Iraqi Journal of Agricultural Sciences –2026:57(6):1771-1782
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/prdaeg10

Effect of Knife Penetration Angle on Improving the Cutting Efficiency and Reducing the Energy Consumption

Saif Ahmed Rawdhan*[1], Waleed Kamel Elhelew[2], Muhammad Ahmed Mayhoub[2]
*[1]Deptartment of Agricultural Machinery and Equipment. College of Agricultural Engineering Sciences. University of Baghdad, Baghdad, Iraq
[2]Department of Agricultural Engineering, College of Agriculture, University of Ain Shams, Egypt.

ABSTRACT

This experiment is dedicated to study the impact of essential technical and engineering parameters on the performance of an agricultural residue shredder for producing non-traditional ruminant nutrition. The study was carried out in the workshop of Agriculture college at Ain Shams University in Egypt, during the academic year of 2023-2024. The investigation tested two shredder knife speeds of (1300 vs 1500 rpm), two feeding rates of (1.5 vs 3 kg.min-1), and two penetration angles of (20° vs 30°). The evaluated technical traits comprised: productivity, cutting efficiency, total required power, and specific energy. The moisture content of palm frond was 39%. The findings displayed that the greatest recorded productivity was 108.23 kg.h-1, with the highest shredding efficiency was 87.67%. The least overall required cutting power was 1.040 kW, furthermore, the least recorded specific energy value was 0.01255 $kW\cdot h\cdot kg^{-1}$. These results indicate that optimizing shredder knives' velocity and feeding rates can lead to enhance efficiency and reduce the energy consumption in agricultural residue handling, contributing to a more efficient feed production. The Statistical System that was adopted for Analysis was Genstat Discovery Edition 4. To analyze the data according to a split experiment in a randomized complete block design (RCBD), the Least Significant Difference (LSD) test $p < 0.05$ was used to compare the means.

Key words: Agricultural residue, Feeding rate, Palms frond, Power analysis, Residue shredder.

Received: 16/12/2024, Accepted: 12/3/2025, Published: 30/6/2026

INTRODUCTION

Agricultural residue is regarded a major concern to farmers, specifically after harvesting, because it requires both cost and effort for managing or disposing of. According to recent investigation, this residue can cause environmental and economic difficulties if not treated correctly. Agricultural residue considered serious environmental and economic challenges, leading to soil, water, and air pollution (Nath et al., 2023) Disposing of this residue is expensive for farmers, and if left untreated, leads to more degradation. nevertheless, utilizing agricultural residue in an effective way can reduce dependence on chemical fertilizers thus improve farm income profitability (Akinyemi and Daikwo, 2022). One primary strategy is promising toward repurposing agricultural residues into animal feed or even as bioenergy sources such as biogas. While this offers a sustainable solution, it often needs huge initial investment (Waqas et al., 2022). The livestock industry significantly depends on conventional feed sources such as corn, alfalfa, oat grass, and soybean meals. However, the excessive cost and scarcity of these resources, especially in developing countries, place major challenges (Mizarhai et al., 2021). In response, researchers and the feed industry are exploring

Iraqi Journal of Agricultural Sciences –2026:57(6):1771-1782
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/prdaeg10

