**Croatian Journal of Food Science and Technology**

*journal homepage: www.ptfos.unios.hr/cjfst/*

*Original scientific paper*

*DOI: 10.17508/CJFST.2018.10.1.16*

# Features of flour composites based on the wheat or wheat-barley flour combined with acorn and chestnut

**IVAN ŠVEC[1*], MARIE HRUŠKOVÁ[1], IVANA KADLČÍKOVÁ[1]**

[1]*University of Chemistry and Technology Prague (UCT), Department of Carbohydrates and Cereals, Technická 5, 166 28 Prague 6, Czech Republic*

ARTICLE INFO

*Article history:*
Received: January 29, 2018
Accepted: May 12, 2018

*Keywords*:
wheat-barley composite flour,
chestnut and acorn flour,
bread,
PCA.

ABSTRACT

To elevate dietary fibre content in wheat bread, additions of barley flour were tested (30%) alone, and in combination with 5% or 10% of chestnut and acorn flour. Acorn flour elevated dietary fibre content more effectively than the chestnut flour did (TDF up to 7.8%). Non-gluten nature of proteins in non-traditional raw materials also affected farinograph, extensograph and amylograph features, used for predicting bakery procedure. Technological parameters (Falling Number, Zeleny sedimentation value) decreased to nearly 30% compared to the wheat flour. Water absorption increased about 2% in total, especially owing to the chestnut presence in the composite flour. All three alternative crops slowed dough development, but the dough softening degree depended on their combination. Viscoelastic behaviour has worsened (mainly parameter extensograph energy), depending on the type and the addition of the non-traditional products in the tested mixtures. Changes of suspension structure were reflected in maximum viscosity, which became lower during the amylograph test. A significant worsening of the buns specific volume and vaulting reflected a partial dilution of the gluten network of the dough. The highest addition of the chestnut flour in the recipe caused a decrease to less than one half compared to the wheat product. By the principal component analysis, some rheological parameters, together with specific bread volume, were identified as principal for sample distinguishing. In terms of wheat flour and bread quality, barley flour addition in the mixtures had a prevailing effect on the tested tri-composites.

## Introduction

For hundreds of years, fine wheat flour represented a “white gold”, accessible to richer minority of the society. Because of this fact plebeian nutrition was based on rye or barley together with legumes and pseudo cereals. Edible fruits given by trees were outstanding in this regard, and served as a feed for domestic animals at the most. Nevertheless, in times of crop failure, caused for example by flooding or local wars, humans gratefully accepted those plant products, as chestnut or acorn to stay alive. Later, industrial revolution supressed social discrepancies and wheat flour became stepwise a basic raw material for nearly all social classes. Alternative plant raw materials had been forgotten, and only rising incidence of lifestyle diseases induced a return to their intentional consumption.

Chestnuts, fruits of the tree called *Castanea sativa* Mill., are traditionally treated by hydrothermal process to their transformation into the form of flour. Compared to wheat, chestnut flour contains multiple higher ratio of simple sugars and dietary fibre (about 2% vs. 16% and 2% vs. 26%, respectively), but approximately a half protein content (6% against 10-15%; Giovanelli (2008) and CREA (2015a, 2015b, 2015c), respectively). In limited amounts, chestnut flour alone or in combination with rice flour may improve volume of biscuits or gluten-free bread, as

[*]Corresponding author E-mail:
ivan.svec@vscht.cz

documented by Hegazy et al. (2014) and Demirkesen et al. (2010), respectively.
Acorns are fruits from several species of oak tree, especially holm oak *Quercus rotundifolia* or *Q. ilex*. To produce acorn flour, fruits traditionally undergo drying or roasting, peeling and milling. Further step may be flour debittering, i.e. tannin extraction. Nutrition characteristics of the gluten-free flour was mentioned by Silva et al. (2016): half protein content (4-5%), ten-time higher fat content (10-14%) and about seven-time higher dietary fibre level (13-17%) when contrasted to wheat flour. Pasting properties of acorn starch differ from the chestnut ones – on viscograph curves, no peak and trough was identified during slurry heating and constant temperature, respectively. The viscosity in 40$^{th}$ min of the test was about approximately one-third lower just for acorn flour (900 vs. 1300 Brabender units) (Correia and Beirão-da-Costa, 2010). On Sardinia, acorn bread belonged to local folklore and its preparation was a ceremony with religious connotations (Pinna, 2013).
Korus et al. (2015) found, than only the lowest (20%) replacement of corn and potato starches in gluten-free bread recipe leads to the rise of the final product volume. Replacing 50% of wheat flour by acorn meal, cookies had some differences in texture, appearance, and flavour, but they were considered as overall acceptable (Sabrin, 2009).
Barley (*Avena sativa* L.), is the one of the basic cereals, i.e. plants bred for human nutrition for the longest time; in ancient Egypt, emmer wheat and barley served for bread and beer production (Samuel, 1997). In barley flour, protein content is lower than in wheat flour (around 10%) and reversely the polysaccharides one (close to 80%). Substantial part of the latter biopolymers form β-glucans and arabinoxylans – Březinová-Belcredi et al. (2009) analysed 12 different samples, and declared level of both components between2.78-6.08% and 3.66-5.46%. These polysaccharides may help in prevention of lifestyle diseases – the European Commission approved health claim for barley and oat β-glucans (EFSA, 2012). Within the Czech Republic, barley flour found its fixed place among bakery raw materials, and e.g. with chia and nopal flour, it extended bread types offer. As reported by Gill et al. (2002), quality of wheat-barley bread depends also on barley type (regular, waxy). For 15% substitution of wheat flour by regular barley one, bread loaf volume was larger and crumb softer than for counterpart containing waxy barley flour. Similarly, molar weight of barley β-glucans predetermines resulted bread properties. Addition of β-glucans of higher molar weight was more effective in increasing the specific bread volume and reducing the crumb firmness (Skendi et al., 2010). The aim of this work was to evaluate basic analytics, viscous and viscoelastic behaviour of wheat or wheat-barley composite flour containing two different dosages of chestnut or acorn flour. Baking potential of the prepared composite flour was evaluated directly within a laboratory baking trial. To distinguish influences of the non-traditional plant material types and dosage levels, statistical analysis of principal components was conducted.

