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PERFORMANCE OF CHOPPER MACHINE FOR CHOPPING FODDER BEET

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ABSTRACT

The objective of the present study was to evaluate the performance of fodder beet chopper under the Egyptian farm conditions. The performance of machine was tested using three drum speeds of 13.50, 17.60, and 20.40 m/s and four feed rates of 90.20,120.30,150.70, and 180.80 kg/h. The machine were tested under two levels of tubers moisture content of about 60.40 and 70.30 % (w.b.) Mean of three replications of each variable was taken to represent the effect of this variable. These parameters were tested to estimate power and energy requirements, final quality as particle size and cost evaluation. Experiments were conducted at Sakha Agricultural Research Station, This experiment was carried out at Mehalt Mousa animal production research station., Kafr EL-Sheikh, Governorate during the summer season of 2011 using fodder beet crop (Rota variety).

The results showed that chopping machine:

Gave the highest percentage of particle mesh size of < 2.0 cm it was reached 63.0 % at drum speed of 20.40 m/s, feed rate of 90.20 kg/h and tuber moisture content of 70.30 %. Regarding to the unit energy consumption for chopping machine gives the lowest values of unit energy in all cases. However it was reached 2.0 kW.h/Mg at drum speed of 13.50 m/s, feed rate of 180.80 kg/h and tuber moisture content of 70.30 %.

The cost analysis indicated that, chopping machine costs a drastic reduction of unit cost 60.3%. Chopping machine was considered the superior machine in reducing the unit energy, unit cost and increasing the percentage of particle mesh size of < 2.0cm. The volumetric capacity of chopped fodder beet in comparison with the whole tubers was 44.4 %. However, the unit cost reached its minimum value of 14.85 L.E/ Mg.

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INTRODUCTION

Fodder beet is a new forage crop in Egypt, the roots are used for animal feeding. The great shortage in animal foodstuff and their distribution around the year are the main problems facing animal production in Egypt. Many attempts have been made to introduce unconventional new forages, especially for the summer season when animals are under-fed. Fodder beet has several advantages and its cultivation may help in overcoming the problem of animal feeding. It could be sown in the new reclaimed sandy soils and its roots and leaves are acceptable for animal feeding beside of green forages in Egypt.

Using chopping machines of fodder beet roots with suitable size for feed animals, was trial to hoped to participate in solving our serious problems of feed shortage during summer season.

Several studies were carried out in Egypt to evaluate and use fodder beet roots in animal feeding **Darwish et al., (1989);** Fodder beet roots could be successfully used for feeding sheep. Chopping energy requirements of forage crops is mainly affected by two factors, namely; physical and mechanical properties of plant stem and the cutter head parameters. At low cutting speeds, cutting energy is a linear function of stalk diameter, however, the effect of stalks moisture content has very little effect on shear energy for sharp blades **Yumnam and Pratap, (1991).** Meanwhile, **Kepner et al., (1982)** reported that chopping energy was related to size of cut . Chopping energy was inversely proportional to size of cut for small cuts, while the relationship become inaccurate as the size of cut increased beyond 1.0 to 1.5 inches. Approximately 40 percent of the total input energy is utilized in the cutter head. Total energy requirements per Mg a forage decrease somewhat as the feed rate is increased, because the power requirements are relatively independent of feed rate.

Mohamed (1998) mentioned that the maximum force needed to cut the beet in the upper part was 540N the middle part 430N and the root part was 188N. Also by increasing the beet diameter from 6 to 15.6 cm the hardness increased from 4.09 to 6.02 N/mm^2. By increasing the sharpness from 0, 0.5 and 1 mm, the cutting resistance increased from 11.11, 22.22 and 166.67 N/mm^2, respectively.

Phipps et al.(1995) incorporated fodder beet into a forage mixture for dairy cow fed diets based on grass silage. The results showed that maize silage, brewers, grains and fodder beet all produced similar increase in milk yield.