non-traditional feed sources, including plant-based agro-industrial byproducts (such as oilseed waste, fruit residues, and sugar by-products) and agro-forestry waste (e.g., rice straw, coffee husks, and cassava peels) (Iram et al., 2022; Mark et al., 2024). These alternative feed sources align with sustainable agricultural practices by repurposing waste materials while reducing feed production costs (Chen et al., 2021) Residue must first identify, then collect, separated, cleaned, and used as needed before it is recyclable too. Residue management is one of the main issues worldwide that need to be dealt with. Despite political support, recycling still needs more attention in the circular economy era. Now that the circular economy is taking the place of linear economies, care must be taken to ensure that the materials being used remain available for reuse, recycling, and renewal for as long as feasible. Considering this, the current study focused on converting waste materials into value-added products. A suitable system should be evolved to ensure that residue does not negatively affect the environment. Iraq is currently experiencing a change toward agricultural mechanization, distinguished by the adoption of advanced technologies, with a special assert on research and development in this major (Awan et al., 2022) Recycling agricultural residue into animal feed or organic fertilizer is a solution that decreases the load on farmers. This solution offers dual benefits, reducing agricultural residue and increasing profitability by providing additional resources. (Bangar et al., 2023; Melcherciket al., 2022) One of the main positives of using a shredder is that it helps in increasing the digestibility of the feed, allowing the cattle to absorb more nutrients, leading to better growth and higher milk production. Moreover, these machines also help in reducing residue, which in turn decreases total production costs. In 2022, it was evident that agricultural machinery, including feed cutters, aids in reducing total feed cost and increases feed profitability. The investigation showed that nutrition costs constitute a considerable proportion of farm costs, often accounting for about two-thirds of the overall cost of agricultural production. Enhancing feed efficiency can lead to significant reductions in these expenses. Feed costs constitute about 70-75% of the total production expenses, thereby driving ongoing efforts to identify other feed sources that can decrease feed costs (Ati et al., 2020) Moreover, the chopping machines play a vital role in the sustainability of modern farming of livestock, ensuring that farmers may effectible manage their resources while improving productivity. Furthermore, the use of feed cutting machines can aid in producing high-quality Silage, that is a type of stored feed used during periods of low feed resources. This Silage helps to increase their production of both meat and milk while enhancing overall animal health. Optimizing cutting velocity and penetration angles in addition to enhancing power consumption and chopping efficiency is important aspect. In one investigation on palm frond cutting, it turned out that using a 45° penetration angle decreased the time required to cut multiple rows in comparison to the penetration angle of 90°. Additionally, these small angles decrease the effect on the material's surface thus enhancing cut quality. decreasing the need for tool maintenance (Zhao et al., 2021). Cutting at small angles obtain smoother, more precise results, decreasing the need for extra processing to improve the cut or finish, saving time, leading to increase productivity. In contrast, if the penetration angle is too small , it could lead to quick wear down of the blades , reducing efficiency if not appropriately managed (chen et al., 2021) , Reducing the penetration angle that may increase productivity in cutting operations that require high forces, such as cutting wood materials or feed, but it increases blade wear, which affects overall economic efficiency (Mizrahi et al., 2021)There is a close relationship between material resistance, cutting speed and friction force. Reducing the cutting angle allows for reduced material resistance, which reduces the mechanical energy required for each cutting operation. Research has also shown that improving the cutting angle reduces wear and friction on tools, which contributes to reduced energy consumption and improves overall process efficiency. (Balasubramanian and R, 2024) stated that the mechanical properties of palm

Iraqi Journal of Agricultural Sciences –2026:57(6):1771-1782
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/prdaeg10

stalk differ in their resistance to cutting. according to the variety, they found that the stalk of Tebarzal palm trees, require the highest cutting force compared to the rest of the varieties studied Furthermore, recent studies in cuttin11g technologies shown that reducing 111material resistance by using appropriate cutting angles or optimizing cutting conditions can reduce energy consumption by up to 30% in some cases, especially when using advanced cutting tools with sharp penetration angles (Shi et al., 2022). Increased cutting speed improves productivity in feed cutting machines, as higher speeds are associated with increased force and energy expenditure, which improves the efficiency of the cutting process (Tomaz et al., 2023) Cutting speed affects tool life and cut quality, thus enhancing productivity in forages cutting machines by improving operational efficiency and reducing costs (Wang et al., 2022). Increasing the speed of the cutting knives improves energy consumption and field/product work capabilities while reducing field energy and product consumption in feed cutting machines (Mustafa and Osman 2019). In a study conducted on a locally manufactured forages chopping machine and studying some of the machine's operational factors, it was found that increasing the speed of the knives led to an increase in the machine's practical productivity, cutting efficiency, and the total energy required to cut the forage. The main factor affecting the productivity of the chopping is its speed. According to the chopping results, the productivity increased from 2.65 to 4.21, from 3.64 to 5.38, and from 4.32 to 6.48 t. h-1 at moisture content of 60, 70, and 77% respectively, when the chopping speed was increased from 1650 to 2400 rpm. (Ghobashy et al., 2023) The cutting feeding rate improves the processing accuracy by 41.8% and reduces the cutting time by 50.8%, which improves the overall efficiency and cutting capacity of the forages cutting equipment (ElShal et al., 2018) Increasing the feed rate moderately can improve efficiency and reduce the specific power required. However, when the feed rate is increased excessively, the power required may increase, resulting in a decrease in efficiency (Muhamed et al., 2018). In a study that evaluated the efficiency of feed cutting machines using diverse feed rates and different feed dimensions, the results confirmed that lower feed rates can reduce the required power but may negatively affect efficiency. (Mulatw, 2021) Indicated that the maximum efficiency was achieved at a chopper rotation speed of 1800 rpm with a moisture content of 22.7% for the chopper (Gupta, 2022). Given the increasing shift toward agricultural mechanization in Iraq, there is a growing need for locally manufactured forage machines that can efficiently process agricultural waste into high-quality ruminant feed. This study aims to evaluate the performance of locally manufactured forage machines by analyzing key mechanical and technical indicators under different operational conditions.

MATERIALS AND METHODS

This study aimed to investigate the effect of knife penetration angle illustrated in schematic diagram in Fig.1 (A, B) and rotation speed of cutting knives on the performance of agricultural cutting machines. A locally manufactured agricultural waste cutting machine was used for this purpose, and is illustrated photographed in Figure 2, with a schematic diagram in Figure 3.

