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WHEAT FLOUR, BREAD AND BISCUITS ENRICHED BY LINSEED FIBRE – COMPARISON OF HARVEST YEAR, LINSEED VARIETY AND ADDITION LEVEL

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ABSTRACT
Wheat flour was fortified by 2.5, 5.0 or 10 wt. per cent of linseed fibre, gained from seeds of golden flax varieties Amon and Raciol and brown one Recital (granulation 500 – 700 m), prepared from 2015 and 2016 harvests. Using analytical tests, namely sedimentation according to Zeleny and Falling Number, basic technological quality of flour composites was mostly independent on all three observed factors (harvest year, linseed variety and addition). Rheological tests included the farinograph, the extensigraph and the amylograph proofs. Enhancement by brown and yellow flax fibre significantly contributed to rise of farinograph water absorption and to dough stability shortening, directed mainly by addition level. Extensigraph curves course depended on dough resting time, higher differences between wheat control and flour composites were observed after 60 min dough resting. Linseed fibre weakened dough extensibility, and energy as area under curve also partially decreased about 3, 8 and 25% in average as portion of alternative materials in dough has risen. Compared to control, suspension viscosities of tested flour composite generally increased; the strongest effect was recorded for composite samples from harvest year 2016. During dough leavening, tested samples were differentiated according to maturograph dough resistance, and interaction of all three factors was identified. Regardless to variantion in dough machinability, specific volumes of composite bread samples were similar through whole sample set – any unequivocal trend was found. Somewhat worse vaulting of bread was calculated for buns manufactured from raw materials of 2016 harvest. Reversely, linseed fibre produced in 2015 improved crumb softness, especially at 5% enhancement (about ca 50% in average). The lowest addition of linseed fibre resctricted biscuits spread during baking in the highest extent, but rising level of enhancement suppressed elevated dough elasticity. Both cereal products were considered as acceptable for common consumers. Multivariate PCA method verified changes mainly in protein visco-elastic properties, which were reflected in bread and biscuits quality in an opposite manner. Based on this statistics, quality of wheat controls was comparable in both harvest year if related to changes induced by linssed fibre. In opposite to this, technological and consumer's parameters of flour composites and manufactured cereal products were statistically dependent of harvest year of linseed. As presumed, the lowest addition level brough the smallest changes; multiplied fortification caused gradual variation in results of all conducted proofs. Owing to high dietary fibre content in linseed fibre (over 50%), the medium dosage of the alternative material (i.e. 5% addition) could be recommended for praxis.

Keywords: brown and golden linseed fibre; dough rheology; bread; biscuits; principal component analysis

INTRODUCTION
Comparably to barley rennasaince passed off a few years ago, also linseed recovery in food industry started recently. A reason for this comeback could be addressed both to nutritional benefit and to new type of commercial products, namely linseed oil and fibre as food supplements of affordable price level. At the same time, interest of consumers in nutritionally richer and innovated bakery products maintains, supporting industrial production of such food supplements.

Fruits of linseed (*Linum usitatissimum* L.) are medium-sized seeds coloured in brown or gold, which represent a raw material traded not only in food industry (e.g., also in cosmetics). Demanded component of seeds, i.e. dietary fibre, consists mainly of hetero-polysaccharides forming 7-12% of seeds weight. Their structure is based on arabinoxylans, acid complex of galacturonic acid and rhamnose **(Kaewmanee et al., 2014)**. Comparably to barley β-glucans, they dispose by high water absorption at concentration lower than 1% **(Mazza and Biliaderis,**

2006) and by gelling properties (mucilage) **(Prazdnik et al., 2016**). In relation to variety type, flow properties between from brown and golden linseed mucilage may differ **(Troshchynska et al., 2016)**. As found **Kaewmanee et al. (2014)**, mucilage viscosity has relation to the neutral sugars and proteins amounts, predefing a final usage (stabiliser, thickener).

Linseed fibre as commercial food supplement is a by-product during linseed oil extraction. From the New Zealand to the whole world, linseed dietary dibre is delivered by the company Functional Whole Foods. The company produces both golden and brown linseed fibre types, which contain ca 45% of total dietary fibre (38% insoluble and 7% soluble fraction; http://fwf.co.nz/). For significant health benefit, consumption of 13 g linseed fibre is recommended daily; in natural form, home consumption may include breakfast fruit cocktails, yogurt spreading etc. Further, it may replace a part of wheat flour when making pancake, cake or bread for family dinners or celebrations.

As in case of other non-traditional seeds, wholemeal flour is the simpliest form to be used. Addition of flax seed flour elevated water absorption and mixing tolerance index, but reduced dough stability and extensibility **(Koca and Anil, 2007; Xu et al., 2014)**. Mentioned changes were softly reflected in principal bread quality characteristics as the volume of bread. Testing influence of full fat or partially defatted flax flour, **El-Demery et al. (2015)** arrived at conclusion of comparable quality of both modified bread variants. Separating hulls only and preparing flaxseed hull flour, composite bread involving 5% of that raw material in recipe was characterised by decreased specific bread volume and higher crumb firmness **(Sęczyk et al., 2017)**.

