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New Method for Differentiation between Irradiated and non-Irradiated Potatoes

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Abstract

This study has been performed in Agricultural Research Directorate labs, Ministry of Science and Technology. Amid to develop a new method to differentiate between irradiated and non-irradiated potatoes. Our laboratory experiments were able to develop a new method for differentiation; this method depends on (volume, viscosity, and color intensity) measurements of potatoes water extract, together with the value of reduced pressure measurements during filtration of the water extract. Doses of (0.075, 0.15 and 0.20 kGy) were applied. The results obtained shows a considerable increase in volume, viscosity and reduced pressure values of the water extract of irradiated potatoes as compared to untreated control, with an increase values between treated samples as the dose increases. While the color intensity values of the water extract show a considerable decrease in values as compared to untreated control. A gradual decrease in values was observed between treated samples as the applied doses increases. The results obtained appeared to be suitable to distinguish between irradiated and non- irradiated potato tubers, and also practically useful for the estimation of the applied doses.

1. Introduction

Storage of potatoes is very important as it represents an important staple food crop across the planet. Due to their short production cycle, any treatment such as irradiation that controls sprout growth and extend shelf life of potatoes could be beneficial. The use of gamma irradiation is gradually increased worldwide [1]. Almost 40 countries have approved the use of irradiation for over 100 food items, but in some countries it is prohibited [2]. Sprouting increases susceptibility to bruise and decreases the marketability and the processing characteristics of potatoes. Irradiation like other processing techniques, results physical, biological and microbiological changes in food [3, 4]. Irradiation treatment is used by many countries all over the world to inhibit sprouting in potatoes [5, 6, 7]. Regulatory authorities in all countries are interested in having reliable methods to detect irradiated food as well as estimated dose [8]. After 1980, extensive research was under taken which resulted in development of test methods that can be used to reliably determine the irradiation status of a wide variety of foods [9, 10]. The magnitude, resistance and reactance of impedance techniques have been used successfully to distinguish between irradiated and non-irradiated potato tubers [11]. It was found that the ratio of the impedance parameters at 5 KHz to 50 KHz got rid of the influence of the type of electrodes, and the ratio of impedance magnitude at 5 KHz to 50 KHz (Z_{5k} / Z_{50k}) resulted in a larger difference between irradiated and un-irradiated potatoes than those of resistance and reactance. Electrical conductivity measurements techniques have been used by [12] which found that electrode inserted into potato measures a decrease in conductivity of a period of approximately 3 min before reaching a study value, and the conductivity for irradiated potatoes was higher than non-irradiated potatoes. Thermoluminescence (TL) measurement techniques were also used to detect irradiated potatoes, it was found that analysis of the minerals from the surface soil of the tuber is a promising method [13], and the minimum dose of 50-150 Gy is sufficient to prevent sprouting of tubers. It was reported that (TL) analysis is useful but the process requires complicated mineral separation and it is also time consuming. There are other physical methods suggested by a number of researchers for irradiation detection, but they have limited application. A study was conducted by [14] to detect the irradiated potatoes by using two different colorimetric methods to measure the intensity of discoloration of the tuber, potatoes were irradiated with (0.1, 0.2, 0.3, 0.5 and 1 kGy). They concluded that in spite of the slight decrease in absorbance of extract of the irradiated tubers at (0.2 and 0.3 kGy) for both varieties been used, doesn't give a suitable result. Although (TL) analysis and some other techniques used to distinguish between irradiated and un-irradiated potatoes is useful, most of the processes are complicated demanding skills, facilities and is time consuming. Therefore, the aim of the study is to develop a new method to identify the irradiated potatoes which is fast to perform, cheaper and also practically useful for the estimation of the applied doses.

2. Experimental Procedure

Preparation and Irradiation of Samples

Potatoes (*Solanium tuberosum*) type (Buren) was purchased from local market. Samples (200g. each) were packed in black polyethylene bags, sealed and irradiated at dose (0.075, 0.15 and 0.20 kGy) using gamma rays emitted from cesium (^{137}Cs) source (Dose rate 0.025 kGy/min) at the University of Baghdad. All samples (non- irradiated and irradiated) were stored under dark condition at chilling storage temperature (1ºC) for up to 2-8 months to confirm the stability of detection parameters.

