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THE EFFECT OF CUTTING KNIFE TYPES AND FORAGE FEEDING SPEEDS ON THE PERFORMANCE OF SOME TECHNICAL INDICATORS FOR THE FORAGE CHOPPING MACHINE MODEL (CH922DH)

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ABSTRACT

In this study, experimental work was undertaken to investigate the engineering factors that influence the agricultural residual chopping machine's performance for producing unconventional feed. The research was conducted at the Textile Agriculture Laboratory, Al-Rasheed Municipality, Baghdad- Iraq. Two types of chopping knives (smooth edges and serrated), two feeding speeds (5.5 and 9.5 rpm), and two types of agricultural Residuals (corn stalks and palm fronds) were used for investigation. The technical parameters evaluated comprised productivity, total required power, cutting efficiency, and fuel consumption. The moisture content of corn stalks was 56% and palm fronds 34%. The results showed that the serrated knife was the most effective achieving the highest productivity of 109.60 $kg.h^{-1}$, the minimal total power consumption of 7.00 kW, and the lowest fuel consumption of 2.22 $l.h^{-1}$. Additionally, the lower feeding speed of 5.5 rpm resulted in the highest cutting efficiency at 66.90%, the lowest power requirement at 7.20 kW, and the lowest fuel consumption at 2.28 $l.h^{-1}$. Among the materials used, corn stalk exhibited the highest cutting efficiency at 72.41%, the lowest total power requirement at 7.00 kW, and the lowest fuel consumption at 2.22 $l.h^{-1}$.

INTRODUCTION

Agricultural field Residuals are considered a severe challenge for farmers in Iraq. However, these residues can be utilized to produce unconventional feed. Annually, Iraq produces approximately 20 million tons of agricultural crop waste, but only a tiny fraction of this is used (Ali & Flayeh, 2023). Poor management of this waste leads to significant environmental problems. Farmers typically either burn the waste or leave it in the field. Corn, a key source of nutrition for humans and animals, is crucial in biofuel production. (Dhannoon, *et al*., 2021). Corn is the third most vital crop, followed by wheat and rice (Al-Hilfy & Al-Temimi, 2017). The availability of these fodder is essential for sustaining livestock (Saeed & Mohammed, 2017). The deficiency of natural pastures and designated areas for growing green fodder has promoted numerous researchers to investigate the use of agricultural crop residues (AL-Samaraae *et al*., 2008). Feed costs represent 70-75% of total production expenses, thereby driving ongoing efforts to identify alternative feed sources that can reduce nutritional costs (Al-Aboudi & Hamodi, 2023). In poultry farming, a significant revenue stream in agricultural production is also associated with various ancillary industries, including the animal feed sector (Mansour & Elsebae, 2020). The cutting process is paramount (GENDEK & NAWROCKA, 2014). The cutting knife engages with the material during the cutting of field crops, thereby increasing its strength and effecting separation. This process induces various deformations in the material, attributable to the geometric form of the cutting knife's edge and its movement during the cutting operation. (El-Hanfy & Shalby, 2009).

The findings reported by (Mageed & Jasim, 2023) indicated that the peat moss medium demonstrated superior performance in terms of the lowest energy consumption, recorded at 2075.8 w, and the lowest capacity, at 0.007751 kW.h. The lowest power demand was achieved at the first speed, amounting to 2047.3 W, and the lowest energy consumption at the third speed, recorded at 0.007703 kW. h. According to (Elnaggar & Saleh, 2014), the rate of energy consumption decreased with the increase in the feed rate of rice and barley straw. Specifically, at a feed rate of 1.5 to 0.18 kg. s^{-1}, the rate of energy consumption decreased from 9.84 to 8.36 kWh.$tonne^{-1}$ for rice and from 8.36 to 7.1 kWh.$tonne^{-1}$ for barley. (Spinelli, *et al*., 2014) emphasized that knife wear is a critical determinant of chipper productivity and product quality. Ideally, knives should be replaced when the cost benefits of sharpening and replacing them equalize with the losses incurred from diminished productivity and elevated fuel consumption. The efficiency of the chipper machine is affected by factors, including the quality of the chipper knife edge and its wear rate. Additionally, the wear of knives during operation results in increased power consumption. Consequently, meticulous research and enhancement of the wood-cutting process in chipper-canters, focusing on the improvement of knife characteristics, can lead to more durable tools, reduced downtime, and ultimately lower production costs (Heidari, *et al*., 2013). It was reported by Rawdhan, *et al*., (2024) that machine productivity at 1,000 rpm increased with escalating feed rate, from 71,174 to 79,086 kg.h^{-1} and from 71,104 to 79,120 kg.h^{-1}, respectively, reflecting an increase of 10.13 percent with and without the sensor.

