Development of Banana Chipping Machine

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Abstract

The electric motor operated and manually operated banana chipping machine with feeding conveyor were evaluated as to its performance on the basis of the weight of chipped banana, thickness of desirable banana chips, chipping capacity, weight of desirable banana chips, chipping efficiency, weight of undesirable banana chips and chipping loss. The bananas were cut longitudinally and cross-sectionally to determine the performance of the machine.

The performance of electric motor operated banana chipping machine with feeding conveyor was higher than the manual operated machine regardless the cross-sectional or longitudinal chipping. The electric motor operated banana chipping with feeding conveyor has the capacity to chip 67.32 kg/hr of banana cross-sectionally and 54.11 kg/hr longitudinally while manual operated machine can only chip 46.67 kg/hr and 37.64 kg/hr respectively. 92.43% chipping efficiency and a relative efficiency of 145.78%. This gives the electric operated machine higher chipping efficiency of 87.55% cross-sectionally and 92.16 % longitudinally than manual operated machine with 87.53% and 92.14% respectively. The electric motor operated machine has lesser chipping loss with 0.75% cross-sectionally and 2.19% longitudinally than of manual operated machine with 2.67% and 7.86% respectively.

The machine has high chipping capacity and efficiency, and has lesser chipping loss which can be attributed by using electric motor operated banana chipping machine with feeding conveyor. In order to further reduce the chipping loss, it is recommended to provide a conveyor to ensure that the chipped banana will go directly to the container. Also, a hopper and a guide will be of great help in a smooth operation of the machine.

Keywords: Banana chipper, chipping capacity, chipping efficiency, electric motor operated

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Introduction

Banana is an important food in the country especially for rural households and is increasingly being recognized as a commercially traded raw material for various food and non-food industrial products. Cooked mature banana, especially that of the saba or cardaba variety, is a common starchy food with a nutritional value similar to potato. Saba banana is scientifically known as Musa paradisiaca l. It is a popular banana variety used for processed banana products such as banana chips, catsup, flour, wine, cakes, and pastries. At present, the Philippines ranked fourth as the world's largest banana producers after India, Uganda, and China. The country is also one of the main world exporters of banana chips which exports to thirty countries.

Banana chips are mainly consumed as a snack. In Mindanao, about 35% of the total cardava production is processed into banana chips and the remaining 65% are sold fresh in wet markets. There are about 26 banana chip processor-exporters in Mindanao with individual capacity ranging from 20 to 60 tons per day, but are currently underutilized either because they are not able to secure enough export orders or when they receive orders they do not have the supply of cardava bananas and could not cope with the volume requirements. The farmers and farmer-cooperators, on the other hand, adopt a production line where husbands produced quality fresh saba banana while their wives are encouraged to process them into banana chips (Philippine Processed Banana Value Chain Analysis, SCCAsia, 2006).

The traditional method of chipping banana is by the use of knife with low chipping efficiency and chipping capacity. Several banana or plantain chippers are available. However, these machines have high investment and operating costs and are often for large scales. Some machines that were developed at CapSU are that of Albaladejo's and Maceda's (2006). Those equipment had high chipping capacity of 43.65 kg/hr, chipping efficiency of 87.00%, and relative efficiency of 120.07%. It was provided with four stainless blades.

In 2009, Albaladejo and Laging modified a banana chipper that cuts banana longitudinally with three fixed stainless blades attached on the chipping plate with a chipping capacity of 51.27 kg/hr. However, it has lower chipping efficiency compared to the previous machine.

In 2018, Dela Cruz and Velado modified the Hand-Operated Household Type Saba Banana Chipper with adjustable chipping blades and cuts banana longitudinally. It has low investment cost and is easy to operate because of its simple mechanism. However, bananas are fed/pushed individually into the chipping drum during the operation. To automate the feeding banana into the chipper, a feeding mechanism was incorporated in the chipper, hence this study.

Objectives of the study

The general objective of this study was to develop an electric-motor operated banana

chipper with feeding conveyor. Specifically, this study aimed to:
1. construct a electric-motor operated banana chipper with feeding conveyor; and
2. evaluate the performance of the machine in terms of chipping capacity, chipping efficiency, and relative efficiency for cross-sectional and longitudinal chipping.
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Materials and Method

Research Design

Technical Description of the Hand-Operated Banana Chipper with Feeding Conveyor

The hand operated banana chipper with feeding conveyor is composed of four major components: feeding conveyor (1), chipping assembly (2), transmission mechanism (3), and support stand (4) as shown in Figure 1.