Preparation of the Extracts

Pieces (15g) from the tuber were blended with 50 ml distilled water to which citric acid (0.5%) was added to prevent browning; the mixture was stirred for 10 min. filtration was carried out using Buchner funnel, a (T- shape plastic tube), and a rubber tube were used to connect the Buchner flask with vacuum pump and the vacuum gauge which is supplied with a flexible valve Figure (1).

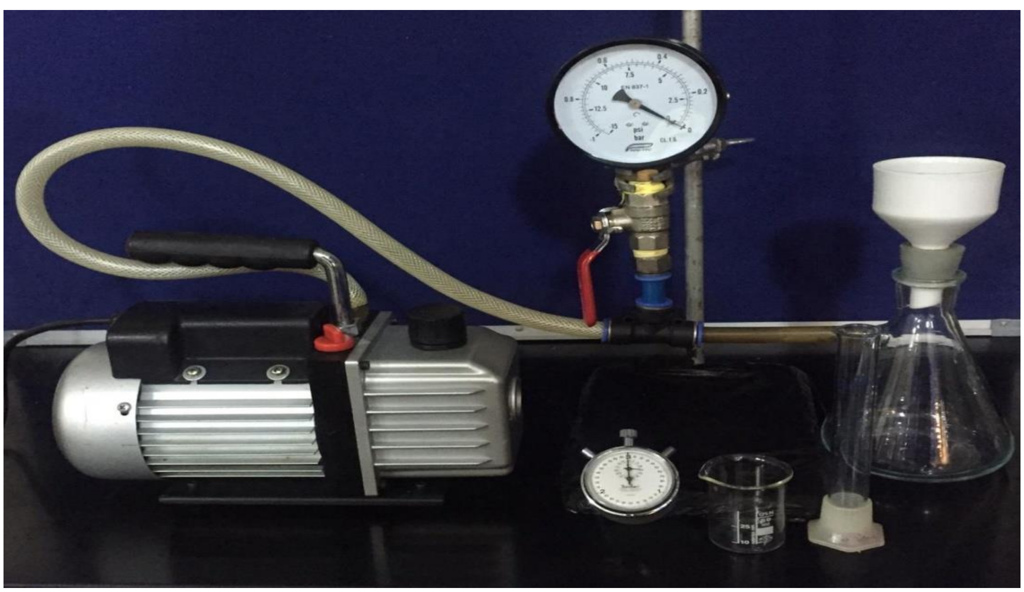

Figure (1). A Photo Representing the Simple Rubber Tube Connection for the Filtration of Potato Extracts.

Working Steps

1. Filter paper (Whatman 3) was washed under vacuum with 50 ml distilled water for 2 min.
2. Water was discarded and the flask was dried by blowing hot air.
3. Blended potato sample was filtered under vacuum.

It should be notified that pouring the blended sample, starting the vacuum pump and turning on the valve should occur at the same time followed by turning the valve off within 5 Sec. after recording the measurement of the vacuum gauge. Filtration should continue for 1.5 min followed by turning off the vacuum pump immediately, releasing the vacuum from the flask and weighing the filter paper with the remained wet residue. Three replicates of each dose were considered.

Color Intensity Measurements

Color Intensity Measurements were performed according to [15] in (ICUMSA) units by spectroscopy instrument and the following equation:

$$\textit{Color intensity} = \frac{1000\times 720nm\ (O.D)\ -420nm\ (O.D)}{Lcm \times CBx} \qquad (1)$$

Viscosity Measurements

Viscosity Measurements of potato extract were performed using Ostwald viscometer made by (poulten self & Lee), according to the following equation:

$$N = \frac{\mathcal{D}1\ t1}{\mathcal{D}2\ t2} \qquad (2)$$

Statistical Analysis

Statistical analysis was carried out by Minitab® 17.1.0 (ANOVA-Tukey) to find differences between the experiment treatments with probability level of 5%.

3. Results and Discussion

Irradiation of potatoes by gamma rays is an effective tool to extend the shelf life; moreover it leads to a decrease in weight loss, a decrease of or preventing sprouting [6,16]. It was reported that the minimum dose of 50-150Gy is sufficient to prevent sprouting of tubers and maintaining quality [6]. Same levels of doses were applied in this study to irradiate Buren potato tubers which is widely grown in Iraq.
In this study Table (1), irradiation exposures of potato tubers caused a significant ($p\leq 0.05$) decrease in wet residue weight of potato extract as compared to untreated control, with a significant ($p\leq 0.05$) decrease in values as the dose increases, this is reflected in the values of filtrate volume, a significant ($p\leq 0.05$) increase in the values of filtrate volume of irradiated potatoes obtained as compared to untreated control, with a significant ($p\leq 0.05$) increase in values between the irradiated potatoes as the doses increased.