Gabra et al. (1992) found that replacement of 40% of a concentrate feed mixture with fodder beet roots resulted in increase feeding value, daily feed intake and milk yield. In substitution for maize silage and concentrates, fresh fodder beet had a positive effect on dry matter intake as well as on net energy intake. When fodder beet was ensiled together with whole maize crop, it positively affected milk yield and fat content.

The chief objective in chopping fodder beet roots is to reducing storage space an handling costs in addition to transform the increasing amount of green fodder during winter season in order to use it in summer season. A suitable chopping machine must be designed for chopping fodder beet roots at small size. Chopping fodder beet roots at suitable size may share in solving the problem of limited consumption of such feed by small ruminants **Gabra and Gad (1999). El-Khateeb (2007)** mentioned that increasing the cutter head speed from (22.1 to 35.3 m/s) tend to increase percentage of chopping length 0.5 to 2.0 cm from (50 to 60%), degree of destruction from (28.7 to 38.2%), machine productivity from (1.32 to 2.81 Mg/h), useful power from (2.19 to 3.86 kW), and with decreasing the unit energy required from (1.87 to 1.37 kW.h/Mg) and chopping machine cost from (16.33 to 7.22 L.E/Mg) at number of knives 2 and corn stalk moisture content of 65.0%.

The main objectives of this study is to evaluate the performance of chopping machine in fodder beet to be used in Egyptian animal production farm. These parameters were tested to estimate power and energy requirements, final quality as particle size and cost evaluation.

MATERAIALS AND METHODS

Field experiments were carried out at Sakha Agricultural Research Station, This experiment was carried out at Mehalt Mousa animal production research station. Kafr EL-Sheikh, Governorate. during the summer season of 2011 using fodder beet crop (Rota variety). The machine was tested three drum speeds of 13.50, 17.60 and 20.40 m/s and

four feed rates of 90.2, 120.3, 150.7 and 180.8 kg/h. The machine were tested under two levels of tubers moisture content of about 60.40 and 70.3% (w.b.) Mean of three replicates of each variable was taken to represent the effect of this variable.

Equipment:

Some physical properties of variety Rota of fodder beet roots as show in Table1.

The stationary chopper machine was mounted on the engine 5hp (3.7kW), the main components of this chopping are showed in Fig. 1 and technical specifications of this chopper are summarized in Table 2.

Table 1: Some physical properties of variety (Rota) of fodder beet roots.

No. of sample	Physical properties			
	Mass, kg	Length, cm	Diameter, cm	Volume, cm^3
1	3.56	25.60	20.53	3357.4
2	3.15	26.11	18.92	2970.7
3	2.92	27.71	18.75	2753.8
4	3.10	28.42	20.91	2923.6
5	3.24	25.00	21.40	3055.6
Total	15.97	132.84	100.51	15061.1
Mean	3.19	26.57	20.10	3012.2

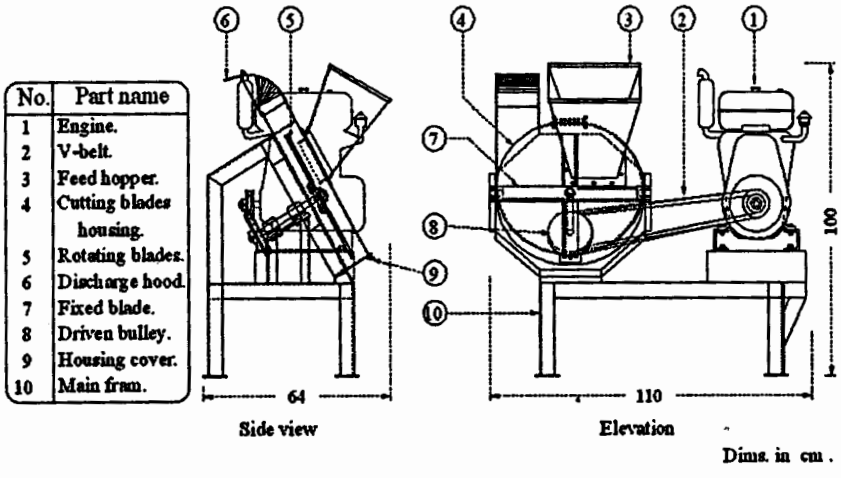

Fig. (1): The chopper machine.

