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Performance studies on power operated arecanut sheath shredder for chopping of sheath used as an animal fodder

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Abstract
Arecanut sheath is one of the important raw materials obtained from the arecanut palm. The sheath attached to the leaf of arecanut tree not only used for commercial plate making. But recently the arecanut sheath was investigated to use as a dry alternative fodder for cattles rather than rice straw in some parts of Kerala and Karnataka. The available machineries for chop making have been tried to chop the arecanut sheath into suitable fodder size. However, due to physical and biological characteristics of the arecanut sheath, none of them were found suitable to get desired size. Hence, arecanut sheath shredder was developed and evaluated for chopping of the arecanut sheath used as an alternative fodder for cattle's. The performance of arecanut sheath shredder was evaluated at three different cylindrical cutter head speeds (13.1, 15.71 and 18.33 m s^{-1}), three feed roller speeds (0.28, 0.36 and 0.45 m s^{-1}) and numbers of knives (2, 3 and 4) was used, the effect of these operational parameters on output capacity and power consumption of shredder were determined.

Keywords: Arecanut sheath, cattles feed

Introduction
Arecanut palm (*Areca catechu Linn*) is a tropical crop and it's grown under variety of climatic conditions. In India, area under crop is 0.2 Mha and producing annually 0.25 Mt of arecanut and majorly grown in southern part and northeastern region of the country. In Karnataka area under crop is 5.38 lakh acres and producing annually 3.26 lakh tonnes of arecanut (Prakash, 2012) [1]. Arecanut leaf sheath is obtained from the arecanut palm (*Areca catechu Linn*) is highly heterogeneous having variations in structure, shape and thickness. Leaf sheath completely encircles the stem forming a protective covering for the developing inflorescence. Freshly fallen sheaths contain 55 - 60 per cent moisture. This reduces to 11 - 16 per cent after drying in open, under shade for 5 - 6 days. The constituents of the leaf sheaths are cellulose - 43 per cent, crude fibre - 33 per cent and ash – 5 per cent (Biddappa, 1960) [2]. In certain regions of Kerala and Dakshina Kannada, leaf sheath is also used as alternative cattle feed by cutting of sheath into small pieces using Kathi (sharp edged straight blade hand tool) and machets (Bavappa, *et al*, 1982) [3].

Currently, considering higher economic profitability of arecanut palm and relatively low investment many farmers have replaced it with paddy cultivation, resulting in shortage of paddy straw for its use as animal fodder (Gaikwad and Bhargav, 2012a) [4]. But recently the arecanut sheath was investigated to use as alternative dry fodder for cattle in certain regions of Kerala and Dakshina Kannada district of Karnataka by cutting of sheath into small pieces using Kathi (sharp edged straight blade hand tool) and machetes and an alternative to paddy straw. The available machineries for chop making have been tried to chop the arecanut sheath into suitable fodder size. However due to physical and biological characteristics of the arecanut sheath, none of them were found suitable to get desired size (Gaikwad and Bhargav, 2012b) [5]. Hence, keeping the above factors in view, an attempt has been made to develop an arecanut sheath shredding machine for making arecanut sheath into suitable fodder size for animals with an objective of evaluate the developed arecanut sheath shredder to obtain small size of arecanut sheath suitable for animal feed.

Materials and methodology
The research was conducted in order to determine the output capacity and power consumption of arecanut sheath after chopping by developed arecanut sheath shredder. The experiments were conducted at different levels of independent parameters *viz.*, cylindrical cutterhead speed,

feed rollerspeed and number of knives. In order to chopping of arecanut sheath, the required cylindrical cutter head speed of 13.1 to 18.33 m s^{-1} and feed roller speed of 0.28 to 0.45 ms^{-1} with 2 to 4 knives were selected. The research was conducted in order to determine the output capacity and power consumption of shredder after chopping of sheath by developed arecanut sheath shredder. The laboratory trials were carried out at College of agricultural Engineering, Raichur during 2014-15. The samples of arecanut sheath can be brought from the Sirsi taluk, Dakshina Kannada, Karnataka. The performance of arecanut sheath shredder was evaluated under lab conditions. The procedure used for evaluating arecanut sheath shredder is given below.

Output capacity

Output capacity of arecanut sheath shredder was measured by weighing the amount of sheath shredded per unit time. It is expressed in metric units by duffee's formula (Ojha and Michael, 2007) [6].

$$C = W \times H \times L \times N \times R \times K$$

Where,

C = Output capacity of arecanut sheath shredder in kg h^{-1},
W = Width of throat, mm
H = Height of throat, mm
L = Chopping length, mm
N = Number of knives on the cutter head
R = Cutter head speed, rpm
K = Constant equal to 2 x 10^{-3}

Power consumption (C_i)

The power consumption of arecanut sheath shredder can be expressed by using formula.

$$Ci = \frac{\text{Amount of material fed, kg}}{\text{Time taken for feeding, h} \times \text{Average wattmeter reading, kW}}$$

Result and discussion

A three factorial completely randomized block design techniques were used to analyze the effect of feed roller speed, cylindrical cutter head speed and number of knives on machine output capacity and power consumption of arecanut shredder were depicted and explained below.

