World Applied Sciences Journal 7 (12): 1504-1507, 2009
ISSN 1818-4952

Potato Variety and Storage for Tuber Sensitivity in Bruising

A. Esehaghbeygi and S. Besharati

Department of Agricultural Engineering,
College of Agriculture, Shahrekord University, Shahrekord, 115, Iran

Abstract: The effects of impact stress, compression and vibration on blackspot bruise sensitivity of three varieties of potato (*Marfona*, *Agria* and *Kosima*) were investigated in Isfahan, Iran. Results showed that rarely any blackspot bruises appeared on potato tubers after 5-month storage in cold bin. In the second stage, the drop height was increased to 70, 90 and 110 cm, which impact energy less than 2 J to ensure internal cell threshold for new samples, which stored in cold bin. The amounts of blackspots and internal bruises measured in tubers with higher drops and stored for additional 35 days at room temperature were subjected to statistical analysis (RCBD, $P<0.05$ and LSD 5% for means). The results showed that the *Kosima* variety was more sensitive than *Agria* to blackspots and internal bruises. Dry matter content had high correlation with tubers blackspot.

Key words: Potato · Impact · Bruise · Blackspot

INTRODUCTION

Several studies have been conducted on mechanical and viscoelastic properties of different potato varieties and damage incidents [1]. Bentini *et al.* [2] showed that *Primura* potato cultivar has greater susceptibility to internal damage than *Vivaldi* variety, with more internal bruising in terms of area and depth of the damage. Incidence of blackspots in potato tubers has been referred to as the physiological deterioration of intracellular compartment [3]. The required time for the dark colored *Melanin* to establish is 24 to 48 hours after the impact at room temperature. An increase in temperature causes an increase in the color changing process [4].

A number of factors are involved in the amount of mechanical damage and sensitivity of potato tubers to mechanical bruises. These include potato variety, maturity level, crop temperature, tuber moisture content, dry matter, falling height, collision surface type, density, curvature radius of sample and collision surface and physical and physiological states [3, 5]. In general, potato tuber internal injuries increase by compaction of ridges, existence of clod and stone in soil and excessive speed of harvesters and conveyors, which increase impacts on tubers [2]. The declining trend in blackspot damages with increasing height from 20 cm upwards have been reported by researchers [6]. The effect of cultivation conditions on the amount of damages from mechanical stresses have been reported in the literature [7]. It is likely that long-term storage of potatoes, more than 60 days would cause internal discoloration in tubers [3]. The objective of this study was to determine the impact endurance limit of three varieties of potato, *Marfona*, *Agria* and *Kosima* in blackspot formation after storage and to specify the most resistant one.

MATERIALS AND METHODS

Three potato varieties (*Marfona*, *Agria* and *Kosima*) were cultivated in the field of Fereidan Isfahan, at separate blocks to study the effects of impact, compression and vibration stress on blackspot bruise sensitivity. Seeds used for this study were cleaned visually from fungus and disease. Soil texture was clay loam with 33% clay, 47% sand and 20% silt. The land had been fallow during the previous year and was ploughed in fall and spring. Fertilizer was applied based on soil requirements and the tubers were harvested manually. Physical properties of tubers including mass, dimensions, volume and sphericity were determined for the three varieties [8]. The samples were weighed before and after oven drying to determine dry matter concentration in the tuber cortices [9].

