SUMMARY

Possibilities of the utilization of agri-food industry by-products using extrusion-cooking technology

The aim of the study was to develop a comprehensive technological solution, in accordance with the 6R principles, enabling the management of plant pomace as a functional additive in food production. The use of plant pomace reduces the demand for technological water and the energy consumption of the extrusion-cooking process, taking into account environmental and process conditions. The study used by-products of the agri-food industry from the pressing of fruit (apple, chokeberry), vegetables (pumpkin) and oilseeds (nigella seed, flaxseed), which are characterized by high nutritional value. These functional additives were added in amounts of 10, 20 and 30% to raw materials mixtures based on starch, in particular potato starch and potato products, which were then processed by extrusion-cooking. For this purpose, a single-screw extruder EXP-45-32 (Zamak Mercator) equipped with a modified plasticizing system with L/D=16 and L/D=20 was used. The study used various forming dies and variable extruder screw speeds of 40, 60 and 80 rpm. The extrusion-cooking process is complex and depends on many factors, including technological, environmental and mechanical parameters. The study determined efficiency, specific energy consumption, temperature and process stability depending on the additives used (by-products of the agri-food industry). The extrudates obtained were tested for selected physicochemical properties determining their functionality. The antioxidant activity of selected extrudates, bulk density, expansion index, resistance to mechanical damage, water absorption (WAI) and solubility (WSI) indices were determined. Particular attention was paid to the impact of the design of the extruder-cooker plasticizing system on the efficiency and stability of the processing mixtures containing plant pomace. At the same time, the energy potential of using post-production materials generated during the start-up of the extrusion-cooking line or extrudates that do not meet quality standards was identified. Due to high contents of easily fermentable organic compounds, these materials were used for anaerobic fermentation, enabling energy recovery in the form of biogas. This type of activity is in line with the principles of the circular economy and makes it possible to reduce the amount and environmental impact of post-production residues. The presented technological concept combines environmental, energy and process approaches, thus enabling comprehensive management of by-products from the agri-food industry. The optimization of the extrusion process and the use of by-products in the production of functional foods and

bioenergy contribute to increased raw material and energy efficiency, while reducing the negative impact of the food industry on the natural environment.

The research conducted during the preliminary study and the main phase made it possible to determine the impact of individual variables, analyzed in relation to the scientific problems formulated, on the extrusion-cooking process and the properties of the snack pellets obtained with addition of selected plant by-products. The data obtained allowed for the development of processing conditions and for the acquisition and deepening of knowledge in the field of changes in the properties of the obtained products as a result of the application of variable extrusion-cooking process conditions in accordance with the idea of sustainable development and eco-design of technological processes. The results obtained may provide valuable guidance in the design of equipment adapted to the sustainable production of extruded snack pellets with the addition of selected plant pomace.

Keywords: extrusion-cooking process, plant pomace, plasticizing system, anaerobic fermentation, biogas, energy efficiency, circular economy