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Development and Performance Evaluation of Enset Corm Pulverizing Machine in Hadiya Zone, Central Region, Ethiopia

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Abstract—*A study was conducted to develop and evaluate the performance of a motorized enset corm pulverizing machine. The experiment test was carried out by factorial design and the levels of operating speeds with levels of feeding rate were taken as treatment. The collected data were analyzed using Statistix 8 software. An analysis of variance revealed that the primary effects of operating speed and feed rate were observed to be significant at the 5% level but the interaction effect was not significant except for capacity. At an operating speed of 1800 rpm and a feeding rate of 10 kg min^{-1}, a maximum pulverizing capacity of 721.4 kg h^{-1} was found; at a speed of 1600 rpm and a feeding rate of 15 kg min^{-1}, the minimum pulverizing capacity of 611.6 kg h^{-1} was found. When the maximum pulverizing efficiency of 97% was found at an operational speed of 1800 rpm and a feeding rate of 15 kg min^{-1}, whereas the minimum pulverizing efficiency of 93.5% was found at an operating speed of 1600 rpm and a feeding rate of 10 kg min^{-1}. The minimum percentage loss was 3.4% at an operating speed of 1800 rpm and feeding rate of 15 kg min^{-1}, while the maximum percentage loss was 6.5% at an operating speed of 1600 rpm and feeding rate of 10 kg min.$^{-1}$ According to test results, when operational speeds were increased from 1600 rpm to 1800 rpm, pulverizing capacity increased from 611.6 kg h^{-1} to 721.4 kg h^{-1}, pulverizing efficiency increased from 93.5 % to 97%, and the percentage of loss decreased from 6.5% % to 3.5%. From the test results, the percentage loss of the pulverizing machine tended to decrease with an increase in operating speed and feeding rate. This motorized machine had a high pulverizing capacity at its operating speed of 1800 rpm.*

Keywords— *Corm; Development; Evaluation; Processing; Pulverization.*

I. Introduction

Enset (Ensetventricosum) is an indigenous root crop typically referred to as the "false banana" which is the main source of food in the heavily populated South and South-Western regions of Ethiopia. It provides food security for about 24 million people in the Southern area of Ethiopia [1]. Enset is one of the most popular foods in Ethiopia and served as the foundation of food sources for Ethiopians due to its significance and adaptability. Enset makes major contributions to assuring year-round access to sustainable food, revenue generation, resource conservation, and food security. This versatile root crop serves as both human and animal sustenance, and its resistance to drought renders it a risk-avoidance crop. [2]. It has a pseudo stem that can reach a diameter of 1.5 meters and grows up to 12 meters in height, much like a banana plant. Ethiopia is the only place where the domesticated enset plant is grown. [4]

Enset is a root crop that is only grown in Ethiopia's highlands and is not well-known outside of the country. [5]. Enset is generally harvested twice a year, but it can be stored for extended periods of time both before and after fermentation. It can be gathered as well at any time of the year and at any stage over a number of years. [6]. The major enset producing areas in South and South-western Ethiopia include Gurage, Hadiya, Kambaata, Wolaita, Silte, Sidama, Gedeo, and Kaffa. Enset grows at an altitude of 1100-3000 meters above sea level, with an annual rainfall of 1100-1500 mm, mostly from March to September, an average temperature of 10-21 °C and a relative humidity of 63-80%. If the soil is well-drained and sufficiently fertile, it can grow well in most types of soil. A household's average crop yield is 61.46 quintals per hectare. Enset covers more than three million hectares of land in Ethiopia, and it produces about 0.69 million tons of crop annually. [9].

Enset is the largest basis of carbohydrates food found in the false stem (pseudo stem) and an underground root (corm) [6]. The main food products of enset crops are kocho, bulla, and amicho, and fiber is the byproduct of enset after decortication [10]. Kocho is a cooked starch eaten mostly with protein products, it is also bulk of fermented starch prepared from a combination of decorticated leaf sheaths and pulverized corm. It keeps well in storage for an extended amount of time. It takes a long time to process and prepare, and women handle this work. Recently, it has been increasingly exported to urban markets from rural markets. Bulla is gained by scraping the leaf sheath, and peduncle, pulverizing the corm into a pulp, squeezing liquid holding starch from the pulp, permitting the resultant starch to distillate into a white powder; and rehydrating with water. Amicho doesn't need to be processed like bulla and kocho. It is just the inner corm portion that is consumed boiled with cabbage or ground into kocho and bulla.

