DEVELOPMENT AND PERFORMANCE EVALUATION OF OLIVE GREADER

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ABSTRACT

Grading of fruits and vegetables is an important operation affecting quality, handling and storage of produce. Manual grading is costly, time-consuming and inefficient. The food industry relies on a rapid and accurate separation and classification of fruits immediately after harvest before spoilage fruits in this study developed a simple prototype machine for olive fruit separation with a small cylinder type grading machine. Two operating parameters each of four levels were studied. The studied parameters included, riddle revolving speed 25, 40, 55 and 70 rpm (0.366, 0.471, 0.576, and 0.680 m/s), and riddles feeding rates (50, 70, 90 and 110 kg/h). The effect of machine parameters on grading efficiency (%), grading productivity (kg/h) and the mechanical damage percentage, were also considered. Results showed that the machine is quite successful for grading Olive fruits. The best result was obtained at 55 rpm riddles revolving speeds and 90 kg/h riddles feeding rate. At these values, maximum grading efficiency of 93.92% and permissible mechanical damage of Olive fruits 3.42% were obtained. These results proved that, the proper operating parameters corresponded with theoretical considerations as the relevant for machine operation.

INTRODUCTION

Olive is one of the economic crops that have multiple purposes and widely grown in Egypt, and it has a very high potential for exportation. In Egypt, the cultivated area of Olive crop is 227683 feddans, which annually produces over 698927 million tones **(Ministry of Agric. and Land Reclamation, Economic Affairs Sector, 2015).** Losses in quantity and quality affect on horticultural crops between harvest and consumption. The magnitude of postharvest losses in fresh fruits and vegetables is an estimated 5 to 25 % and 20 to 50 % in developing countries, depending up on the commodity.