Uniaxial test was selected to simulated potato compression in the cold bin. Compression forces exerted perpendicularly to the length of the tuber axis and parallel to the long axis. According to the height of bags in

Corresponding Author: A. Esehaghbeygi, Department of Agricultural Engineering, College of Agriculture, Shahrekord University, Shahrekord, 115, Iran, Tel: +983814424428

the cold bin storage, maximum 16 bar was exerted to each tuber. Vibration table was constructed with 1 mm stroke eccentric shaft below its plate. Table shaft was rotated 1650 rpm with an electrical motor. Vibration treatment on tubers was done for one hour. Impact test was done on 120 tubers similar in shape and weight (170±20 g) from each block of potato varieties. The tissue properties of tuber against shattering in the weight range of 170 to 340 g showed significant differences [9]. The tubers were, then, fallen from 6 faces on a steel surface from 4 heights (15, 20, 25 and 30 cm) with three repetitions, which impact energy less than 0.5 J according to their weights in potato harvester. To evaluate incidence of internal bruises in tubers, all the samples were stored in a cold warehouse for 5 months at 5±1 °C with a relative moisture content of 90% wet basis. Samples were held at room temperature for 24 h after the storage period, in order to stabilize their impacted temperature. A manual peeler was used to peel the tubers (1-1.5 mm in depth) in order to identify the blackspot areas. Afterwards, the tubers were sliced individual of thickness 1.5 mm. Internal damage was evaluated as blackspot weight percentage, total weight of lesions per tuber, to normalize in respect to the mass.

In the second stage of impact test, new intact potatoes, which stored in cold bin, were fallen upon a thick steel plate from 3 heights (70, 90 and 110 cm), which impact energy less than 2 J according to their weights. The falling height of 120 cm caused skin tearing in some tubers. Damage levels in tubers were examined after additional 35 days at room temperature, 25 °C. In order to analyze the experiment data, randomized complete block design with three varieties and dropping height with three repetitions in the statistical software packages, MINITAB. Ver. 13.2. State College Pennsylvania, *Minitab* Inc., was used. Means were compared using LSD, $P<0.05$.

RESULTS AND DISCUSSION

Internal damages appearing as blackspots or bruises under the tuber skin were not significant in the three varieties of potatoes and stress types. This means that the quantity or condition of impact, compression and vibration stress did not lead to internal damages in the form of blackspots after 5 month, or that damages were not visible due to the curing and repairing capabilities of cell walls during storage [10]. If tuber skin has formed completely, most of the injuries will be sustained at the skin region, which could be recovered during curing in storage to eliminate its negative effect on marketing. It is important to note that sliced potato samples during experimentation will expose cells to oxygen at the time of sampling, which speeds up the discoloration chemical reactions. Previous research's showed significant difference in susceptibility to internal damage and tissues resistance of potato varieties [2, 11]. The formation of blackspot depends on the amount of distinct materials in the tuber background and on the existence of certain enzymes and impact conditions. It is possible that the optimal environmental or physiological state of the tubers or storage conditions in the warehouse have not made them susceptible to blackspot damages and that the stress levels have not been enough to cause laceration in cell walls in common impact induced by potato harvester, compression in bins and vibration in handling.

In order to increasing the impact energy level to ensure cell wall laceration, falling height of tubers was increased to 110 cm. ANOVA showed that the three potato varieties had a significant sensitivity to blackspots (RCBD, $P<0.05$). The amount of damage was the highest for the 110 cm height and *Kosima* samples exhibited the maximum, while *Agria* exhibited the minimum level of blackspots (Table 1).

Since natural *Marfona* shrubs have dried leaves at the time of harvest, they must produce tubers with more tyrosine and therefore, be more susceptible to blackspots. However, it was found that *Kosima*, which had a longer growth period and older tubers among the three varieties exhibited more blackspot bruises. Potato tuber maturity, stage, variety and environmental factors influence the amount of tyrosine that a tuber can maintain. The kinds of potato varieties that do not have leaves at the time of harvest are older tubers with more tyrosine, which are more susceptible to blackspot bruises [12]. It was shown previously that the shape of the bruise spot depends either on the tested product or the object shape, which was in contact with the product before forming the spot [13, 14]. The variation coefficient in the variance analysis was 12.46%, which shows the relative scattering of damage amounts in different treatments. Scrutinizing the coefficient of determination of treatments (R^2) showed that 72 percent of diversities observed in the amounts of damages were caused by the three selected factors and the remaining was the result of other factors such as different enzymes, incidence of oxidation reactions, storage time and conditions, etc., which are not considered in this study. The physiological properties of the tuber probably had most influence on physiological blackspot bruise susceptibility [3]. Since previous investigations on potato blackspot bruise susceptibility have not distinguished between micro-shatter and physiological bruise, it is difficult to assess the relative importance of aspects from studies available in the literature.