Machine performance determination:

a) Chopping size :-

Copping size of fodder beet tubers were measured by using crumb structure measuring device. It consisted of three sieves having different mesh sizes. The sieve diameter was 20cm and the mesh sizes are 60, 40 and 20 mm. Chopped fodder samples were randomly taken from product with three replicates. The sieve apparatus containing the chopped fodder samples is put into motion in a semi- circulating fashion for one minute. After sieving the entire individual fraction, were massed and converted as a percentage of total sample mass. After each chopping treatment material was taken into laboratory and separated into three categories (< 2cm – 2-4cm and > 5cm each chopping length in the sample was weighed and calculated as a percentage from the total weight of the sample.

Table 2: Machine Specifications:

Item	Detail
Model	Fc-1 Flywheel – Type Inclined Axis Chopper
Country	Philippines
Power source	Gasoline Engine 5hp
Feeding system	Manually
Number of knives on cutter head	4- Knives
Cutting, rpm.	900 – 1500 rpm
Weight	40 kg
Labor requirement	2 persons

b) Machine Productivity:-

Was calculated by using the following formula:

$$P = W / T, \text{ Mg/h} \quad \ldots\ldots 1$$

where:

P = productivity in Mg/h;

W = mass of the sample in Mg, and

T = time in h.

c) Estimation of power requirement :

Chopping power requirements was estimated by using the following formula, ***Suliman et al., 1993.***

$$E_P = (F_C \times \frac{1}{3600})\rho_F \times L.C.V. \times 427 \times \eta_{th} \times \eta_m \times \frac{1}{75} \times \frac{1}{1.36}, \text{kW}.....2$$

where;

E_P = power requirement;

F_C =the fuel consumption, L/h;

ρ_F = the density of fuel, 0.85 kg/l;

$L.C.V$ = the lower calorific value of fuel, 10000 k cal/kg;

η_{th} = the thermal efficiency of engine, 35% for diesel engine;

427 = thermo- mechanical equivalent, kg.m/k.cal, and

η_m = the mechanical efficiency of engine, 80% for diesel

Useful Power=power with load – power without load, kW.....3

The energy requirement was calculated by using the following equation:

$$\text{Energy requirement} = \frac{\text{useful power,kW}}{\text{machine productivity,Mg/h}}, \text{kW.h/Mg} \ldots\ldots\ldots\ldots\ldots 4$$

(c) <u>Feeding animals</u>:

Daily ration of chopped fodder was offered to two mature Rahmay rams twice daily for one week and water was available at all time. This experiment was carried out at Mehalt Mousa animal production research station. It was repeated using stored chopped fodder beet to study the effect of storage on voluntary consumption of rams and the ability to eat it.

(d) <u>Storage of chopped fodder beet</u>:

The chopped fodder beet roots were stored on a natural ventilated storage three months in order to study the effect of mold growth and volumetric capacity on storage of fodder.

(e) <u>Machine operation costs</u>:

The machine operation costs were calculated according to ***(Younis, 1997)***

Fixed costs:

- Depreciation = (original cost- salvage value)/ mechanical life, L.E/year

- Salvage value is 10% of original cost.
- Interest = Interest rate x (original + salvage value)/2, L.E/year.
- Shelter, taxes insurance = 4% x original cost.

$$Total\ fixed\ cost = \left[\frac{Depreciation + Interest + Shelte,\ taxes\ and\ insurance}{Hours\ of\ use\ per\ year}\right], L.E./h \quad \ldots\ldots 5$$

Variable costs:

- Repairs and maintenance = 5.77% of original cost / hours of use per year, L.E/h, as mentioned by ***(Bowers, 1987)***
- Electricity cost=Maximum power consumed, (kW/h) x electricity price, L.E. /h.
- Greasing = 1.5 x 0.25 / No. of hours per day, L.E./h.
- Labor cost = 4.0 L.E. /h
- Total Variable costs = (Repair cost + Electricity +Greasing + Labor), L.E./h.

