A NONDESTRUCTIVE TECHNIQUE FOR DETECTING INTERNAL DISCOLORATIONS IN POTATOES

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INTRODUCTION

Internal discoloration is one of the major defects of potatoes. Previously it has been impossible to evaluate accurately the degree of discoloration of a tuber without cutting it. A nondestructive method of determining the discoloration would make it possible to remove the discolored tubers from a given lot of potatoes and thus improve the over-all quality. This paper describes the application of light-transmittance techniques to detecting internal discolorations in potato tubers with particular emphasis on hollow heart.

Most efforts directed toward detecting internal defects in potatoes have been attempts to detect hollow heart. Size grading and specific gravity can to used to indicate severe hollow heart, but these techniques are not sufficiently accurate to be practical (4). In 1937 Harvey (2) reported an attempt at using egg-candling lamps and X-ray equipment to detect hollow heart. However, in these investigations the researcher was looking for the image of the void or the hollow in the potato. It is possible to view an image of the void when X-rays are used, but the cost of X-ray equipment has hindered the development of this technique for the hollow heart problem. An image of the void cannot be seen when visible or near infrared energy is used, but there is a selective absorption of energy in the near infrared region which is indicative of hollow heart. This selective absorption of energy is due to the discoloration in the vicinity of the void.

MATERIALS AND METHODS

The data presented in this paper were secured with the Rephobiospect, a specially designed spectrophotometer for recording spectral absorption curves of biological materials. This instrument as described by Norris (3) recorded spectral curves on a linear energy scale. It has since been modified to record on a logarithmic energy scale and a new method of presenting the sample has been developed. The use of an integrating sphere to enclose the sample for recording spectral absorption curves of biological materials has proven satisfactory for most applications; however, in the case of detecting hollow heart the direct phototube mount shown in Figure 1 is better. This alternative apparatus measures only the light passing through the center of the tuber giving the technique more sensitivity to small discolored areas located near the center of the tuber. The potato is oriented in the instrument so the light passes through the shortest dimension of the potato. The phototube housing is mounted on a vertical shaft so this portion of the assembly can be raised to insert a potato for measurement. A telescoping housing encloses the potato to exclude all ambient light.

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The phototube housing rests on the potato while the measurement is made; thus, the vertical position of the phototube is an indication of the size of the potato. A scale was placed at a convenient location so the size of potato could be recorded when the transmittance measurement was made.

Normal practice in spectrophotometry uses the ratio between the energy incident on a sample and the energy transmitted as the index of composition of the sample. In measuring the transmittance of agricultural products this ratio is a function of size as well as composition. Information can be gained about the composition of the sample by using an index which indicates the shape of the absorption curve. Figure 2 shows the spectral absorption curve of a sound potato (Curve A) and one with hollow heart (Curve B); Figure 3 is a photograph of these potatoes. In recording the curves the minimum absorption (800 m\(\mu\)) is arbitrarily given the value of zero optical density, and all other points are plotted in reference to this value. Both curves include the system response of the Rephobiospect. The potato with hollow heart absorbs considerably more energy in the 650 m\(\mu\) to 750 m\(\mu\) region than the sound potato. The optical density difference between 800 m\(\mu\) and 710 m\(\mu\) \([\Delta OD (800-710)]\) gives an indication of the shape of the curve in this part of the spectrum and can be used to indicate hollow heart. The selection of these wavelengths is desirable because both are at an absorption minimum; thus, there is a maximum amount of energy available and the measurement is least affected by other compositional factors.

Two tests were made to demonstrate the ability of this technique to detect hollow heart and other discolorations. The procedure followed in these tests was to place the washed potato in the Rephobiospect and record the \(\Delta OD_{(800-710)}\) and size. Then the tuber was removed and cut. A visual evaluation of the hollow heart was made on a scale of 0 to 3; i.e., 0—no hollow heart; 1—small void, very slight discoloration; 2—medium hollow heart; 3—large hollow heart. The presence of blackspot, greening or decay was noted. In the analysis of the data a dividing line was selected and potatoes having a \(\Delta OD\) above this value were termed accepted and those having a \(\Delta OD\) below the dividing line, rejected. The location of the dividing line was selected to give the best fit between the \(\Delta OD\) values and the visual observations of the potatoes.

**Results**

The first test was made with Katahdin potatoes, Figure 4. Of the 68 potatoes in this test 81 per cent of those with discolored tissue were rejected and 10 per cent of the sound potatoes were rejected. Considering the types of discoloration separately, 83 per cent of the hollow heart potatoes were rejected. The hollow heart potatoes which were accepted had very slight discoloration and could probably be considered acceptable for some purposes. Fifty per cent of the potatoes with greening were rejected and one of two potatoes with decay was rejected. The rejection rate for these defects is lower because decayed areas and greening occur at random locations on the tuber and the apparatus has been designed to look at a cylinder of tissue through the center of the tuber. Blackspot occurs at random locations in the tuber also, but in this test the potatoes with blackspot had a fairly large amount of discolored tissue; i.e., approxi-