Journal of Food Engineering 172 (2016) 31–37

Contents lists available at ScienceDirect

Journal of Food Engineering

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

Influence of spelt flour addition on properties of extruded products based on corn grits

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A R T I C L E I N F O

Article history:
Received 6 October 2014
Received in revised form
13 April 2015
Accepted 15 April 2015
Available online 27 April 2015

Keywords:
Spelt
Corn grits
Extrusion
Physical properties
Rheological properties

A B S T R A C T

Production of corn extrudates with addition of various types of flours is widely used in the food process industry, both for final products and for the modification of flours for the bakery industry. Because of its chemical composition spelt is recently used for production of various types of food products. The aim of this study was to determine the effect of spelt flour addition to corn grits (ratios grits: flour = 95:5; 90:10 and 80:20) on extrudates properties. Prepared samples with 15% of moisture content were extruded in the laboratory single screw extruder, and then physical and rheological properties were determined.

The obtained results showed that addition of spelt flour to corn grits resulted in decrease of expansion ratio (ER) and fracturability, whereas bulk density (BD) and hardness of extrudates increased. After extrusion process water absorption index (WAI), water solubility index (WSI) and damage of starch (DS) significantly increased, while resistant starch (RS) content decreased. Spelt flour addition and extrusion process significantly changed the color, decreased peak, hot and cold viscosities, and the extruded samples were less prone to retrogradation.

1. Introduction

Extrusion cooking is a relatively modern, high temperature short-time (HTST) processing technology that was invented in 1940's to manufacture snack foods. This technique has gained ground in human food and animal feed industries world-wide, primarily for the processing of cereal grains (Athar et al., 2006). It can be used for production of a wide range of products such as snack-foods, baby-foods, breakfast cereals, noodle, pasta and cereals based blends (Semasaka et al., 2010). During extrusion cooking, the raw materials undergo many chemical and structural transformations, such as starch gelatinization, protein denaturation, complex formation between amylose and lipids, and degradation reactions of vitamins, pigments, (Ilo and Berghofer, 1999). Since corn grits is a major ingredient for extruded foods, such as ready-to-eat breakfast cereals and snack (Gujral et al., 2001), nowadays there is a need to improve the nutritional value of this kind of food, particularly because cereal-based snack products are often consumed by children (Pastor-Cavada et al., 2011). The effect of addition of various type of grains, legumes and other ingredients to corn grits on properties of extrudates has been studied extensively (Ainsworth et al., 2007; Delgado-Licon et al., 2009; Karkle et al., 2012; Lazou and Krokida, 2010; Nascimento et al., 2012; Onwulata and Konstance, 2006; Semasaka et al., 2010; Wang and Ryu, 2013a; Wu et al., 2007).

In the last years, there is considerable interest in the use of spelt (*Triticum aestivum* ssp. *spelta*) for production of health and organic food products. Spelt is an ancient subspecies of modern bread wheat (*T aestivum* ssp. *aestivum*). Until the beginning of the 20th century, spelt was the predominant grain for bread production in many regions, for example in southwestern Germany, and parts of Switzerland and Austria (Escarnot et al., 2010). Since then, however, wheat has largely replaced spelt. This is due to spelt's lower yield and its long straw with a tendency to lodge, especially if levels of nitrogen fertilizer applied are too high. Furthermore, as spelt is a hulled grain, a dehulling step prior to milling is required (Schober et al., 2006).

Today, more spelt-based products are available including flour, bread, breakfast cereals, pasta and crackers. It seems that this cereal has valuable nutritional and/or physiological properties, which could help promoting the consumption of these products (Marques et al., 2007). Because of that, there are an increasing number of international publications on spelt food quality, spelt proteins,

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http://dx.doi.org/10.1016/j.jfoodeng.2015.04.012
0260-8774/

rheology of spelt dough or gluten, or comparisons of spelt and wheat (Abdel-Aal, 2008; Bonafaccia et_al., 2000; Escarnot et_al., 2010; Marconi et_al., 2002; Marques et_al., 2007; Schober et_al., 2006; Zieliński et_al., 2008).

Escarnot et_al. (2010) reported that spelt has a higher protein content than wheat, a higher lipid content, especially in Δ7-avenasterol and higher magnesium, phosphorus, iron, copper and zinc contents. The spelt-based products are easily digestible and have a slightly higher protein content than wheat. The main difference in the nutritive value of spelt flours is the variation in the amount and type of grain proteins, especially the prolamins (Zieliński et_al., 2008). Spelt with high protein content (⩾13.5 g/100 g dry matter) and high temperature during drying were required to produce good quality spelt pasta (Abdel-Aal, 2008). Furthermore, this author reported that flaked breakfast cereal with appealing flavor and texture can be produced from spelt.

