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Teff or chia influence on starch behaviour of wheat-barley mixture

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Abstract

This paper is focused on behaviour of starch in wheat-barley composite flours modified by 5.0% or 10.0% chia and teff, determined by amylograph and RVA apparatuses, and on baking test results. Regarding the temperature at gelatinization beginning and viscosity maximum, curves appearance depended on both type of non-traditional crop and amount added. In wheat-barley flour premix, barley flour increased amylograph viscosity (790 units in wheat-barley mixture vs. 680 units for control). Combined addition of chia and teff lowered viscosity about approximately 35%. RVA test distinctly differentiated the flour composites. Barley flour and chia wholemeal significantly reduced the specific volume of composite bread, while both teff wholemeal types partially compensated that volume diminishing (approx. -37%, -25% and -12%, respectively). A combination of white teff and dark chia wholemeal showed higher baking potential, since the specific bread volumes were comparable to wheat-barley control (230±15 ml/100 g vs. 233 ml/100 g, respectively).

Keywords: chia, teff, composite flour, amylograph pasting behaviour, RVA, leavened bread volume

1. Introduction

Nowadays, a spectrum of approved non-traditional plant materials, such as spelt, amaranth, quinoa or lupine, is further broaden by other alternatives, e.g., chia, teff, chestnut flour or flax seed [1, 2]. Enhancement of bakery products with such crops follows two main aims; first, to improve the bread nutritional value, and second, to broaden an offer of bakery products. Introduction of non-starch polysaccharides and non-gluten proteins requires partial adaptations in technological process; in contrast to that, improved content of amino or fatty acids, and higher contents of dietary fibre and minerals are guaranteed.

Barley (*Hordeum sativum* L.) has already been planted and used in nutrition in ancient Egypt. Recently, its consumption underwent a renaissance due to the positive effect of barley β-glucans [3] on diseases of affluence (e.g. prevention of colon cancer, or lowering of cholesterol level in blood). In the Czech Republic, the Federation of the Food and Drink Industries of the Czech Republic support the barley utilization in food industry.

Influence of chia (*Salvia hispanica* L.) on pasting behaviour of wheat flour was solved earlier [4]. Within the European Union, chia seeds are considered a novel food (2009/827/ES [5]). Chia seeds have high content of fat, including unsaturated fatty acids [6], easy digestible proteins [7], soluble dietary fibre [8], as well as minerals [7].

Teff (*Eragrostis tef*) is an Ethiopian grass, used for human nutrition and as animal feed. Wholemeal flour, prepared from minuscule seeds, is used for flat bread and fermented beverages manufacturing. From a nutritional point of view, teff proteins belong to easy digestible prolamins. Nutritional benefit of teff

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wholegrain flour lies in high mineral (mainly iron, calcium, phosphorus and copper) and B_1 vitamin contents [9].

Mixing of wheat flour with single non-traditional plant materials as teff, chia or nopal flour and testing their technological qualities represent recent trends in the cereal chemistry and technology. Technological properties of flour multi-composites remain, however, still quite unexplored. Combinations of three or even more of different types of flour and wholemeal would bring a new idea into the bakery products innovation. Scientific papers did not render a huge number of articles relevant to our work. Results of our research are therefore discussed with findings of other authors, who referred about effects of chia or teff on rheological behaviour of bi-composite blends only.

The aim of presented work is to evaluate a pasting behaviour of wheat-barley flour affected by addition of two types of chia or teff wholemeals; either alone, or in their combinations. The amylograph and RVA apparatuses were employed to study the viscous behaviour of composite flours. Within the European region, amylograph represents a traditional tool to study the baking properties of flour through plant starch gelatinisation and amyloses activity. On the other hand, the RVA is a relatively new instrument that spread out from Australia all over the world in the last decade. Thus, the comparison of both techniques should verify whether the RVA is able to describe the pasting behaviour distinctly. A laboratory baking trial was also performed to assess a potential use of tested blends in baking practice; specific volume and shape of composite bread variants were evaluated.

