THE INFLUENCE OF FIBRE FROM DIFFERENT LINSEED SOURCES ON WHEAT FLOUR AND CEREAL PRODUCT CHARACTERISTICS

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SUMMARY
Wheat flour was fortified by 2.5, 5.0 and 10% wt. of linseed fibre, gained from seeds of golden flax varieties Amon and Raciol (granulation 500-700 µm, prepared from 2015 flax harvest). Technological quality of the tested flour composites was described by Falling Number and Zeleny sedimentation test. Both screening methods sustained a little impact on amylases activity and protein quality, respectively. Rheological tests included the farinograph, the extensograph and the Rapid Visco Analyser (RVA) proofs. Internal laboratory procedures were used for the preparation of bread and cookies. The addition of brown and yellow flax fibre significantly increased farinograph water absorption and shortened dough stability, somewhat stronger by the addition of brown linseed fibre. Extensograph features depended on dough proof resting time. Linseed fibre supported dough extensibility, and energy as the area under curve significantly decreased about 7-18%. In general, fibre is characterised as hydrophilic material, which was confirmed by pasting profiles of flour composites. During dough leavening, dough resistance and optimal leavening time of wheat-linseed fibre dough was shorter than wheat control. Regardless of the described modifications in dough machinability, specific volumes of bread buns were similar through the whole sample set. A weak worsening of buns vaulting reflected a partial dilution of dough gluten skeleton. Cut-off biscuits were characterised by gradually lowering spread ratio, in line with the elevated dough elasticity. All cereal products were found to have acceptable sensory profiles. PCA method verified partial lowering of protein quality and pointed at differentiation of the tested sample according to the amount of the linseed added.

Keywords: brown and golden linseed fibre, dough rheology, bread, biscuits, PCA

INTRODUCTION
Flax (Linum usitatissimum L.) is a utility crop used for the production of thread and seeds, or raw material for the production of linseed oil and linseed fibre. Wild flax can be found in Asia, and its seeds are naturally brown in colour; the yellow (gold)
variant is cultivated by humans. As in case of other seeds, their cover layers are built from polysaccharides; specific heteropolysaccharides forming 7 - 12% of cover weight (Kaewmanee et al., 2014) are described by high water absorption capacity (up to 1 200%), similar to chia or basil. Gel formed in excess of water at room temperature is called mucilage.

After oil extraction, linseed press cake is milled and sieved, producing food supplement known as linseed fibre. One of the world’s producers is the Functional Whole Foods New Zealand Ltd. (earlier Walramcom Ltd.), offering linseed fibre from both brown and gold seeds. They declare content of dietary fibre equal to 45%. Within the Czech Republic, the company Agritec Šumperk occupies with linseed breading and planting, and they rendered seeds of two golden linseed variants Amon and Raciol for this study (total dietary fibre contents over 50%). During farinograph testing, ability of huge water absorption was confirmed by Koca and Anil (2007). Linseed flour replaced from 5% to 20% of wheat one, and significant increase of water absorption was registered (from 63.7% up to 65.6%, respectively). Flax non-gluten proteins weakened dough during kneading as expected. Besides bread recipe enhancement, linseed fibre has a potential to be used in formulas of muffins (Lee et al., 2004), cookies (Hrušková and Švec, 2016) and pasta Kishk et al. (2011) with improved nutritional score.

The aim of this study was to determine a baking potential of wheat-linseed fibre composite flour samples and to compare influence of two types of the non-traditional material on analytical features of flour, rheological behaviour of composite flour and quality of bread prepared in a laboratory scale.

**MATERIALS AND METHODS**

Semi-bright wheat flour (WF) was delivered by the industrial mill Delta Prague. It was characterized by protein content 11.2%, Falling number 432 s and Zeleny value 39 ml. Linseed fibre characterised by granulation range 500-700 μm was produced in laboratory conditions (mill Stephan UM/SK 5, Stephan Machinery, Germany; vibration laboratory sieving apparatus, Stavební strojírenství n.p. Brno, Czechoslovakia), treating seeds from golden varieties Amon and Raciol, harvested in year 2015. In tested composites, linseed fibre replaced either 2.5, 5.0 or 10% wt. of wheat flour. Samples’ abbreviations combined the amount of the added linseed fibre and the name of linseed variety (2.5Amon, 5.0Amon, 10.0Amon, 2.5Raciol, 5.0Raciol, 10.0Raciol).

