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Evaluation of snack foods from barley–tomato pomace blends by extrusion processing

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Abstract

Blends of barley flour and tomato pomace were processed in a co-rotating twin-screw extruder. Experimental design with die temperature (140–160 °C), screw speed (150–200 rpm) and tomato pomace level (2–10%) as independent variables produced 20 different combinations that were studied using response surface methodology to investigate the effect of these variables on system parameters (SME, die melt temperature and die pressure) and product responses (expansion, bulk density, water absorption and solubility indices, texture and color). Extrudate from five experiments within 20 samples was selected for sensory evaluation in terms of color, texture, taste, off-odor and overall acceptability. Regression equations describing the effect of each variable on the system parameters and product responses were obtained. The system parameters and product responses were most affected by changes in temperature, pomace level and to a lesser extent by screw speed. Extrudates with 2% and 10% tomato pomace levels extruded at 160 °C and 200 rpm had higher preference levels for parameters of color, texture, taste and overall acceptability. The results suggest that tomato pomace can be extruded with barley flour into an acceptable and nutritional snack.

Keywords: Extrusion cooking; Barley; Tomato pomace; Response surface methodology

1. Introduction

Tomato (*Lycopersicon esculentum*) is one of the most popular vegetables and an integral part of human diet worldwide. Significant amounts are consumed in the form of processed products such as juice, paste, puree, ketchup, sauce and salsa. During tomato processing a by-product, known as tomato pomace, is generated. This by-product represents, at most, 4% of the fruit weight (Del Valle, Camara, & Torija, 2006). Tomato pomace consists of the dried and crushed skins and seeds of the fruit (Tadeu-Pontes, Carvalheiro, Roseiro, & Amaral-Colloço, 1996). The skin, important component of pomace, is source of lycopene. Lycopene is an excellent natural food color and also serves as a functional ingredient with important health benefits beyond basic nutrition (Kaur, Sogi, Gary, & Bawa, 2005). A diet rich in lycopene is related to a decreased risk of certain cancers, particularly cancers of the digestive tract, prostate cancer and pancreatic cancer due to protective effect of lycopene against oxidative damage (Johnson, 2000). It also was found that tomato pomace significantly reduced cholesterol level in liver and heart by 15% and 18%, respectively (Bobek, Ozdin, & Hromadova, 1998). The use of tomato processing by-products could provide gaining valuable substances and at the same time reduce the waste disposal problem.

Dietary fiber has received increased attention recently. As consumers become more concerned about eating food with health benefits, barley, which is naturally healthy, easily available and inexpensive crop is strongly favored for increased incorporation into human diet (Czuchajowska, Klamczynski, Paszczynska, & Baik, 1998). The dietary

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fiber content of barley contributes to its nutritional value, making it a highly desirable cereal grain today.

Extrusion cooking is an important and popular food processing technique classified as a high temperature/short time process to produce fiber-rich products (Gaosong & Vasanthan, 2000; Vasanthan, Gaosong, Yeung, & Li, 2002). In the extruder, the food mix is thermomechanically cooked to high temperature, pressure and shear stress which are generated in the screw-barrel assembly. The cooked melt is then texturized and shaped in the die (Arhaliass, Bouvier, & Legrand, 2003). The thermomechanical action during extrusion brings about gelatinization of starch, denaturation of protein and inactivation of enzymes, microbes and many anti-nutritional factors; all this occurs in a shear environment, resulting in a plasticized continuous mass (Bhattacharya & Prakash, 1994).

In recent years, there is an increasing demand for conversion of fruit and vegetable wastes into useful products. The primary motivation is to minimize environmental impact of these by-products and to utilize valuable constituents that remain, such as lycopene and dietary fiber. One viable method for utilization of fruit and vegetable by-products into useful products is extrusion processing due to its versatility, high productivity, relative low cost, energy efficiency and lack of effluents. Successful incorporation of tomato pomace into extruded products that deliver physiologically active components represents a major opportunity for food processors providing the consumer a healthy barley-based product to choose from which is currently lacking in the marketplace. Therefore, the objective of this research was to investigate processability of barley flour with the combination of tomato pomace to produce snack food in a twin-screw extruder. The effect of the variables such as tomato pomace content, extrusion die temperature and screw speed on system parameters and physical properties of extrudates were evaluated by using response surface methodology. Sensory properties were determined in terms of color, texture, taste, off-odor and overall acceptability for selected extrudate samples.