Enset processing leading to size reduction includes decorticating, pulverizing, and squeezing. Enset corm pulverizing needs more labour and time-consuming work which demands for technology to handle it effective and ease the problem on women [11]. It is an extra weight for women in addition managing day-to-day household works. The burden leftovers a problem for women for a long time and this impacts gender relationships at the family stage. The traditional processing approaches are unwieldly; labour demanding, unsanitary, levy large number of troublesomeness to the

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operational women, and are accompanying with excessive produce loss [2]. Manually 2 to 2.5hr per root is needed to pulverize enset corm. But the developed corm pulverizing machine mainly differs from traditional methods in terms of time and labour taking, and providing high quantities and quality products.


Figure 1. Manually method of enset processing in Hadiya Zone

The purpose of motorized enset corm pulverizing is to reduce women's drudgery and pulverize the corm in high quality and quantity in a short time. Currently, the demand for enset products is highly increased in rural and urban areas of the country even if its products are exported from Ethiopia to other countries. Therefore, this study aimed to mechanizing enset processing in enset growing areas which is completely necessary in Ethiopia to replace manually pulverizing with machine.

II. Materials and Methods

2.1. Study Area

The study of the development and performance evaluation of the enset corm pulverizing machine was conducted in Hadiya Zone, Central Ethiopia Region, it is located 231km from Addis Ababa, the capital city of Ethiopia. This region has a latitude and longitude of (7°33′N37°51′E) with an elevation of 2177 meters above sea level. The mean annual temperature of the study area ranges between 15.1 to 20°C and the annual rainfall ranges from 1001 to 1200mm per year.

2.2. Materials

TABLE 1. Machines and materials were used to develop a pulverizing machine

No.	Machine	Application	Specification
1	Lathe machine	Turning, facing, and boring	2500mm bed length
2	Drilling machine	Making holes	Radial max 45mm
3	Milling machine	For key way cutting	Universal
4	Rolling machine	Rolling sheet metal	6mm
5	Arc welding	For Welding	380V
6	Power hacksaw	For cutting	
7	Portable grinder	Grinding and cutting	220V
8	Spanner	Tighten and loosen the nut	Open and ring
9	Screwdriver	Tighten or loosen the screw	Open and ring
10	Hammer	kicking	1000g
11	Center punch	Pointing	
12	Bolt and nut	Connecting	(M6×20) mm
13	Paint	Coloring	1000ml
14	Belt	Power transmission	V- belt
15	Pulley	Power transmission	(150×80×30) mm
16	Engine Motor	Power source	5hp
22	Digital Varner caliper	Measuring	150mm
23	Pocket meter	Measuring	3000mm

Materials were used for developing the enset corm pulverize machine listed below along with their application and specification.

2.2.1. Experimental Materials

A sample of enset corm was obtained from the Central Ethiopia Region, farmers' fields of the Hadiya Zone, from the lemo district to conduct preliminary and actual tests on the corm pulverizing machine.

2.2.2. Instruments for evaluating

Various apparatuses and devices were used to implement numerous records on the enset corm. The length of the corm was taken using a tape meter, and the diameters were obtained with a Varner caliper. The weighing balance could be utilized to measure the mass of the corm both before and after it was pulverized. A stopwatch was utilized to record time during the evaluation of the pulverizing machine. A tachometer was to measure the rotary revolution of the pulverizing machine as well as the partial size reduction of enset corm was conducted by a knife manually.

2.3. Procedures

The preliminary test of the pulverizing machine can be conducted at three levels of operating speeds and two levels of feeding rates depending on operating speeds of 1600rpm, 1700rpm, and 1800rpm concerning feeding rates 10kg $min^{-1,}$ and 15kg min^{-1} before carrying out the final test of the machine. When the operating speeds were carefully chosen for evaluating the machine performance on enset corm based on studies by [11]. To evaluate the machine's performance, two hundred twenty-five (225kg) of freshly uprooted and cleaned enset corm of Ginbo variety free from any damage could be used for investigation.