Table 1: Mean weights for blackspot bruise

Potato variety	Falling height (cm)	Bruise (%)
Agria	70	1.29±0.04h
	90	1.85±0.2 defg
	110	1.95±0.2 cdef
Marfona	70	1.75±0.1fgh
	90	2.42±0.2 bc
	110	2.58±0.08 ab
Kosima	70	2.33±0.3 bcd
	90	2.77±0.3 ab
	110	2.93±0.3 a

[a-h] Different letters shows significant difference, LSD, 5%.

Table 2: Physical attributes of potato varieties

Variety	Attribute	Mean	Max.	Min.	Standard deviation
Agria	Mass (g)	158.6	288.7	70.5	73.80
	Major dia. (mm)	81.7	112.3	60.0	18.10
	Minor dia. (mm)	51.6	62.5	38.6	7.66
	Sphericity (%)	78.6	83.8	72.2	4.40
	Volume (cm^3)	148.1	269.6	65.5	68.90
	Dry matter (%)	21.9	24.5	19.4	4.50
Marfona	Mass (g)	188.2	355.6	62.9	100.40
	Major dia. (mm)	86.3	122.0	63.0	20.90
	Minor dia. (mm)	53.1	70.0	37.6	9.84
	Sphericity (%)	77.8	87.5	65.9	6.36
	Volume (cm^3)	177.5	334.5	59.9	94.50
	Dry matter (%)	21.7	23.6	17.8	5.10
Kosima	Mass (g)	158.6	318.9	58.9	8.33
	Major dia. (mm)	82.9	117.0	51.6	20.30
	Minor dia. (mm)	49.4	66.0	39.0	9.51
	Sphericity (%)	77.5	90.3	69.7	6.54
	Volume (cm^3)	57.5	290.6	54.4	77.50
	Dry matter (%)	23.8	25.5	20.2	4.80

Physical attributes of tubers showed that *Marfona* had higher weight, geometric mean diameter and volume, so it's good for export. Standard deviation of weight density of *Marfona* was less, which is more uniform (Table 2). The increase in dry matter in the tubers may result in increased disruption of the membranes as an immediate effect of the impact. It was found that the dry matter increased at *Kosima*, *Agria* and *Marfona*, respectively (Table 2). Workman and Holm, [15] found that blackspot bruise incidence was positively correlated with the dry matter content of tubers for freshly harvested tubers but not for tubers held in long term storage. The highest correlations between blackspot susceptibility and dry matter content are normally found when the tuber mass contributes to the level of energy applied to the tubers. Same results had shown in Baritelle and Hyde, [9] and McGarry *et al.* [16].

ACKNOWLEDGEMENT

The authors would like to thank the research assistant of Shahrekord University for providing the laboratory facilities and financial support for this project.

CONCLUSIONS

Blackspots and bruises in potato tubers increased by increasing the falling height, which causes more impact energy levels from 0.2 to 2 J. The type of cultivar predominantly determines the type of blackspot bruise occurs most frequently in commercial potato production. It seems that the energy potential is present for the occurrence of both micro-shatter and physiological blackspot bruises. Dry matter content had high correlation with tubers blackspot. *Kosima* variety was the most

sensitive and *Agria* was the most resistant to incidence of blackspots and internal defects above a certain threshold to induce blackspot formation among the three varieties studied. Optimal environmental or physiological state of the tubers or storage conditions in the warehouse is necessary to make tuber susceptible to blackspot damages. The relatively high tuber turgidity, commonly experienced at harvest and early in the storage period, increases micro-shatter blackspot bruise susceptibility.

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