The Harvest of Table Olives from the Plant by Means of an Hand Harvester

Paschino F., Caria M., Gambella F.
University of Sassari, Department of Agricultural Engineering, Viale Italia 39, 07100 Sassari.

**Corresponding author gambella@uniss.it.*

Abstract

The production of table olive showed in Sardinia an increase of production in line with the national production (+17.3%) unfortunately the low mechanization level penalizes the sector strongly. Problems which priority have to be faced are bound to the damage induced by the work organs and especially the material which they are coated with from their conformation. The study has the aim of evaluating the mechanical damage produced by a hand harvester modified for the harvest of olives by the plant. The hand harvester is constituted from a narrow and light comb with 11 teeth in titanium with 4 mm diameter and coated by a sheath in silicone of the thickness of 1 mm for the experimentation the silicone covering was removed, some theet coated with vulcanized rubber of the thickness of 3 mm, 10 mm and 15 mm were produced and various rotation speeds were tested (200, 300 and 400 RPM). The number of turns was determined by the mechanical revolution counter (DEUMO 2) making one of the two electrical units of measurement change (v, to A). The damage produced by modified teeth on olives was ranging from a minimum of 4.2% with speed of 200 RPM. and a protection of 15 mm to a maximum of 21.3% with 400 RPM speed and protection teeth of 15 mm.

Key words: tables olives, damage, mechanical harvesting

Introduction

The table olive sector is one of great importance in Italy. According to the latest data on commerce (ISTAT), in the three-year period from 2006 to 2008, Italy produced 68,452.7 t of table olives (+11%) and processed them with the "Greek natural" "Seville" and "green" methods. In Sardinia, the production of table olives has seen an increase in line with the rest of Italy (+17.3%), owing mostly to the renovation of old processing plants and the planting of new varieties with a two-fold attitude. The most widespread cultivars are the "Bosana", the "Manna" (Fig. 1) and the "Niedda", followed by "Maiorca", "Sivigliana" and "Pizz'e Carroga". All these varieties have shown an excellent propensity for processing using different technologies, among these the "natural" or "traditional" system.[1] Harvesting is the final stage of in-the-field production and if performed at the wrong time and in the wrong way

Figure 1. Olives of the "Manna" variety picked and calibrated by hand

[1] "Natural" processing consists of removing the bitterness of the drupes in solutions of water and salt in concentrations that vary from 6 to 10%.

it may impact on the economic return of producers. Two aspects of primary importance which come before processing are thus connected to how and when table olives are harvested. Both are important since on them depend the quality and thus the market value of the processed olives. Damage to the drupes during picking, transport and processing represents one of the main causes of losses in quality and their value. At present, the harvest of table olives for "green" processing takes place prevalently by hand since, besides the calibre, lesions, abrasions and bruising of the skin of a fruit gathered even with the harvesting system used determines the depreciation of the product. This aspect is of fundamental importance, so much so that many researchers and producers have invested large amounts of money in the search for techniques capable of classifying damage by means of artificial vision systems (Diaz et al., 2000, 2004; Mateos et al., 2005; Barreiro et al., 2003) compared to selection by hand. In the case of table olives, these are the most important factors to take into consideration in introducing a mechanical harvesting system. Harvesting efficiency and the percentage of olives that fall following mechanical vibration, the arrangement of drupes and their position on the branches become secondary in importance, while they are indispensable in the harvesting of olives for the production of oil. At the base of the introduction of machinery is undoubtedly the high cost of labor, which is further aggravated by a shortage of workers. However, at present there is no alternative to the system of harvesting table olives by hand and consequently when profits are unsatisfactory the product is destined to the production of oil. Thus these two factors have caused certain producers to invest in the research and development of mechanical olive harvesting systems. The issues involved, which must be addressed with the highest priority, are connected to the damage inflicted by the movement of the working organs, the material with which they are covered and their shape. This work thus has the purpose of evaluating damage produced by a labor-saving machine (comber) on table olives according to the following points: a) the best thickness for the protection of the working organs used (teeth); b) the working parameters: velocity, thickness and distance**,** with the three types of combers compared to that having a thickness of 1 mm; c) classification of the damage produced on the drupes by the plastic material used to protect the teeth of the comb.

