



Modification of Engine powered Single Disc Coffee Pulper to Double Disc and Evaluation its Performance

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ABSTRACT

An engine powered single disc coffee pulping machine was modified in to double disc machine with an objective increases the capacity of single disc due to high production of coffee in the areas, minimizing the postharvest losses, reduced the drudgery load on children and women in rural areas. The machine was developed in Jimma agricultural Engineering research center and its performances were evaluated in local woredas. The evaluated performances of the machine were; pulping capacity, percentage of mechanical damage, pulping efficiency and none pulped losses of the coffee. Results of the evaluations indicated, maximum output pulping capacity, minimum percentage of mechanical damage, pulping efficiency and minimum none pulped losses of; 509.89kg/hr maximum rpm 260 and 14kg/min feed rate, 1.28 % at 7 kg/min and 92 rpm, 97.10 % at 14kg/min and 208 rpm and 1.87 % at 14 kg/min and 208 rpm, respectively of double disc while 173.06kg/hr capacity and 95.5% pulping efficiency of the single disc. The performance of this machine is based on the adjustment of the machine (the clearance between discs and guide) especially mechanical damage, pulping efficiency and none pulping loss. Therefore, we recommended that coffee producing farmers and organizations can use this machine to increase their coffee products pulping capacity and efficiency, save time of pulping, minimize losses and maintain quality of their coffee bean

Keywords: coffee, pulper, machine, disc, Performance

Introduction

Coffee is the world's favorite beverage and most traded commodity [2]. Ethiopia is the center of origin for highland coffee (*Coffea arabica* L), which is one of the most valuable cash crops in the country. It represents the major agricultural export crop, providing 20–25% of the foreign exchange earnings [5]. The coffee sector contributes about 4–5% to the country's Gross Domestic Product (GDP) and creates hundreds of thousands of local job opportunities [4]. Ethiopia is the center of origin for Coffee Arabica and possesses a diverse genetic base for this Arabica coffee with considerable heterogeneity [7]. Jimma Zone is one of coffee growing zones in the Oromia Regional State, [11] found that the share of coffee income from total income in coffee producing districts of Jimma zone is 77%. On other hands, share of land allocated to coffee crop in these areas is more than 69%. This shows that coffee is not only the source of cash and income; but also the means of livelihood for the smallholder farmers of the area.

Coffee berries' pulping, is the first phase of the coffees' post harvest processing, that can be done in to methods called wet and dry pulping.. The wet pulping is the process that can be done immediately after harvesting. The wet method currently varies depending on the degree of fermentation [10]. Any of the methods employed, which depends on locality, types of coffee and prevailing weather conditions, is followed by hulling which is the removal of hull or parchment to obtain two usual beans from cherry.

[3] Reported that, out of the Jimma's coffee sent to the coffee quality inspection center laboratory. In years 2003 to 2007, more than 60% of dry processed coffee were classified into grade 3 as compared to 80% of wet processed classified into grade 2 and 3. According to the author, the problem of post harvest processing and handling in the area were the causes, for resulted poor quality as a main contributing factor. The poor quality due to post harvest processing and the subsequent drop in earnings had severely affected coffee farmers in woredas like Gomma, Limmu Kossa, and Manna, where coffee provides a larger portion of their annual income. [6] Studied that coffee beans sampled from cooperatives had higher quality scores and were classified as specialty 1 (Q1) (33%) or specialty 2 (Q2) (67%). About 78% of coffee beans sampled from private traders fall in grade 3, while 22% of their beans qualified for Q2. Coffee certification, in general, did not add any value to coffee quality. No quality differences were also observed between coffee beans sampled from farmers. Coffee quality differences were observed between coffee processing methods. Due to absence of such technologies the cost of their coffee would be reduced and children and women were enforced to pulp by hand using teeth. Therefore, these farmers were forced to sell for local investors who reduce the costs of coffee since the farmers didn't have alternative. The existing coffee pulper had some problems in addition to low capacity such as break coffee and not separate coffee husk from pulped coffee as well as difficult to adjust it. Therefore, they require the coffee processing technologies which reduced their worries. Hence the main objective of this work was to increases the capacity of single disc to double disc due to high production of coffee in which wet coffee deteriorate after few days, minimizing the postharvest losses, reduced the drudgery load on children and women in rural areas.