2.3.1. Description of Machine

The developed enset corm pulverizing machine shown in (Figure 2) was composed of the following components such as feeding hopper, covering, pulverizing drum, outlet, supporting frame, shaft, pulley, bearing, V-belt, engine setting, bolt, and nut. The machine's dimensions were 1430 mm in height, 500 mm in width, and 700 mm overall length. The drum was made up of a cylindrical perforated stainless steel sheet metal which was held by a shaft passing through the rolled cylindrical sheet metal and it was welded in both side by circular discs. This drum was then wrapped with the perforated mesh, which were held in position through riveting and bolt. The motorized corm pulverizing machine consists of a trapezoidal feeding hopper made up of 2mm thick stainless steel sheet metal, the hopper was the receptacle through which corm was admitted into machine for pulverizing. It was fixed at the top center of the cover. The outlet was constructed of stainless steel and it would accept the pulp and sent it out into storage container because of its inclination.

The machine frame supports the other parts of the corm pulverizing machine, as well as providing stability. It was subjected to the weighs of other members of the machine and also vibration from the drum and motor. The motorized machine was coupled by a V- belt pulley on the shaft. The machine had other components like bearing to enhance smooth rotation of the shaft; and bolts & nuts that fasten other components together. The developed corm pulverizing machine

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was widely used in the peeled enset corm processing into pulp. This machine was readily affordable for the farmers due to the fact that it was fabricated from locally sourced materials. The pulverizing machine was simple to operate and it could be used for both household and market purposes.

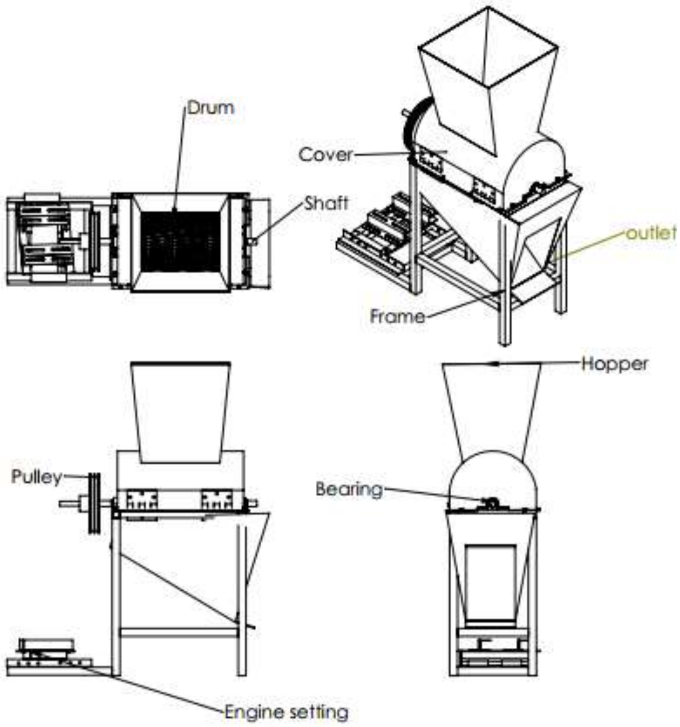

Figure 2. Drawing views for developed machine

2.3.2. Power source for machine

Human, engine, and electrical motors are among the well-known power source for corm pulverizing machines. However; to mechanize enset corm pulverizing operation either an engine or electrical motor was used as a power source because human lobar has been used for a longer period of time and no appreciable results were obtained. Because diesel and gasoline are widely available, farmers can employ motorized graters [12]. The engine power was recommended due to its availability for the rural areas of farmers so, for this reason, diesel engine powered motor was used in this research work.

2.3.3. Operating principles

The pulverizing machine was composed of the pulverizing unit where the pulverization process takes place. The motions of the drum were transmitted through the V-belt, pulleys, shafts and bearings by the torque of the engine motor. The continuous abrasive force delivered to the corm by the rough surface of the drum which was achieved by the rotating drum. The enset corm were hand fed simultaneously into the machine through the feeding hopper into the pulverizing unit while the pulverization process was occurred rough surface of the drum. Uprooted enset corm was peeled manually with knife then feed into the machine through the hopper these corms came in contact with the cylindrical drum, they were reducing into pulp, this was achieved due to the perforations on the surface of the rotating drum. Finally, it falls and goes through the outlet then collected by sack.

