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Pasting characteristics of wheat-chia blends

I. Švec*, M. Hrušková, I. Jurinová

Department of Carbohydrates and Cereals, University of Chemical Technology Prague, Technická 5, 166 28 Praha 6 – Dejvice, Czech Republic

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ABSTRACT

White or black chia seeds, substituting 2.5% or 5.0% of wheat flour in prepared blends, were treated by milling, hydration, or combination of both. In terms of ash and protein contents, chia addition influenced chemical composition in higher extent than its type – increases up to about 0.5% and 1.3%, respectively, were evaluated. Protein quality was diminished to 35% in maximum, within any impact of chia type. A higher chia addition raised total dietary fibre content almost about one half (from 3.21% to 4.58%). White chia caused gradual lowering of amylases activity, while its dark type had insignificant effect. Composite bread volumes overcame the control one about 6–30%; positive chia effect has risen in order of forms whole hydrated (+9% in average), hydrated milled chia (+20%) and milled dry chia (+29%). As presumed, crumb firmness corresponded to bread volumes ($r = 0.83$, $P = 99.9\%$), demonstrating ease of crumb mastication.

1. Introduction

Chia seeds originate from Spanish variant of sage (*Salvia hispanica* L.), annual plant of *Labiatae* family, bred mainly in South American countries. White or black coloured, they are of elliptic shape and tiny size (around 1 mm). Name "chia" is a derivation of Aztec word "chian" meaning oily (Ayerza and Coates, 2005). The word "chia" is incorporated in name of the present Mexican state Chiapas, in which chia production reaches the highest volume. Similarly to nowadays, chia seeds were eaten already in Aztec epoch alone or blended with cereals, in whole or milled into flour. Mixed with water, thick gel is formed after five minutes only. According to their hydrophilic character, amount of absorbed water comes up to volume magnifying 12 times (Moroni et al., 2010; Talandová et al., 2013). Chia seeds were recognised as valuable food raw-material, containing 91–96 g/100 g dry matter, 4–6 g/100 g ash, 20–22 g/100 g proteins, 25–41 g/100 g saccharides, 30–35 g/100 g fat, 18–30 g/100 g dietary fibre (crude fibre; Direction 2013/50/EU). In chia seeds, non-saturated fatty acids (C18:2 and C18:3) are presented, and further easy digestible proteins, soluble fibre and minerals (calcium, iron, zinc, phosphor, magnesium) (Reyes-Caudillo et al., 2008; Ayerza and Coates, 2011; Ciftci et al., 2012; Pizzaro et al., 2013). Non-starch polysaccharides are also represented by fructo-oligosaccharides (2–3%; Pszczola, 2012). Both forms (black and white) exhibit a high antioxidant activity due to the presence of phenolic compounds and tocopherols (Capitani et al., 2012). Usage of chia seed as novel food ingredient was authorised by Directive 2009/827/EC. Considering bakery product, addition level was allowed up to 5% (Regulation 258/97/EC, valid to year 2012). Recently the limit was increased to 10% (Direction 2013/50/EU).

Chia products are tasteless and owing to this they do not affect a traditional sensorial profile of bread. Because they are not hard when bitten, milling is not necessary compared to other such seeds. Bakery products involving chia are characterised by higher nutritional value and significantly prolonged shelf-live (Peiretti and Gai, 2009; Mohd et al., 2012; Segura-Campos et al., 2013).

Wheat flour fortification by different chia forms is reflected in quality parameters change of composite flour, depending on used level. Characteristics of chia-enriched dough are solved in papers of e.g. Ixtaina et al. (2008), Capitani et al. (2012) or Iglesias-Puig and Haros (2013). Inglett et al. (2013) describe behaviour of blend composed from barley and chia flour and state that addition up to 10% had no verifiable effect on both dough viscosity and elasticity.

Chia addition into wheat flour causes gluten proteins dilution as well as bread volume decrease. Ortega-Ramirez et al. (2013) determined a diminishing up to 25% against non-fortified control, using 5% or 10% chia into recipe. Similar negative effect observed Farrera-Rebollo et al. (2012) – volume of sweet bread containing 12% of chia flour attained approx. 88% of the control.

The aim of the study was to compare proximate chemical

* Corresponding author.
E-mail address: Ivan.Svec@vscht.cz (I. Švec).

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composition and pasting properties of wheat-chia composite flour in terms of determination of the Solvent Retention Capacity profile and the amylograph proof. Influence of two chia botanical types of white and black coloured seeds was compared, testing three different forms of chia (milled dry, whole hydrated, milled hydrated). A baking value of wheat-chia blends was also evaluated, focusing on comparison of both chia samples as well as the applied forms.

2. Materials and methods

2.1. Flour samples, blends preparation

Basic wheat flour was rendered by the commercial mill Delta Prague, and its quality corresponds with both level of the Czech food wheat (protein content 10.73%, Zeleny value 41 ml). According to the mentioned quality parameters, it is also suitable for its partial replacement by non-gluten raw material. Chia seed samples (white CH1, black CH2) originated in Mexico, and were bought in specialised food shops in Prague. To disintegrate the seeds, laboratory grinder Concept KM 5001 was used (type of blade grinder, seeds dosage ca 50 g, treatment time 1 min). In accordance to Regulation EC 258/97 limiting chia usage in bakery products up to 5.0%, only two dosages 2.5% and 5.0% were used in case of the Solvent Retention Capacity, the dietary fibre content (testing milled dry form), and the amylograph as well as laboratory baking test (testing all three mentioned chia forms). Whole seeds or wholemeal hydration was performed by stirring of 7.5 g or 15.0 g chia in 150 ml of distilled water of ambient temperature left in laboratory beaker for 10 min, and remixed immediately before usage.

