5- Summary and Conclusions

Citrus crops are considered one of the main Egyptian fruits. They are considered the first of fruits and third of major crops after cotton and rice. They represent about 35% from fruits area in Egypt and about 21% from the fruit cost annually mean. Egyptian citrus production is mainly concerning the three major types namely:

Orange, tangerine and Egyptian sour lime. These types represent 98% from citrus production area.

Grading of fruits and vegetables is important for export and local marketing. There are many methods of fruits and vegetable grading like manual grading and mechanical grading. Mechanical grading may be classified based on the difference in physical parameters such as length, diameter and width, and by weight. The machine, which grade by length, diameter and width is more accurate and high throughputs for sphere and like sphere crops. But it is less flexible when changing from one grading policy to another, from variety to another and has no ability to grade fruits which oddly in shape.

The farmers or the sellers make grading to the fruits produced from the farm into more classes to be very easy for sealing. The grading machine reduces the costs of grading process than the manual grading. However, it will increase the price for the product fruits with high quality on the farm. A locally machine for grading the vegetables and fruits was manufactured and evaluated under different conditions. The manufactured grading machine was tested and evaluated under different critical distances of the beam (0.4, 0.5 and 0.6 m), cylinder speeds of feeding cells 10,20, 30 and 40 r.p.m, (0.11, 0.21,0.32 and 0.42 m/s) fruit feeding chain speeds 10, 15, 20 and 25 r.p.m (0.053, 0.08, 0.11 and 0.13 m/s) fruit sizes (60, 70, 80 and 90 mm) and tilt angles (5, 10, 15 and 20 degrees for the weight grading but, 0, 5, 10 and 15 degrees for the size grading. The energy and costs required for mechanical grading were determined and compared with the manual grading.

The specific objectives of the present study were planned to be realized through the following:

1- Study of some physical and mechanical properties for orange and muskmelon (Honey dew- Charantais) fruits.

2- Manufacture a locally grading machine suitable for different fruits on the base of weight and size.

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

4- Proceeding a cost analysis and economic feasibility of the manufactured machine.

Structure and elements of the prototype unit:

1- Main frame

2- Feeding hopper.

3- Sorting unit.

4- Size grading unit.

5- Weight grading unit:

6- Power source.

The results can be summarized under the following main items:

1- Physical properties.

2- Mechanical properties.

3- Performance evaluation of the grading machine.

5.1. Physical properties:

Some physical properties of orange and muskmelon (Honey dew – Charantais) fruits were measured or calculated to provide database can be employed in increasing functional subsystem of grading machine.

5.1.1. Dimensions of fruits:

1- The mean values of fruits length were ranged from 60.4 – 88.4 mm, 60.4 – 89.5 mm and 79 – 89.5 mm for orange and muskmelon (Honey dew – Charantais) respectively.

2- The mean values of the fruits width were ranged from (64.2 – 87.4 mm, 64.2 – 87.4 mm and 76.8 – 95.2 mm for orange, muskmelon (Honey dew – Charantais) varieties respectively.

3- The mean values of shape index were 0.995, 0.986 and 1.014 for orange, muskmelon (Honey dew – Charantais) varieties.

5.1.2. Mass, volume and density of fruits:

1- The mean values of fruit mass were ranged from 200 – 320 , 200 – 320, and 220 – 310 g for orange, muskmelon (Honey dew – Charantais) varieties.

2- The obtained mean values of fruits volume were 19 –350, 190 – 350 and 230 – 340 mm^3 for orange and muskmelon (Honey dew – Charantais) respectively.

3- The corresponded main values of real density for orange and muskmelon (Honey dew – Charantais) varieties were 0.878, 0.883 and 1.001 respectively.

5.2. Mechanical properties:

5.2.1. Coefficient of friction:

The estimated mean values of coefficient of friction with rubber surface for orange and muskmelon (honey dew – charantais) varieties were 0.99, 0.89 and 1.01 respectively, and 0.93, 0.82 and 0.97 with galvanized steel sheet surface.

5.2.2. rolling angle:

The mean values of rolling angle for orange, muskmelon (Honey dew – Charantais) varieties were 0.15 rad. (9^0), 0.12 rad. (7.1^0)and 0.2 rad. (12^0) for rubber sheet surface. While, the mean values of rolling angle were 0.13 rad. (7.8^0), 0.10 rad. (6^0)and 0.18 rad. (10.8^0) for galvanized sheet surface for orange, muskmelon (Honey dew – Charantais) respectively.

5.2.3. Impact height:

1- The estimated mean values of impact damage height were (1.7, 1.4 and 1.6 m) and (1.5, 1.2 and 1.4 m) with rubber and galvanized steel sheet surface for orange, muskmelon (Honey dew – Charantais) varieties.

