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Characteristics of Wheat, Barley and Hemp Model Composites

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Abstract

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Barley is known as health-benefit raw material, mainly due to beta-glucan. To explore the nutritional benefit of barley and hemp plants, wheat-barley flour premixes were prepared (70 : 30 and 50 : 50 w/w, respectively). Hemp flour of wholemeal and fine type was added to each cereal base on levels of 5 and 10%. Barley flour diminished both protein content and its quality, but it played a positive role in an increase in amylase activity. Hemp addition levelled the protein content back (at least to the value comparable to wheat flour), but its quality was worsened further correspondingly to a hemp portion. Enzymatic activity of the composite was modified weakly by the non-traditional material. Determining the SRC profiles of wheat-barley and wheat-barley-hemp blends, changes mentioned above were sufficiently verified.

Keywords: composite flour; barley; hemp; solvent retention capacity; dietary fibre

Application of non-traditional components in cereal technology can extend possibilities for production of alternative cereal-based goods. Barley and hemp products can serve for wheat flour fortification. Above-mentioned innovative components are known for a specific chemical composition with higher nutritional value compared to wheat. In spite of enhancing the analytic properties composites increase bread quality and nutritional value. Among the basic composite characteristics belong protein content and quality according to the Zeleny test and prediction of starch polysaccharide behaviour when heated to 100°C as the Falling Number. A more precise description of the cereal blend behaviour is enabled by the Solvent Retention Capacity Profile (SRC) determination, within which partial results correspond to the hydration capability of flour components forming dough net structures, damaged starch content together with pentosan content and quality. The SRC method, registered as AACC 56-11 (AACC 2000; Gaines 2000), represents a modern analytical procedure of quality prediction for wheat flour. The test principle is based on gravimetric evaluation of absorbed amounts of distilled water (WASRC), and water solutions of sucrose (SUSRC), sodium carbonate (SCSRC), and lactic acid (LASRC) (50, 5, and 5% w/w, respectively). A review on the SRC application in the cereal field was published by (Kweon *et al.* 2011). In recent literature, wheat flour quality according to SRC is discussed (Xiao *et al.* 2006; Duyvejonck *et al.* 2011). Further scope was found also for wheat flour enrichment with ten types of commercial fibre of different origin (e.g. wheat, oat, apple or bamboo ones; Rosell *et al.* 2009). Within the own research results of Cereal Laboratory of the University of Chemistry and Technology Prague, the SRC method was validated for qualitative measurement of composites containing wheat, rye, barley, oat, and corn wholemeal (Hrušková *et al.* 2011) or wheat/hemp characteristics (Švec & Hrušková 2014).

Barley (*Hordeum vulgare* L.), a member of the *Poaceae* family, belongs to a major cereal grain. Important uses include animal fodder, and a source of fermentable material for beer and certain distilled

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beverages. Pearl barley may be processed into a variety of barley products, including flour or flakes similar to oatmeal and grits. According to Newman and Newman (2008) study, eating whole-grain barley can regulate blood sugar for up to 10 h after consumption compared to whole-grain wheat, which have similar glycaemic indices. In addition, barley's dietary fibre is high in β-glucan, which helps to lower cholesterol by binding to bile acids and removing them from the body via the faeces. According to the FDA, barley's soluble fibre reduces a risk of the coronary heart disease and can lower cholesterol. Barley also contains insoluble fibre, which reduces a risk of type 2 diabetes and colon cancer. Grain content of protein, fat and starch is known to be 10–12%, 1.5–1.8%, and approx. 75%, respectively. Hordeins as stable protein stuff raise different behaviour in bakery technology. Starch consists of approx. 80% of amylopectin and the remaining part is amylose. Larger grains of elliptic shape (40 μm) participate in 90% starch content. Smaller ones (1–10 μm) are wrapping with proteins and lipids, which regulate the speed of enzymatic splitting.