## Materials and methods

### *Materials*

Two samples of white wheat flour (WF1 and WF2), used as a basis for bi- and tri-composite blends, was produced by the Czech commercial mill Delta Prague in 2015 and 2016. Sample WF1 was used as a base for flour composites wheat-chestnut and wheat-barley-chestnut, while WF2 for blending firstly with acorn, and further with barley and acorn flour. They were characterised by protein contents 11.2% and 13.2%, Zeleny values 50 and 39 ml and Falling Numbers 341 and 432 s, respectively. Barley flour (BF) was delivered by the Czech commercial mill Křesín (production year 2015), and it was described by protein content, Zeleny value and Falling number as 9.23%, 23 ml and 119 s, respectively. Total dietary fibre (TDF) ratio was close (3.40, 3.38 and 4.47% for WF1, WF2 and BF, respectively). The flour was used for premixes preparation on the base of both WF1 and WF2, and mixing ratio was 70:30 (w/w, abbreviations WF1B and WF2B), respectively.
Further non-traditional plant materials, namely chestnut (Ch) and acorn (A) flour, were bought in domestic specialised food shops. The former item was produced by Sonnentor Kräuterhandelsgesellschaft GmbH (Austria) and the latter was delivered by Bioobchod, Czech Republic (agriculture production EU mentioned on a label). Declared protein contents were 4.9% and 4.1%, respectively. Ratio of TDF was determined analytically as 13.52% and 44.49%, respectively. Replacement levels of both wheat flour and wheat-barley premix were chosen as 5 and 10 wt. % (coding e.g. WF1+5Ch, WF2+10A, WF1B+5A).

### *Analytical proofs*

Analytical testing of wheat controls and prepared flour composites comprised technological parameters the Falling number (ISO 3039) and the Zeleny sedimentation value (ISO 5529). In correspondence to EU legislation (Regulation 1169/2011), TDF was calculated from data determined for pure flour samples (wheat, barley, chestnut and acorn flour; AOAC method 991.43). Accuracy of this determination, determined within the Cereal laboratory of the UCT Prague earlier, is equal to 0.22 percent points.

*Pasting properties and rheological behaviour*

Viscous behaviour was determined according to ICC method No 126/1, using the Amylograph Brabender (Germany) apparatus. Rheological characteristics of wheat and composite non-fermented dough were recorded during the Farinograph and the Extensograph proofs (Brabender Germany; ISO 5530-1:2013 and ISO 5530-2:2013, respectively). Due to the preparation of leavened bread, whose proofing takes 50 min, only the extensograph data after 60 min of dough resting was considered. Viscosity of suspensions, dough consistency and extensograph elasticity were recorded in Brabender's units (BU).

