ABSTRACT

Common beans especially biofortified beans have potential to contribute to improvement in nutrition if widely consumed. This study was undertaken to explore the potential of extrusion in value addition for common beans. The overall goal of this research was to investigate extrusion processing behaviour of selected conventional and biofortified common bean varieties and determine the best processing conditions for production of extruded bean-based composite foods with optimal expansion, bulk density, texture, and protein digestibility characteristics. The physicochemical properties of common beans that affect their extrusion behaviour were determined. In addition, the effect of extrusion processing conditions on bean extrudate properties, were assessed. Optimal extrusion conditions for desirable bean snack extrudate were determined and later applied to develop nutrient-rich composite bean-based puffed snack with a focus on increasing nutrient intake for children aged 4 to 12 years.To assess the physicochemical properties of beans that affect their extrusion behaviour, the composition (protein, starch, amylose, crude fibre, dietary fibre, iron, zinc, total ash) of five common bean varieties (Bishaz, K131, NABE19, Roba1 and RWR2245) were determined and their association to extrudate physical and functional properties (water absorption, water solubility, expansion, bulk density, pasting properties) investigated. The effect of feed moisture, die temperature and screw speed (extrusion conditions) on bean extrudate nutritional, physical and functional properties (protein digestibility, polyphenols, phytates, water absorption, water solubility, expansion, bulk density, texture and pasting properties) was also determined. Extrudate responses that showed significant variation due to change in extrusion conditions were subjected to multi-response desirability optimization, from which optimal conditions were established. Optimal extrusion conditions established were applied to develop a composite bean-based puffed snack. The snack formulation with optimal nutritional, textural and sensory properties was determined. The composition of the beans varied among varieties. Beans protein, fibre, amylose, total ash and iron content showed significant relationship with the extrudate physical and functional properties. Beans with high fibre content produced high density extrudates. Positive relationships were found between dietary fibre and pasting properties. However, fibre content of the beans had negative relationship with water solubility of extrudates. The protein in beans had positive relationship with the water solubility and negative relationship with expansion of extrudates. Raw material feed moisture, extruder die temperature and screw speed had influence on the physical, nutritional and functional properties of bean extrudates. High expansion of extrudates was observed at low feed moisture. Increase in expansion resulted in low bulk density for extrudates, which is a desirable characteristic for expanded snacks. High water solubility of extrudates was observed at low feed moisture, while high feed moisture resulted in high water absorption index (WAI). High feed moisture and high die temperature resulted in increased WAI of extrudate which was attributed to increased gelatinization of starch. Increase in water solubility index was observed at high die temperature and high screw speed. This could be due to the extensive fragmentation of starch granules as a result of increased shear and pressure in the extruder. The hardness of bean extrudates increased with increase in feed moisture, which may

be attributed to the limited of extrudates. High die temperature and screw speed produced soft and crunchy extrudates. Optimal bean extrusion conditions that were established and subsequently applied to process composite extruded bean-based snack were 15 % feed moisture, 60/120/142 °C barrel temperatures and 45 Hz screw speed. Increased expansion and low hardness (thus improved texture) of bean extrudate were observed at high die temperature and high screw speed combined with low feed moisture. The texture was dependent on the extent of expansion of extrudates. The study revealed that the extrusion conditions required to produce soft crunchy high expanded bean extrudates, with desirable consumer attributes to be low feed moisture (15 %), high die temperature (142 °C) and high screw speed (45 Hz). Rapid viscoanalysis of extruded bean flour showed cold peak viscosities almost similar to corresponding final viscosities. This was indicative of complete or near complete gelatinization of bean starch granules during extrusion. The studies however showed that fibre-starch and protein-starch interactions may hinder complete gelatinization of starch in beans during extrusion.The snack extrudates exhibited high protein digestibility (81.3 %). Sensory evaluation of the snack extrudates revealed moderate scores ≥ 5 on a hedonic rating of 1 to 9 (where 1, disliked extremely; 9 like extremely). With further product improvement such as flavouring the product, higher scores in terms of appearance, taste, flavour, texture and overall acceptability could be obtained. An optimal desirability of 0.97 based on taste, flavour, texture (hardness and crunchiness) was predicted for a product mix containing 82 g beans for every 100 g of formulation. The product obtained would provide at least 20 g protein, 4.8 mg iron and 1.5 mg zinc per serving of 100 g.Results from this study showed that production of nutritious and acceptable bean-based snack foods with high protein, fibre, iron and zinc content is possible through extrusion processing. Ingredient complementation with beans can strategically be applied in the development of nutritive extruded snacks to boost nutritional quality and sensory properties, and subsequently improve nutrient intake by consumers. The findings would be important for future application in the food industry.