Ghobashy, *et al*., (2023) 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, and a crusher rotation speed of 1200 rpm with a screen opening diameter of 10 mm for the crusher, resulting in efficiency values of 94.17. and 92.85% for the grinder and crusher, respectively. These optimal operating parameters resulted in machine throughputs of 2.44 and 0.31 tons.$hour^{-1}$, specific energy requirements of 3.22 and 4.50 kW.h^{-1}, and estimated production costs of 23.56 and 121.24 EGP.ton^{-1} or 1.25 and 6.38 USD.ton^{-1}, respectively. Agricultural residues represent a significant challenge in Iraqi agriculture, compounded by the high cost of imported fodder and the need to address the shortage in livestock fodder. However, with appropriate use and explanation of chopping machines, attention is provided to their importance and optimal utilization. The current study evaluated and quantified the performance, productivity, and energy requirements of a shredding machine, demonstrating their suitability for processing agricultural residues and producing alternative feed that mitigates imported feed costs.

MATERIALS AND METHODS

This study aimed to investigate the impact of various engineering and control parameters on the performance of an agricultural cutting machine. An American-made BEARCAT agricultural residual shredder, model CH922DH was utilized for this purpose, its specifications are shown in Table (1) and illustrated in Figure (1), with a schematic diagram provided in Figure (2). The fundamental components of the machine are outlined as follows:

Table (1): specifications of the cutting machine:

Engine Type	2.2 Liter Kubota
Gross HP	48
Model Number	CH922DH
Fuel type	diesel
the total weight	1226 kg
Fuel tank capacity	68 liters
Origin and model	USA 2013

Figure (1): general view of a residue chopping machine.

Chopping unit

The chopping unit comprises a dynamic disc with a diameter of 76 cm, a thickness of 3.2 cm, and a weight of 125 kg, which produces substantial chopping force. It operates at a rotational speed of 1450 rpm. The disc is equipped with four reversible heat-treated steel cutting blades. The dimensions of the blades are as follows: length 12.7cm, width 10.2cm, and thickness 1.3cm, with an edge angle of 45 degrees. Two types of blades were employed in the experiment: smooth and serrated, as depicted in Figure (3). The serrated blade, locally manufactured from the same heat-treated steel as the smooth-edged blade, possesses identical characteristics and features a tooth spacing of 3 mm.