2- The corresponded mean values of bruised high were 1.4, 1.3 and 1.2 m for orange, muskmelon (Honey dew – Charantais) with rubber sheet surface. In general, the maximum height used not exceeds 0.4 m for the three tested varieties.

5.3 Evaluation of grading machine:

5.3.1. Machine grading capacity:

1- Grading machine capacity decreased when the critical distance of the beam was increased from 0.4 to 0.6 m for all the cylinder speeds of feeding cells and tilt angles.

2- The obtained values of grading machine capacity increased by 22.2 % when the cylinder speed of feeding cells was increased from 10 to 40 r.p.m (0.11 – 0.42 m/s) for muskmelon fruits at different levels of tilt angles and critical distances of the beam.

3- Increasing the tilt angle from 0 to 15 or 5 to 20 degrees for size and weight grading machine tended to increase the capacity of feeding machine for all the fruit types, critical distances of the beam and cylinder or chain speeds.

4- The highest values of total capacity of grading machine (2.225, 2.255 and 2.295 ton/h) were achieved at cylinder speed of about 40r.p.m (0.42 m/s), chain speed of 25 r.p.m (0.13 m/s), critical distance of the beam of about 0.4 m and tilt angle of about 20 degrees.

5.3.2. Grading machine efficiency:

1- The grading machine efficiency decreased by increasing the critical distance of the beam for all the cylinder speeds of feeding cells and tilt angles. The grading efficiency decreased by 15.9, 8.7 and 8.2 % when the critical distance was increased

from 0.4 to 0.6 m at 10 r.p.m (0.11 m/s) cylinder speeds of feeding cells and 5 degrees tilt angle.

2- Increasing both cylinder speed of the feeding cell from 10 to 40 r.p.m (0.11 to 0.42 m/s) and tilt angle from 5 to 15 degrees tended to increase the grading machine efficiency for all the critical distances and the graded fruits. The grading machine efficiency increased by 10.04 % when the tilt angle was increased from 0 – 15 degrees at 0.4m critical distance of the beam and cylinder speeds ranged from 10 to 40 m/s for the muskmelon (honey dew).

3- The fruit feedings chain speed of about 15 r.p.m (0.08 m/s) gave the maximum grading efficiency of the size grading machine in comparison to 10,20 and 25 r.p.m (0.05, 0.11 and 0.13 m/s) chain speeds for all fruits sizes, tilt angles and types of fruits.

4- The maximum grading machine efficiency was obtained at 15 r.p.m (0.08 m/s) fruit feeding chain speed, 10 and 15 degrees tilt angles for the weight and size grading machine, critical distance of beam of about 0.4 m, chain speed of about 15 r.p.m (0.08 m/s) and cylinder speed of feeding cells of about 40 r.p.m (0.42 m/s).

5.3.3. Energy requirements:

1- The energy required for grading the orange and muskmelon (Honey dew – Charantais) were 0.146, 0.1954 and 0.204 kW.h./ton at critical distance of the beam of about 0.4 m, cylinder speed of feeding cells of about 40 r.p.m (0.42 m/s) and tilt angle of about 5 degree (0.083 rad.).

2- The energy requirements for grading the different fruits by the weight-grading machine were less than that were consumed by the size grading machine at all the different variables.

3- The minimum value 0.107 kW.h/ton of energy requirements were recorded with the critical distance of about 0.6 m, cylinder speed of feeding cells of about 10 r.p.m (0.11 m/s) and tilt angle of about 10° . This due to increase the field

capacity with the mentioned parameters in comparison to the other levels.

5.3.4. Grading cost :

1- 1- The total cost of grading one ton of orange and muskmelon (Honey dew – Charantais) varieties were 2.74, 2.71 and 2.67 LE respectively at critical distance of the beam of about 0.4 m, cylinder of feeding cells of about 40 r.p.m (0.42 m/s) and tilt angle of about 20 degrees.

2- The lowest value of grading cost was achieved with the weight grading machine at 0.4 m critical distance of the beam, 40-r.p.m (0.42 m/s) cylinder speed of feeding cells, 20 degrees tilt angle.

Recommendations:

1- The proposed size and weight-grading machine should be manufactured with local material in small workshops.

2- The manufactured machine should be used for grading the different varieties of fruits and vegetables in order to increase its economic value and reduce the grading cost per ton.

3- The optimum performance of the manufactured grading machine was achieved with critical distance of the beam of 0.4 m, cylinder speed of feeding cells of 10 and 40 r.p.m (0.11 and .42 m/s) and tilt angle of the grading unit of 15° degrees.

4- The present fabricated grading machine is not complicated to allow using it with all small and medium holding farms, it could be achieved increasing in the income as a result of selling the grading fruits with higher price.