FRICTION FORCE AND PRESSURE CAUSING "SKINNING" OF POTATOES

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INTRODUCTION

Mechanical injuries which occur to potatoes during harvesting and subsequent handling are of economic importance. Increased use of mechanical methods in harvesting and handling of potatoes has emphasized the need for methods which will reduce injuries to the product as well as development of varieties of potatoes which are more resistant to mechanical damage.

A technique for evaluating the resistance of potatoes to mechanical injuries should be of value both to the design engineer who must have a knowledge of the strength of the material to be handled by the machine and to the plant breeder who is to develop the injury-resistant variety of potatoes.

In harvesting and handling, in addition to bruises and cuts, potatoes are subjected to "skinning" which is an abrasive process that loosens or removes a thin layer of periderm from the potato. It occurs during the digging operation, separation from soil, dumping and loading, hauling, filling the bins in storage, and other handling operations where potato tubers are subjected to friction and abrasion. One study showed that an average of 15.6% of the skin had been removed from potatoes by the time they reached the storage bins (1).

Although a number of experimental techniques are found in the literature dealing with impact bruising and pressure bruising of potatoes, little information exists on resistance of potatoes to skinning. This work was undertaken to develop a technique and procedure for measuring and evaluating the forces involved in feathering and skinning. Some data are included to show the type of information which can be obtained by using this technique.

MATERIALS AND METHODS

The Apparatus — The apparatus developed for the friction tests is shown in Fig. 1. A pivoting plate [7] held one-half of the potato specimen while the other half of the specimen was fixed on three nails projecting from the bed of a carriage [5]. The weights [8] exerted the normal force. The carriage was pulled by a pneumatically-operated and hydraulically-controlled pulling device. The carriage could be stopped instantaneously at any point on tract [4] or pulled at a desired speed. The pneumatic machine was a Bellows-Valvair Air Motor Hydrocheck Model DC50A-150. A variable speed electric motor with proper controls could be used in place of the pneumatic machine to serve as the pulling device.

As the carriage, carrying one-half of the specimen, passed under the stationary plate, the two halves of potatoes were rubbed against one another under a known normal force. The horizontal pull or friction force

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corresponding to the "peak-to-peak" position was sensed by the strain gage cantilever beam [2] and recorded on the chart of a Sanborn strain gage recorder.

The "peak-to-peak" position of the two halves of the specimen were located by the dial indicator [9] and marked on the chart by the Sanborn marker.

To obtain the contact area, the "peak-to-peak" position of the specimen was re-established by backing up the carriage to the point where the dial indicator showed the same reading as when the specimen was skinned. The carriage was then stopped at this location, a thin layer of Prussian Blue was applied to the contacting surfaces of the specimens, and the contact area for the given normal weight was printed on a sheet of paper. For greater accuracy, the printed contact areas were first enlarged by a Keuffel and Esser pantograph before being measured with a planimeter. Knowing the normal force, the contact area and the pulling force for the "peak-to-peak" position, the normal pressure and the friction force required for removing or loosening a thin layer of skin from the surface of the potato was determined. If instead of the lower half of the specimen, plates with various surfaces were mounted on the carriage, the static and sliding coefficient of friction as well as force and normal pressure required to cause skinning of a potato against these surfaces could be determined.

The slight friction of the pulleys and the rollers of the carriage against the track were compensated for in calibration and zero adjustment of the recording instrument.