*Laboratory baking trial*

Bread preparation and its characteristic assessment were described in previous work (Švec and Hrušková, 2004). Leavened dough was prepared by using of farinograph, and the basic formula follows: wheat flour – 100% (or wheat-barley flour 70:30), yeast – 4.0%, salt – 1.7%, sugar – 1.5%, fat – 1.0% (amount of ingredients on flour base) and distilled water needed for preparation of dough characterised by consistency of 600 ± 20 BU (consistency based on experience of the Research Institute of Milling-Baking Industry, Czech Republic). Commercial French-type yeast "Fala" and the Czech margarine "Perla" (fat content 40%) were used. Dough fermentation and leavening took 50 and 45 min in thermostat (30 °C, RH 95%); 70 g of dough pieces were moulded manually and placed on a baking plate. Baking that lasted for 14 min was performed in a laboratory oven (Bakery Research Institute, Poland) preheated to 240 °C, steamed immediately after full baking plate insertion. After two-hours of cooling at laboratory conditions, the specific volume and the shape (height-to-diameter ratio) was determined in triplicate. For a crumb compactness evaluation, crumb samples (of 35 mm in height and 30 mm in diameter) were cut out of the bun halves centre. The penetrometer PNR-10 (Petrotest Instruments, Germany) equipped with stainless steel 25 mm hemisphere in a screw holder was used (total weight 150 g), and the penetration depth was determined five times. In eight-point sensory analysis, three skilled assessors were used. Thus, results of the test have only informative character. On a hedonic scale, summary sensory profile could reached values from 8 to 24 points as the best and the unacceptable bread, respectively.

*Statistical analysis*

In Statistica 13.0 software (StatSoft Inc., USA), data were firstly evaluated statistically for single 26 qualitative features in terms of ANOVA (Tukey test, P = 95%). Secondly, multivariate analysis of principal components (PCA) was conducted for 14 representative parameters (selection on the base of PCA results for whole dataset). In both cases, considered factors were composite flour base (wheat, wheat-barley, wheat-barley-chestnut/acorn) and enhancement level of non-tradition plant material (0, 5/10 chestnut/acorn, B30, B30+5/10 chestnut/acorn).

## Results and discussion

*Analytical properties of flour and flour composites*

Contrasting both WF standards together, a verifiable difference was determined by the Falling number test, reflecting diverse weather during two following harvest years. For barley flour sample, the value reached about half level, signifying higher amylases activity as well as a higher rate of damaged starch. Correspondingly, values of Falling number of premixes WF1B and WF2B were determined about one-third lower at least (Table 1).
Baking quality of proteins was satisfying for both wheat controls – in praxis, demanded minimum is 35 ml. Additions of all non-traditional materials induced predictable decrease of sediment volumes at the end of the Zeleny test – the softest worsening was observed for 5 or 10% of chestnut flour. The combination of barley and especially acorn flour led to approx. half technological quality of composite flour (Table 1).
According to TDF contents in non-traditional materials tested, significant contribution was observed mainly for acorn flour. Compared to standard WF2, TDF content was elevated approx. twice to maximum (from 3.40% to 7.29 and 7.58%, samples WF2+10A and WF2B+10A; Table 1). Such leavened bakery product should already have some health benefit.

**Table 1.** Analytical features of wheat flour and flour composites

| Flour, flour composite | Falling number (s) | Zeleny value | TDF (%) |
|---|---|---|---|
| WF1 | 341[de] | 50[g] | 3.40[ab] |
| WF2 | 420[f] | 38[ef] | 3.18[a] |
| B | 107[a] | 22[a] | 4.25[bcde] |
| WF1B | 304[c] | 31[cd] | 3.72[abc] |
| WF2B | 168[ab] | 27[abc] | 3.50[ab] |
| WF1+5Ch | 323[cd] | 40[f] | 3.91[abcd] |
| WF1+10Ch | 317[cd] | 39[f] | 4.41[cde] |
| WF2+5A | 408[f] | 34[de] | 5.23[ef] |
| WF2+10A | 388[ef] | 31[cd] | 7.29[g] |
| WF1B+5Ch | 286[c] | 29[bc] | 4.21[bcd] |
| WF1B+10Ch | 276[c] | 26[ab] | 4.70[def] |
| WF2B+5A | 178[ab] | 25[ab] | 5.54[f] |
| WF2B+10A | 185[b] | 23[a] | 7.58[g] |
| Repeatability | 25 | 1 | 0.22 |

TDF – total dietary fibre content; Samples coding: WF1, WF2 – wheat flour (controls), WF1B, WF2B – wheat-barley flour premixes 70:30; WF1+5Ch, WF2+10A – flour composites containing 5% or 10% of chestnut and acorn, respectively. a-f: values in columns signed by the same letter are not statistically different (P = 95%)