2. Materials and Methods

2.1 Materials and flour composites

Fine wheat flour (WF) was supplied by Delta Mill (Prague, Czech Republic), fine barley flour (BF) was obtained from L. Klíma Automatic Mills (Křesín, Czech Republic). White and dark chia seeds (CH1, CH2; seed origin in Paraguay) were purchased at local stores Aida Organic and Country Life, respectively, and white and brown teff fine wholegrain flour (T1, T2; seed origin in Ethiopia) were supplied by Tobia Teff Company (London, UK). Chia wholemeals were prepared by disintegration of whole seeds with the blade grinder Concept KM 5001 (Elko Valenta Europe, Czech Republic). Seeds dose was 50 g and the disintegration took approx. 1.0 min.

Protein and dietary fibre content are important parameters characterising the baking quality of wheat flour intended for manufacture of leavened products enriched with non-traditional crops. Wheat flour composition was 13.0% of proteins, 2.26%, 1.66% and 3.27% of soluble (SDF), insoluble (IDF) and total dietary fibre (TDF), respectively. In barley flour, the content of protein was lower (9.26%), on the contrary, the level of dietary fibre was higher than in WF (10.12% of IDF, 3.65% of SDF, and 14.21% of TDF). According to the labelling, white chia seeds (CH1) contained 17.5% of saccharides, 20.0% of proteins and 21.4% of fat (of which 13.0% was saturated fat). The composition of dark chia seeds (CH2) declared by the supplier was 31.4% of dietary fibre, 4.5% of carbohydrates, 21.2% of proteins, and 31.4% of fat (of which 3.8% was saturated). Both white and brown teff wholegrain flours (T1 and T2, respectively) had identical composition: 70% of carbohydrates (of which starch was 54.0%), 11.5% of proteins, 2.6% of fats, and 7.6% of dietary fibre.

Basic cereal premix WBF was prepared by blending WF and BF in a ratio of 70:30 (w/w). With respect to the EU legislation effective from 2013 [10], the maximum allowed content of chia seeds in bakery products is 10%. Therefore, 5% or 10% substitution of WBF by chia and teff was chosen for this study. In tests, where both chia and teff were added together, four possible combinations were derived, with the total enrichment of 5.0 or 10.0 wt. %, as mentioned above (Table 1).

2.2 Methods

Sucrose and sodium carbonate retention capacities (SUSRC and SCSRC, respectively) were measured in WF, WBF and WBF composites according to the AACC method 56-11.02. Sucrose and sodium carbonate were purchased from Penta Company (Prague, Czech Republic). Both SUSRC and SCSRC parameters have relation to damaged starch and pentosans content [11]. In ten replications, the repeatability was determined with calculated relative standard deviations of 0.727% and 0.667%, respectively. The degree of damaged starch and amylose activity was tested by the Falling number method ISO 3039, using the apparatus FN 1400 (Perten Instruments, SWE). Viscous behaviour of biopolymers, such as polysaccharides and proteins, was further determined using both amylograph AS1 (Brabender, Germany) and Rapid Visco Analyser 4500 (RVA; Perten Instruments, Sweden) following the ICC method 126/1 and AACC method 22-08.01, respectively.

Baking test was performed in a laboratory scale according to an internal method described elsewhere [12]. Dough was prepared using Farinograph (Brabender, Germany) using 300 g WF, WBF or WBF plus chia and/or teff (Table 1). Leavened full-formula doughs were prepared to consistency 600 ± 20 Brabender units (BU), based on experiences of the Research Institute of Milling-Baking Industry in Prague. The dough mass fermentation and proofing of manually moulded buns was carried out in a laboratory incubator FTP 90l (Velp Scientifica S.r.l., Italy) at 32 °C and the relative humidity of 95%, for 50 and 45 min, respectively. Baking was performed in a laboratory baking oven (Research Institute of Baking Industry Ltd., Poland). The oven was preheated to 240 °C and steamed by 50 ml of distilled water immediately after inserting a baking tray. Baking process was finished in 14 min. After 2 h of cooling at ambient temperature, bread quality was assessed. Evaluated characteristics measured in triplicates were: specific bread volume (SBV) and diameter-to-shape ratio (bread shape). Bread volume was determined by a rapeseed displacement method (AACCI Method 10-05.01), and buns dimensions were measured using a slide calliper.