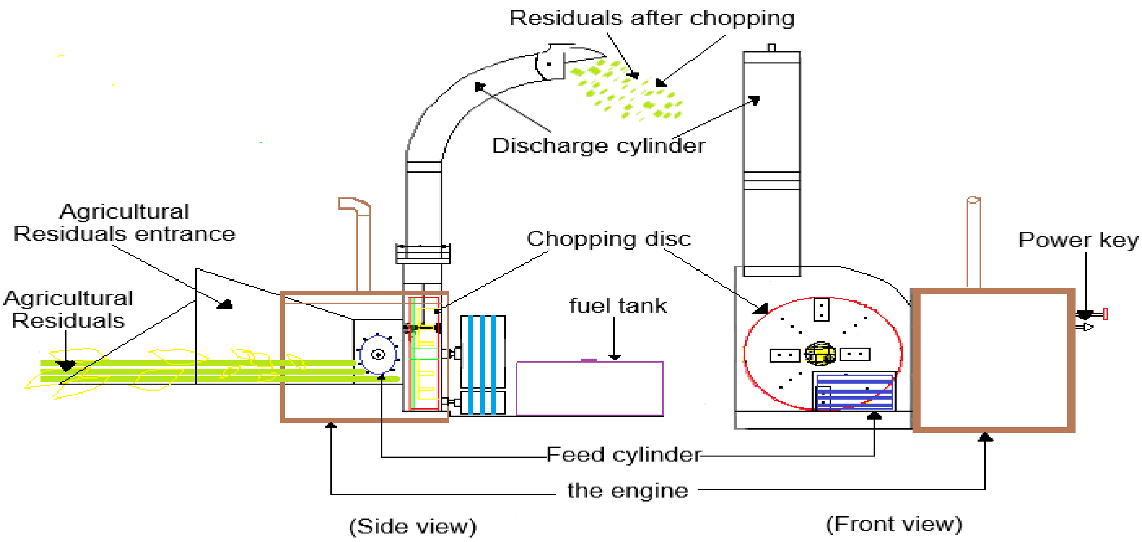

Figure (2): Graphical diagram of the Chopping machine body

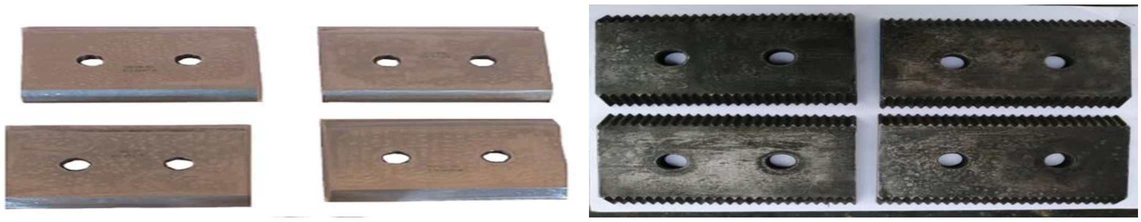

Figure (3): A- knife with a serrated edge B- knife with a smooth edge

Feeding unit

The feeding unit consists of an autonomous hydraulic system that regulates a feeding cylinder with a diameter of 38 cm and is equipped with 10 blades. Two feeding speeds were used in the experiment: fast at 9.5 rpm and slow at 5.5 rpm. The feeding aperture measures 23 x 23 cm, with a feeding angle of 90 degrees, and the length of the feeding table was 96.5 cm. The basin is completely horizontal to facilitate entry of long legs and provides a pathway for directing materials to be processed. The feeding cylinder functions to collect, compress, and transport the materials towards the cutting cylinder, ensuring a uniform feed into the cutting machine.

Hydraulic Feed System

- Steel hydraulic reservoir, 11.5 liters (3 gal.) capacity.
- Self-contained hydraulic feed system allows you to evenly feed limbs into the chipper.
- Variable feed rate with load sensing two-stage pump.
- Feed rate 0-46 m/min (0-150 fpm). Average 30 m/min (100 fpm).
- Self-contained system with infinite speed settings, dedicated neutral and full reverse, pump output 25 LPM (6.6 GPM) and 4 hp with maximum pressure and maximum flow, however this is rarely required.
- Feed system operates under 2,500 psi.
- Single 38cm (15") diameter top feed roller.

Circumstances for the experiment

The following parameters were used in the experiment to measure the machine's performance in terms of:

A. Chopping cylinder peripheral velocity (1450 rpm).
B. Feeding rate peripheral velocity (5.5 rpm and 9.5 rpm).
C. Two types of cutting knife (smooth edged and serrated).
D. Agricultural field Residuals (Corn stalks and palm fronds). 10 samples of crop residues (corn stalks and palm fronds) were taken to study some of the physical properties mentioned in Table (2).
E. The type of statistical design used: A split-split plot design used to implement the experiment with three factors.

Table (2): Specifications of corn stalks and palm fronds.

sequence	Corn stalks				Palm fronds			
	Length cm	weight gm	Min. stem Diameter cm	Max. stem Diameter cm	Length cm	weight gm	Min. stem Diameter cm	Max. stem Diameter cm
1	178	231	0.88	2.49	341	832	0.47	7.48
2	182	381	0.65	3.14	297	685	0.37	6.95
3	175	355	0.93	2.79	293	390	0.33	6.46
4	169	155	0.65	2.09	261	373	0.36	5.54
5	174	313	0.97	2.90	329	620	0.24	6.48
6	183	177	0.93	3.14	356	820	0.39	8.02
7	172	246	0.88	2.45	321	905	0.41	7.37
8	179	321	0.64	2.35	305	670	0.40	6.56
9	168	107	0.85	2.12	346	614	0.22	6.63
10	162	142	0.58	1.65	315	620	0.38	7.16
Mean	1742	242.8	0.796	2.512	3164	6529	0.357	6.865

