# BENDING STIFFNESS OF RAPESEED STRAW PULP

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**Abstract**

The paper deals with chemi-mechanical pulping of rapeseed straw (species *Brassica napus* L. convar. *napus*). The influence of caustic soda charge applied in the leaching process upon the bending stiffness, and bending modulus of elasticity of pulp was investigated. The results obtained for rapeseed straw were compared with those measured for unbleached spruce groundwood and waste paper.

***Keywords**: pulping; rapeseed straw; bending stiffness*

## Introduction

In the present context, non-woody plants are receiving more attention in order to fulfil the shortage of wood fibres in pulp and paper industry due to its abundance and cost effectiveness [1, 2]. Among various sources of non-wood fibre, rice straw [3, 4], as well as wheat straw [5, 6] have been utilised in huge quantity and contribute as the largest source of non-wood raw material for the paper industry.

Rapeseed is the third most important oilseed crop after soybean and palm. Its applicability is not only limited to edible oil production but also used in biodiesel production. Furthermore, it can be extended in pulp and paper industry as a source of non-wood fibre [7].

Hence, the objective of this work is to prepare pulp from rapeseed straw by chemi-mechanical pulping and to investigate the influence of the varying alkaline dosages in the leaching process on the strength properties like bending stiffness, and bending modulus of elasticity.

## Materials and Methods

Rapeseed straw (*Brassica napus* L. convar. *napus*, in our case linie genotype Ontario) from Bohemian-Moravian Highlands was used for forming chemi-mechanical pulp. Fine mass of stalks with varying diameter was obtained separating the valves of silique, debris and leaves from rapeseed straw. Then, the stalks were cut manually by flower scissor into small pieces producing the chips having length of 20 mm approx. Using a laboratory vibrating mill containing a roller and collar in the milling space, the dry chips were ground for 25–30 s and screened with wire sieve to remove fines. The accepts retaining on +50 mesh size were leached into aqueous solution of caustic soda with different dosages of caustic soda, namely 0, 3.65, 9.75, and 15.9 % of $Na_2O$ on oven dry straw, for 20 h at a laboratory temperature (Table 1). The straw was also leached only into tap water for 40 hrs to obtain mechanical pulp. The straw after leaching was washed.

Using a laboratory conical beater, the wet straw after leaching process was beaten from initial beating degree of 11 to 50–58 SR (Table 1). Beating degree was measured by Schopper-Riegler method according to ISO 5267-1 Standard. Both sorts of beaten pulps, chemi-mechanical and mechanical, were used to make handsheets on a PTI-Rapid-Kothen sheet forming machine. Handsheets of two different levels of basis weight (B.W.), approximately 260 g/m$^2$ and 520 g/m$^2$, were prepared.

**Table 1.** Leaching conditions and properties of chemi-mechanical pulp specimens

| Leaching | | | Pulp specimens | | |
|---|---|---|---|---|---|
| Liquor-to-straw ratio | Time h | $Na_2O$-charge % on o.d. straw | Beating degree SR | Thickness mm | Basis weight g m$^{-2}$ |
| 102 : 1 | 40 | 0 | 58 | 0.99 | 260 |
| 102 : 1 | 40 | 0 | 58 | 1.87 | 519 |
| 47 : 1 | 20 | 3.65 | 50 | 0.90 | 266 |
| 47 : 1 | 20 | 3.65 | 50 | 1.79 | 554 |
| 44 : 1 | 20 | 9.75 | 55 | 0.64 | 245 |
| 44 : 1 | 20 | 9.75 | 55 | 1.19 | 508 |
| 82 : 1 | 20 | 15.9 | 51 | 0.60 | 263 |
| 82 : 1 | 20 | 15.9 | 51 | 1.08 | 521 |

The stripes cut from handsheets were used to measure the bending stiffness on a TIRA test 26005 device using three-point loading method. Details can be found in refs [8, 9].

## Results and Discussion

Bending stiffness is a property of paper and board which expresses its rigidity or resistance to bending. Generally, for given material the bending stiffness depends strongly upon the thickness of test specimen and rises linearly with increasing moment of inertia, theoretically with the third power of thickness of paper sheet [8].

The results obtained showed that the bending stiffness is apparently higher for specimen with higher thickness whereas, in contrast, the bending modulus is somewhat lower for the higher thickness. Figure 1 shows the dependence of bending stiffness on the caustic soda charge (expressed as % $Na_2O$ on oven dry straw of rapeseed) used in the leaching process. For the specimens with lower basis weight (245 – 266 g/m$^2$), it is evident that the bending stiffness increases slightly with increasing caustic soda charge. However, in the case of specimens with higher basis weight (508 – 554 g/m$^2$), the effect of caustic soda charge is ambiguous. It reveals that the specimens having lower basis weight become less elastic with increasing caustic soda dosage, which may probably influence the delignification of the chemi-mechanical pulp.

The bending modulus of elasticity in the region of reversible deformation as a function of caustic soda charge is illustrated in Fig. 2. It is clear that the bending modulus of elasticity is not appreciably different for specimens having various basis weights, except for zero caustic soda charge when mechanical pulp was made. The bending modulus of elasticity obtained for chemi-mechanical pulps lies within the limits of 0.22 to 1.11 kN mm$^{-2}$ and, for the same thickness of specimen, is somewhat lower than that reported by Potůček *et al.* [9] for unbleached spruce groundwood (0.9 – 1.9 kN mm$^{-2}$).