Feeding conveyor (1). The feeding conveyor serves as the entrance duct of the peeled banana into the chipping plate. It holds and conveys the peeled banana for chipping operation. Figure 2 shows the perspective view of the feeding conveyor. The feeding conveyor was made of food graded belt driven by stainless steel roller (1d). The lower conveyor (1a) has two guides (1c) with suitable diameter and are arranged in suitable distances. In the upper conveyor (1b), a spring was installed on the top and was connected to the support stand of the machine to allow adjustments for different sizes of banana.

Chipping assembly (2). Figure 3 shows the sectional front view of the chipping assembly. It consists of chipping plate (2a), blades (2b), drum (2c), and discharge hopper (2d). The chipping plate (2a) was designed to slice the peeled banana into longitudinal strips. It was directly installed beside the feeding hopper. It was provided with four adjustable and equally spaced stainless blades (2b). The chipping plate was made up of stainless steel plate. For manual operation, an external hand lever and stainless steel round the shaft was attached at the center of the chipping plate which was used in turning the chipping plate in order to slice the peeled banana. On the other hand, for electric motor driven machine, a belt and pulley connection driven by electric motor was attached to said stainless steel round shaft. The chipping drum (2c) was made up of stainless steel sheet and was firmly welded by stainless steel welding rod. The discharge hopper (2d) conveys the sliced banana from the chipping plate to the collecting tray. It was made of stainless sheet. It was installed directly beneath the chipping plate and was welded into the support stand.

Transmission assembly (3). Chain and sprocket were used to transmit rotation power from the handle to the conveyor for manual operation. The drive sprocket was firmly welded to the handle. A driver gear was attached at the rightmost portion of the conveyor shaft which transmits rational force by 90˚ and a gear attached at head pulley of the feeding conveyor. On the other hand, for electric driven machine, pinion gears were attached to the shaft to transmit rotational electric power to the conveyor. The mechanisms allow continuous feeding and chipping of saba banana.

Support stand (4). The support stand (4) holds the chipping plate, feeding conveyor, and discharge hopper together. It was made up of metallic material and was firmly welded to resist the vibration and to maintain stability during the operation.

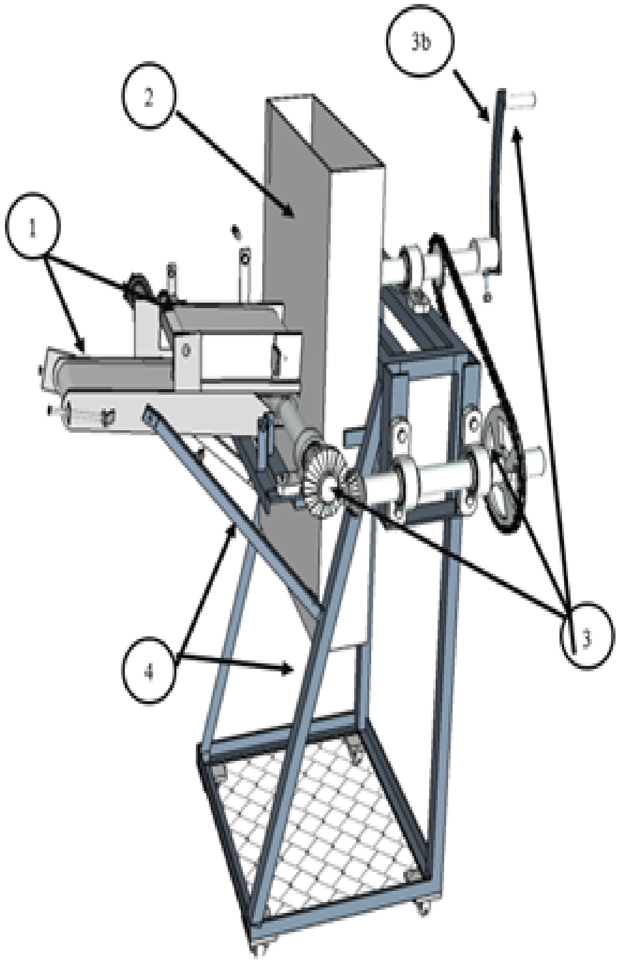


Figure 1. Isometric view of the hand-operated banana chipper with feeding conveyor. (Note: Not drawn to scale)