Measurements of Studied Characteristics

Moisture of the agricultural residues

To determine the moisture content in the agricultural crops under study, mass measurements were obtained using an electronic balance with accuracy of 0.1 mg, both before and after drying the samples at a temperature of 65 degrees Celsius using an electric drying oven. The samples were maintained until a stable weight was achieved over 9 hours. Following this, the samples were allowed to cool. The moisture content was then estimated on a wet foundation using the following equation (Orisaleye, *et al*., 2022):

$$\text{Mc} = \frac{Sb - Sa}{Sb} \times 100$$

Where Mc: Moisture content%, Sb: weight before drying (g); Sa: weight after drying (g).

The machine productivity (ton.h^{-1})

Three air-dried samples of agricultural waste (about 2 kg each) were collected. Each sample was processed by the machine. An accurate digital stopwatch with a resolution of 0.1 seconds was utilized to measure the output of cutting material and record the corresponding time. The average machine productivity was subsequently determined by weighting the output material. The productivity of the machine was calculated using the following equation. (Al-Gezawe, *et al*., 2016):

$$P = \frac{W}{T} \times 3600$$

Where P: Machine productivity (ton.h^{-1}); W: mass of plant (Kg); T: Time (sec).

Total power required (kW)

The following formula was used to determine the engine power needed to operate the crop residue cutting machine. (Abdrabo, *et al*., 2014) (Okasha, 2016):

$$EP = \frac{FC \times Pr \times L.C.V \times 427 \times \eta_m \times \eta_{th}}{3600 \times 75 \times 1.36}$$

Where EP: Power requirements consumption during the chopping operation (kW); FC: Fuel consumption (L.h^{-1}); Pr: Density of the fuel (0.85 kg. L^{-1}); L.C.V: Lower calorific value of fuel (10000 kcal/kg); 427: Thermal mechanical equivalent (kg.m/kcal); η_m: Mechanical efficiency of engine, 80%; η_{th}: Thermal efficiency of the engine, (considered to be about 40% for diesel engine).

Cutting Efficiency (%)

In order to produce compost and fodder the chopping efficiency (%) was calculated following Equation as stated by (Nipa, *et al*., 2021):

$$\eta c = \frac{Wout - Wuncut}{Win} \times 100$$

where ηc: Cutting Efficiency (%); W_{in}: the inlet mass of the fodder (kg); W_{out}: the outlet mass of the fodder (kg); W_{uncut}: amount of no chopped fodder (kg). unchopped feed determined separate the stems or parts of the unchopped fronds and weigh them.

Fuel consumption (L.h^{-1})

Fuel consumption was calculated in liters per hour by measuring the amount of diesel fuel utilized during each run. Before each run, the fuel tank was filled, serving as a calibrated container for measuring the fuel consumption (Sayed, *et al*., 2019). The following formula was used to get the fuel consumption rate:

$$Fc = \frac{V}{T}$$

Where Fc: rate of fuel consumption (L.h^{-1}); V: rate of consumed fuel (L); T: time of operating engine (h).

RESULTS AND DISCUSSION

Machine productivity(kg.h^{-1})

Table (3) presents the impact of knife types, feeding speeds, crop types, and their interaction on productivity (kg.h^{-1}). It is apparent from the table that a distinguishable difference exists with variations in knife types; the serrated knife demonstrated superior performance compared to the smooth knife, achieving the highest average productivity of (109.60) kg.h^{-1}, whereas the smooth knife recorded a productivity of (103.20) kg.h^{-1}. This discrepancy may be attributed to the increased surface area of the serrated knife, which enhances the chopping efficiency within a reduced timeframe. This is consistent with the findings of (Mady, *et al*., 2015). Furthermore, Table (3) indicates a significant difference in productivity with changes in the feeding speed, with speed exceeding 9.5 rpm recording the highest productivity of (122.60) kg.h^{-1}, whereas a speed of 5.5 rpm resulted in a productivity rate of (90.20) kg.h^{-1}.