Figure 3(a). Uprooted corm

Figure 3(b). Size reduced corm

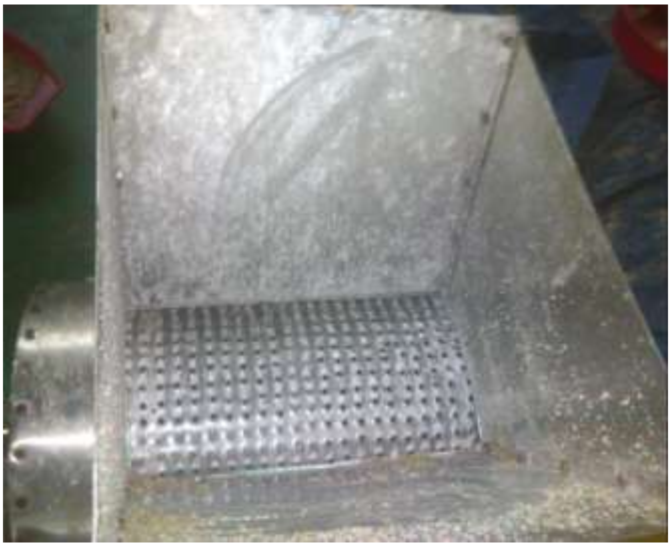

Figure 3(c). Pulverizing drum of machine

Figure 3(e). Machine during operation

Figure 3(f). Pulverized pulp

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2.3.4. Statistical analysis

The experiment test was carried out by factorial design and the levels of operating speeds with levels feeding rate taken as treatment. The experiment to be replicated three time there were 18 experimental units (3x2x3 = 18). The collected data were analyzed using Statistix 8 software, a commercial software package developed by the United States Department of Agriculture (USDA). The confidence intervals of 95% were used to indicate a significant effect of an independent variable on the dependent variable. Comparison between treatment means was conducted by least significance difference (LSD) at 5% level. A two-way analysis of variance was implemented on the data by following an appropriate procedure for the design of the experiment [13].

III. RESULTS AND DISCUSSION

The machine pulverizing capacity, pulverizing efficiency, percentage of loss, and pulverizing time, were evaluated at two feeding rate levels and three operating speed settings. After starting the machine, the speed was changed with a tachometer to 1600rpm, 1700rpm, and 1800 rpm. After being manually peeled and size reduced with knives and thoroughly cleaned for hygienic reasons, the uprooted enset corm was measured in sets of 10kg and 15kg for separately operating speed on a weighing balance. Tachometer measurements were obtained under load in each scenario and pulverizing of each feed rate was timed to completion using a stopwatch. Once the enset corm were fed into the machine, they were pulverized according to size categories. The final output corm pulp was measured after the machine had completed pulverizing. The pulverizing machine's fuel consumption was recorded as 2.14L h^{-1} while the performance evaluation process.

3.1. Performance Evaluation

3.1.1. Capacity

An analysis of variance (ANOVA) for the impact of operating speed, feeding rate, and their interaction effect on the machine's pulverizing capacity is presented in (Table 2). Consequently, based on a result obtained (Table 2), analysis of variance showed that the effect of operating speed, feeding rate, and their interaction effect was significant at a 5% level since the p values were less than 0.05 (P< 0.05). The results suggested that the operating speed, feeding rate, and their interaction effect all had an impact on a machine's pulverizing capacity.

TABLE 2. Analysis of variance for pulverizing capacity of the machine

Source	DF	Sum of squares	Mean squares	F-value	P-value
Replication	2	5.1	2.5		
Operating speed	2	27374.6	13687.3	319.27	0.0000
Feeding rate	1	459.9	459.9	10.73	0.0084
Speed×Feed	2	588.6	294.3	6.87	0.0133
Error	10	428.7	42.9		
Total	17	28856.8			

CV =1.00, grand mean = 656.32, P < 0.05, significant at 5 % level, P > 0.05, non significant at 5 % level, DF = degrees of freedom.

Figure 4 illustrates the machine's mean pulverizing capacity, which varied between 611.6 kg h-1 and 721.4 kg h-1. The capacity to pulverize rose from 611.6 to 721.4 kg h-1 with an increase in operating speed from 1600rpm to 1800rpm. The results presented in (Figure 4) indicate that while the machine's capacity tended to rise with increased operating speed, it decreased with the feeding rate. This suggests that capacity was directly associated with operating speed and inversely associated with corm feeding rate.

