Nigerian Journal of Technology (NIJOTECH)
Vol. 32, No. 1, March, 2013, pp. 137–140.

ISSN 1115-8443

# Technical Note:
# ASSESSMENT OF IMPACT DAMAGE TO APPLE FRUITS

**O.M. Unuigbe**[a], **S.N. Onuoha**[b]

Department of Agricultural and Bio-Environmental Engineering, Auchi Polytechnic, Auchi, P.M.B. 13, Auchi, Edo State, Nigeria. ***Emails:*** [a]*unuigbeom@yahoo.com;* [b]*sollywise2000@yahoo.com*


## Abstract

***An impact damage assessment of fresh apple fruits was carried out to ascertain the effects of height and surfaces on bruise area and impact energy. Five different impact surfaces namely: Cardboard (E), wood (F), metal (G), plastic (H) and foam (I) were used for the experiment. The weighed fruits were dropped from different heights onto the different surfaces and the impact bruised diameter and impact energy were determined. The results showed that impact damage measured in terms of bruise diameter is highly influenced by the drop height. Fruits dropped from H1 (1400mm) absorbed the greatest impact energies of 2.647KJ for wood, metal, plastic, foam and cardboard respectively which indicate that they suffered the most impact damage while the damaged area increased from 1,018.01mm***$^2$***, 951.27mm***$^2$***, 660.61mm***$^2$***, 460.02mm***$^2$*** and 227.00mm***$^2$*** for wooden, metallic , plastic, cardboard and foam surfaces respectively at a height of 1400mm. The results obtained can be useful to food process engineers in designing fruits packages to reduce mechanical damage.***


**Keywords:** impact damage, apple fruits, packaging, height

## 1. Introduction

The demand for fresh fruits and vegetables such as apples is on the increase as it provides some of the basic nutritional requirements of the diets consumed by man all over the world. The production and distribution of bulk of these fruits require special attention to reduce mechanical damage due to impact. The globalization of markets and the trend for some countries or areas to specialize in specific fruits encourage domestic and inter-state transportation Berardinelli et al [1] which make heavy losses to be incurred in the process. It is however very difficult to estimate losses for fruits and vegetables especially in Nigeria. Oyeniran [2] reported that about 50-70% losses are common in the tropics between the production areas and the points of consumption.

Mechanical damage is the major cause of these losses due to impact which could be caused by either vibration or sudden drop of the fruits from certain heights. Some studies have been carried out to assess the mechanical properties and susceptibility to bruising of fruits and vegetables by many researchers [3, 4, 5, 6, 7, 8, 1].

According to Alltisent [9] bruising in fruits and vegetables occurs when the produce rubs against each other, packaging containers, parts of processing equipment and the tree. During loading and unloading operation, the fruit loads or packages are at times thrown from certain heights and made to hit some hard surfaces which could result to impact damage in the form of bruise. The economic implications of bruising are enormous [10].

Reducing the mechanical damage can increase the shelf life of the fruits and the vegetables and as well reduce microbial infestation to the barest minimum. An assessment of the different sources of the losses in fresh fruits and vegetables is necessary if the product quality is to be guaranteed. It is important to assess the level of bruising that occurs in fresh apple fruits under certain conditions during handling operation most especially the various surfaces that the fresh produce comes in contact with and the height of drop of the packages during handling.

In this research, the effects of different impact surfaces and the height of drop on bruised area and energy absorbed were investigated with the aim of generating data or information that can be used in the design and management of handling and transport devices that will reduce mechanical damage.

## 2. Materials and Methods

The materials and equipment that were used for the experiment include measuring tape, digital weighing balance, Digital Vermier Caliper (Model A2583), Stainless steel Knife, impact surfaces (metal, wood, plastic, cardboard and foam).

### 2.1. Procedure

Fresh Red Delicious apple cultivar fruits (*Malus domestical*) used in this study were harvested in China on the 8th day of September, 2012 and bought in a supermarket in Auchi, Edo State of Nigeria. Sixty apple fruits devoid of any form of damage were bought in a supermarket in Auchi, Edo State of Nigeria. Twenty (20) samples of the apple fruits were carefully selected and stored in the refrigerator at a temperature of 0°C for a day before they were used for the study. They were weighed separately using a digital weighing balance (Ohaus, 250) and the average value of weight used. The fresh apple fruits were dropped from certain height onto the impact surfaces on the impact platform. The height of fall and rebound of the fruits were measured with steel rule. Five different impact surfaces (cardboard,-E, wood-F, metal-G, Plastic-H and foam-I) were used. Five apple fruits were dropped onto each of the different surfaces placed on the platform from four different heights: H1-1400mm, H2-1100mm, H3-800mm and H4-500mm. White powdered chalk were spread on the different surfaces to ascertain the correct dimensions of the impacted area. The impacted apple fruits were coded and stored for three days. The diameter and the depth of the apples that were covered with white powdered chalk were neatly cut off with a small stainless steel knife. The diameters of the damaged portion were measured with a Digital Vernier Caliper (Model A2583) while a pin was placed on the cut-off part of the apple to determine the depth of damage. The pin was then placed on the steel rule to determine the exact depth of the damaged apples.

