DEVELOPMENT OF BELT GRADING MACHINE FOR OLIVE FRUIT

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ABSTRACT

Grading of olive fruits is important for export and local marketing. Grading parameters were length, width, thickness, and weight of olive. The mechanical grading, reduce the period needed to sort the olive varieties compared to manual grading, and the olives price depend on its size.

The Belts grading machine for olive fruits was manufactured, and installed at the Agricultural, Engineering Department, Faculty of Agriculture, El-Mansoura University. However, the experiment was carried out at Kafr-Awd, Aga, Dakahlia Governorate. The machine was tested in grading of Agize, Manzanillo and Picual olive varieties. Grading was based on olive parameters such as (dimensions of fruits and mass) and machine parameters conditions (belts speed m /s, grading unit slop age, Rad. and olives feeding rate g/s).

Result indicated that the maximum grading efficiency of olive varieties Manzanillo, Agiza and Picual, it was 93 %, 92 % and 91, %, respectively. These results were obtained at the same operation conditions of feed rate 50 g/s, belts speed 0.110 m/s and tilt angle of -0.035 Rad.).

INTRODUCTION

Olive's varieties are of great nutritional value. They are important sources of carbohydrate, vitamins and minerals. Also, olive is considering one of the main sources of oil. The Cultivated area of olive trees (*Oleo uropea*) increased rapidly in the last decade (Ministry of Agriculture, 1999). The cultivated area of olives reached 1034608 feddan producing about 288.027 metric tons. New reclaimed lands represent 73.47% of total production area in Egypt, and 70.34 % of total production.

Grading is defined as the process, which separated the fruits into different sizes based on their dimensions, volume and weight according to the standards or marketing requirements. Grading of size and quality of fruits is important for export and local marketing and for price determination. There are two methods of olive fruits grading like manual or mechanical grading. Mechanical grading was classified based on the difference in physical characteristics such as length, width, thickness, and weight. The mechanical grading was expected to reduce the period needed to sort the olive varieties compared to the manual one. Many types of machines were available for grading fruits and vegetables, but most of them are expensive for farmers and small factories of olives.

O'Brien *et al.* (1983) concluded that sizing operations involve passing the fruits over diverging belts having holes, wire mesh belting, and drop roll size. The belts with holes and the wire mesh sizes separate the fruit into two sizes while the others provide up to five or six sizes by gradual

widening of the sizing members that support the fruit. The small fruit fall through first, then the successively lager ones. Each size is carried to the side by belt conveyors that deliver them to containers. Sorting for quality may be done following sizing. Sorting is usually done at this point by hand to discard culls. Chen. *et al.* (1988) studied a muskmelon sorter machine. Improvements on spiral-roller type sorters and a nylon brush-roller type cleaning sorter and their effect on grading different Muskmelon shapes were studied. Experiments showed that it had a sorting capacity of 5.5 ton/h ($\approx$ 90% accuracy), and almost zero damage. Nevkar,Gs and kanawade (1996) reported that a divergent roller-type fruit sorting machine was developed in 1991 and tested for its capacity and separation efficiency performance for lemon and sapota (Manilkara zapota) fruits. The machine parameters tested were roller speed, inclination of roller and gap between diverging rollers. The maximum sorting capacities of 1140 and 1531.9 kg/h were achieved, respectively, for lemon and M.sapota respectively. While the maximum separation efficiencies for lemon and M. sapota fruit were 84.7 respectively. The overall separation efficiency of the machine was 69.1%.

The main objective of the present study was to develop and evaluate performance of belt grading machine to grade olive varieties of Agize, Manzanillo and Picual. This objective was achieved by studying the following:

1-Some physical and mechanical properties of three different Egyptian olive varieties (Agize, Manzanillo and Picaul).

2-Develop Belts grading machine suitable for different varieties of olives.

3-Test and evaluate the performance of the Belt grading machine under different operational conditions.