This increase in the volume of filtrate of potato extract as the exposure dose increased is in harmony with [14] who reported that a dose exposure of 0.20 and 0.15 kGy to potato tubers increases solubility significantly ($p\leq 0.05$) as compared to lower doses, in addition [17,18,19] reported that irradiation induced softening for a number of fruits and vegetables. The phenomena of potato discoloration have been used by [14] to distinguish between irradiated and un-irradiated potatoes. Two different colorimetric methods been used (color measurement on potatoes slices and spectrophotometric measurement of potato extract at 440 nm) they concluded that in spite of the slight decrease in absorbance of extract of irradiated tubers at 0.2 and 0.3 kGy the spectrophotometric method did not seem to correlate with the fact that irradiation increases discoloration of potatoes. However discoloration intensity of potato extracts using spectrophotometric method Table (1) shows a significant ($p\leq 0.05$) decrease in color intensity values as compared to untreated control, with a significant ($p\leq 0.05$) decrease in values as the dose increases.

Radiation also can lead to viscosity changes of solution and suspensions, the viscosity of homogenates and suspensions of biological materials in solvent like water depends on the extent of the penetration of solvent into cells, thus cell wall permeability increases after irradiation. In some materials viscosity increases after irradiation, where as in other materials it decreases [20, 21]. However, viscosity measurements of potato extract Table (1) shows a significant ($p\leq 0.05$) increase in the extract flow time of the irradiated tubers as compared to untreated control, together with a significant ($p\leq 0.05$) increase between the irradiated tubers as the dose increased up to 0.15 kGy. This is reflected in the viscosity measurements, although the increased value in viscosity is not significant, there is about 20% to 60% increase in values for potatoes exposed to 0.075 and 0.20 kGy respectively as compared to untreated control. A new parameter was used to differentiate between the irradiated and non-irradiated potatoes Table (1)., the results obtained shows a gradual increase in the reduced pressure values of the water extract of irradiated potatoes as compared to untreated control. Although the values obtained is not significant there is about 5.7% increase in values for potatoes exposed to 0.20 kGy as compared to untreated control.

Table (1). Comprises some parameter measurements for Identification of Irradiated potatoes.

Dose Exposure (kGy)	Filtrate volume (ml)	Wet Residue (g)	Color Intensity (ICUMSA)	Extract Flow Time (Sec.)	Viscosity Values	Reduced Pressure (Bar)
Control	40 ^{b}	26.45 ^{a}	2705 ^{b}	35 ^{c}	1.0 ^{a}	0.87 ^{a}
0.075	44 ^{ab}	23.40 ^{b}	1816 ^{c}	45 ^{b}	1.2 ^{a}	0.89 ^{a}
0.15	47 ^{ab}	20.00 ^{c}	1246 ^{d}	56 ^{a}	1.5 ^{a}	0.90 ^{a}
0.20	51 ^{a}	17.00 ^{d}	6042 ^{a}	58 ^{a}	1.6 ^{a}	0.92 ^{a}

* Values with same letters in the same column have no significant differences between them according to tukey ($p \leq 0.05$).

4. Conclusions

The application of 0.075, 0.15 and 0.20 kGy of ionizing radiation to potato tubers type Buren led to a significant ($p \leq 0.05$) decrease in wet residue and color intensity parameters of Potato water extracts values as compared to untreated control. While the effect on filtrate and flow time parameters showed a significant increase of values as compared to untreated control. The values obtained from those parameters appeared to be suitable to distinguish between irradiated and non-irradiated potato tubers. In addition dose estimation could be determined. The method been used is recommended to distinguish between irradiated and non-irradiated potato tubers since it's simple, accurate, easy to perform, rapid, undemanding in skills and facilities. It will help to strengthen national regulation on legislative control.

Nomenclature

O.D Optical Density
Bx Total Soluble Solids
C Concentration of the water extract = °Brix
Lcm Length of the cuvette used for the Sample (cm)
N viscosity
Ɗ1 Density of the extract
t1 Flow time of the extract
Ɗ2 Density of water ($1g/cm^3$)
t2 Flow time of the water

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