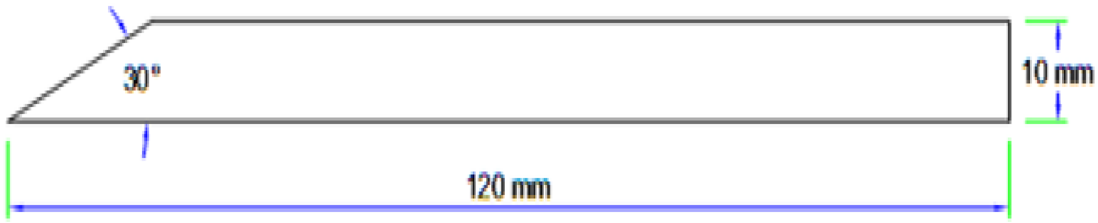

Figure 1. (A) - Side view of penetration angles (30°)

Iraqi Journal of Agricultural Sciences –2026:57(6):1771-1782
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/prdaeg10

Figure 1. (B) - Side view of penetration angles (20°)

Figure 2. Used machine.

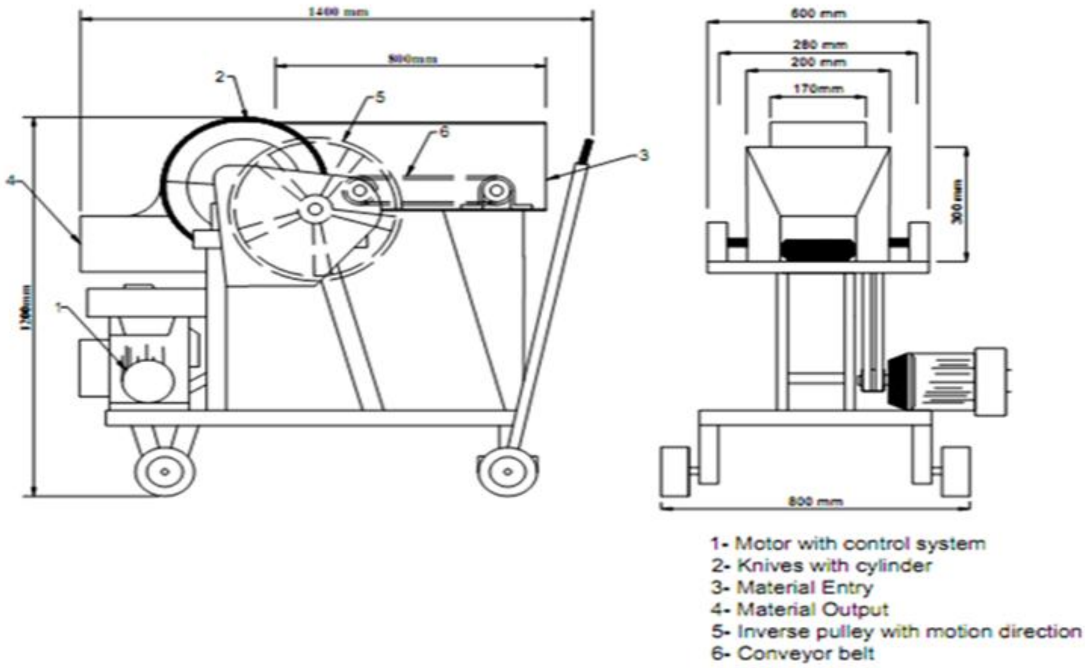

Figure 3. Schematic diagram for machine

The machine was developed locally with four cutting knives that were processed with heat. The hardening was accomplished by placing the knives in the thermal oven of processing heat of 1000-1100°C for ten minutes, afterward cooled in oil , then a second heating process in the oven of 350 °C for ten minutes then cooled by air room temperature thus this process makes the knives wear resistant.

Experimental treatments and statistical design: A tachometer was used to measure the rotational speed of the chopping cylinder.

Iraqi Journal of Agricultural Sciences –2026:57(6):1771-1782
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/prdaeg10

Measurements were taken both when the machine was unloaded and when it was operating under load conditions. The feeding rates were controlled by conveyor belt with one assistant labor. Samples of chopping material separated from each experiment were taken to determine the chopped mechanical properties, and plants moisture content. The Statistical System that was used for Analysis was Genstat Discovery of Edition 4 to analyze the data according to a split experiment in a randomized complete block design (RCBD), the means were compared using the Least Significant Difference (LSD) test P< 0.05.

Experimental conditions

The experiment was conducted to evaluate the performance of the machine and was measured experimentally under the following parameters:

A - Chopping cylinder peripheral velocity (1300 and 1600 rpm).

B - feeding rate (1.5 and 3 kg)

C - knife penetration angle (20° and 30°)

E- palm tree**:**

Samples of ten palm trees were taken to determine the mentioned specification in (Table 1).