The cost of production (CP) was calculated by using the following formula:

$$CP = Total\ cos\ ts\ /\ Machine\ Pr\ oductivity\ , L.E./Mg \quad \ldots\ldots\ldots\ldots 6$$

RESULTS AND DISCUSSION

Energy and unit cost:

Concerning with the results obtained from the experimental work. It can be stated that there was a direct proportion between the unit energy consumption and drum speed. These due to several of the energy components are proportional to the square or cube of drum speed ***(Kepner et al., 1982)***. Table 4 show the relationships between drum speeds and unit energy at four levels of feed rates and two different levels of fodder beet moisture content.

It may be pointed out that the increase of drum speed from 13.50 to 20.40 m/s leads to increase the unit energy consumption from 4.0 to 4.7, 3.5 to 4.1, 3.3 to 3.5 and 2.8 to 3.2 kW.h/Mg at feed rates of 90.20,

120.30,150.70 and 180.80 kg/h, respectively, using fodder beet moisture content of 60.40 % (w.b.).

Hence, by increasing beet moisture content from 60.40 to 70.30 % tends to decrease unit energy at the same above mentioned feed rates and drum speed.

It was found that, machine productivity was increased by increasing the drum speed, feed rate and moisture contents. This increase in machine productivity may be attributed to the decrease in the time required for chopper process.

Table 3 summarizes the cost calculations for chopping machine. The unit cost was deduced to determine the machine cost. So, it can be stated that, chopper machine resulted a drastic reduction of 60.3% .

Table 3: Cost calculations for chopping machines.

Cost items, L.E/h							Total cost, LE/h	Productivity, Mg/h	Unit cost, LE/Mg
Fixed cost			Variable cost						
Dep.	Int.	She.	R&M	Energy	Grease	Wages			
0.90	0.55	0.4	0.58	0.13	0.05	1.25	3.86	0.26	14.85

Table 4: Effect of drum speed , feed rates and fodder beet moisture content on unit energy .

Drum speed, m/s	Feed rates, Kg/h	Unit energy, kW. h/Mg	
		Fodder beet moisture content, %	
		60.4	70.3
13.5	90.2	4.0	3.0
	120.3	3.5	2.5
	150.7	3.3	2.2
	180.8	2.8	2.0
17.6	90.2	4.2	3.5
	120.3	3.8	3.0
	150.7	3.4	2.4
	180.8	3.0	2.2
20.4	90.2	4.7	4.0
	120.3	4.1	3.3
	150.7	3.5	2.8
	180.8	3.2	2.5

Chopping sizes:

a) Effect of drum speed, feed rates and fodder beet moisture on chopping size of < 2.0 cm.

Chopping machine :

Dealing with the results showed in Table 4. It can be mentioned that, there was a positive effect of drum speed on the chopping sizes. Increasing the drum speed from 13.50 to 20.40 m/s increases the percentage of chopping from 45 to 55, 43 to 52, 40 to 50 and 38 to 45% at feed rates of about 90.2, 120.3, 150.7 and 180.8 kg/h, respectively for fodder beet moisture content of 60.40 % (w.b.).

Whilst, the same increase in drum speed tends to increase the percentage of sizes from 55 to 63, 50 to 59, 46 to 57 and 44 to 55% at the same above mentioned feed rates and fodder beet moisture content of 85.13%, respectively.

Table 4:-Effect drum speed, feed rates on the percentage of chopping size for two different moisture content.