The spelt cultivars had higher contents of soluble dietary fiber and protein than the standard wheat or durum. In the bread of spelt flour, there was more rapidly digested starch (RDS) and a higher starch digestion index (SDI) in comparison to wheat bread. In pasta and extruded products of whole spelt flours, more protein, ash and dietary fiber was found in comparison to the same products made of white spelt flour (Bonafaccia et_al., 2000).

Since there are not enough researches about the production of extruded products with spelt flour, the aim of this study was to determine the effect of spelt flour addition to corn grits (ratios grits: flour = 95:5; 90:10 and 80:20) on extrudates properties.

2. Materials and methods

2.1. Materials

Corn grits used in this study was obtained from the mill Đakovo of the "Žito" Company Ltd. Osijek, Croatia, produced in 2012. Spelt was purchased from Family Farm "Jazbec", Ivanovac, Croatia, and milled at laboratory mill IKA MF10 with 2 mm sieve.

2.2. Blend preparation

Corn grits and spelt flour were mixed in ratios: 95:5; 90:10 and 80:20. Control sample of corn grits and blended mixtures were conditioned to 15% of moisture by spraying with calculated amount of demineralized water and mixing continuously in laboratory mixer. The samples were then packed in plastic bags and kept in the refrigerator overnight at 4 °C to equilibrate the moisture. Before extrusion cooking the samples were brought to room temperature.

2.3. Extrusion

Prepared samples were extruded in the laboratory single screw extruder 19/20DN, Brabender, Germany. *Extrusion parameters* were as follows: screw: 4:1; die: 4 mm; temperature profile: 135/170/170 °C; screw speed: 100 rpm; dosing speed: 20 rpm. Obtained extrudates were air-dried overnight and stored in plastic bags until required for analysis.

2.4. Expansion ratio

Expansion ratio (ER) was determined according to Brnčić et_al. (2008), where expansion ratio was calculated as follows:

$$ER = extrudate\,diameter\,(\mathrm{mm})/die\,diameter\,(\mathrm{mm}) \quad (1)$$

2.5. Bulk density

Bulk density (BD) was calculated according to the method of Alvarez-Martinez et_al. (1988):

$$BD\,(\mathrm{g}/\mathrm{cm}^3) = 4m/\pi d^2 L \quad (2)$$

where m is mass (g) of a length L (cm) of extrudate with a diameter d (cm).

2.6. Texture analysis

Texture properties of extrudates were determined by texture analyzer TA.XT2Plus, Stable Microsystem, United Kingdom, using method "Measurement of the hardness and fracturability of pretzel sticks" with following settings: pre-test speed: 1.0 mm/s; test speed: 1.0 mm/s; post-test speed: 10.0 mm/s; distance: 3 mm; trigger type: auto − 5 g.

2.7. Color

Color was measured using Chroma Meter CR-300, Konica Minolta, Japan with granular materials attachment. The instrument was calibrated using white standard calibration plate and color was expressed in CIE-Lab parameters as L^* (whiteness/darkness), a^* (redness/greenness) and b^* (yellowness/blueness) and in CIE-LCh parameters as C (Chroma) and $h°$ (hue). The total color change (ΔE) was calculated as:

$$\Delta E = \sqrt{(L - L_0)^2 + (b - b_0)^2 + (a - a_0)^2} \quad (3)$$

where the subscript '0' indicates initial color values of the corn grits.

2.8. Water absorption index (WAI) and water solubility index (WSI)

WAI and WSI were determined according to Anderson et_al. (1969). The ground sample (2.5 g) was suspended in 30 mL of distilled water at room temperature. After standing for 30 min (with intermittent shaking every 5 min), the sample was centrifuged at 3000 rpm for 15 min. The supernatant was decanted into an evaporating dish of known weight and dried at 105 °C until constant weight. The remaining gel in the centrifuge tube was weighed, and WAI and WSI were calculated as following equations:

$$\mathrm{WAI}\,(\mathrm{g/g}) = \text{weight of gel/dry weight of sample} \quad (4)$$

$$\mathrm{WSI}\,(\%) = (\text{weight of dry solids in supernatant /dry weight of sample}) \times 100 \quad (5)$$

2.9. Pasting properties

Pasting properties of non-extruded and extruded samples (10% d. m., 100 g total weight) were measured using a Micro Visco-Analyser (Model 803202, Brabender Gmbh & Co KG, Duisburg, Germany). The flour suspensions were heated at 7.5 °C/min from 32 to 92 °C, held at 92 °C for 10 min, cooled at 7.5 °C/min to 50 °C, and held at 50 °C for 1 min.