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To reduce these losses, producers and handlers must understand the biological and environmental factors involved in deterioration and use post-harvest techniques that delay senescence and maintain the best possible quality. Fruit processing in the fruit industry is highly sensitive to time and speed. Thus, it is of great importance to select and separate fruits rapidly after harvest. The mechanical grading, reduce the period needed to sort the olive varieties compared to manual grading, and the olives price depend on its size. Some attempts were carried out to evaluate the available grader for Olive and other crops under Egyptian conditions. Mechanized grading is not only to replace the manual work by mechanical grading but also to adapt systems, which may help growers and market dealers to determine their prices in an accurate and accepted way to the consumer. In other words, the cheapness and simplicity of these machines would encourage the farmers to grade Olive fruits for obtaining a uniform fruits category to suite different needs. **Liza and Kader (2003)** showed that the size grade of an item might be determined by one, two or three linear dimensions or its mass (weight). Single dimension is determined by the minimum distance apart of a pair of parallel bars between which the produce can pass. Two dimensions are determined by the distance between the sides of a square hole or diameter of a circular hole, through which the product can pass. Inclination is normally set to 10°, but some machines allow this to be adjusted to suit crop flow characteristics. **Mostafa (2003)** developed and fabricated an appropriate system for grading bulbs by size. He showed that, the optimum operational conditions at 0.23 m/s and zero longitudinal angles achieved maximum grading efficiency of (94.9 %) for Olive variety. While, **Genidy (2003)** concluded that the machine grading capacity increased by 22.2 % when the cylinder speed of feeding cells was increased from 10 to 40 rpm (0.11- 0.42 m/s) at different levels of tilt angles during grading the muskmelon. **Abd El-Rahman (2004)** adapted a portable shaker type-grader to suit grading of bulbs. He found that, the best result was obtained at bulbs feeding rate of 800 kg/h and oscillation levels of 30 osc./s for the grading unit. At these levels, 94.57% grading efficiency and 3.69% mechanical damage were obtained. **EL- Sheikha *et al*. (2004, a and b)** manufactured, and tested a cylindrical grading machine for olive fruits. The machine was tested in grading of Agize, Manzanillo and Picual olive varieties. The grading efficiencies of all the olive fruit varieties under study increased with increasing the length and decreasing the tilt angle of grading mechanism. Results indicated the maximum grading efficiencies were 94 %, 92 % and 91 % for, Manzanillo, Agiza, and Picual olive varieties, respectively. These values were obtained at grading cylinder length of 600-mm, cylinder rotating speed of 8 rpm, and grading cylinder tilt angle of 0.0175 rad. Also, the belts grading machine for olive fruits was manufactured, and tested in grading of some olive varieties. The machine parameters was (belts speed m /s, grading unit slop age, rad., and olives feeding rate g/s). They concluded that the maximum grading efficiency of olives under study, ranged between 91 and 93 %. These results were obtained at operation conditions of feed rate 50 g/s, belts speed 0.11 m/s and tilt angle of 35º. **Stanley and David (2004)** showed that sorting and grading olives are more desirable for processors than delivering the olives "as is" off the orchard. With sorting and grading the expectations are that the batches will: be of single variety; be of uniform size, and have no leaves, small, defective or damaged olives. Sorting and grading can be undertaken by hand or by machine. Olives can also be damaged during any vigorous grading procedures so appropriate precautions must be taken. Injuries such as bruising, when the olives pass through mechanical sorters and graders, can lead to the formation of brown spots, gas pockets or blisters during processing. **Kerry (2005)** showed that the base of grading Olive fruits depends on weight or size. Hence, identifying fruits properties is meaningful to design special grading machines and to determine the operational parameters such as cell shape, drum (sieve) speed and slope of drum axis. From the standpoint of quality pack, it would be desirable to remove the large diameter products first to avoid the damage during handling through each grading unit. Size separation could be made with a screen, chain, holes in belt, cup, roller above a belt, or over a diverging opening, such as made by a roller and spring or two rollers. In more detailed study, **Sibbett and Ferguson (2005)** conducted sizing operations by passing the fruits over diverging belts having holes, wire mesh belting, drop roll sizes, or volumetric size. The belts with holes and the wire mesh sizes separate the fruit into two sizes while the others provide up to six sizes by gradual widening of the sizing members that support the fruit. **Ghuman and Kumar (2005)** studied on development of low cost rotary disc size grader for fruits and vegetables. A low cost, on-farm rotary disc size grader was designed and fabricated for grading spherical fruits and vegetables using rubber balls of different diameters in the laboratory. It was observed that the disc speed of 60- 70 rpm was the most suitable for proper separation of different grades. The grader shall be tested for various fruits and vegetables both in laboratory as well as in the field. **Narvankar *et al* (2005)** a rotating screen grader suitable for fruits like lemon, ber, a onla was developed in to grade the samples in 4 grades. The grader was tested for capacity and optimum grading performance as a function of rotating speed of screen, diameter of screen, exposure length and input each at four levels by using second order response surface design in 80 design points. Capacity of the grader varied from 45 to 327.27 kg/h for lemon, 43.63 to 464.51 kg/h for a onla and 46.75 to 436.36 kg/h for ber. The maximum grading efficiency for lemon, a onla and ber was found to be 79, 93.8 and 97.96%, restively. **Muhammad and Muhammad (2007)** showed that fruit was graded for external characteristics only, by visual examination, this is still the case in many markets where labour is inexpensive. As agricultural labour becomes less available, however, there is a market push to mechanize grading operations. Initially, a local manufacturer of mechanical grading devices served each fruit production region. The technology used was relatively simple, starting with diverging belt devices to sort fruit on diameter, and progressing to cup conveyors able to mechanically grade fruit for weight. **Ukey and Unde (2010)** developed a sapota fruit grader. In order to increase the output of fruit grading and save time and labour, a sapota fruit grader based on divergent roller type principle was designed and developed. The best combination of roller speed, its inclination and roller gap was found to be 223 rpm, 4.5º and 38 to 64 mm, respectively for highest efficiency of 89.5%.The capacity of machine was 1,440 kg h^{-1}. **Abd El-Rahman (2011)** adapted a portable cylinder sieve type-grader to suit grading of onion sets. The optimum operating parameters for the modified grading machine were 55 rpm riddles revolving speeds, and 125 kg/h of riddles feeding rate. At these values, maximum sorting accuracy of 94.34% and permissible mechanical damage 4.66% were obtained for grading of onion sets. **Umari (2011)** designed and evaluate the performance of a mechanical olive size grading system, with three different grading speeds (10, 16, 23 rpm). The results showed that grading accuracy was relatively affected by grading speed and harvesting date. Percent of accurately graded fruits was nearly (95%, 93 %, 90 %) at the first, second, third harvesting date, respectively. **Dattatraya *et al* (2013)** reported that grading fruits is considered very important as it can fetch higher price to the grower. Grading also improves packaging, handling and other post-harvest operations. Grading is basically separating the material in different homogenous groups according to its specific characteristics like size, shape, color and on quality basis. It saves time and energy in different processing operations and reduces the handling losses during the transportation. **Gayathri *et al* (2016)** reported that a manually operated onion grader was designed, developed and evaluated for Rose onion verities into three grades based on geometric dimensions of the selected variety. Experiments were conducted with three types of slopes, at each slope three different feed gate opening lengths and two swing directions. The statistical analysis showed that the standard parameters were slope 4°, length wise swing direction and feed gate at full opening. The grader has a grading capacity 1105 kg/h at overall grading efficiency 75 % and required grading efficiency 75%. **Abdel-Azeem (2017)** designed and fabricated grading machine for sphere like crops using grading belts. The experiments showed that the best working conditions for the machine were 0.20 m/s for fruit feeding conveyor speed, 0.30 m/s grading belts speed and zero degree of grading belts slope angle during oranges grading which produced maximum grading efficiency of 95.8 % and permissible mechanical damage 0.115% for oranges. The main objectives of the study were:

1. Modify and test a simple cylinder riddles type grading machine for olive fruits to produce a uniform fruits suitable for different processing needs.
2. Study the effect of some operating parameters such as, speed of cylinder riddles and feeding rate of olive fruits on the machine

grading efficiency, grading productivity and mechanical damaged percentage.

