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USE OF ELECTRONIC FRUITS TO EVALUATE FRUIT DAMAGE ALONG THE HANDLING PROCESS

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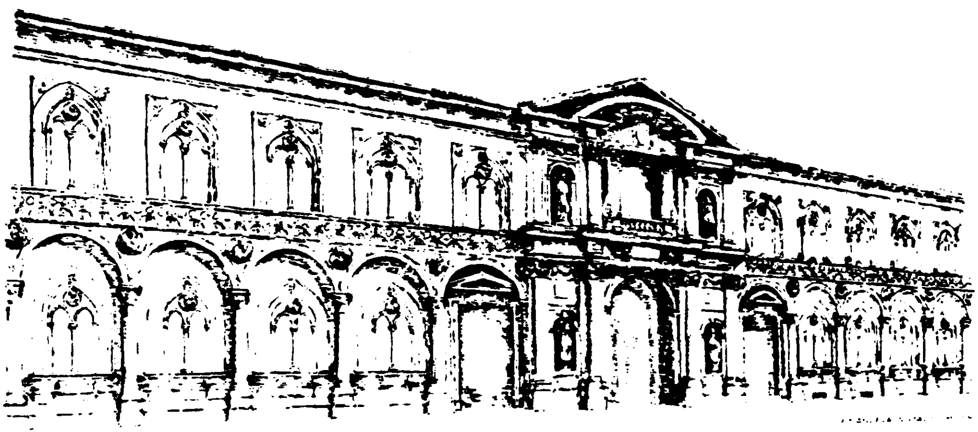
SUMMARY:

Two electronic fruits (SEP-1, Simulated Electronic Product, developed in Scotland, and Techmark IS-100, Instrumented Sphere, developed in USA) have been compared in laboratory tests and then used to evaluate handling operations, in several cooperatives of two areas of Spain: Lérida (pome fruits) and Valencia (stone fruits).
Advantages of each device were evaluated. Harvest, mechanical bin unloading, and grading line transfers and sizers were identified as operations causing fruit damage.

KEYWORDS: Instrumented Sphere, Damage, Fruit



1. Introduction

In the last years, several devices ("electronic fruits") have been developed to evaluate accelerations and forces during the course of the handling process, in order to improve these operations by avoiding fruit damage. The electronic fruits are introduced through the mechanical operations as a real fruit, giving information of the impacts suffered by the fruits in the process.

SEP-1 (Simulated Electronic Product), developed by the SAC (Scottish Agricultural Centre), is a non-spherical device of 257 g. The sensitive area is based on the piezo-electric effect (Anderson, 1990). It is equiped with a clock, a memory and a rechargeable internal batery, and detects and classifies impacts into eigth damage levels (0-7).

Techmark IS-100, developed by the Michigan Agricultural Experiment Station and USDA's Agricultural Research Service, is a spherical device of 300.6 g, equiped with a tri-axial accelerometer, and also with a clock, a memory and a rechargeable internal batery (Zapp et al., 1989). This device is able to identify the type of the impacted surface by measuring the peak acceleration and velocity change (Brown et al., 1990); these data, combined with available impact damage threshold results (Schulte-Pason et al., 1990), can be used to determine where bruise damage may occur.

Timm et al. (1989) reported that a multiple linear regression based on peak acceleration, impact duration, velocity change (parameters measured by the IS-100) and Magness-Taylor firmness provided good predictions for bruise dimensions.

Both devices have been already used to evaluate handling operations. SEP-1 has been used by Jarén (1991) to evaluate onion packing lines. IS-100 has been used to evaluate apple packing lines (Brown et al., 1990), apple transportation (Schulte-Pason et al., 1989), onion packing lines (Timm et al., 1991) and tomato and bell pepper packing lines (Sargent et al., 1992).

2. Material and methods

Two types of experiments were carried out with the electronic fruits SEP-1 and IS-100: laboratory experiments and real handling process tests.

2.1 Laboratory experiments

Both electronic fruits were dropped from different heights onto the following surfaces:

- Steel, flat surface. Heights: 1, 3 and 6 cm.
- Steel, 2.1 cm curvature radius. Heights: 1, 3 and 6 cm.
- Steel, 1 cm curvature radius. Heights: 1, 3 and 6 cm.
- Poron 15250, flat surface. Heights: 20, 40 and 60 cm.
- Pasteboard, flat surface. Heights: 20, 40 and 60 cm.
- Apple, 3.8 cm curvature radius, average firmness 22 N (8 mm diameter probe). Heights: 10, 20 and 40 cm.

"Golden Delicious" apples (after storage, average firmness 22 N) were subjected to the same drops and produced bruise volume was measured, using the equation of Chen and Sun (1981). Ten repetitions were made of each test.