The height of rebound of the apples was measured using the procedure provided by France [11]. An apple was held at a height of 1400mm of fall using a stainless rule placed closely to a legibly calibrated wall and the rebound height from the impact surface was carefully observed to avoid error of parallax and recorded. This process was replicated for three times at the various height of fall (1400, 1100mm, 800mm and 500mm) and their corresponding heights were also determined and recorded for each impact surface considered.

The impacted energy was determined from the relationship given by Mohsenin [12]

$$E = (1 - e^2)mgh \tag{1}$$

Where $E$ is the impact energy, $m$ is the mass of the fruit, $g$ is the acceleration due to gravity, $h$ is the height of drop and $e$ is the coefficient of restitution

$$e = \frac{v_2}{v_1} = \left(\frac{h_2}{h_1}\right)^2 \tag{2}$$

Where $v_1$ and $v_2$ are the initial and rebound velocities and $h_1$ and $h_2$ are the heights of fall and rebound respectively. For each of the impact surfaces, the samples were dropped from the various heights and the bruise area was computed using the formulae $\frac{\pi d^2}{4}$ from which the impacted energy was determined for each using equation 2.

## 3. Results and Discusssion

### 3.1. Bruise area

Tables 1-5 show the results of the effect of impact surfaces on the bruised area. One parameter that is used to determine the impact area in fruits generally is the bruised diameter [13]. The average bruise diameter obtained was between 11.3mm-36.0mm from which the bruise area was computed. Earlier studies have graded degree of impact damage in relation to average bruise diameter as follows (Vursavus and Ozguven,2008): bruise diameter of less than 12mm, the damage is classified as None; 12-19mm: Trace damage; 19-25mm : Slight damage; 25-32mm: Medium damage and greater than 32mm as severe damage. From the results obtained in the Tables below, it can be seen that the samples dropped onto the wooden and metal surfaces suffered severe damages while the plastic surfaces suffered medium damage. However, the wooden surface inflicted the greatest impact damage on the fresh apple fruits dropped onto it than any other surface used in this paper, followed by metal materials. This is because these materials are generally rougher and harder than the others. Foam materials inflicted trace damage to the apple fruits while the cardboard materials inflicted slight damage on the apple fruits.

The results obtained from this study are in agreement with Altisent [9] who revealed that the severity of impact damage to fruits is primarily related to the type of impact surface in addition to the physical properties such as the hardness of the fruits. The effects of drop height and impact surfaces on the bruised area are shown in Tables 1-5

### 3.2. Impact energy

Table 6 shows the results of the effect of drop height and impact surfaces on the impact energy available for bruising as shown in Tables 1-5, the samples of Apple fruits dropped from height H1 (1400mm) on all the surfaces considered absorbed the greatest energy. These results are in agreement with other studies [6] which revealed that as the drop height increased, the impact energy also increased.

Table 1: The effect of wooden surface on the diameter of damage of Apple fruits.

| Weight(g) | Height of Fall (mm) | Rebound height (mm) | Depth of damage (mm) | Diameter of Damage (mm) | Damaged Area ($mm^2$) |
|---|---|---|---|---|---|
| 150.00 | 1400 | 44.0 | 19.8 | 36.0 | 1,018.01 |
| | 1100 | 42.0 | 19.5 | 34.2 | 908.04 |
| | 800 | 36.0 | 17.0 | 32.9 | 850.23 |
| | 500 | 31.0 | 13.0 | 32.6 | 834.80 |

Table 2: The effect of metal surface on the diameter of damage on Apple fruits.

| Weight(g) | Height of Fall (mm) | Rebound height (mm) | Depth of damage (mm) | Diameter of Damage (mm) | Damaged Area ($mm^2$) |
|---|---|---|---|---|---|
| 150.00 | 1400 | 40.0 | 20.0 | 34.8 | 951.27 |
| | 1100 | 38.0 | 19.8 | 32.4 | 824.59 |
| | 800 | 30.0 | 18.0 | 28.1 | 620.24 |
| | 500 | 28.0 | 15.0 | 25.2 | 498.82 |

Table 3: The effect of plastic surface on the diameter of damage on Apple fruits.

| Weight(g) | Height of Fall (mm) | Rebound height (mm) | Depth of damage (mm) | Diameter of Damage (mm) | Damaged Area ($mm^2$) |
|---|---|---|---|---|---|
| 150.00 | 1400 | 39.0 | 19.6 | 29.0 | 660.61 |
| | 1100 | 42.0 | 19.3 | 27.6 | 598.36 |
| | 800 | 37.0 | 16.0 | 26.4 | 547.46 |
| | 500 | 30.0 | 11.0 | 25.1 | 494.87 |

Table 4: The effect of foam surface on the diameter of damage of Apple fruits.