The effects of chia/teff type and addition levels on mixtures rheological behaviour, as well as results of baking trials were evaluated by Tukey HSD test (P = 95%), using the Statistica 7.0 software (Statsoft, USA). The strength of association among the all determined features was tested by correlation analysis (P = 95%, 99%, and 99.9%).

Table 1. Constitution of flour composites tested

Flour, flour composite	Wheat flour portion (g)	Barley flour portion (g)	Chia flour portion (g)	Teff flour portion (g)
WF	300.0	-	-	-
WBF	210.0	90.0	-	-
WBF5.0Ch1	199.5	85.5	15.0	-
WBF10.0Ch1	189.0	81.0	30.0	-
WBF5.0Ch2	199.5	85.5	15.0	-
WBF10.0Ch2	189.0	81.0	30.0	-
WBF5.0T1	199.5	85.5	-	15.0
WBF10.0T1	189.0	81.0	-	30.0
WBF5.0T2	199.5	85.5	-	15.0
WBF10.0T2	189.0	81.0	-	30.0
WBF-2.5T1-2.5Ch1	199.5	85.5	7.5	7.5
WBF-2.5T1-2.5Ch2	189.0	81.0	15.0	15.0
WBF-2.5T2-2.5Ch1	199.5	85.5	7.5	7.5
WBF-2.5T2-2.5Ch2	189.0	81.0	15.0	15.0
WBF-5.0T1-5.0Ch1	199.5	85.5	7.5	7.5
WBF-5.0T1-5.0Ch2	189.0	81.0	15.0	15.0
WBF-5.0T2-5.0Ch1	199.5	85.5	7.5	7.5
WBF-5.0T2-5.0Ch2	189.0	81.0	15.0	15.0

WF - wheat flour; WBF - wheat-barley composite flour 70:30 (w/w), respectively;
CH1, CH2 - fine wholegrain flour from white and black chia seeds, respectively;
T1, T2 - white and brown wholegrain teff flour, respectively.
2.5, 5.0, 10.0 - addition levels of non-traditional plant material.

3. Results and Discussion

3.1.Approximate changes in polysaccharides representation

The proportion of damaged starch and other polysaccharides, which contribute to pasting properties of dough, can be evaluated by the SUSRC (starch content) and SCSRC (pentosans content) methods. An increase in both mentioned characteristics is obvious as a result of barley, and especially, chia flour addition, reflecting the actual dose of material added (Figure 1). Similar trends in both SRCs induced by barley flour addition were observed in wheat-barley-hemp composites [13]. WBF enhancement by both teff wholemeal types did not bring a significant change. Combination of chia and teff caused a moderate increase in contents of damaged starch and pentosans, but total enhancement level (i.e. sum 5% or 10%) did not have a verifiable impact.

With respect to the Falling Number repeatability (±25 s, ČSN ISO 3039), an estimated α-amylases activity in tri-composite flour samples (WBF + chia or teff) was comparable to one in WF and WBF controls. Within the tetra-composites subset (WBF + chia + teff), a mild increase of enzymatic activity could be observed (Table 1); the subset median 353 s was verifiably different from the one calculated for WBF-chia (433 s; [14]).

