Evaluation of Integrated Corm Grating and Leaf Sheath Decorticating Machine

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***Abstract*– Enset processing, in Ethiopia at present, is labour demanding and time-consuming activity which calls for technology to make it efficient and lighten the burden on women. Multipurpose enste processing machine was adapted. So, integrated corm grate and leaf sheath decorticate machine was evaluated at three levels drum speed 1900, 2000 and 2100rpm for corm grating and four levels of drum speed 800, 900, 1000 and 1100rpm for leaf sheath decorticating for the most dominate two varieties (Baladat, and Lemate local names) at farmer's farm. Performance of the machine was evaluated interims of Grating capacity (Kg/hr) and Decorticating capacity for both varieties. Based on the results obtained, the grand mean grating capacity of 1658Kg/hr (~1.5ton/hr) for corm and decorticating capacity, decorticating efficiency of 497.00Kg/hr and 90.33% for leaf sheath is recorded for the prototype at 1mm concave clearance. Fuel consumption of 0.6lit/hr was recorded at drum speed of 1100 rpm and strongest variety as the farmers' response (Baladati variety) for leaf sheath decorticating. And 1.1lit/hr fuel consumption was recorded at drum speed of 2100 rpm and baladeti variety for corm grate. The machine can be used by farmers for all varieties at drum speed range of 2000 – 2100rpm for corm grating while 900 – 1100rpm and 1mm concave clearance for leaf sheath decorticating.**

***Keywords*– Evaluation, Grating, Decorticating and Enset**

I. INTRODUCTION

Enset (*Enset ventricosum*) is commonly known as "false banana" and it is a traditional staple crop or co-staple food in the densely populated South and South-Western parts of Ethiopia. It serves as food security for about twelve million people in Southern region of Ethiopia (Brandt *et al.*, 1997). It is a multipurpose crop used as human food, animal feed, to shade other crops like coffee, decoration, is a drought resistant crop which makes it risk avoidance crop. It resembles the banana plant, but is somewhat larger, up to 10 m tall with a pseudo stem up to 1 m in diameter and is produced primarily for the large quantity of carbohydrate rich food found in the false stem (pseudo stem) and an underground bulb (corm).

The major foods obtained from enset are *kocho*, *bulla* and *amicho*. *Kocho* needs a lengthy period of processing and preparation, which is carried out by women. The first stage involves removing the leaf stalks and grading of the corm. *Kocho* is increasingly exported to urban markets. *Bulla* is the unfermented starch of a mature plant, which can be prepared as a pancake or porridge. *Amicho* is the core of a young plant, which is boiled and consumed as other tuber crops. Due to their low protein content these foods are eaten in combination with protein rich products like milk. The fiber is used to make sacks, bags, ropes, mats, construction material and sieves. Fresh enset leaves are used as food wrappers, serving plates and for stall feeding of cattle. There are many other uses, e.g. for medicines.

It is expected that enset can be introduced in many other regions to improve food security. However, this needs further study and work on trial demonstration farms. Further research is needed on: diseases, processing technologies, improvement of the livestock component, and production of protein-rich food crops in enset systems, marketing of *kocho*and sustainability of enset farming under increasing population pressure and marketing.

However, little effort or research is made to improve the processing aspect of the crop, especially corm grating and thus traditional processes are predominantly used by farmers. Both men and women are involved in growing and managing enset at field level in most cases, however, there are places where it is most commonly associated with women. Women are mainly responsible for harvesting and processing enset. Enset processing requires more lab our and thus it is additional burden for women beside to handling daily house routines. The burden remains as a challenge of women for a long time and this has influence on gender relations at household level. Some enset processing technologies (e.g. scraping and squeezing tools) have been developed by Bako Agricultural Engineering Research Center, Sodo Rural Technology promotion Research Centre and Melkassa Agriculture Research Institution.

However, the technologies that farmers used for enset corm grating and leaf sheath decorating still in the area were traditional. The introduced technologies mainly differ from traditional methods in terms of time and labour taking, and their provided yield of quantities and qualities. The traditional harvesting and post harvesting procedures are cumber some; labour intensive, unhygienic, impose a lot of inconvenience to the working women, and associated with great yield lose. Traditionally 2-3hrs per tuber require to grating.