Table (3): The effect of knife type, feeding speed, and crop type on productivity (kg.h^{-1}).

productivity(kg.h^{-1})					
Crop types (C)	Feed speeds (S)	Knife types (N)		C * S	
		Serrated	Smooth		
Palm	Slow (rpm5.5)	96.20	87.90	92.00	
	Fast (rpm9.5)	119.70	128.50	124.10	
Corn	Slow (rpm5.5)	99.20	119.20	88.30	
	Fast (rpm9.5)	123.20	119.20	121.20	
LSD $_{C*S*N}$		N.S		LSD $_{C*S}$	N.S
C * N					
Crop types		Serrated	Smooth	Average crop	
Palm		108.00	108.20	108.10	
Corn		111.20	98.30	104.70	
LSD $_{C*N}$		3.57*		LSD $_{C}$	4.49*
S * N					
Feed speeds		Serrated	Smooth	Average feeding speed	
slow (rpm5.5)		97.70	82.60	90.20	
Fast (rpm9.5)		121.40	123.80	122.60	
LSD $_{S*N}$		4.13*		LSD $_{S}$	4.04*
N					
Knife types		Serrated	Smooth		
Average type of knife		109.60	103.20		
LSD $_{N}$		2.44*			

* LSD; Least significant difference at probability.

** N.S.; No significant difference at probability.

This variation may be due to the lack of chopping time and the increase in the mass of the shredded material, as corroborated by (Rawdhan, *et al*., 2024). Additionally, the table reveals a significant difference concerning crop type in terms of productivity. Palm fronds recorded the highest productivity rate of (108.10) kg.h^{-1}, whereas corn stalks recorded an average productivity of (104.70) kg.h^{-1}. This difference may be attributed to the lower moisture content of palm fronds, which is consistent with (EL-Khateeb & EL-Keway, 2012).

With regard to bilateral interaction between knife type and the feeding speed, it remarkably influences productivity. As indicated in the table, the smooth knife operating at 5.5 and 9.5 rpm recorded the lowest and highest productivity levels, respectively. Additionally, the table reveals notable differences in the interaction between knife type and crop type with respect to productivity. Specifically, the smooth knife employed with palm fronds and corn stalks resulted in the highest and lowest productivity levels, respectively (108.20 and 98.30) $kg.h^{-1}$.

In relation to the interaction between crop type and feeding speed, it showed no significant effect on productivity. The feeding speed of 9.5 rpm with palm fronds achieved the highest productivity at (124.10) $kg.h^{-1}$, whereas the feeding speed of 5.5 rpm with corn stalks resulted in the lowest productivity (88.30 $kg.h^{-1}$).

In terms of three-way interaction between knife type, feeding speed, and crop type, no significant effect was observed. Specifically, the smooth knife operating at feeding speed 9.5 rpm with palm fronds achieved the highest productivity at (128.50) $kg.h^{-1}$, whereas the smooth knife with feeding speed of 5.5rpm and palm fronds exhibited reduced productive (87.90) $kg.h^{-1}$.

Total power required (kW)

Table (4) illustrates the effect of knife types, feeding speeds, crop types, and their interaction on the total power required (kW). The table indicates a significant difference associated with changes in knife type, as the serrated knife demonstrated superior performance by recording the lowest power requirement of (7.00) kW, compared to (8.10) kW for the smooth knife. This difference may be attributed to the fact that a knife with a smooth edge requires a higher force, thereby increasing the powerneeded for chopping, which aligns with findings by Mady, *et al*. (2015) and EL-Khateeb & El-Keway, (2012). Table (4) reveals a significant variation in total power requirement with changes in feeding speed, where a speed of 9.5 rpm required the highest power of (7.90) kW, whereas a speed of 5.5 rpm required (7.20) kW. this increase may be due to higher volume of agricultural waste presented to the shredding unit, thereby elevating the total power requirement, consistent with the observations by (Abo-Habaga, *et al*., 2019) and (Radwan, *et al*., 2016). Moreover, the table indicates significant differences in power requirements across different crop type, with palm fronds demanding the highest total power of (8.10) kW, while corn stalks required (7.00) kW. This variation could be the result of the difference in the mechanical properties of the crop tissues, as the power required for cutting is influenced by the material's specific mechanical properties and design of cutting implement, consistent with the research of (Kminiak & Kubs, 2016).

