DEVELOPMENT OF A GARLIC ROOT AND STEM CUTTING MACHINE

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ABSTRACT

The main purpose of this research is to design a garlic root and stem cutting machine suitable for cutting root and stem part of the garlic. It can help farmer to reduce human effort and degree of discomfort involved during cutting. A garlic cutting machine was designed, fabricated and evaluated for its performance and techno-economic feasibility. Some shearing properties of garlic stem that are pertinent to the mechanical processing were measured and considered in the design of the machine. The developed machine was evaluated at three levels of knife speed (K_S) (8.5, 12.1 and 20.5 m s^{-1}) and two levels of garlic bulb moisture content (M_C) (61.5% and 70.3% w.b.). The Evaluation was based on the following parameters: machine capacity (P_m), bulb damage (BD), consumed energy (CE) and cost. The results recommended operating the machine at combinations of $K_S = 8.5 \rightarrow 20.5$ m s^{-1} and M_C value of 61.5% to maximize P_m with minimize BD. The garlic cutting machine increased the capacity to about 1.5 times and reduced the cutting cost to about 29.2 % comparing with manual method.

Keywords: *Garlic, root, stem, cutting, design, damage.*

INTRODUCTION

Garlic (*Allium sativum L.*) has been used as a food, a condiment, and for medicinal purposes for many centuries. Garlic is one of the most widely used traditional culinary herbs in the world. In Egypt, the cultivated area of garlic is about 11875 Ha and production is 280216 tons (**FAOSTAT, 2016**). Postharvest treatments of garlic may be performed treatments were included in the trial, both separately and in combination: tops cut; roots cut; washed; high-tunnel dried; and open-air dried. Before the garlic is sent to market for retail selling, the roots and stems of garlic are required to be removed. This operation processed by hand labour. Due to scarcity of agricultural labour (in Egypt villages), farmers find it difficult to complete this task in time.

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The proposed machine is intended to help the farmers to cut the root and stem in the proposed processing time. The garlic roots cutting were cut while garlic still moist using a pruning or knife shears, where cares was taken not to damage the basal plate. The heights of top cutting were six inches, while garlic was green. *Qi et al. (2011)* stated that the factor affects the cutting process is the cutting tools. The knife sharpness can significantly affect storage life, whereas dull knives cause bruises and damage to the tissue layers (*Gil and Allende 2012*, *Mishra et al., 2012*). The most familiar geometric shapes of fresh-cut vegetables and fruits are: disc, baton, cube, shred and slice. The shapes depend on the types of product and their requirement (*Koidis et al. 2012*). For some fruits like mango and yellow melon, it is important to determinate the cutting types for their processing (*Ngamchuachit et al. 2014; Russo et al. 2012*). The value addition through packaging, storage and other post harvest technologies of garlic will be root and stem cutting. So, the objective of the present work is to design, fabricate and evaluate a low-cost garlic root and stem cutting machine.

MATERIALS AND METHODS

2.1 Sample preparation

The garlic bulbs (Egyptian Baladi variety) were randomly collected from different farms. Similar to local practice, the bulbs were dried by spreading in a thin-layer inside a darkroom with open windows near the farms for 15 days.

The garlic moisture content was determined by following *ASAE, (1999a)* standard. The samples were, weighed and the moisture content was calculated in percent wet basis (w.b.).

2.2 Physical and mechanical properties of garlic

Some physical and mechanical properties of garlic bulb that are related to the cutting processing were measured and considered by the design of the machine.

2.2.1 Dimensions, mass and volume of garlic bulb

Some physical properties of garlic bulb were determined by *Ibrahim (2013)*. The properties that were measured are presented in Table (1).

2.2.2 Static coefficient of friction

The friction static coefficient of bulb garlic with different materials, plywood, galvanized metal and rubber was determined by *Ibrahim (2013)* at moisture

content of 70.3% determined, the friction static coefficient of bulb garlic are presented in Table (1).

Table (1): Some physical and mechanical properties of garlic bulb.

Property		Min.	Max.	Mean	Stand. Dev.
Length, mm.		30.6	41.7	36.5	3.1
Width, mm.		39.9	71.9	51.4	6.8
Thickness, mm.		40.2	65.6	50.7	5.9
Mass, g.		87.6	45.3	62.5	11.6
Volume, cm^3.		30.6	41.7	36.5	3.1
Bulk density, g cm^{-3}.		0.41	0.56	0.45	0.25
Coefficient of friction.	Metal	0.28	0.70	0.42	0.09
	Wood	0.30	0.68	0.30	0.08
	Rubber	0.43	0.73	0.5	0.10

2.2.3 Shearing characteristics

The ultimate shear strength test was performed out according to (***ASAE, 1999 b***). The shear force was measured in double shear using a shear box (Fig. 1) consisting essentially of two fixed parallel hardened steel plates 15 mm apart, between which a third plate can slide freely in a close sliding fit. Shear force was applied to the specimens by mounting the shear box. The test was carried out between the standard Instron stainless steel polished platens of a model Instron Universal Testing Machine (Instron, USA) using a 1 kN load cell. The shear stress was calculated as follows:

$$\tau = \frac{F}{2A}$$

(1)

Where

τ : Shear stress, MPa.

F : Shearing force at failure, N.

A : Initial cross – sectional area, mm^2.