A) Statement of the problem

Women in rural community of Ethiopia have more workload in general as compared to men. The workload is expressed in household, farm and social activities. Almost all the household activities (including child care) are performed

by women alone. Therefore, women are busy all the day from very early in the morning to late in the evening. Men do not involve in household activities and in some places, in certain area women are not allowed even to share bread with their husbands in some cases, i.e., women eat what is left from their husbands. Women are also involved in farm operations mainly at planting, weeding and harvesting of different crops. Some crops are more managed by women than men. Such crops include enset, vegetables and spices. Moreover, milking and managing calves is among the daily routines of women. Processing of the staple food source enset is entirely done by women because traditionally men are not allowed to involve on such activities.

Enset processing is labour demanding and time-consuming activity which calls for technology to make it efficient and lighten the burden on women. It is unimaginable to perform social activities such as wedding, funeral and circumcisions ceremony without active involvement of women. Due to all these workload, women may not have enough time to have adequate care for their child and may not perform the house needs to the satisfaction of men. This at times creates conflict among spouses. In general the existing enset processing coupled with other farm and household activities has negatively affected the relationship between men and women biasing the work load to women and affecting maternity health (Sodo Rural Technology Promotion Center report document, 2010). Thus, different development programs have introduced enset processing technologies as a solution to lessen the burden on women.

The tubers of enset cannot be stored longer after harvest before decaying, and so processing follows immediately after harvesting. Enset processing leading to size reduction includes decorticating, grating, and squeezing. A typical enset processing plant should therefore consist of units produced to achieve all the stages or steps mentioned above.

Traditional processing method have low productivities and tedious, solution to these problems the BAERC develop and evaluate the machines that can grate the corm of enset at high quality in a short period of time and reduce human drudgery. Performance of the machine was evaluated interims of Grating capacity (Kg/hr) and Grating uniformity (%) for all varieties. Grating efficiency (%) and Fuel consumption (Kg/ml) were taken for Baladati variety. Based on the results obtained, the grand mean grating capacity of 1048.3Kg/har (~1ton/hr) is recorded for the prototype. The optimum grating capacity of 1277Kg/hr was observed when the drum was operated at velocity of 2200rpm at Sharte variety; whereas the minimum grating capacity of 604.0Kg/hr was observed when the drum speed was 2000 rpm at Baladati variety. Fuel consumption of 1.32lit/hr was recorded at drum speed of 2400rpm and Baladati variety. The machine can be used by farmers for all varieties at drum speed range of 2200–2400rpm (Gelgelo, 2018).

Additionally, the BAERC also develops and evaluate enset decorticating machine for leaf sheet solely. The maximum decorticating capacity of 255.38 kg/hr was obtained at drum speed of 850 rpm, when the concave clearance was 1 mm and the feeding rate was 0.074 kg/s. Nonetheless, the decorticating capacity of the prototype machine decreased with increasing concave clearance and increased with increasing feeding rate. The highest decorticating efficiency of 98.97% was obtained at drum speed of 850 rpm, concave clearance of 1 mm and feed rate of 0.074 kg/s while the lowest decorticating efficiency of 72.41% occurred at drum speed of 950 rpm, concave clearance of 6 mm and feed rate of 0.037kg/s. The mean decorticating efficiency with respect to the feeding rates of 0.037, 0.056 and 0.074 kg/s were 86.77, 89.41 and 89.91 %, respectively (Merga, 2019).

Eventhough, the center develops and evaluate the machines that are effective for enset corm grating and leaf sheet decorticating solely, taking one rather than two machines to the farmers for one crop is compulsory.

Hence, engine operated enset processing machine that can grate the corm and decorticate the leaf sheath of enset was adapted. The machine was consists basically three parts; the hopper, the grating and decorticating drum on one shaft. All these components are mounted on an angle iron frame that has trapezoidal shape. The machine assembly is powered engine of small horse power of 5hp.

Therefore, this paper is initiated to evaluate integrated corm grate and leaf sheath decorticate machine to determine the performance of the machine.

II. MATERIAL AND METHOD

A) Experimental Site

The experiment (evaluation of the machine) was conducted in Southwest Shoa Zone of Oromia Regional State, Southwest highlands of Ethiopia.

Materials

The instruments used during performance evaluation and data collection were: digital balance, spring balance, tachometer and stopwatch.

