Identification of mechanical injury of potatoes on packing lines

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Misener, G.C., McLeod, C.D.and McMillan L.P. 1992. **Identification of mechanical injury of potatoes on packing lines.** Can. Agric. Eng. 34:055-059. The level of mechanical injury of potatoes was measured in a survey of table potato packing companies. Four packing lines were monitored during a two year study with samples taken at eight locations on each line. The sampling procedure was repeated three times during the first season and once during the second year. A damage index that included black spot and measures the severity of injury sustained by the potatoes was calculated for each sample. The potatoes at the on-farm storages had an average damage index of 490.6 whereas the indexes of the graded potatoes packed as count boxes, Canada No. 1 and Canada No. 2, were 529.4, 594.1, and 591.7, respectively. Parameters considered to influence the damage levels during the handling and grading process were compared with the injury levels of the potatoes at each sampling location. The parameters found in the analysis to have a direct relationship to damage levels were the accumulated drop heights and the number of drops occurring on the packing lines.

Le dégré des blessures mécaniques des pommes de terre a été mesuré dans le cadre d'une étude réalisée auprès d'entreprises de conditionnement de pommes de terre de consommation. Quatre lignes d'emballage ont été suivies de près au cours d'une étude s'étalant sur deux ans, et pour chaque ligne, il y avait huit endroits où l'on prélevait des échantillons. L'échantillonage a été fait à trois reprises au cours de la première saison et une fois pendant la deuxième. Un indice de lésions comprenant les taches noires et les mesures de la gravité des blessures subies par la pomme de terre a été calculé pour chaque échantillon. Les pommes de terre qui étaient entreposées dans la ferme avaient un indice de lésions moyen de 490,6 et celles triées et embalées dans les catégories boîtes standards, Canada n^0 1 et Canada n^0 2 avaient des indices de lésions de 529, 4, 594,1 et 591,7 respectivement. Les facteurs que l'on considèrent qui influent sur le degré de lésions pendant le processus de manipulation et de triage ont été comparés avec le degré de blessures des pommes de terre à chaque endroit où les échantillons ont été prélevés. D'après l'analyse, les facteurs liés directement au degré de lésions sont l'accumulation de la hauteur des chutes et le nombre de chutes se produisant sur les lignes d'emballage.

INTRODUCTION

Preservation of potato quality is an important consideration for systems transporting, handling, grading, and packing potatoes. Reduction in potato quality through most of the stages of handling results from increased mechanical injury to the potatoes. In a recent study conducted in Sweden, Larsson (1989) found that the incidence of mechanical injury sustained by potatoes on packing lines was equivalent to or greater than that produced by the harvesting process. McRae (1985) reviewed factors contributing to potato injury during handling and grading. He suggested that the industry needed to have improved tuber damage assessment methods. He also concluded that improved designs for buckets or scoops used for potatoes were needed and would make a significant contribution to reducing injury. Use of cushioning materials was also cited as having potential to reduce tuber injury levels.

Hudson and Orr (1977) measured the magnitude of injury that occurred to potatoes during commercial harvesting and bin-filling operations. They concluded that the type of bulk scoop or handling treatment used to remove potatoes from storage bins and move them to the grading line did not produce significantly different levels of injury. They indicated that 60 percent of the tubers which reached the grading line were free of injury.

De Haan (1983) suggested that internal bruising (black spot) and cracks are common types of post storage injuries that occur during grading and handling. He noted that susceptibility of potatoes to black spot injury was influenced by factors such as varietal characteristics, growing and storage conditions, and tuber temperature during grading and handling. The extent of injury sustained by tubers was considered to be related to handling and grading operations.

In his survey of packing lines in Maine, Stiles (1983) found that a significant number of the tubers sampled at the bagging station had slight bruises and that others had serious bruises all of which occurred on the packing lines. Tubers with serious bruises were considered out of grade.

The objective of this study was to identify the incidence and magnitude of mechanical injury sustained by potatoes during commercial handling and packing operations in eastern Canada and to identify parameters on the packing lines that increase the injury levels of the potatoes.

MATERIALS AND METHODS

A two year study of commercial packing lines was undertaken to identify the causes and amount of mechanical injury sustained by potatoes passing over the lines. Four packing companies that represented the range of packing lines used in eastern Canada were selected for the study.