Moisture content, %	Drum speed, m/s	Feed rates, Kg/h	Chopping sizes, %		
			< 2 cm	2-4 cm	> 5 cm
60.4	13.5	90.2	45	20	35
		120.3	43	19	38
		150.7	40	17	43
		180.8	38	16	46
	17.6	90.2	50	25	25
		120.3	48	22	30
		150.7	46	20	34
		180.8	42	18	40
	20.4	90.2	55	28	17
		120.3	52	26	22
		150.7	50	23	27
		180.8	45	20	35
70.3	13.5	90.2	55	25	20
		120.3	50	22	28
		150.7	46	20	34
		180.8	44	18	38
	17.6	90.2	60	30	10
		120.3	58	28	14
		150.7	55	25	20
		180.8	51	20	29
	20.4	90.2	63	32	5
		120.3	59	30	11
		150.7	57	27	14
		180.8	55	24	21

b) Effect of drum speed, feed rates and beet moisture content on chopping size of > 5 .0 cm:

Chopping machine :

There was a reverse proportion between drum speed and chopping size of > 5.0cm. Whereas, the increase in drum speed from 13.50 to 20.40 m/s decreases the percentage of chopping size from 35 to 17, 38 to 22, 43 to 27 and 46 to 35 % at feed rates of 90.2, 120.3, 150.7 and 180.8 kg/h, respectively for fodder beet moisture content of 60.40 % and fodder moisture content of 60.40% (w.b.), respectively as shown in Figs 3 and 4. In the same manner, the increase in drum speed decreases the percentage of chopping size from 20 to 5, 28 to 11, 34 to 14 and 38 to 21 % at the same above mentioned feed rates and moisture content of about 70.30 %, respectively.

Chopped fodder beet storage:

The chopped fodder beet was stored for three months to observe the effect of mold growth in them. It has been noticed that there was an absence of mold-growth in feedstuffs at moisture content 19.45% of forage materials. Therefore, the safe moisture content of chopped fodder beet storage was 19.45%.

These results are in agreement with those obtained by *(Susawa, 1978)* the safe moisture content for chopped fodder beet storage was obtained without mold-growth after subjecting them to natural drying a period of time of about 24 to 48 h after chopping operation by using solar energy before storage.

The volumetric capacity of chopped fodder beet in comparison with whole tubers has been studied. It has been noticed that a mass of 100 kg of a chopped fodder beet occupies a volume of about 0.05 m^3. Whereas, the same mass of whole tubers occupies a volume have about 0.09 m^3. These results indicated that, the volumetric capacity of chopped fodder beet was about 44.4 %. More than the volumetric capacity of whole tubers. This encourages using them as a summer ration.

Feeding animals:

The chopped fodder beet roots were offered to two mature Rahmay rams were chosen to be of almost the same body mass (45 kg) to observe their voluntary consumption. It has been noticed that, the palatability of rams was very good and they eat all of meal readily without leaving residues. The nutrition of rams was continued for 7 days, the meal was suitable for feeding and the rate of rams intake was 7.30 kg fresh/day (0.669 kg dry matter). This experiment was repeated after natural drying and stored of chopped fodder beet to study the effect of drying and storage on the voluntary consumption of rams and palatability to eat them. The same observation was also noticed. These results evidenced clearly that, storage did not leave any harmful effect on both chopped fodder and palatability of rams. These encourage the transformation of the amounts of feedstuffs during winter season to use them in a summer ration.

CONCLUSION

From the previous results the following conclusions are derived:

1. In general the increase in both drum speed and tuber moisture content increases the percentage of particle mesh size of < 2.0 cm. However, increasing the feed rate decreased it.
2. It was evident that, the chopping machine gave the highest percentage of particle mesh size of < 2.0 cm it was reached 63 % at drum speed of 20.40 m/s, feed rate of 190.20 kg/h and tuber moisture content of 70.30 %.
3. Regarding to the unit energy consumption for chopping machine gives the lowest values of unit energy in all cases. However it was reached 2.0 kW.h/Mg at drum speed of 13.50 m/s, feed rate of 180.80 kg/h and tuber moisture content of 70.30 % .
4. The cost analysis indicated that, chopping machine costs a drastic reduction of unit cost 60.3 % However, the unit cost reached its minimum value of 14.85 L.E/ Mg.