The binary interaction between knife type and feed speed had no significant effect on the total power required, as evidenced by the table which shows that the serrated knife and a speed of 5.5 rpm recorded the minimum total power required (6.80) kW, whereas the Smooth knife and a speed of 9.5 rpm achieved the maximum power requirement (8.60) kW. It is also observed from the table that there are no significant differences between the type of knife and the type of crop concerning the total power required. The table indicated that the serrated knife with corn stalks achieved the lowest total power requirement (6.40) kW, whereas the smooth knife with palm fronds required the maximum power (8.60) kW.

The binary interaction between crop type and feeding speed significantly affects the total power required. The data reveal that a feeding speed of 5.5 rpm with corn stalks resulted in the lowest total power requirement (6.30) kW, whereas the same feeding speed with palm fronds resulted in the highest power requirement (8.20) kW.

Table (4): The effect of knife type, feeding speed, and crop type on total power required (kW).

Required total power (kW)					
Crop types (C)	Feed speeds (S)	Knife types (N)		C * S	
		Serrated	Smooth		
Palm	Slow (rpm5.5)	8.40	7.90	8.20	
	Fast (rpm9.5)	6.80	9.30	8.10	
Corn	Slow (rpm5.5)	5.20	7.80	6.30	
	Fast (rpm9.5)	7.60	7.80	7.70	
LSD $_{C*S*N}$		0.56*		LSD $_{C*S}$	0.39*
C * N					
Crop types		Serrated	Smooth	Average crop	
Palm		7.60	8.60	8.10	
corn		6.40	7.60	7.00	
LSD $_{C*N}$		N.S		LSD $_{C}$	0.21*
S * N					
Feed speeds		Serrated	Smooth	Average feeding speed	
Slow (rpm5.5)		6.80	7.60	7.20	
Fast (rpm9.5)		7.20	8.60	7.90	
LSD $_{S*N}$		N.S		LSD $_{S}$	0.39*
N					
Knife types		Serrated	Smooth		
Average type of knife		7.00	8.10		
LSD $_{N}$		0.34*			

* LSD; Least significant difference at probability.

** N.S.; No significant difference at probability.

The three-way interaction among knife type, feeding speed, and crop type had a significant effect on the total power required. Specifically, the smooth knife at a feeding speed of 9.5 rpm with palm leaves recorded the highest total power requirement (9.30) kW, whereas the lowest total power requirement (5.20) kW was recorded with the serrated knife at a feeding speed of 5.5rpm and corn stalks.

Cutting Efficiency (%)

The results of cutting efficiency are presented in Table (5), which illustrates thats the effect of knife types, feed speeds, crop types, and their interaction on cutting efficiency (%). The table reveals a significant difference associated with used. Specifically, the smooth knife achieved superior cutting efficiency (66.62%) compared to the serrated knife which recorded an efficiency of 62.14%. This variation is attributed to the increased number of heterogeneous cuts per unit time when employing the knife serrated, consistent with the findings by (EL-Khateeb & El-Keway, 2012). Additionally, Table (5) indicates a significant effect of feed speed cutting. Speed exceeding 5.5 rpm and resulted in the highest cutting efficiency (66.90%), while a speed of 9.5 rpm recorded a lower efficiency of (61.85%). This decrease may be due to the waste passage without cutting, thereby reducing overall cutting efficiency, as noted by (Metwally, *et al*., 2006).

Table (5): The effect of knife type, feeding speed, and crop type on Cutting Efficiency (%).

Cutting Efficiency (%)					
Crop types (C)	Feed speeds (S)	Knife types (N)		C * S	
		Serrated	Smooth		
Palm	Slow (rpm5.5)	62.60	62.72	62.66	
	Fast (rpm9.5)	44.52	55.53	50.03	
Corn	Slow (rpm5.5)	68.68	74.60	71.15	
	Fast (rpm9.5)	72.75	74.60	73.67	
LSD $_{C*S*N}$		N.S		LSD $_{C*S}$	5.73*
C * N					
Crop types		Serrated	Smooth	Average crop	
Palm		53.56	59.13	56.34	
Corn		70.72	74.11	72.41	
LSD $_{C*N}$		N.S		LSD $_{C}$	4.40*
S * N					
Feed speeds		Serrated	Smooth	Average feeding speed	
slow (rpm5.5)		65.64	68.17	66.90	
Fast (rpm9.5)		58.63	65.07	61.85	
LSD $_{S*N}$		N.S		LSD $_{S}$	5.70*
N					
Knife types		Serrated	Smooth		
Average type of knife		62.14	66.62		
LSD $_{N}$		3.74*			

* LSD; Least significant difference at probability.
** N.S.; No significant difference at probability.