The results obtained for rapeseed straw were compared with those measured for unbleached spruce groundwood and for moulded fibre products, which were published earlier [8, 9]. At almost constant thickness of the handsheets, the bending stiffness and bending modulus of elasticity in the region of reversible deformation measured for highest charge of caustic soda are comparable to those measured for unbleached spruce groundwood and are

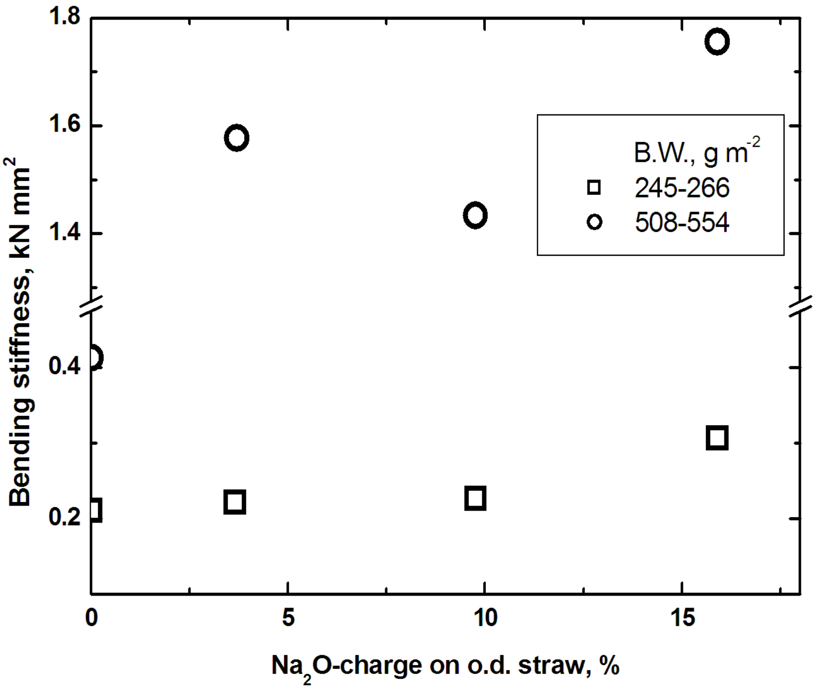


**Figure 1.** Bending stiffnes as a function of $Na_2O$-charge on oven dry straw

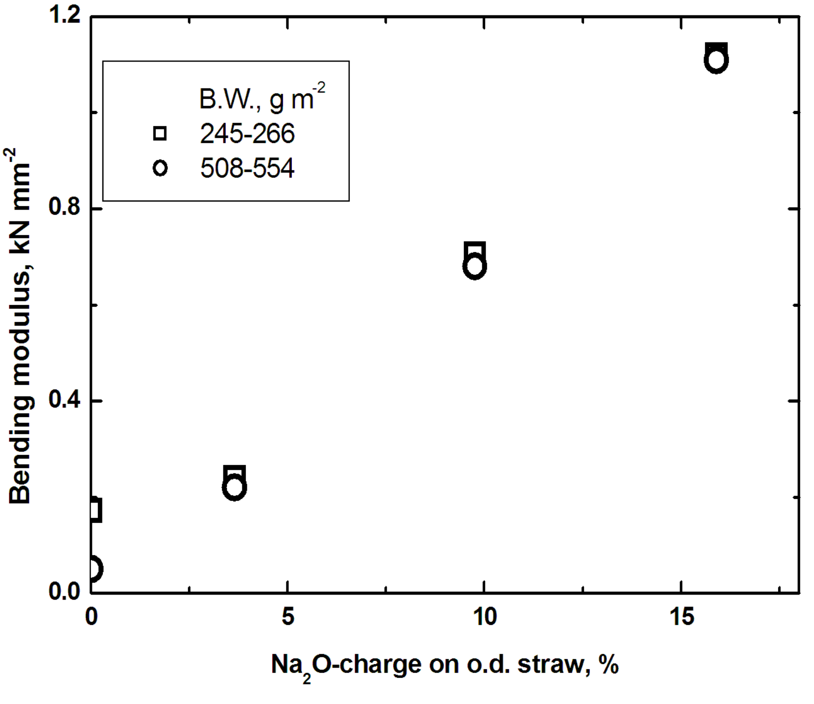


**Figure 2.** Bending modulus of elasticity as a function of $Na_2O$-charge on oven dry straw

much greater in comparison with those obtained for moulded fibre products made from waste paper (Table 2). However, the bending stiffness and bending modulus of elasticity determined for mechanical pulp, when leaching into only tap water was carried out, are somewhat lower than those published for moulded fibre products previously [8].

**Table 2.** Comparison of stiffness properties measured for various materials

| Material | Thickness mm | Bending stiffness kN mm$^2$ | Bending modulus kN mm$^{-2}$ |
|---|---|---|---|
| Rapeseed straw pulp (0 % $Na_2O$) | 0.99 | 0.220 | 0,180 |
| Rapeseed straw pulp (15.9 % $Na_2O$) | 1.08 | 1.756 | 1.109 |
| Spruce groundwood [9] | 1.006 | 1.624 | 1.274 |
| Waste paper (moulded fibre products) [8] | 1.01 | 0.343 | 0.265 |

## Conclusion

The preliminary results obtained offer a possibility to utilize rapeseed straw, at least partial, in the pulp and paper industry as an additive fibre source to wood pulp, depending on mainly the expected properties of the moulded fibre products.

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**Abstrakt**

Cílem práce bylo připravit chemickomechanickým způsobem buničinu ze slámy řepky olejky (*Brassica napus* L. convar. *napus*). Sledován byl vliv dávky hydroxidu sodného v operaci vyluhování na tuhost buničiny a modul pružnosti v ohybu. Naměřené výsledky byly porovnány s hodnotami dosaženými pro nebělenou dřevovinu ze smrku a pro sběrový papír.