| Weight(g) | Height of Fall (mm) | Rebound height (mm) | Depth of damage (mm) | Diameter of Damage (mm) | Damaged Area ($mm^2$) |
|---|---|---|---|---|---|
| 150.00 | 1400 | 45.0 | 16.6 | 17.0 | 227.00 |
| | 1100 | 32.0 | 14.3 | 14.0 | 615.00 |
| | 800 | 26.0 | 12.0 | 12.4 | 120.78 |
| | 500 | 24.0 | 11.0 | 11.3 | 100.30 |

Table 5: The effect of cardboard surface on the diameter of damage of Apple fruits.

| Weight(g) | Height of Fall (mm) | Rebound height (mm) | Depth of damage (mm) | Diameter of Damage (mm) | Damaged Area ($mm^2$) |
|---|---|---|---|---|---|
| 150.00 | 1400 | 44.0 | 17.5 | 24.2 | 460.02 |
| | 1100 | 42.0 | 15.5 | 22.0 | 380.18 |
| | 800 | 36.0 | 12.1 | 21.3 | 356.37 |
| | 500 | 31.0 | 10.1 | 20.4 | 326.89 |

Table 6: The effect of drop height on impact energy of Apple fruits.

| Height of fall (mm) | K Joules | | | | |
|---|---|---|---|---|---|
| | wood | metal | plastic | Foam | cardboard |
| 1400 | 2.647 | 2.647 | 2.647 | 2.647 | 2.647 |
| 1100 | 1.616 | 1.617 | 1.616 | 1.618 | 1.616 |
| 800 | 1.174 | 1.176 | 1.175 | 1.175 | 1.175 |
| 500 | 0.733 | 0.733 | 0.733 | 0.734 | 0.732 |

## 4. Conclusion

An impact damage assessment of Apple fruits has been conducted by dropping the fruits from various heights onto different impact surfaces to see the effects in terms of bruise area and the impact energy. From the experiment carried out, it can be concluded that the bruise area is greatly influenced by the surface with which the fresh Apple fruits comes in contact. Wooden material inflicted the greatest bruise area. The impact energy is on the other hand influenced by the drop height and the mass of the fruits. The data obtained can be useful for designers of fruits packaging products, processing equipment and handlers of the produce at various stages of distribution to eradicate or reduce mechanical damages to such fruits.

## References

1. Berardinelli A.; Donati, V. and Ragni, L. Damage to pears caused by simulated transport. *Journal of Food Engineering*, Vol. 66, 2005, pp 219-226.

2. Oyeniran, J.O. *Reports of activities of nationally coordinated research project on fruits and vegetables in Nigeria*. Proceedings of National Workshop on Improved Package and Storage System for Fruits and vegetables, in Nigeria, March 30, 1988, pp 18-39.

3. Holt, J. E. and Schoorl, D. A theoretical and experimental analysis of effects suspension and road profile on bruising in multilayered apple packs. *Journal of Agric. Engineering Resources*, Vol. 31, 1985, pp 297-308.

4. Roudot, A.C.; Duprat, F. and Wenian, C. Modeling the response of apples to loads. *Journal of Agric. Engineering Resources*, Vol. 48, 1991, pp 249-259.

5. Singh, A. and Singh, Y. Effect of vibration during transportation on the quality of tomatoes, Journal of Agric. Mechanization, Asia, Africa and Latin America, Vol. 23, 1992, pp 70-72.

6. Hyde, G.M.; Bajema, R.W. and Zhang, W. *Measurement of impact damage thresholds in fruits and vegetables*. Proceedings of 4th International Symposium, Fruits, Nut and Vegetable production Engineering, Valencia- Zaragoza, Spain, March 22-26, 1993, pp 1-9.

7. Ogut, H.; Peker, A. and Aydin, C. Simulated transit studies on peaches: Effects of containers, cushion materials and vibration on elasticity modulus. *Journal of Agric. Mechanization in Asia, Africa and Latin America*, Vol. 30, 1999, pp59-62.

8. Vursavus, K. and Ozguven. Determining the effects of vibration and packaging method on mechanical damage in golden delicious apples. *Journal of Agriculture*, Vol. 28, 2004, pp 311-320.

9. Altisent, M.R. *Damage mechanisms in the handling of fruits. Progress in agricultural physics and engineering*. John Matthew (Ed). Common Wealth Agricultural Bureaux (CAB) International, Willingford, UK, 1991, pp 231-255.

10. Anong. *Prevention of postharvest food losses: fruits, vegetables and root crops*. A training manual, Food and Agricultural Organisation (FAO) of the United Nations training series No. 17/2. Rome, Italy, 1989.

11. France, C. *Energy Transfer*. http://www.gcsescience.com/pen30-energy-ball-bounce.htm. Accessed on June 7, 2012, 2008.

12. Mohsenin, N.N. *Physical properties of plant and animal materials*. Vol. 1, Gorden and Breach Science Publ., New York, USA, 1986.

13. Idah, P.A.; Ajisegiri, E.S.A. and Yisa, M.G. An assessment of impact damage to fresh Tomato fruits. *AU J. T*, Vol.10, Number 4, 2007, pp 271-275.