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Evaluation of two types of electrical shellers locally manufactured to shelled maize (*Zea mays*. L.) at three rotational speeds

Akram A. A. Alkhalidy, Asmaa. A. Al -Edan, Ali. A. Alwan, Aqeel. J. Nassi
Department of Agricultural Machinery and Instruments, College of Agriculture, University of Basrah, Iraq
Email: akram.ahmed@uobasrah.edu.iq

Abstract

An electric sheller was manufactured locally to shelled corn in the engineering workshop of the College of Agriculture of the University of Basrah. The sheller is equipped with a 745.7 W electrical motor. The sheller was tested after drying the corn kernels to a moisture content of 15%. The study aimed to evaluate the effect of three rotational speeds of 85, 120, and 150 rpm and two sheller machines. One sheller with metal fingers and the other with metal fingers heavily coated with rubber. Compare them in terms of shelling efficiency, productivity, spreading grains, and damage to the grains. percentage.The experiment was conducted with three replicates according to a completely randomized design (CRD) and the comparison was made using the least significant difference (LSD) method at a significance level of 0.05. The results showed that the shelling machine with metal fingers covered with a large percentage of rubber achieved high shelling efficiency and productivity with less spreading and mechanical damage at all rotational speeds of the shelling machine compared to the shelling machine with metal fingers, It reached its highest average at a rotational speed of 150 rpm, 60.67 kg h^{-1}, 96.67%, 92.00% and 2.548%, respectively.

Keywords: yellow corn, shelling machine, rotational speed, shelling efficiency, Capacity, mechanical damage rate

I. Introduction

Maize (*Zea mays*. L.) is the third most important food crop after wheat and rice in terms of food and industrial uses, [1], [2]. Corn is also known as the queen of grains and the king of fodder, due to its important role in human and animal nutrition [3] , [4]. [5].

Therefore, it requires the provision of important supplies and technologies that contribute to the production of this product, such as distinctive operations, grain separation, warehouses, and resulting damage from disorganization of devices harvesting the crop, or the shelling of its grains, or its bad storage.

Most farmers hull dried cobs by repeatedly beating them with a club while they are placed in open bags or barrels, or by spreading them out on a plastered house floor or outdoors [6] & [7]. These methods cause grain damage, are time-consuming, and involve heavy labor.

Agriculture has become a major economic activity in many countries and is said to be the nation's wealth. In many developed countries, agriculture has improved through the development of machines for seeding, husking, and dehulling. However, these machines are highly sophisticated and difficult to obtain, forcing farmers to resort to manual farming methods, thus increasing labor and wages, [8].

Corn processing includes harvesting, dehulling, drying, shelling, storage, and milling. Compared to other processes, shelling remains the most difficult and requires further work to improve. [9].

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Corn threshing machines were designed and manufactured to improve the living standards of rural residents in developing countries. Many electric threshing machines are available for bulk threshing. Farmers typically transported their gunthreaded grain to these factories, where they obtained their final product, the overthreaded corn, and then sold it on the market. This incurred transportation costs between farms increasing the cost of the product. Most contractors offer lower prices for non-overripe corn, so farmers make more profit from overripe corn. [10].

The traditional method of shelling yellow corn after harvest is cariedd out in a humid atmosphere, after which the cobs are peeled and marketed to factories for shelling and drying. This method results in problems in the manufacturing process due to the high moisture content of the grains due to their exposure to rain and the presence of the grains on the wet soil surface. Therefore, it is necessary to perform appropriate organization processes for cob grain shelling devices of the cobs in terms of the rotational speed of the shelling machine and the appropriate moisture content that ensures the safety of the sheller grains from damage at the highest rate. [11]. Mechanical damage to corn grains has a significant effect on the permissible storage period for this crop, as indicated that [12] when mechanical damage to corn grains increases from 0 to 40 %, the storage time decreases significantly [13] found that the productivity of yellow corn and the efficiency of the sheller increased by increasing the rotation speed of the sheller machine from 40 to 60, then to 80, then to 100, then to 120 rpm from 0.36 to 1.13 tons hr^{-1} and from 95.89 to 98.96 %, respectively.

The process of shelling the cob is important to maintain its safety and extend their storage period for later use in food manufacturing later. Therefore, the study aims to test two types of shelling machines with different rotational speeds to determine the best machine for shelling grains and rotational speed with the least loss and damage and the highest quantitative and qualitative results.

II. Materials and Methods

Manufacture of two yellow corn shelling machines:

The yellow corn sheller machine was manufactured in the workshop of the Department of Agricultural Machinery and Equipment of the Faculty of Agriculture of the University of Basra, Karma Ali site.

