LWT - Food Science and Technology 44 (2011) 650–655

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Effect of buckwheat flour addition to wheat flour on acylglycerols and fatty acids composition and rheology properties

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ARTICLE INFO

Article history:
Received 13 February 2009
Received in revised form
4 July 2010
Accepted 31 August 2010

Keywords:
Buckwheat
Wheat
Dough
Lipids composition
Rheology

ABSTRACT

In this paper, the rheological properties and lipids composition with an emphasis on acylglycerols and fatty acids composition of dough with various portions of buckwheat flour (BWF) are investigated. The results show lipids from wheat–buckwheat flour mixture has higher ratio of total unsaturated to saturated fatty acids content (3.77–4.78 g/100 g) than those of wheat flour only (3.71 g/100 g). The value of dough water absorption (WA), development time (DT), dough stability (DSt), gelatinization temperature (T_{max}) and maximal pasta viscosity (η_{max}) increases when content of free fatty (FFA) acids increases, i.e. when buckwheat flour portion in flour mixtures increases, so FFA content has a proper influence on these dough properties. Dough with buckwheat flour has higher WA (54.3–56.0 ml/100 g), T_{max} (82.0–84.1 °C) and η_{max} (630–860 AU), longer Dst (0.7–4.6 min) and lower Dsf (82–90 FU) than dough with wheat flour only, whose appropriate values are 54.3 ml/100 g, 81.2 °C, 480 AU, 0.3 min and 90 FU, respectively. So, the flour mixture with buckwheat flour of at least 5 g/100 g can be considered good quality flour.

1. Introduction

Buckwheat (*Fagopyrum esculentum* Moench) is not a cereal but usually grouped with cereals due to its way of cultivation and because the main nutritional value of buckwheat is similar to that of cereals. The importance of buckwheat is that it is a gluten-free food. Buckwheat is abundant in nutritive, such as protein, essential amino acids, dietary fiber, starch, vitamins B1 and B2, C and E (Watanabe, 1998; Wijngaard & Arendt, 2006) and it is also a good source of trace elements (Ikeda & Yamashita, 1994; Pomeranz, 1983). In comparison to cereals, buckwheat protein is of high nutritional quality due to relatively high levels of lysine and arginine (Watanabe, 1998) and well-balanced amino acids composition (Pomeranz & Robbins, 1972).

In buckwheat seed protein, the salt-soluble globulin represents the major Osborn fraction (Belozersky, 1975), classified as a legume-like storage protein (Derbyshire, Wright, & Boulter, 1976). Buckwheat seed also contains antioxidants, where rutin and quercetin are the main antioxidants (Oomah, Campbell, & Mazza, 1996; Watanabe, Ohshita, & Tsushida, 1997). Different cultivars of buckwheat may have different content of rutin (Ohsawa & Tsutsumi, 1995) and most rutin is accumulated in the inflorescence, up to 12 g/100 g based on dry weight base (Hagels, 1999).

Due to these components and high fiber content of 20 g/100 g (Bonafaccia, Marocchini, & Kreft, 2003; Farrell, 1978), retrograded starch (Kreft & Skrabanja, 2002) and dietary selenium (Stibilj, Kreft, Smrkolj, & Osvald, 2004), buckwheat is an important functional food: it appears to be a suitable component of food products and serviceable raw material for bakery products as the most important foods consumed by a large population (Holasova et al., 2002) and in many forms in foods (noodles, spaghetti, pancakes, etc.) in Japan, Russia, Central and Eastern Europe.

Due to its effectiveness in controlling blood vessels buckwheat has been mentioned in preventing edema, hemorrhagic diseases and stabilizing high blood pressure (Havsreen, 1983; Xiaoling, Xie, Na, & Jinliang, 1992).

In general, lipids comprise a small part of cereals and pseudo cereals, but have an important physiological role and role in food quality. In buckwheat lipids are concentrated in the embryo. The total lipids content in whole buckwheat grain depends on cultivar and it ranges from 2.6 to 3.2 g/100 g. The major fatty acids are palmitic (16:0), oleic (18:1) and linoleic (18:2) (Mazza, 1988). In buckwheat lipids, stearic, oleic, linoleic, linolenic, arachidic, behenic and lignoceric acids were also detected (Dorrell, 1971). As the fatty acids are not distributed uniformly, the type of tissues included in the flour affects directly its composition while the lipids in buckwheat affect proteins thermal properties (Chuan, 2007).

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doi:10.1016/j.lwt.2010.08.017

There are rheological properties data about gelatinization temperature and water absorption for samples with 100, 90, 80, 70 and 60 g/100 g buckwheat flour based on wheat flour (Yoo, Kim, Yoo, Oh, & Ham, 2007) as well as capability of CO_2 retention and baking behavior of buckwheat dough as gluten-free dough (Pruska-Kedzior, Kedzior, & Goracy, 2008).

The addition of buckwheat flour and bran affected the spaghetti sensor properties (Chillo, Lavrse, Falcone, Protopapa, & Del Nobile, 2008), extrusion and cooking quality (Manthey, Yalla, Dick, & Baraddin, 2004) and tarhana chemical and functional properties (Nermin, 2009). Hromádková, Stavová, Ebringerova, and Hirch (2007) have reported that buckwheat hull hemicelluloses addition of 0.5 g/100 g has considerable effect on bread flour quality in relation to the resistance, extension and fermentation of dough and improved sensory properties of fresh bread and high scores for overall acceptability.