Theoretical Considerations of the Cylindrical Sieves:

The mix of olive fruits is delivered from one end of the rotating cylindrical sieve (inclined or horizontal) and tries to reach the other end of the cylinder. During this action, olive fruits located at the lower portion of the cylinder are lifted upward by the screen surface, after which they are again lifted along with it and slide down. They gradually move toward the opposite end of the cylinder. The fruits are in contact with only a part of the cylindrical surface with no relative velocity with respect to it during their lift. The nature of the motion of olive fruits over the surface of a cylindrical sieve depends upon the coefficient of friction on the given surface; the kinematics operating condition is governed by centripetal acceleration $r\omega^2$, the initial conditions of motion of the particles, the point at which they are delivered onto the sieving surface and their initial velocity. Depending upon the relationship between the above factors, the fruits in the cylinder may slide along it, separate from its surface and perform a free flight or may move with the surface being at rest relative to it. In the last case the fruits material is not sieved **(Bosoi *et al*. 1991).** At neglected the sliding motion of the olive inside the sieves; the release of olive fruits through a cylindrical sieve depends upon their relative velocity and the forces acting on them. These forces are:

The weight of olive fruit mg, directed downward; and the centrifugal force $mr\omega^2$

Where:

m**:** is the mass of the olive fruit; kg.

r **:** is the radius of the cylinder; cm.

ω**:** is the olive fruit angular velocity.

The motion of the particle on the cylinder surface is not determined by the tangential forces alone. But, if the resultant of the normal forces *(N)* is not directed towards the cylinder surface, the particle will lose contact with the cylinder.

To find the equation that describes the motion of the olive sets through the cylindrical sieve **(Fig. 1),**

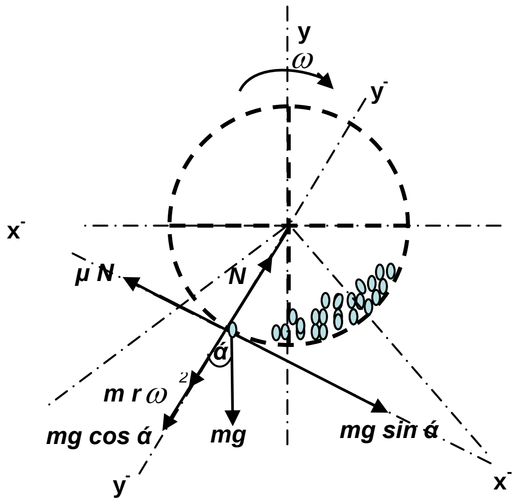


Fig. (1): The forces acting on a particle of olive fruit in a rotating cylinder

It can be found that:

N = m r ω^2 + mg cos ά . in the normal direction (at y$^-$ y$^-$)…. (1),

mg sin ά = μ N ……… ..in the tangential direction (at x$^-$ x$^-$)..(2)

Where:

N: is the reaction force;

ά: is the angular position of the particle on the sieve surface measured from the horizontal axis in the direction of rotation;

μ: is the friction coefficient between the particle and the cylindrical surface.

By substituting (N) from equation (1) into equation (2) then:

mg sin ά = μ (m r ω2 + mg cos ά) ……….. …….(3)

$\frac{mg \sin ά}{\mu}$ = m (r ω2 + g cos ά) ……………….. ….(4)

g sin ά = μ(r ω2 + g cos ά) ………………… ….. (5)

μ r ω2 = g sin ά - μ g cos ά …………………… …(6)

$$\omega^2 = \frac{g \sin \alpha' - \mu g \cos \alpha'}{\mu r} \quad \text{……………………} \quad (7)$$

$$\omega = \sqrt{\frac{g}{\mu r}\left(\sin \alpha' - \mu \cos \alpha'\right)} \quad \text{…………….....…………}(8)$$

$$\omega = \frac{2\pi n}{60} \qquad \text{..(9)}$$

But

Where (n) is the revolution numbers of the cylinder sieve.