It consists of a rectangular feed tank for coops, with dimensions of 50 x 70 cm at the lower base, 65 x 80 cm at the upper base, and 75 cm in height , cylinder with a length of 80 cm and an internal diameter of 70 cm. In its center, the hulling machine is fixed, which includes a shaft with a diameter of 40 mm and a length of 100 cm, supported by bearings at both ends. Around its perimeter, round rods with ends each 10 cm long are distributed at equal and alternating distances.

A portion of the top of the cylinder was cut to represent the feeding opening for the cobs as they descended from the tank installed at the top of the cylinder. The lower half of the cylinder's circumference was perforated so that the holes allowed the excess corn grains to pass through and be collected in the collection basin.

Regarding the hulls, an opening was allocated on one side of the cylinder to collect them after each feeding load to facilitate their removal after the manual shelling process.

The cylinder is mounted on a tin base that is fixed on four supports to reduce vibrations during rotation of the shelling machine.

The power is transmitted to the steel-bar shelling machine shaft by a conveyor belt, the upper end of which is fixed to the shelling machine shaft pulley and the lower end to the pulley of a 1 HP electric motor whose speed is controlled by an inverter to drive the shelling machine at three rotational speeds of 85, 120 and 150 rpm.

Electric Corn Sheller Test:

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The yellow electric corn shelling machine shown in figure(1) and Scheme (1) was tested using two types of shelling machine at a grain moisture content of 15%, the first was in the form of rods with rounded ends, 10 cm long, and the second type was in the form of rods covered with rubber fingers with a covering ratio of 80 % and also 10 cm long. The two machine were tested at three rotation speeds of 85, 120 and 150 rpm, to evaluate the performance of the machine and determine the shelling machine and rotational speed that achieves the highest efficiency , productivity , the least loss and damage to the grains.

The following characteristics were measured. Samples were taken from each treatment at a rate of 100 g for each sample and the treetment was repeated three times. The difference sheller performance indices were calculated using Equations 1-4 according to [14] as follows:

1- $P_S = \frac{W(kg)}{T(hr)}$ …………(1).

Ps: Sheller productivity, (kg/hr)

Wo :Weight output, (kg)

T: Time, (hr)

2- $SE = \frac{WS\ (kg)}{TK(kg)} \times 100$……….... (2)

SE: Shelling Efficiency(%).

WS Weight of shelled kernels(kg).

TK: Total Kernel intput(kg).

Then the grains damaged by the shelling process were isolated and weighed on a sensitive scale to determine both the shelling percentage and the damaged grains, using the following equations.

3- $Shp = \frac{Nsh}{(Ngc + Nsh)} \times 10 \ldots\ldots$ (3) . [15].

Shp: Shelling percentage(%).

Nsh:Number of grains sheller.

Ngc: Number of grains remaining on the cob.

4 - $Pdg = \frac{Wdg(kg)}{WS(kg)} \times 100$……….(4). [16].

Pdg: percentage of damaged grains (%).

Wdg: Weight of damaged grains(kg).

WS: Total weight of the sample (kg).

Statistical analysis: The experiment was carried out using two types of maize Shelling machines and three rotational speeds for the two machines, with three replicates, resulting in 18 experimental units. The experiment was carried out according to a completely randomized design (CRD). The study factors were Symboling as follows: the type of the shedding machine Sh(Sh1: Rod with metal finger , Sh2: Rod with rubber finger) and its rotation speed V(V1: 85 , V2: 120 , V3: 150 rpm). Means were compared using the least significant difference (LSD) method at a significance level of 0.05.

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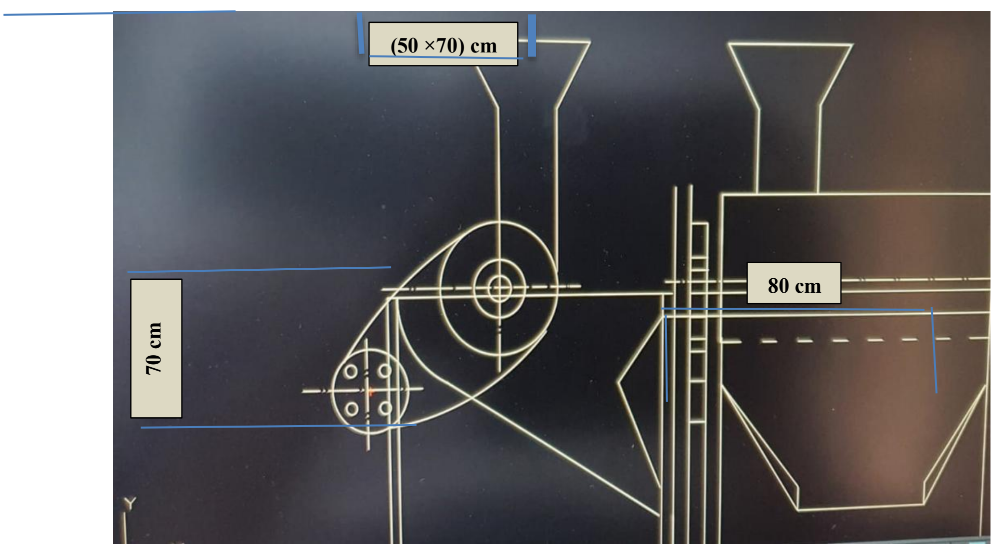
Figure (1) Yellow Corn Sheller Machine



