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Extended Abstract

Optimization of Formulation Variables and Conditions of the Extrusion Process Large Snack Products Containing Bene cake- Flour

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Abstract

In this study, response surface methodology (RSM) was used to optimize extrusion conditions, including semi-defatted Bene cake (PDBC) content(10-30%), moisture content (12-18%), temperature (120-180 °C), and screw speed (120-220 rpm). The effects of the independent variables were investigated on some physical and functional properties including bulk density(BD), expansion rate, hardness, water absorption index (WAI),water solubility index (WSI), oil absorption index (OAI). Our result revealed that the addition of PDBC improved the functional and physical properties of extruded Bene snack (EBS).BD was remarkably increased by increasing PDBC. The addition of PDBC to cornmeal increased the fiber content contrary to the starch content. It also brought about a reduction in the average size of the cells and creation of holes on the cell wall. Hardness was also increased by adding PDBC. WAI of EBS was remarkably decreased by adding PDBC. WSI of EBS increased as PDBC increased. OAI of EBS increased by increasing PDBC and extrusion temperature. Among the independent variables, bene content had the largest effect on all of the responses. 21.14% PDBC, 17.45% moisture content, 160 rpm screw speed and 133.2 °C were found to be the optimal conditions for PDBC production.

Keywords: Bulk Density, Expansion Ratio, Extrusion, Functional Properties, Texture Analysis

Introduction

Health and nutrition are the most important challenges for the present and future demands. Maintaining and enhancing the quality of food during processes are the most important potential research areas in food science (Capriles *et al.*, 2009).

Extrusion is one of the most important inventions of the twentieth century, which is theoretically and technologically applicable to different industries such as polymer, plastic, food, and paper. Extrusion cooking is an economically progressive and advanced technological process in food processing and in the production of a variety of textured foods.

Pistacia atlantica, known as "Bene" in Iran, is used after grinding and mixing with other substances as food by the natives. Bene oil contains essential fatty acids and several bioactive and health-promoting components (Farhoosh *et al*., 2008).

The aim of the present study was to examine the effects of feed characteristics and extrusion conditions on some physicochemical properties including bulk density (BD), expansion ratio, water absorption index (WAI), water solubility index (WSI) and oil absorption index (OAI) of extruded Bene snack (EBS) produced by a co-rotating twin-screw extruder.

Material and methods

Extrusion

In this study, a parallel twin-screw extruder (SAIXIN, model DS56, China) was applied at high shear and temperature in the final zones with a screw length of 40 cm, screw diameter of 15 mm, die diameter of 3 mm, and maximum rotation speed of 450 rpm. The extrudates were produced at three levels of extrusion temperature (120, 150 and 180 °C), three levels of screw speed (120, 170 and 220 rpm), and three levels Bene ground (10, 20 and 30%). Furthermore, the feeding material moisture content was adjusted to three levels (12, 15 and 18%).

Determination of the product properties

Bulk density

Bulk density was calculated using the method described by (Asare *et al*., 2004) and the following formula (assuming a cylindrical shape for the extrudate):

$$\rho_b = \frac{4 \times m}{\pi \times l \times d^2} \quad (1)$$

Where ρ_b (g/cm^3), d (cm), and l (cm/g) are bulk density, extrudate diameter, and length per gram of the extrudate, respectively.

Expansion ratio

Expansion of the extrudate was reported as sectional expansion, indeed the ratio of extrudate diameter (D^2_e) to die diameter (D^2_d). The extrudate diameter was determined by a Vernier caliper, assuming that the extrudate was cylindrical. The expansion ratio of five samples of each lot was calculated by the following equation and the average was reported (Fan *et al*., 1996).

$$\text{Expansion ratio} = D^2_e / D^2_d \quad (2)$$

Functional properties

Water absorption index (WAI)

WAI was estimated using the method previously presented by (Anderson *et al*., 1969) with some modifications. Briefly, 5 mL of distilled water was added to 0.2 g of the ground sample in a previously-weighed 15 mL centrifuge tube. The mixture was stirred using a vortex mixer for 2 min followed by centrifugation at 700 g for 20 min. The supernatant was transferred to a tarred evaporating dish. After weighing the remaining gel, WAI was calculated using the following formula:

$$WAI = m_g / m_s \quad (3)$$

Where m_g (g) and m_s (g) are the weights of the hydrated gel and the sample, respectively.