Materials and methods

Characteristics of the experimental field, sampling of biological material and determination of damage during harvesting

The farm where the experimental field was located was in the place known as "Mes'e Rios" at approximately 40 km from the Department of Agricultural Engineering of the University of Sassari. It consisted of an overall surface area of six hectares planted exclusively with olive trees with a two-fold attitude or destined for processing as table olives exclusively. The "Manna" variety occupies approximately one hectare of the overall area. The trees are of the same age (5 years) with an estimated production per plant between 5 and 8 kg and reach a maximum height of 2.5 m, suitable for hand

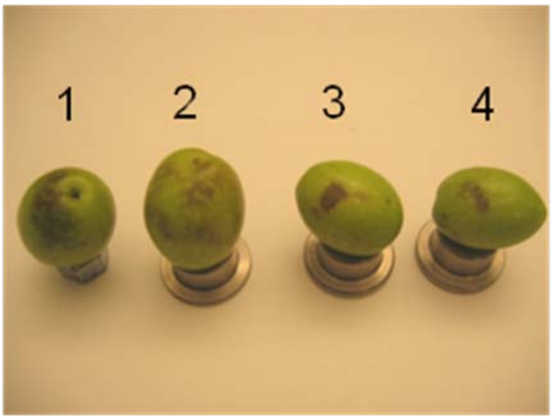


Figure 2. Example of damage caused by the Olivella Pick-Machine

picking. Overall, 36 olive trees were sampled and from each of these 4 kg of olives were harvested, following which the parameters necessary for their classification according to the COI (COI/OT/NC no. 1 December 2004) standard were determined. All the olives gathered were selected by hand and the following were determined: number per kilo, the percentage of healthy drupes, the percentage of those with biological damage (FAO 1987, USDA 1967), of those with rubbing damage (drupes that could be processed and with slight oxidation) and those that could not be processed due to excessive oxidation caused by striking with the comb or by slight injuries caused by striking the collecting boxes.

Table 1. Attributes of the screening design.

Number of experimental factors: **3**				
Number of responses. **1**				
Factors	***High***	***Low***	***Unit***	***Continuous***
Velocity	-1.0	1.0	rpm	Yes
Thickness of protection	-1.0	1.0	mm	Yes
Distance between teeth	-1.0	1.0	mm	Yes
Responses				
Damage				

Table 2. Experimental tests performed with different velocities, thicknesses and distances between teeth.

Test	Block	Replication		Velocity (rpm x 10^3)	Thickness (mm)	Distance (mm)
		Plant	Plant			
1	1	1	2	2	7	2
2	1	1	2	4	19	2
3	1	1	2	4	7	6
4	1	1	2	2	19	6
5	1	1	2	3	14	4
6	1	1	2	3	14	4
7	2	1	2	4	7	2
8	2	1	2	2	19	2
9	2	1	2	2	7	6
10	2	1	2	4	19	6
11	2	1	2	3	14	4
12	2	1	2	3	14	4

The mechanical damage caused by machine harvesting consisted of impact damage as defined by Moshenin (2000) for fruits harvested with mechanical systems and classified into four types (Fig. 2): (1) drupe-drupe rubbing following vibration; (2) drupe striking drupe; (3) comb tooth striking the drupe and (4) drupe striking the collector box. To better define the origin of impacts (with the collecting box, random rubbing or contact with the comb teeth) and the area of contact between the machine and the drupe the olives were exposed to air in the twenty-four hours following picking so as to favor the appearance of non-enzymatic oxidation phenomena caused by the different kinds of impacts described above. The experimental screening design was obtained with "Statgraphic centurion XV" software (Statpoint Inc.) using a factorial in two blocks ($2^{\wedge 3}$) and with an experimental design that called for the use of three factors (velocity, thickness and distance between teeth) and a single response (damage) according to the combination shown in Tables 1 and 2.