Scheme (1) Yellow Corn Sheller Machine

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III. Results and Discussion

1. productivity of the sheller mechanism:

The results of Table (1) show significant differences between the average productivity of the shelling mechanism, affected by the type of shelling mechine and its speed.

The rubber-coated metal fingers recorded the highest productivity, amounting to 55.89 kg hr^{-1}, while the metal (uncoated) shelling mechine recorded the lowest productivity, amounting to 48.11 kg hr^{-1}**.** This is due to the increase in excessive grains, which resulted in an increase in their weight when using the shelling mechine with metal fingers covered with a large proportion of rubber, which reduced their weight, which increased the number of strikes of their fingers on the fed cobs, compared to the shelling mechine with heavy metal fingers.

The high speed of 150 rpm achieved the highest productivity of 58 kg hr^{-1}, while the slow speed of 85 rpm recorded the lowest productivity of 46.67 kg hr^{-1}. The reason for the increase in shelling productivity at high speed is due to the increase in the weight of shelling grains per unit time compared to the decrease in shelling grains low speed, which is what [17], [18], [19] found.

The interaction between the type of shelling mechine and its rotational speed had a significant effect on the productivity of the sheller. The highest average productivity was 60.67 kg h-1 when using the shelling mechine with rubber coated metal fingers at the highest rotational speed of 150 rpm, while the sheller mechine with metal fingers at the lowest rotational speed of 85 rpm recorded a lower productivity of 51.00 kg hr^{-1}.

Table (1) Effect of the type of yellow corn grain shelling mechanism, its rotational speed and the interaction between them on the Sheller productivity (kg hr^{-1})

Type of shelling Mechanize	Rotational speed (rpm			
	V1	V2	V3	Mean
Sh1	**42.33** ± 0.577 **f**	**46.67** ±1.528 **e**	**55.33** ±1.528 **db**	**48.11 b**
Sh2	**51.00** ±1.00 **c**	**56.00** ±1.00 **b**	**60.67** ±1.00 **a**	**55.89 a**
Mean	**46.67 c**	**51.33 b**	**58.00 a**	

2. Efficiency of the shelling machine:

The results in Table (2) show significant differences between the average values of the shelling mechine efficiency, depending on the type and speed of the shelling mechine.

The highest efficiency reached 90.78 % when the shelling mechanism had metal fingers covered with solid rubber, and the lowest efficiency was 81.56 % when the shelling mechine was used with metal fingers. This is due to the significant decrease in the weight of the metal fingers to which solid rubber was added compared to the weight of the metal fingers alone. This resulted in a higher number of strikes on the cobs and an increase in the number of excess grains.

The 150 rpm recorded the highest efficiency of 90.33 %, while the 85 rpm recorded the lowest efficiency in shelling the grains, which reached 81.67 %. This is due to the increase in the weight of the shelling grains resulting from the increase in their number with the increase in the speed of the shelling mechine, which was concluded by et al. [13] , [18], [19] found.

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As for the interaction between the type of shelling mechine and the rotational speed of the two shelling mechine, its effect was significant on the efficiency of the sheller. The rubber finger shelling mechine recorded the highest shelling efficiency of 96.67 % at a high rotational speed of 150 rpm, while the metal finger shelling mechine recorded the lowest shelling efficiency of 79.00 % at the slow rotational speed of 85 rpm.

Table (2) Effect of the type of yellow corn grain shelling mechine, its rotational speeds and the interaction between them on the efficiency of the shelling mechine (%)

Type of shelling Mechanize	Rotational speed (rpm			
	V1	V2	V3	Mean
Sh1	**79.00** ±1.00 ef	**81.67** ±0.577 e	**84.00** ±1.00 cd	**81.56** b
Sh2	**84.33** ±1.528 c	**91.33** ±0.577 b	**96.67** ±0.577 a	**90.78** a
Mean	**81.67** c	**86.50** b	**90.33** a	

3. percentage of shelling grains (%):

Table (3) shows the presence of significant differences between the averages of wasting rates when using two types of shelling mechine.