4-Cost analysis proposition for the Belts grading machine.

MATERIALS AND METHODS

The present study was carried out at Kafr-Awd, Aga, Dakahlia Governorate. The experiment was divided into two main stages.

The first stage included the study of some physical properties (shape size, mass, volume, and bulk density), and mechanical properties (rolling angle, repose angle and firmness) to determine the basic standards for developing Belt grading machine for olive fruits. Three varieties of olive fruits were used in this study, which were Agize Manzanillo, and Picual. The olive fruits were obtained from Qaroon, Fayoum Governorate during the harvesting season (August/September) of 2002 and 2003.

The second stage of experiments was to test and evaluate the performance of Belts grading machine. The Belt machine was operated under different operational conditions as follow:

1. Liner speeds were selected by a primary experiment on the belts grading machine at the speeds of 0.0471, 0.79, 0.11, and 0.142 m/s.

2. Tilt angles were selected by a primary experiment too and they were, -0.035 (upward), 0, 0.035, and 0.070 radians.

3. The feeding rates were 50, 200, 150, and 200 g/s.

4. All treatments were carried out using constant length of grading unit of 600 mm.

A schematic diagram of the prototype of the grading machine is shown in Fig.1.

1. Electric motor
2. Drive pulley
3. First grade outlet
4. Second grade outlet
5. Third grade outlet
6. Feeding hopper
7. Roller bearing
8. Roller
9. Tension unit
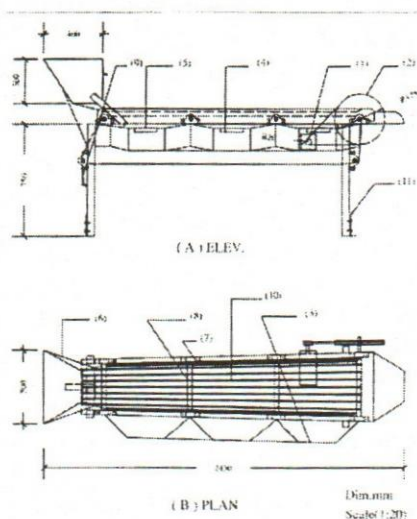10. V-belt
11. Stand mover

Figure 1: Schematic diagram of prototype belts grading machine

The grading mechanism used to grade the fruit according to size, from small to large based on the smaller diameter of olive. The grading mechanism consists of a set of seven belts (1.3×457.8 cm). Belts were placed on groves that were cut in each roller such that each two adjacent groves were having bigger distance in between as olive move forward. Consequently, the smaller diameter olive would fall first. The grading machine was provided with four receiver boxes three of which were placed under the three belt sectors, and the fourth is placed under the rear end of machine to receive the rest of the olives.

A 0.25Kw and 220 volts electrical motor with suitable transmission system was used to drive the grading machine at a speed of 300 r.p.m.

Physical properties

Physical and mechanical properties of olive fruits were determined based the shape and size, mass, actual volume, and density of olive fruits.

One hundred olive fruit sample was taken randomly from the three varieties under study. The shape of each variety was studied in terms of length (L) and diameter (d) by using sliding caliper (± 0.05 mm). The obtained data were used to calculate the shape index (s.x.=L/d) of each sample according to IOOC, 2000.

Shape index values less than 1.25 was considered spherical. However, shape index values from 1.25 to 1.45 ovoid, otherwise, the shape was considered as elongated.

The average weight of each individual olive was obtained by weighing 100.

The actual olive fruits volume was measured by using 100cm^3 capacity graduated beaker. The graduated beaker was filled with water to a certain level, and then the olive was completely immersed in the beaker using a pen and a thread. The actual olive volume was obtained based on the displacement of water for each fruit. Real density of the fruit was calculated using the equation (D=Mass/Volume) of Buyanov and voronyk (1985).

