IMPEDANCE MEASUREMENT OF IRRADIATED POTATOES: A METHOD TO IDENTIFY RADIATION PROCESSING

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Abstract

Radiation-induced chemical interactions may be manifested by a change in physical properties. Beside the nucleus, membranes are vital targets during cell irradiation. Membranes of living tissue, regardless of plant or animal origin, play a vital role for the selective transport of ions. A change in membrane properties may be traceble by a change in ion transport mechanism implicating a shift in electrical impedance.

The potato is firmly established in many parts of the world as a major staple food. Then, radiation processing of potato is approved in many countries for sprouting inhibition and extension of shelf life in a dose range from about 0.01 to 0.15 kGy of ^{60}Co.

The use of electrical conductance methods for the detection of Salmonella, some virus or the action of herbicides on plant has been reported and differences have been observed between instruments in respect of the magnitude of condutance change or rates of change in conductance response.

A reliable technique to identify potatoes or other food products has not been established so far, though several methods have been reported. Electrical impedance migth thus serve for characterization of unirradiated and irradiated tissues and cells. In this work, potato tubers from an European variety, named Bintje, grown in São Paulo State were employed. Potatoes were punctured with steel electrodes and impedance measured at different frequencies (1 kHz–100 kHz) by passing 3–5 mA alternating current through it. The impedance ratio of 50 kHz/5 kHz calculated from ten replicate samples decreased with the increment of the dose when doses of 0, 0.75 and 0.15 kGy from a GammaCell 220 were utilized. The impedance measurement were slighty affected by the place of puncture.

Introduction

The inhibition of the sprouting of fresh potatoes can be achieved by the treatment with low doses of radiation. Irradiation of potatoes occurs in bulk containers and the dose varies, for example, over the range of 60 to 150 Gy. There is no commercial advantage in irradiating potatoes at higer doses. Because a detection method, in practice, only needs to distinguish between irradiated and unirradiated potatoes there is only a requirement for a qualitative test[2].

More recent work on potatoes, based upon early condutivity measurements, revealed that impedance measurement can be used as a reliable and practical technique for identification of irradiated potatoes[4,6,7,].

It is well known that the membranes of living tissue, regardless of whether of plant or animal origin, play a vital role for the selective transport of ions. The implications for the electrical impedance of tissue are obvious. Impedance is a complex quantity depending on the frequency of the measuring alternating current. In some cases the magnitude of the impedance is sufficient to characterize the properties of cells or tissue. Impedance has for example been used to estimate winter hardiness of tree seedlings, virus infections or the efficiency of the action of herbicides on plants. Electrical impedance and derived quantities such as condutivity migth thus serve for characterization of unirradiated and irradiated tissue and cells[1].

Materials and Method

Potato samples — The potato tubers (Solanum tuberosum L. sp.), used in this study belong to the cultivar Bintje. The potatoes were obtained from Cooperativa Agrícola de Cotia (CAC).

Irradiation — Potatoes were irradiated one week after harvested with doses of 0, 0.075 and 0.15 kGy, using a ^{60}Co Gammacell 220 (Atomic Energy of Canada Ltda). dose rate — 689 Gy/h.

After irradiation, the potatoes were stored at room temperature in a dark room.

Impedance measurements — stainless-steel electrodes of 1 mm diameter, 1 cm long and 1 cm apart were employed (Fig. 1). The impedance was determined by puncturing the potato tuber with the electrodes connected to an equipment that can measure the impedance at different frequency within seconds after passing an 3–5 mA alternating current through it (Fig. 2). The electrodes were punctured along the three potato axes: A — longitudinal; B — short transversal and C — long transversal direction.

Results and Discussion

Fig. 3 shows the ralationship among the impedance measured at different frequency. In the low frequency range the impedance was different depending upon the radiation treatment, but at higher frequencies that difference could not be observed (Tukey multiple range test at a 95 confidence level). Eletrical impedances in the range 100 Hz to 800 kHz were measured in potato tubers before and after freeze-thaw cicles where freeze-killed potatoes were characterized by a 30-fold decrease in extracellular resistance. A 7-fold decrease in intracellular resistance and a 10-fold decrease in plasma membrane capacitance, showing a massive rupturing of protoplasts during lethal freeze-thaw injury[8]. Our results shown an increase of the electrical impedance,them the phenomena could not be a easily reported to some injury of internal organella.