Furthermore, the table demonstrates a significant effect of crop type on cutting efficiency. Corn stalks achieved the highest cutting efficiency (72.41%), whereas palm fronds recorded a lower cutting efficiency of (56.34%). This disparity may be attributed to the higher resistance of palm fronds to cutting, due to their greater fiber content compared to corn stalks, which results in variations in cutting efficiency.

The bilateral interaction between knife type and feed speed does not significantly affect cutting efficiency. The table indicates that the smooth knife at a feed speed of 5.5 rpm recorded the highest cutting efficiency (68.17%). Additionally, there is no significant difference between knife type and crop type concerning cutting efficiency, as evident by the table showing that the smooth knife with corn stalks achieved the highest cutting efficiency (74.11 %). However, the interaction between crop type and feed speed significantly impacts cutting efficiency, with a feed speed of 9.5 rpm combined with corn stalks resulted in the highest cutting efficiency (73.67 %).

Regarding the three-way interaction among knife types, feeding speeds, and crop types, no significant effect was observed. The smooth knife at a feeding speed of 5.5 and 9.5 rpm achieved the highest cutting efficiency (74.60%), whereas the serrated knife at a feeding speed of 9.5 rpm with palm fronds exhibited a reduced cutting efficiency (44.52%).

Fuel consumption (L.h^{-1})

Table (6) shows the effect of knife types, feeding speeds, crop types, and their interaction on fuel consumption (l.h^{-1}). The table indicates that knife type does not significantly affect fuel consumption, with smooth knife exhibiting a higher rate of fuel consumption (2.57) l.h^{-1} compared to the serrated knife (2.22) l.h^{-1}. The reason may be due to the decrease in cutting effort, which leads to optimal utilization of the power consumed in the shortest time, which reduces fuel consumption. Additionally, Table (6) reveals that a significant impact of feed speed on fuel consumption. Specifically, a speed of 5.5 rpm resulted in the lowest average fuel consumption (2.28) l.h^{-1}, while the speed of 9.5 rpm recorded a higher average fuel consumption (2.50) l.h^{-1}. This increase is likely due to greater distance traveled per unit of time requiring higher cutting capacity, which in turn elevates fuel consumption. Moreover, the table shows a significant effect of crop type on fuel consumption, with corn stalks resulting in the lowest fuel consumption (2.22) l.h^{-1} compared to palm fronds which had a higher average fuel consumption (2.57) l.h^{-1}. This difference is possibly due to the lower moisture content and denser pulp of palm fronds compared to corn stalks, resulting in increased cutting resistance and consequently higher fuel consumption.

As for the binary interaction between knife type and feed speed, it did not significantly affect fuel consumption. The data indicates that the serrated knife at a speed of 5.5 rpm recorded the lowest average fuel consumption (2.15) l.h^{-1}, whereas the smooth knife at a speed of 9.5rpm recorded the highest average consumption of (2.72) l.h^{-1}.

In addition, there is no significant effect observed from the interaction between knife type and crop type on fuel consumption. The data shows that the serrated knife with corn stalks achieved the lowest average fuel consumption (2.02) l.h^{-1}, while the smooth knife with palm fronds recorded the highest average fuel consumption (2.72) l.h^{-1}.

In contrast, the bilateral intervention between crop type and feeding speed had a significant effect on the fuel consumption. Specifically, a feed speed of 5.5 rpm with corn stalks resulted in the lowest fuel consumption rate (1.99) l.h^{-1}, whereas the same speed with palm leaves recorded the highest average fuel consumption (2.58) l.h^{-1}.

