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Development and characterization of extruded snacks from New Zealand *Taewa* (Maori potato) flours

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ABSTRACT

Crispy extruded snacks were prepared by mixing ungelatinized dried potato flours from four different *Taewa* cultivars and a modern potato cultivar with corn flour at two different ratios (25:75; 50:50), and their quality characteristics studied. All of the potato flours showed differences in colour, dry matter content, starch content and pasting characteristics. Among the extrudates prepared with 25% potato flours, Huakaroro snacks showed an L^* value of 51.71, whereas pure corn flour snacks had the highest L^* value of 61.22. The b^* at both levels of potato flour incorporation were lowest for Tutaekuri snacks. The microstructural characteristics of the extrudates such as cell structure and cell wall thickness changed considerably when potato flour was incorporated (50%) in the extruder feed. Moemoe, Tutaekuri and 100% corn flour snacks had the highest toughness, whereas the highest crispness was observed for the Huakaroro snacks. Lower and higher cold peak viscosities of 91 and 597 cP were observed for corn and Tutaekuri extrudates (in powdered form), respectively. The extrudates with 50% potato flour had higher breakdown and lower final viscosity than those containing 25% flour. The peak G' values were highest for 100% corn, Moemoe and Karuparera snack pastes.

1. Introduction

The twin screw extrusion of raw materials to produce corn snacks and ready-to-eat (RTE) cereals has increased significantly owing to favourable economics and product quality (Garber, Hsieh, & Huff, 1997; Onwulata & Konstance, 2006). Common food or feed products produced by the extrusion process include breakfast cereals, snacks, pre-gelatinized flours and starches, pet foods and animal feedstuffs (Harper, 1986). Extrusion variables, composition and particle size distribution of the feed material, and additives significantly affect extrusion parameters and product properties (Ryu, Neumann, & Peleg, 1993; Singh & Singh, 2004). The effect of various process variables on the extrusion behaviour of corn grits has been studied extensively by many researchers (Fletcher, Richmond, & Smith, 1985; Garber et al., 1997; Onwulata & Konstance, 2006). Reports on the effects of extrusion parameters such as feed moisture, extrusion temperature, feed rate and screw speed on physico-chemical, pasting and textural properties of extruded products made from different materials are available in the literature. Chinnaswamy and Hanna (1988) studied the effect of extruder barrel temperatures (110–200 °C) on the expansion ratio and shear strength of extrudates made from corn starch having 14% moisture content. Relationships between the texture, mechanical properties and structure of corn flakes have been studied by Chaunier, Della-Valle, and Lourdin (2007).

Potato flour is a traditional commercial potato product, which has long been associated with the baking of bread. Potato flour is generally prepared by pressure cooking the potatoes, then cooling under running water to room temperature and further drying in a cabinet drier (Pant & Kulshresthra, 1995). The chemical composition of potato flours from different American potato cultivars (carbohydrates 77–79%, protein 9–11%, ash 4–4.5%, crude fiber 1.17–1.18% and fat 0.1–0.2%) has been reported by Treadway, Willits, Heisler, Ross, and Osborne (1950). Identification and screening of potato cultivars is required as the functional properties of potato flours vary from cultivar to cultivar (Kaur, Singh, Singh, & Ezekiel, 2007; Pant & Kulshresthra, 1995; Singh, Singh, Sharma, & Saxena, 2003; Willard & Hix, 1987). Willard and Englar (1959) studied the viscosity of potato flour using a Brookfield viscometer as well as a viscoamylograph and reported that the viscosity increased as the screen size decreased.

Various methods of measuring texture-related and rheological properties can provide information on the behaviour of foods when deformed; the best method to use depends on the type of food and the purpose of the measurement. Scanning electron microscopy (SEM) is often used to analyse the internal morphology of a food product including how finely or coarsely the material is subdivided into cells (Gao & Tan, 1996). Dynamic rheometers have been

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widely used to study the viscoelastic characteristics of liquid, solid and semi-solid foods. Singh, Kaur, McCarthy, Moughan, and Singh (2008) studied the rheological properties of potato flesh using dynamic rheometry. Very few reports are available in the literature regarding the use of potato flour for producing extruded snacks. Bhattacharya, Sudha, and Rahim (1999) studied the pasting characteristics of an extruded blend of potato and wheat flours. They reported the effect of varying the moisture content of the feed on the pasting characteristics of the extrudates produced through an extrusion cooking process.

Taewa is a collective noun referring to the traditional cultivars of potatoes (*Solanum tuberosum*) that have been cultivated by *Maori*, the early settlers and natives of New Zealand for at least 200 years. These cultivars are known for their unique nutritional and sensory characteristics. *Taewa* are believed to have been a staple food crop of *Maori* before the main European settlement began in the mid-19th century (Roskruge, 1999). The objectives of the present study were to (1) characterize ungelatinized flour from different *Taewa* potatoes and a modern potato cultivar and (2) to study the characteristics of crispy snacks produced by extrusion cooking potato and corn flour blends.