Materials and Methods

Materials

The materials used for construction of the machine were: -

- Sheet metal, square pipe, knives, disc and angle iron for construction of the prototype

The instruments used were:-

- Stopwatch: used to measure time,
- digital tachometer: used to measure rpm of the discs,
- digital weight balance: to measure weight of sample and
- 5hp engine to run the machine

Description of the machine and it's working principle

The modified coffee pulp machine was operated by 5HP motor (engine) and feed by one person. The machine had two discs which attached to one shaft and common hopper. Pulping involves removal of outer red skin, white fleshy pulp, separation of the pulp and wet parchment coffee. This machine do these activities by squeezing the cherries between a pulper guidance and disc. The opening of the machine between disc and guidance is adjusting according to the size of coffee.



Fig. 1 – (A). Manual operated single disc coffee pulper, (B). Modified engine driven Double disc coffee pulper.

Method

The capacity of the machine was increased by adding the number of disc and increase the size of the machine. Hence the machine was modified into two disc and increased it size as well as changing the power source from human power to engine power. The other part need modification is the complexity of adjustment and minimize breakage and separation of beans from husks. Therefore, by fixing the clearance between the knife and the disc into two millimeters (2mm) and only adjust the coffee parchment guidance easily to control overfeeding.

Data collection and analysis

The experimental was conducted in split plot design having speed of disc as main plots and feeding rate as sub plots with the three levels of disc speeds, the three levels feeding rates and three replication. The collected data were: the broken grain, un-pulp coffee, pulped coffee, feeding rate and rpm of the disc. The pulping capacity of the machine was calculated as weight of coffee cherry fed into the pulper per unit of time, expressed in kilogram per hour as stated by [8]. The pulping efficiency was calculated by the ratio of total weight of parchment coffee collected at all outlets to the total coffee cherry to the machine, expressed in percentage [9]. Finally, the the unpulped loss and mechanical damage were calculated using the formula stated by (9) as follow

$$\text{pulping capacity} = \frac{\text{total weight of pulped coffee}}{\text{time taken}} \quad (1)$$

$$\text{pulping efficiency} = \frac{\text{weight of pulped}}{\text{weight of total}} * 100 \quad (2)$$

$$\text{Unpulpeloss}(\%) = \frac{\text{weight of unpulped coffee}}{\text{total weight of input coffee}} * 100 \quad (3)$$

$$\text{Mechanical damage}(\%) = \frac{\text{weight of damaged coffee}}{\text{total weight of sample}} * 100 \quad (4)$$

(1)

Result and Discussion

Pulping capacity

The maximum output pulping capacity of the machine was 509.89kg/hr was obtained at maximum rpm 260 and 14kg/min feed rate. As shown in the table 1, the capacity of the machine is not significantly different among feed rate means except at high feed rate which is 14kg/hr. According to [1] threshing capacity increased with an increased drum speed.

Table 1. Pulping capacity of double disc coffee pulper

Feed rate x speed		Speed (rpm)			Speed (rpm)	Mean	Feed (kg/min)	Mean
		92	208	260				
Feed rate (kg/min)	7	280.81^b	413.04 ^a	434.74 ^a	92	382.83 ^b	7	376.20 ^b
	10.5	412.35 ^a	440.29 ^a	419.22 ^a	208	448.08 ^{ab}	10.5	423.95 ^b
	14	455.33 ^a	490.92 ^a	509.89^a	260	454.62 ^a	14	485.38 ^a
SE		44.937				24.802		25.94
LSD		0.2420				0.0788		0.0043
CV						10.49		

Pulping efficiency

The maximum pulping efficiency of the machine of 97.10% was recorded at 9kg/min feed rate and 208 rpm of disc where as the minimum pulping efficiency was 94.26% recorded at 92rpm of the disc and 9kg/min feed rate. The pulping efficiency of the machine was varies with increase in disc speed which studied by [1]. This efficiency was not significantly different among feed rate means