Description of the machine

The machine consisted basically 3 parts: the hopper, the grating and decorticating drum. All these components are mounted on an angle iron frame that has trapezoidal shape. The machine assembly is powered engine of small horsepower of 5hp.

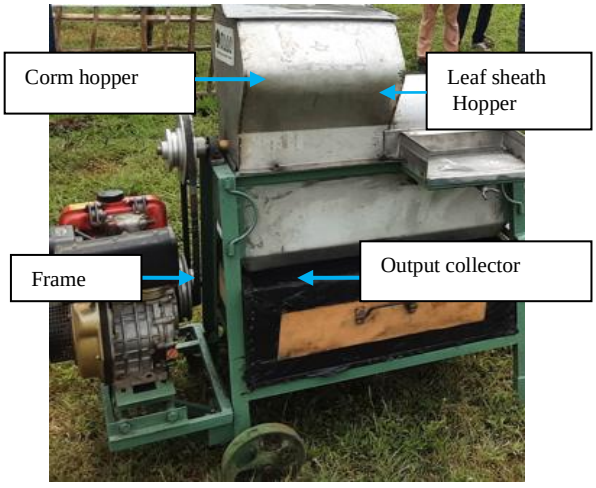

Fig. 1. Major parts of modified enset processing machine

B) Performance Evaluation

Series of tests were conducted using the machine. The hardest and best yielded variety (baladati) and the easiest variety lemate while processing were used. The experiment was conducted in a factorial RCBD with three replications. The treatments considered for this experiment was two factors, namely drum speed and variety for corm grating and drum speed and concave clearance for leaf sheath decorticating.

Evaluation was carried out on using 21kg of corm for three (5, 7 and 9kg) samples with combination of three levels drum speed (1900, 2000 and 2100rpm (Adetunji and Quadri. 2011) and four levels of drum speed 800, 900, 1000 and 1100rpm and 1 and 3mm concave clearance for leaf sheath decorticating with 10 and 5kg samples were used. The time taken for each treatment was accurately checked and recorded.

The following parameters were taken to determine the performance of the machine

The grating efficiency is given as:

$$GC = \frac{W_{tg}}{T_g}, \quad GE = \frac{W_{col}}{W_{feed}} x100\%$$

Where: GC – Grating capacity, kg/hr, W_{tg} – Total weight grate, kg, T_g – Grating time, hr, W_{col} = Weight of sample at collector, kg, and W_{feed} = Weight of sampled feed in, kg

Fuel consumption (Kg/ml) – amount of fuel consumption for sample of corm and leaf sheath was recorded by refill mechanism the hardest variety.

Decorticating efficiency and capacity was determined as follows,

$$DC = \frac{W_d}{Td},$$

$$DE = \frac{W_d}{W_d + W_{ud}}$$

Where: DC – Decorticating capacity, kg/hr, W_d–Total weight decorticated, kg, T_g – decorticating time, hr, η_d = decorticating efficiency, %, W_d = Total decorticated weight recovered, kg, and W_{un} = weight of un decorticating, kg.

C) Statistical Analysis and Interpretation

The experimental was conducted in a factorial experimental analysis of variance. Analysis was made using genstat 15th edition statistical software. Mean comparisons were carried out to estimate the differences between treatments using Fisher's least significant difference (LSD) at 5% probability level.

III. RESULT AND DISCUSSION

This study was undertaken to adapt and evaluate corm grating machine to enset processing machine. Performance of the machine was evaluated in terms of Grating capacity (Kg/hr), Grating efficiency (%) and Fuel consumption (Kg/ml), Decorticating capacity (Kg/hr) and efficiency (%).

Corm Grating capacity (Kg/hr) and Efficiency (%)

The overall grand mean grating capacity and efficiency of the prototype is 1658Kg/hr (~1.5ton/hr) and 96.64% respectively. The optimum grating capacity of 1703Kg/hr was observed when the drum was operated at velocity of 2100rpm; whereas the minimum grating capacity of 1606Kg/hr was observed when the drum speed was 2000 rpm. The optimum grating efficiency of 97.51%r was observed when the drum was operated at velocity of 2000rpm. Generally, increasing drum speed increases grating capacity and efficiency.

