EFFECTS OF IMPACT LOCATIONS ON MECHANICAL AND DYNAMICAL PROPERTIES OF FRUITS

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Abstract

Generally, bruise is one of the most important issues caused by impact during handling or transport of fruits. Numerous impact damage test studies have been performed (M. Van Zeebroeck *et al.*, 2007). These were mostly done on the lateral sides of fruits for data accusation or modelling. For the majority of fruits there is no detail of mechanical and dynamical properties on different locations (stem side and blossom side). This information is essential for better positioning of fruits during packaging and in packages to avoid or reduce bruising. The key aim of this work is to carry out more detailed mechanical and dynamical properties studies of fruits (a stem side, two lateral sides, and a blossom side) and to develop impacts tests in order to use data in the future models that can be applied to optimise the design of sorting equipment and packaging media. In this paper, we deal with the comparison of the impact location effects on mechanical and dynamical properties of fruits in impact tests. 'Jonagold' apples of same size and same maturity state were chosen for the experiments. Four different impact locations (stem side, two lateral sides, and a blossom side) were marked on apples for a test by an impactor. The results illustrate that a significant difference exists between the locations, while no significant difference has found between the samples. In addition, the maximum restitution coefficient was found on the blossom sides of apple fruits. The result can inform us how to orient the fruits in packaging systems and impact test. The restitution coefficient can be a new parameter during the impact tests.

Keywords: Impact, Location, Bruise, Fruits, Restitution coefficient.

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1. Introduction

A large percentage of fruits are wasted yearly because of damage such as bruising. Bruise is mostly caused by impact during handling, packaging, and transport of fruits. During fruit transport and handling, dynamical loads are causing by far the most bruise damage, because these loads are higher in incidence and magnitude than static loads (Mohsenin, 1986; Kupferman, 2006).The fruit journey from orchard to supermarket is extremely complex and fruits are subjected to a variety of dynamical loads that could result in this damage. It plays a key role for rejecting fruits at quality inspection. In some cultivars, apple bruising can result in product losses up to 50 % (Pang, 1992), although typically loss levels are between 10 to 25 %, depending on consumer's awareness (Studman, 1997). Apple bruise damaged of bulk bins during orchard transport was 15.0 to 47.5% and graded 67.5 to 92.5% U.S. Extra Fancy (Timm *et al*., 1998). In a case study, rough filling of an unpadded bin resulted in 89% bruised fruit and scientists in Michigan suggest that 35% of bruising occurs during harvesting and hauling (Kupferman, 2006). He also mentioned that impact bruising is still the most common type and a significant problem in post harvest processes.

Numerous impact damage test studies have been preformed (e.g. Van Zeebroeck, 2006; Bajema and Hyde, 1998; Zhang, 1994; Schulte-Pason *et al*., 1992). These were mostly done on the lateral sides of fruits for data acquisition or modelling. For the majority of fruits there is no detail of the mechanical and dynamical properties on different locations (stem side and blossom side). This information is necessary for better positioning of fruits during packaging and in packages to avoid or reduce bruising.

In addition, the fruits include different locations, which may have a potential to affect mechanical and dynamical properties because of orientation and position. Hence, it is essential to deal with dynamical loads on different locations when studying a process such as handling or transport, so far due to no standard methodology. We therefore restrict our attention to find out a suitable methodology for dynamical properties. This work focuses on effects of impact locations on mechanical and dynamical properties of fruits and to develop impact tests in order to use data in the future models that can be applied to optimise the design of sorting equipment and packaging media.

2. Materials and methods

'Jonagold' apples were purchased from a local supermarket during February 2007 and December of 2007. Unbruised 'Jonagold' apples of same size and same maturity state were chosen for the experiments. Four different impact locations (stem side, two lateral sides, and blossom side) were marked on apples for a test by a pendulum impactor. The pendulum at KULeuven was used to induce impact bruises and to measure coefficients of restitution.