Table 1. Residue type: Palm tree specifications

No	Plant Length cm	Minimum stem Diameter cm	Maximum stem Diameter cm
1	167	0.49	4.34
2	171	0.46	4.29
3	159	0.52	4.89
4	184	0.38	3.67
5	177	0.42	4.21
6	181	0.39	3.58
7	158	0.50	5.20
8	166	0.48	4.55
9	170	0.44	4.49
10	168	0.41	4.86
Mean	170.1	0.449	4.408

*The palm frond moisture content was on the basis of 39%.

Calculation of the affected variables

A- Moisture content of the residues: Using the conventional oven method, the moisture content of the stems of agricultural residues was measured by weighing samples of these agricultural residues (with an accuracy of 0.1 g using an electric balance) and drying them in an oven set at 70 °C for 48 h. The following formula was used to determine.

$$M = \frac{M_b - Ma}{M_b} x\ 100$$

Where:

M: moisture content

M_b: $mass\ of\ the\ sample (g) before\ drying$

$Ma \quad mass\ of\ the\ sample\ (g) after$

Chopping efficiency: Three samples of palm stems weighing 1.5 and 3 kg were fed into the chopping for each treatment, and the resulting materials were weighed, and the cutting efficiency was determined as follows. Nipa et al., 2021):

$$chopping\ efficiency = \frac{w_{out} - w_{uncut}}{w_{in}} x\ 100$$

Where:

w_{out} = Output mass, (g)

w_{in} = Input mass, (g)

w_{cut} = The mass of cutting maximum category, (g)

w_{uncut} = Uncut residues after chopping process, (g)

B- Machine productivity

The following equation was used to calculate machine productivity.

$$P = \frac{w}{t}$$

Where: P= Machine productivity, (kg/h)

W= mass of plant, (Kg), and t = Time, (h)

C- Total power requirement: A clamp meter was used for measuring potential difference value and current strength, respectively before and during experiment been read of volt (V) and ampere (I) were taken both prior to and throughout each procedure. The power consumption (P) was calculated from the

Iraqi Journal of Agricultural Sciences –2026:57(6):1771-1782
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/prdaeg10

values of volt (V) and ampere (I) by using the following equation (Mohamed, 2024).

Total consumed power (P) = Load

$$Ep = \frac{I * V * \eta * \cos\theta}{1000}$$

Where:

Ep = Required power for cutting, (KW)

I = Line current strength in Amperes, (A)

V= Potential strength (Voltage) equal to 220V.

$\cos\theta$= Power Factor (being equal 0.84)

η = mechanical efficiency assumed (90%)

D- Specific energy consumption: Estimation of the consumed specific energy was conducted using the following equation, (Mohamed 2024)

$$EC = \frac{EP}{P}$$

Where: EC = Specific energy consumption ($kw.h.kg^{-1}$)

Ep = Required power for cutting (KW), and

P= machine productivity, ($kg.h^{-1}$).

RESULTS AND DISCUSSION

Statistical analysis results show in Table 2, it was observed that there was an effect of penetration angle, velocity of chopping and feeding rate on the productivity. The results showed a significant effect in productivity from 92.25 to 86.89 $kg.h^{-1}$, when increasing penetration angle from 20° to 30° degrees. The reason for this is that the decrease in cutting sharpness increases the resistance of the plant, which contributes to increasing the time taken to penetrate the plant stem. Furthermore, the results show that there were significant differences when increasing the cutting speed from 1300 to 1500 rpm. The productivity increased from 84.41 to 94.73 $kg.h^{-1}$. This is because increasing the speed of the knives leads to shortening the time required to cut the plant stems. From the same Table 2, it was shown that there were significant differences when the feeding rate increased from 1.5 to 3 kg. Productivity increased from 83.26 to 95.88 $kg.h^{-1}$. This is attributed to the fact that increasing the feeding rate leads to an increase in the amount of cutting materials in a shorter time. The binary interaction was significant only between cutting speed and feed rate; it recorded the highest value of 104.10 $kg.h^{-1}$.

Table 2. Effect of penetration angles, cutting knife speed and feeding rate on productivity $kg.h^{-1}$

	productivity($kg.h^{-1}$)			
C *f	**Knife penetration angle (D)** 30°	20°	**Feed rate (f)**	**Chopping speed (C)**
81.16	79.30	83.01	1.5 kg	1300 rpm
87.66	84.19	91.13	3 kg	
85.36	84.08	86.64	1.5 kg	1600 rpm
104.10	99.08	108.23	3 kg	
2.48 LSD $_{C*f}$	N. S		LSD $_{C*f*D}$	
		C * D		
Average Chopping speed	30°	20°	Chopping speed	
84.41	81.75	87.07	1300 rpm	
94.73	92.03	97.44	1600 rpm	
2.11 LSD $_{C}$	N. S		LSD $_{C*D}$	
		f * D		
Average feeding rate	30°	20°	Feed rate	
83.26	81.69	84.83	1.5 kg	
95.88	92.08	99.68	3 kg	
2.01 LSD $_{f}$	N. S		LSD $_{f*D}$	
		Knife penetration angle (D)		
	30°	20°	Average Knife penetration angle	
	86.89	92.25		
	2.41		LSD $_{D}$	

