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Low temperature post-harvest storage of New Zealand *Taewa* (Maori potato): Effects on starch physico-chemical and functional characteristics

Jaspreet Singh [a,*], Owen J. McCarthy [b], Harjinder Singh [a], Paul J. Moughan [a]

[a] *Riddet Centre, Massey University, Palmerston North, New Zealand*
[b] *Institute of Food, Nutrition and Human Health, Massey University, Palmerston North, New Zealand*

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Abstract

Fresh tubers from four traditional *Taewa* (Maori potato) cultivars (Karuparera, Tutaekuri, Huakaroro and Moemoe) and one modern potato cultivar (Nadine) of New Zealand, were stored at 4 °C and 80–90% relative humidity for six months after harvest. Starch was isolated from tubers after every three month period, and its physico-chemical and functional properties measured. Considerable changes in these properties occurred during storage. The extent of changes varied significantly from cultivar to cultivar. Starch swelling power, solubility and light transmittance decreased during tuber storage while a slight increase was observed in starch amylose content. The starch granule size distribution shifted to smaller granule size during tuber storage. Scanning electron micrographs showed degradation/erosion and pitting on the surfaces of many of the starch granules isolated from stored tubers. Transition temperatures and enthalpies of gelatinization of the starches increased somewhat during tuber storage, suggesting that changes in the stability of starch crystalline structures had occurred. Pasting, viscoelastic and texture profile analysis (TPA) characteristics of starch gels were found to have been influenced by tuber storage time for all the cultivars, but to the greatest extent for Nadine and Huakaroro. Gels made from starches from the stored tubers had a reduced tendency towards retrogradation as evidenced by the decrease in syneresis (%) during gel storage at 4 °C.

Keywords: Potato; Starch; Cultivar; Storage; Physico-chemical; Morphological; Thermal; Pasting; Viscoelastic

1. Introduction

Taewa are a unique resource cultivated and valued by *Maori*, the early settlers and natives of New Zealand. *Taewa* is a collective noun referring to the traditional cultivars of *Solanum tuberosum* that have been cultivated by *Maori* for at least 200 years, and were a staple food crop of *Maori* before the main European settlement in the mid-nineteenth century (Roskruge, 1999). The prolonged storage of potatoes at low temperature is required to ensure regular supplies throughout the year. Post-harvest cool storage provides a necessary environment to prevent loss of weight, spoilage and sprouting. The potato tuber is not a static entity during storage as physiological changes continue to occur owing to the constant release of sugars from the starch for respiration (Burton, 1989). The carbohydrate composition in tubers has been observed to change during post-harvest storage, and this affects the eating quality as well as the processing traits of potato and its products (Herrman, Love, Shafaii, & Dwelle, 1996). The quality of potatoes continues to change as a result of physiological activity owing to accumulation of reducing sugars and depletion of starch (Nourian, Ramaswamy, & Kushalappa, 2003a, 2003b). Therefore, sugar and starch are the main components affected by post-harvest metabolism in potato tubers, which ultimately affects potatoes' cooking, sensory and processing characteristics.

* Corresponding author. Tel.: +64 6 3505799x2534.
E-mail address: j.x.singh@massey.ac.nz (J. Singh).

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Numerous studies based on the measurement of enzymic activity in tubers have suggested marked changes in starch as well as individual and total sugar concentrations during storage (Hagenimana, Vezina, & Simard, 1994; Takahata, Noda, & Sato, 1995). The first step in the pathway of starch degradation is catalyzed by enzymes such as α-amylase, which are capable of metabolizing polymers at the surfaces of the semicrystalline granules (Smith, Zeeman, & Smith, 2005). The rate of starch depletion and sugar accumulation depends largely on the cultivar and temperature of storage, possibly owing to variation in enzyme activities (Kazami, Tsuchiya, Kobayashi, & Ogura, 2000). As no single potato cultivar has been shown to be appropriate for all food applications and storage stabilities, screening of cultivars is needed to determine their ability to provide optimum processing performance and product quality after low temperature storage. Therefore, the accumulation of reducing sugars in potato tubers stored at low temperatures is a phenomenon of great economic importance in the potato processing industry.