Some of the larger potato packing houses have more complex processes to accommodate several grading options and alternatives needed to serve broad international markets. However, a representative process utilized in eastern Canadian packing houses to meet Canadian grade standards includes the following activities:

-Potatoes are unloaded directly from a standard bulk body truck onto a conveyor which delivers them to a bulk holding hopper.

-The holding hopper acts as a buffer for the process, allowing for a constant flow of potatoes through the remainder of the system.

-The potatoes are delivered from the holding hopper to a wire mesh sizing bed by another conveyor .

-The small potatoes are separated from the main flow at this point and the remainder pass through a spray tunnel on a roller conveyor where the potatoes are tumbled and washed.

-At the end of the spray tunnel the potatoes may be treated with a sprout inhibitor spray. After the tunnel they pass onto a manual inspection conveyor.

-The potatoes are manually or automatically sorted into Canada #1 potatoes, count box potatoes, and Canada #2 potatoes.

-Canada #1 potatoes are bagged for the tablestock market.

-The selected baking size potatoes are packed in count boxes.

-Canada #2 potatoes are moved by conveyor to a temporary bulk storage for later utilization.

The four packing lines differed in complexity but each contained the functions listed above (Fig. 1). Detailed information on the four packing lines are presented in Table I.

The study was divided into three phases in order to identify the types of mechanical injury sustained by the potatoes on the packing lines. Each phase employed a different method of either sampling or measuring the injury. The phases included:

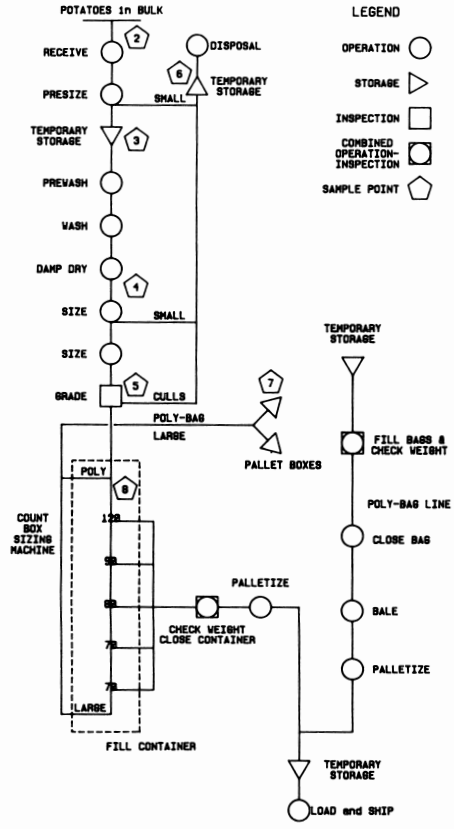

Fig. 1. Configuration of packing line.

Phase I

Each packing company was visited on three separate occasions, in December 1988, January, and February 1989. During each visit, samples were taken three times per day from eight sampling locations along the packing line. The sampling locations were chosen, in so far as possible, to provide equivalence in sampling procedures between the four packing companies. The eight sampling locations were:

1. The farm storage bin
2. The bulk delivery truck
3. The holding hopper
4. After the washer
5. After the grader
6. In the temporary bulk storage - Canada #2 potatoes
7. In the count boxes - Canada #1 potatoes
8. In the poly bags - Canada #1 potatoes

Each sample of potatoes had a mass of approximately 10 kg. With three samples selected per location and visit, a total of 72 samples were collected for each packing line. Efforts were made to ensure that the samples collected during each of the three periods of the sampling day, at the eight sampling locations along the packing line, were delivered from the same truck load of potatoes. The samples of potatoes were collected and placed in storage at room temperature for 2-3 weeks to allow time for all bruises to be identifiable. The samples were then assessed for mechanical injury.