When comparing, we note that the percentage of wasting was higher using the wasting mechine with metal fingers covered with a large percentage of rubber, reaching 92.00 %, while the percentage of wasting was lower using the metal shelling mechine, reaching 86.56 %. The reason for the high percentage of overdischarge using the rubber-coated finger shelling mechanism is attributed to the increase in the number of oversheller grains as a result of the increase in the number of strokes of its fingers resulting from its small weight compared to the metal finger shelling mechanism.

The effect of the speed of the rotary shelling mechine was also significant on the percentage of over shelling grains. The highest percentage of over- sheller grains reached 92.3 % at a speed of 150 rpm, and the lowest percentage of over- sheller reached 86.17 % at a speed of 85 rpm. The reason for the high percentage of shelling is due to the increase in the number of shelling grains resulting from the increased speed of the shelling mechine, which is consistent with what [20], [21] found.

The interaction between the type of shelling mechine and its rotation speed also had a significant effect on the percentage of shelling grains. The shelling mechine with rubber coated metal fingers achieved an increase in the shelling ratio at all rotational speeds, with the highest shelling ratio reaching 96.00 % at 150 rpm, while the shelling mechine with metal fingers (not rubber coated) achieved the lowest grain shelling ratio at 85 rpm reaching 84.67 %.

Table (3) Effect of the mechine of yellow corn sheller mechine grains, its rotational speed, and the interaction between them on the percentage of shelling grains (%)

Type of shelling Mechanize	Rotational speed (rpm			
	V1	V2	V3	Mean

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Sh1	1.155 **84.67** ± **f**	0.577**86.33** ± **e**	0.577 **88.67** ± **cd**	**86.56** **b**
Sh2	±1.528 **87.67** **c**	±0.577 **92.33** **b**	±1.00**96.00** **a**	**92.00** **a**
Mean	**86.17** **c**	**89.33** **b**	**92.33** **a**	

4. Percentage of damaged grains:

The results of Table (4) show a significant effect of the type of grain shelling mechine on the percentage of damaged grains, as the shelling mechine rubber coated metal fingers shelling mechine achieved the lowest percentage of damage to excessive grains, which is 2.548 %, compared to the mechine metal finger shelling mechine, which recorded the highest percentage of damage, which is 3.441 %. The reason for this is due to the lower intensity of the blows of the shelling mechine with rubber-covered fingers, which preserved the grains from damage to a greater extent than the grain shelling mechine with metal fingers.

The rotational speed of the shelling mechanism also affected the percentage of damage, as the percentage of damage increased from 1.932 to 4.162% when the rotational speed increased from 85 to 150 rpm. The reason is due to the increase in the fingers of the force of the feeding machine, which increases with the increase in the rotational speed of the shelling mechine, which led to an increase in the percentage of damaged grains. This is what was reached by [13], [22].

Regarding the effect of the interaction between the type of shelling mechanism and its rotational speed, it was significant in the percentage of damaged grains. The grain damage rate increased for both shelling mechine with increasing rotational speed, but the feeding mechine with cachok fingers achieved the lowest grain damage rate at both slow and high speeds, reaching 1.277 and 3.927 %, respectively, compared to the shelling mechine with metal fingers, which recorded the highest percentage of damaged grains, reaching 2.587 and 4.397 %, at shelling speeds of 85 and 150 rpm, respectively.

Table (4) Effect of the type of yellow corn grain shelling mechine, its rotational speed, and the interaction between them on the percentage of damaged grains (%)

Type of shelling Mechanize	Rotational speed (rpm			
	V1	V2	V3	Mean
Sh1	0.180**2.587** ± **d**	±0.010 **3.340** **c**	±0.025**4.397** **a**	**3.441** **a**
Sh2	±0.012**1.277**	±0.020**2.440** **e**	±0.006**3.927** **b**	**2.548** **b**
Mean	**1.932** **c**	**2.890** **b**	**4.162** **a**	

IV. Conclusions

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Based on of the results obtained from the study, we conclude the following.

1- The use of a corn shelling mechine with steel fingers coated with a high percentage of rubber resulted in higher productivity and shelling efficiency, a higher percentage of hulling, and less mechanical damage to the grains compared to used of a shelling mechine with steel fingers alone**.**

2- The high rotational speed of the shelling mechine achieved high productivity and shelling efficiency with a higher threshing ratio and greater damage to grains compared to the medium and low speeds.

3. The interaction between the type of shelling mechine and the rotational speed of the shelling mechanism had a significant effect on all performance indicators, as productivity, efficiency, shelling rate, and grain damage rate increased using both shelling mechine with metal fingers and metal fingers covered with a large percentage of rubber when the rotational speed of the shelling mechine increased. However, the average values of the aforementioned performance indicators were better using the shelling mechine with metal fingers covered with a higher percentage of rubber.

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