The shearing energy was calculated by integrating the area under the shear force and displacement curve (***Chen et al., 2004***). The specific shearing energy was found as:

$$E_{SC} = \frac{E_S}{A}$$

(2)

Where

Esc	:	Specific shearing energy, mJ mm^{-2}.
Es	:	Shearing energy, mJ.
A	:	Initial cross – sectional area, mm^2.

The measured shearing properties of the garlic root and stem are presented in table (2).

Loading plate   Supported plates
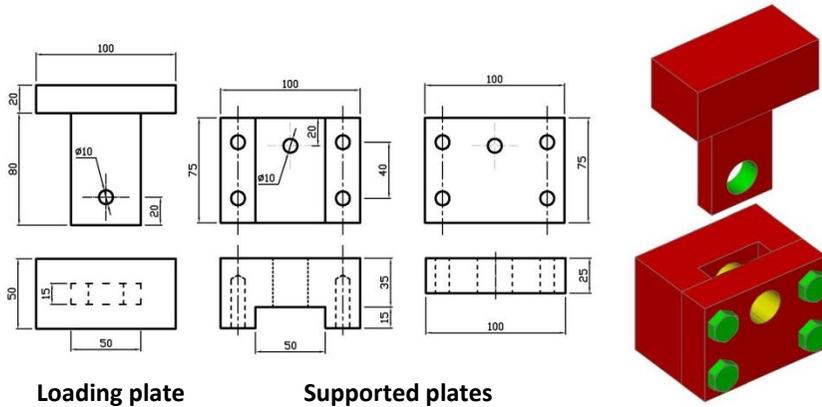
Fig. (1): The shear force measuring device.

Table (2): Shearing characteristics of garlic root and stem.

Property	Value			
	Min.	Max.	Mean	Stand. Dev.
	Root			
Shearing force, N.	1.10	3.75	1.98	0.63
Shearing stress, MPa.	0.02	0.05	0.03	0.01
Shearing energy, mJ mm^{-2}.	0.12	0.34	0.18	0.05
	Stem			
Shearing force, N.	2.00	7.50	3.94	1.15
Shearing stress, MPa.	0.13	0.32	0.22	0.07
Shearing energy, mJ mm^{-2}.	0.49	1.36	0.72	0.22

2.3 Developed machine

The design following were considered in the of the machine ability to cut root and stem from the garlic bulb with a rate higher than the manual method, ease of operation, economy to make the machine affordable and within the capacity of the local farmers. The main components of the proposed machine

are (Fig. 2): (1) cutting and cleaning units, (2) rotating shaft and bearings, (3) power transmission unit, and (4) main frame and supporting unit. The garlic plant is manually fed to the root cuter, root end down, through a protective guard shaped protective slot in the tabletop. The garlic bulb is stopped at the guard. Garlic bulbs with stems are horizontally fed, into the slot where they slide down through a guiding device and get cut by a cutting device. It is able to adjust the central positions of bulbs at an appointed point and is able to cut stems and roots of the individual bulbs to a predetermined extent, in spite of the variations of their size and shape. A discharge device below the rotating blade discharges the roots and debris through a duct to a collecting system.

2.3.1 Frame and support

The frame was manufactured locally from steel structures of angle-cross section (L 40 mm $\times$ 40 mm$\times$ 4 mm). The dimensions of the frame are 60 cm length, 50 cm width, and 70 cm height. The frame includes two parts first part for supporting the motor and second part for supporting the machine.

.3.2 Power transmission unit

Pulley size: The basic formula of designing a V-belt as the following, according to ***Khurmi and Gupta (2005)***:

$$N_1 D_1 = N_2 D_2 \qquad\qquad (3)$$
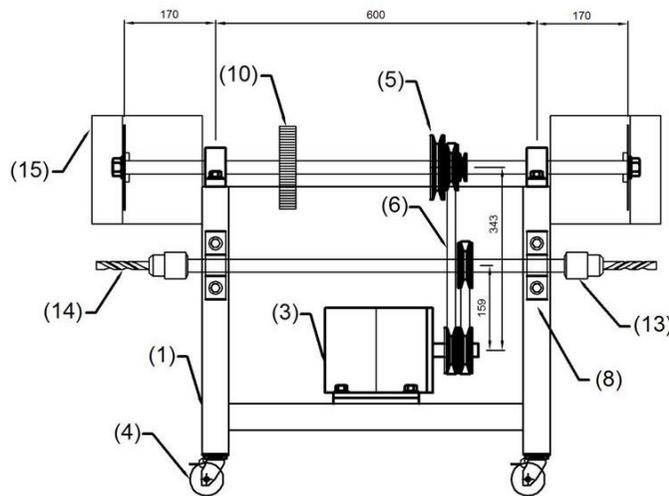
Where

N_1, N_2 :   Speed of driving and driven pulley respectively, rpm.