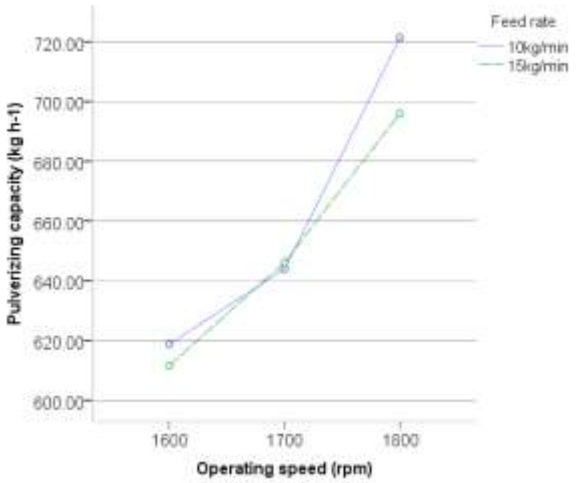

Figure 4. Effect of operating speed and feeding rate on pulverizing capacity

At an operating speed of 1800 rpm and a feeding rate of 10 kg min^{-1}, a maximum pulverizing capacity of 721.4 kg h^{-1} was found; at a speed of 1600 rpm and a feeding rate of 15 kg min^{-1}, the minimum pulverizing capacity of 611.6kg h^{-1} was founded. This motorized machine was expected to have a high pulverizing capacity at its operating speed of 1800 rpm because its operating speed of 1800 rpm was comparatively fast. The throughput capacity obtained in this study was higher compared to the value of 360kg h^{-1} reported by [14]

3.1.2. Efficiency

An analysis of variance for operating speed, feeding rate, and their combined impact on machine efficiency is presented in (Table 3). While the p-value found in (Table 3) was less than 0.05 (P<0.05), indicating that the main effect of operating speed and feeding rate was significant at a 5% level, but the analysis of variance showed that their interaction effect was not significant at the same level. Thus, the findings suggested that while feeding rate and operating speed had an impact on a machine's pulverizing efficiency, their interaction had no such effect.

TABLE 3. Analysis variance for pulverizing efficiency of machine

Source	DF	Sum of squares	Mean squares	F-value	P-value
Replication	2	0.0268	0.0134		
Operating speed	2	31.7815	15.8908	19.34	0.0004
Feeding rate	1	4.3611	4.3611	5.31	0.0440
Speed×Feed	2	3.8988	1.9494	2.37	0.1435
Error	10	8.2169	1.9494		
Total	17	48.2852			

CV = 0.95, grand mean = 95.06, P < 0.05, significant at 5 % level, P > 0.05, non significant at 5 % level, DF = degrees of freedom.

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Figure 5 illustrates the findings that the machine's mean pulverizing efficiency varied from 93.5% to 97%. Pulverizing efficiency rose from 93.5% to 97% when operating speed was increased from 1600 rpm to 1800 rpm. The machine's efficiency tended to rise as the operating speed and feeding rate increased, as indicated by the results in (Figure 5), also it indicating a clear relationship between the pulverizing efficiency and operating speed and feeding rate.

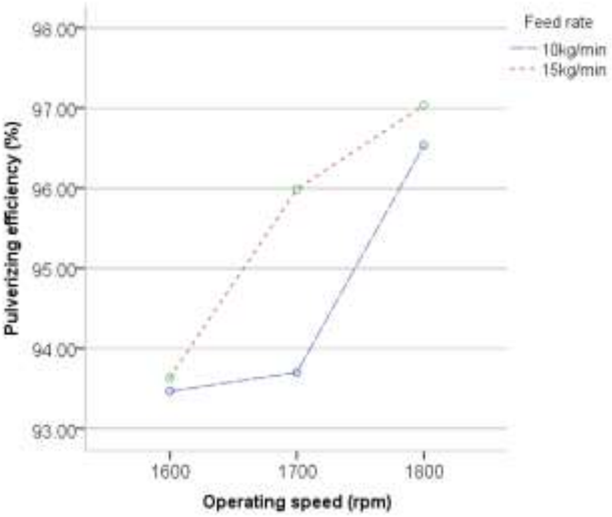

Figure 5. Effect of drum speed and feed rate on grating efficiency

At an operational speed of 1800 rpm and feeding rate of 15 kg min^{-1}, the maximum pulverizing efficiency of 97% was found, whereas the minimum pulverizing efficiency of 93.5% was found at an operating speed of 1600 rpm and feeding rate of 10 kg min^{-1}.