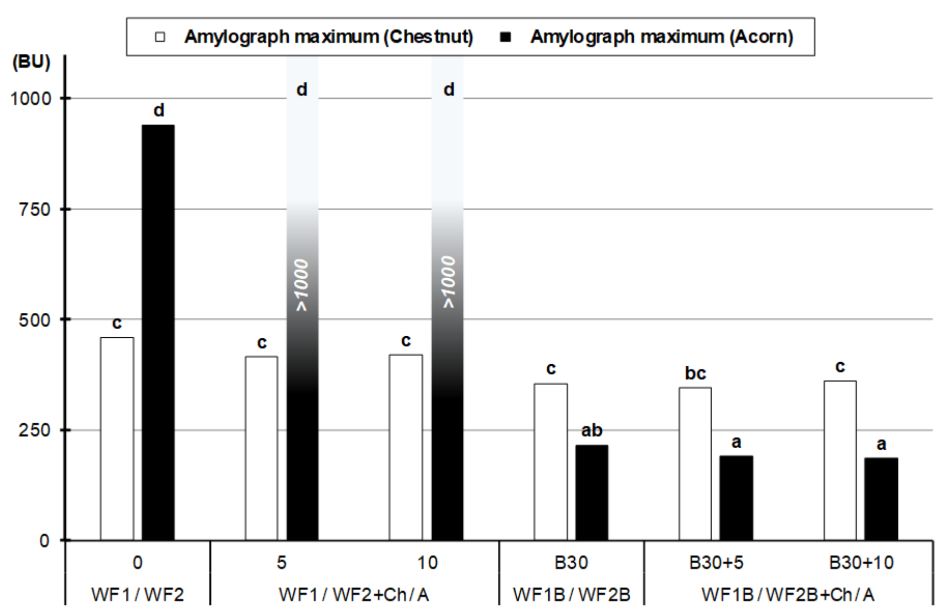


**Fig. 1.** The influence of non-traditional plant raw materials on wheat flour pasting behaviour. Samples coding: see Table 1. *a-e*: columns or dots signed by the same letter are not statistically different (P = 95%)

*Rheological properties of flour and flour composites*

For WF controls and 10 flour composites, differences in amylograph viscosity maximum corresponded with level of Falling number ($r$ = 0.92, P = 99.9%; data not shown). According this viscosity parameter, partial differentiating of flour composites tested may be attained. A soft influence of chestnut flour and strong one of acorn and barley flour could be noticed on Figure 1. A negative influence of chestnut flour confirmed by Hegazy et al. (2014) by the RVA test – viscosity for wheat-chestnut flour 90:10 (w/w) was verifiably lower than for wheat control (2036 vs. 2651 mPa·s; decreased about 23%). In agreement with high TDF content, addition of acorn flour caused reversely an increase of the maximal viscosity over the amylograph technical limit of 1000 BU. In combination with BF, high amylases activity in the alternative cereal flour suppressed the thickening effect of the acorn flour. For wheat-barley-chestnut composites, it seems that chestnut flour partially buffered that effect of BF. Yoo et al conducted the direct comparison of pasting of the chestnut and the acorn starches (2012) by the RVA proof, and unlike our results, they reported lower peak viscosity for the acorn starch than chestnut one (4874 mPa·s against 5640 mPa·s, respectively).

For both wheat dough controls, behaviour during kneading was more levelled together than the Zeleny test indicated – the WF2 sample had a little shorter dough development time but about 50% longer dough stability (Table 2). Water absorption values as well as dough softening degrees could be considered as comparable and sufficient for enhancement by non-traditional plant materials. With increasing portion of chestnut flour, water absorption of the composites rather decreased, while dough development has been somewhat decelerated (time was prolonged) and degree of dough softening softly increased (Table 2). Using bakery weaker wheat flour, Hegazy et al. (2014) got different results – 10% replacement by chestnut flour improved dough viscoelastic properties (e.g. water absorption has been increased from 56.5% to 60%, and stability was shortened from 9.0 min to 7.5 min). Acorn flour showed farinograph behaviour of wheat flour in similar course – water amounts arose about 2 percent , dough development time was magnified four-times and dough stability fell from 11.0 min to 9.0 min (Table 2). Comparing amylograph and farinograph results, acorn polysaccharides have a better absorption capacity at lower temperatures than when they are heated. This premise was confirmed by Yoo et al. (2012) – during the cold phase (beginning) of the RVA test, acorn starch demonstrated a higher viscosity than chestnut one (5594 mPa·s against 4483 mPa·s, respectively).

Two principal properties of wheat proteins are elasticity and extensibility, expressed as their ratio. For bakery products, the extensograph elasticity should be 2 or 2.5-times higher than the extensibility; value ranges 450 – 600 BU and 140 – 170 mm, respectively, indicate optima of the parameters. In addition, extensograph energy as area under the curve gives a complex overview of flour technological quality (Příhoda and Hrušková, 2007); its empirical minimum starts at 100 $cm^2$ (Kovaříková and Netolická, 2011). With respect to experiences supra, both wheat flour controls WF1 and WF2 fulfilled the demand for good technological quality (the energies 139 and 115 $cm^2$, the ratios 2.03 and 2.81, respectively; Fig. 2a, 2b). Both chestnut and acorn flour added alone improvably elevated the energy level, but they clearly worsened dough machinability as the elasticity-to-extensibility ratios rose twice and three-times with rising enhancement level (Fig. 2b). In combination with barley flour, the influence is obvious – BF proteins released the non-fermented dough to be more elastic and less tensile. Within the composites set on base of technologically stronger WF1, a drop in the energy reached larger extent. For the wheat-barley-acorn counterparts, acorn fibre supported dough elasticity, i.e. it showed a certain potential to correct such quality loss. On the other hand, a trend registered in the plot verifies a stepwise deprivation in dough handling properties – the higher wheat flour replacement rate, the multiple higher extensograph ratio (up to 14.5 and 11.1 for samples WF1B+10Ch and WF2B+10A, respectively).