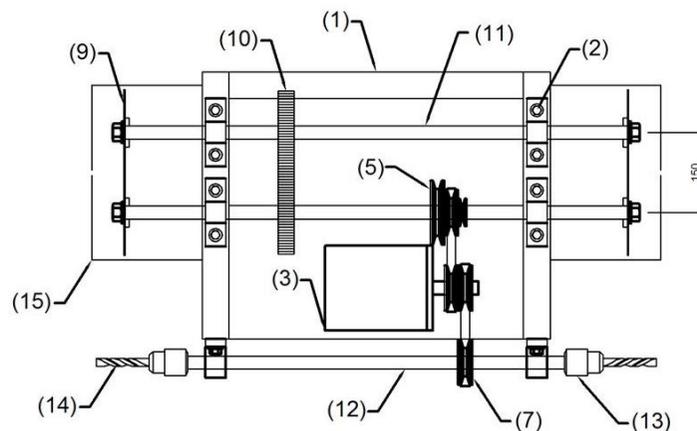D_1, D_2 :   Diameter of driving and driven pulley respectively, mm.

The machine will operate at three speeds: 1020 (8.5), 1440 (12.1) and 2448 (20.5) rpm (m s^{-1}). So, Substituting the required speeds at the Knife (N_1 are 1020, 1440 and 2448 rpm, the rated speed of the electric motor N_2 was 1440 rpm), D_1 and D_2 where calculated as given in the table (3).

Table (3): Values of D_1 and D_2.

Knife velocity (m sec^{-1})	Pulley of machine		Pulley of motor	
	N_1 (rpm)	D_1 (mm)	N_2 (rpm)	D_2 (mm)
8.5	1020	120	1440	85
12.1	1440	85	1440	85
20.5	2448	50	1440	85

15	2	Cover	St37
14	2	Twist Drill (Right + Left)	HSS
13	2	Drill Chuck	St37
12	10	Side shaft	St50
11	2	Main shaft	St50
10	2	Spur gear 150 mm diameter	St37
9	4	Circular knife 160 mm Diamater	St 37
8	6	Bearing housing UCP205-100	
7	1	Single-pulleys blok	Al
6	1	V-belt = 16mm	Rubber
5	2	Malti-pulleys blok	Al
4	4	Rotary caster single bearing wheel	
3	1	Motor	
2	12	Bolts and nut M10	St37
1	1	Machine base	St37
Itemref	Quantity	Title/Name	Material
Designed by Dr./Mohamed Ibrahim	Checked by		

Dims. in mm

Fig. (2): Diagrammatic sketch of the developed machine

Length of belt (**L**): The 0.9 m length of the belt was calculated from the following equation:

$$L = \frac{\pi}{2}(D_1 + D_2) + 2x + \frac{(D_1 - D_2)^2}{4x} \qquad \textbf{(4)}$$

Where

X   :   Distance between centres of the two pulleys (= 40 cm).

2.3.3 Cutting and cleaning units

The machine works on shear cutting principle. The cutting unit consists of two pairs of knife blade fixed on two shafts (1, 2). The cleaning unit consists of two twist drill and drill chuck; they fixed on shaft (3) as shown in Fig. (3).

The power required for cutting the garlic stem

In Fig. (4), A and B are the pair knives, G is the garlic stem, W is the weight of the garlic stem, Fc the normal force acting on the G and Ft is the tangential force acting the G.

The power required to operate the machine is the first step to be consider in the design procedures. The power required to cut the garlic stem (P, in W) was estimated according to **_Shigley (2015)_** as follows:

$$P = n_r \, T \, \omega \qquad \textbf{(5)}$$

Where

P   :   Power required to cut the garlic stem, W.

n_r :   Number of the rotating knives ($n_r = 4$).
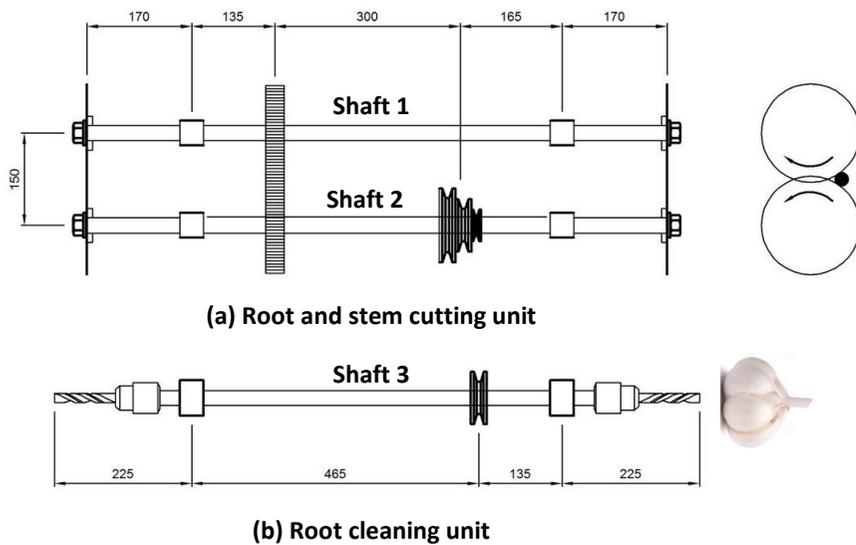
ω :   Angular velocity of the roller, rad/second, ($\omega = 2\pi \, N_s/60$).