5. Chopping machine was considered the superior machine in reducing the unit energy, unit cost and increasing the percentage of particle mesh size of < 2.0 cm which, preferable by animal nutrition.
6. The volumetric capacity of chopped fodder beet in comparison with the whole tubers was 44.44 %.

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الملخص العربى

أداء آلة الفرم في فرم بنجـــر العلف

أ.د/ حمادة على الخطيب، د/سمير خضر، د/ محمود العطار و د/ عبد الجواد على سليمان

يعتبر نقص الأعلاف هي أساس الفجوة الغذائية في مصر، وان الحيوان يستهلك ما يوازى ٦,٣ مليار جنية من الدخل القومي السنوي ويعتدي على ما هو مخصص للإنسان ومع ذلك هناك عجز في الثروة الحيوانية لمجابهة الاكتفاء الذاتي في مجال البروتين الحيواني. وإثراء لخلق موارد علفيه غير تقليدية تزيد من حيث النوع والكم في هذا الاتجاه الجديد للأعلاف الغير تقليدية كان زراعة محصول بنجر العلف أحد أهم الحلول الفعالة للتغلب على مشكلة نقص العلف الصيفي. وحيث أن متوسط المادة الجافة للفدان لمحصول بنجر العلف والتي تمثل الغذاء الأساسي للحيوان تمثل ما يوازى إنتاج ٥ أفدنه من الذرة من المواد الكربوهيدراتية بالإضافة إلى ارتفاع نسبة البروتين فيه أكثر من الذرة ومذاقه الحلو ونضجه يتم في يونيو حيث قمة الاحتياج إلى المواد النشوية اللازمة للأعلاف. لذ فان الهدف الرئيسي من الدراسة هو الحصول على أحجام قطع مختلفة ومناسبة لتغذية الحيوانات المختلفة (الماشية والأغنام)

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ولقد تناول البحث دراسة تأثير كل من سرعة الدرفيل (من ١٣,٥ إلى ٢٠,٤متر/ثانية) ومعدل التغذية (من ٩٠,٢ إلى ١٨٠,٨كج/ساعة) ومستويات رطوبة بنجر العلف (من ٦٠,٤ إلى ٧٠,٣ ٪ على أساس رطب) للآلة ، ،وذلك على وحدة الطاقة المستهلكة، وأحجام القطع، وتكاليف عملية التقطيع لمحصول بنجر العلف صنف روتا.

ويمكن تلخيص النتائج المتحصل عليها كما يلي:-

١- وجد أن الآلة أعطت أعلى نسبة تقطيع ٦٣ % لأحجام قطع اقل من ٢ سم حيث أنها مرغوب فيها لتغذية الحيوان، وأقل طاقة لازمة لعملية التقطيع كانت ٢ كيلو وات. ساعة/ ميجا جرام ، وأقل تكاليف ١٤,٨٥جنية / طن عند معدل تغذية ٩٠,٢ كج/ ساعة، وسرعة الدرفيل ٢٠,٤ متر/ ثانية، ومحتوى رطوبى للبنجر ٢٠,٤٪.

٢- انخفضت السعة الحجميه لتخزين بنجر العلف المقطع إلى ٤٤,٤٤٪ بالمقارنة بمثيلتها قبل عملية التقطيع مما يساعد على إمكانية تخزين وتداول بنجر العلف المقطع.

٣- بصفة عامة يمكن القول بان استخدام الآلة في عملية تقطيع بنجر العلف كان مرضيا للغاية.