



Extrusion of a hard-to-cook bean (*Phaseolus vulgaris* L.) and quality protein maize (*Zea mays* L.) flour blend

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Abstract

Heated extrusion was tested as an alternative process for incorporating “hard-to-cook” beans into food products. A 3² factorial design was used to evaluate extrusion conditions for a 40/60 (w/w) blend of “hard-to-cook” beans and quality protein maize. Tested extrusion variables were temperature (155, 170 and 185 °C) and moisture content (15.5, 17.5 and 19.5 g/100 g). Screw speed was fixed at 130 rpm. The extrudates obtained at 155 and 170 °C with 15.5% moisture had the best physical characteristics and were chosen for comparative analysis of nutritional changes between the unprocessed “hard-to-cook” bean/quality protein maize flour blend and the resulting extrudates. *In vitro* protein digestibility was higher in the extrudates (80%) than in the flour blend (76%). *In vitro* starch digestibility was higher at 155 °C (89%) and 170 °C (92%) than in the flour blend (12%). Processing conditions decreased dietary fibre content by 38% at 155 °C and 44% at 170 °C.

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1. Introduction

Bean seeds undergo physical, biological and chemical changes during storage. Physical factors such as seed moisture content, temperature, seed condition and available oxygen in storage have a decisive effect on degradation because they influence seed quality (Rodríguez, 1992). Beans stored under high humidity (>75%) and high temperature conditions (30–40 °C) experience serious losses in quality characteristics, particularly increased cooking time due to hardening (Kigel, 1999). Some mechanisms proposed to explain hardening include conversion of lipids to oxygenated polymers, formation of insoluble pectates, lignification, protein denaturalization and hydrolysis; all occur mainly in the cotyledon. Hardening leads to what is called the hard-to-cook phenomenon. This involves changes in cell adherence that inhibit cell separation

during cooking, which affects cooked seed texture, and limits protein availability due to denaturalization and hydrolysis, lowering seed nutritional contribution (García, Filisetti, Udaeta, & Lajolo, 1998).

A number of alternative technologies have been proposed for use of hard-to-cook beans, such as dry and wet fractionating, soaking in saline solutions, alkaline thermal treatment and extrusion. Of particular interest is extrusion, since it is already widely used to incorporate hard-to-cook seeds into cereals which are then used to produce precooked flours, infant food and expanded snacks. These extruded products have advantages in terms of their sensory characteristics (texture, flavour, smell and colour) and nutritional properties (increased protein content and balanced amino acid profile).

A food extruder is a high temperature, short processing time bioreactor that can transform a variety of ingredients into intermediate or finished products such as precooked flours, expanded snacks, breakfast cereals, pastas and texturized protein (González, Torres, & Degreef, 2002). During extrusion,

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