N_S :   Roller speed, rpm ($N_S = 2448$ rpm).
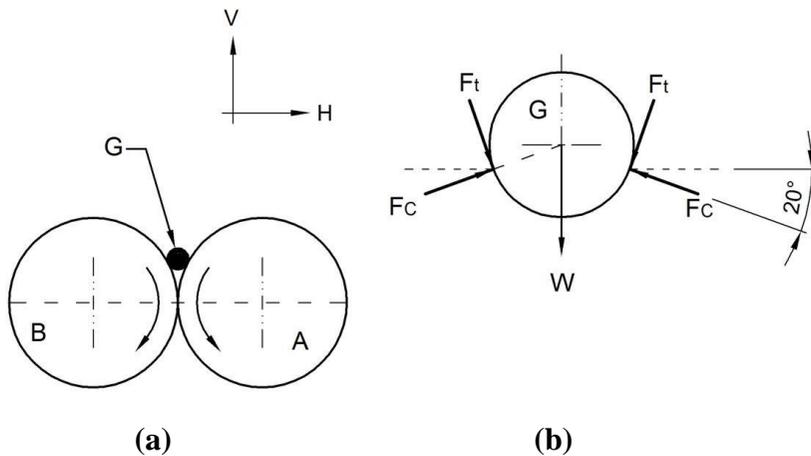
T   :   Torque, N-m = r F_t .

r   :   Radius of the rotating knife, m (r = 0.80 m).

F_t :   Total friction force between the knife surface and the garlic stem = the tangential force.

(a) Root and stem cutting unit

(b) Root cleaning unit

Fig. (3): Cutting and cleaning units.

(a)   **(b)**

Fig. (4): Diagrammatic sketch for the forces acting on a garlic stem during the cutting process: (a) Pair knives, (b) a garlic stem.

For one garlic stem, the normal force ($2 \times F_N$) that is required to cut one garlic stem (shear force for cutting garlic stem), it was measured to be 7.5 N (Table 2), (F_N = 3.75 N) and the corresponding tangential force (F_t) was estimated based on a friction coefficient (μ = 0.7) between the steel and the garlic stem (Table 1); the value of $F_t = \mu\, F_N$ is equals to 2.625 N. Accordingly, the number of the garlic stem that will be cut simultaneously is 2. The value of T (in Eq., 5) is equal to 0.21 N-m and the power required (Eq.

2) is equal to 215.23 watt to operate the cutting shafts at 2448 rpm. The chosen power engine is 0.5 HP = 375 W.

Design of the rotating shaft (No. 2): In order to transfer the power from the shaft, the various members (such as pulleys) are mounted on it. The design of shaft is based on combined shock and fatigue, Bending and torsional moment (Fig. 7).

Hence, the diameter of the shaft was calculated as follows (***Eric, 1976***):

$$d^3 = \frac{16}{\pi S_s} \sqrt{[K_b M_b]^2 + [K_t M_t]^2} \qquad (6)$$

Where

d : Diameter of shaft, m.

M_b : Resultant bending moment, N-m.

M_t : Torsional moment, N-m.

K_b : Combined shock and fatigue factor applied to bending moment.

K_t : Combined shock and fatigue factor applied to torsional moment.

Ss : Allowable shear stress of the shaft material, MN-m^{-2}.

The values of K_b and K_t were taken as 1.5 and 1.0 respectively for the gradually applied load on the rotating shaft and the allowable shear stress of the shaft (Ss) as 40 MN-m^{-2} based on ***ASME code***.

M_b was calculated by analyzing moments due to both horizontal and vertical loading in bending moment diagrams of the shaft.

M_t was calculated by the following equation:

$$M_t = \frac{P \times 60}{2\pi N} \qquad (7)$$

Using P = 375 W and N = 1020 rpm, the maximum M_t was calculated as **3.51** N-m.

Determination of the Maximum Bending Moment:

The position of the electric motor in relation to the main shaft is such that T_1 and T_2 act vertically downward.

For the pulley:

Weight of pulley (Wp)   = Vp × ρ_p × g   **(8)**

Where

Vp : Volume of the pulley, m^3 (120 mm – diameter and 40 mm – thick)

ρ_p : Density of the pulley material (for aluminium = 2700 kg m^{-3}).

So, Wp = **16.3** N.

According to ASTM Standards, the V-belt is 16 mm that can transmit $2 - 15$ kW.

Belt Force: The power transmitted by a belt drive is a function of the belt tensions and belt speed. The belt tensioning forces on the pulley was calculated according to the following equations (***Khurmi and Gupta, 2005***).

$$2.3 \log T_1 / T_2 = \mu\, \theta \, \text{cosec}\, \beta \qquad \textbf{(9)}$$

$$Mt = (T_1 - T_2)\, R_1 \qquad \textbf{(10)}$$

Where

T_1 : Belt tension in tight side, N.

T_2 : Belt tension in loose side, N.

μ : Coefficient of friction between belt and pulley ($\mu = 0.25$).

θ : Belt wrap angle, radian $= (180 - 2\,\alpha)\,\pi/180$.

α : $\sin\alpha = \dfrac{D_1 - D_2}{2x}$.

x : Distance between centres of the two pulleys ($= 37$ cm).

$2\,\beta$: Groove angle of the pulley (32˚).

Mt : Torsional moment (N-m).

R_1 : Radius of the machine pulley (m).

Torque transmitted by the pulley (Mt) = **3.51** N-m. From the previous equations, T_1 and T_2 were calculated and are given in table (4):

Table (4): Values of T_1 and T_2.