From equation (8) and equation (9) we get:

$$n = \frac{60}{2\pi}\sqrt{\frac{g}{\mu r}\left(\sin\alpha' - \mu\cos\alpha'\right)} \qquad \text{..........................(10)}$$

At ά = 90°

$$n = \frac{60}{2\pi}\sqrt{\frac{g}{\mu r}} \qquad \text{..(11)}$$

The behavior of olive depends on the cylinder number of rotations at a given radius with a certain factors such as Olive layer, internal friction and others, that affecting the performance of grading. Let us determined above factors as a certain value of (K) that ranged from 0.33 to 0.40 according to Klenin et al., 1985. Then the equation (11) may be equal

$$n = \frac{30K}{\pi}\sqrt{\frac{g}{\mu r}} \qquad \text{..(12)}$$

By knowing of, g = 9.81 m/s, r = 0.10 m and μ = 0.33 (the measured friction angle was 18.5 deg.) and by substituting in equation (12).

The number of rotation per minute (n) for the cylinder sieve should be lower than 55.8 rpm (critical speed). The sieves are set inclined to the horizontal plane, to improve the internal pressure forces during the rotation of the particles mass. In this study, the slope angle of the cylindrical sieves on the horizontal plane (10°) was selected according to Klenin et al. (1985).

MATERIALS AND TEST PROCEDURE

To fulfill the objective of this study, a small scale cylinder type grading machine was constructed and tested in the Ag. Eng. Res. Inst., Ag. Res. Center, to suit grading of olive fruits for the different process.

Materials:

The experiments were carried out using (Azize) of olive fruits as double purpose variety. This variety was obtained from Horticultural Research

Institute, Olives Res. Dept., Giza, Egypt. These varieties were selected based on its recent coverage area and the expected future expansion according to Ministry of Agriculture yearly bulletins.

Fruit physical and mechanical characteristics:

The data in Table (1) shows the fruit length, diameter, shape index, weight and the rolling angle of fruits.

From the data listed in **Table (1),** it shows that, the avg. range of olive length, and diameter were 22 and 19.45, mm. while the rolling angle of olive fruits on galvanized sheet, was 8.6 deg. With respect to the shape index, it is clear that the olive variety used in this investigation may be considered as spherical varieties. These results help in designing the sieve openings for the grading unit, which depends on the small length of fruit.

Table (1): Physical and mechanical properties of Azize olive variety.

Property of Azize variety	Max.	Min.	Average
Fruit length, mm	29.2	14.8	22.0
Fruit dia., mm	24.5	14.4	19.45
Shape index (Spherical)	1.19	1.02	1.07
rolling angle on galvanized sheet, deg.	8.6		8.6

The developed machine:

According to the theoretical considerations, physical and mechanical properties of olive variety, The technical specification of the developed machine is shown in **Fig 2 (a and b),** the machine structure consists of:

Machine frame:

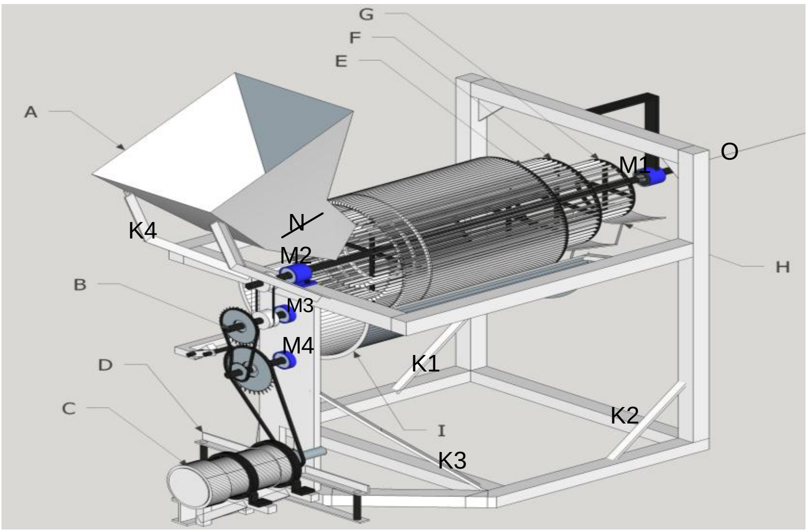
The machine frame constructed from steel angles 25x25 mm, meanwhile the stand of the riddles unit was made from steel section C-channel of 150 x 50 mm, welded together and provided by adjusting screws to tilt the riddles unit. The frame dimensions are 1050 mm long, 550 mm wide and 1250 mm high. All parts of the machine are mounted on the frame in alignment.