Biscuits recipe modification in this way may be reflected in dough stickiness and overall acceptability of final product. Flaxseed flour portions 6% and 12% resulted in still acceptable sweetmeat, while is dosage at level 18% was found as unsatisfactory **(Khouryieh and Aramouni 2012)**.

Scientific hypothesis

The goal of the paper is a statistical comparison of harvest year, linseed variety and linseed fibre addition level effects on technological quality of wheat flour. Properties of prepared flour composites were described by basic analytical tests, and their rheological behaviour was determined in form of non-fermented as well as fermented dough. In term of final product, bread and biscuit baking trials were conducted including assessment of sensory quality.

MATERIAL AND METHODOLOGY

Preparation of flour composites

Semi-bright wheat flour (WF) was delivered by industrial mill Delta Prague in years 2016 and 2017, and they were characterized by protein contents 11.2 and 13.1%, Falling number 432 and 394 s and Zeleny values 39 and 45 mL, respectively. Linseed fibre was produced at laboratory conditions, treating seeds from golden varieties Amon and Raciol and brown one Recital, harvested in years 2015 and 2016. To disintegrate the seeds, mill Stephan UM/SK 5 (Stephan Machinery, Hameln, Germany) was employed. Using vibration laboratory hand sieve machine (Stavební strojírenství n.p. Brno, Czechoslovakia) with sieve openings: 1.0, 0.8, 0.71, 0.50, 0.315 and >0.315 mm, demanded fraction 0.5 – 0.7 mm was collected to ensure comparability with our previous study (**Hrušková and Švec 2017**). In tested composites, linseed fibre replaced 2.5, 5.0 or 10 wt. per cent of wheat flour. Samples abbreviations combined simplified wheat flour sign, addition level of linseed fibre and first letter of flax variety name (2.5Am, 5Am, 10Am; 2.5Ra, 5Ra, 10Ra; 2.5Re 5.0Re, 10Re). Harvest years of linseed are differentiated as follows: 2.5 Am for the former and 2.5 Am for the latter one.

Technological quality of flour composites

Technological features of WF and flour composites are described by Zeleny test (abbreviation ZT; ISO 5529) and Falling number (abbreviation FN; ISO 3093). Non-fermented dough properties were determined with the help of farinograph and extensigraph Brabender (Germany) according to the approved norms ISO 5530-1 and ISO 5530-2. Behaviour of flour-water suspensions was recorded on the Amylograph Brabender (ICC norm 126/1). According to internal methods of the Cereal laboratory of the UCT Prague, rheological behaviour parameters of fermented dough was recorded by using of the Fermentograph SJA (Sweden), Maturograph and Oven rise recorder (OTG) Brabender (Germany). From mixed wheat-linseed fibre composites, leavened bread and cut-off biscuits were manufactured manually. Their quality assessment included also informative sensory analysis, employing three trained pannelists.

Dilution of skeleton in wheat dough by linseed proteins of non-gluten nature probably bring a partial worsening of composite dough machinability (viscoelastic properties) and conseutivelly final products quality. To these results also may contribute high water binding capacity of linseed fibre, which will influence viscosity of composite flour during mixing and heating (pasting phase). Besides, tested addition levels could be considered as a low, thus both types of cereal products may reach a sufficient sensory score.

Statisic analysis

Statistical evaluation of linseed fibre effect

Influence of harvest year, type and addition level of non-traditional material on selected dough rheological properties and final product features was evaluated by HSD test (p = 95%). Owing to the Principal Components Analysis (PCA), finding of final product quality features dependent on three observed factors is allowed. For PCA datasets, two analytical features, three farinograph and two extensigraph ones, a pair of the pasting characteristics and foursome of the product quality attributes immanent to the product type were selected.

RESULTS AND DISCUSSION

Evaluation of technological quality of flour composites

Within compared harvest years, protein technological quality of both controls (*WF'15* and WF'16) were close together (39 and 45 mL, respectively). Their partial replacement by linseed fibre caused a soft worsening as expected, and the effect was similar for composites of harvest 2015 and 2016 (ranges 40 – 30 mL vs. 45 – 29 mL; Figure 1) as well as for tested linseed varieties (controls mean 42 mL vs. averages 35, 36 and 36 mL, respectively). In this regard, the only one factor whose effect was statistically significant was the addition level (controls mean 42 mL vs. 39, 36 and 31 mL for enhancement 2.5, 5 and 10%, respectively).

In observed harvest years, Falling number test disclosed a rather reversal contribution to linseed fiber on amylases activity. For samples from crop 2015, 2.5% enrichment meant a lowering of the FN (from -11% to -16%). For flour composites of the year 2016, a verifiable increase of the FN caused the highest linseed fibre dosage (from +11% to +22%). Due to method repeatability quantified as ±10%, a majority of determined differences are insignificant in fact (variance '*a', 'ab', 'b'* only; Table 1).