*** LSD; Least significant difference at probability.**

**** N.S.; No significant difference at probability (5%)**

Iraqi Journal of Agricultural Sciences –2026:57(6):1771-1782
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/prdaeg10

The palm frond moisture content was on the basis of 39%.

Table 3 shows the effect of penetration angles, cutting knife speed and feed rate on requirement power. Considering the results, it was shown that there was a significant effect on the required power from 1.246 to 1.512 kw, when increasing the penetration angle from 20° to 30° degrees. The reason behind that was decreasing the cutting sharpness increases the resistance of the plant, which contributes to increasing the required power to penetrate the plant stem. Furthermore, show that there were significant differences when increasing the cutting speed from 1300 to 1500 rpm, as the required power increased from 1.278 to 1.480 kW, because increasing the speed of the knives leads to an increase in the amount of cut plant stems, moreover, increases the load on the cutting tool, which increases the power required for cutting. From the same Table 3, it was found that there were significant differences when increasing the feed rate from 1.5 to 3 kg, as the required power increased from 1.315 to 1.443 kW, because increasing the feed rate leads to an increase in the amount of cut materials, which in turn increases the friction between the cut plant stems and the cutting tool.

Table 3. Effect of penetration angle, cutting knife speed and feed rate on requirement power (kw)

C *f	**Power (KW)** **Knife penetration angle (D)**		**Feed rate (f)**	**Chopping speed (C)**
	30°	20°		
1.193	1.347	1.040	1.5 kg	1300 rpm
1.362	1.490	1.233	3 kg	
1.437	1.570	1.303	1.5 kg	1600 rpm
1.523	1.640	1.407	3 kg	
N. S LSD $_{C*f}$	N. S		LSD $_{C*f*D}$	
	C * D			
Average Chopping speed	30°	20°	Chopping speed	
1.278	1.418	1.137	1300 rpm	
1.480	1.605	1.355	1600 rpm	
0.063 LSD $_{C}$	N. S		LSD $_{C*D}$	
	f * D			
Average feeding rate	30°	20°	Feed rate	
1.315	1.458	1.172	1.5 kg	
1.443	1.565	1.320	3 kg	
0.0331 LSD $_{f}$	N. S		LSD $_{f*D}$	
	Knife penetration angle (D)			
	30°	20°	Average Knife penetration angle	
	1.512	1.246		
	0.0731		LSD $_{D}$	

*** LSD; Least significant difference at probability.**
**** N.S.; No significant difference in probability**
The palm frond moisture content was on the basis of 39%.

Table 4 shows the effect of penetration angles, cutting knife speed and feeding rate on specific energy. Based on these facts, it was found that there was a significant effect on specific energy from 0.01359 to 0.01749 $kw.h.kg^{-1}$, when the penetration angle increased from 20° to 30° degrees. This may be due to the increased contact between the cutting tool and the plant stems, which increases friction, which consumes additional energy that leads to an increase in specific energy. Furthermore, show that there were significant differences when the cutting speed increased from 1300 to 1500 rpm, as the specific energy increased from 0.01525 to 0.01583 $kw.h.kg^{-1}$, because increasing the speed of the knives leads to an increase in the amount of cut plant stems. In addition, the load

Iraqi Journal of Agricultural Sciences –2026:57(6):1771-1782
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/prdaeg10

on the cutting tool increases, which increases the required power and specific energy for cutting. From the same (Table 4), it was found that there were significant differences when the feeding rate increased from 1.5 to 3 kg, as the specific energy decreased from 0.01585 to 0.01523 $kw.h.kg^{-1}$, This could be attributed to the fact when the feeding rate increases, a larger quantity of plant stems is cut in less time, in addition to the total energy required for cutting being distributed over a larger volume of the cut material, and thus the specific energy decreases.