Technological features of WF and flour composites were described by Zeleny test (ISO 5529), Falling number (ISO 3093) and total dietary fibre content (TDF, AOAC 985.29). Non-fermented dough properties were determined with the help of farinograph and extensograph apparatuses (Brabender, Germany), following the international norms (ISO 5530-1 and 5530-2, respectively). Due to bread fermentation, which lasted for 50 min, extensograph data collected after dough resting, which lasted for 60 min, were only take into the account. Behaviour of
flour-water suspensions was recorded on the Amylograph (Brabender, Germany; ICC method 126/1) and on the RVA 4500 equipment (Perten Instruments, Sweden; AACC method 76 - 21). The former traditional test takes 45 min, while the latter novel machine collects similar data in 16 min only. According to the internal procedure of the Cereal laboratory of the UCT Prague, wheat and wheat-linseed composite bread was prepared and assessed in terms of consumer’s quality (Hrušková et al., 2006).

Statistical analysis of the obtained data combined two-way ANOVA and principal component analysis. Considered factors were linseed type and the added amount. For the latter analysis, matrix of 23 features was reduced to 16 representative ones (e.g. extensograph test is represented by elasticity-to-extensibility ratio and energy), based on correlations to bread characteristics.

RESULTS AND DISCUSSION

Analytical features of flour composites
As is documented in Table 1, linseed fibre partially lowered the Falling number value of the control, but the observed positive decrease was not verifiable with respect to the measurement accuracy (± 25 s). In protein quality, similar trend was registered, but lowering the Zeleny value under 35 mL may already have influenced volume of baked goods negatively. Addition of 5.0% golden linseed fibre from the New Zealand affected the Zeleny value similarly – it meant decrease from 37 to 23 ml (Hrušková and Švec, 2016). Positive effect of linseed fibre was measured in total content of dietary fibre; from the nutritional point of view, 10% enhancement should be recommended (double increase compared to WF).

Table 1 The influence of golden linseed fibre on basic analytical features of wheat flour (WF)

<table>
<thead>
<tr>
<th>Composite flour</th>
<th>Addition (%)</th>
<th>Falling number (s)</th>
<th>Zeleny value (mL)</th>
<th>Total dietary fibre (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WF</td>
<td>0</td>
<td>432&lt;sup&gt;a&lt;/sup&gt;</td>
<td>39&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>3.40&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>WF+Amon</td>
<td>2.5</td>
<td>362&lt;sup&gt;a&lt;/sup&gt;</td>
<td>40&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.61&lt;sup&gt;ab&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>387&lt;sup&gt;a&lt;/sup&gt;</td>
<td>37&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.83&lt;sup&gt;bc&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>10.0</td>
<td>399&lt;sup&gt;a&lt;/sup&gt;</td>
<td>30&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.25&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>WF+Raciol</td>
<td>2.5</td>
<td>386&lt;sup&gt;a&lt;/sup&gt;</td>
<td>40&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.64&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>384&lt;sup&gt;a&lt;/sup&gt;</td>
<td>38&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>5.88&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>10.0</td>
<td>384&lt;sup&gt;a&lt;/sup&gt;</td>
<td>32&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.37&lt;sup&gt;d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Repeatability</td>
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<td></td>
<td>25</td>
<td>1</td>
<td>0.22</td>
<td></td>
</tr>
</tbody>
</table>

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Rheological behaviour of flour composites

The RVA test offers a detailed description of a pasting process, but main variation was recognized in curve points Peak viscosity, Hold viscosity and especially in Final viscosity (signs “+” in Figure 1). With exception of 2.5% addition, Peak viscosities of composites containing Amon fibre were almost comparable to WF control. In Hold and Final viscosities, both linseed fibre types caused a significant thickening of composite suspensions (increase from 9% to 55%; data not shown). Linseed fibre from the New Zealand demonstrated the same character – the viscosity points were about 11%, 27% and 21% higher than WF control, respectively (Hrušková and Švec, 2016).