Characteristics of the pick machine (Olivella MINI 105 C) used in the experiments.

The labor-saving machine produced by the COIMA Italy srl, company consists of a narrow, light comb with eleven undulating titanium teeth having a diameter of 4 mm protected with a silicon cover having a thickness of 1 mm. For the experiment the silicon cover was modified and the teeth were covered with vulcanized rubber having thicknesses of 3, 10 and 15 mm (Fig. 3).

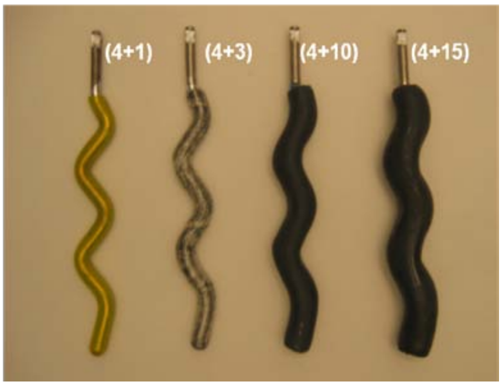


Figure 3 Modified titanium combs with different thicknesses (mm).

The pick machine is driven by a battery-powered (12 V) electric motor with a consumption of 5 Ah/h. The electric comb has a width of 17.5 cm and a varying number of teeth were inserted, from a maximum of 10 with the 1 mm silicon protection to a minimum of 6 in the comb with the vulcanized rubber protection with thicknesses of 3, 10 and 15 mm (Fig. 4).

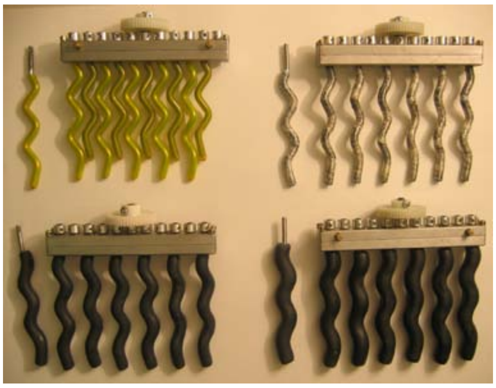
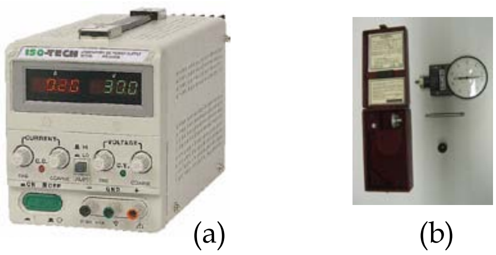


Figure 4. The complete combs with the different thicknesses used.

The electric motor of the Olivella MINI 105 C was powered by a portable generator and connected to a power source (ISO-Tech) (12V, 30 A) for regulating the number of rpms of the teeth around their rotation axes, while the number of rpms was determined by means of a DEUMO 2 mechanical tachometer by varying one of the two units of measurement (V, A) (Fig. 5 "a" and "b").



(a) (b)

Figure 5. The ISO-Tech power supply (a) and the DEUMO 2 mechanical tachometer (b).

Results and discussion

Product calibration

The 24 samples collected were classified according to the COI standards for table olives with the different teeth used, and of these, 12 belonged to the calibre 11 class (54%), 10 to class 12 (42%) and only two belonged to the classes 10 and 14 (4% respectively). On the basis of the number of fruits per kilo, the drupes had medium to large sizes with a number of drupes per kilo between 181 and 200 (classe 11) and 231 to 260 (class 12) as shown in

These sizes are the most suitable for processing as table olives since as is known, consumers prefer olives with these size characteristics and with an average weight between 3 and 5 grams. In fact, the average weight of 100 olives in the two replications varied from a minimum of 3.66 g of sample 5 of replication no. 1 to a maximum of 5.51 g of sample 9 of replication 2. The percentage of drupes below size was negligible, about 2%, in almost all the samples collected and in any case this small percentage was not discarded, but was destined for processing in brine.