Mechanical properties

Rolling angle was measured by using an inclined plane with two types of surfaces (steel and rubber) and two positions. Position "A" in which the long axis of fruit was laid parallel to the direction of motion, while in position "B" the long axis of fruit was laid perpendicular to the direction of motion. By placing the fruit on the horizontal surface of the inclined plane one by one and gradually increasing the angle of surface inclination, the fruit began to roll, and that angle was considered as the rolling angle of the fruit (Buyanov and voronyk 1985).

Repose angle was measured by using a rectangular box (40 × 40 × 60 cm^3), which was kept in the vertical position and the free surface of the fruits was leveled .The box is gradually tilted into the horizontal position .Then the free surface of the olive fruit makes an acute angle with respect to the horizontal position. Repose angle was estimated by measuring the angle between the free surface and the horizontal plane.

Fruit firmness was estimated by applying a force to each sample of the investigated varieties by using a portable hand tester (hardness tester. No 174806) Fruits were pressed by the end of the tester (diameter 5mm); meanwhile the analog reading was increased with increasing the pressure of the fruit until the fruit is cracked. At this point the analog reading was considered as fruit firmness.

Machine performance

The grading efficiency was calculated by classification of olive fruits into three categories (15 to 18, 18 to 21 and 21 to 26 mm). The grading efficiency was determined according to Amin, 1994.

$$\eta = \frac{M_1}{M} x100 \qquad\qquad 1$$

Where:

η = Grading efficiency of fruits, %;

M_1 = Mass of the classified fruits for each outlet (kg).

M = Total mass of fruits for each outlet in the machine in kg.

The total efficiency of the machine was calculated using the following equation:

$$\eta = \frac{M_1 + M_2 + M_3}{M} x100 \qquad\qquad 2$$

Where:

η = Total grading efficiency of the machine, %

M= Total mass of fruits for all outlets in kg.

$M_1 + M_2 + M_3$ = Masses of the classified fruits for first, second, and third outlets.

Grading capacity

The grading capacity was calculated according to the equation **Amin**'s equation, **1994,** as follows:

$$C = \frac{M}{T_G} x60 \qquad\qquad 3$$

Where:

C = Grading capacity of the machine (kg/ hr);

M = Mass of classified fruit (kg);

T_G = Grading time (min).

The mechanical damage was considered as the visible damage to human eyes after each pass of the olive fruits through the grading machine. The tested samples were marked and stored for one day in a refrigerated room to examine the damage.

The consumed power (kW) was estimated by using the sup clamp meter-300k to measure the line current strength (I) and the potential difference value (V), that were used to calculate the total consumed power and the useful power according to Platezehiem, 1979.

Fixed costs (deprecation, interest on investment, housing, insurance and taxes) and running costs (repair and maintenance, electricity, and labor) are the major capital input for most farmers. Grading cost in L.E./h or in L.E./ton for the proposed grading machine was estimated according to the Ministry of Agric., 1995.

RESULTS AND DISCUSION

1.Physical properties of fruits

The relationships between mass of olive varieties, length and diameter were studied and the data were analyzed. Results showed a positive linear relationship between mass and the above mention parameters as shown in Figures 2 and3, respectively. The obtained equations relating mass and length, mass and diameter and mass with length and diameter are listed in tables 1, 2 and 3.
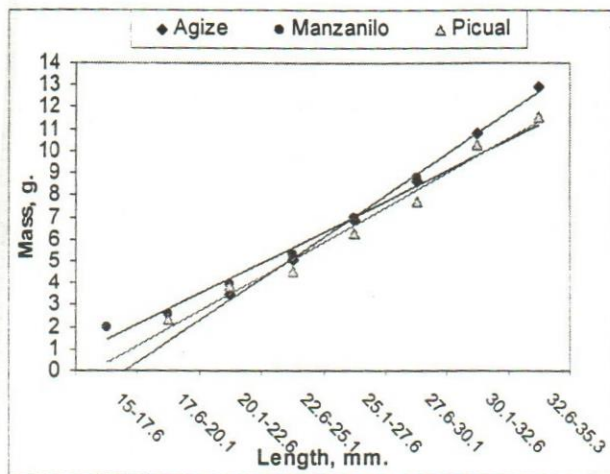
Figure 2: The relationship between mass and lengths of olive varieties.