Regarding the three-way interaction among knife type, feed speed, and crop type, a significant effect on fuel consumption was observed. The serrated knife at a feed speed of 5.5 rpm with corn stalks recorded the lowest fuel consumption (1.64) l.h^{-1}, whereas the smooth knife at a feed speed of 9.5 rpm with palm fronds exhibited the highest fuel consumption (2.95)1.h^{-1}.

Table (6): The effect of knife types, feeding speeds, and crop types on Fuel consumption (L.h^{-1}).

Fuel consumption (L/h)					
Crop types (C)	Feed speeds (S)	Knife types (N)		C * S	
		Serrated	Smooth		
Palm	Slow (rpm5.5)	2.66	2.50	2.58	
	Fast (rpm9.5)	2.17	2.95	2.56	
Corn	Slow (rpm5.5)	1.64	2.50	1.99	
	Fast (rpm9.5)	2.40	2.50	2.45	
LSD $_{C*S*N}$		0.14*		LSD $_{C*S}$	0.07*
C * N					
Crop types		Serrated	Smooth	Average crop	
Palm		2.41	2.72	2.57	
Corn		2.02	2.42	2.22	
LSD $_{C*N}$		N.S		LSD $_{C}$	0.05*
S * N					
Feed speeds		Serrated	Smooth	Average feeding speed	
Slow (rpm5.5)		2.15	2.42	2.28	
Fast (rpm9.5)		2.29	2.72	2.50	
LSD $_{S*N}$		N.S		LSD $_{S}$	0.07*
N					
Knife types		Serrated	Smooth		
Average type of knife		2.22	2.57		
LSD $_{N}$		0.09*			

* LSD; Least significant difference at probability.
** N.S.; No significant difference at probability.

CONCLUSIONS

According to the study performed on the machine, the conclusion can be drawn as follows**:**

- The smooth-edged knife demonstrated the highest cutting efficiency for corn stalks at speed of 5.5 rpm.
- The serrated-edged knife produced the highest productivity when cutting palm fronds at a feed speed of 9.5 rpm.
- The lowest total power requirement and fuel consumption were observed with the serrated-edged knife at a feed speed of 5.5 rpm while cutting corn stalks.

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CONFLICT OF INTEREST

The authors state that there are no conflicts of interest with the publication of this work.

تأثير أنواع سكاكين القطع وسرعات تغذية العلف على أداء بعض المؤشرات الفنية لماكينة تقطيع العلف طراز (CH922DH)

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الخلاصة

أجريت هذه التجربة لدراسة بعض العوامل الهندسية لآلة تقطيع المخلفات الزراعية لإنتاج أعلاف غير تقليدية، وقد أجريت في مختبر الزراعة النسيجية في بلدية الرشيد، بغداد- العراق. وقد تمت دراسة تأثير نوعين من سكاكين التقطيع (ناعمة الحواف ومسننة)، وسرعتي تغذية (5.5 و9.5 دورة في الدقيقة)، ونوعين من المخلفات الزراعية (سيقان الذرة وسعف النخيل). وتضمنت المؤشرات الفنية المدروسة الإنتاجية والقدرة الكلية المطلوبة وكفاءة القطع واستهلاك الوقود. وكانت نسبة الرطوبة في سيقان الذرة 56% وسعف النخيل 34%. وأشارت النتائج إلى تفوق نوع السكين (مسنن) في تسجيل أعلى إنتاجية بلغت 109.60 كجم. ساعة$^{-1}$، وأقل قدرة كلية مطلوبة بلغت 7.00 كيلو واط، وأقل استهلاك للوقود بلغ 2.22 لتر. ساعة$^{-1}$. بينما سجلت سرعة التغذية البطيئة 5.5 دورة في الدقيقة أعلى كفاءة قطع بنسبة 66.90%، وأقل طاقة مطلوبة كانت 7.20 كيلو وات، وأقل استهلاك للوقود 2.28 لتر. ساعة$^{-1}$، بينما سجل محصول الذرة أعلى كفاءة قطع بنسبة 72.41%. وأقل طاقة إجمالية مطلوبة كانت 7.00 كيلو وات، وأقل استهلاك للوقود 2.22 لتر. ساعة$^{-1}$.

الكلمات المفتاحية: كفاءة القطع، المخلفات الزراعية، استهلاك الوقود، انتاجية الآلة.

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