3.2 Viscous behaviour of flour composites

Pasting behaviour of WF demonstrated a usual course, and measured amylograph maximum (AMA) of 680 BU was close to the empirical technology optimum of 400-600 BU [15]. Barley flour addition caused a mild, but significant change in wheat flour amylogram; the determined value was 790 BU (Table 1; repeatability ±4.2%, ICC method 126/1). An addition of both chia wholemeal types caused also verifiable increase in amylograph viscosity, documenting an ability of chia seeds to absorb water in amount several times higher than its weight [16]. The AMA values have risen for WBF-CH2 blends mainly (about 20% at least, compared to WBF sample). Bushway et al. [17] referred about xylose and arabinose as the major constituents of chia polysaccharides. Such pentosans, either water-extractable or water unextractable arabinoxylans, are known hydrocolloids able to improve water absorption capacities, dough stability time, and viscosity [18]. The absorption capacity of barley-teff flour was higher than the one of barley. That property could be attributed to a higher dietary fibre content in teff wholemeal (10.74%) [19]. Alaunyte et al. [20] also mentioned a small size of teff starch granules, i.e. larger surface area for water to be absorbed. The AMA values in flour composites containing teff were comparable to chia blends (foursome means 950 and 920 BU, respectively). Regardless the mentioned amylograph viscosity growth when chia or teff were added separately, combined WBF enhancement with both chia and teff caused approximately 50% reduction in amylogram heights (480-560 BU; Table 2). As the data show, that change was not statistically dependent on white or dark chia and teff type. On the other hand, the amylograph test confirmed similar trend screened previously by the Falling Number test. A higher proportion of damaged starch in tested flour composites meant a reduction of polymerization degree of amylopectin. Consecutively, a content of amylose rose increasing the viscosity of water suspension [21, 22].

Comparing the RVA profiles of WF and BF, two clearly different curves could be identified (Figure 2). With respect to blending ratio, the WBF curve was drawn closer to WF sample (with peak viscosity of 2288 mPa·s vs. 2386 and 1520 mPa·s for WF and BF, respectively; Table 2). In case of whole-wheat flour substituted by 28% of whole-barley flour, the wheat-barley composite suspension was more viscous than the one containing pure wheat (peak viscosities 915 and 756 mPa·s, respectively [23]). On the other hand, the amylograph test results pointed to an inverse tendency between WF and WBF samples. Wheat flour, barley flour and wheat-barley flour composites could be statistically differentiated according to the hold and final viscosities (Table 2). With respect to the reproducibility of peak viscosity (1.4%, [24]), flour composites containing chia or teff (with foursome averages 3333 mPa·s vs. 2671 mPa·s, respectively) could be verifiably distinguished from both WF and WBF samples and also each one from another. Both alternative raw materials similarly affected the hold and final viscosities; the Tukey test revealed a comparable variance as for the peak viscosity (12, 14 and 13 homogenous groups, respectively; Table 2). In comparison to our data, a study testing the viscous behaviour of wheat-rye and wheat-rye-teff blends (50:50 and + 5% teff, respectively) presented that the profiles did not significantly differ until the end of the RVA test (the final viscosities were 1794 ± 8 mPa·s and 1821 ± 14 mPa·s, respectively; [19]).

A combination of wheat and chia flour was analysed in a work [25], and in line with our findings, the authors stated that 10% or 15% chia provably increased the suspensions viscosity (from 2245 mPa·s in control sample, up to 2639 mPa·s in blend with 15% of chia). However, the incorporation of 5% chia only did not have that effect (the peak viscosity was 2289 mPa·s)

Pasting profiles of wheat-teff blends, containing teff wholemeal from 0% to 30%, showed a gradual growth in peak viscosities with increasing amount of teff added [20].