Table 3. Samples, size class and average weight of drupes collected in the two replications

Test number	Sample	Manna	Manna size class		Manna Average weight	
	Replication 1	Replication 2	Replication 1	Replication 2	Replication 1	Replication 2
	no. of olives/kg	no. of olives/kg	class	class	G	g
1	217	222	11	11	4.75	4.50
2	249	237	12	10	4.50	4.83
3	215	208	11	11	5.00	5.10
4	242	214	12	11	4.33	4.67
5	300	238	14	12	3.66	4.20
6	204	201	11	11	4.92	5.03
7	252	231	12	12	4.10	4.33
8	242	243	12	12	4.24	4.12
9	232	208	12	11	5.40	5.51
10	202	209	11	11	5.00	4.78
11	191	232	10	12	5.55	5.30
12	217	222	11	11	4.37	4.44

Evaluation of damage caused by mechanical harvesting

Harvesting was performed by a single worker who worked for 30 minutes on each plant. The yield was approximately 4 kg of olives per plant. Mechanical damage to the drupes was of two kinds: breakage, cuts, rubbing) externally and mostly enzymatic browning (EB) internally. The browning was directly visible and this made it possible to discard the damaged drupes during the harvesting and selection of the product. Browning takes place in the layers under the skin of the drupes following enzymatic reactions (oxidation of ammino acids by polyphenoloxidasis) when the cell membrane is broken following a mechanical impact.
The factors involved in mecanical damage to drupes depend on the characteristics of the machines used for harvesting and the way they are used, transport and processing of the product. From the tests carried out (Table 4) the number of drupes per kg and healthy drupes varied from a minimum of 761 olives/kg (test 11) to a maximum of 1077 fruits/kg (test 5). The percentage of healthy drupes varied from a minimum of 47.1% in test no. 6 to a maximum of 86.8 % in test no. 8. As can be seen in Table 4, damage is connected with the operating conditions of the picking machine, the variety and the way the machine is handled by the operator during harvesting operations. If we compare the two tests performed with different velocities and kinds of protection, they show an increase in damage of +39.7%, test

2 compared with test 8, while tests 11 and 12 are distanced from the latter by 7.6% and 10.1% respectively. Comparison of tests 8 and 2 (same velocity and protection) shows a decrease of 34.1% in the healthy product harvested. The tests performed with intermediate velocities and thicknesses of protection (tests 5, 6, 11 and 12) show a percentage of healthy product above 70% in the latter three and close to 50% in test no. 5, which is the one with the highest number of drupes per kilo. Damage produced during machine harvesting is summarized in Table 5. Biological damage varied from a minimum of 0.4% in test 11 to a maximum of 3.5% in tests 3 and 9. Classification of biological damage was made on the basis of FAO Directive 1987 and the USDA 1967 classification. For the most part, the olives presented damage caused by external agents such as temperature and humidity ("agostado or wrinkled olives") and damage caused by meteorological phenomena ("granizo or hail-damage") and lastly damage of undefined origin ("molestado or undefined damage") caused by the interaction of different factors. Damage found following the rubbing together of drupes varied from a minimum of 6.9% in test 8 to a maximum of 37.6% in test 6. The high percentage of oxidated drupes was due prevalently to the excessive number of branches on the trees and thus to involuntary impacts between drupes during harvesting. Damage produced by impacts against the collecting boxes (wounds) was 0.3% in test 8 and 3.6% in test 10. The reduction of this kind of damage, caused prevalently by the high kinetic energy reached by the fruits during the vibration and detachment stages, may be obtained by devising and adopting specific interception systems for use in combination with the harvesting machine so as also to improve the working capacity of the operators. Finally, oxidation due to impacts with the harvesting system (combs), varied from a minimum of 3.5% in test 8 to a maximum of 20% in test 2. The reduction of contact damage is possible by varying the thickness of the protection of the teeth, but also by varying their rotation velocity. Test 2, with a rotation of 2 x 10^3 rpms and the maximum tooth protection (19 mm), had the highest percentage of impact damage.
The causes of damage are mainly three: the highest number of fruits per kg, the highest average weight and size of the drupes which, during the combing of the plant, strike the others or are pressed while passing through the interaxes of the working organs. The total of drupes that could not be processed was minimum in test 8 (3.8%) and maximum in test 2 (21.7%). Considering all the tests carried out, as many as five presented a percentage of drupes unsuitable for processing below 10% while the remaining ones were between 13% and 20%.