Table 1: Equations relating mass and length and R^2 for olive varieties

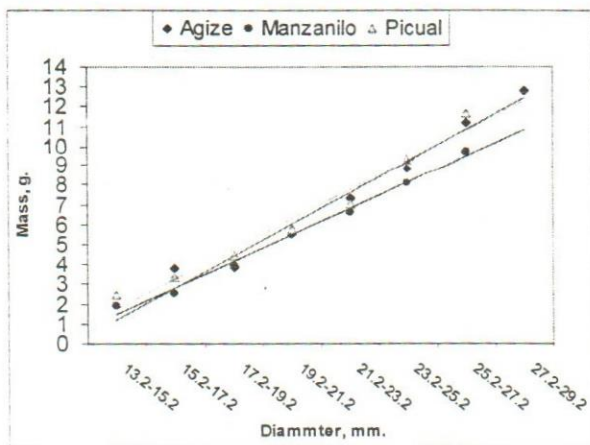| Relation	Varieties	Equations	R^2
Fruit mass and length.	Agize	M = 0.7403 L -13.617	0.9974
	Manzanillo	M = 0.5557 L - 8.3258	0.982
	Picual	M = 0.6213L - 8.3258	0.98

Figure 3: The relationship between mass and diameter of olive varieties.

Table 2: Equations relating mass and Diameter and R^2 for olive varieties

Relation	Varieties	Equations	R^2
Fruit mass and Diameter	Agize	M = 0.8027 D - 10.991	0.9732
	Manzanillo	M = 0.6675 D - 8.6781	0.9921
	Picual	M = 0.753 D - 9.6601	0.9668

The relationships between volume, length and diameter of olive varieties were studied and analyzed. Results showed a positive linear relationship between volume and previously mentioned parameters as presented in figures 4 and 5 respectively. The attained equations relating volume and length, volume and diameter and volume with length and diameter are listed in tables 3, 4, 5.
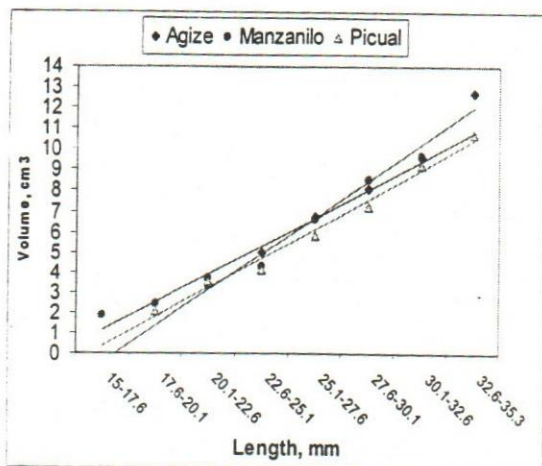

Figure 4: the relationship between volume and length of olive varieties.

Table 3: Equations relating mass, length and diameter and R^2 for olive varieties

Relation	Varieties	Equations	R^2
Fruit mass, length and Diameter	Agize	M = 2.677L + 6.2D -13.683	0.9732
	Manzanillo	M = 2.018L + 4.273D – 8.275	0.981
	Picual	M = 2.745L + 5.08D – 11.311	0.9668

Table 4: Equations relating volume, length and R^2 for olive varieties.

Relation	varieties	Equations	R^2
Fruit volume, and length	Agize	V = 0.7027 L - 12.718	0.9849
	Manzanillo	V=0.5661 L - 8.996	0.9604
	Picual	V= 0.5969 L - 10.478	0.9763

Table 5: Equations relating volume, diameter and R^2 for olive varieties.