Feeding hopper:

A square section metal hopper was fixed on the main frame of the machine to feed the fruits into the riddles unit. It was made of iron sheet 1.0 mm thick, with dimensions of 500 x 400 x 500 mm for the length, width and height, respectively. The sides of the hopper had a gradual slope of 18.5 degree to allow sliding of olive fruits. This angle was chosen according to the measured friction angle. The bottom of the hopper was slightly tilted downwards to encourage fruits to pass through the center of the internal riddle. The hopper has a sliding gate to control feed rate.

The grading unit:

The grading unit consists of three cylindrical riddles (sieves) having a parallel bars cells. The riddles arranged one inside the other according to the size (the large mesh riddle being the internal, while the smaller meshes riddle being external. The cylindrical riddles are fixed on the drive shaft and fixed with the machine frame. As shown in Fig 1 (a and b), the dimensions of the internal riddle were 800 mm long and 200 mm diameter with cell size of 20 mm; the middle riddle has 650 mm long and 300 mm diameter with cell size of 17 mm; while, the external riddle has 500 mm length and 400 mm diameter with cell size of 10 mm.



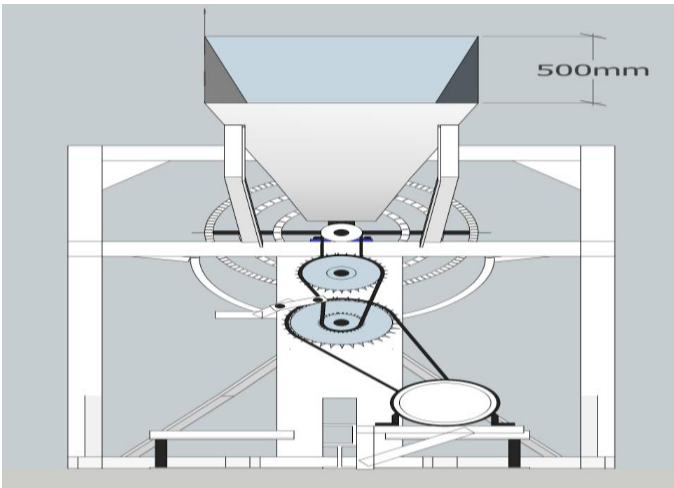
A - feeding hopper	B- drive chains	C- motor
D - frame	E- external riddle	F- middle riddle
G- internal riddle	H- outlets	O- driving shaft
I - riddles cover	k1,2,3 and 4 – brackets	N - sliding gate

M1, M2, M3 and M4 - ball bearing

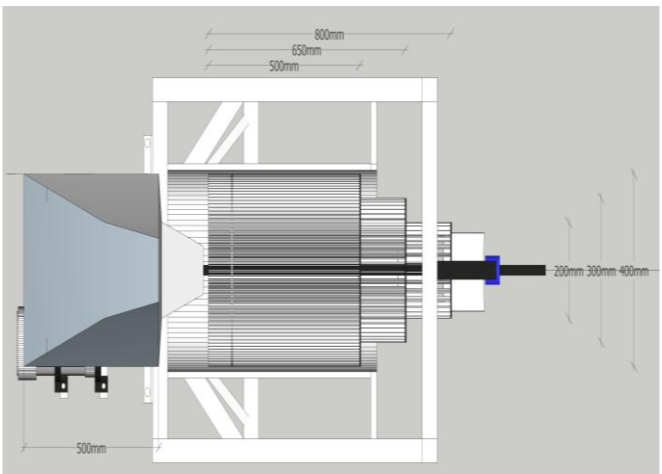
Fig. (2 - a): Schematic diagram of the developed olive grader

These cell sizes were selected according to the specification of quality standard of olive fruits as recorded by, (U. S. STANDERDS, 1983), olive fruits may be sized into four different categories (canned whole and pitted ripe olives) as follow:

Rank (1) fruits diameters > 20mm, (extra large).
Rank (2) fruits diameters 17 - 20mm (large).
Rank (3) fruits diameters 10 -17mm (medium).
Rank (4) fruits diameters < 10mm (small).



Elevation View



Plan View

Fig.(2 - b): Elevation and plan view of the developed olive grader

Experimental Treatments:

The experiments were designed, and carried out to study the effect of the following variables:

1- Four different speeds of the cylinder riddles unite 25, 40, 55, and 70 rpm (0.26, 0.42, 0.58, and 0.73 m/s), were selected according to the theoretical analysis (equation No. 12).

2-Four different feeding rates of olives 50, 70, 90 and 110 kg/h. ach experiment was repeated three times and the average values were considered.

Experimental Procedure:

- Olive variety Azizy was harvested manually. Then, the olives were inspected for damage to eliminate the unfit products (cull and defective olives) by manual picking.