Output capacity

It was observed that, the output capacity increases as the cylindrical cutter head speed and feed roller speed increases for all numbers of knives (Table 3). The data presented in Table 3 shows that a minimum output capacity of 53.90 kg h^{-1} was observed at a cylindrical cutter head speed of 13.1 m s^{-1} and feed roller speed of 0.28 m s^{-1} for 2 number of knives and maximum output capacity of 133.1 kg h^{-1} at cylindrical cutter head speed of 18.33 m s^{-1} and feed roller speed of 0.45 m s^{-1} for 4 number of knives. The data in the Table 4 presents that interaction effect (C x F, F x K, K x C and C x F x K) on output capacity of arecanut sheath shredder at 1 per cent level of significance. Similar findings were reported by Ismail *et al.* (2009) [7] for chopping of grape trashes and similar trends were reported by Ojha and Michael (2007) [6].

Power consumption

The effect of cylindrical cutter head speed, feed roller speed and numbers of knives on power consumption was presented in Table 3 & analysis of variance on percentage loss in Table 4. The power consumption increased as the cylindrical cutter head speed increased and feed roller speed and all numbers of knives decreased. The data presented in Table 3 shows that a minimum power consumption of 110.82 kg kWh^{-1} was observed at a cylindrical cutter head speed of 13.1 m s^{-1} and feed roller speed of 0.45 m s^{-1} for 4 number of knives and maximum output capacity of 217.39 kg kWh^{-1} at cylindrical cutter head speed of 18.33 m s^{-1} and feed roller speed of 0.28 m s^{-1} for 2 number of knives. Table 4 presents that interaction effect (C x F, F x K, K x C and C x F x K) on power consumption of arecanut sheath shredder at 1 per cent level of significance. Similar findings were reported by Ismail *et al.* (2009) [7] for chopping of grape trashes and similar trends were reported by and El-hanfy and Shalby (2009) [8].

Table 1: Effect of cylindrical cutter head speed (C), feed roller speed (F) and numbers of knives (K) on output capacity

S. No	Cylindrical cutter head speed (C), m s^{-1}	Feed roller speed (F), m s^{-1}	Output capacity, kg h^{-1}		
			Numbers of knives (K)		
			2	3	4
1	13.1	0.28	53.90	71.80	100.84
		0.36	56.28	78.37	111.13
		0.45	60.06	86.50	116.00
2	15.71	0.28	56.72	88.30	120.37
		0.36	59.23	92.00	123.43
		0.45	61.77	98.80	128.53
3	18.33	0.28	70.30	102.17	123.03
		0.36	84.30	104.13	130.50
		0.45	89.28	108.27	133.10

Table 2: Analysis of variance for output capacity

SV	DF	SS	MSS	F
Treatment	26	51386.53	1976.40	269.76 *
Cylindrical cutter head speed (C)	2	7726.83	3863.41	527.33 *
Feed roller speed (F)	2	1490.42	745.21	101.71 *
Numbers of knives (K)	2	41108.45	20554.23	2805.52*
C × F	4	76.35	19.08	2.60 *
C × K	4	656.37	164.09	22.39 *
F × C	4	111.02	27.75	3.78 *
C × F × K	8	217.05	27.13	3.70 *
Error	54	395.62	7.32	
Total	80	51782.15		

CV = 2.92
SD = 2.70
* = Significant at 1 per cent level

Table 3: Effect of cylindrical cutter head speed (C), feed roller speed (F) and numbers of knives (K) on power consumption

S. No	Cylindrical cutter head speed (C), m s^{-1}	Feed roller speed (F), m s^{-1}	Power consumption, kg kW^{-1}-h^{-1}		
			Numbers of knives (K)		
			2	3	4
1	13.1	0.28	179.97	152.26	130.40
		0.36	174.46	148.77	124.00
		0.45	165.30	140.09	110.82
2	15.71	0.28	205.02	166.64	137.60
		0.36	193.67	155.13	132.04
		0.45	187.90	142.61	125.20
3	18.33	0.28	217.39	183.12	148.84
		0.36	207.43	168.69	140.00
		0.45	201.59	163.61	136.91

Table 4: Analysis of variance for power consumption

SV	DF	SS	MSS	F
Treatment	26	98964.08	3806.31	11.08 *
Cylindrical cutter head speed (C)	2	8256.01	4128.00	12.01 *
Feed roller speed (F)	2	8544.15	4272.07	12.43 *
Numbers of knives (K)	2	45075.45	22537.73	65.61 *
C × F	4	9943.99	2485.99	7.23 *
C × K	4	3722.21	930.55	2.70 *
F × C	4	9844.49	2461.12	7.16 *
C × F × K	8	13577.76	1697.22	4.94 *
Error	54	18547.15	343.46	
Total	80	117511.2		

CV = 11.78
SD = 18.53
* = Significant at 1 per cent level

Conclusion

The overall size of arecanut sheath shredder developed is 1000 x 780 x 500 mm (length x height x width). The output capacity of shredder increased as the feed roller speed, cylindrical cutter head speed and number of knives increased. Power consumption of arecanut sheath shredder decreased as the feed roller speed and number of knives increased and it has increased when cylindrical cutter head speed increased. It was observed that, the maximum output capacity obtained at 0.45 ms^{-1} feed roller speed and 18.33 m s^{-1} cylindrical cutter head speed with 4 numbers of knives, whereas, minimum power consumption was observed at 0.45 ms^{-1} feed roller speed and 13.1 m s^{-1} cylindrical cutter head speed with 4 numbers of knives.

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