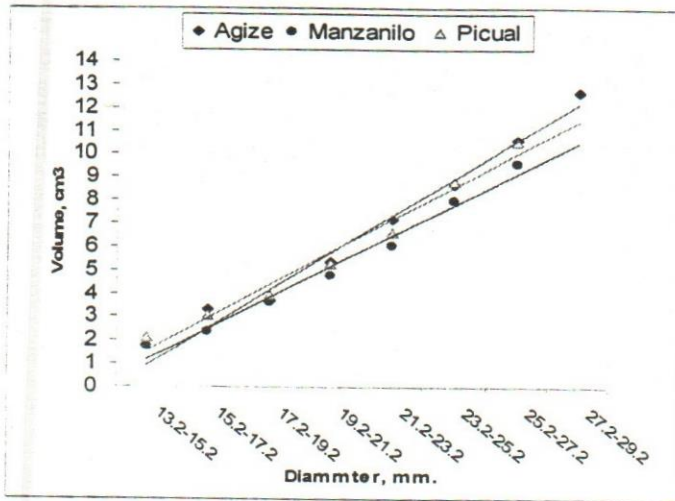| Relation	varieties	Equations	R^2
Fruit volume and diameter.	Agize	V = 0.8048D - 11.309	0.9815
	Manzanillo	V=0.6627 D - 8.8759	0.981
	Picual	V= 0.7009 D - 9.0732	0.974

Figure 5: The relationship between mass and lengths of olive varieties.

Table 6: Equations relating volume, and both length and diameter and R² values for olive varieties.

Relation	varieties	Equations	R²
Fruit volume, length and diameter.	Manzanillo	$V = 1.381 L + 5.184D - 8.36$	0.973
	Agize	$V = 2.62 L + 6.417D - 14.081$	0.952
	Picual	$V = 2.745 L + 5.08D - 11.311$	0.958

The relationships between mass of olive varieties and volume were studied and analyzed. Results showed a positive relationship between mass and volume as presented in Figure 6. Regression analysis was carried out and equations relating volume and mass are demonstrated in table 7.
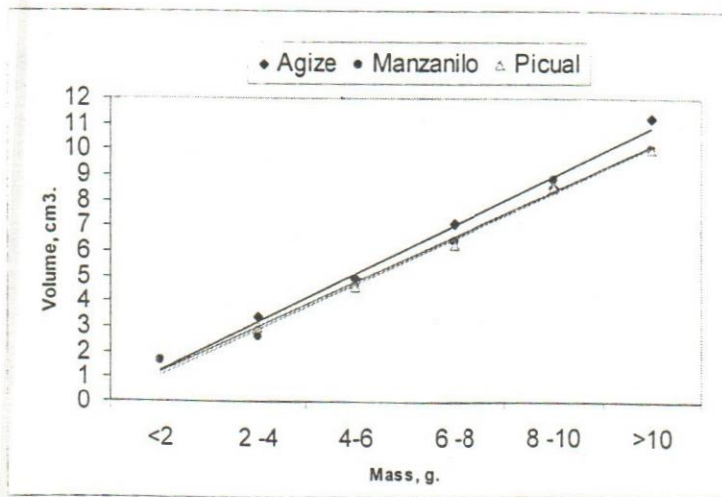

Figure 6: the relationship between volume and mass of olive varieties.

Table 7: Equations relating volume and mass and R² for three olive varieties under study.