As shown in figure 1, the pendulum impactor consists of a 0.505m long wooden arm with an aluminium impactor of spherical shape which has a curvature radius of 25mm. The impactor is connected to a force sensor of Dytran instruments 1051V3 with a sensitivity of 11 mV/N. At the same height, it is also attached to an accelerometer of PCB piezotronics 352C22 with a sensitivity of 10 mV/g. At the turning point of the pendulum arm, an incremental optical encoder (Heidenhain RON 275) is mounted. A National Instrument PCI-MIO-16E-1 card is used to perform data acquisition from these three sensors. The collected data processed by a LABVIEW program.

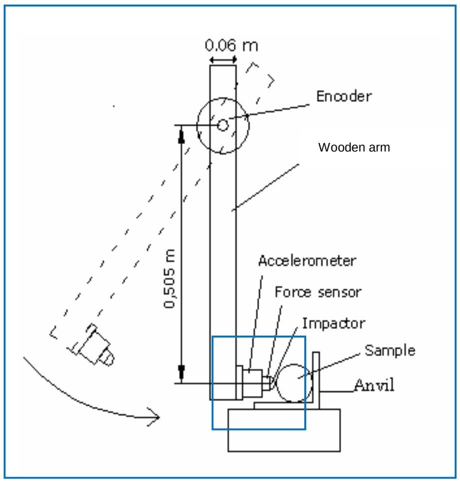
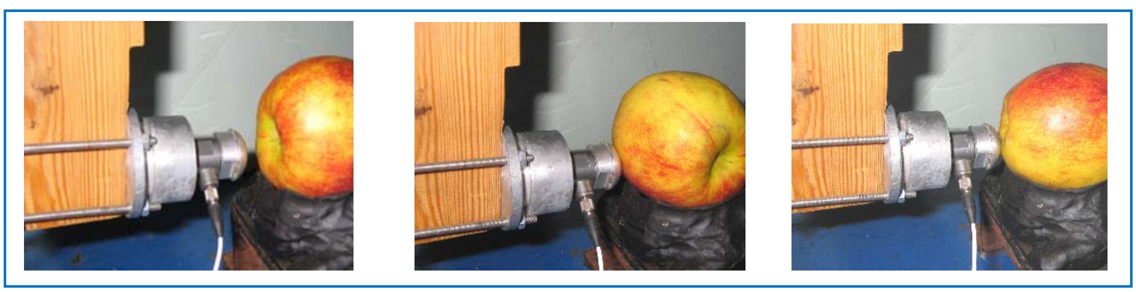


Figure 1. Scheme of the pendulum impactor.



(S) (L) (B)

Figure 2. A sample in stem, lateral, and blossom side positioning

(from left to right) is hold by the elastic materials(black) on the anvil.

For the experiments, each complete apple was placed on the anvil and was held by elastic materials as can be seen in figure 2.

To apply the same energy, an initial angle of the pendulum arm was fixed. Four different impact locations (stem side, two lateral sides, and blossom side) were placed in face to impactor. Every location was hit only once. The impact energy was about 0.11 J. for each impact. The coefficient of restitution (C_R) was also measured during impact tests based on the following formula:

$$C_R = \frac{V_f}{V_i}$$

where V_f and V_i are the scalar velocity(m/s) of the impactor after and before impact, respectively.

After impact, the apples were stored at a room temperature of 20 °C for 24 hours. Afterwards, the diameter of bruises on the marked apples was measured by a digital calliper.

3. Results and discussion

The results illustrate that a significant difference exists between the locations, while no significant difference has found between the samples and also between two lateral sides at the 95% confidence level. In addition, the maximum and minimum restitution coefficients were found on the blossom sides and stem sides of apple fruits, respectively. Figure 3 shows the coefficients of restitution versus four locations on the ‘Jonagold’ apples.