Legend:
1. Feeding conveyor
2. Chipping assembly
3. Transmission assembly
4. Support stand

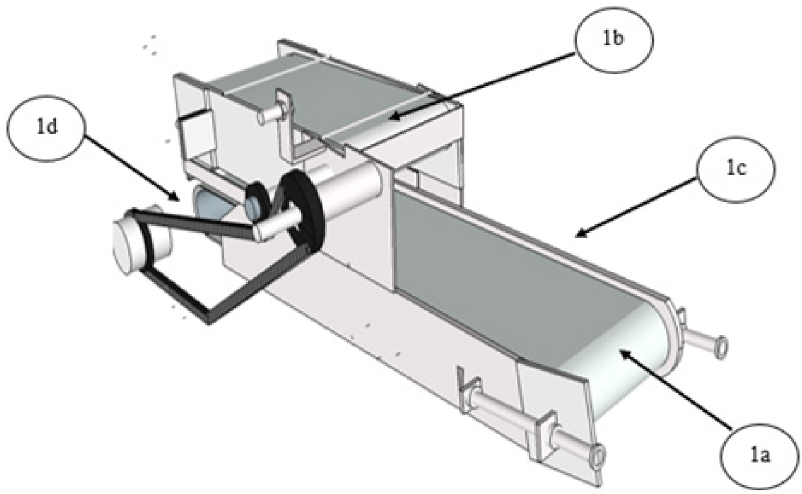
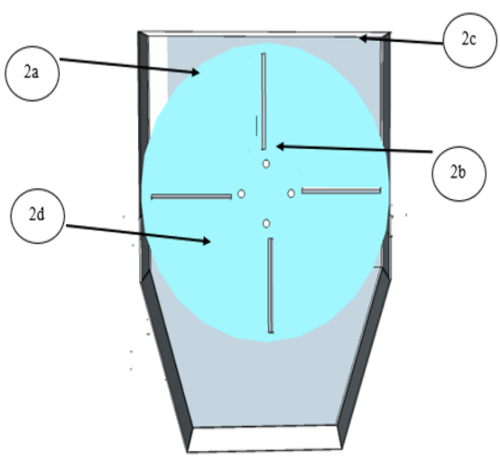


Figure 2. Perspective view of the feeding conveyor.
(Note: Not Drawn to Scale)

Legend:

1a	lower conveyor
1b	upper conveyor
1c	guide
1d	stainless steel roller



Legend:

2a	chipping plate
2b	chipping blades
2c	chipping drum
2d	discharge hopper

Figure 3. Sectional front view of the chipping assembly
(Note: Not Drawn to Scale)

Modification Aspect

The existing hand-operated banana chipper was modified by constructing a feeding conveyor to allow ease in feeding bananas for chipping and to increase efficiency by reducing the operation time. The feeding conveyor was made of food graded belt driven by pulleys and idles. Gears and sprockets were used to transmit rotational power from the hand lever to the driver pulleys of the feeding conveyor. Springs were installed at the topmost portion of the feeding conveyor to allow compression and adjustments for different sizes of bananas. The chipping assembly which is composed of the chipping plate, the chipping drum, and the discharge hopper were constructed based on the design of Dela Cruz and Velado in 2018.

Process of Banana Chipping

The following procedure was followed in banana chipping (Figure 3):

Selection. Newly harvested green and matured saba banana of uniform sizes and free from fungal diseases were selected and used as samples in this study.
Peeling. The saba samples were peeled manually using a sharp stainless knife.
Washing. The peeled banana samples were washed thoroughly with clean water.
Weighing. The peeled saba banana samples were weighed using digital weighing scale.
Chipping. The peeled banana samples were fed into the chipping drum through the feeding conveyor.
Sorting. The banana chip samples collected were measured and classified whether desirable or undesirable chips.
Weighing. Desirable and undesirable chips were identified, weighed, and recorded.
Packaging. Desirable banana chips were packed in a clean plastic and were sealed to prevent exposure to dirt and other foreign matters.