*Baking test results*

During leavened dough preparation, recipe water additions was evaluated in ranges 58.0 - 62.5% and 53.5 - 59.5% within the “chestnut” and “acorn” sample subgroups, respectively (data not shown). For flour composites based on WF1, initial water amount 62.5% was diminished as the chestnut content increased (similarly for samples on WF1B base), contrasted to results published by Hegazy et al. (2014). Also Kučerová et al. (2013) determined increasing recipe water amount during wheat bread preparation enhanced by 1% and 3% of bamboo fibre. Within the subgroup on base of WF2 and WF2B, a decreasing trend was noticed . Compared to the farinograph water absorption, it means a reversal course. In spite of significant rise of TDF content (Table 1), bread formula components salt, sugar and fat perhaps restricted water molecules incorporation into protein chains coating, and lowered total amounts of added water.

**Table 2.** Farinograph features of wheat flour and flour composites

| Flour, flour composite | Water absorption (%) | Dough development (min) | Dough stability (min) | MTI (BU) |
|---|---|---|---|---|
| WF1 | $67.7^{cd}$ | $3.75^{ab}$ | $7.50^{b}$ | $50^{ab}$ |
| WF1+5Ch | $66.6^{bc}$ | $8.00^{de}$ | $9.00^{c}$ | $50^{ab}$ |
| WF1+10Ch | $65.5^{ab}$ | $6.50^{c}$ | $7.50^{b}$ | $70^{bc}$ |
| WF1B | $70.0^{e}$ | $10.00^{f}$ | $17.00^{e}$ | $30^{a}$ |
| WF1B+5Ch | $68.2^{d}$ | $4.00^{b}$ | $4.00^{a}$ | $100^{de}$ |
| WF1B+10Ch | $67.5^{cd}$ | $4.00^{b}$ | $4.00^{a}$ | $100^{de}$ |
| WF2 | $65.1^{a}$ | $2.75^{a}$ | $11.00^{d}$ | $40^{a}$ |
| WF2+5A | $66.1^{ab}$ | $8.50^{e}$ | $4.50^{a}$ | $50^{ab}$ |
| WF2+10A | $67.5^{cd}$ | $10.50^{f}$ | $9.00^{c}$ | $70^{bc}$ |
| WF2B | $68.0^{d}$ | $4.50^{b}$ | $3.50^{a}$ | $120^{e}$ |
| WF2B+5A | $68.3^{d}$ | $7.00^{cd}$ | $8.00^{bc}$ | $90^{cd}$ |
| WF2B+10A | $68.5^{d}$ | $8.25^{e}$ | $11.00^{d}$ | $50^{ab}$ |
| Repeatability | 0.2 | 0.20 | 0.20 | 4 |

MTI - mixing tolerance index (dough softening degree), BU - Brabender unit. a-g: values in columns signed by the same letter are not statistically different (P = 95%)

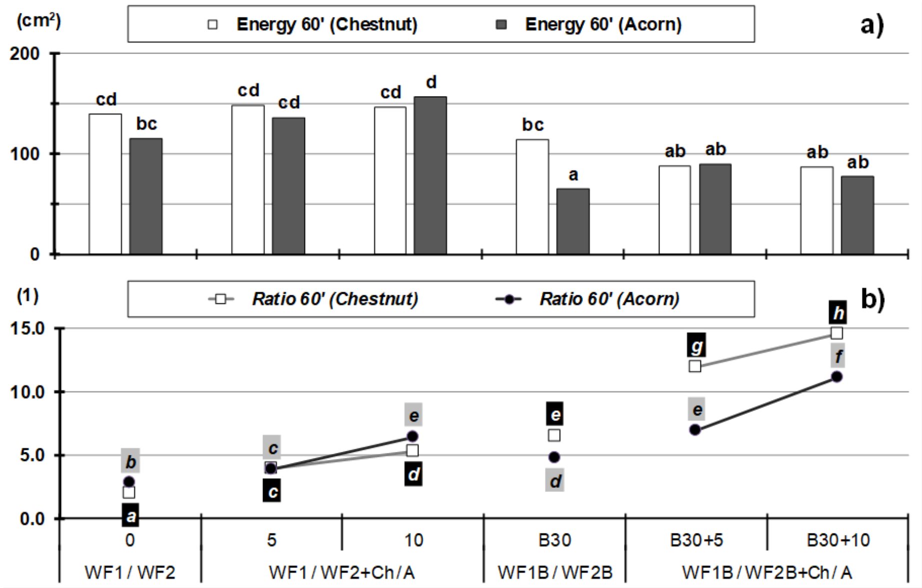


**Fig. 2.** The influence of non-traditional plant raw materials on viscoelastic properties of wheat flour. a) Extensograph energy, b) extensograph ratio (elasticity-to-extensibility). Samples coding: see Table 1. *a-g*: columns or dots signed by the same letter are not statistically different (P = 95%)