2.2. Analytical quality of blends

Chemical composition of bi-composite flour was determined in terms of ash and proteins contents, following the ČSN 560512-8 and the ČSN ISO 1871 methods; further, bakery quality of proteins and amylose activity in wheat-chia blends were estimated as the Zeleny sedimentation value and the Falling Number (ČSN ISO 5529 and 3039, respectively; measurements in duplicate). The Falling Number could be considered as primary (screening) method for estimation of water suspension viscosity of material tested, as well as amylases activity participating on wheat polysaccharides properties when heated in water. Conducting the Solvent Retention Capacity profile (AACC method 56-11, abbreviation SRC), overall chia influence on blends chemical composition was evaluated. The water, the sucrose, the sodium carbonate and the lactic acid SRC have a relation to overall absorption ability of all network-forming flour constituents, level of damaged starch, pentosan and gliadin characteristics as well as to glutenin characteristics, respectively, contributing to viscous behaviour. For pasting characteristics of wheat-chia blend, more information can be obtained from sucrose SRC. For the SRC foursome, repeatability as standard deviations 0.287, 0.811, 0.672 and 0.871 were determined in advance. By using Megazyme assay kit, dietary fibre percentage was screened as total content and its soluble and insoluble fractions rate (AOAC method 985.29, single measurement). For the cited analytical procedures, chia was used in a milled dry form.

2.3. Rheological behaviour of blends

Influence of milled dry, whole hydrated and milled hydrated form of the non-traditional plant material was compared during rheological and baking trials. Pasting properties of wheat control and prepared flour composites were measured with the help of the Amylograph (Brabender GmbH., Duisburg, Germany) in a correspondence with ICC procedure No. 126/1 (single measurement, standard deviation 4.2% for the amylograph viscosity maximum). The method is internationally approved, and especially in bakery branch, it testifies about potential usage of wheat flour or flour composite, especially to describe the pasting characteristics. Using an office scanner, original paper record of amylograph curve of the wheat control was grabbed. To illustrate influences of chia type and chia form on suspension viscosity development, amylograms of wheat blends with 5% of chia were transformed into multiline plot (ca 50 viscosity points, read in each whole minute) combining wheat flour and the relevant triple of the CH1 or the CH2 group.

2.4. Laboratory baking test

Laboratory baking test was performed following the internal method of the UCT Prague (Hrušková et al., 2006). Briefly, full-formula dough was prepared with the help of the Farinograph (Brabender GmbH., Duisburg, Germany) adding distilled water of 30 °C to consistency 600 ± 20 Brabender units. Fermented at standard conditions, 70 g dough pieces were manually formed and left to leaven, and baked on a baking sheet. Baking procedure takes 14 min in a laboratory apparatus preheated to 240 °C with steaming at the beginning, using 50 ml of distilled water. After 2 h of buns cooling at ambient temperature, bread specific volume was evaluated by rapeseed displacement method in triplicate. Buns were split manually to halves by serrated knife and five cylindrical crumb samples were cut out (35 mm in height, 30 mm in diameter) for crumb firmness determination. By using the Penetrometer PNR-10 (Petrotest GmbH., Germany) with semisphere probe 25 mm in diameter fixed in screw holder (total weight 150 g), crumb samples were compressed and penetration depth was recorded after deformation taking 5 s.

Factors influence of chia type, chia form and addition level was explored by analysis of variance (ANOVA) using Statistica 7.1 software (Statsoft Inc., Tulsa, USA). When the F value was significant ($p < 0.05$), means were separated using the honest significant difference test (Tukey's HSD test).

3. Results and discussion

3.1. Analytical quality of blends

Changes in chemical composition of tested blends were clearly attributed to chia addition level than to chia type factor (Table 1; agreement with Ayerza, 2013). The values of ash and protein contents have been increased owing to gradually higher chia rate in blends – an increment was evaluated as 15% and 2% absolutely, respectively. Coelho and Salas-Mellado (2014) confirmed both characteristics rise by analysis of bread involving 7.8% of hydrated chia flour and 11.0% of hydrated chia seeds. Compared to wheat control, protein baking quality (Zeleny test) has been reversely diminished about ca 20% and 24% for blends with 2.5% and 5.0% of chia, respectively (Table 1). Due to higher measurement error (25 s), amylose activity estimated as the Falling Number differed between control and samples with 5% chia flour only.

As Ayerza and Coates (2005) confirm, chia contains multiply higher protein and dietary fibre content compared to wheat; that fact was significantly reflected in variation of the control SRC profile. Overall absorption capacity (water SRC) increased approx. about 10% and 33% in cases of 2.5% and 5.0% chia additions, respectively (Fig. 1). The same tendency was registered for sodium carbonate SRC, so both introduced chia proteins and pentosans have demonstrated their hydrophilic nature. In relation to control bread, the positive influence of chia was further reflected in specific