3.1.3. Percentage of loss

An analysis of variance for operating speed, feeding rate, and their combined impact on the pulverizing machine's percentage loss is presented in (Table 4). An analysis of variance, based on the data in (Table 4), revealed that the feeding rate and operating speed were significant at a 5% level because the p-value was less than 0.05 (P<0.05). On the other hand, the interaction effect was not significant at a 5% level because the p-value was greater than 0.05 (P > 0.05). The findings showed that feed rate and operating speed had an impact on a pulverizing machine's percentage of loss, but not the interaction effect.

TABLE 4. Analysis variance for percentage loss of the pulverizing machine

Source	DF	Sum of squares	Mean squares	F-value	P-value
Replication	2	0.0304	0.0152		
Operating speed	2	31.6437	15.8219	19.31	0.0004
Feeding rate	1	4.4402	4.4402	5.42	0.0422
Speed×Feed	2	3.9184	1.9592	2.39	0.1417
Error	10	8.1947	0.8195		
Total	17	48.2274			

CV = 18.34, grand mean = 4.9367, P < 0.05, significant at 5 % level, P > 0.05, non significant at 5 % level, DF = degrees of freedom.

Figure 6 illustrates the mean percentage loss of the pulverizing machine, which was found to vary between 3.4% and 6.5%. As operating speed increased from 1600 rpm to 1800 rpm, the loss percentage dropped from 6.5% to 3.4%. Accordingly, the results were displayed in (Figure 6) which indicates that the percentage of loss had an inverse association with the speed and feeding rate of enset corm. The percentage loss of the pulverizing machine tended to decrease with an increase in operating speed and feeding rate.

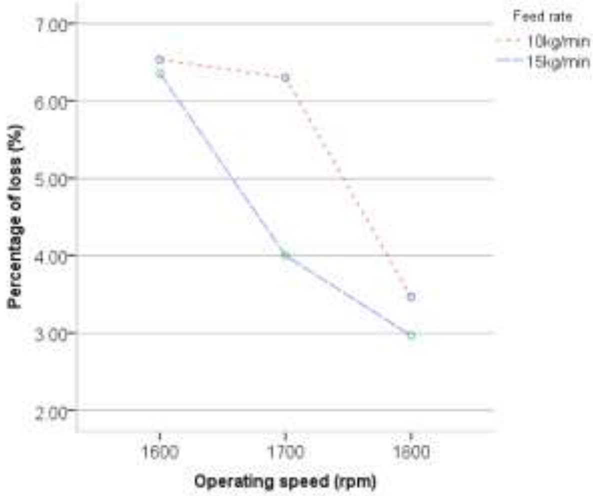

Figure 6. Effect of operating speed and feeding rate on percentage of loss

At an operating speed of 1800 rpm and feeding rate of 15 kg min^{-1}, the minimum percentage loss was 3.4%, whereas the maximum percentage loss was 6.5% at an operating speed of 1600 rpm and feeding rate of 10 kg $min.^{-1}$ Due to the fact that, in comparison to other operating speeds, 1800 rpm had the minimum percentage of loss.

3.1.4. Pulverizing time

The results of an analysis of variance for the operating speed, feeding rate, and interaction effect on the pulverizing machine's pulverizing time were displayed in (Table 5). Because the p value in (Table 5) was less than 0.05 (P<0.05), an analysis of variance revealed that the feeding rate and operating speed were significant at a 5% level; however, the interaction effect was not significant at a 5% level. The findings therefore indicated that the feeding rate and operating speed of a pulverizing machine affect the pulverization time, but not the interaction effect.