Early studies with fish, showed that under laboratory conditions a change in impedance at frequencies from 50 Hz to 100 kHz indicated radiation treatment and an estimation of the radiation dose applied was possible[3].

The ratio of impedance at low frequency to that at high frequency has been recommended as a parameter for the diagnosis of plants.

As recommended by HAYASHI (1982, 1988)[4,5], we employed the parameter Z_{50} kHz/Z_5 kHz in order to examine the possibility of differentiation between unirradiated and irradiated potatoes. The results are shown in Table I.

Table I. Ratio 50 kHz/5 kHz of potatoes samples: a) longitudinal; b) short transversal; c) long transversal axes.

Dose kGy	50 kHz/5 kHz		
	a	b	c
	0.33	0.38	0.37
	0.35	0.37	0.35
	0.34	0.37	0.38
	0.35	0.32	0.32
0	0.39	0.40	0.37
	0.34	0.39	0.47
	0.42	0.39	0.39
	0.32	0.32	0.34
	0.37	0.37	0.41
	0.40	0.41	0.40
	$X = 0{,}361$	$X = 0{,}372$	$X = 0{,}380$
	$SD = 0{,}033$	$SD = 0{,}030$	$SD = 0{,}042$

Dose kGy	50 kHz/5 kHz		
	a	b	c
0.075	0.28	0.29	0.28
	0.30	0.32	0.31
	0.34	0.34	0.30
	0.28	0.31	0.29
	0.33	0.33	0.35
	0.32	0.32	0.29
	0.33	0.29	0.33
	0.29	0.29	0.30
	0.31	0.31	0.31
	0.32	0.31	0.31
	$X = 0{,}310$	$X = 0{,}311$	$X = 0{,}307$
	$SD = 0{,}022$	$SD = 0{,}017$	$SD = 0{,}021$
0.15	0.28	0.27	0.27
	0.32	0.30	0.30
	0.30	0.29	0.29
	0.29	0.30	0.28
	0.26	0.27	0.30
	0.24	0.29	0.26
	0.27	0.25	0.25
	0.29	0.30	0.28
	0.25	0.30	0.30
	0.29	0.27	0.28
	$X = 0{,}279$	$X = 0{,}284$	$X = 0{,}281$
	$SD = 0{,}024$	$SD = 0{,}018$	$SD = 0{,}017$

These results indicated the possibility of differentiate between unirradiated and irradiated potatoes by means of impedance measurements with the parameter Z_{50} kHz/Z_{5} kHz.

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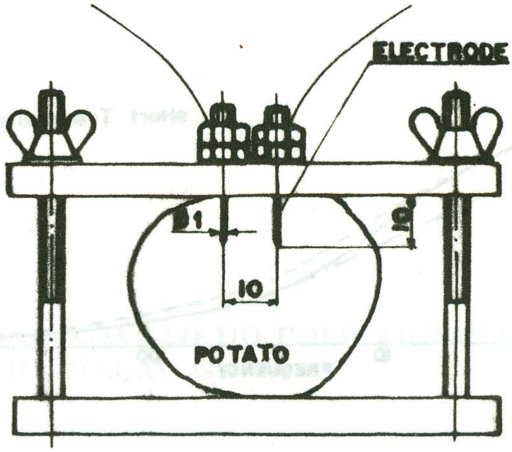

Fig. 1. Diagram of steel electrodes used in measuring the impedance of a potato tuber.

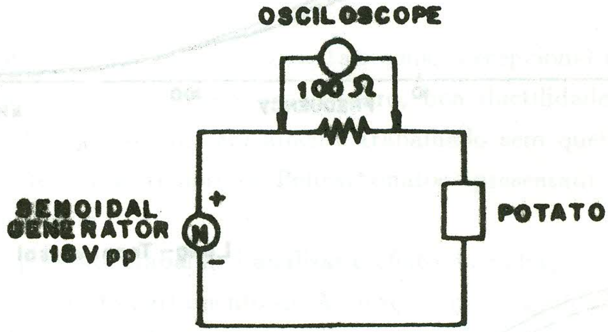

Fig. 2. Circuit of impedance measurement

$$Z = \frac{V_1 - V_2}{\frac{V_2}{100}} = \frac{(V_1 - V_2)\,100}{V_2}$$

V_1 Was kept constant ($V_1 = 17.5$ Vpp)
V_2 Is measured for each one of the frequency value.