Hemp (*Cannabis sativa*) is planted as two subspecies, namely ssp. *culta* and ssp. *indica*. The latter is called hash hemp and belongs to banned raw materials with respect to production of intoxicating substances. Hemp flour composition depends on variety and planting locality, it also differs according to defatting. Protein, fat and starch contents are known to be 30–33%, 7–13%, approx. 40%, respectively. The seed contains a significant level of β-carotene and vitamins B_1 and E. Considering the mineral component aspect, a benefit could be found in a higher portion of iron and zinc. Approx. two-thirds of hemp proteins are composed of edestin, belonging to low molecular weight globulins (Callaway 2004). The 10–15% content of insoluble fibre (Dimic *et al.* 2009) may be also a reason for wheat flour fortification.

With respect to available references, neither the behaviour of cereal wheat/barley/hemp blend nor its evaluation by means of the SRC testing has been published yet.

The aim of the present study is to explore model cereal composites on the basis of wheat, barley and hemp flours, including different commonly available food forms (conventional, organic, i.e. "bio"), in terms of analytical quality and nutritional value. The evaluation also includes a new method of Solvent Retention Capacity profile, used for the estimation of changes in both polysaccharides and protein parts of composites in four solvents (water and sucrose, sodium carbonate, lactic acid solution). The statistical pattern used should reveal relationships between particular quality features and also the influence of diverse recipe composition of partial models.

MATERIAL AND METHODS

Preparation of cereal blends. Based on commercial wheat flour produced in 2012 (designated by WF), composites were prepared by using barley fine flour and four hemp flour samples designated by BF and H4–H7, respectively. In detail, H4, H5, and H7 originated in conventional and H6 in bio-planting regime, and all above-mentioned samples are of fine granulation. Furthermore, samples H4 and H5 are laboratory prepared ones, from dehulled and hulled hemp seeds, respectively, thus both have a wholemeal character. Hemp samples H6 and H7 come from commercial production. Composites were mixed at wheat to barley ratios of 70 : 30 and 50 : 50 (w/w). To both cereal bases, 5 or 10% of hemp flour was added.

Cereal blend quality. In accordance with the standards ČSN ISO 1871:2010 – Food and feed products – General guidelines for the determination of nitrogen by the Kjeldahl method, ČSN ISO 5529:2011 – Determination of the falling number according to Hagberg-Perten. and ČSN ISO 3039:2011 – Wheat – Determination of the sedimentation index – Zeleny test, protein content according to Kjeldahl method (abbreviation PRO), protein quality according to Zeleny sedimentation (ZT), and amylolytic activity estimation as the Falling Number (FN), respectively, were determined. The analytical features were measured in duplicate, correspondingly to the above-mentioned Czech standards.

Solvent retention capacity (SRC) profiles. To obtain the profiles, the AACC norm No. 56-11 was followed, i.e. standard sample of 5 g was used and centrifuged by using Eppendorf 5072 (Eppendorf AG, Hamburg, Germany). The method accuracy was determined in terms of the test repeatability, allowing single measurements of tested mixtures. The calculated relative standard deviations were 0.342, 0.727, 0.667, and 0.476% absolutely for WASRC, SUSRC, SCSRC, and LASRC, respectively.

Nutritional benefit of barley and hemp flours. The advantage of both non-traditional plant materials lies in higher dietary fibre content, which was determined according to AOCC method 985.29 by using the

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Megazyme commercial kit (Megazyme International Ireland, Bray, Ireland). The proof combines evaluations of total fibre content (TDF) and its soluble and insoluble portion (SDF and IDF, respectively).

Statistical analysis. Data representing the chemical composition of wheat flour and its blends with barley and hemp flour were subjected to analysis of variance (ANOVA, $P < 0.05$); the aim of statistical process was to compare impacts of both non-traditional plant materials as well as their different dosages.

RESULTS AND DISCUSSION

Analytical characteristics of tested composites. The basic component WF is characterised by PRO and ZT (11.98% and 48 ml; Table 1) satisfying quality for the purpose of addition of alternative plant materials containing non-gluten proteins such as barley and hemp. The FN of 317 s corresponds to the harvest year weather course and with respect to final usage for bakery product manufacturing, it is moderately above the technological optimum of 250 seconds.