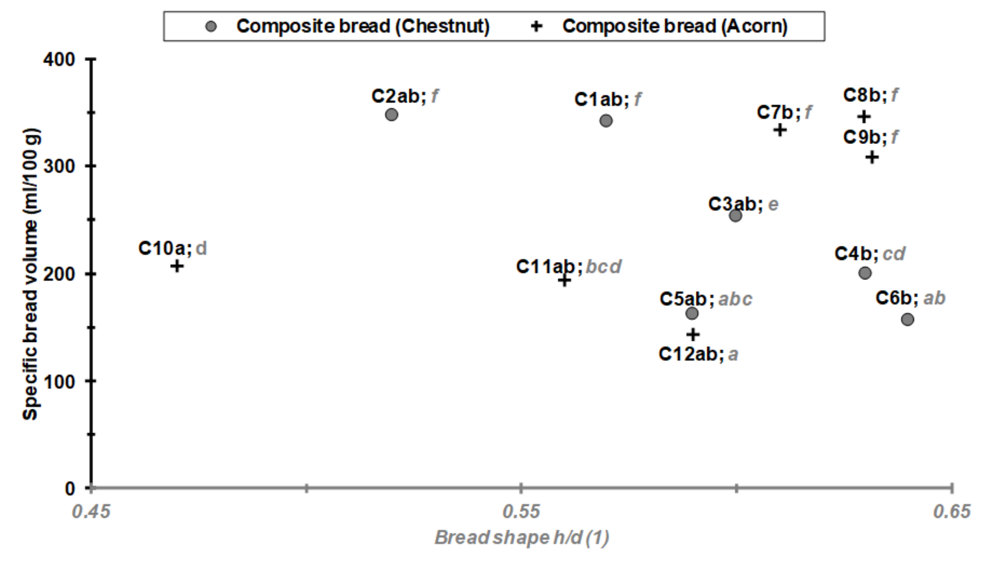


**Fig. 3.** The influence of non-traditional plant raw materials on wheat bread quality. Composite samples coding: C1 – WF1; C2 – WF1+5Ch; C3 – WF1+10Ch; C4 – WF1B; C5 – WF1B+5Ch; C6 – WF1B+10Ch (codes C7-C12 similarly within WF2-acorn subset). Variable coding: h/d – height-to-diameter ratio of bread bun. a-f, *a-f*: means of specific bread volume and bread shape, respectively, signed by the same letter, are not statistically different (P = 95%).

On the Fig. 3, bread samples quality was differentiated according to the absence or presence of BF in dough recipe (flour composites coded C1-C3 and C7-C9 vs. C4-C6 and C10-C12, respectively). Although chestnut and acorn flour were added in small portions, both materials decreased specific bread volume (Demirkesen et al., 2010) as well as modified bread shape. Also, a tight relationship between specific bread volume and crumb penetration was verified ($r$ = 0.93, P = 99.9%), with somewhat harder crumb for bread with acorn flour.

Sensorial profiles of composite bread were close to wheat control in majority what is shown in Figure 4. Barley and acorn flour are characterised by their own typical flavour, which may be not pleasant for consumers, and thus summary organoleptic evaluation ascended to 14.5 points for the most enriched bread variants. The most affected parameters were just taste and aroma, chewiness and stickiness (data not shown). As the best score is equal to 8 and the worst 24 points, mentioned value means a soft worsening of consumer's quality.

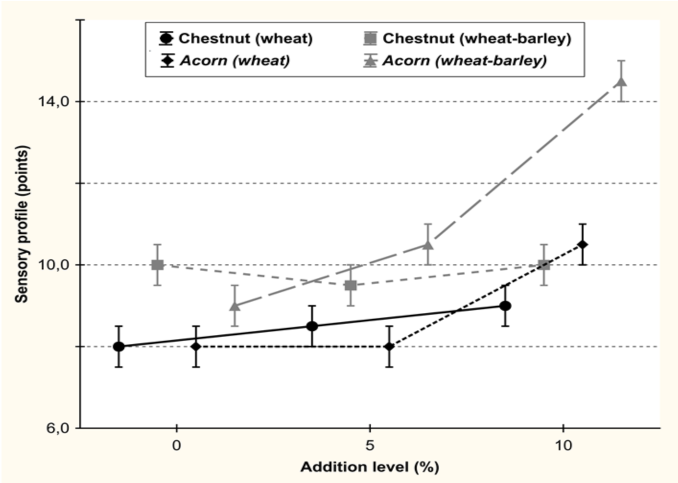


**Fig. 4.** The influence of non-traditional plant raw materials on sensory profile of wheat bread. Whiskers denote measurement repeatability.