Table I: Effect of drum speed on Corm grating capacity (Kg/hr) and Efficiency (%)

Velocity (rpm)	Mean		Grand mean	
	Grating capacity (Kg/hr)	Grating Efficiency (%)	Grating capacity (Kg/hr)	Grating Efficiency (%)
1900	1664a	95.42a	1658	96.64
2000	1606a	97.51a		
2100	1703a	97.00a		
lsd(5%)	296.3	3.315		
cv (%)	21.2	4.1		

Leaf sheath decorticating capacity (Kg/hr)

The overall grand mean decorticating capacity of the prototype is 577.00Kg/hr. Maximum and least decorticating capacity of 782 and 431kg/hr was recorded at 3mm concave clearance and 1000rpm and 1mm and 900rpm drum speed respectively. Decorticating capacity of the prototype at 1mm concave clearance is 497.0Kh/hr. Drum speed and concave clearance has direct relationship to decorticating capacity. A similar trend was obtained by Ahmed I. Imam *et al*., 2016.

Table II: Effect of drum speed, concave clearance & combination on leaf sheath decorticating capacity (Kg/hr)

Velocity (rpm)	Concave Clearance		Velocity (rpm)	Mean	Con. Clearance	Mean	Grand mean
	1mm	3mm					
800	462a	591de	800	526ac	1mm	497a	577.0
900	431a	638bcf	900	535a			
1000	507bc	782cg	1000	645cd	3mm	657b	
1100	586d	618bch	1100	602de			
Lsd (5%)	112.8		79.7		56.4		
CV (%)	24.1						

Leaf sheath decorticating efficiency (%)

The optimum decorticating efficiency of 94.56% was observed when the drum was operated at velocity of 900rpm and 1mm concave clearance; whereas the minimum decorticating efficiency of 78.66% was observed when the drum speed was 900 rpm and 3mm. Drum speed and concave clearance have direct and indirect relationship to decorticating efficiency respectively. The overall grand mean decorticating

efficiency of the prototype is 87.05%. The decorticating capacity of the prototype at 1mm concave clearance is 90.33%.

Table III: Effect of drum speed, concave clearance & combination on leaf sheath decorticating efficiency (%)

Velocity (rpm)	Concave Clearance		Velocity (rpm)	Mean	Concave Clearance	Mean	Grand mean
	1mm	3mm					
800	87.63a	81.50de	800	84.57a	1mm	90.33a	87.05
900	94.56a	78.66bcf	900	86.61a			
1000	87.42bc	84.34cg	1000	85.88a	3mm	83.76b	
1100	91.71d	90.54bch	1100	91.12b			
lsd (5% level)	5.04		3.56		2.52		
CV (%)	7.1						

Fuel Consumption

Fuel consumption of 0.6lit/hr was recorded at drum speed of 1100 rpm and strongest variety (Baladati) as the farmers' response for leaf sheath decorticating. And 1.1lit/hr feul consumption was recorded at drum speed of 2100 rpm for corm grating machine.

IV. CONCLUSION AND RECOMMENDATIONS

Conclusion

Enset processing, in Ethiopia at present, is labour demanding and time-consuming activity which calls for technology to make it efficient and lighten the burden on women. Integrated engine operated enset processing machine was evaluated at the most enset produce farmers. Based on the results obtained, the grand mean grating and decorticating capacity of 1658Kg/hr (~1.5ton/hr) and 577Kg/hr was recorded for the prototype respectively. The optimum decorticating efficiency of 94.56% was observed when the drum was operated at velocity of 900rpm and 1mm concave clearance; Whereas the minimum decorticating efficiency of 78.66% was observed when the drum speed was 900 rpm and 3mm. Fuel consumption of 0.6lit/hr was recorded at drum speed of 1100 rpm and strongest variety (Baladati) as the farmers' response for leaf sheath decorticating. Fuel consumption 1.1lit/hr was recorded at drum speed of 2100 rpm for corm grating machine.

The machine can be used by farmers for all varieties at drum speed range of 2000 – 2100rpm for corm grating while 900 – 1100rpm and 1mm concave clearance for leaf sheath decorticating. Also it solves the quality problem compare to the traditional method. Regarding those, it can be concluded that the machine can be used and solve the enset processing problems of the farmers.

Recommendation

From obtained result the machine has a very good performance for both activities (corm grating and leaf sheath decorticating) similar to performance result mentioned above. But it can be more efficient if extra work is done on it, particularly splashing out of grated amicho through inlet and concave clearance at leaf sheath decorticating part for batter fiber quality produce.

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