Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(3): 2307-2309
Received: 04-03-2019
Accepted: 06-04-2019

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Effect of induced mechanical injury on *aggregatum* onion (CO-5) during post-harvest handling

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Abstract
A study was conducted to determine the extent of mechanical damage to *aggregatum* onion (CO-5) in post-harvest handling. The mechanical damage was assessed by artificially creating injury to the onion bulb and the treatments were Control, drop on metal surface, cut + drop on metal, cut + drop on wood, cut and drop on wood. Among all the treatments the cut +drop on both the platforms was found to induce more mass loss in onion. The percentage of rotten was found to be maximum for cut + drop on metal platform, whereas minimum for drop on wood and drop on metal. The firmness decreased gradually during storage of all treated onion expect for cut +drop on metal platform. The onions had significant effect between the treatments and mechanical damage showed its rigorousness during the storage period.

Keywords: *Aggregatum* onion, induced mechanical injury, mass loss, rotten and firmness

Introduction
The present scenario of *aggregatum* onion production in India showed that Tamil Nadu ranks second in the production of small onion, contribute to 22 % share in total production of the small onion. In Tamil Nadu the annual production of *aggregatum* onion was 282,714 tonnes from 35,809 hectares with productivity of 7.9 tonnes per hectare during 2015-16 (Season and Crop report TN, 2015-16). The freshly harvested onions are generally cured in the field by either windrow method or heap method. Cured onions are stored in an indigenous storage structures locally called as "Vengayapattarai". Presently storage needs are fulfilled by vengayapattarai designed by the farmers themselves with low cost materials. These structures are made manually using bamboo sticks, coconut thatches, wooden board and stones.
However, the post-harvest losses in onion accounted for about 35 to 40 % which occurred during various operations of handling and storage. The onions were damaged during handling process such as loading or unloading, storage, grading, packaging, transporting and in retail markets. Mechanical damage caused during handling of onions will unmask during the storage. A study by Maw *et al*., (1995) [2] reported that the injury caused by an impact could damage the internal scales of the bulb of onion. Yoo and Pike (1995) [6] observed that the impact and pressure damage on onion can affect the surface and the internal scales providing entry to the pathogen and increases the respiration rate of onion. Further, the fungal growth and decay could be avoided by proper ventilation using 40 to 50 % RH at 24ºC air to heal the damaged bulbs. Bruising of onion usually occurs more in cured onions because of their firmer texture. Onion damage can happen on surface of the bulb or internally and if the damage is on the surface it can be easily identified. If there is an internal bruise, there occurs a gap between the concentric scales where the tissue juice tends to accumulate which can be an excellent spot for microbial spoilage (Timm *et al*., 1991) [5]. Herold *et al*., (1998) [1] reported that the height of drop and the material on which the onions were dropped influences the mass loss. The total mass loss increased as the drop height increased on the hard surface when compared to the soft surface. The respiration rate of onion increased as the onion cell tissues were affected while dropping on hard surface. There were different ways by which the produce are affected mechanically i.e., impact when dropped, compression by over stacking, vibration during transport, cut from sharp edges and punctures- nails etc. Very minimal studies were reported on the assessment of mechanical damage of onion during handling. Therefore, this study was undertaken to evaluate the loss by artificially creating mechanical injuries to onion.

Materials and methods
aggregatum onion of cultivar CO-5 were harvested during the month of November, 2018 and cured by windrow method in the field. The curing was carried out for 3 days at an average

atmospheric temperature and relative humidity of 26 ºC and 74 %. It was ensured in each step of handling process that the onion was free from any secondary infection or any injury. Mechanical damage was assessed through the following the treatments namely: (i) Control, (ii) dropping onto a metal surface (T_1), (iii) cut + drop on metal (T_2), (iv) cut + drop on wood (T_3), (v) cut (T_4) and (vi) dropping onto a wood (T_5). The onion is raised above rigid plane surface and released to strike the hard surface after a free fall, the height 1 m. The drop test was conducted using a laboratory drop tester the dropping was repeated twice so that the onions get good impact. The onions were artificially injured by cut with serrated knife 5 mm depth at three locations. The combinations of both cut and drops with metal and wood surfaces were also studied individually. The treated bulbs of 500 g each were stored in a carton box 15x15x10 (cm) with holes for air circulation. The mass loss (due to respiration and transpiration), % rotten and firmness (N) were studied once a week for 5 wk. The firmness of onions was determined using the texture analyser (Stable Micro System and TA-HDi Analyser Model, UK). The mass loss % and % rotten were calculated using the following formula given by Yoo and Pike (1995) [6].

$$\text{Mass loss } \% = \frac{\text{Mi}-\text{Mn}}{\text{M1}} \times 100 \quad (1)$$

$$\text{Rotten}\% = \frac{Wr}{Mi} \times 100 \quad (2)$$

Where,
M_i-Initial mass of onion
Mn-mass of onion at that time
Wr-mass of rotten onions at that time
The data were statistically analyzed using Analysis of variance with mean separation by Duncan's multiple range test.