As rheological properties have great relevance in predicting the product quality such as mixing behavior, sheeting and baking performance (Dobraszczyk & Morgenstern, 2003) and no data is available about development time (DT), dough stability (DSt), degree of softening (DSf), energy (E), resistance (R), extensibility (Ex), gelatinization temperature (T_{max}) and maximal pasta viscosity (η_{max}), these rheological properties of wheat and buckwheat flours mixtures were investigated.

The present work has been undertaken with the following objectives: (1) to prepare wheat–buckwheat flour mixtures with buckwheat flour portion in range from 3 to 30 g/100 g, (2) to investigate the effect of buckwheat flour addition on rheological properties, on fatty acids and acylglycerols composition with an emphasis on total saturated fatty acids (TS), total monounsaturated fatty acids (TMUS), total polyunsaturated fatty acids (TPUS) and total unsaturated fatty acids content (TU) and (3) to find the correlation coefficients (between some rheological properties and lipids components) and Euclidean distances (between flours and flours mixtures).

2. Materials and methods

2.1. Flour and mixtures

The wheat flour (WF) and whole grain buckwheat flour (BWF) were bought from the local market. A 291, 285, 270, 240 and 210 g of wheat flour and 9, 15, 30, 60 and 90 g of buckwheat flour, respectively, were used to make 300 g of flour mixture with buckwheat flour portion of 3, 5, 10, 20 and 30 g/100 g, without adding additives.

2.2. Methods

2.2.1. Flour analysis

Flour protein content was determined by the Kjeldahl method (N×5.95). The ash content was determined by 920.153, AOAC 1995 method and the moisture content by 985.14, AOAC 1995 method.

2.2.2. Lipids content

The lipids content was determined by n-hexane duplicate extraction, for the same sample, by using reflux (1: 20 w/v at boiling temperature, 60 min). The extracts were combined and 3 ml were dried at 110 °C to a constant weight and the dry residue content was read out on the analyzer display (Scaltec SMO 01, Scaltec instruments, Germany). For lipids isolation, the rest of combined n-hexane extracts was evaporated under vacuum.

2.2.3. Rheology measurement

The Brabender farinograph (Brabender Model 8 10 101, Duisburg, Germany) according to ISO 5530-1 test procedure, was used for water absorption values (WA value in ml/100 g), development time (DT in minutes), dough stability (DSt in minutes), degree of softening (DSf in FU) and farinograph quality number (QN) determination.

For extensograph measurement, the Brabender extensograph (Brabender, Model 8600-01, Duisburg, Germany) and test procedure ISO 5530-2 were used. The samples were prepared from flour, distilled water and salt, and data for energy (E in cm^2), resistance (R in EU), extensibility (Ex in mm) and ration number (R/Ex) were recorded on extensograph curve.

To obtain amylograph data such as gelatinization temperature (T_{max} in °C and gelatization maximum η_{max} in AU), the amylograph (Brabender Model PT 100, Duisburg, Germany) and ISO 7973 test procedure was used.

2.2.4. HPLC analysis

For HPLC analysis, Holčapek, Jandera, Fisher, and Prokeš (1999) modified HPLC method and the Agilent 1100 High Performance Liquid Chromatograph, a Zorbax Eclipse XDB-C18 column: 4.4 m × 150 mm × 5 μm (Agilent Technologies, Wilmington, USA) and a UV/ViS detector were used. The flow rate of binary solvent mixture (methanol, solvent A, and 2-propanol/n-hexane, 5:4 by volume, solvent B) was 1 ml/min with a linear gradient (from 100% A to 40% A+ 60% B in 15 min).

The column temperature was held constant at 40 °C. The components were detected at 205 nm. The monoacylglycerols (MAG), diacylglycerols (DAG) and triacylglycerols (TAG) were identified by comparing the retention times of the lipids components with those of standards. The samples of the reaction mixture were dissolved into a mixture of 2-propanol:n-hexane, 5:4 v/v and filtered through 0.45 μm Millipore filters.

2.2.5. GC analysis

For GC analysis, fatty acids methyl esters were prepared. The lipids were alkaline hydrolyzed and methylated by methanol and BF_3 as catalysts. The final fatty acids methyl esters concentration was about 8 mg/ml in heptane.

For obtaining a methyl esters GC spectra, the HP 5890 SERIES II GAS-CHROMATOGRAPH, HP with FID detector and 3396 An HP integrator was used. Column was ULTRA 2 (25 m × 0.32 mm × 0.52 μm) (Agilent Technologies, Wilmington, USA), injector temperature of 320 °C, and injector volume of 0.4 μl. The carrier gas was He at a constant flow rate of 1 ml/min. The flame ionization detector was at 350 °C and split ratio was 1:20. Oven temperature was initially 120 °C and was maintained at 120 °C, for 1 min, then increased by 15 °C/min until 200 °C, increased by 3 °C/min until 240 °C, increased by 8 °C/min until 300 °C and maintained at 300 °C for 15min. The fatty acids were identified by comparison of retention times of the lipids components with those of standards.

2.2.6. Statistical analysis

STATISTICA, version 5.0 software was used to perform the statistical analysis: the means and standard deviations, the correlation coefficients and cluster analysis. The means and standard deviations were obtained by Descriptive Statistics, marking the Median & Quartiles and Confirm Limits for Means. In order to classify flours and mixtures of wheat flour with different buckwheat flour portion into groups, the cluster analysis and the Euclidean method with the complete linkage was used.

3. Results and discussion

3.1. Flour properties

The wheat flour was B_2 quality number (QN), and had protein content (PC) of 9.8 ± 0.3 g/100 g, ash content (AC) of 0.5 ± 0.04 g/100 g,