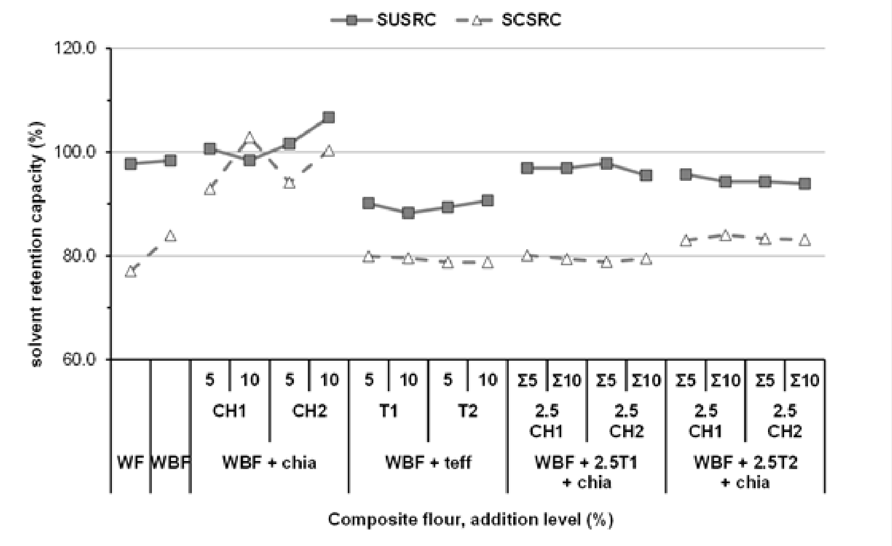

Figure 1. Solvent retention capacity (SRC) of wheat flour and wheat-barley composite flour (M, MJ) as affected by chia, teff and combined chia-teff additions. CH1, CH2 – chia seeds wholegrain flour from white and black seeds, respectively; T1, T2 – white and brown teff wholegrain flour, respectively; 2.5, 5.0, 10.0 – addition levels of non-traditional plant materials (%).

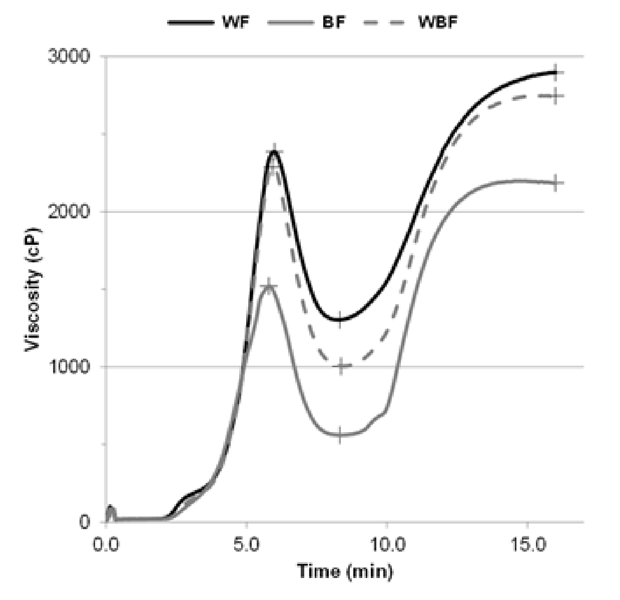

Figure 2. RVA profiles of wheat, barley and wheat-barley flour (WF, BF, and WBF, respectively).

Table 2. Influence of chia, teff, of chia-teff addition on amylases activity and viscous behaviour of wheat-barley composite flour