2.2. Handling process tests

Tests were carried out in two areas of Spain: Lérida (pome fruits) and Valencia (stone fruits). Both electronic fruits were used to evaluate harvest, transport, handling and grading. In every case, the real procedure was observed, and then repeated with the electronic fruit; 2-4 repetitions were made at each operation.

3. Results

3.1. Laboratory experiments

Laboratory tests showed a good relationship between peak acceleration, parameter measured by the IS-100, and SEP-1 digit, with slight variations among the different surfaces (Table 1).

Lower values of peak acceleration and SEP-1 digit were obtained with curved surfaces (Table 1, Fig. 1). This result needs further study.

Prediction of bruise damage from electronic fruit parameters was not so accurate and depended on the impacted surface (Table 1). Apple (considered as impact surface) showed low values of peak acceleration (IS-100, Fig. 1) and SEP-1 digit, but bruise damage caused in drop tests was higher than that expected from electronic fruit data. The reason of these differences has to be searched. Deformation is a critical parameter in fruit bruising, and it is influenced by the viscoelastic behaviour of apple, while steel and poron can be considered as elastic materials. It can be the cause of the different results with apple.

3.2. Handling process tests

Values displayed by the electronic fruits in handling processes have been compared with the values measured in the laboratory, showing that in most cases damage thresholds were clearly overpassed during handling and procesing operations. Harvest (in rough conditions), mechanical bin unloading, and grading line transfers and sizers were identified as operations causing fruit damage (Tables 2 and 3).

Results in pome fruits (Lérida) showed that bin unloading and sizing were operations causing more damage, especially when unloading was carried out manually (Table 2). Usually, cooperatives in Lérida are not large enough to carry out bin unloading by water inmersion, and it is made manually or with a mechanical unloader.

Tests in Valencia (stone fruits) showed also that fruit sizing was the most damage producing operation, though a rough harvest can be even worse (Tables 2 and 3).

At grading lines, the main damage is caused at jumps and also when the fruit falls from the sizer. It has been shown that most of the impacts could be eliminated by changing the rubber foam usually weaken and by adding brushes under the sizers so that the fruit is slowed down during falling.

There are some effects which can not be measured using the electronic fruits. Impacts against a bin's edge or a hook give equal or lower values of peak acceleration and SEP-1 digit, while the results are very different, since a hook impact can cause skin damages.

H, cm	A(IS), g's	V(IS), m/s	D(SEP)	BD, mm	BV, mm^3
Steel,	flat	surface			
1	43	0.54	2	0	0
3	89	0.96	4.3	12.0	275
6	128	1.29	6.9	15.7	556
Steel,	2.1 cm	curvature	radius		
1	37	0.58	1	7.4	64
3	76	1.04	2.6	11.9	332
6	121	1.45	4.7	14.2	577
Steel,	1 cm	curvature	radius		
1	39	0.61	1	6.5	50
3	74	1.06	3	10.9	289
6	114	1.49	4.5	12.7	502
Poron,	flat	surface			
20	90	2.67	2.9	2.5	2
40	178	3.72	5.1	3.2	8
60	231	4.22	>7	6.4	51
Pasteb.,	flat	surface			
20	111	2.71	2.8	0	0
40	155	3.23	4.4	3.4	8
60	354	4.14	>7	9.6	193
Apple,	3.8 cm	curvature	radius		
10	46	2.21	1	10.9	216
20	54	2.52	2	15.8	677
40	84	3.54	3.3	22.1	1830

Table 1. Parameters obtained by dropping onto different surfaces the devices IS-100 and SEP-1, and "Golden Delicious" apples (mean of 10 drops). H: drop height. A(IS): peak acceleration. V(IS): velocity change. D(SEP): SEP-1 digit. BD: bruise diameter. BV: bruise volume