Results and Discussion

Results from the table 1 indicated that the percent mass loss for T_1, T_2, T_3 and T_4 was found to increase rapidly for *aggregatum* onion bulbs till 4th wk, then decreased for the 5th wk. The maximum mass loss of 96.2% was recorded for T_2 followed by 89% for T_3 during 4th wk of storage. The percent mass loss of T_5, T_6 was on par with control during 1st wk. There was no relative significant difference between T_2 and T_3 during 5th wk. Likewise, similar results were obtained by Herold *et al*., (1998) [1] and reported that deformations were induced on both hard and soft impact surfaces. The effect of impact on hard surface deformed the cell tissue and increased the respiration, whereas the effect on soft surface on cell tissue deformation was less. As the onion was cut and dropped on metal surface, the difference between the initial mass and final mass was high. Mass loss % is related to respiration and transpiration of moisture from the deformed surface of onion.

Table 1: Effect of mechanical injury on percent mass loss of *aggregatum* onion

Treatment	Week 1	Week 2	Week 3	Week 4	Week 5
Control	5.13^{a}	8.32^{a}	9.35 ^{a}	11.79 ^{a}	12.60 ^{a}
T_1	10.02^{b}	14.75^{b}	15.71^{c}	20.90^{b}	18.90^{b}
T_2	31.87^{e}	42.69^{e}	45.87^{f}	96.53^{e}	50.54^{d}
T_3	28.19^{d}	39.29^{d}	42.08^{e}	89.47^{d}	50.90d
T_4	20.75^{c}	26.94^{c}	33.94^{d}	66.72^{c}	45.11^{c}
T_5	8.58^{ab}	9.82^{a}	12.27^{b}	18.44^{b}	19.06^{b}

Table 2: Effect of mechanical injury on percent loss due to rotting of *aggregatum* onion

Treatment	Week 1	Week 2	Week 3	Week 4	Week 5
Control	-	-	0.17^{a}	0.28^{a}	0.62^{ab}
T_1	2.22^{b}	1.31^{bc}	0.91^{ab}	0.57^{ab}	0.74^{ab}
T_2	4.09^{c}	2.90^{d}	1.59^{bc}	1.31^{ab}	0.85^{b}
T_3	2.67^{b}	2.62^{d}	1.59^{bc}	1.30^{ab}	0.68^{ab}
T_4	2.37^{b}	2.07^{cd}	2.36^{c}	1.48^{ab}	-
T_5	-	0.6^{ab}	0.69^{ab}	0.69^{ab}	1.69^{c}

Treatments: T_1 –Drop on metal platform, T_2 –Cut +drop on metal platform, T_3- Cut +drop on wood platform, T_4 –Cut and T_5 –Drop on wood platform

It is inferred from the Table 2 that the percent loss due to rotting was maximum for T_2 (4.09) after first week storage, while minimum for control and T_5 followed by T_1 during 5 wks of storage. There was no significant difference in control during 5 wks and all treatments were significantly different till 3wks of storage.

The firmness decreased drastically for T_2 (31.58 to 16.53 N) followed by T_3 (31.42 to19.60 N) and the results were presented in the Table 3. There was no significant difference between the treatments during first week whereas significant difference was observed between the treatments from second week onwards. The minimum decrease in firmness was observed for control (30.17 N) and T_5 (26.31). Due to mechanical damage the firmness decreased as the bruising induced decay in softer bulbs (Smittle and Maw, 1988) [4].

Table 3: Effect of mechanical injury on Firmness of *aggregatum* onion

Treatment	Week 1	Week 2	Week 3	Week 4	Week 5	Mean
Control	32.5^{bc}	32.21^{f}	32.21^{f}	30.73^{f}	30.17^{f}	31.56
T_1	31.04^{a}	28.00^{b}	28.00^{b}	25.43^{c}	22.80^{c}	27.05
T_2	31.58^{ab}	27.34^{a}	27.34^{a}	17.99^{a}	16.53^{a}	24.16
T_3	31.42^{ab}	28.87^{c}	28.87^{c}	23.31^{b}	13.60^{b}	25.21
T_4	34.01^{d}	30.17^{d}	30.17^{d}	26.29^{d}	23.37^{d}	28.80
T_5	33.57^{d}	31.46^{e}	31.46^{e}	28.90^{e}	26.31^{e}	30.34

Treatments: T_1 –Drop on metal platform, T_2 –Cut +drop on metal platform, T_3- Cut +drop on wood platform, T_4 –Cut and T_5 –Drop on wood platform

Conclusion

It was observed that all the treatments, the cut +drop on metal and wood platform was found to have more mass loss of 96% and 89% during 4th week of storage respectively. The rotten onion bulbs was also higher in cut + drop on metal (4.09%) during first week of storage. The firmness decreased gradually during storage of all treated onion except for cut +drop on metal platform which decreased rapidly. The maximum decrease in firmness was observed for cut +drop on metal platform (16.53 N) and minimum decrease in firmness was observed for onion dropped on wood platform (26.31 N) during 5wks of storage. It is concluded that the onions had significant effect between the treatments and mechanical damage shows its rigorousness during the storage period. Bulb firmness, mass loss and loss due to rotting were responsible for quality losses caused by bruising, puncturing, and cutting during various harvesting and post harvesting operations.

Acknowledgement

Authors are thankful to Agricultural Engineering College & Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India.

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