Physical Properties	varieties	Equations	R²
Fruit volume and mass	Agize	V = 0.717 M + 0.8638	0.9788
	Manzanillo	V = 0.6987 M+ 0.4398	0.9412
	Picual	V = 0.6528 M+ 0.8601	0.9379

2. Mechanical properties

a. Repose angle

The highest values of repose angle were 31.3, 30.38 and 32.56 degrees for Agize, Manzanillo, and Picual varieties, respectively. The surface roughness, shape and size of olive varieties played important roles on repose angle values.

b. Rolling angle

The maximum values of rolling angles for rubber surface were 14.1 and 7.45, degree for Picual variety at positions A and B, respectively. The corresponding values for steel surface were 12.38 and 6.59 degrees for positions A and B, respectively. Also lower rolling angle was obtained for Agize and Manzanillo varieties.

c. Firmness for olive fruits

The average values of firmness for the different olive varieties were determined. The mean values of firmness force were 1.25, 0.704 and 0.705, N/mm² for olive varieties Agize and Manzanillo and Picual, respectively. In other words, the highest average firmness value was attained with Agize olive variety.

3. General evaluation of the grading machine

The grading machine was tested for grading efficiency for grading the previously mentioned olive varieties. The results could be discussed as follows:
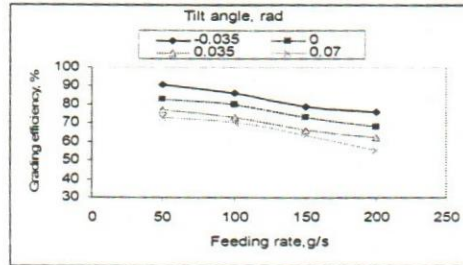
a. Efficiency of belts grading machine

The maximum grading efficiencies of olive varieties Manzanillo, Agiza, Picual, were 93 %, 92 % and 91, %, respectively.   These results were obtained at the same operation conditions; feed rate of 50 g/s, belts speed of 0.11 m/s and tilt angle of -0.035 Radians for the three olive varieties. It was apparent that grading efficiency was maximized at a tilt angle of -0.035 Rad. and a speed of 0.110, m/s. The direction of movement of olives might have been against the grading surface inclination that might lower the rolling speed of olives on the grading belts. Consequently, a high chance was given to the olive fruits to fall in between the grading belts. As a result, a good chance of separation of different olive sizes was attained, consequently, the grading efficiency increased, Figure 7.
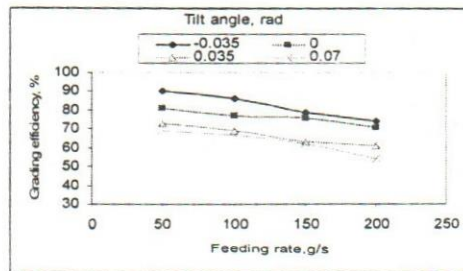
Manzanillo
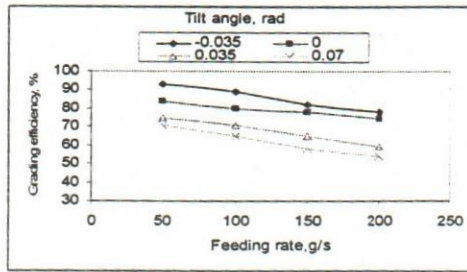
Agize

Picual

Figure 7: Effect of tilt angle and feeding rate on grading efficiency at speed 0.11 m/s for olive varieties.

b. Capacity of grading machine

The average grading capacity of the three varieties was 180 kilogram per hour at optimum operation conditions.

c. Power consumption

The calculated power consumed by the belt grading unit was 0.215 Kw.h. for the olive varieties; Manzanillo, Agize and Picual. This power was measured at the optimum operating condition.

d. Mechanical damage for olives

Mechanical damage results indicated negligible values for all olive varieties under investigation for different operational condition.

4. Cost analysis

From the economic view point, the use of any machine usually depends upon its purchase price, labor and working capacity. The use of belts grading machine was evaluated and costs were summarized in table 8.

Results indicated a relatively low grading cost for each ton of olive fruits compared the exported grading machines.

Table 8: Cost analysis for a belt grading machine.