Tested fibre influenced rheological properties of non-fermented dough – the lowest addition supported dough elasticity in three-time higher extent than extensibility. Higher fibre ratios in recipe lessened the elasticity to values comparable to WF; in the same comparison, the extensibility fell up to about 16% (data were presented on poster). Differences in dough machinability were confirmed by Koca and Anil (2007) for linseed/wheat composite flours with 5 - 20% of the non-traditional material. The same authors also mentioned that additions higher than 10% may worsen volumes of the leavened bread.

Figure 1 (a, b, c) Influence of 2.5, 5.0 or 10% golden linseed fibre on pasting behaviour of wheat flour (WF). Amon, Raciol – golden linseed varieties. From left to right, signs “+” identify pasting curve points Peak, Hold and Final viscosity. a-g: values of pasting points on single RVA curves described by the same letter are not statistically different (p = 95%)
Baking test results
Golden linseed fibre influenced the water addition in recipe positively; its amount has risen from 59.0% (WF control) up to 65.0% and 69.0% for samples 10.0Amon and 10.0Raciol (data not shown). Both lower enhancement levels improved bread quality at least, while 10% addition lowered specific volume, as well as varied bread shape (height-to-diameter ratio; Figure 2). Crumb firmness, defined as penetration depth, corresponded with the size of bread buns – value 14.9 mm was elevated over 20 mm by 2.5 and 5.0% linseed fibre, while 10% of the alternative raw material lowered penetration to 12.9 mm and 9.9 mm (data not shown). Sensory profiles of all tested variants fell into “acceptable” or “acceptable with minor objection” category, related to harder chewiness and partial stickiness of mouthful in case of most fortified samples.

![Figure 2](image_url)

**Figure 2** The influence of 2.5, 5.0 or 10% golden linseed fibre on quality of wheat bread (WF). Amon, Raciol – linseed varieties; 5.0Raciol – composite flour from wheat one and linseed fibre 95:5 wt. %

Multivariate statistics (PCA)
Within the area of the first two components (PC), data scatter was explained from 74%, i.e. from 52% by PC1 and from 22% by PC2 (Figure 3). In the mentioned plot, presumed connections between dough rheological characteristics and bread quality features were verified. For example, specific bread volume and crumb penetration reflect properties of proteins (Zeleny value ZT, extensograph energy EEN), or bread sensory profile connection to Falling number (FN) and mixing tolerance index (MTI). Interesting binding was revealed between amylograph maximum (AMA) and RVA curve points Peak and Final viscosity; within the flour
Composite group, the last mentioned parameter had the greatest capacity to differentiate the tested material.

Samples location in PC1xPC2 plane corresponds to their overall technological potential, i.e. influence of 2.5% or 5.0% linseed fibre from Raciol variety could be regarded as improving.

**Figure 3** Principal component biplot of loadings and scores. Variables: FN – Falling number, ZT – Zeleny test, TDF total dietary fibre content, WAF – farinograph water absorption, MTI – mixing tolerance index (dough softening degree); ERA 60, EEN 60 – extensograph elasticity-to-extensibility ratio and energy; AMA, Tmax – amylograph viscosity maximum and proper temperature; PV, PTe, FV – Peak viscosity, Peak temperature and Final viscosity on RVA curve, SBV – specific bread volume, BRS – bread shape (height-to-diameter ratio), PEN – crumb penetration depth, SEN – bread sensory profile.
CONCLUSIONS
Replacement of wheat flour by golden linseed fibre brought an expected decrease in protein quality, i.e. in dough machinability, resulting in lowered specific bread volume and elevated crumb hardness. Differences between two tested fibre types, gained from Amon and Raciol varieties, were recorded considering the effect on pasting behaviour of flour mixtures and quality parameters of composite bread. As a compromise between satisfying technological quality and nutritional benefit, enhancement at the level of 5% on wheat flour base could be recommended.

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REFERENCES