Thermoelectric Effect on Potato Tuber (*Solanum tuberosum* L.) – Short Communication

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Abstract

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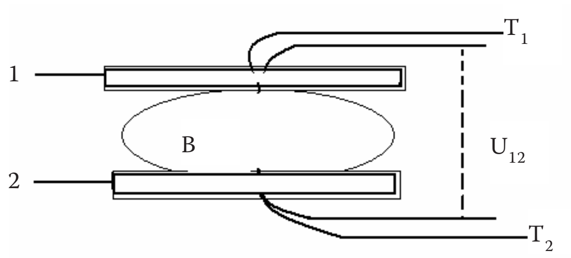
For scaning rheological properties of tuber tissue during heating, different physical techniques are used. The experiments done on low solids tubers of cv. Magda have shown that maximum thermoelectric effect was obtained at about 60°C in the temperature region where the gelatinisation process of intra-cellular starch starts and some few cell disruptions occur.

Keywords: potato; cell integrity; thermoelectricity

The effect of heating on the rheological qualities of potato tuber tissue is very interesting in many fields of potato processing (Vacek 1997; Lamberti *et al*. 2004). It is usually connected with the swelling of intra-cellular starch, thermal degradation of the middle lamella (Ormerod *et al*. 2002) and disruption of some few cells followed by gelatinised starch penetration into the extra cellular region (Reewe 1977). It is believed that there some correlations exist between the electrical and rheological properties (Dejmek *et al*. 2002). We have developed a new monitoring technology which seems to be very fast and effective.



T1, T2 – Omega thermocouples Cu-constantan, U_{12} – measured thermoelectric potential, 1, 2 – Peltier elements. In the centre of each Peltier element is a hole through which the thermocouples touched potato sample surface, B – potato slice

Figure 1. Set of thermoelectrical effect

MATERIAL AND METHODS

The measurement of the thermoelectrical effect was realised with the set up shown in Figure 1.

For the measurements we used low dry matter (DM) potato tubers of Magda cultivar from experimental station Valecov. The tubers were held for one day before the measurement at 20°C

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and 40% relative humidity. The samples for the measurement were cut out from in the tuber centre perpendicularly to the axis bud end – stolon end. The sample – potato slice (thickness 10–30 mm) was placed between two electrical isolated Peltier elements which formed the temperature gradient. The temperature gradient was recorded by two Omega thermocouples (cooper-constantan). The measurement was done in such a way that, at first, we left the galvanic phenomenon drop to the lowest value without setting the temperature gradient (Peltier elements are switched off) (Figure 2).

After that, it was possible to start the measurement of arisen voltage with temperature gradient. The temperature gradient was scanned by two thermocouples from Omega (copper-constantan) while thermovoltage was scanned either on Pt probes or directly on Cu wires of the thermocouples, the results having been identical.

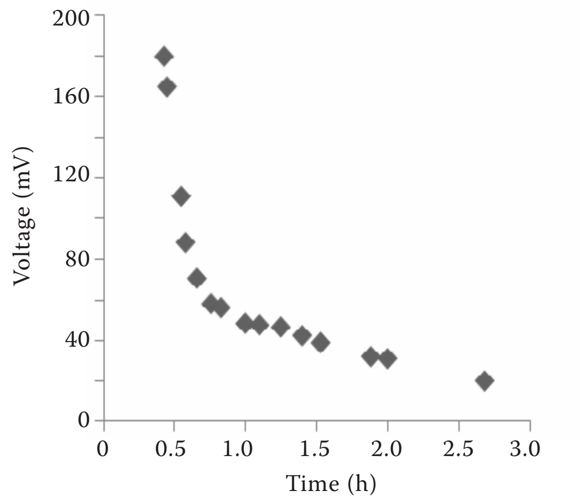

Figure 2. Time dependence of galvanic effect

RESULTS AND DISCUSSION

The obtained results with potatoes from the autumn harvest of 2009 are largely similar (typical measurement on Figure 3). The time dependence of thermovoltage shows a marked maximum which corresponds to the mean temperature value of approximately 60°C. We repeated the measurements with 15 samples of tuber slices coming from three different cultivars (Magda, Rosara, Adela) always in the same arrangement, similar courses of thermovoltage were obtained. In contradistinction to solids (e.g. metals, semiconductors and dielectrics) where temperature gradient generates thermoelectric effect due to electron or hole transport, in potato tissue there should be observed potential bound mainly with ion diffusion of the water components (mainly of H^+, OH). With increasing temperature the diffusion will increase up to the moment of the appearance of the gelatinisation process. Singh and Kaur (2009) reported for potato the interval of 59.72–66.2°C.

Mortensen *et al.* (2005) with low field ^{1}H NMR relaxometry revealed the major events related to water mobility during cooking which occur for medium DM potatoes at 53°C and low DM at 60°C; they found a fast relaxing component (primarily assigned to water associated with starch granules and cell walls). Comparing our measurements with these results and in accordance with the results of Karlsson and Ellasson (2003) we can associate our measured course of the thermovoltage potential

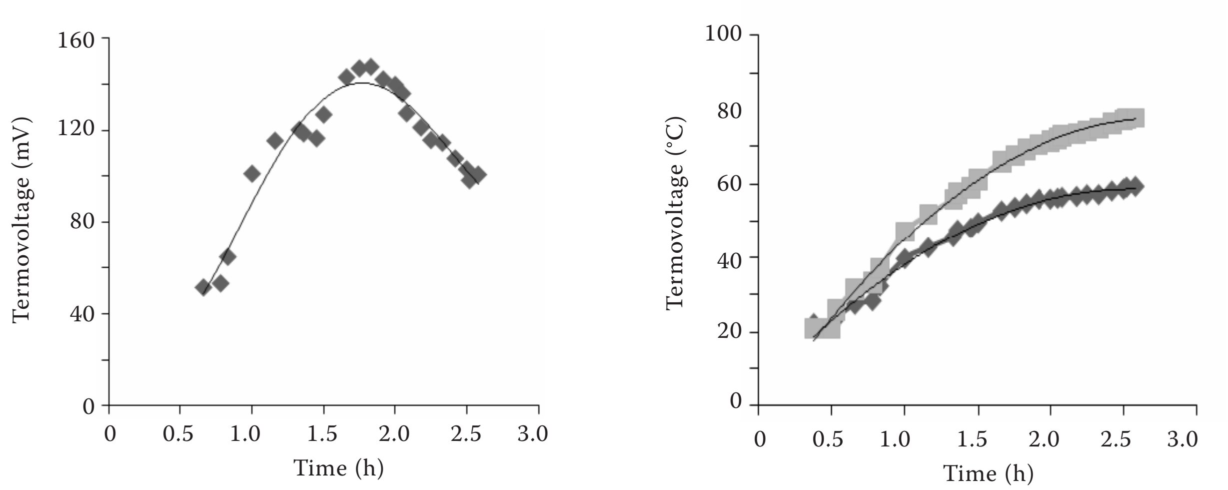

Figure 3. The time dependence of (a) measured thermovoltage and (b) temperature on both thermocouples

on the temperature gradient with the onset of the gelatinisation process in water-rich tissue.

The evolving gel structure in the extracellular region results in a hindrance for ion thermodiffusion and consequently a decrease of thermovoltage potential with increasing temperature.

Our results bring a new experimental method for the study on structural changes which occur during potato cooking.

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