*Statistical analysis*

In constructed biplot of loadings and scores, the first two principal components explained 74% of data scatter, i.e. 55% was covered by PC1 and 19% by PC2 in average (Fig. 5). The third PC explained 20% of variance of the features TDF, extensograph ratio, recipe water addition and bread shape. In addition, PC4 was substantial for both farinograph features, i.e. for the water absorption and the mixing tolerance index (38% of traits variability). Fourteen representative variables are conjoined into four main groups, demonstrating relationships to bread quality. For the flour composites tested, specific bread volume and crumb penetration were positively dependent protein quality (Zeleny value, extensograph energy, recipe water addition) and negatively on polysaccharides pasting behaviour (Falling number and both amylograph features). As it could be presumed, increasing rate of TDF had an impact on dough rheological properties (water absorption, mixing tolerance index, extensograph ratio) and bread characteristics including sensory profile.

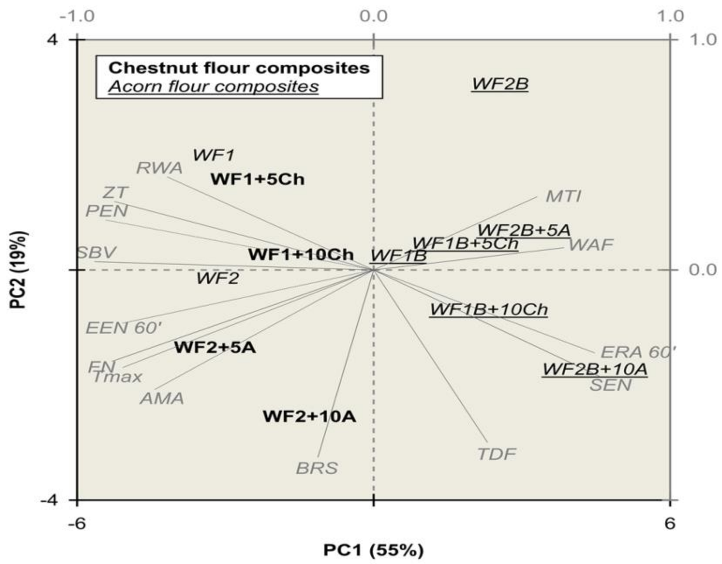


**Fig. 5.** Principal components (PC) biplot of barley, chestnut and acorn flour influence on wheat flour, dough and bread properties and quality. Samples coding: see Table 1. Variables coding: TDF – total dietary fibre content; FN – Falling number; Zeleny – Zeleny sedimentation value; WAF – farinograph water absorption; MTI – mixing tolerance index (dough softening degree); ERA 60', EEN 60' – extensograph ratio and energy after 60 min of dough resting; AMA, Tmax – amylograph maximum and proper temperature; RWA – recipe water addition; SBV – specific bread volume; BRS – bread shape (height-to-diameter ratio; PEN – crumb penetration; SEN – sensory analysis

As mentioned above in the text, absence or presence of BF in dough or bread recipe is a key for flour composites distinguishing. Along the PC1 axis, barley flour lowered baking potential of bi-composite mixtures. The PC2 could be associated with additional level of non-traditional plant materials. In this regard, a contradictory effect could be identified for 10% of chestnut and 5% of acorn flour – the former had a worsening, but the latter an improving effect (i.e. specific bread volumes 253 and 347 ml/100 g, respectively).

To sum up , wheat flour composites with 10% of chestnut flour and wheat-barley ones with 5% of chestnut or acorn flour could be recommended for bakery praxis.

## Conclusion

The testing of increased level of dietary fibre in wheat flour composites confirmed a knowledge about diverse impact of different plant materials on dough properties and bread quality. With respect to enhancement level, chestnut, acorn and barley flour as naturally gluten-free raw materials limited dough machinability and worsened consumer attributes of bread. As a compromise between fibre content and final properties of bakery product, wheat flour composites with 10% of chestnut flour and wheat-barley ones with 5% of chestnut or acorn flour had somewhat higher baking potential.

*Acknowledgement*

The study was conducted under the grant No QI111 B053 of the NAZV, Czech Republic.

## References

Březinová-Belcredi, N., Ehrenbergerová, J., Běláková, S., Vaculová, K. (2009): Barley grain as a source of health-beneficial substances. *Cz. J. Food Sci.* 27, 242-244.

Correia, P.R., Beirão-da-Costa, M.L. (2010): Chestnut and acorn starch properties affected by isolation methods. *Starch/Stärke* 62, 421-428. http://doi.org/10.1002/star.201000003.