Composite flour	Falling Number (s)	Amylograph test: Tbeg (°C)	Amylograph test: Tmax (°C)	Amylograph test: Amylograph maximum (BU)	RVA test: Pasting temperature (°C)	RVA test: Peak viscosity (cP)	RVA test: Hold viscosity (cP)	RVA test: Final viscosity (cP)
WF	403 f	61.2 c	91.1 fg	680 d	67.0 ab	2387 f	1303 g	2896 d
WBF	372 d	60.9 c	91.9 gh	790 e	83.7 de	2288 c	1005 a	2746 a
WBF5.0Ch1	432 g	60.2 bc	94.7 h	820 e	66.1 a	3235 j	1687 l	3736 i
WBF10.0Ch1	449 h	56.5 a	90.3 efg	900 g	64.7 a	3378 l	1719 m	3774 j
WBF5.0Ch2	426 g	58.0 ab	91.8 gh	960 hi	66.1 a	3301 k	1727 m	3870 k
WBF10.0Ch2	433 g	56.5 a	90.3 efg	1000 j	64.9 a	3418 m	1747 n	3905 l
WBF5.0T1	390 e	65.5 ef	84.5 bc	990 ij	77.9 cd	2873 i	1618 j	3725 i
WBF10.0T1	408 f	64.0 de	82.0 b	1000 j	87.6 e	2793 h	1648 k	3794 j
WBF5.0T2	390 e	64.0 de	82.5 b	860 f	87.2 e	2517 g	1480 h	3393 g
WBF10.0T2	400 f	67.0 f	75.5 a	950 h	88.4 e	2503 g	1515 i	3470 h
WBF-2.5T1-2.5Ch1	345 a	61.0 c	86.5 cd	510 ab	68.6 ab	2285 c	1159 d	2889 cd
WBF-2.5T1-2.5Ch2	356 bc	60.3 bc	87.3 cde	560 c	67.3 ab	2333 d	1190 e	2943 e
WBF-2.5T2-2.5Ch1	346 a	64.0 de	86.5 cd	520 b	69.0 abc	2396 f	1189 e	2963 e
WBF-2.5T2-2.5Ch2	363 cd	65.5 ef	87.3 cde	510 ab	67.3 ab	2503 g	1255 f	3042 f
WBF-5.0T1-5.0Ch1	340 a	62.0 cd	86.5 cd	510 ab	75.8 bcd	2271 c	1135 c	2874 cc
WBF-5.0T1-5.0Ch2	372 d	58.0 ab	87.6 cde	480 a	67.3 ab	2353 e	1181 e	2895 cd
WBF-5.0T2-5.0Ch1	349 ab	61.0 c	88.0 def	490 ab	67.8 ab	2204 a	1098 b	2797 b
WBF-5.0T2-5.0Ch2	382 e	59.5 bc	86.5 cd	510 ab	67.3 ab	2242 b	1195 e	2877 cd

Tbeg, Tmax - temperature od gelatinisation beginning and maximum, respectively;
WF - wheat flour; WBF - wheat-barley composite flour 70:30 (w/w), respectively; CH1, CH2 - fine wholegrain flour from white and black chia seeds, respectively; T1, T2 - white and brown wholegrain teff flour, respectively; 2.5, 5.0, 10.0 - addition levels of non-traditional plant material;
a-n - column means signed by the same letter are not statistically different (P = 95%).