TABLE 5. Analysis of variance for pulverizing time of the machine

Source	DF	Sum of squares	Mean squares	F-value	P-value
Replication	2	0.4	0.2		
Operating speed	2	1690.8	845.4	122.72	0.0000
Feeding rate	1	11250.0	11250.0	1633.0	0.0000
Speed×Feed	2	26.3	13.2	1.91	0.1982
Error	10	68.9	6.9		
Total	17	13036.4			

CV = 1.57, grand mean = 167.56, P < 0.05, significant at 5 % level, P > 0.05, non significant at 5 % level.

Figure 7 illustrates the data that indicates the machine's mean pulverizing time, which varied between 131 and 151.7 seconds at a feed rate of 10 kg min^{-1} and 1800 and 1600 rpm operating speeds. The machine's pulverizing time generally decreased as operating speed increased at the same feed rate, according to (Figure 7) results. This is because higher operating speeds operated more quickly than lower ones, meaning that pulverizing time was directly associated with feeding rate but inversely associated with operating speed.

At an operating speed of 1800 rpm and a feeding rate of 10 kg min^{-1}, the minimum pulverizing time of 131 seconds was recorded, whereas the maximum pulverizing time of 151.7 seconds was recorded at an operating speed of 1600 rpm and a feeding rate of 10 kg min^{-1}. The pulverizing time dropped from 151.7 seconds to 131 seconds at the same feed rate and operating speed of 1600 rpm to 1800 rpm. Thus, among the various operating speeds, the 1800 rpm speed was relatively fast and could pulverize corm in a short amount of time.

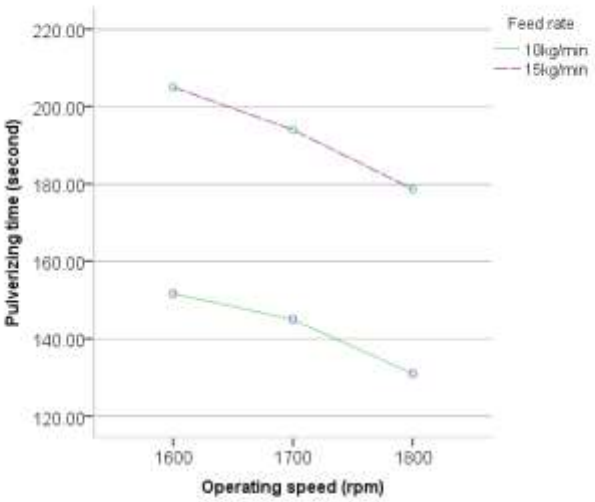

Figure 7. Effect of drum speed and feed rate on grating time

TABLE 6. Comparison of treatment means

No	Treatment combination	Operating speed (rpm)	Feeding rate (kg min^{-1})	Capacity (kg h^{-1})	Efficiency (%)	Loss (%)	Time (sec)
1	V1F1	1600	10	618.79^{d}	93.467^{b}	6.53^{a}	151.7^{d}
2	V1F2	1600	15	611.57^{d}	93.633^{b}	6.35^{a}	205^{a}
3	V2F1	1700	10	643.97^{c}	93.700^{b}	6.35^{a}	145^{e}
4	V2F2	1700	15	646.20^{c}	95.987^{a}	4.0^{b}	194^{b}
5	V3F1	1800	10	721.37^{a}	96.533^{a}	3.5^{b}	131^{f}
6	V3F2	1800	15	696.03^{b}	97.033^{a}	3.4^{b}	178.7^{c}

In order to determine whether there were any significant differences between the treatment means, the data was subjected to the LSD all pairwise comparisons test of dependent variables for three different operating speeds and two different feeding rates. The results of this test were provided in (Table 6). As a result, the LSD all pairwise comparisons test revealed that, at the 5% level, the treatment means for capacity, efficiency, loss, and except time in six groups (a, b, c... f) did not differ significantly from one another.

3.1.5. Comparison of Pulverizing Machine with Traditional Method

TABLE 7. Comparison of pulverizing machine with traditional method

No.	Method of pulverizing	Capacity (kg hr^{-1})	Efficiency (%)	Percentage of loss (%)
1	Pulverizing machine	568.4	92.07	7.32
2	Traditional method	38.9	59.1	38.26

It is clear from contrasting the results that the motorized machine was more productive, easier to use, and faster. The results of (Table 7) showed that the pulverizing machine had a higher efficiency (92.07%) than the traditional method, which had an efficiency of 59.1%. Additionally, (Table 7) shows that the pulverizing machine completed tasks faster, with a higher capacity and fewer losses than the traditional one. This reduced the amount of time required and the sense of boredom that was usually related with the traditional method.