Item		costs
Fixed costs	Deprecation and interest costs, L.E / year.	108
	Housing and insurance costs, L.E / year.	51.6
Total Fixed costs L.E / year.		159.6
Total Fixed costs L.E / h.		0.2
Running cost	Repair and maintenance costs, L.E / h.	0.135
	Energy (electricity) costs L.E / h.	0.0301
	Labor costs L.E / h.	0.75
Total running costs L.E / h		0.929
Total costs L.E / h		1.115
Total grading costs of olive varieties in L.E / ton.		6.28

CONCLUSION

The mass, length and diameter of olive fruits were positive related. As well as, the volume, length and diameter were positive related. A positive relationship was found between mass and volume of olive fruits.

Grading efficiency increased with increasing tilt angle and decreasing feeding rate at a speed of 0.047 m/s. Also, grading efficiency increased with increasing tilt angle to 0.035Rad and then decreased at a tilt angle of 0.07 Rad. and a speed of 0.079 m/s. Grading efficiency increased with decreasing tilt angle to -0.035 and with decreasing feed rate at speeds of 0.11and 0.14 m/s.

The maximum grading efficiencies of Manzanillo, Agize and Picual olive varieties were 93%, 91 % and 90%, respectively. These results were obtained at feeding rate of 50 g/s, belts speed of 0.110 m/s and tilt angle of - 0.035 rad.

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ويلهم بلاتزرهتيم (١٩٧٩) الرياضة الفنية للكهرباء مجموعة كتب الكهرباء – الناشر الجهاز المركزى للكتب الجامعية – مطابع شركة الإعلانات الشرقية.

التعداد الزراعى، نتائج التعداد الزراعى عن السنة الزراعية (١٩٩٩). ادارة التعداد الزراعى _ وزارة الزراعة المصرية_ الدقى.

تطوير ماكينة ذات السيور لتدريج الزيتون

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تعتبر عملية تدريج الزيتون من أهم العمليات اللازمة للحفاظ على جودة ونوعية المنتج النهائي سواء فى حالة إعداده للتصدير أو الاستهلاك المحلي. حيث تتوقف جودة المنتج بعد عملية التصنيع على الفترة الزمنية من الحصاد إلى التدريج ثم التصنيع وكذلك تعتمد القيمة السعرية على مدى تساوى أحجام للثمار داخل العبوة الواحدة سواء كان للتصدير أو الاستهلاك المحلى.

وذلك يهدف البحث إلى تطوير آلة التدريج ذات السيور لثمار الزيتون لتلائم المزارع الصغيرة وكذلك المعامل الأهلية الصغيرة.

وقد تم تجربة آلة التدريج ذات السيور على ثلاث أصناف من محصول الزيتون (مانزانيللوا – عجيزى – بيكوال) ودراسة تأثير كل من أربع سرعات و أربع معدل التغذية و أربع ميول لوحدة التدريج على كفاءة التدريج.

ومن الدراسة تم الحصول على النتائج الآتية:

ب-مواصفات التشغيل للآلة ذات السيور:

كانت أقصى كفاءة تدريج للثلاث أصناف ٩٣% ، ٩١% ، ٩٠% على التوالي عند معدل تغذية ٥٠جم/ث، وسرعة ٠,١١ م / ث ، زاوية ميل،- ٠,٠٣٥ زاوية نصف قطرية.

ج-التلف الميكانيكي للثمار:

لم يحدث أى نوع من التلف الميكانيكي للثمار أثناء عملية التدريج.

د- الطاقة المستهلكة في التشغيل:

بلغت الطاقة الكهربية المستهلكة ٠,٢١٥ كيلو وات / الساعة

ه- الإنتاجية الكلية للآلة والتكاليف:

١-بلغت الإنتاجية للآلة عند معاملات التشغيل الموصى بها ٠,١٨٠ طن/ ساعة .

٢- تكلفة إنتاج الطن الواحد ٦,٢٨ جنيه مصري.