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Effect of selected parameters on process efficiency and energy consumption during the extrusion-cooking of corn-rice instant grits

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Abstract

More and more people begin to pay attention to how foodstuffs are produced. Due to the changing lifestyle, consumers seek products that do not require long preparation. The extrusion-cooking process responds to this type of applications with an easy management of processing promising product stability and quality. Extrusion-cooking involves the extruding of granular material under high pressure and high temperature. Such a method of treatment of raw materials makes extrudates produced from natural ingredients, i.e. corn or rice, suitable for direct consumption and guarantees their prolonged shelf-life. In our study, mixtures for instant grits were prepared from corn with a rice additive of 25% and 50%. Extrudates were prepared using a single-screw extruder TS-45 (L/D=12:1). The range of the temperatures of the extrusion process was 125/130/135°C. The process was carried out with the variable screw rotation speed of 80, 100 and 120 rpm. This paper presents the results of process efficiency and energy consumption during the extrusion-cooking of instant corn-rice grits. Based on a bidirectional analysis of variance, the process efficiency, regression equation and correlation coefficients were determined for evaluating the impact of the processing conditions on selected properties.

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Keywords: extrusion-cooking; gluten-free; efficienty; specific mechanical energy

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1. Introduction

Currently, food processing plays an important role in the manufacture of functional foods, supplemented with healthy components and as well as being convenient to use and requiring a short preparation time. Food manufacturers introduce products that contain plant materials and valuable extracts, which ensures that the human body is supplied any essential nutrients. Nowadays, consumers attach more and more attention to healthy food, which is a challenge for manufacturers of products intended for direct consumption. New techniques and technologies employed in food processing, such as extrusion-cooking, micronization, expanding, and combination of plant additives, replace popular snacks with a new generation of healthy products (Guy 2001; Ramirez-Jimenz et al. 2003, Wójtowicz 2007; Wójtowicz et al. 2012).

Extrusion-cooking is a process that involves the treatment of bulk material under high pressure (up to 20 MPa) and high temperature (up to 200°C), which yields significant changes in the physicochemical characteristic of the product and its quality. During processing, mixing, heating and shearing take place in order to give products specific properties corresponding to the pre-set manufacturing parameters (Mościcki et al. 2012; Yeh et al. 1999; Drożdż et al. 2010). The extrusion process is carried out on devices known as extruders. Products undergo starch gelatinization, so the extrudates are already precooked and do not require additional cooking. The extrusion process enables the use of raw materials with a wide range of granulation. Through a combination of process parameters and the use of a variety of recipes, it is possible to obtain an array of products with specific properties (Wójtowicz 2008). Extrusion-cooking technology is used in the food industry for the production of various types of foodstuffs, such as snacks, instant cereals, baby food, breakfast cereals, texturized vegetable protein, crisp bread, etc. (Harper 1981; Mercier et al. 1998; Mitrus et al. 2011, Mościcki et al. 2007; Sing et al. 2007).

Corn/maize grit is one of the most popular materials used in the production of extrusion-cooked food (Jurga 2012; Naz et al. 2005). Rice comes in many varieties characterized by hard, glassy grains and starch granules firmly embedded in a protein matrix (Mościcki et al. 2007). Processing with appropriate conditions allows new type of products to be obtained with a different texture, appearance and quality (Gondek et al. 2013, Wójtowicz et al. 2012; Zarzycki and Rzedzicki 2009). In qualitative terms, better products are derived from harder maize, which is caused by the higher amylose content in composition (Czerwińska 2011). Corn and rice products and dishes are hypoallergenic and gluten-free. Due to the specific protein composition, compared to other cereals, corn and rice products are recommended for people suffering from celiac disease (Oniszczuk et al. 2015; Gondek et al. 2013; Jurga 2012; Mościcki et al. 2007). The aim of the study was to evaluate the impact of selected processing parameters on process efficiency and energy consumption during the extrusion-cooking of corn-rice instant grits.

2. Materials and Methods

As raw materials, corn grit (distributor Aviko, Ciecierzyn, Poland) and rice (from Kobierzyce, Poland) were used. Instant grit composition is presented in Table 1. The moisture content of the raw materials was checked by the dryer (ASAE Standard 269.3 1989) before the extrusion process, and then the mixtures of components were moistened to the degree of 12, 14, 16 and 18% of moisture content, using a specific volume of water (Wójtowicz and Juśko 2012) at 20°C. A ribbon mixer was used along with a dispensing nozzle to ensure that the material is properly moistened and to avoid unequal level of hydration of the raw material. The mixing time was set for 15 minutes to obtain a loose structure. The mixture of raw materials was rested for 1 hour to uniform the moisture. The mixtures prepared in this manner were fed into the extruder's hopper. The extrudates were processed using a single-screw extruder TS-45 (L/D=12:1). The range of the temperatures of the extrusion-cooking process was the following: 125/130/135°C. The process was carried out by modifying the rotational screw speed between 80, 100 and 120 rpm. A forming die with a single hole of 3 mm was used. The extrudates were dried for 24 hours and ground by a laboratory grinder LMN10 (TestChem, Radlin, Poland) to a granulation below 1 mm.