For composites B30 and B50, statistically verifiable diminishing of PRO correspondingly to the BF addition level was evaluated (Table 1). A higher portion of BF also caused the broader interval of PRO measured, and interacted with the hemp flour recovering effect. The strongest positive impact on PRO could be noticed for H6, where the amount of proteins was enhanced up to about 2%. Reversely, both BF and all four hemp flours worsened the protein technological quality. In B30 and B50 blends, the ZT values were lessened to 71 and 54%, respectively. The further negative change was not dependent on the hemp wholemeal of fine type, but as expected, on the portion of hemp flour included. Also for the ZT, the strongest influence was evaluated for H6 – the change was crucial (to 20 and 16 ml for 10% of hemp in B30 and B50, respectively), limiting the use of such blend in bakery. Švec and Hrušková (2014)

Table 1. Influence of hemp addition on the composition of wheat-barley composites (70 : 30 and 50 : 50, w/w)

Composite	Hemp addition (%)	Protein content (%)	Zeleny sedimentation test (ml)	Falling Number (s)
70 : 30 (w/w)				
WF	0	11.98[b]	48[f]	379[b]
B30	0	11.20[a]	34[e]	294[a]
B30 + H4	5	11.85[ab]	29[d]	285[a]
	10	12.62[c]	24[b]	271[a]
B30 + H5	5	11.71[a]	29[d]	282[a]
	10	12.00[b]	24[b]	273[a]
B30 + H6	5	12.59[c]	27[c]	272[a]
	10	13.85[d]	20[a]	285[a]
B30 + H7	5	11.95[b]	30[d]	289[a]
	10	12.59[c]	25[b]	283[a]
50 : 50 (w/w)				
WF	0	11.98[f]	48[g]	379[d]
B50	0	10.35[a]	26[f]	280[ab]
B50 + H4	5	11.11[bc]	20[cd]	269[a]
	10	11.78[ef]	15[a]	281[ab]
B50 + H5	5	11.19[c]	23[e]	292[bc]
	10	11.42[d]	19[c]	294[c]
B50 + H6	5	11.65[e]	21[cd]	301[c]
	10	13.04[g]	16[ab]	276[a]
B50 + H7	5	10.95[b]	21[d]	295[c]
	10	11.90[f]	17[b]	276[a]

WF – wheat flour; B30 – blend of wheat and barley flour 70 : 30 (w/w); B50 – blend of wheat and barley flour 50 : 50 (w/w); hemp flour: H4 – dehulled wholemeal, H5 – hulled wholemeal, H6 – conventional fine, H7 – organic fine; [a–f]means designated by the same letter are not statistically different ($P < 0.05$)