IV. CONCLUSION

The performance test of the enset corm pulverizing machine was carried out at three levels of operating speeds and two levels of feeding rate at a moisture content of 56.4% for Ginbo variety corm. The machine was evaluated in terms of pulverizing capacity, pulverizing efficiency, percentage of loss, and pulverization time. The outcomes revealed that the performance indicators were obtained in the range of 611.6kg h^{-1} to 721.4kg h^{-1}, 93.5% to 97%, 3.4% to 6.5%, and 131sec to 205sec respectively. According to test results, when operational speeds was increased from 1600 rpm to 1800 rpm, pulverizing capacity increased from 611.6 kg h^{-1} to 721.4 kg h^{-1}, pulverizing efficiency increased from 93.5 % to 97%, and the percentage of loss reduced from 6.5% % to 3.5%. An analysis of variance revealed that the primary effects of operating speed and feed rate were observed to be significant at the 5% level but the interaction effect was not significant except for capacity. The results thus showed that while feeding rate and operating speed affected a machine's pulverizing capacity, efficiency, percentage of loss, and time, yet interaction had no effect on any of these factors other than capacity.

REFERENCES

[1] J. S. Borrell et al., "Enset in Ethiopia: A poorly characterized but resilient starch staple," Ann. Bot., vol. 123, no. 5, pp. 747–766, 2019, doi: 10.1093/aob/mcy214.
[2] A. Zewdie, "Assessment of performance and adoption of improved enset processing technologies," pp. 1–58, 2012.
[3] L. S. Faculty and P. Sciences, Genetic Diversity , Selection Signatures and Nutritional Composition of Enset (Enset ventricosum) from Ethiopia. 2023.
[4] T. M. Olango, B. Tesfaye, M. Catellani, and M. E. Pè, "Indigenous

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knowledge, use and on-farm management of enset (Ensete ventricosum (Welw.) Cheesman) diversity in Wolaita, Southern Ethiopia," J. Ethnobiol. Ethnomed., vol. 10, pp. 1–18, 2014.
[5] J. S. Borrell et al., "Enset-based agricultural systems in Ethiopia: A systematic review of production trends, agronomy, processing and the wider food security applications of a neglected banana relative," Plants People Planet, vol. 2, no. 3, pp. 212–228, 2020, doi: 10.1002/ppp3.10084.
[6] A. Tesfaye and A. Girma, "Phytochemistry , Pharmacology and Nutraceutical Potential of Enset (Ensete ventricosum)," vol. 9, no. 3, pp. 112–117, 2017,
[7] Gizachew Tefera, "Development and Evaluation of Enset Fermenting Box," Int. J. Eng. Res., vol. V8, no. 10, pp. 667–676, 2019, doi: 10.17577/ijertv8is100334.
[8] T. H. Kassahun Sadessa, "Evaluation of Enset Clones Resistance against Enset Bacterial Wilt Disease (Xanthomonas campestris pv. musacearum)," J. Vet. Sci. Technol., vol. 06, no. 03, 2015, doi: 10.4172/2157-7579.1000232.
[9] T. Sirany, E. Tadele, T. Hibistu, A. Kefalew, and H. Reta, "Economic Viability and Use Dynamics of the Enset Food System in Ethiopia: Its Implications for Food Security," Adv. Agric., vol. 2022, 2022, doi: 10.1155/2022/5741528.
[10] L. D. Daracho, "Review on Enset (Enseteventr icosum) Value Chain in Ethiopia," vol. 65, pp. 17–24, 2020, doi: 10.7176/JRDM/65-03.
[11] G. Kibi, "Development and Evaluation of Engine Driven Corm Grating Machine," pp. 16 21, 2018.
[12] B. James et al., "Producing Gari from Cassava: An illustrated guide for smallholder cassava processors," 2012.
[13] K. A. Gomez and A. A. Gomez, Statistical procedures for agricultural research. John wiley & sons, 1984.
[14] L. Kebede, B. Getnet, M. Teamir, G. Moges, and F. Kelemu, Results of Agricultural Machinery and Post-harvest Engineering Research. 2018. doi: 10.13140/RG.2.2.24706.02249.