- The olives were put into baskets and manually discharged into the feeding hopper to calibrate the feeding rates of the machine. After machine calibration, the gate opening was adjusted on the desired feeding rate, and then the machine was run. The olives were discharged and rolled to the collecting baskets.

- During the grading process, the consumed time of operation from the moment of olives dropping until the end time was measured, and the amount of graded olives was recorded. Then the machine productivity (kg/h) and the machine grading efficiency (%) and power (kW) and energy requirements (kW. h./ton), were determined. The effect of machine parameters on the total mechanical damage (%) was also considered.

Measurements:-

Fruit physical and mechanical characteristics:

Some physical and mechanical properties of olive fruits were determined to design the machine hopper, cells of the cylindrical sieves and sieves inclination on the horizontal plan. The following procedures were carried out to determine the fruit principal dimensions (fruit length, diameter and shape index), fruit firmness and fruits rolling angle, as follows.

Fruit principal dimensions:

One hundred olive fruit sample was taken randomly from the variety under study. The shape of the variety was studied in terms of length (L) and diameter (d) using a sliding caliper accurate to (± 0.05 mm). The obtained data were used to calculate the shape index of each sample of olive according to (International Olive Council, 2000 and Kader, 1992) as follows:

Shape index = greatest diameter (d) / length (L)

If shape index values < 1.25 the fruit may be considered belong to spherical group. If, shape index values between 1.25 -1.45 fruit may be considered belong to ovoid, and at shape index values > 1.45 the fruits are considered elongated.

Rolling angle:

Rolling angle of olive fruits was measured on a metal surface according to **(EL-Raie et al., 1996)**. The Olive fruits samples were placed over the surface of the metal sheet and by lifting up the sheet around its side pivot; the angle of friction was determined when 75% of the fruits reached the end of the sheet surface. The rolling angle of the fruits samples was taken as the average of four replicates.

Machine grading capacity:

Machine grading capacity was calculated using the following formula:

Machine capacity = m / t, (kg/h) ……………….……………….. (1)

Where:

m = Mass of Olive fruits received at all outlets in kg;

t = the time consumed in operation, h.

Machine grading efficiency:

The total grading efficiency of the machine was estimated according to (**Klenin et al., 1985**) using the following formula:

η = (m1 + m2 + m3 +m4) / m, % ………………………….. (2)

Where:

η : total machine grading efficiency %;

m: total mass of olive fruits in kg;

m1 + m2 + m3 + m4 = averaged mass of classified fruits received at all outlets in kg.

Mechanical damaged percentage:

Mechanical damaged percentage for the olive variety was measured during olives grading as follows.

olive's bruises were evaluated, immediately as visible damage, which can be seen by bare eye. Scuffed fruits (with surface abrasion damage to skin) and those with flesh damage were separated from each fraction and there percentages based on the weights of the corresponding fractions were taken as olives mechanical damage. Then the mechanical damage of fruits was classified according to (**Kader,1992**) into the following categories:

Bruising score	% of fruit area affected	
1- No symptoms	Zero	
2- Slight	< 2 %	
3- Moderate	2 - 5 %	
4- Severe	5 - 10%	Unmarketable
5- Extreme	> 10%	

RESULTS AND DISCUSSION

In order to select the appropriate operational parameters for the grading process, it was necessary to determine the percentage of total mechanical damage of Olive fruits and machine grading efficiency. These parameters varied with olive fruits feeding rates, and riddles revolving speed. In other words, the quality of graded fruits is largely depending upon the performance of the grading unit.

Machine Grading Capacity:

The effect of both riddles revolving speeds and riddles feeding rates during grading process of olive fruits on the machine grading capacity (kg/h) are shown in **Fig. (3).** It was appeared that, increasing riddles revolving speed during the grading process from 25 – 70 rpm at all studied levels of riddle feeding rates in the range of 50 - 110 kg/h cause a corresponding increase in the machine grading capacity. The maximum machine grading capacity, which was recorded during the grading process at riddles revolving speed of 70 rpm and riddles feeding rate of 110 kg/h.

Meanwhile, the lowest grading capacity was 41.6 kg/h at riddles revolving speed of 25 rpm and riddles feeding rate of 50 kg/h. This increase in machine grading capacity by increasing riddles revolving speeds may be attributed to the increase of olive fruits speed which resulted in reducing the time of grading and consequently increasing the grading capacity. In other words, increasing the speed of riddles increases the throughput of olive from the riddles openings which in turn, increase the machine grading capacity.