CREA 2015a (Il Centro di Ricerca Alimenti e Nutrizione). Tabelle di composizione degli alimenti – 11) Farina di castagne. http://nut.entecra.it/646/tabelle_di_composizione_degli_ alimenti.html ?idalimento=504010&quant=100. Accessed Sep 12, 2017.

CREA 2015b (Il Centro di Ricerca Alimenti e Nutrizione). Tabelle di composizione degli alimenti – 3) Farina di frumento tipo 00. http://nut.entecra.it/646/tabelle_di_composizione _degli_alimenti.html?idalimento=000220&quant=100. Accessed Sep 12, 2017.

CREA 2015c (Il Centro di Ricerca Alimenti e Nutrizione). Tabelle di composizione degli alimenti – 2) Farina d'orzo. http://nut.entecra.it/646/tabelle_di_composizione_degli_alimenti .html?idalimento=000220&quant=100. Accessed Sep 12, 2017.

Demirkesen, I., Mert, B., Sumnu, G., Sahin, S. (2010): Utilization of chestnut flour in gluten-free bread formulations. *J. Food Eng.* 101, 329-336. https://doi.org/10.1016/j.jfoodeng.2010.07.017.

Gill, S., Vasanthan, T., Ooraikul, B., Rossnagel, B. (2002): Wheat bread quality as influenced by the substitution of waxy and regular barley flours in their native and cooked forms. *J. Cereal Sci.*, 36, 239-251. http://dx.doi.org/10.1111/1541-4337.12064.

Giovanelli, C. The chestnut: from wood to table tradition and innovation [Master thesis]. Padova, Italy: Università degli studi di Padova, 2008. 83 pp. (in Italian). http://tesi.cab.unipd.it/21829/1/TESI_CASATAGNA.pdf. Accessed Sep 12, 2017.

Hegazy, N.A., Kamil, M.M., Hussein, A.M.S., Bareh, G.F. (2014): Chemical and technological properties of improved biscuit by chestnut flour. *Internat. J. Food Nutri. Sci.*, 3, 7-15.

Kovaříková D., Netolická V.: *Quality of cereals for for mill processing. Educational material for subject Technological conditioning*. Střední průmyslová škola potravinářská Pardubice, Pardubice, Czech Republic. 1st ed., 2011, 56 pp (in Czech). https://www.spspas.cz/esf-technologicka-priprava, assessed Sept 12, 2017.

Kučerová, J., Šottníková, V., Nedomová, Š. (2013): Influence of dietary fibre addition on the rheological and sensory properties of dough and bakery products. *Czech J. Food Sci.*, 31, 340-346.

Paciulli, M., Rinaldi, M., Cirlini, M., Scazzina F., Chiavaro E. (2016): Chestnut flour addition in commercial gluten-free bread: A shelf-life study. *LWT - Food Sci. Technol.*, 70, 88-95. https://doi.org/10.1016/j.lwt.2016.02.034.

Pina C. (2013): Acorn bread: A traditional food of the past in Sardinia (Italy). *J. Cult. Her.*, 14S, S71-S74. https://doi.org/10.1016/j.culher.2012.11.012.

Samuel D. (1997): Cereal foods and nutrition in ancient Egypt. *Nutri.*, 13, 579-580. https://doi.org/10.1016/S0899-9007(97)00027-0.

Příhoda J., Hrušková M.: *Quality assessment. Application of recommended devices, methods and interpretation of results for practice*. Svaz průmyslových mlýnů České republiky, Praha, 1st ed., 2017, pp. 104-108 (in Czech).

Sabrin M.D.: Characterization of acorn meal [Master thesis]. Providence, USA: Johnson & Wales University, USA, 2009. 154 pp. (in English) https://getd.libs.uga.edu/pdfs/sabrin_michael_d_200908_ms.pdf, accessed Sep 12, 2017.

Silva S., Costa E.M., Borges A., Carvalho A.P., Monteiro M.J., Estevez Pintado M.M. (2016): Nutritional characterization of acorn flour (a traditional component of the Mediterranean gastronomical folklore). *Food Meas.*, 10, 584-588. https://doi.org/10.1007/s11694-016-9340-1.

Skendi, A., Biliaderis, C.G., Papageorgiou, M., Izydorczyk, M.S. (2010): Effects of two barley β-glucan isolates on wheat flour dough and bread properties. *Food Chem.*, 119, 1159-1167. https://doi.org/10.1016/j.foodchem.2009.08.030.

Švec, I., Hrušková, M. (2004). Image data of bread crumb structure from flour of Czech spring wheat cultivars. *Cz. J. Food Sci.*, 22(4), 133-142.

Yoo, S.-H., Lee, C.-S., Kim, B.-S., Shin, M. (2012): The properties and molecular structures of gusiljatbam starch compared to those of acorn and chestnut starches. *Starch/Stärke*, 64, 339-347. https://doi.org/10.1002/star.201100104.