Viscoelastic behaviour of flour composites

With respect to ANOVA resuls in Table 2, comparable water absorption of controls *WF'15* and WF'16 was more supported by all three linseed fibre types harvested in 2015 (means 73.3% and 70.2%). Increasing portion of the alternative raw material lead to provable increased amount of water during the farinograph test – an accrual caused by 10% LF was similar through the whole flour composites set (4.0 – 5.0 per cent points, related to 5% LF dosage). Testing 5% flaxseed wholemeal, water absorption maintained comparable to wheat control, but dough development time has been prolonged **(Koca and Anil 2007)**. Autors addressed this finding to increased fraction of fat in blend.

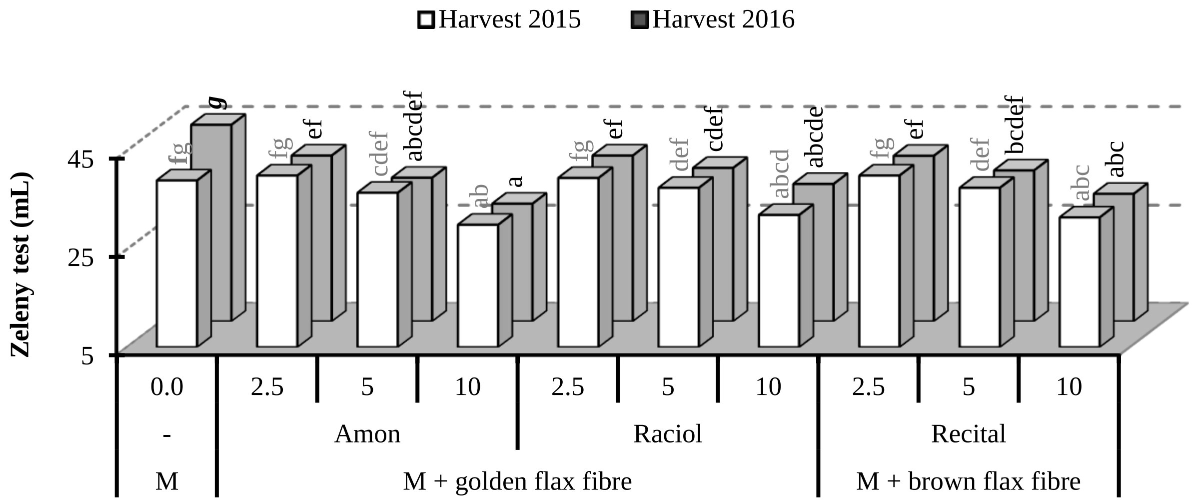

Figure 1 Zeleny test results of wheat flour (WF) and wheat-linseed fibre composites. A – f: coulmns signed by the same letter are not statistically different (p = 95%).

Table 1 Falling number of wheat flour and flour composites.

Composite flour	Harvest	Falling Number* (s) Linseed fibre addition (%) 0	2.5	5	10
WF	2015	432b	-	-	-
	2016	394ab	-	-	-
WF+Am	2015	-	362a	387a	399ab
	2016	-	403ab	411ab	466b
WF+Ra	2015	-	386a	384a	384a
	2016	-	408ab	407ab	451b
WF+Re	2015	-	378a	364a	339a
	2016	-	390ab	434b	476b

Note: WF - wheat flour. Linseed varieties: Am - Amon, Ra - Raciol (both golden), Re - Recital (brown). * a-b: values signed by the same letter are not significantly different (p = 95%).

Combination of elevated dietary fibre content as well as water portions was reflected in dough stability shortening and degree of dough softening increase, reversely to influence of the same material from the New Zealand **(Hrušková and Švec 2016)**. The changes extent was comparable within both harvest subgroups, but twice-longer stability for *WF'15* than for WF'16 meant decrease by all three additions. Within the subset 2016, 2.5% LF addition firstly led to substantial stability prolongation (from 6.25 min up to 9.50 min); values for blends containing 5% LF were comparable to the control and only 10% of non-traditional material had a negative impact (Table 2). For the tested composites, degree of dough softening was determined in usual ranges 70 – 135 BU and

Table 2 Farinograph characteristics of non-fermented dough from wheat flour (WF) and flour composites.

Composite flour	Harvest	Water absorption* (%)	Dough stability* (min)	Dough softening degree* (FU)
WF	2015	65.1a	11.00d	40a
	2016	65.2a	6.75abc	35a
2.5Am	2015	70.0c	9.75cd	100ef
	2016	67.4b	8.50bcd	55ab
5.0Am	2015	72.5d	7.00abc	95ef
	2016	69.4c	6.00ab	80cde
10.0Am	2015	77.5f	6.00ab	70bcd
	2016	73.4de	5.00a	110f
2.5Ra	2015	70.0c	9.25bcd	85cde
	2016	67.8b	9.00bcd	65bc
5.0Ra	2015	72.5d	6.50abc	135g
	2016	69.4c	7.00abc	90def
10.0Ra	2015	77.0f	4.50a	90def
	2016	73.8e	4.75a	80cde
2.5Re	2015	70.3c	7.45abc	80cde
	2016	67.4b	9.50cd	40a
5.0Re	2015	72.8de	6.75abc	95ef
	2016	69.5c	7.50abc	90def
10.0Re	2015	76.8f	4.75a	100ef
	2016	73.8e	4.50a	95ef

Note: WF - wheat flour. Golden linseed varieties: Am - Amon, Ra – Raciol, brown one: Re - Recital. Example of sample coding: W2.5A - wheat composite flour with 2.5 wt. % Amon linseed fibre. * a-f: row means described by the same letter are not significantly different (p = 95%).