2. Material and methods

2.1. Materials

Potatoes of four New Zealand *Taewa* (*S. tuberosum* L., cv. Karuparera, Huakaroro, Tutaekuri, Moemoe) and one modern potato cultivar (Nadine) were procured from local sources in New Zealand (2006 harvest). Uniformly sized potatoes were selected from each cultivar batch. The cultivar 'Tutaekuri' is long in shape and has purple skin and flesh; 'Moemoe' is round with purple skin and white flesh; 'Huakaroro' is oblong in shape with yellow skin and flesh; and 'Karuparera' has purple skin and yellow eyes and flesh. 'Nadine' potatoes are round/oval in shape and have pale flesh. Corn flour (spec # 600) was purchased from Corson Grain Limited (Gisborne, New Zealand). The starch content of the corn flour was 72% (as specified by the manufacturer).

All the reagents used in the study were of analytical grade.

2.2. Dry matter (%) and starch content (%)

The dry matter content (%) and starch content (%) of raw potatoes were determined using the methods described by Bu-Contreras and Rao (2001): dry matter (%) was determined by drying weighed potato slices in an aluminum dish in a vacuum oven at 100 °C for 24 h, and starch (%) was calculated from the dry matter (%) using the following equation:

$$\text{Percentage starch} = 17.546 + (0.891 \times \text{percentage dry solids} - 24.18) \quad (1)$$

2.3. Ungelatinized potato flour preparation

Potatoes were washed, brushed and peeled using a laboratory scale manual abrasive peeler. The eyes and all bruises were pitted out manually after peeling. The peeled potatoes were sliced into ~2–3 mm thick slices using a laboratory scale slicer. The slices were immediately dipped in water containing a small amount of potassium metabisulphite (30 g/100 l) for 10–15 s to prevent browning; and then dried at a temperature of 45 °C in a hot air cabinet drier to 6–7% moisture. The dried potato slices were ground so as to pass through a fine sieve (500 μm).

The powdered potato flour was packed in air-tight containers and stored at 5 °C for further use.

2.4. Extrusion cooking process

Potato flour from each cultivar was mixed with corn flour in two different ratios, 50:50 and 25 potato flour:75 corn flour, along with the incorporation of 1% salt to each formulation. The final moisture content of the feed was ~10%. Samples were extruded as expanded round spherical snacks using a Clextral co-rotating twin-screw extruder Model BC 21 (Clextral SAS, Firminy, France) with seven separate temperature controlled barrel zones, equipped with a 2 × 3 mm die. Experiments were performed at a screw speed of 300 rpm and feed screw speed of 195 rpm (equating to a feed rate of ~18 kg/h). Water was introduced into the feed at a controlled rate (0.75 kg/h) by a piston pump. Barrel temperature was maintained at 30 °C in the feed section, 50, 100, 100, 115 and 120 °C in the next five zones and 120 °C in the die zone by electric cartridge-type heaters enclosing the barrel together with coolant circulation in the barrel jacket to eliminate temperature spikes. The screw configuration was: 4× coarse forward rotating; 5× medium forward rotating; and 5× fine forward rotating. The extruded snacks were dried in a hot-air drier for 3 h at 35 °C and then packed into sealed containers until further use.

2.5. Colour characteristics

Colour measurements on ground potato flours and extruded snacks prepared from the mixtures of corn and potato flours were carried out using a colourimeter (Minolta Chroma meter CR-200, Minolta Ltd., Osaka, Japan) and the CIE 1976 ($L^*a^*b^*$) colour space. Five measurements were made on each sample. The instrument was calibrated against a standard white reference tile ($L^* = 97.75$, $a^* = -0.49$, $b^* = 1.96$).

2.6. Microstructural characteristics

2.6.1. Scanning electron microscopy

Selected extruded samples were fractured using forceps and mounted on aluminum stubs using double adhesive tape. The samples were sputter-coated with gold and then the fractured surface imaged in a scanning electron microscope (Stereoscan 250 Mk3, Cambridge Instruments Limited, Cambridge, UK).

2.6.2. Light microscopy

To determine the macroscopic morphology of the extruded snacks, the samples were fractured using forceps, and observed under a binocular microscope. Photographs were taken using a digital camera.

2.7. Textural characteristics

The textural characteristics of expanded snacks (samples of about 5 g) in terms of toughness and crispness were measured in triplicate using a Texture Analyser (TAXT Plus, Stable Microsystems, Surrey, UK). Samples were placed in a wired aluminum plate (35 mm × 35 mm) in a single layer and then 90% compressed at a test speed of 0.25 mm s^{-1} using a horizontal platen (30 mm × 30 mm) and a 50 kg load cell. The parameters determined from force versus displacement compression curves were calculated as described in the software provided with texture analyser: *toughness*, which was taken as the mean area under the curve; *crispness*, which was taken as the mean linear distance; and the mean number of major peaks (also crispness).

2.8. Rapid viscosity analysis (RVA)

The pasting properties of the potato flours were determined using a Rapid Visco Analyser (RVA-4, Newport Scientific Pty Ltd.,