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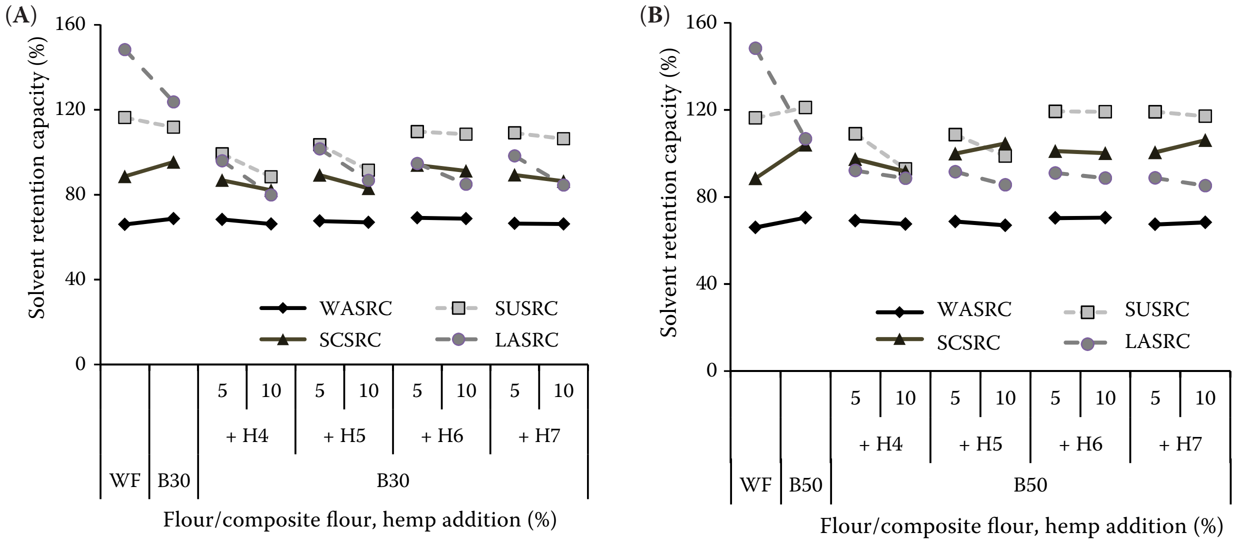

Figure 1. Influence of (**A**) 30% barley (B30) and (**B**) 50% barley (B50) and hemp flour on the solvent retention capacity profile of wheat flour (WF)

WASRC, SUSRC, SCSRC, LASRC – water, sucrose, sodium carbonate, and lactic acid SRC (for sample abbreviations see Table 1)

tested five hemp samples and found corresponding tendencies – e.g. for the composite containing 10% of K1 fine hemp flour, PRO increase up to about 7% and protein quality (ZT) lowering to 80%.

Trends observed in the FN were unequivocally positive, when BF fortification significantly increased the amylose activity – both for B30 and B50, a decrease in the order of 90 s was recorded (Table 1). Variation caused by hemp items was insignificant with respect to measurement accuracy (± 25 s, ČSN ISO 3039:2011). Contrary to results published earlier (Švec & Hrušková 2014), 20% addition of the hemp flour alone did not affect the FN distinctly.

Compared to the SRC profile of WF, those of tri-composite blends were affected mainly by barley flour addition; considering the hemp types tested (wholemeal H4–H5 vs. fine H6–H7), they could also be partially differentiated from each other (Figure 1). The WASRC was changed minimally regardless of the alternative plant material tested. Barley flour addition at an amount of 30% led to a significant decrease in the LASRC (gluten dilution), while the other SRC values rose to a small extent (non-starch polysaccharide supplement). Generally, hemp constituents affected the particular capacities verifiably; a decreasing trend prevailed in cases of B30 blends similarly to BF impact. A strong worsening is obvious for the LASRC; further, dosages of fine H6 or H7 hemp flour did not demonstrate any provable effect on the SUSRC. Profiles of tri-composite flour based on B50 premix followed those occurring within the B30 group, and at the same time, the mentioned differences were similar and they were in agreement with the higher portion of BF in evaluated composites. Differences revealed between blends involving wholemeal or fine hemp flour were confirmed within a set of 20 wheat-hemp blends (Švec & Hrušková 2014), because the wheat flour quality was influenced by hemp flour directly.

Nutritional benefit of barley and hemp flour. With respect to the milling treatment of BF and hemp samples H6 and H7, TDF and SDF contents were lower compared to wholemeal hemp H4 or H5 (Figure 2). Compared to WF sample, TDF levels in barley and hemp flour samples were approximately four times higher. Collar and Angioloni (2014) reported a somewhat lower TDF level for wheat flour (2.2%) and reversely a higher one for barley flour (17.4%) with IDF : SDF ratios of 1.31 and 1.95, respectively. In the Finola hemp cultivar, Callaway (2004) determined twice higher TDF content in whole seeds (27.6%); 5.4 and 22.2% were represented by digestible and non-digestible fibre, respectively. The American Dietetic Association recommends the fibre intake for adults of 25–30 g per day with an IDF : SDF ratio of 3 : 1 (Borderías *et al.* 2005). Only BF and H7 were the closest to this ratio (2.77 and 2.35, respectively). Within the composites tested, the main contribution to TDF was attributed to BF correspondingly to its principal proportion in blends; 5% or 10% of each of the tested