Table 2. Pulping efficiency of double disc coffee pulper

Feeding rate x speed		Speed (rpm)			Speed (rpm)	Mean	Feed (kg/min)	Mean
		92	208	260				
Feeding rate (kg/min)	7	95.44 ^{ab}	95.37 ^b	94.32 ^b	92	94.96 ^b	7	95.04 ^a
	10.5	95.17 ^b	95.93 ^{ab}	95.27 ^{ab}	208	96.13 ^a	10.5	95.45 ^a
	14	94.26^b	97.10^a	95.56 ^{ab}	260	95.05 ^{ab}	14	95.64 ^a
SE		0.7011				0.4034		0.4048
LSD		0.0854				0.0766		0.3521
CV						0.90		

Un - pulped loss

High un pulped loss of around 4.43% was obtained at maximum speed of the machine, 260 rpm, and at low feed rate of 7kg/hr and the minimum unpulped loss was 1.87% which was occurred at 208rpm speed of the machine and at 9kg/hr feed rate. As the physical observation, the maximum un-pulped loss was occurred due to the adjustment between the discs and the guidance parts and also due to the non-uniformity of coffee.

Table 3. Un-pulped loss of coffee due to double disc coffee pulper

Feeding rate x speed		Speed (rpm)			Speed (rpm)	Mean	Feed (kg/min)	Mean
		92	208	260				
Feeding rate (kg/min)	7	3.40 ^b	3.15 ^{bc}	4.43^a	92	3.29 ^a	7	3.66 ^a
	10.5	3.08 ^{bc}	2.53 ^{cd}	2.98 ^{bc}	208	2.52 ^b	10.5	2.87 ^b
	14	3.40 ^b	1.87^d	2.53 ^{cd}	260	3.31 ^a	14	2.60 ^b
SE		0.4263				0.0945		0.2461

LSD	0.0726	0.0017	0.0028
CV		17.17	

Mechanically damaged parchment coffee

The minimum broken percentage was 1.28 % obtained at combined effect of 7 kg/min feed rate and 92 rpm of the machine. This percentage of broken was occurred due to the adjustment of clearance between discs and coffee guidance parts and also due to non-uniformity of coffee dimensions. Norris, E.R and G.L.Wall. (1986) studied that, increased concave open area resulted in a decreased kernel damaged.

Table 4. Mechanical damaged of coffee due to pulping by this machine

Feeding rate x speed	Speed (rpm)			Speed (rpm)	Mean	Feed (kg/min)	Mean	
	92	208	260					
Feeding rate (kg/min)	7	1.28^c	1.40 ^{abc}	1.56 ^{abc}	92	1.30 ^b	7	1.42 ^a
	10.5	1.30 ^c	1.43 ^{abc}	1.67 ^{ab}	208	1.47 ^{ab}	10.5	1.47 ^a
	14	1.33 ^{bc}	1.58 ^{abc}	1.71^a	260	1.65 ^a	14	1.54 ^a
SE	0.1414			0.0823		0.0816		
LSD	0.9384			0.0356		0.3416		
CV				11.75				

Conclusion and Recommendation

Conclusion

The modified coffee pulping machine was tested and evaluated which the results were as follow. The maximum pulping efficiency of the machine is 97.10 % at 14 kg/min feed rate and 208 rpm of the machine. The maximum output pulping capacity of was about 509.89kg/hr maximum rpm 260 and 14kg/min feed rate. The maximum un-pulping loss of the machine was 1.87 % at 14 kg/min feed rate and 208 rpm of the machine speed. The maximum percentage of breakage was 1.71 % at speed of 260 rpm and feed rate of 14 kg/min. the pulping capacity and the pulping efficiency of the modified engine powered were 468.2% and 1.67% higher than manual operated single disc coffee pulper respectively. In addition to its pulping capacity and efficiency, the machine is so easy to adjust to increase its performance and also simple to transport from one place to another.

Recommendation

It was recommended that due to the results obtained were good the double disc coffee pulper is appropriate for farmers and all who participated on coffee production. But to get good result the users can train on the adjustment of the machine and how to operate. The machine is comfortable for operation and easy to transport from place to place.

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