Conclusions

In conclusion, it can be stated that the screening test performed to establish the best operating conditions for the harvesting of table olives with a picking machine, the best rotation velocity and protection, has produced encouraging results. The test showing the lowest level of damage was test 8 with a rotation velocity of 2 x 10^3 rpm and with a protection thickness of 19 mm. The tests performed with a velocity of 3 x 10^3 rpm and a thickness of 14 mm show a good performance with damage percentages between 8% and 13%, but in any case they were worse than all the other tests carried out. The system for protecting the teeth can be further improved by using other kinds of plastic materials, while for the system of interception specific solutions that call for either the use of an under canopy system or one brought directly by the operator are being studied.

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Table 4. Samples collected, velocity and thickness of protection, number of drupes per kg and percentage of fruits suitable for processing in the samples collected.

Samples	**Velocity**	**Thickness**	**Total fruits Average (1st and 2nd test)**	**Healthy fruits Average (1st and 2nd test)**
	(rpm x 10^3)	(mm)	**no.**	**(%)**
1	2	7	876	76.7
2	2	19	912	52.7
3	2	7	822	66.3
4	4	19	912	68.6
5	3	14	1077	70.5
6	3	14	806	47.1
7	4	7	967	54.4
8	2	19	970	86.8
9	2	7	794	66.3
10	4	19	822	54.2
11	3	14	761	79.2
12	3	14	910	76.7

Table 5. Rotation velocity, thickness, type and percentage of damage produced in the operating conditions and with the teeth used during the harvesting of table olives.

Test	**Tooth rotation velocity (rpm x 10^3)**	**Thickness of protetion of teeth (mm)**	**Healthy drupes (%)**	**Damage**				
				biologic	**rubbing**	**Impact against box (wound) (unsuitable for processing) (a)**	**Impact against teeth (oxidation) (unsuitable for processing) (b)**	**Damage on the drupes unsuitable for processing (excessive oxidation + wound) (a + b)**
				(%)	**(%)**	**(%)**	**(%)**	**(%)**
1	2	7	76.7	3.2	10.4	0.8	8.9	9.7
2	2	19	52.7	1.1	21.1	1.7	20.0	21.7
3	2	7	66.3	3.5	12.3	1.0	17.1	18.0
4	4	19	68.6	1.4	16.6	1.2	12.1	13.3
5	3	14	70.5	0.6	20.7	2.5	5.8	8.2
6	3	14	47.1	1.9	37.6	3.3	10.0	13.3
7	4	7	54.4	3.4	28.4	1.0	15.5	16.5
8	2	19	86.8	1.6	6.9	0.3	3.5	3.8
9	2	7	66.3	3.5	12.3	1.0	17.1	18.0
10	4	19	54.2	0.8	27.6	3.6	13.9	17.4
11	3	14	79.2	0.4	11.2	1.1	8.8	9.9
12	3	14	76.7	3.0	11.0	1.6	7.9	9.0