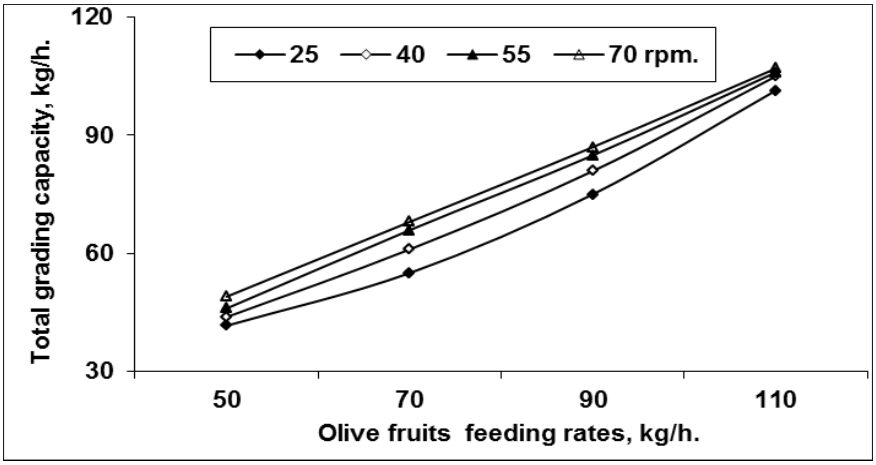


Fig. 3: Effect of different riddles feeding rates of Olive fruits and different riddles revolving speeds on the machine grading capacity.

Total grading efficiency of fruits:

Data demonstrated in **Fig. (4)** show the percentage of total grading efficiency of fruits as affected by different experimental variables. The results revealed that, at any riddles revolving speed ranged from 25 to 70 rpm, the total grading efficiency increased as riddles feeding rates were increased from 50 to 90 kg/h. However, at 90 kg/h riddles feeding rates the total grading efficiency tended to decrease slightly from 93.92 to 92.8 % as riddles revolving speed was increased from 55 to 70 rpm. Also, it can be seen that, at riddles feeding rates of 90 kg/h the total grading efficiency increased as riddles revolving speed increased from 25 to 55 rpm. This increase was followed by an obvious decrease in the machine
On the other hand, the results revealed a marked reduction of grading efficiency at 110 kg/h feeding rate. This decrease in the grading

efficiency especially at the higher riddles revolving speed may be due to the increase in the speed of material displacement, which, in turn shortened the time of grading, and also, makes difficult penetration of olive fruits through the sieve openings.

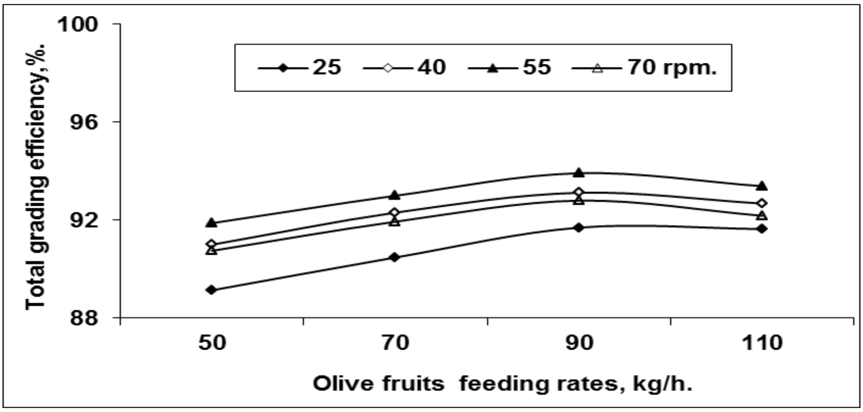


Fig. 4: Effect of different riddles feeding rates of olive fruits and different riddles revolving speeds on the machine grading efficiency.

Olive Mechanical Damage:

Data presented in **Fig. (5)** show the total mechanical damage percentage as affected by different levels of riddles revolving speeds, different levels of Olive fruits feeding rates. It can be seen that, the mechanical damage percentage of Olive fruits increased gradually as the feeding rates increased from 50 to 90 kg/h and as revolving speed of riddles increased from 25 to 70 rpm under study conditions. The data indicated that, increasing the riddles revolving speed from 25 to 70 rpm caused a gradual increase in the total mechanical damage from 1.15 to 4.36; from 1.60 to 5.27 and from 1.94 to 5.75 % at feeding rates of 50, 70 and 90 kg/h, respectively. Meanwhile, as the riddle speeds increased from 25 to 70 rpm, the excessive increase in the fruits mechanical damage percentage(sever) was observed when grading fruits at 110 kg/h feeding rate, which was increased from 5.10 to 6.77 %, respectively. The same trend of excessive increase in the total mechanical damage percentages was found as the riddle revolving speeds increased from 55 to 70 rpm, which was increased from 2.25 to 5.12; from 2.81 to 5.27; and from 3.42

to 5.75, % at feeding rate of 50, 70, and 90 kg/h, respectively. Increasing the riddles feeding rate to 110 kg/h at any riddles revolving speed from 25 to 70 rpm caused an extreme increase in the total mechanical damage percentages from 5.10 to 6.77 %, respectively. This damaged value is more than the values equivalent to the total marketable yield quality. This increase may be ascribed to the increase in rolling action of Olive fruits, which always associated with the increase the impact time of Olive fruits. In addition, olives may not sustain the impact. Therefore, the injuries occurred when Olives hit each other during the grading process. In general, the best allowable mechanical damaged of olive fruits (3.42, %) was obtained at 55 rpm riddles revolving speed and 90 kg/h of riddles feeding rate during the grading process of olive fruits.