Table I. Characteristics of the four packing lines

	Packing line			
	a	b	c	d
Accumulated drop height (m)	8.8	5.7	9.1	10.3
Number of drops	18	13	16	22
Length of travel on line (m)	20	12	16	22
Average conveyor speed (m/s)	0.35	0.44	0.44	0.36
Number of people	20	9	12	14
Wash water temperature (°C)	6.7	6.1	6.7	4.4

Phase II

Concurrently with Phase I of the study, sample lots of 25 tubers were collected at four locations along the packing line. These were assessed for damage immediately with the aid of catechol, a chemical indicator used to identify fresh injuries to potatoes (Thornton 1969). Catechol reacts rapidly with fresh bruising (bruises that have occurred within the previous hour) to produce a vivid pink colour. This staining technique allowed potatoes to be assessed immediately for mechanical injury that had occurred specifically on the packing line. Black spot cannot be identified by this approach but was measured during Phase I. The sampling locations chosen for the catechol test were:

1. Bulk delivery truck
2. Canada #1 potatoes - poly bags
3. Canada #1 potatoes - count boxes
4. Canada #2 potatoes

Phase III

The third phase undertaken to measure damage levels occurring on the packing lines used an approach similar to the one employed by Brown et al. (1989) to determine apple packing line impact damage levels. This phase of the study was completed during the second year of the study. Damage free potatoes of the Red Pontiac variety were stored at the Fredericton Research Station for three months. They were then transported by van to the packing companies. The damage free potato samples were placed on the surface of a load of Russet Burbank potatoes located at the packing line. As the load of potatoes was transferred to the packing line, the red-skinned Red Pontiac tubers mixed with the Russet Burbank tubers. The Red Pontiac potatoes were retrieved at two locations:

1. Canada #1 potatoes - poly bags
2. Canada #1 potatoes - count boxes

The red-skinned potatoes were visible and removed from among Russet Burbank tubers that were being packed at the time. Phase III gave us an opportunity to evaluate the packing lines for imparting black spot damage to the potatoes in addition to measuring the external mechanical injury induced. Samples of potatoes were peeled before the test at the Research Station to confirm the absence of black spot in the potatoes prior to the test.

Potatoes collected during Phase I and III were stored for 3 weeks at room temperature after the tests. They were then evaluated for mechanical injury assessment by the method described by Thornton (1969). Tuber damage was determined using a potato peeler to remove a slice approximately 3 mm thick with each stroke. Damage was classified as follows: (a) undamaged; (b) scuffed or skinned - skin only broken; (c) slight or peeler - flesh damage removed by a 3-mm deep stroke of the peeler; (d) severely damaged - damage to flesh which was not removed with one peeler stroke, and; (e) black spot. A damage index was then calculated based on the percentage of tubers in each category multiplied by a weighting factor of 0, 1, 3, 7, and 5, respectively, and then summed to give a total index (Robertson 1970; McGechan 1980).

Differences in magnitude of mechanical injury at the sampling points were analyzed statistically using the analysis of variance, Duncan's multiple range test and regression analysis techniques available with the SAS Statistics Version 5 software.

RESULTS AND DISCUSSION

The mean damage indexes at the sampling points on the packing lines are presented in Table II. The damage index of 490.6 at the storage bin was considerably higher than that found during a study in 1986 where the average index was measured at 368.6 (Misener et al. 1989). During the 1986 study, the potatoes were sampled directly from bulk trucks during harvesting. In this study, the potatoes were sampled from the storage bin. Additional handling could account for the increase in the damage index.

As the potatoes passed through the packing lines, the damage index increased (Table II). In Phase I of the study, the initial damage index at storage was 490.6, and potatoes that were injured during harvesting contributed to the final index regardless of additional injury occurring on the packing lines. Only if an added injury caused during the packing operation was sufficient to change the depth of cut or add black spot damage to existing surface damages, would the value of the index change. The index does not accumulate multiple injuries of the same magnitude on a single potato and it represents only the most severe injury. Consequently, the increase in magnitude of the index does not appear as severe in Phase I as it does in Phase II and III.