D_1 (mm)	D_2 (mm)	A (degree)	θ (rad.)	T_1 / T_2	T_1 (N)	T_2 (N)	T_1+T_2 (N)
120	85	0.047	2.7	15.86	62.44	3.94	66.37
85	85	0	0	17.3	87.65	5.07	92.72
50	85	-0.047	2.7	15.86	149.85	9.45	159.30

The maximum value of (T_1+T_2) with T_1 = **149.85** and T_2 = **9.45** N was taken in the calculations. So, Total load acting on pulley = T_1+T_2 + Wp = **297.15 N**.

For the knife

$$\text{Weight of knife } (W_C) = \rho \times Vc \times g \qquad \textbf{(11)}$$

Where

ρ : Density of the Material (for steel, 7800 kg m^{-3}).
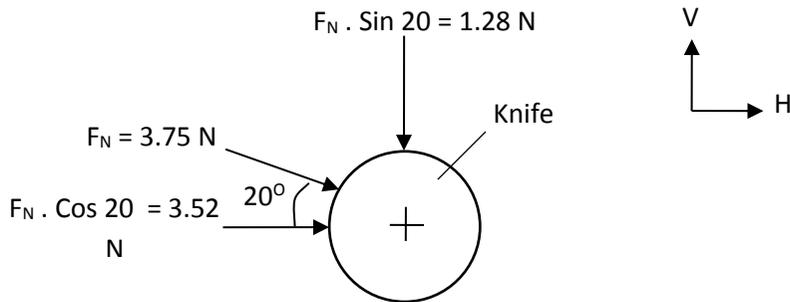
V_C : Volume of the knife.

g : Acceleration due to gravity.

So, the weight of knife (W_C) = **3.1 N**. Normal force extorted by garlic stem on the one knife (F_N) = **3.75 N**, this load acts at 20° to the horizontal as shown in Fig. (5)

Resolving the load F_N into vertical and horizontal components (Fig. 5), the vertical component = $F_N \sin 20° = 3.75 \times \sin 20°$ = **1.28 N**

The horizontal component of = $F_N \cos 20° = 3.75 \times \cos 20° = $ **3.52 N**

Fig. (5): The normal force due to the cutting.

Vertical loading ($\mathbf{F_{TV}}$) on the shaft = $F_N \sin 20 + W_C = 1.28 + 3.1 = $ **4.38 N**.

Horizontal loading ($\mathbf{F_{TH}}$) on the shaft = **3.52 N**.

For the gear: The forces act on the gear is shown in Fig. (6)

$$\text{Weight of gear } (W_G) = \rho \times V_G \times g \qquad \textbf{(12)}$$

Where

ρ :   Density of the Material (for steel, 7800 kg m^{-3}).

V_G :   Volume of the gear.

g :   Acceleration due to gravity.

So, the weight of gear **(W_G) = 43.29 N**.

$$F_t = \frac{P}{r \times \omega}$$
$$F_r = F_t \times \tan \phi \qquad \textbf{(13)}$$

Where

F_t :   The tangential force, N.

P :   Power required to cut the garlic stem, W.

r :   Radius of the pitch circle (r = 77.5 mm).

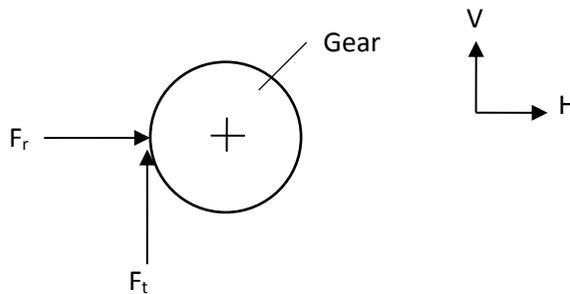ω :   Angular velocity of the gear, in rad/second, ($\omega = 2\pi N_s/60$).

N_S :   Gear speed (in rpm) = 1020 rpm.

F_r :   The radial force, N.

ϕ :   Pressure angle of the tooth (ϕ = 20°).

So, $F_t = 0.76$ N and $F_r = 0.28$ N.

The horizontal force acting on the gear = **0. 28** N.

Fig. (6): The forces act on the gear.

Accordingly, the shaft is subjected to vertical loads of the values presented in table (5) and Fig. (7).

Table (5): Vertical and horizontal loads on the shaft (N).

Type of load	At (A)	At (B)	At (C)	At (D)
Vertical	**4.38**	**43.29**	**297.15**	**4.38**
Horizontal	**3.52**	**0.28**		**3.52**

The bending moment diagram for vertical and horizontal loading are shown in Fig. (7).

From the shear force diagram of Fig. (7), it is obvious that *C* is the point of maximum bending moment. Maximum bending moment (M_b) was found to be **M_b = 36.41 N-m**. The maximum torque was found to be **M_t = 3.51** N-m.

By applying in the equation (6), shaft diameter (d) should be equal or more than **19.13** mm = **20** mm.

2.3.4 Bearing selection

The selection of a rolling bearing is made from a manufacturer's catalogue. By using FAG rolling bearing catalogue for the machine ball bearing was selected.

2.3.5 Electric motor

A single phase electric motor with a rated speed of a 1440 rpm and power of 0.5 hp was used.