Table 3 Results of extensigraph test of wheat flour (WF) and flour composites.

a) Energy, resting time 30 min

Composite flour	Harvest	Linseed fibre addition (%) 0		2.5 - 10	
WF	2015	105f	-	-	-
	2016		76abcdef	-	-
WF+Am	2015	-	-	91cdef – 68abcde	
	2016	-	-		73abcdef – 48a
WF+Ra	2015	-	-	98def – 65abcd	
	2016	-	-		86bcdef - 52ab
WF+Re	2015	-	-	86bcdef - 73abcdef	
	2016	-	-		71abcde – 58abc

b) Energy, resting time 60 min

Composite flour	Harvest	Linseed fibre addition (%) 0		2.5 - 10	
WF	2015	115de		-	-
	2016		90abcde	-	-
WF+Am	2015	-	-	118e – 80abc	
	2016	-	-		71ab – 66a
WF+Ra	2015	-	-	120e – 82abcd	
	2016	-	-		88abcde – 73ab
WF+Re	2015	-	-	112cde – 87abcde	
	2016	-	-		89abcde – 72b

Note: WF - wheat flour. Linseed varieties: Am - Amon, Ra - Raciol (both golden), Re - Recital (brown). * a-b: values signed by the same letter are not significantly different (p = 95%).

40 – 100 BU, and narrower extent of the latter 2016 composites corresponds to lower water absorptions. Main impact on dough resistance to overmixing could be noticed for 5% LF, because values of dough softening for counterparts containing 10% LF were comparable or lower.

By the extensigraph test, presumed lowering of bakery quality of non-fermented dough was confirmed. Values of energy after 30 min of dough resting were lowered by higher LF additions, for samples with 10% about 23 up to 38%. Twice longer resting time had a positive effect on the feature, depression against control was about 3 – 16% less (e.g. 105 and 83 cm^2 for *WF'15* and *WF'15-5Am* at 30 min of dough resting, and 115 and 105 cm^2 at 60 min of dough resting) (Table 3). **Koca and Anil (2007)** concluded that only 20% of flaxsedd wholemeal lowered the energy significantly (from 111.0 to 85 cm^2). Dough machinability was in majority of cases affected by variation of extensigraph elasticity and extensibility (i.e. elasticity-to-extensibility ratio) **(Inglett et al., 2013**). The lowest LF dosage lowered dough elasticity with patial support of its extensibility, while the highest dosage modified these physico-mechanical parameters in terms of prevailing decrease of extensibility (data not shown). In this regard, 5% LF addition could be consider as optimal for flour blends usage in bakery.

Pasting properties of flour composites

For all tested samples, characteristic points of amylograph curves differed mainly in parameter temperature of gelatinization beginning, which likely reflected diverse structural and physical properties of linseed polysaccharides in fibre from three tested varieties. For example, golden Amon fibre originated in the former harvest stepwise decresed this temperature; effect of the brown Recital fibre was reversal (Figure 2a). Maximal viscosity of control suspensions was analysed as statistically different; fibre from linseed harvested in 2015 modified the value 940 BU according to addition level. Fibre from the next harvest demonstrated this effect only in case of golden Amon variety; the Raciol and Recital ones reached maximum of 1000 BU (homogenous group '*m*'; Figure 2b).

Linseed fibre originated in New Zeeland also caused significant increase of viscosity during RVA test **(Hrušková and Švec 2016)**. **Inglett et al. (2013)** arrived at contrary conclusion for flaxseeds wholemeal, perhaps of testing of blends on base of barley flour.