Test Preparation

Before the start of the test, the chipper underwent running-in period wherein various adjustments of the chipper were made to ensure the performance of the machine. Twenty five (25) kilograms of mature unpeeled saba banana of uniform sizes was selected and used as test materials.

Performance Evaluation

The performance of the hand-operated banana chipper with feeding conveyor was evaluated and was compared with the existing machine for 15 minutes operation for three trials in terms of chipping capacity, chipping efficiency, and relative efficiency. Twenty five (25) kilograms of unpeeled saba banana was prepared for chipping in each trial for each machine. The fifteen (15) minute duration of each test trial started during chipping operation and ended after feeding of the last batch. The technology valuation was determined considering personnel services, maintenance, and other operating expenses. The chipping performance parameters were evaluated based on PAES 223: 2004 Agricultural Machinery – Chipping Machine. The different performance parameters were calculated as follows:

Chipping capacity. The chipping capacity was obtained by dividing the total weight of the whole and peeled banana by the total time of chipping. This was obtained using the equation:

$$CC = \frac{tws}{ttc}$$

Where: CC = chipping capacity, kg/hr
tws = total weight of sliced banana, kg
ttc = total time of chipping, hour

Chipping efficiency. The efficiency of the machine in chipping saba was measured by dividing the total weight of desirable chipped banana to the total weight of the whole and peeled banana samples, multiplied by 100. This was computed using the equation:

$$CE = \frac{twds}{twsu} x100$$

Where: CE = chipping efficiency, %
twds = total weight of desirable sliced banana, kg
twsu = total weight of sample used, kg

Chipping loss. This was the ratio of the difference in the total weight of chipped banana minus the desirable weight of chipped banana to the total weight of the sliced banana, multiplied by 100. This was computed using the equation:

$$CL = \frac{tws-twds}{tws} x100$$

Where: CL = chipping loss, %
twds = total weight of desirable sliced banana, kg
tws = total weight of sliced banana, kg

Relative efficiency. To compute the relative efficiency of the banana chipper, the two machines were compared. The relative efficiency was measured in terms of each chipping capacity. Three trials were made using three different operators and the average output of each method was used in the computation of relative efficiency using the equation:

$$RE = \frac{sc}{tm} x100$$

Where: RE = percent relative efficiency, %
SC = slicing capacity of the constructed banana chipper, kg/hr
tm =slicing capacity of the traditional method of slicing banana, kg/hr