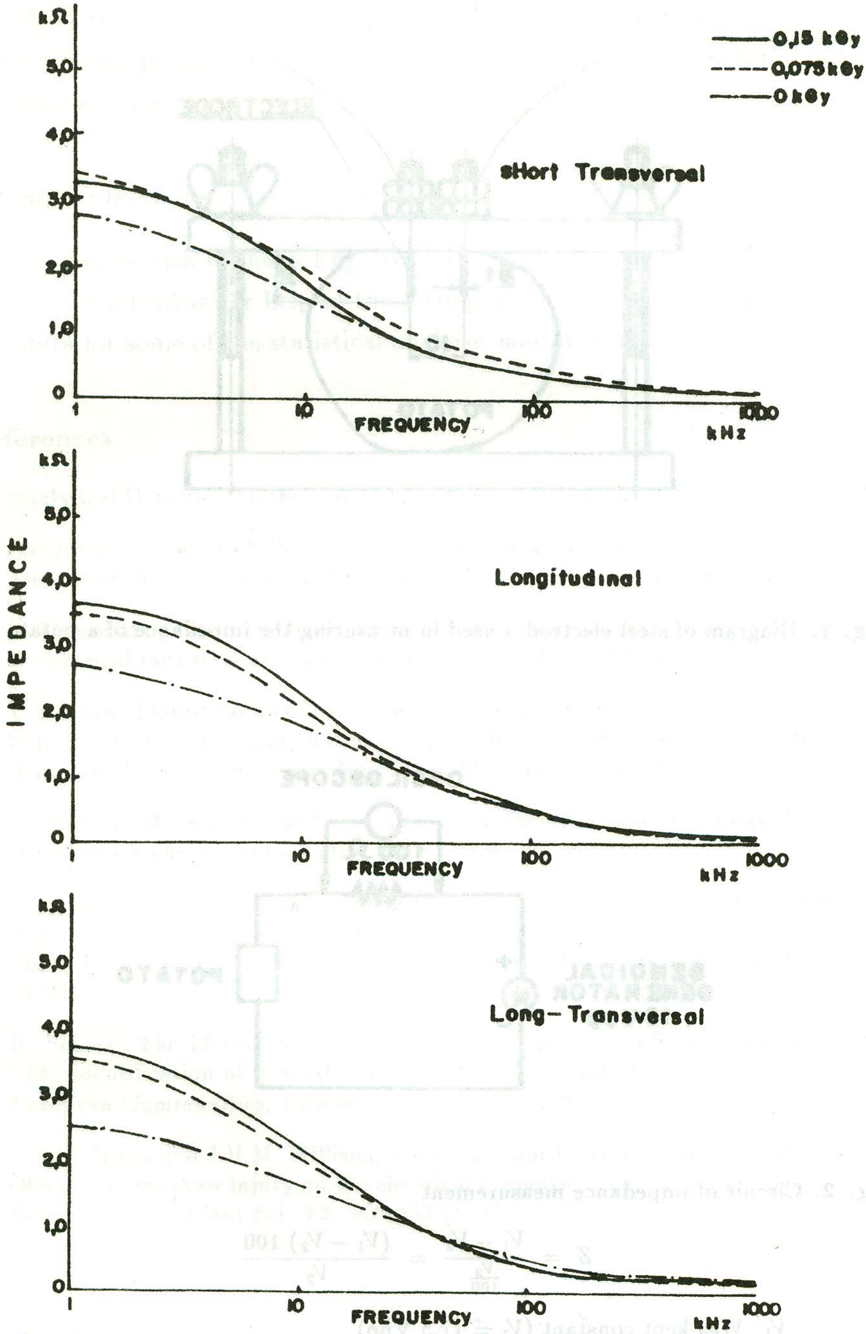

Fig. 3. Impedance vs Frequency along the three different axes of potatoes.