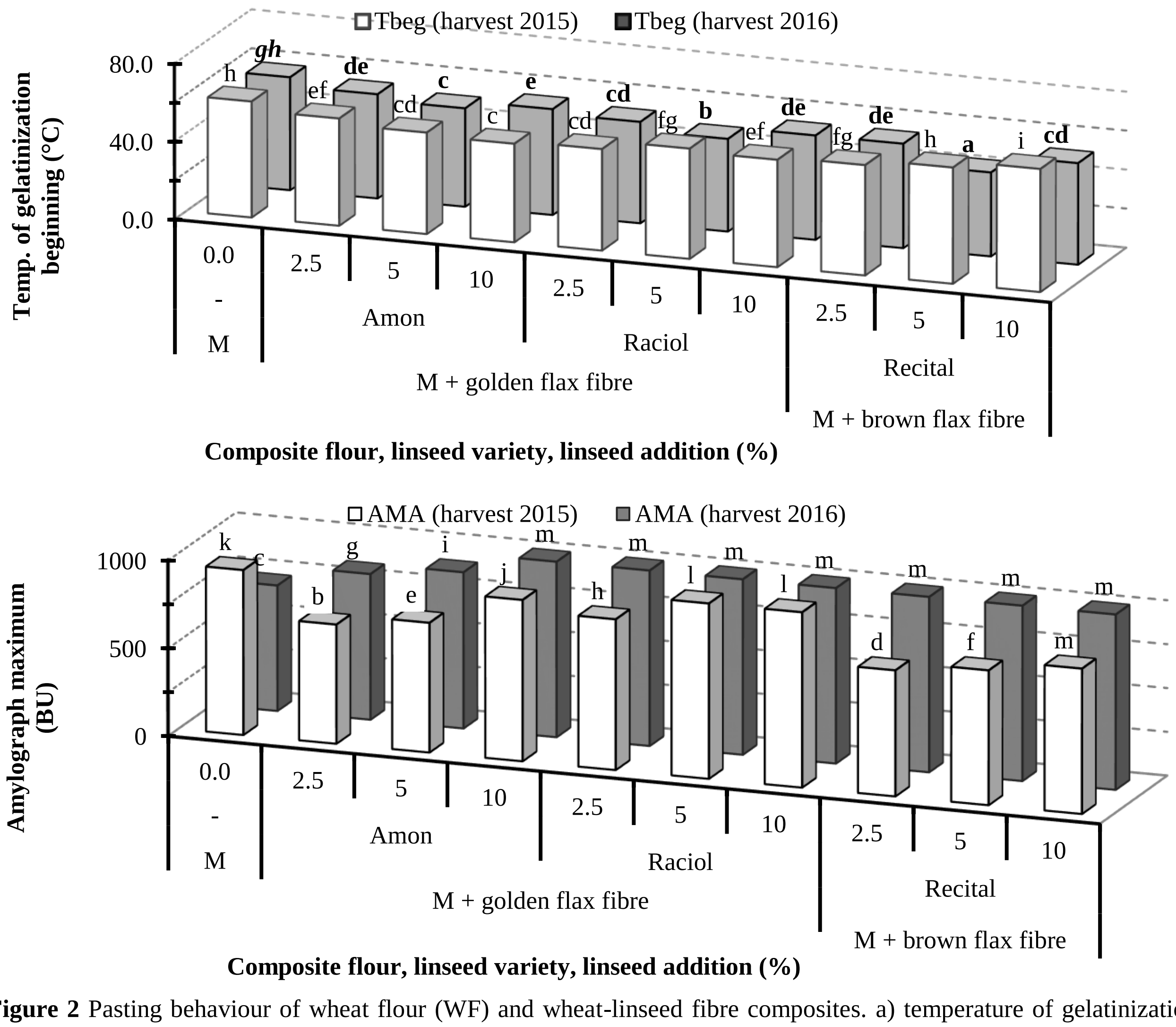

Figure 2 Pasting behaviour of wheat flour (WF) and wheat-linseed fibre composites. a) temperature of gelatinization beginning, b) amylograph viscosity maximum. For samples coding, see Table 2. a-m: columns signed by the same letter are not statistically different (p = 95%).