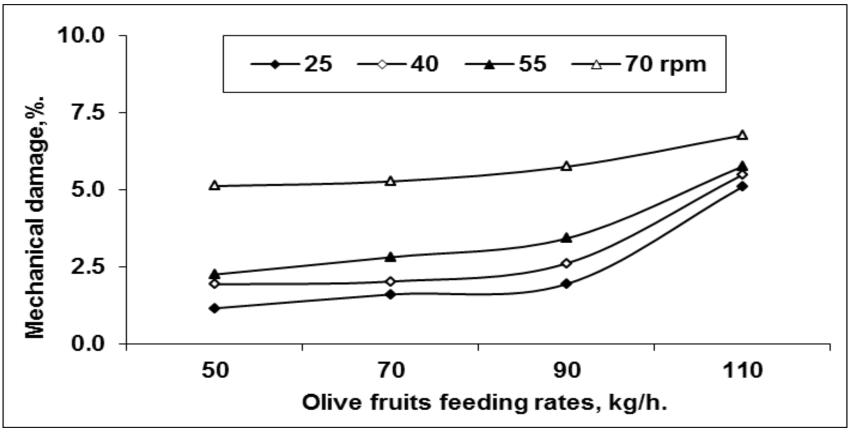


Fig. 5: Effect of different riddles feeding rates of Olive fruits and different riddles revolving speeds on the mechanical damage.

CONCLUSION

The optimum operating parameters for the modified grading machine were riddles revolving speeds of 55 rpm, and riddles feeding rate of 90 kg/h. At these values, maximum sorting accuracy of 93.92% and permissible mechanical damage 3.42, % were obtained for grading of olive fruits. These results proved that, the proper operating parameters coincided with the theoretical considerations as the relevant for machine operation.

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الملخص العربي

تطوير وتقييم الأداء لآلة تدريج الزيتون

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الزيتون أحد المحاصيل الهامة في مصر، وتنجح زراعته في الأراضي المستصلحة نظرا لقدرته علي تحمل الظروف المناخية الصعبة كالجفاف والملوحة. وتصل المساحة المنزرعة في مصر ٢٢٧٦٨٣ فدان عام ٢٠١٥ تنتج حوالي ٦٩٨٩٢٧ طن (قطاع الشئون الاقتصادية - وزارة الزراعة، ٢٠١٥). وقد أجريت هذه الدراسة بهدف تصنيع وتقييم أداء آلة بسيطة محلية الصنع من النوع الأسطواني لتدريج ثمار الزيتون بهدف توفير ثمار متجانسة في الشكل والحجم مما يساعد على تقليل نسبة الفاقد والتالف من الثمار خلال مراحل التداول المختلفة، وبالتالي تزداد نسبة الثمار الصالحة للتسويق فيزداد الربح وتنخفض تكاليف الانتاج. أجريت التجارب باستخدام صنف الزيتون العجيزي وكان متوسط طول الثمار هو ٢٢مم، ومتوسط قطرها ٤٥و١٩ مم، ومعامل الشكل للثمار يميل إلي المستدير.

- تم دراسة بعض العوامل الهندسية المؤثرة على سعة وأداء وكفاءة آلة التدريج المقترحة باستخدام صنف الزيتون العجيزي. وكانت عوامل الدراسة هي أربعة مستويات لسرعة دوران اسطوانات التدريج للآلة ٢٥، ٤٠، ٥٥، ٧٠ لفة/د وأربعة مستويات لمعدل تغذية الثمار كجم/س وهى ٥٠ ، ٧٠، ٩٠، ١١٠ كجم/ س.

- وقد أوضحت الدراسة أن العوامل المثلي لتشغيل الآلة تم الحصول عليها بتشغيل الألة عند سرعة دوران لاسطوانات التدريج قدرها (٥٥ لفة/د) ومعدل تغذية لثمار الزيتون قدرها ٩٠ كجم/س حيث أعطت الآلة أعلى كفاءة تدريج ٩٢,٩٣%، وأقل نسبة تلف ٣,٤٢ %.

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