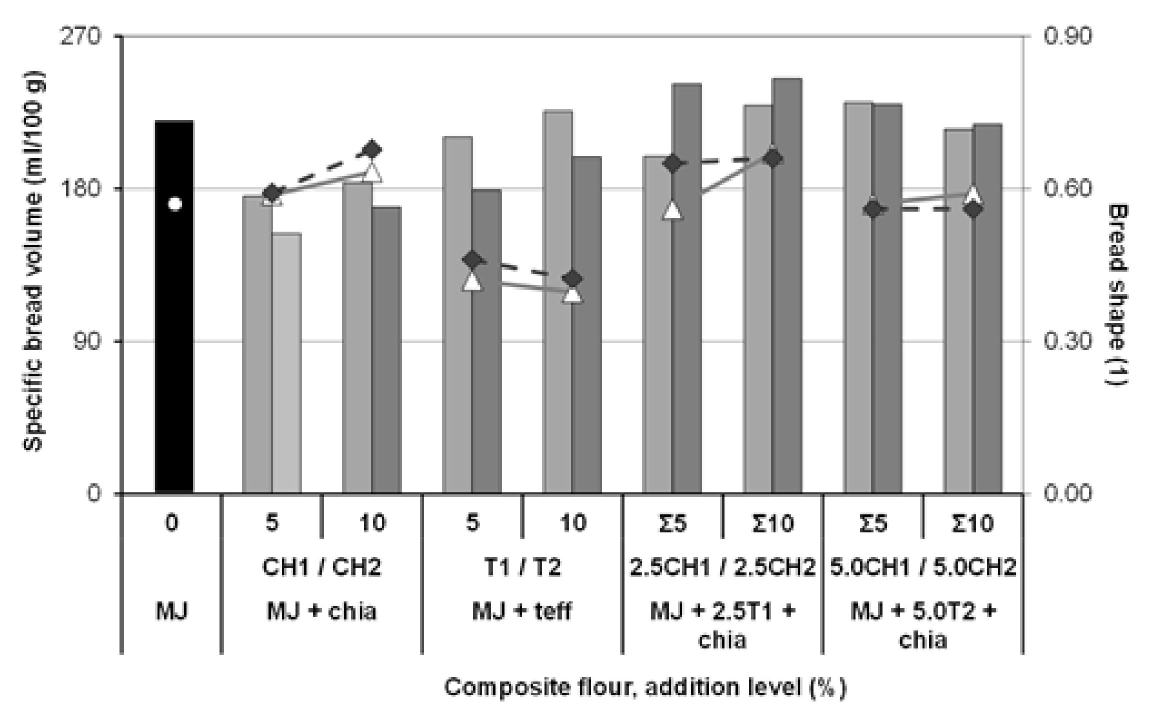

Figure 3. Influence of chia and teff wholegrain flour and it combination on specific bread volume of wheat-barley composite flour (MJ). CH1, CH2 – chia seeds wholegrain flour from white and black seeds, respectively; T1, T2 – white and brown teff wholegrain flour, respectively; 2.5, 5.0, 10.0 – addition levels of non-traditional plant materials. Specific volume of wheat bread reached 374 ml/100 g, and its shape ratio was 0.59.

Table 3. Correlation analysis between viscous behaviour data and bread volume

Feature	SBV	RVA test				Amylograph test			FN	SCSRC
		Final Visc	Hold Visc	Peak Visc	Pasting Temp	AMA	Tmax	Tbeg		
SUSRC	-0.22	0.27	0.27	0.51*	-0.51*	0.18	0.53*	-0.63**	0.35	0.67*
SCSRC	-0.56*	0.61**	0.61**	0.84***	-0.48*	0.42	0.55*	-0.71***	0.72***	
FN	-0.35	0.84***	0.88***	0.87***	-0.06	0.79***	0.24	-0.38		
Tbeg	0.21	-0.10	-0.14	-0.40	0.66**	0.03	-0.70**			
Tmax	0.05	-0.01	0.01	0.34	-0.69**	-0.12				
AMA	-0.40	0.88***	0.85***	0.74***	0.42					
Pasting temperature	-0.04	0.09	0.03	-0.22						
Peak viscosity	-0.55*	0.92***	0.92***							
Hold viscosity	-0.49*	0.99***								
Final viscosity	-0.58*									

SUSRC, SCSRC - sucrose and sodium carbohydrate retention capacity, respectively; FN - Falling Number; Tbeg, Tmax – temperature of gelatinization beginning and maximum, respectively, AMA - amylograph viscosity maximum; PastingTemp - pasting temperature, PeakVisc, HoldVisc, FinalVisc - viscosity at pasting maximum and minimum, respectively, and at the end of the RVA test;
*, **, *** - correlations provable at P = 95%, 99% and 99.9%, respectively.

3.3 Baking test results

The enrichment by barley flour in the bread formula led to approx. 33% diminishing of specific volume in comparison to the wheat bread (from 374 to 233 ml/100 g, Figure 3). Higher portion of barley flour in a formula (50:50, w/w) caused a specific bread volume decrease; to less than one half in comparison to wheat bread control (from 215 ml/100 g to 95 ml/100 g; [26]).

In general, the baking quality decrease had two reasons: a higher rate of damaged starch in BF and dilution of gluten proteins net in WBF dough. During the dough preparation, damaged starch required higher amount of water to reach demanded dough consistency. It allowed a higher production of fermentation gases, which easily escaped from the pores in weakened composite dough. Collapses of pore walls probably caused a fall in bread volume. Heat treatment released water, bound previously by proteins into dough, and this free water was thereafter captured by polysaccharides. Higher amylose rate then supported dough cohesiveness; meanwhile the diminished volume of dough piece was fixed in the first minutes of baking. Pure pentosans in concentrations up to 5% have a positive effect on wheat bread volume [18, 27]. Pentosans in barley flour and chia wholemeal (together with the other components) penetrated gluten structures and had a partially negative effect on our product volume and texture.