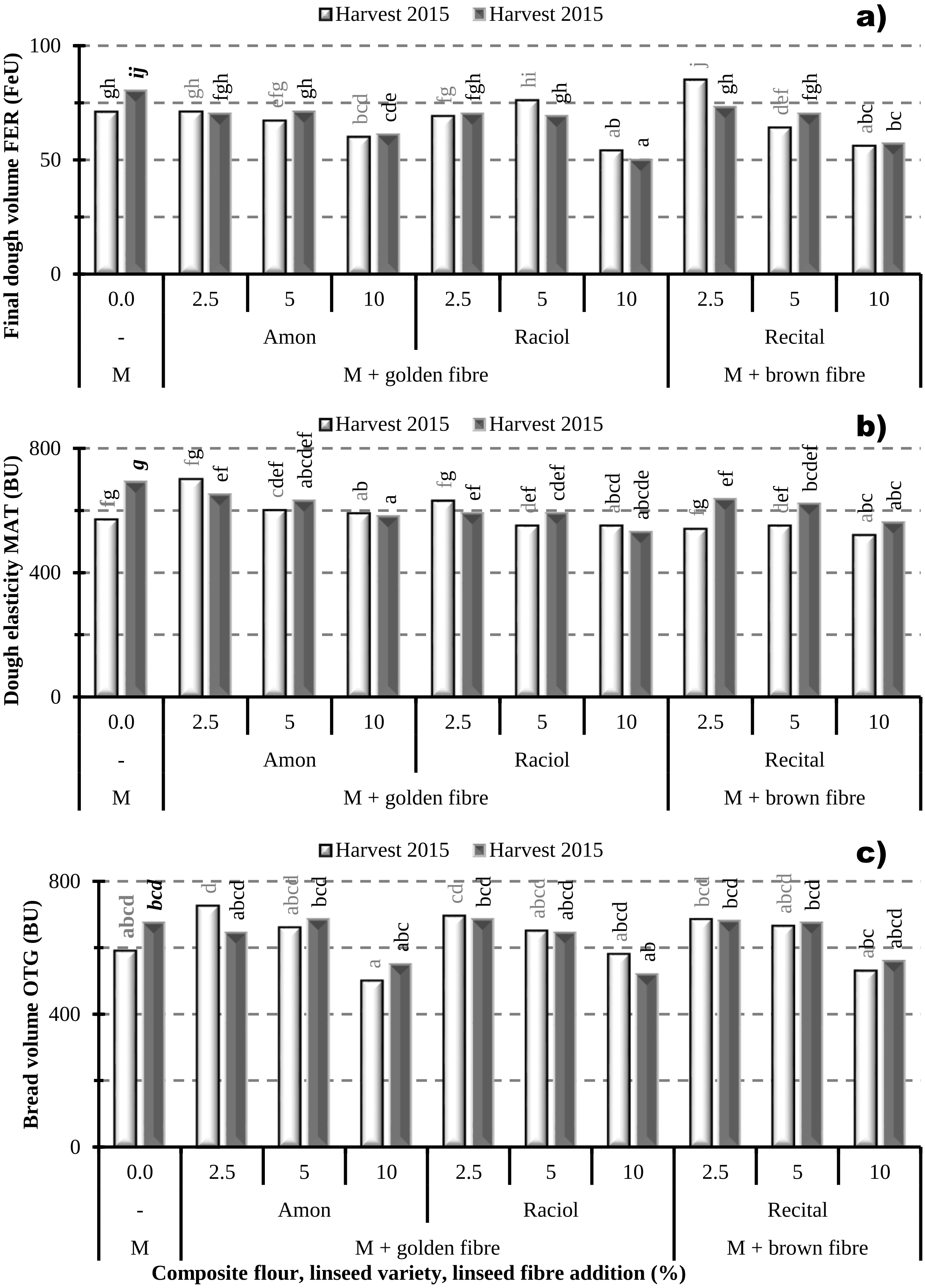

Figure 3 Rheological behaviour of leavened dough prepared from wheat flour (WF) and wheat-linseed fibre composites. FER – fermentograph, MAT – maturograph, OTG – oven rise recorder. For samples coding, see Table 2.

Evaluation of fermented dough behaviour

Within a bakery praxis, fermentation process is divided into three stages from the technological reasons – fermentation of dough mass after dough kneading, leavening of shaped dough pieces, and the first stage of baking. The fermentograph final dough volume, the maturograph dough resistance and OTG bread volume represent these operations. As illustrates Figure 3, LF affected all three technological phases of fermentation in a different extent. During the fermentograph test, identification of LF type and enhancement level could be more precise than in case of maturograph and OTG proofs (variations '*a*'-'*f*' vs. '*a*'-'*d*'; Figure 3a, 3b, 3c). However, LF incorporation into fermented wheat dough meant lowering of values of the representative features, especially by golden Amon and brown Recital fibre. Those conclusions signified potentionally worse results of baking trial.

Table 4 Quality features of leavened bread prepared from wheat flour and flour composites.

Flour, flour composite	Harvest	Specific bread volume* (mL.100 g^{-1})	Bread shape*, ** (-)	Crumb penetration* (mm)
WF	2015	334abcd	0.61c	14.3abcd
	2016	349abcd	0.69d	23.6h
2.5Am	2015	253a	0.62c	22.6fgh
	2016	397d	0.62c	12.3abc
5.0Am	2015	354abcd	0.62c	23.1gh
	2016	255a	0.53ab	19.9defgh
10.0Am	2015	336abcd	0.57b	9.8a
	2016	341abcd	0.58b	21.5defgh
2.5Ra	2015	282abc	0.56b	22.0efgh
	2016	410d	0.58b	10.6ab
5.0Ra	2015	357abcd	0.52ab	20.1defgh
	2016	378bcd	0.56b	18.1bcdefgh
10.0Ra	2015	278ab	0.57b	20.8defgh
	2016	405d	0.67d	14.6abcde
2.5Re	2015	365bcd	0.58b	21.0defgh
	2016	308abcd	0.54ab	16.0abcdefg
5.0Re	2015	387cd	0.49a	12.1abc
	2016	385cd	0.55ab	18.2cdefgh
10.0Re	2015	338abcd	0.56b	14.8abcde
	2016	331abcd	0.51ab	15.3abcdef

Note: WF – wheat flour. Linseed varieties: A – Amon, Ra - Raciol (both golden), Re - Recital (brown). For samples coding, see Table 2. * a – g: column means described by the same letter are not significantly different (*p* = 95%).

Table 5 Quality features of biscuits prepared from wheat flour and flour composites.