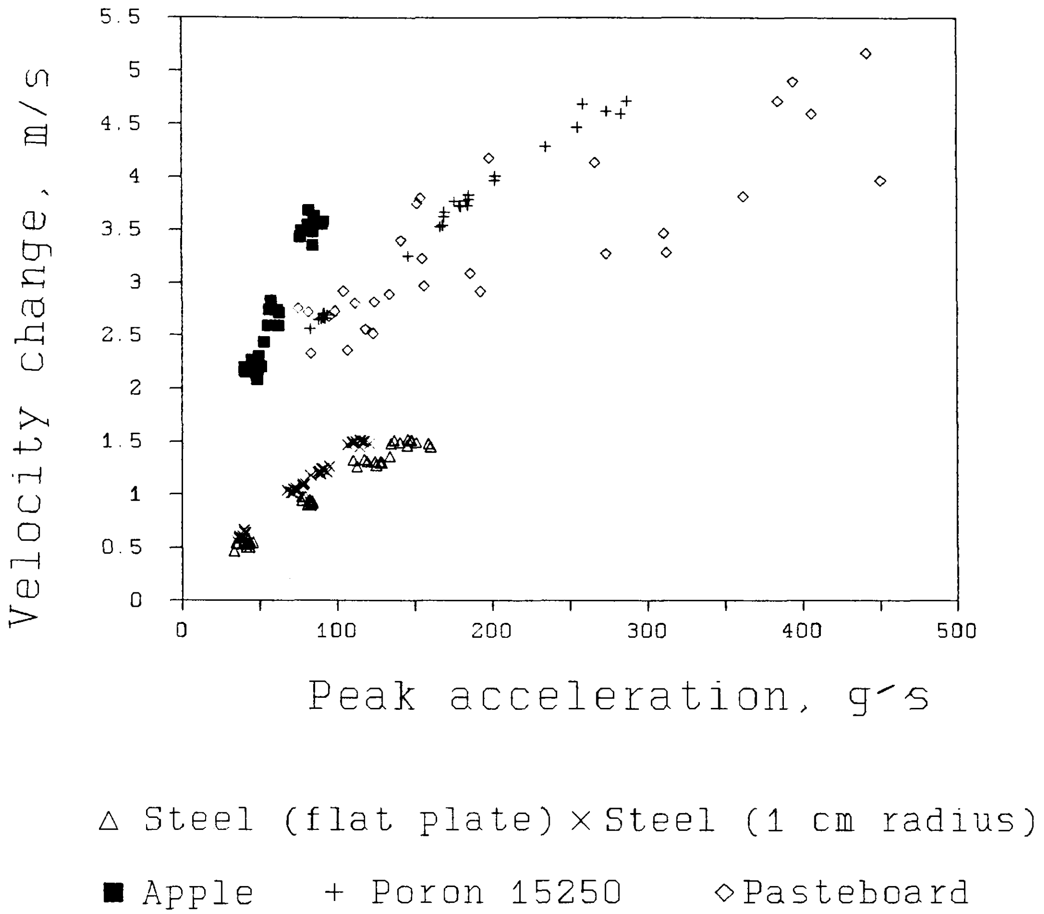


Fig. 1. Values of peak acceleration, g's, and velocity change, m/s, measured by the device IS-100, for different impact surfaces

Operation	Electronic fruit parameters
Harvest	
Apple harvest; careful operation	30 / 0.71 / 1
Apple harvest; rough operation	44 / 1.13 / 2
Peach harvest; careful operation	33 / 0.80 / -
Peach harvest; rough operation	102 / 1.29 / -
Bin transport	
Inside the field	22 / 0.29 / 1
From the field to the storage center	40 / 1.59 / 1

-: no data

Table 2. Maximum values of peak acceleration, g's (IS-100), velocity change, m/s (IS-100) and SEP digit (SEP-1) in fruit harvest and transport

3.3. Comparison of electronic fruits

IS-100 spherical shape seemed to be more suitable than SEP-1 non-spherical shape. SEP-1 tended to lay over one side in the packing lines, causing some irregular results. Impacts in the non-sensitive sides were not detected. However, a sufficient number of repetitions gave satisfactory results, similar to those from the IS-100 (Tables 2 and 3).

4. Conclusions

Both electronic fruits Techmark IS-100 and SEP-1 have proved to be useful detecting damage producing operations in Spanish cooperatives. The spherical shape of IS-100 seem to be more suitable.

The relationship between electronic fruit parameters and fruit bruise damage seem to be different against elastic surfaces (steel, poron) than against viscoelastic surfaces (apple). A protocol was established to evaluate fruit handling operations.

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	Bin unloading	Transfers	Washers	Sizers
1. Apple line	66/0.8/2	34/0.5/2	-	77/1.0/3
2. Apple line	125/1.8/3	34/0.7/2	-	84/1.3/2
3. Apple line	-	-	54/0.8/2	60/1.0/2
4. Apple line	53/0.7/1	-	36/0.5/1	45/2.2/1
5. Manual line	66/1.7/-	-	-	-
6. Peach line	41/2.1/-	92/1.3/-	-	47/2.3/-
7. Peach line	132/1.4/-	102/1.3/-	-	241/2.6/-
8. Apricot line	-	75/0.8/-	-	82/1.1/-
9. Citrus line	85/0.9/-	58/0.8/-	-	103/0.9/-

-: No data

Table 3. Maximum values of peak acceleration, g's (IS-100), velocity change, m/s (IS-100) and SEP digit (SEP-1) in fruit grading lines

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