Table 4. Effect of penetration angle, cutting knife speed and feed rate on specific energy ($kw.h.kg^{-1}$)

specific energy ($kw.h.kg^{-1}$)					
C *f		**Knife penetration angle (D)**		**Feed rate**	**Chopping speed**
		30°	20°	**(f)**	**(C)**
0.01478		0.01702	0.01255	1.5 kg	1300 rpm
0.01573		0.01776	0.01370	3 kg	
0.01691		0.01872	0.01511	1.5 kg	1600 rpm
0.01474		0.01646	0.01303	3 kg	
N. S	LSD $_{C*f}$	N. S		LSD $_{C*f*D}$	
		C * D			
Average Chopping speed		30°	20°	Chopping speed	
0.01525		0.01739	0.01312	1300 rpm	
0.01583		0.01759	0.01407	1600 rpm	
0.000551	LSD $_{C}$	N. S		LSD $_{C*D}$	
		f * D			
Average feeding rate		30°	20°	Feed rate	
0.01585		0.01691	0.01383	1.5 kg	
0.01523		0.01474	0.01336	3 kg	
0.000586	LSD $_{f}$	N. S		LSD $_{f*D}$	
		Knife penetration angle (D)			
		30°	20°	Average Knife penetration angle	
		0.01749	0.01359		
		0.000878		LSD $_{D}$	

*** LSD; Least significant difference at probability.**
**** N.S.; No significant difference in probability**
The palm frond moisture content was on the basis of 39%.

These results in Table 5,indicate that there was an effect of the penetration angle, cutting speed and feed rate on the cutting efficiency (%), as the results showed a significant effect on the cutting efficiency from 84.47 to 81.79 (%), when the penetration angle increased from 20° to 30° degrees, the reason for this is due to the decrease in cutting sharpness and increased friction, which makes it susceptible to corrosion and thus reduces the cutting efficiency. Furthermore, show that there were significant differences when increasing the cutting speed from 1300 to 1500 rpm, when the cutting efficiency increased from 81.80 to 84.46 (%), because increasing the speed of the knives leads to smooth flow of the cut stems and reduces friction between the cutting knife and the plant stems. From the same (Table 2), it was found that there were significant differences when increasing the feed rate from 1.5 to 3 kg. The cutting efficiency increased from 81.51 to 84.75 (%). This could be attributed to increasing the feed rate results in more material being cut in a shorter time, which increases productivity, in addition turn improves efficiency.

Iraqi Journal of Agricultural Sciences –2026:57(6):1771-1782
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/prdaeg10

Table 5. Effect of penetration angle, cutting knife speed and feeding rates on chopping efficiency (%)

Chopping efficiency (%)					
C *f		**Knife penetration angle (D)** **30°**	**20°**	**Feed rate (f)**	**Chopping speed (C)**
80.29		78.81	81.77	1.5 kg	1300 rpm
83.31		81.77	84.85	3 kg	
82.72		81.86	83.58	1.5 kg	1600 rpm
86.20		84.73	87.67	3 kg	
N. S	LSD $_{C*f}$	N. S		LSD $_{C*f*D}$	
		C * D			
Average Chopping speed		30°	20°	Chopping speed	
81.80		80.29	83.31	1300 rpm	
84.46		83.30	85.62	1600 rpm	
0.709	LSD $_{C}$	N. S		LSD $_{C*D}$	
		f * D			
Average feeding rate		30°	20°	Feed rate	
81.51		80.34	82.67	1.5 kg	
84.75		83.25	86.26	3 kg	
0.605	LSD $_{f}$	N. S			
		Knife penetration angle (D)			
		30°	20°	Average Knife penetration angle	
		81.79	84.47		
		0.90		LSD $_{D}$	

*** LSD; Least significant difference at probability.**
**** N.S.; No significant difference in probability/ The palm frond moisture content was on the basis of 39%.**

CONCLUSION

The obtained results show that the knife penetration angle plays a vital role in improving productivity, increasing efficiency, and reducing the wear of cutting knives, in addition to reducing the power required for cutting**.** The balance between the operational factors of the machine leads to achieving optimal performance**.** The study infers that the shredder machine can be applied to larger farms through using larger inlet opening in other words increasing capacity. The research focused on the shredder's performance under the given conditions of the study and recommended the following:

1. Using penetration angle of 20° with the cutting speed of 1600 rpm and feeding rate of 3 kg.
2. Adopting the hardening method of two levels first to heating the metal to 1000°C then cooling afterward by oil second to 350 °C and cooling by air room temperature led to durability of the blades thus decreasing the wear out over time.
3. This machine can be used precisely for small farm holdings efficiently.

ACKNOWLEDGEMENT

Here I sincerely acknowledge the contributions of my colleagues [W. K. Elhelew]and [M. A. Mayhoub], who dedicated their time and expertise to improving the writing, structure, and clarity of this paper. Their collective input significantly enhanced the final version of this work. Dr W. K. Elhelew wrote the introduction and result and discussion. Dr. M. A. Mayhoub wrote part of the materials and methods along with the tables and figures. The first author S. A. Rawdhan manufactured the machine, implemented the research, part of review and the result and discussion.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

AUTHOR/S DECLARATION

This research is a formal, signed statement that affirming the originality, authenticity of the study. I assures that the work is free from plagiarism, free from undisclosed conflicts of interest, and adheres to strict academic and ethical standards

AUTHOR'S CONTRIBUTION STATEMENT

Saif responsible for designing and machine manufacturing and writing. Walid responsible for simulations. Mohamed Mayhoub conducting data analysis.