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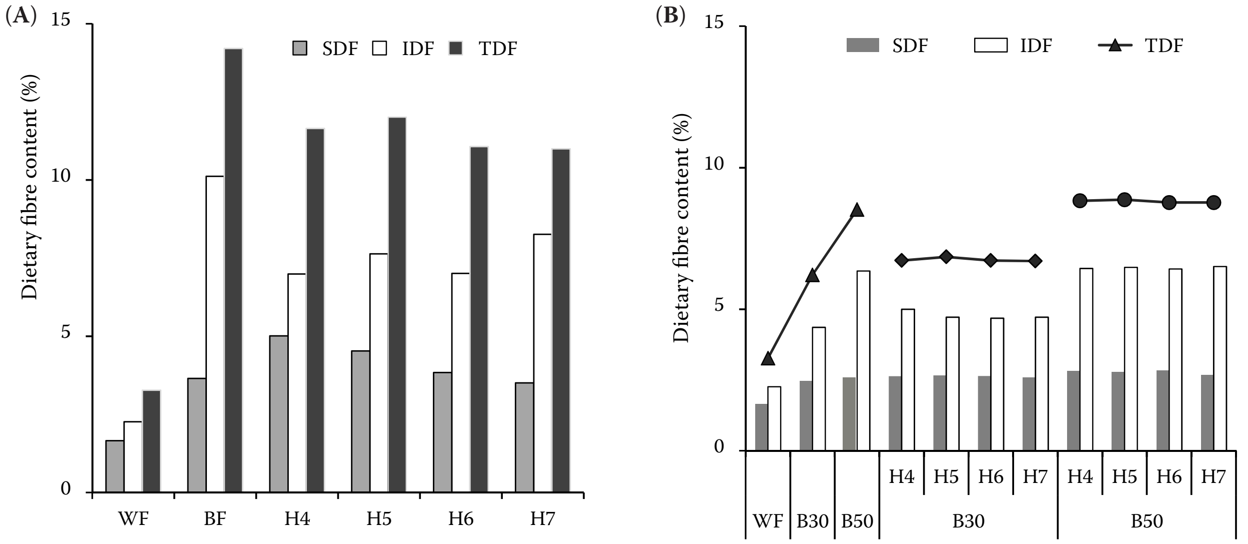

Figure 2. Dietary fibre contents in (**A**) wheat, barley and wholemeal or fine hemp flour and (**B**) wheat (WF), wheat-barley, and wheat-barley-hemp flour composites (for sample abbreviations see Table 1)

hemp flour influenced the fibre content similarly with a weak impact of wholemeal or fine type (Figure 2).

CONCLUSIONS

Cereal composites were prepared on the basis of commercial fine wheat and fine barley flour, mixed at ratios of 70 : 30 and 50 : 50, respectively, to which hemp flour samples (2 fine or 2 wholemeal) on levels of 5% or 10% were added. Chemical composition of 18 tested blends was changed significantly in terms of an increase in protein and dietary fibre content, less or more independently of the tested hemp type. Non-gluten proteins present in both barley and hemp flour worsened the protein quality (lowering of the Zeleny sedimentation values) in all tested blends. A stronger effect was observed for the level of hemp addition than for the hemp type used. The Falling Number (estimation of amylolytic activity) showed a verifiable decrease owing to the barley flour proportion; hemp dosages influenced the characteristic minimally. The SRC profile of wheat flour was mainly dependent on the barley flour ratio in blends – the water SRC and the lactic acid SRC were the least and the most modified parameters. The nutritional benefit of both alternative plant materials is attributed to a significant increase of dietary fibre content, both its soluble and its insoluble part.

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