In comparison with bread prepared from WBF flour composite as a control, additions of both chia types caused a significant decrease of buns size by 23% for WBF-CH1 and about 31% for WBF-CH2 breads. Similar trend (i.e. the volume reduction by 25%) was also observed in wheat bread containing 10% of chia described by Ortega-Ramirez et al. [28]. Reversely, an incorporation of teff wholegrain flour into the formula had rather an insignificant effect on the bread quality, perhaps owing to some botanical closeness of wheat and teff plants [29]. For wheat-rye-teff bread, a slightly lower specific volume was determined in comparison to wheat-rye standard (3.0 ± 0.2 ml/g and 3.1 ± 0.2, respectively); this finding corresponds to higher final viscosity of wheat-rye-teff flour blend, as mentioned above.

Volumes of WBF-T1 bread samples were similar to standard, and the WBF-T2 ones close to it (pair means 218 and 189 ml/100 g, respectively; Figure 3). Ronda et al. [30] tested the effect of three Ethiopian teff varieties on baking quality of wheat composite flour. In relation to wheat control, 10% teff dose caused a verifiably higher specific bread volume. Specific volume of pan bread with brown teff flour (357 ml/100 g) was even significantly higher than in breads containing two diverse white teff flour types (349 and 353 ml/100 g against 321 ml/100 g for the wheat control). Volume increments represent 11%, 9% and 10%, respectively. In our research, the combined addition of 5 or 10% of chia-teff flour did not affect the bun volume to a large extent (median

230±15 ml/100 g; Figure 3), and somewhat higher baking potential could be noticed for white teff and dark chia wholemeal blends.

3.4 Correlation analysis

Using a simplified matrix, results of correlation analysis are summarised in Table 3. As expected, pasting behaviour was partially dependent on rates of damaged starch and mainly on pentosans present in flour composites. All mentioned chemical changes influenced the quality of laboratory prepared bread.

Both retention capacities have a potential to predict a majority of observed features. The results of sodium carbonate SRC displayed the weakest correlation (r = -0.48, P = 95%) with pasting temperature determined by the RVA. The Falling Number was related to 5 parameters from 10 in total, but all these relationships were very tight (from 0.71 to 0.88, P = 99.9%).

Besides a different construction of the amylograph and the RVA apparatuses, temperature and viscosity characteristics of both tests were interdependent. In comparison with their relations to other features measured, detailed description of pasting curve provided by the RVA enabled better differentiation of tested samples. That is why the number of significant correlations was higher for the RVA data and all three viscosity points (Peak Viscosity, Hold Viscosity, Final Viscosity) had a direct link to specific bread volume (r = -0.55, -0.49, -0.58, respectively; P = 95%).

4. Conclusions

Enhancement of wheat-barley composite flour by chia and teff flour and their combination provably affected the chemical composition of blends proportionally to the amount added, and had an effect on viscoelastic properties and baking quality of composite mixtures. The sucrose and sodium carbonate SRC confirmed increased contents of damaged starch and pentosans, introduced mainly by barley flour and chia wholemeal. Due to this fact, also the pasting behaviour of tested flour composites depended on non-traditional plant material type and its proportion; both chia and teff wholemeals increased viscosity of water suspensions. The differences in viscous properties between tested white or dark chia and teff variants were not significant. The consumer's quality of composite breads corresponded to chemical and rheological parameters determined for individual flour blends. Chia additions lowered bread volume significantly. In this regard, bread recipe enhancement by teff did not have such detrimental effect, but shape of final bakery product was worsened.

Combinations of chia and teff wholemeals with wheat-barley premix can provide valuable bakery products. Viscous behaviour of such composites was comparable to wheat flour. In addition, specific volumes of these bread variants corresponded to wheat-barley control. Another benefit of prepared bread lies in increased portion of dietary fibre as an important constituent in healthy human nutrition.

Within the study, the potential of the RVA method to distinguish unequivocally tested samples was verified. In the cereal research, the RVA technique could replace the Falling Number test and become a screening method for detailed description of pasting behaviour of flour and flour composites.

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Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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