By using the catechol solution to detect surface injury in Phase II of the study, an indication of the magnitude of injury caused during the packing operations can be compared to the harvesting operation. The values presented in Table II indicate that the packing lines do nearly as much surface mechanical damage as does the harvesting process. In Phase II, the index for the new surface damage found in the Canada #1 count boxes at the end of the line was 453.1. In Phase I, the potatoes starting in the storage bin had an index of 490.6. This result was similar to that presented by Larsson (1989). It is difficult to compare the magnitude of the damage indexes measured in

Table II. Mean level of mechanical injury of potatoes passing through the four packing lines

Location	Phase I Overall damage index (mean)	Phase II Overall damage index (mean - does not include black spot)	Phase III[1] Overall damage index (mean)
Storage bin	490.6 a		
Bulk truck	515.7 ab	160.3 a	
Holding hopper	534.0 bc		
After washe	555.5 c		
After grader	536.3 bc		
Canada #1 - Poly bags	594.1 d	266.0 b	317.8 a
Canada #1 - Count Boxes	529.4 bc	453.1 c	381.5 b
Canada #2	591.7 d	347.3 d	

a-d Means followed by the same letter in columns are not significantly different at the 95% confidence level as measured by the Duncan's Multiple Range test.

[1]Packing house "b" was not included in Phase III due to phytosanitary reasons.

Phase II and III because of the difference in response of the two varieties of potatoes to mechanical injury. However, the trend of the count boxes having higher injury was similar for Phase II and III.

Table III summarizes the type of injury sustained by potatoes during Phase III of the study. The contribution of each category of injury to the overall index is presented. Injury classified as peeler was the largest factor influencing the magnitude of the index. The incidences of black spot and severe also contributed large effects. Hyde et al. (1990) identified high impact levels at many locations on packing lines as an instrumented sphere passed along the lines. The high impact levels occurred at transfer points where hard surfaced materials were often used in combination with large drops. The data collected in our study were also analyzed to determine the effect on the damage index of the number and magnitude of drops encountered by the potatoes as they passed along the packing lines. The increase in the damage index caused by the packing lines in Phase I of the study was significantly correlated ($P < 0.05$) to both the number and cumulated drop height (Table IV). Similar results were also found in Phase II of the study. The distribution of number and magnitude of the various drops at specific locations in the packing lines is shown in Fig. 2. The results suggest that reduction in the overall injury level of potatoes might be possible by reducing the number and magnitude of drops and by the addition of cushioning materials.

CONCLUSIONS

The extent of mechanical injury sustained by potatoes passing over packing lines was measured at four table potato packing companies. Injury sustained by the potatoes increased incrementally as they travelled through the packing lines. A significant correlation was found between the damage index calculated for potatoes and the number of drops and cumulated drop height on the packing lines. Injury classified at the level of peeler was identified as the largest category contributing to the overall damage index.

The study has identified the significant effect of drops on the mechanical injury level of potatoes. To reduce the injury level of potatoes, improvement in lines to reduce these drops need to be undertaken.

Table III. Distribution of type of injury contributing to the overall damage index for Phase III

Damage Classification	Canada #1 Poly Bags[1]	Canada #1 Count Boxes[1]
(b) Scuffed	4.5	2.6
(c) Peeler	40.5	39.6
(d) Severe	33.5	27.6
(e) Black spot	21.5	30.2

[1]Expressed as percentage of total index

Table IV. Correlation of the damage index with packing line parameters

	Number of drops	Cumulated drop height
Change in damage index Phase I (n = 288)	0.61*	0.62*
Damage index Phase II (n = 91)	0.67*	0.67*

* Significant at the 5% level

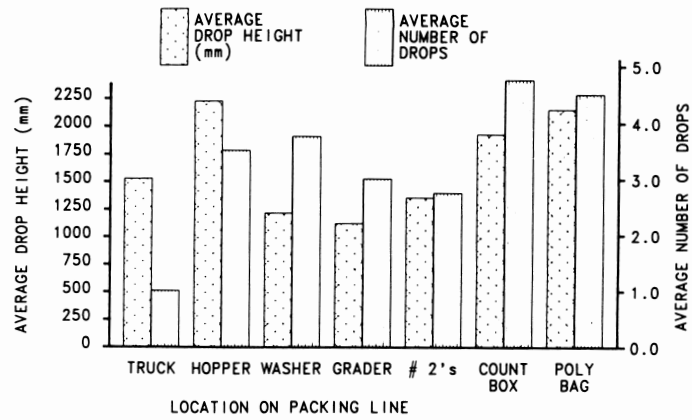

Fig. 2. The average drop height and average number of drops occurring on the packing lines.

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