of 16% for 60 min, and a 10:1 liquid to biomass ratio

After the thermal treatment under controlled and defined extraction conditions, the pulp slurry was removed from the black process liquor by decantation and rinsed with water. In a Valley beater (Techlab Systems (TLS), Spain), pulp was diluted with tap water to maintain the pulp suspension at a 1.5% consistency and fiberized. Finally, the pulp was drained by Manual Sheet Former TAPPI (Techlab Systems (TLS), Spain) and allowed to dry to a moisture content of approximately 7% at the room temperature.

2.2 Forming laboratory newsprint with variable contents of wheat pulp

The obtained unbleached wheat pulp was mixed with recycled newsprint in different weight ratios in order to form laboratory newsprint sheets at 45 g/m^2 basis weight needed for this research. According to the general process flow of forming newsprint sheets presented in Fig. 1, three sheets containing variable content of straw pulp (Paper Sample No. 1-3) and a control sheet (Paper Sample No. 0), made only from repulped recover paper were formed (Table 2.).



w, %	
Repulped recover paper	Wheat pulp
100	0
90	10
80	20
70	30

Figure 1: Workflow of forming newsprint sheets

Table 2: Combination of different ratios of wheat pulp and repulped recovered paper for laboratory newsprint sheets

Paper Sample No.		0	1	2	3
Content	Wheat pulp	0%	10%	20%	30%
	Repulped recover paper	100%	90%	80%	70%
Explanations		Control sheet	Gradual reduction of repulped recover paper and increment of imported wheat fiber pulp		
Appearance					

2.3 Analysing strength properties of formed newsprint sheets

The newsprint sheets properties were determined according to TAPPI standards except for thickness, which was determined by the ISO standard method.

The thickness of newsprint sheets was determined according to ISO 534 (2011), which defines a single sheet thickness as a distance between one surface of a paper and the other, measured under an applied static load. These measurements were taken with a digital electronic thickness gauge (Enrico Toniolo S.R.L., Italy), where cylindrical stainless steel weight makes pressure of 0.5 kg/cm2 (49.03 kPa).

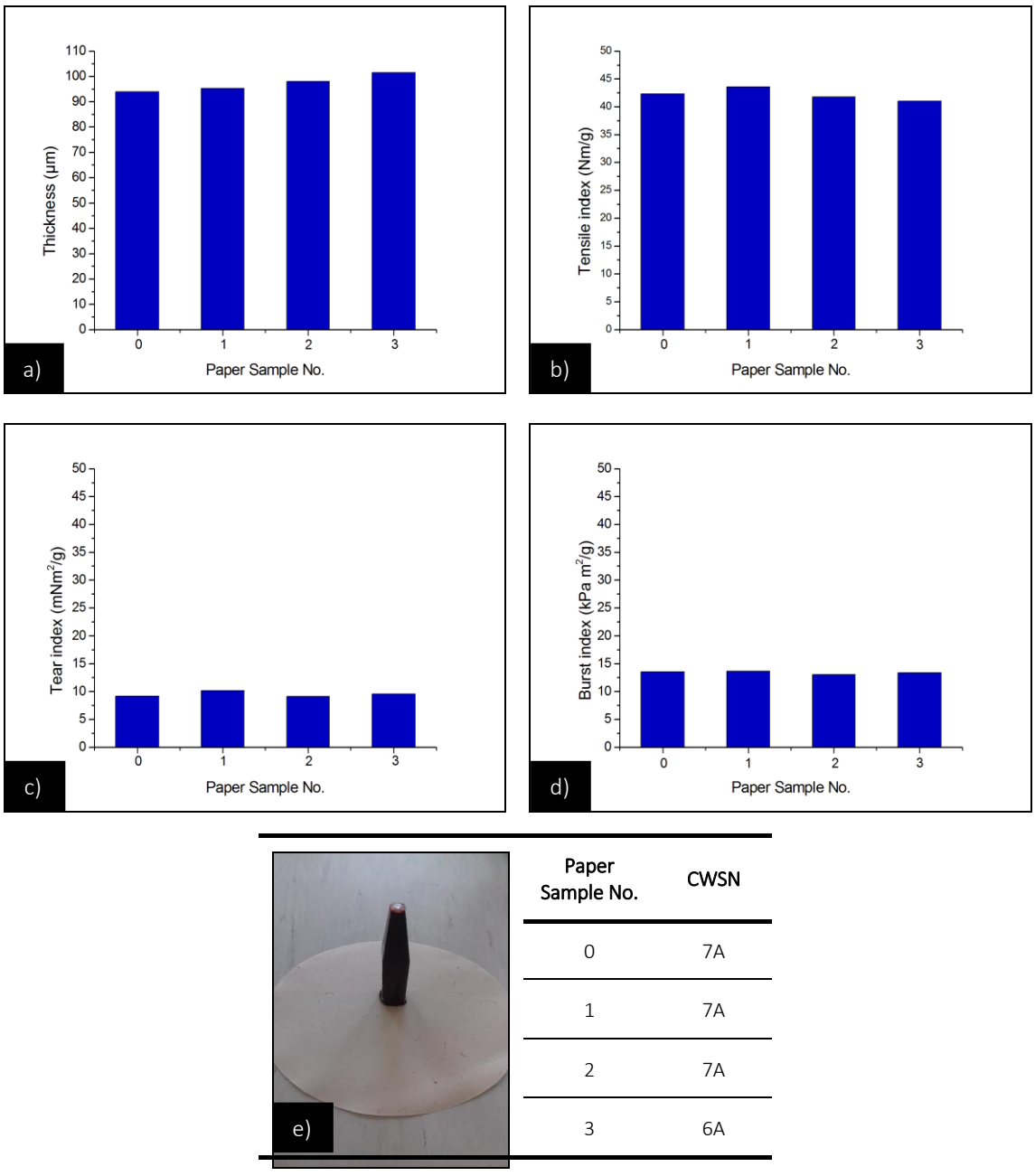
By TAPPI standard method, TAPPI T494 (2001), the test piece of laboratory sheet was stretched to the point where the rupture occurs. The maximum tensile force the test piece can withstand before it breaks and the corresponding elongation of the strip were measured and recorded. Meanwhile, TAPPI T414 (1998) Elmendorf-type procedure, was used to measure the mean force needed to tear a single thickness of sample of newsprint that has an initial cut i.e. internal resistance of laboratory made newsprint sheets. The burst strength of each sheet was measured according to TAPPI T403 (1997) procedure.