Water solubility index (WSI)

The WSI of the dry solids regained through the evaporation of the supernatant obtained from the water absorption test was calculated as:

$$WSI=(m_{ds}/m_s)\times 100 \quad (4)$$

Where m_{ds} (g) and m_s (g) represent the weight of the supernatant dry solids and that of the sample, respectively.

Textural measurement

In order to evaluate the mechanical properties of the product during storage, the force needed to vertically compress 30% of the product was measured. A texture analyzer MODELTA-PLUS (Micro Systems, UK) was employed at a compression rate of 2 mm/s using a circular plate 70 mm in diameter. The experiments were done at room temperature (25 °C) in triplicate.

Results and discussion

BD

BD was remarkably increased by increasing PDBC, which could be ascribed to the rise in the fiber content of the raw material. It can be due to the occurrence of the fiber compounds inclined to collapse the cell walls before the full expansion of the gas bubbles to their highest possible potential. However, changes in humidity did not change BD of Bene cake based extruded snack.

Extrusion temperature and screw speed had reducing effects on BD. Generally, shear is increased by enhancing the speed of screw followed by a decrease in melt viscosity (Kokini *et al.*, 1992). On other hand, temperature plays the main role in the degree of puffing through determining the vapor pressure of the moisture. The viscosity of the dough mass was decreased by increasing the extrusion temperature, resulting in a higher linear velocity at the die.

Expansion ratio

The addition of PDBC to cornmeal increased the fiber content contrary to the starch content. It also brought about a reduction in the average size of the cells and holes on the cell wall. In addition, fiber causes the rupture of the walls of air cells and the external surface of the extrudates, whereby hindering the full expansion of gas bubbles and decreasing the expansion ratio. On the other hand, the expansion rate of EBS was gently reduced by increasing the moisture content due to the decreasing shear. Generally, moisture content strongly influences the degree of gelatinization as an agent in interaction with other ingredients (Holay & Harper, 1982).

Hardness

The hardness of the extrudates was decreased by increasing the screw speed and temperature during the extrusion of PDBC and corn flour. The high screw speed caused a rise in the product temperature, leading to a higher expansion and thus, a decrease in hardness. On the other hand, the rise in the screw speed elevated the specific mechanical energy (SME), which positively affected the expansion ratio and brought about a decrease in hardness.

Water absorption index (WAI)

WAI of EBS was remarkably decreased by adding PDBC, which is probably attributed to the

decrease of the starch molecular degradation. The decreased starch content by adding PDBC may have influenced the starch gelatinization and caused a reduced water absorption. WAI was gradually increased by decreasing the screw speed and increasing the extrusion temperature

Water solubility index (WSI)

WSI of EBS increased as PDBC increased and the feed moisture content decreased. WSI was increased with the rise in the screw speed and extrusion temperature, which is ascribed to the breakdown of macromolecules to smaller ones with higher solubility through high mechanical shear.

Oil absorption index (OAI)

OAI of EBS was increased by increasing PDBC and extrusion temperature; it however decreased by increasing the screw speed and the feed moisture content. This increase can be probably ascribed to the creation of smaller molecules caused by the dextrinization of starch that happens at high degree of cooking of extrudates by increasing the extrusion temperature (Drago *et al*., 2007). The increasing feed moisture content reduced the degree of cooking, which resulted in a decreased OAI. The rise in the screw speed during extrusion reduced the degree of starch dextrinization by decreasing the residence time. Therefore, the highest values of OAI were expected at lower screw speeds which was observed in the present research.

Conclusion

This study revealed that the addition of PDBC improved the physical and functional properties of EBS extrudates. The selected independent variables significantly influenced the responses (P<0.05). Among the independent variables Bene concentration had the highest effect on all responses. 21.14% PDBC, 17.45% moisture content, 160 rpm screw speed, and 133.2 °C were found to be the optimal conditions for the production EBS extrudates.

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