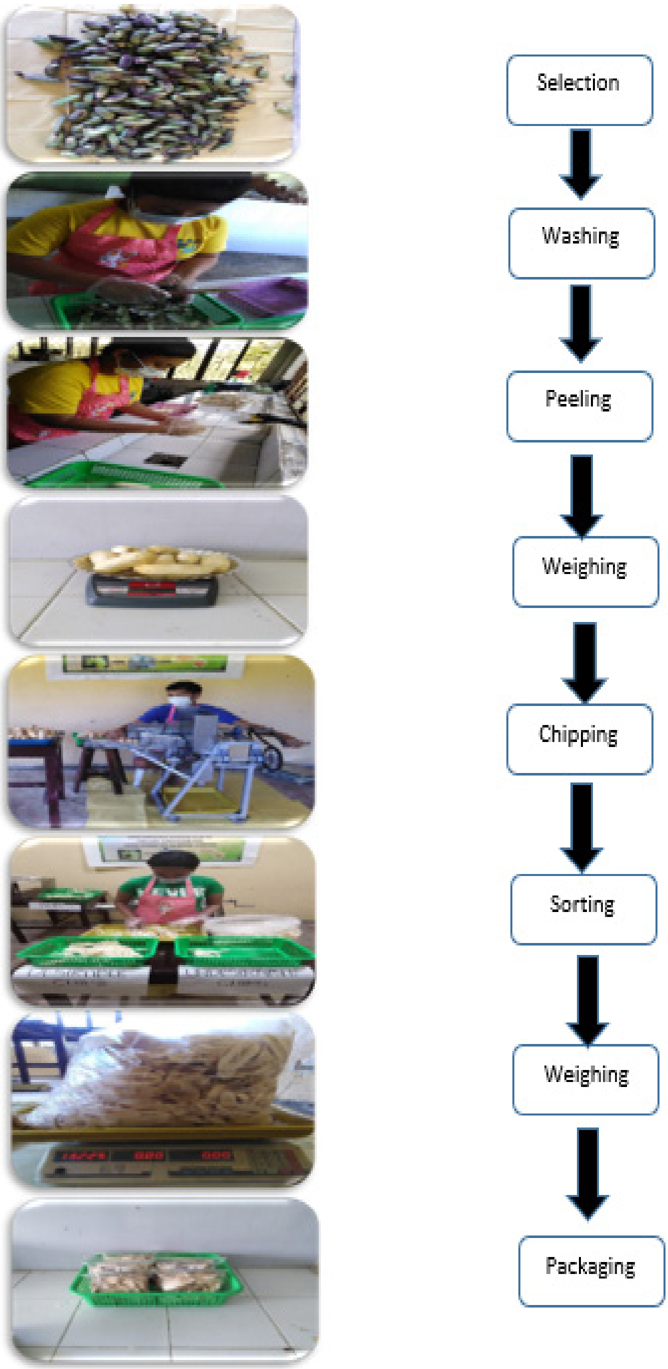


Figure 3. Process flow of banana chipping.

Results and Discussion

The EMO machine produced higher mean weight of banana chips when cut longitudinally and cross-sectionally with 13.53 kg and 16.83 kg than in MO with 9.41 kg and 11.67 kg respectively in 15 minutes of operation. In terms of the thickness of the desirable banana chips, the mean thickness of banana in MO machine is 2.1 and 2.0 in EMO machine. This is within the commercial standard size requirement for saba banana chips.

The EMO machine has the capacity to chip 67.32 kg/hr of banana cross-sectionally and 54.11 kg/hr longitudinally which is higher than the capacity of MO machine with 46.67 kg/hr and 37.64 kg/hr respectively. This gives the EMO machine higher chipping efficiency of 87.55% cross-sectionally and 92.16 % longitudinally than MO machine with 87.53% and 92.14% respectively. The high chipping capacity and efficiency can be attributed by using the electric-motor operated machine.

With mean weight of 14.84 kg cross-sectionally and 12.75 kg longitudinally, the EMO machine gives heavier weight of desirable banana chips than MO machine with 10.06 kg and 8.67 kg respectively. This implies that the weight of the desirable banana chips was increased using EMO machine. With this, the weight of undesirable banana chips produced from EMO machine of 1.49 kg cross-sectionally and 0.63 kg longitudinally is lesser than 1.75 kg and 0.74 kg of the MO machine.

The EMO machine has lesser chipping loss with 0.75% cross-sectionally and 2.19% longitudinally than of MO machine with 2.67% and 7.86% respectively. This implies that the chipping loss was significantly reduced by using EMO banana chipping machine with feeding conveyor.

Table 1. Performance of *Banana Chipping Machine with Feeding Conveyor for 15 minutes*

PARAMETERS	Manually operated		Electric motor operated	
	Longitudinal	Cross-sectional	Longitudinal	Cross-sectional
Weight of Chipped Banana, (kg)	9.41	11.67	13.53	16.83
Thickness of the Desirable Banana Chips, mm	2.1	2.1	2.00	2.00
Chipping Capacity, kg/hr	37.64	46.67	54.11	67.32
Weight of Desirable Banana Chips, kg	8.67	10.06	12.75	14.84
Chipping Efficiency, %	92.14	87.53	92.16	87.55
Weight of Undesirable Banana Chips, kg	0.74	1.75	0.63	1.49
Chipping Loss, %	7.86	2.67	2.19	0.75

Conclusions and Recommendations

The performance of electric motor operated banana chipping machine with feeding conveyor was higher than the manual operated machine regardless the cross-sectional or longitudinal chipping The machine has high chipping capacity and efficiency, and has lesser chipping loss which can be attributed by using electric motor operated banana chipping machine with feeding conveyor. In order to further reduce the chipping loss, it is recommended to provide a conveyor to ensure that the chipped banana will go directly to the container. Also, a hopper and a guide will be of great help in a smooth operation of the machine.

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