The standard Dennison wax pick test was performed to determine the highest wax number that will not give paper failure when pulled from the surface in accordance with the TAPPI T459 (1993). This test uses a series of waxes having different adhesiveness that are numbered from 2A to 26A. The lowest wax number that does not disturb the test surface is quoted as the Critical Wax Strength Number (CWSN) and is used as a measure of the surface strength of uncoated and coated papers. A high CWSN designates a strong surface strength.

As laboratory made newsprint sheets are not homogenous materials, in all strength paper testing measurements were repeated 10 times to obtain a more precise estimate of the value for the property measured.

3. RESULTS

After the experiment data processing, the effects of varies blending levels of two pulp types (wheat pulp and repulped recover paper) on the average thickness and strength properties (tensile index, tear index, burst index and CWSN) of the newsprint handsheets was established. Figures 2a-e summarise the influence of variable soda wheat pulp content in laboratory made newsprint samples on paper strength properties. Paper Sample No.0 is Control sheet formed only from repulped recover paper, while in Paper samples No. 1-3 repulped recover paper content were gradual reduced by increment of imported wheat fiber pulp (10-30%).



Paper Sample No.	CWSN
0	7A
1	7A
2	7A
3	6A

Figure 2: Effect of wheat fibre pulp on: a) thickness of newsprint sheets; b) tensile index of newsprint sheets; c) tear index of newsprint sheets; d) burst index of newsprint sheets; e) CWSN of newsprint sheets

4. DISCUSSION

The strength properties of paper samples are substantially influenced by individual characteristics of cellulose fibres as well as by the paper network structure. It is important to say how this research was studied at laboratory scale. Namely, if we talk about commercial newsprint behaviour due to the orientation of fibres some strength properties are derminated for two directions. Namely, for measuring tensile and tear resistance from the same sheet of paper two strips were cut in two directions: machine direction (MD - the direction in which the paper moves during manufacture) and cross-machine direction (CD - the direction at right angles to the machine direction). In laboratory made newspapers, fibres are not properly oriented as in commercial papers, due to the way of functioning semi-automatic Rapid-Kothen sheet former used for making laboratory sheets. Laboratory papers as fibre-based material contain significant variations in a structure. These variations are natural due to fact that its individual fibres are differ in length, shape, chemical structure etc. The differences and variations of properties of

fibres increase during pulping and in papermaking process variations in the structure and properties of paper are created as well. The inhomogeneity of the pulp and paper material strongly effect on the strength properties results of the paper.

The effect of wheat fibre pulp on strength properties of laboratory newspaper samples were discussed by comparison with control sheet (Paper sample No.0). On the basis of these results (Figure 2a-e), it can be concluded that all variety of wheat fiber pulp, carried out by conventional soda process, resulted in laboratory newspapers having almost equal values in all of the observed properties.

In the case of thickness, results were in a range between 94.0 and 101.5µm. The Figure 2a shows the relationship between thickness and imported wheat fiber pulp in repulped recover paper of handsheet. Namely, addition of wheat fiber pulp to the main recovered paper portion produced laboratory newspapers with higher thickness.

Tensile index, tear index and burst index are probably the most used ones for the direct measurement of the paper strength potential. Figure 2b shows the relationship between tensile index and laboratory newsprint samples composition. It can be seen that the trend of tensile strength development after wheat fiber pulp addition was negligible decreased. The tensile index of Control sheet was 42.34 ± 3.45 Nm/g and of Paper sample No.3 with the highest content of wheat fiber pulp was 41.02 ± 1.61 Nm/g. Tear index and burst index values were similar for all analysed Paper samples. No significant changes were observed in tear index (Figure 2c) and burst index (Figure 2d) of laboratory made newsprint sheets with the addition of wheat straw pulp.

From Figure 2e it could be clearly seen how the surface strength (CWSN value) of the laboratory papers containing straw fibre pulp were similar to those of the control sheet (CWSN =7A), except for Paper Sample No.3 with 30% of straw fibre pulp (CWSN= 6A).

In the scope of our study, the preliminary results obtained offer a possibility to utilize soda pulp from wheat straw, at least partially, in the pulp and paper industry, e.g., in admixure with recovered paper to manufacture newsprint.

5. CONCLUSIONS

The aim of the research was to point out the influence of wheat fibre pulp on strength properties of newsprint. The admixture of 10% of soda wheat fibre pulp and 90% recovered paper produced laboratory newsprint with greater tensile, tear and burst strength than the control sample of 100% recovered paper newsprint. The maximum portion of wheat fibre pulp in newspaper handsheet was 30%, and strength properties of those papers were negligible lower in comparison to control sample. Overall, the results of this study suggest that the potential of wheat straw in supplying fibre for making newsprint should be further considered.

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