REFERENCES

Akinyemi, M. G., & Daikwo, E. (2022). Analysis of agro-waste utilisation as source of organic manure by vegetable farmers in Kumbotso Local Government Area of Kano State, Nigeria. FUDMA Journal of Agriculture

Iraqi Journal of Agricultural Sciences –2026:57(6):1771-1782
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/prdaeg10

and Agricultural Technology, 8(1), 18-25. https://doi.org/10.33003/jaat.2022.0801.070

Al-Sammarraie, M. A. J., & Özbek, O. (2019). The effect of knife clearance on the machine performance in disc type silage machines. Selcuk Journal of Agriculture and Food Sciences, 33(2), 74-81. https://doi.org/10.15316/SJAFS.2019.159

Ati, A. S., Wahaib, H. A., & Hassan, A. H. (2020). Efeect of irrigation management and fertilization on N, P and K concentration of two wheat varieties. Diyala Agricultural Sciences Journal, 12(Special Issue), 402-417. https://doi.org/10.52951/dasj.20121034

Awan, M. R., Rojas, H. A. G., Benavides, J. I. P., & Hameed, S. (2022). Experimental technique to analyze the influence of cutting conditions on specific energy consumption during abrasive metal cutting with thin discs. Advances in Manufacturing, 10(2), 260-271. https://doi.org/10.1007/s40436-021-00361-2

Balasubramanian, N., & Balasubramanian, R. (2024). Turning discarded agricultural remnants and poultry waste into usable hybrid polymer matrix reinforcements: An experimental study. Journal of Composites Science, 8(10), 411. https://doi.org/10.3390/jcs8100411

Bangar, S. P., Kajla, P., & Ghosh, T. (2023). Valorization of wheat straw in food packaging: A source of cellulose. International Journal of Biological Macromolecules, 227, 762-776. https://doi.org/10.1016/j.ijbiomac.2022.12.117

Chaciński, T., Zieliński, B., & Nadolny, K. (2023). Effect of feed rate on the force and energy in the cutting process using planar technical blades. Applied Sciences, 13(3), 2013. https://doi.org/10.3390/app13032013

El Ghobashy, H., Shaban, Y., Okasha, M., Abd El-Reheem, S., Abdelgawad, M., Ibrahim, R., & Khater, E. S. (2023). Development and evaluation of a dual-purpose machine for chopping and crushing forage crops. Heliyon, 9(4), e15460. https://doi.org/10.1016/j.heliyon.2023.e15460

El Shal, A., & El Didamony, M. (2018). Performance of a maize chopping machine with an attached sharpener unit. Journal of Soil Sciences and Agricultural Engineering, 9(12), 793-798. https://doi.org/10.21608/jssae.2018.36533

Gupta, S., Kumar, P., & Pandey, V. (2022). Unconventional feed resources in animal nutrition: An overview. Journal of Animal and Feed Sciences, 31(2), 145-153. https://doi.org/10.1016/j.eng.2017.05.025

Iram, S., Cekmecelioglu, D., & Demirci, A. (2020). Distillers' dried grains with solubles (DDGS) as a sustainable and alternative feed ingredient for ruminants. Tropical Animal Health and Production, 52(7), 1234-1242. https://doi.org/10.1007/s11250-020-02343-1

Lin, C. J., Lin, C. H., & Wang, S. H. (2021). Using fuzzy control for feed rate scheduling of computer numerical control machine tools. Applied Sciences, 11(10), 4701. https://doi.org/10.3390/app11104701

Marak, T. B., Tiwari, A., & Roy, A. (2024). Conversion of agricultural residues into high-value animal feed. In Transforming agriculture residues for sustainable development: From waste to wealth (pp. 205-221). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-61133-9_9

Melicherčík, J., Krilek, J., Kováč, J., Kuvik, T., & Kučera, M. (2022). Testing of cutting tools on a pneumatic experimental device and evaluation of cutting edge wear using a non-contact 3D method. Machines, 10(12), 1158. https://doi.org/10.3390/machines10121158

Mizrahi, I., Wallace, R. J., & Moraïs, S. (2021). The rumen microbiome: Balancing food security and environmental impacts. Nature Reviews Microbiology, 19(9), 553-566. https://doi.org/10.1038/s41579-021-00521-8

Mohammed, K. A. (2024). The effect of some engineering factors of the BearCat Forage cutting machine on the machine's performance [Master's thesis, University of Baghdad]. College of Agricultural Engineering Sciences. https://coagri.uobaghdad.edu.iq/?p=37735

Muhammad, K., Walusimbi, K. H., Jimmy, K., & Swidiq, M. (2018). Design and performance evaluation of a NARO forage chopper prototype for smallholder dairying systems. International Journal of Design and Performance, 5(11), 547-551.