Flour, flour composite	Harvest	Specific biscuit volume* (mL.100 g^{-1})	Spread ratio*, ** (-)	Sensory profile* (mm)
WF	2015	164.6b	4.35de	12.0a
	2016	166.7b	3.66abc	12.0a
2.5Am	2015	150.1ab	3.68abcd	12.0a
	2016	152.3ab	3.77abcd	12.0a
5.0Am	2015	142.2ab	3.55ab	12.0a
	2016	152.6ab	4.01abcd	11.0a
10.0Am	2015	163.7b	3.33a	12.0a
	2016	137.8ab	3.44a	11.5a
2.5Ra	2015	143.4ab	3.53ab	11.0a
	2016	149.8ab	3.56ab	12.0a
5.0Ra	2015	153.7ab	3.76abcd	11.0a
	2016	158.9ab	3.52ab	12.0a
10.0Ra	2015	166.9b	4.17bcde	12.0a
	2016	116.6a	3.91abcd	12.0a
2.5Re	2015	127.1ab	3.73abcd	11.0a
	2016	124.3ab	3.70abcd	11.0a
5.0Re	2015	129.5ab	4.34cde	11.0a
	2016	145.1ab	3.87abcd	11.0a
10.0Re	2015	151.0ab	4.76e	12.5a
	2016	133.9ab	3.73abcd	12.0a

Note: WF – wheat flour. Linseed varieties: Am – Amon, Ra – Raciol (both golden), Re – Recital (brown). For samples coding, see Table 2. * a – d: column means described by the same letter are not significantly different (p = 95%).

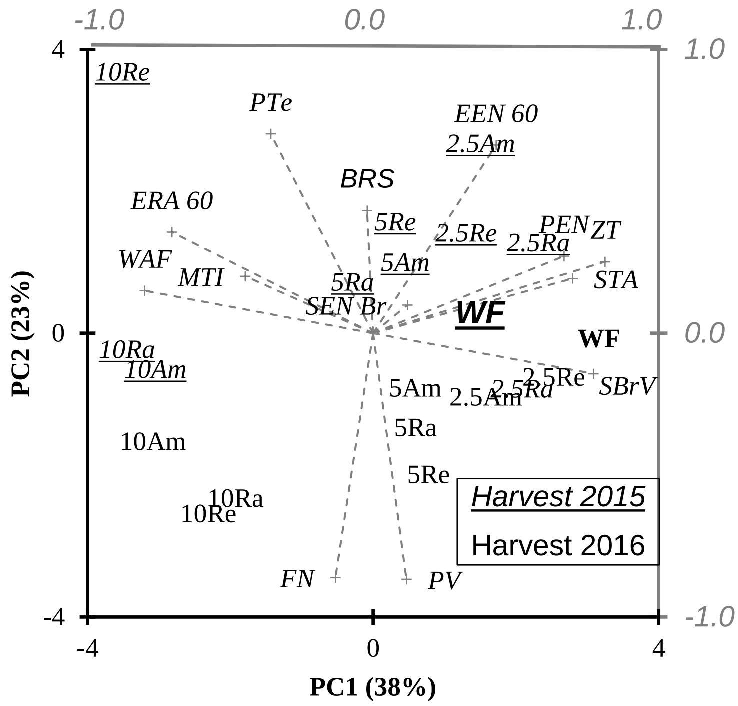

Figure 4 Principal component (PC) analysis of linseed fibre effect on dough and bread technological quality. FN – Falling number, ZT – Zeleny test; WAF – water absorption (farinograph test), STA – dough stability, MTI – mixing tolerance index (dough softening degree); ERA 60, EEN 60 – extensigraph (elasticity-to-extensibility) ratio and energy, respectively (dough resting 60 min); Tbeg – temperature of gelatinization beginning, AMA – amylograph (viscosity) maximum; SBrV – specific bread volume, BRS – bread shape (height-to-diameter ratio), PEN – crumb penetration, SEN Br – bread sensory profile. For samples coding, see Table 2.

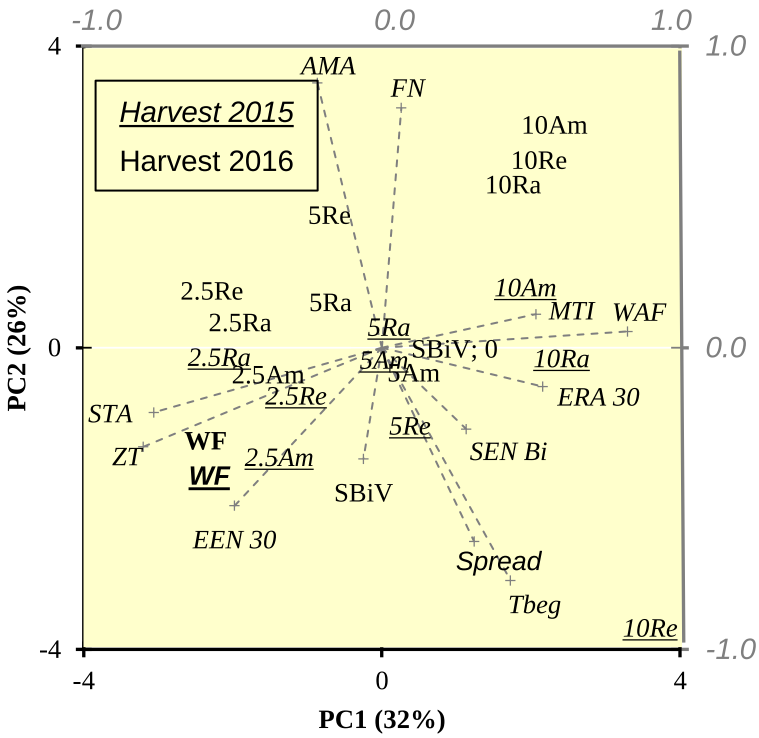

Figure 5 Principal component (PC) analysis of linseed fibre effect on dough and biscuits technological quality. For variables abbreviation FN, ZT, WAF, STA, MTI, Tbeg and AMA see Figure 4. ERA 30, EEN 30 – extensigraph (elasticity-to-extensibility) ratio and energy, respectively (dough resting 30 min); SBiV – specific biscuit volume, Spread – biscuit shape (diameter-to height ratio), SEN Bi – bread sensory profile. For samples coding, see Table 2.