Potato starch is one of the most abundant industrially produced polymers. It is synthesized naturally in potatoes as a storage carbohydrate composed of linear (amylose) and branched (amylopectin) glucose polymers arranged in highly ordered, supramolecular structures, the starch granules. Potato starch is a highly versatile raw material in the manufacture of both food and non-food products. It has its own distinctive physico-chemical, thermal and rheological characteristics and is sufficiently bland to be incorporated easily into food preparations. The functional characteristics of potato starch depend on physical and chemical characteristics such as mean granule size, granule size distribution, amylose/amylopectin ratio and mineral content (Kaur, Singh, & Singh, 2005). A few studies have been carried out to evaluate changes in the cooking quality of potato tubers as a function of storage conditions (Kazami et al., 2000; Nourian et al. 2003a, 2003b). However, to our knowledge, no comprehensive study has been carried out to assess the effect of low temperature post-harvest storage on the starch characteristics of different potato cultivars. Hence, the present study was designed to evaluate changes in the starch characteristics of a number of New Zealand *Taewa* and a modern potato cultivar as a function of storage time at 4 °C.

2. Materials and methods

2.1. Plant material

The tubers of four traditional New Zealand *Taewa* cultivars (*Solanum tuberosum* L. cv. Karuparera, Huakaroro, Tutaekuri, Moemoe) and one modern potato cultivar (Nadine) were procured from several local sources in New Zealand (2004 harvest). Twenty-five kilograms of tubers of uniform size of each cultivar were washed in running water to remove surface dirt, dried in air and stored at 4 °C and 85–90% relative humidity for six months. The tubers were stockpiled by using crates throughout the storage chamber to minimize the effects of differences in temperature and relative humidity, if any. At selected times, sample tubers were removed from storage for starch isolation and analysis.

2.2. Starch isolation

Starch was isolated from each cultivar using a slight modification of the method described by Singh and Singh (2001). Tubers were washed, brushed in warm water and hand peeled. The eyes and all bruises were pitted out. Immediately after peeling, the tubers were manually cut into small cubes (approximately 4 cm^3) and dipped in water containing sodium metabisulphite (0.35 g/l). Pieces with dark spots were discarded. The juice (containing starch) was extracted from the tuber pieces using a laboratory scale juicer (Model JE 90J, Breville Pty Ltd., Australia). The juice was filtered through a muslin cloth. The residue left on the muslin cloth was washed with distilled water until only a small amount of starch was passing through the cloth. The filtrate was collected in a glass beaker and the residue left on the muslin cloth was discarded. The filtrate was passed through fine sieves (200 and 100 μm mesh size, respectively) and left undisturbed for four hours. A solid layer of starch settled. The supernatant was decanted, the starch layer was reslurried in distilled water and, again, the starch was allowed to settle. This procedure was repeated 4–5 times, until the supernatant became transparent. The starch cake was collected and dried at a temperature of 40 °C to a moisture content of 6% using a hot-air cabinet drier.

2.3. Morphological characteristics

2.3.1. Granule size distribution

The starch granule size distribution was determined with a laser diffraction particle size analyzer (Malvern Mastersizer, Malvern Instruments Limited, UK). The starch sample (0.1125 g, dry weight basis) was mixed with 150 ml distilled water. The suspension was agitated at 100 rpm using a magnetic stirrer (MR 3000, Heidolph, Germany) for 1 h at room temperature. The starch suspension was then filled into the small-volume sample presentation unit of the Mastersizer to obtain an obscuration level of ~20%. Refractive indices of 1.530 and 1.330 were set for the starch and liquid phases, respectively, while the starch granule absorption was set at 0.1 (Singh, McCarthy, Singh, Moughan, & Kaur, 2007a).

2.3.2. Granule morphology

Electron micrographs of the starch granules were obtained with a scanning electron microscope (Stereoscan 250 Mk3, Cambridge Instruments Limited, Cambridge, UK). Powdered starch samples were sprinkled onto double-sided sticky tape placed on an aluminum stub, and coated with gold.