2. Materials and methods

2.1. Materials

Barley flour was obtained from Bob's Red Mill Natural Foods (Milwaukie, OR, USA). The particle size distribution of the barley flour was 12.1% (on mesh 40); 42.9% (on mesh 60); 38.9% (on mesh 80); 5.5% (on mesh 100); 0.4% (on mesh 120) and 0.2% (mesh 120). Barley flour was stored at 4 °C until use. Tomato pomace, tomato-processing by-product, was obtained from the ConAgra Foods tomato processing plant located in Oakdale (California, USA). The pomace, obtained from the paste line, had a moisture content of 46.4% (w.b.). It was dried at 50 °C overnight in a forced-air drier (Model # R-4, Commercial Dehydrator System, Inc., Eugene, OR, USA). The dried tomato pomace was coarsely ground and passed on sieve with mesh size of 20. Then, the sieved tomato pomace was finely ground and stored in polyethylene bags at −20 °C for further usage. The moisture content of dried tomato pomace was 2.43 ± 0.2% (w.b.).

2.2. Sample preparation

Blends were prepared by mixing barley flour and tomato pomace in the ratios of 100:0, 98:2, 94:6, 90:10 and 87.27:12.73 on a dry-to-dry weight basis. These blends were chosen according to preliminary tests without jamming of extruder and for acceptable product's physical characteristics. The blended samples were conditioned to 21–22% (w.b.) moisture by spraying with a calculated amount of water and mixing continuously at medium speed in a mixer (Model F-30T, Blakeslee, Chicago, IL, USA). The samples were put in buckets and stored at 4 °C overnight. The feed material was then allowed 3 h to equilibrate at room temperature prior to extrusion. This preconditioning procedure was employed to ensure uniform mixing and hydration and to minimize variability in the state of the feed material. Moisture content of samples was determined by halogen moisture analyzer (Model HR83 and HR83P, Mettler-Toledo GmbH, Greifensee, Switzerland) at 105 °C.

2.3. Extrusion cooking

A laboratory-scale co-rotating twin-screw extruder (APV, Staffordshire, England) with a System9000 torque rheometer (Haake Buchler, Paramus, NJ) that provided computer control and data acquisition was used. The slit die (Haake Buchler, Paramus, NJ, USA) had dimensions of 1.47 mm × 20 mm × 150 mm. The barrel diameter and its length to diameter ratio (L/D) were 30 mm and 13:1, respectively. The MPC/V-30 had a clamshell barrel consisting of three independent temperature zones controlled by electrical heating and compressed air cooling. A computerized data acquisition system was used to control five set temperatures and rotor speed and to record five melt temperatures, pressure at the slit die and torque data. Data acquisition rate was every 6 s. The barrel zone temperatures were set at 30, 60, 100 and 130 °C throughout the experiments. The actual extruder screw speed is 2.5 times the rotor speed. The screws were composed of screw elements and lope-shaped paddles which could be assembled on the hexagon-shaped shafts to give different screw configurations. The screw configuration used is shown in Fig. 1. The screw configuration had three pieces of 1.5D twin lead feed screws, two 1D twin lead feed screws, nine kneading elements oriented at 30° feed forward, one 1D single lead feed screw followed by nine kneading elements oriented at 30° feed forward and 1D discharge screw. Barley flour and tomato pomace blends were fed into extruder with a K-tron Type T-20 twin-screw volumetric feeder (K-Tron Corp., Pitman, NJ, USA) at a rate of 2.11 ± 0.042 kg/h. Extrudate was collected when the operation condition was at steady state identified by torque value that vary less