Evaluation of wheat and wheat composite bread quality

Within laboratory baking test, satisfying technological potential of tested wheat-linseed fibre composites was verified. Unexpectedly, specific bread volumes from 6 composites containing 5% LF were the lowest thorough whole samples set (diminishing about 15 – 24%). In previous study, similar lowering of specific volumes caused linseed fibre produced by Walramcom company (around 33%) **(Hrušková and Švec 2016)**. For the rest of specimens, specific volumes were comparable to proper controls at least (Table 4), independently to modified dough machinability. Within both harvest years, the most together levelled volumes rendered composites WF'16-Ra and WF'16-Re (353 ±33 mL.100 g^{-1} and 351 ±24 mL.100 g^{-1}, respectively). Changed dough viscoelastic properties affected bread buns shape, their vaulting was worsened owing to gluten skeleton disruption. That effect is dominant within the harvest 2016, but together this, also samples triple *WF'15-Re* fell into this category. Increasing percentage of dietary fibre in recipe induced a worsening of crumb softness – penetration depth gradualy decreased up to about one-fourth in average. The drop by foreign linseed fibre enahncemed caused comparable drop in consumer's quality (range 5.8 – 10.4 mm vs. 14.3 mm) **(Hrušková and Švec, 2016)**, similarly to flaxseed wholemeal or flaxseed hull flour **(Conforti and Davis 2006; Sęczyk et al. 2017)**. On the other hand, our experience shown that bread with penetration 15 mm at least could be still acceptable.

From a statistical point of view, harvest year was the dominant factor directing the quality of both flour composites and leavened bread. Within the area of the first two principal componets (PC1 and PC2), all tested samples are conjoined according to this factor (Figure 4). The effect of linseed variety was important mainly for composites and bread involving 5% LF – relative shorter distance between flour composites with golden Amon and Raciol than to brown Recital ones could be noticed. In case of 10% replacement, higher dissimilarity among tested samples properties was confirmed. The plot verified protein quality-related parameters (Zeleny value ZT, dough stability STA, extensigraph energy EEN 60', and specific bread volume SBrV) as the most dependent on composition of actual flour mixture, predominating bread quality.

Evaluation of wheat and wheat composite biscuits quality

For confectionery goods, wheat flour of different technological quality than for bread is demanded. Data in Table 5 verify that premise – not specific biscuit volume, but its spread ratio (shape) is parameter the most affected by tested formula. Within both subsets, any distinct trend could not be found in specific volume of biscuits (harvests means 148 and 141 mL.100 g^{-1}). In terms of biscuits spread, an increase perhaps predominated according to rising amount of LF in the cereal products. Considering observed factors, the primary effect had linseed variety – the best results was determined for mixtures containing the Recital fibre (the lowest average specific biscuit volume 135 mL.100 g^{-1} and the highest spread 4.02). Informative results of sensory analysis indicate an acceptability of all modifications (Table 5). The non-traditional material rather lowered sweet taste, and during samples mastication, mouthful seemed to be drier and non-sticky. Similar findings published **Khouryieh and Aramouni (2012)** – up to 12% flaxseed wholemeal in recipe, biscuits had physical properties and sensory profiles close together.

PCA biplot of quality characteristics and composite samples (Figure 5) documented a primary role of harvest year on biscuits quality. In terms of further two factors, addition level partially overcame the linseed variety one. Items location along the both PC1 and PC2 is reversal related to PCA of bread, but at the same time, counterparts from harvest years 2015 and 2016 could be differentated diagonally As is mentioned supra, the best quality of biscuits is based on technological parameters water absorption WAF, degree of dough softening MTI, extensigraph ratio ERA 30, pasting profile (Tbeg) and spread factor.

CONCLUSION

Nowadays, return to local domestic plants and forgotten dishes in human nutrition intensifies. Combined with modern operation techniques, a category named novel food was established. From this category, final products render a higher nutritional benefit, either better amino- and fatty acids composition, or dietary fibre content. Flaxseed wholemeal flour or processed linseed fibre meet the pre-conditions, and their technological potential is documented in the present study. Addition of linseed fibre affected both flour analytical and dough technological properties – quality of proteins was softly weakened, but linseed polysaccharides supported water asorption during dough preparation. For bread manufacturing, linseed fibre form golden as well as brown flax seed seemed to be applicable, reaching up to 5 – 10% of flour weight in recipe.

In case of composite cut-off biscuits, all modifications were comparable to wheat control, unaffected by linseed colour type or addition level. Fibre partially depressed biscuits sweetness, but their complex sensory profile was acceptable. For biscuits preparation, linsef fibre may replaced 10% of wheat flour or likely more.

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