2.4 Performance evaluation

According to literature data (*ASAE, 1999c; Srivastava et al., 2006; CIGR, 1999*), evaluation parameters of the developed machine were machine capacity, bulb damaged, consumed energy and cost. The development machine was evaluated at two different levels of moisture content of garlic and three levels of knife speed (Table 6).
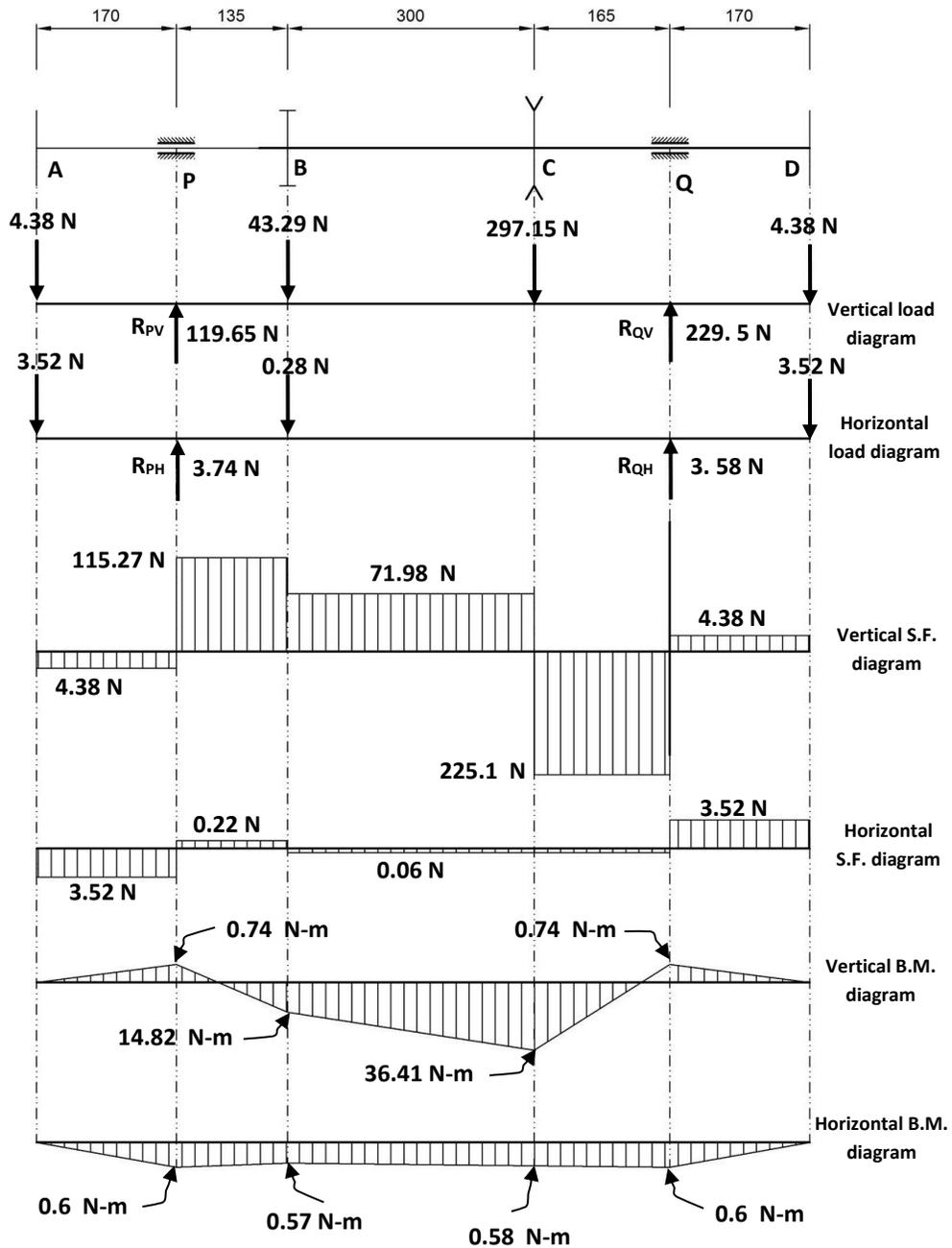
Fig. (7): The shearing and bending moment diagrams of the shaft.

Table (6): Experimental plan for evaluating the machine.

Variables	Levels
Moisture content, M_C (% w.b)	61.5, 70.3
Knife speed, K_S, m s^{-1} (rpm)	1020 (8.5), 1440 (12.1) and 2448 (20.5)

2.4.1 Machine capacity (P_m)

The machine capacity was calculated as follows:

$$P_m = \frac{N_P}{T} \qquad (14)$$

Where

P_m	:	The machine capacity, piece h^{-1}.
N_p	:	Number of cutting, piece.
T	:	Cutting time, hour.

2.4.2 Bulb damage (BD)

Bulb damage percentage (BD) was calculated by the following equation:

$$BD\,(\%) = \frac{\text{Number of damaged bulb}}{\text{Total weight of bulb}} \times 100 \qquad (15)$$

2.4.3 Required power (RP) and consumed energy (CE)

The required electric power under machine working load (RP) was calculated as *Chancellor (1981)* by the following equation:

$$RP = V \times I \times \cos\theta \qquad (16)$$

Where

RP	:	The required power for separating bulb, W.
V	:	Potential difference, Volt (single phase = 220 volt).
I	:	Line current intensity, Amperes.
$\cos\theta$	:	Power factor (0.64).