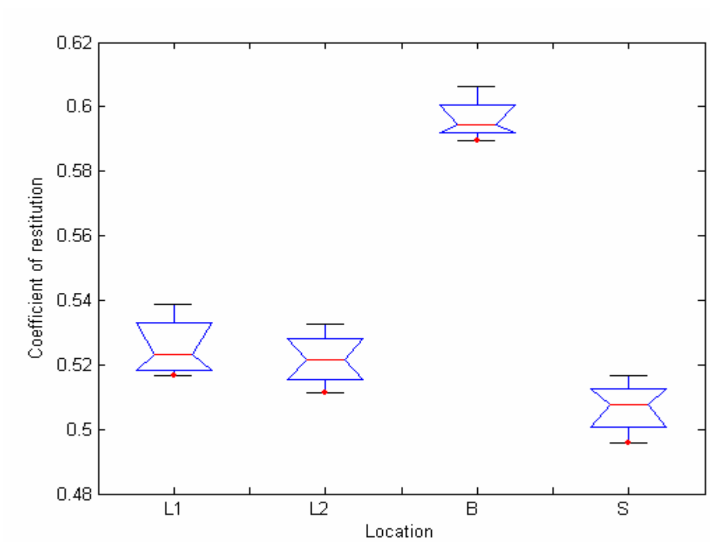


Figure 3. Coefficients of restitution versus four locations on ‘Jonagold’ apples

(L_1, L_2=Lateral sides 1 and 2; B=Blossom side; S=Stem side).

Averages of restitution coefficients were calculated for lateral sides, blossom side and stem side 0.524, 0.596 and 0.507, respectively. In comparison, the size of bruise on the stem side was bigger than other sides. Figure 4 shows mean diameter of bruise versus locations. It can be seen form the figures (3 and 4) that a maximum bruise is on the stem side with the lowest restitution coefficient. Therefore, a restitution coefficient can be a new parameter to indicate bruising by considering the stem side as a key location.

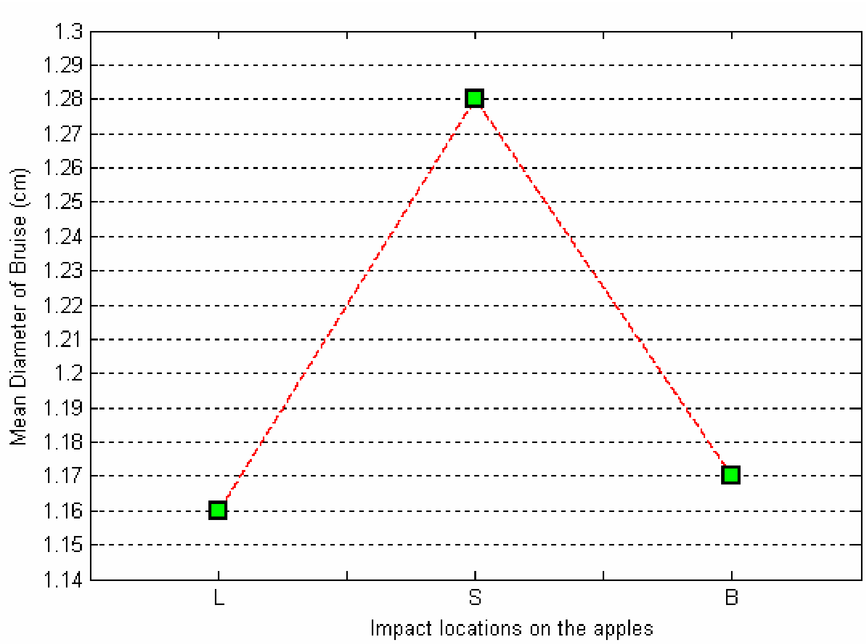


Figure 4. Mean Diameter of Bruise (cm) versus locations on 'Jonagold' apples

(L =Average of two lateral sides; B=Blossom side; S=Stem side).

4. Conclusion

This study illustrated the effect of impact locations on mechanical and dynamical properties of 'Jonagold' apples. The results show that the maximum and minimum restitution coefficients were found on the blossom sides and stem sides of apple fruits, respectively.

The result can inform us how to orient the fruits in packaging systems and impact test. By considering different locations, the restitution coefficient can be a new parameter during the impact tests on biomaterials. Moreover, this is a new step forward to find a standard methodology for impact test of fruits. The methodology can be applied to other biomaterials especially large sized.

Acknowledgments

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