Mulatu, Y. (2021). Design, fabrication and performance evaluation of animal feed chopping machine. African Journal of

Agricultural Research, 17(8), 1155-1160. https://doi.org/10.5897/AJAR2021.15541
Nath, A., Das, K., & Dhal, G. C. (2023). Global status of agricultural waste-based industries, challenges, and future prospects. In Agricultural waste to value-added products: Technical, economic and sustainable aspects (pp. 21-45). Springer. https://doi.org/10.1007/978-981-99-4472-9_2
Nipa, J. F., Monda, M. T., Islam, M., & Islam, M. (2021). Design, development and performance evaluation of small-scale fodder chopping machine for farmers. Research in Agricultural Engineering, 67(3), 116-122. https://doi.org/10.17221/52/2020-RAE
Shi, K. N., Liu, N., Liu, C. L., et al. (2022). Indirect approach for predicting cutting force coefficients and power consumption in milling process. Advances in Manufacturing, 10, 101–113. https://doi.org/10.1007/s40436-021-00370-1
Wang, L., et al. (2022). Optimization analysis of high-speed cutting parameters based on tool life of edge cutting machine. Journal of Manufacturing Science and Engineering, 10(1). https://doi.org/10.57237/j.mse.2022.01.001
Waqas, M., Hashim, S., Humphries, U. W., Ahmad, S., Noor, R., Shoaib, M., & Lin, H. A. (2023). Composting processes for agricultural waste management: a comprehensive review. Processes, 11(3), 731. https://doi.org/10.3390/pr11030731
Zhao, J., Li, L., Nie, H., Chen, X., Liu, J., & Shu, X. (2021). Multi-objective integrated optimization of tool geometry angles and cutting parameters for machining time and energy consumption in NC milling. The International Journal of Advanced Manufacturing Technology, 117(5), 1427-1444. https://doi.org/10.1007/s00170-021-07772-2

Iraqi Journal of Agricultural Sciences –2026:57(6):1771-1782
P-ISSN: 0075- 0530 /E-ISSN: 2410-0862
DOI: https://doi.org/10.36103/prdaeg10

تأثير زاوية اختراق السكين على تحسين كفاءة القطع وتقليل استهلاك الطاقة

سيف أحمد روضان[1]، وليد كامل الحلو[2]، محمد أحمد ميهوب[2]
[1*]قسم المكائن والآلات الزراعية، كلية علوم الهندسة الزراعية، جامعة بغداد، العراق.
[2]قسم الهندسة الزراعية، كلية الزراعة، جامعة عين شمس، مصر

المستخلص

هدفت هذه التجربة إلى دراسة تأثير المعايير الفنية والهندسية الأساسية على أداء آلة تقطيع المخلفات الزراعية المستخدمة في إنتاج أعلاف غير تقليدية للحيوانات المجترة. حيث أُجريت الدراسة في ورشة كلية الزراعة بجامعة عين شمس في مصر، خلال العام الدراسي 2023-2024. واختبرت سرعتان لشفرات آلة التقطيع (1300 و1500 دورة في الدقيقة)، ومعدلا تغذية (1.5 و3 كجم/دقيقة)، وزاويتا اختراق هي (20° و30°). شملت الخصائص الفنية المدروسة: الإنتاجية، وكفاءة التقطيع، وإجمالي الطاقة المطلوبة، والطاقة النوعية. حيث بلغت نسبة الرطوبة في سعف النخيل 39%. وأظهرت النتائج أن أعلى إنتاجية مُسجَّلة بلغت 108.23 كجم/ساعة، مع أعلى كفاءة تقطيع بلغت 87.67%. وكانت أقل طاقة قطع إجمالية مطلوبة 1.040 كيلوواط، كما كانت أقل قيمة مسجلة للطاقة النوعية 0.01255 كيلوواط ساعة/كيلوغرام. تشير هذه النتائج إلى أن تحسين سرعة شفرات آلة التقطيع ومعدلات التغذية يمكن أن يؤدي إلى تعزيز الكفاءة وتقليل استهلاك الطاقة في معالجة المخلفات الزراعية، مما يساهم في إنتاج أعلاف أكثر كفاءة. تم اعتماد نظام Genstat Discovery Edition 4 للتحليل الإحصائي للبيانات وفقًا لتجربة مقسمة في تصميم القطاعات العشوائية الكاملة (RCBD)، تم استخدام اختبار أقل فرق معنوي (LSD) عند مستوى دلالة $p< 0.05$ لمقارنة المتوسطات.

الكلمات المفتاحية: المخلفات الزراعية، معدل التغذية، سعف النخيل، تحليل الطاقة، آلة تمزيق المخلفات.