A digital clamp meter and Voltmeter were used for measuring current intensity and voltage respectively.

The consumed energy (CE) is specific power per unit capacity; it was calculated by using the following equation:

$$\text{Consumed energy} = (RP/P_m), \quad \text{W h piece}^{-1} \qquad (17)$$

2.4.5 Costs

Machine cost was determined using the fixed costs and variable costs according to **Srivastava et al. (2006)**. The estimated cost of the cutting machine was about 5000 L.E. The operational cost was determined using the following equation:

$$\text{Operating costs} = \frac{\text{Machine cost (L.E h}^{-1})}{\text{Machine capacity (piece h}^{-1})} \qquad \textbf{(18)}$$

RESULTS AND DISCUSSIONS

3.1 Machine capacity (P_m)

The machine capacity ranged from 522 to 728 Piece h^{-1} with knife speed of 8.5 to 20.5 m s^{-1} and moisture content of 61.5 to 70.3 %. The machine capacity was influenced by the knife speed and moisture content. The machine capacity was the least at the lowest knife speed of 8.5 m s^{-1} and increased with increasing speed. This due to with increasing the knife speed the root and stem cut easily. The machine capacity decreased with increasing moisture content, this due to increase the cutting strength of root and stem, as shown in figure (8).
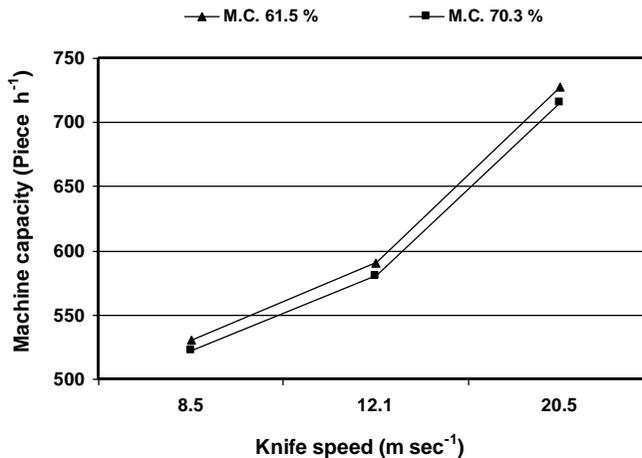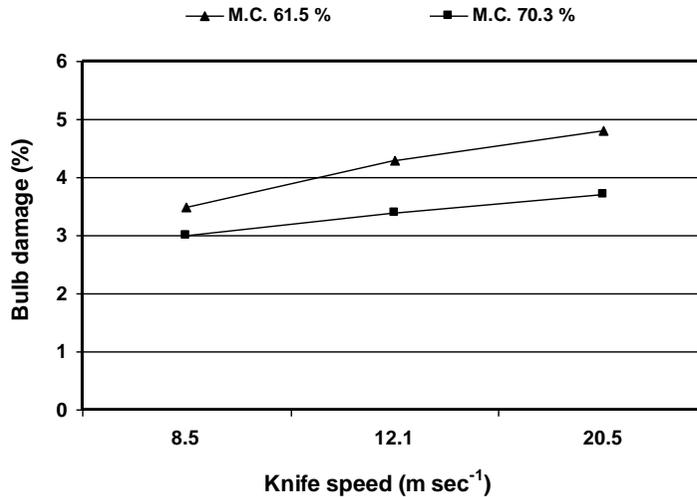

Fig. (8): The effects of knife speed and moisture content on machine capacity.

3.2 Bulb damage (BD)

The bulb damage percentage ranged from 3 % to 4.8 % with knife speed of 8.5 to 20.5 m s^{-1} and moisture content of 61.5 to 70.3 %. The bulb damage was influenced by the knife speed and moisture content. The bulb damage

was the least at the lowest knife speed of 8.5 m s^{-1} and increased with increasing speed. The bulb damage increased with reduction in moisture content, as shown in figure (9).

Fig. (9): The effects of knife speed and moisture content on bulb damage percentage.
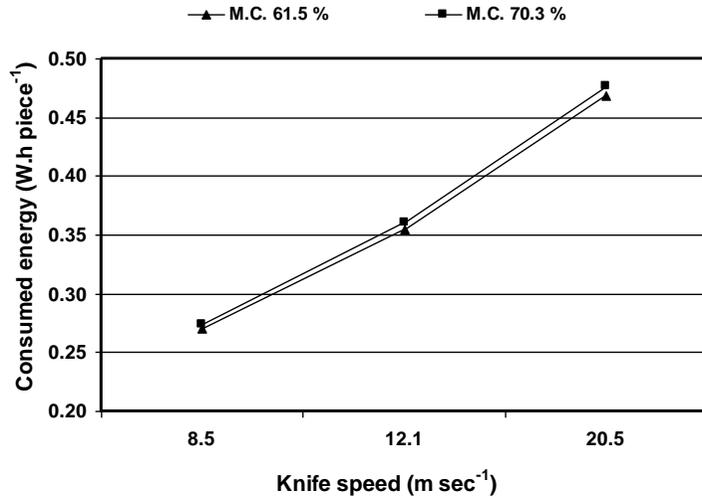
3.3 Consumed energy (CE)

The consumed energy ranged from 0.27 to 0.48 W h piece^{-1} for knife speed of 8.5 to 20.5 m s^{-1} and moisture content of 61.5 to 70.3 %. The consumed energy was influenced by the knife speed and moisture content. The consumed energy was the least at the lowest knife speed of 8.5 m s^{-1} and increased with increasing in speed, this due increasing in required power with increase the speed. The consumed energy was almost same at the moisture contents of 61.5 % to 70.3 %., as shown in figure (10).

