THE EFFECT OF EXTRUSION CONDITIONS AND CEREAL TYPES ON THE FUNCTIONAL PROPERTIES OF EXTRUDATES AS FERMENTATION MEDIA

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Abstract

Extrusion cooking is used world wide for the production of expanded snack food, modified starch, ready-to-eat cereal foods. Recently a considerable interest has arisen in the appliance of extruded products, such as raw materials with specific physical properties, for the production of fermented products. Product quality can vary considerably depending on the extruder type, screw configuration, feed moisture, temperature profile in the barrel, screw speed, feed rate and die profile. In this study, the effect of feed moisture content on functional properties (water solubility index, water absorption index and degree of gelatinization) of different extrudates was investigated. Different extruded samples were prepared using wheat (flour and meal), rye (flour, meal and wholemeal), barley, triticale, maize and rice wholemeals, pursuant to selection of fermentation media. Cereal products were passed through a one-screw extruder using moisture contents of 30% and 50%.

The performed study revealed that functional properties of extrudates are strongly related to the cereal type and feed moisture content. The higher feed moisture content (50%) influenced the higher water solubility index (WSI), yet the lower water absorption index (WAI) and degree of gelatinization (DG). The highest values of WSI, WAI and DG were demonstrated by barley, triticale and rye flour extrudates and were as follows: 10.1%, 2.31 g g^{-1} and 100%. Meanwhile, the lowest values of functional properties were observed on triticale, rice and wheat extrudates, and were in the values of 1.8%, 0.63 g g^{-1} and 6.1%, respectively.

Key words: extrusion, feed moisture content, WAI, WSI, DG.

Introduction

Extrusion is one of the most common industrial processes used to make snacks, and it is among the most versatile technological processes for making food products, usually from cereals. Cereals, in turn, are the customary, traditional snack ingredient due to their high starch content (Perez-Navarrete *et al.,* 2006). Extrusion technology has many advantages, including its versatility, high productivity, low cost, and the ability to produce unique product shapes and high product quality (Singh and Smith, 1998; Singh *et al.,* 1999; Koksel *et al.,* 2004).

Extrusion-cooking is a versatile and feasible alternative for manufacturing snacks and water reconstitutable foods, and it has been the object of studies to enhance the nutritional and functional properties of extrudates for the development of products (Sacchetti *et al*.., 2005; Shankar and Bandyopadhyay, 2005; Gonzalez-Soto et al., 2006; Hernandez-Diaz *et al*., 2007). In extrusion cooking, important parameters for product quality include moisture content of the material, residence time, which is influenced by feeding rate, screw speed and configuration, die geometry, temperature and time (Gogoi and Yam, 1994; Obatolu *et al.,* 2005). The results of extrusion are gelatinization of starch, denaturation of proteins, inactivation of many native enzymes and antinutritional factors, reduction of microbial counts, and improvement in digestibility and biological value of proteins (Martin-Cabrejas *et al.,* 1999; Milan-Carrillo *et al.,* 2002). The suitability of extruded foods for a particular application depends on their functional properties like water absorption and water solubility indexes, expansion index, bulk density and viscosity of the dough (Hernandez-Diaz *et al.,* 2007).

The objective of this study was to investigate the effect of feed moisture content as processing variables on functional and physical quality of extrudates from different cereal types.

Materials and Methods

The extruded samples: wheat (flour and meal), rye (flour, meal and wholemeal), barley, triticale, maize and rice wholemeals were used throughout this study. Cereal products were passed through a one-screw extruder using feed moisture contents of 30% and 50%.

Water absorption index (WAI) and water solubility index (WSI). WAI and WSI were determined in duplicate following the method described by Anderson (1982). Each sample (1 g) was suspended in 6ml of distilled water and stirred for 30 min at 30 ^{o}C temperature.

Subsequently, the dispersions were centrifuged at 4000 g for 20 min using Heraeus Labofuge 200 Centrifuge (Thermo Electron LED GmbH, Langenselbold, Germany). The supernatants were poured into dry test tubes and stored overnight at 110 ^{o}C for the process of evaporation. WAI and WSI were calculated using following equations:

WAI = weight of sediment / weight of dry solids

WSI = weight of dissolved solids in supernatant x100/weight of dry solids

Degree of gelatinization (DG). Degree of gelatinization was determined by comparing OD values of a particular extrudate to its control (non-extruded) sample. OD values of the samples in triplicate were measured using Spectrophotometer Genesys 10 (Thermo Electron LED GmbH, Langenselbold, Germany) at a wavelength of 608 nm. Calculations were made using the following equation:

DG=optical density of extrudate x100/optical density of control sample.

Results and Discussion

Water solubility and water absorption indexes. Water solubility index (WSI) is used as a measure for starch degradation; it means that at lower WSI there is minor degradation of starch and such condition leads to less numbers of soluble molecules in the extrudates (Hernandez-Diaz *et al.,* 2007). Higher moisture content in extrusion process can diminish protein denaturation and starch degradation. The experimental results show that WSI of all examined extrudates (excluding maize) decreased with increasing moisture levels. The effect of feed moisture content on WSI is illustrated in Figure 1 (A).

The highest WSI under 50.0% feed moisture content in extrusion process were determined in barley and maize extrudates, being 8.7% and 5.9%, respectively. Whereas the lower WSI under same conditions were measured in rye meal and triticale extrudates, with the values of 2.0% and 1.8%, respectively. In the case of 30.0% feed moisture content, barley extrudate had the highest WSI, yet in triticale extrudate was measured the lowest WSI, being 10.1% and 3.6%, correspondingly.

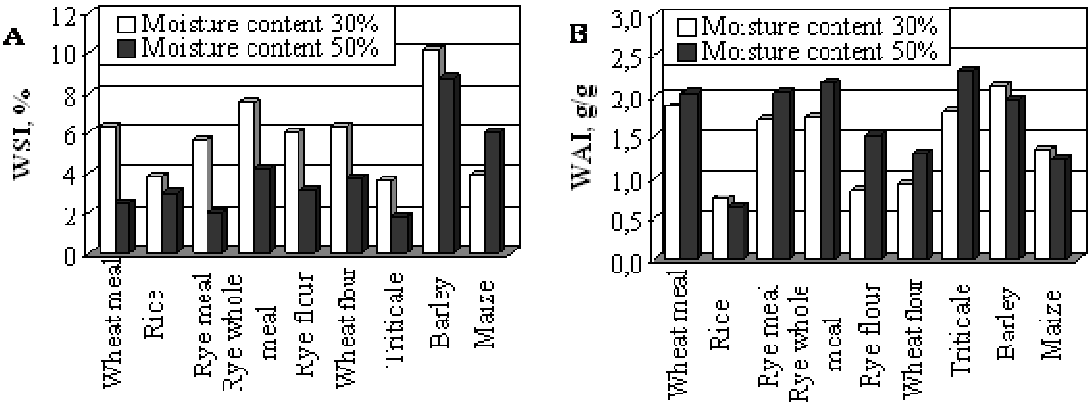

Figure 1. Effect of feed moisture content on WSI (A), WAI (B) and extrudates from different cereal types

WAI, an indicator of the ability of flour to absorb water, depends on the availability of hydrophilic groups which bind water molecules and on the gel-forming capacity of macromolecules. The results of the effect of feed moisture content on WAI of extrudates from different cereal types are demonstrated in Figure 1 (B).

The higher feed moisture content influenced higher WAI for all but rice, barley and maize extrudates. The highest WAI was determined in triticale extrudate (2.31 g g^{-1}) along with the lowest WAI in rice extrudate (0.63 g g^{-1}), both under 50.0% feed moisture content. Badrie and Mellowes (1991) and Hernandez-Diaz (2007) reported similar findings where WSI of several extrudates decreased and WAI increased with increasing moisture levels.

Degree of gelatinization. Degree of gelatinization was mainly affected by different cereal types. It was observed that lower feed moisture enhanced gelatinization in all except rye flour and wheat flour extrudates. The effect of feed moisture content on DG of different extrudates is illustrated in Figure 2.

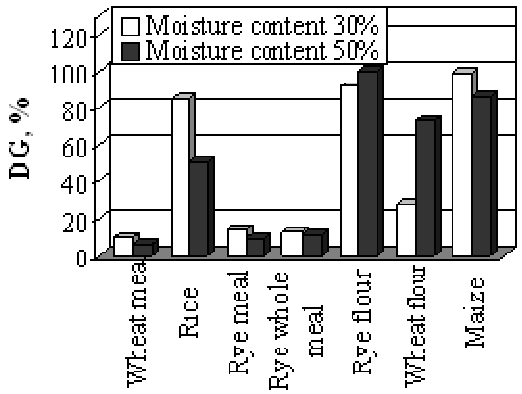

Figure 2. Effect of feed moisture content on DG and extrudates from different cereal types

Nevertheless the highest DG was examined under 50.0% feed moisture content in rye flour extrudate where all starch was gelatinized, yet in the wheat meal extrudate only 6.1% of starch gelatinization showing the lowest DG was achieved.

Conclusions

1. The effect of moisture content in extrusion process on functional properties of different cereal types was examined throughout this study. Experimental data indicate that the extrudate type had a significant influence on water solubility index (WSI), water absorption index (WAI) and degree on gelatinization (DG). Extrusion conditions have to be chosen considering cereal type of extrudate in order to get the preeminent functional properties for fermentation process.
2. Samples with higher degree of gelatinization resulted in lower water solubility and higher water absorbability. Therefore, extrudate samples with a higher degree of gelatinization have a higher gelling capacity and could be incorporated into foods as thickeners or in dough where retaining the moisture is important for the maintenance of the texture.

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