The most suitable conditions for machine that take the best cutting condition: were observed at combinations of knife speed $=8.5 \rightarrow 20.5$ m s^{-1} and moisture content value of 61.5%.

3.4 Techno-economic feasibility

The cost of cutting the garlic root and stem was 6.3 L.E for 100 pieces^{-1} which were much cheaper than the manual method (8.9 L.E for 100 pieces^{-1}) according to 2018 local conditions. Using the developed machine increased the capacity to about 1.5 times and reduced the separation cost to about 29.2 % comparing with manual method, as shown in figure (11).

M.C. 61.5 %　　　**M.C. 70.3 %**

Fig. (10): The effects of knife speed and moisture content on consumed energy.
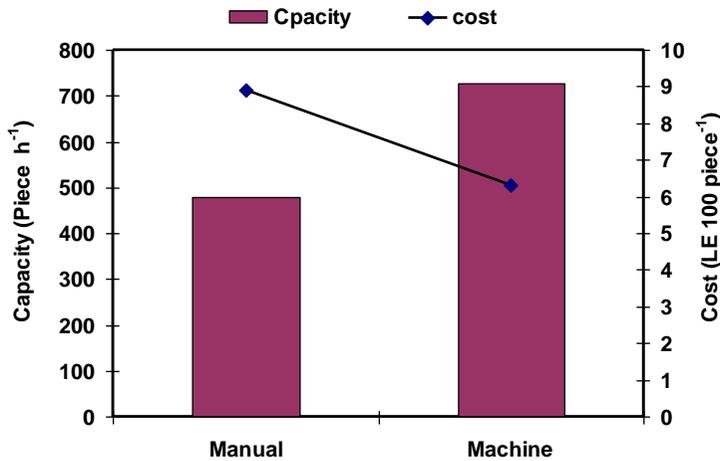
Fig. (11): Capacity and cost of the garlic cutting with manual and mechanical methods.

CONCLUSION

The obtained results can be summarized as follows:

1. Machine capacity increased with the increase of knife speed, and decrease in moisture content.
2. Bulb damage increased with the increase in knife speed, but decreased with increase in moisture content.

3. Consumed energy increased with the increase in moisture content, and knife speed.

4. It is recommended to use the following operating variables at combinations of knife speed = 8.5 → 20.5 m s^{-1} and moisture content value of 61.5%

5. Using the developed machine increased the capacity to about 1.5 times and reduced the separation cost to about 29.2 % comparing with manual method.

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الملخص العربى

تطوير آلة لقطع جذور وسيقان الثوم

د. محمد محمود إبراهيم (١) **ماهر فتحي عطية (٢)**

يهدف هذا البحث إلي تصميم وتصنيع أحد الآلات المحلية التى تستخدم فى عمليات ما بعد الحصاد حيث تقوم الآلة بتقطيع جذور وسيقان الثوم من أجل تجهيزها للتصدير أو إستخدامها فى عمليات تصنيعية أخرى، حيث ان الطريقة اليدوية للتقطيع تحتاج إلى مجهود ومكلفة. قد تم تقدير القوة اللازمة لقطع جذور وسيقان الثوم والمتعلقة بعملية التصميم. قد تم تصميم وتصنيع الآلة، والتى تتكون من وحدتين من القطع كل وحدة عبارة عن سكنتين قطرهما ١٦ سم،

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بالإضافة إلى وحدة لعملية التنظيف للجذور الصغيرة، ومجموعة لنقل الحركة بالإضافة إلى محرك كهربائى قدرته ٠,٥ حصان. وقد تم إختبار الآله عند ثلاث سرعات مختلفة لسكين القطع (٨,٥ ، ١٢,١ ، ٢٠,٥ م ث⁻¹) ومحتوى رطوبى مختلف (٦١,٥ % ، ٧٠,٣ % على أساس رطب)، وقد تم تقدير السعة الإنتاجية للآلة، نسبة الفقد، الطاقة المستهلكة.

وقد بينت الدراسة ما يلي:

١. إنتاجية الآلة تزداد مع زيادة سرعة السكين وتقل مع زيادة المحتوى الرطوبى.

٢. نسبة الفقد تزداد مع زيادة سرعة السكين، وتقل مع زيادة المحتوى الرطوبى.

٣. الطاقة المستهلكة تزداد بزيادة كلا من سرعة السكين والمحتوى الرطوبى.

٤. ينصح بتشغيل الآلة على مدى من السرعات ٨,٥ الى ٢٠,٥ م ث⁻¹ عند محتوى رطوبى ٦١,٥%.

٥. بإستخدام الآلة سوف يزيد السعة الإنتاجية إلى حوالى ١,٥ مرة ويقلل تكاليف القطع إلى حوالى ٢٩,٢ % مقارنة بالتقطيع اليدوى.