DEVELOPMENT AND PERFORMANCE EVALUATION OF COCOA POD BREAKER CUM BEAN EXTRACTOR

BY

ARUN JOSHY

GEETHU S

KRISHNENDU K M

NIKHIL C S

Department of Food and Agricultural Process Engineering

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

TAVANUR- 679573, MALAPPURAM

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ARUN JOSHY (2011-06-003)

GEETHU.S (2011-06-007)

KRISHNENDU K.M (2011-06-009)

NIKHIL C.S (2011-06-010)

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TAVANUR, MALAPPURAM - 679 573

DECLARATION

We hereby declare that this project report entitled **"Development and Performance Evaluation of Cocoa Pod Breaker Cum Bean Extractor"** is a bonafide record of project work done by us during the course of project and that the report has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title of any other University or Society.

Tavanur

Date 13.2.2015

Arun Joshy (2011-06-003)

Geethu S (2011-06-007)

Krishnendu K M (2011-06-009)

Nikhil C S (2011-06-011)

CERTIFICATE

Certified that this project report, entitled **"Development and Performance Evaluation of Cocoa Pod Breaker Cum Seed Extractor"** is a record of project work done by **Mr. Arun Joshy (2011-06-003), Ms. Geethu S (2011-06-007), Ms. Krishnendu K M (2011-06-009), Mr. Nikhil C S (2011-06-011)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship.

Er Rajesh G.K

Assistant Professor

Dept. of Food & Agricultural Process Engg.

K.C.A.E.T, Tavanur

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Arun Joshy

Geethu S

Krishnendu K M

Nikhil C S

Dedicated to our loving parents

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SYMBOLS AND ABBREVIATIONS

Dept.	Department
et al.	and others
etc.	et cetera
Fig.	figure
h	hour
ha	hectare
N	Newton
i.e.	that is
w.b.	wet basis
KAU	Kerala Agricultural University
K.C.A.E.T	Kelappaji College of Agricultural Engineering and Technology
kg	kilograms
m	meter
min	minute(s)
mm	millimeter
kWh	kilo Watt hour
MS	mild steel
MT	million tonnes
Mha	million hectares
GI	Galvanized Iron
rpm	revolutions per minute
s	second (s)
t/ha	tons per hectare
Sl. No.	Serial number
/	per
%	Per cent
viz.,	namely
wt	weight
ml	milliliter

Introduction

CHAPTER I

INTRODUCTION

Cocoa (*Theobroma cacao*) is a tropical crop and native to Amazon region of South America. It grows in tropical environment within 15-20° latitude from equator. The primary cocoa growing regions are Africa, Asia and Latin America. The global production of cocoa during 2012-13 was 4.1 MT. Cote d' Ivoire is the world's largest producer of cocoa, accounting for about 33 per cent of the global production *(www.worldcocoafoundation.com).*

Cocoa is the main raw material in the production of chocolates, cosmetics, health drinks, pharmaceuticals etc. It contains about 50 per cent fat which is useful in the production of candle, soap, ointments etc. (Opeke, 1987). Cocoa butter is also used in the production of pharmaceutical products. The beans are ground into powder for making beverages, chocolates, ice cream, soft drinks, cakes, biscuits, flavouring agents and other confectionaries. Cocoa husks can be hydrolysed to produce fermentable sugar. Cocoa cake is used as part of feed ingredients for poultry, pig, sheep, goat, cattle and fish after removing the theobromine (Adeyanju *et al*., 1975). The shell (pod) is a good source of potassium and can be used in the production of potash fertilizer, local soap, biogas and particle boards (Adeyanju *et al*., 1975; Opeke, 1987). The world demand for cocoa bean has steadily increased over recent decades as a result of increased world demand for chocolate and chocolate flavoured products. Today, cocoa trees are cultivated in more than 40 countries around the world, across an estimated area of 5 Mha, producing an annual crop more than 3.6 million tons of dried beans ready for processing (ICCO, 2012)

Cocoa is a commercial plantation crop in India. Though it has being known as a beverage crop even before tea and coffee, it is relatively a new crop in India. In our country, cocoa is mainly grown in Kerala, Karnataka, Andhra Pradesh and Tamil Nadu. The annual production of cocoa in India during 2011-2012 was 13,000 metric tonnes from an area of 46,318 ha *(www.dcd.gov.in).*

Kerala state is the largest producer of cocoa in India with an annual production of around 8,673 metric tonnes from an area of 12,759 ha *(www.wikipedia.com).* India has exported 15,962 million tonnes of cocoa products to the world worth of Rs 571 crores during the year 2013-2014 *(www.apeda.gov.in).*

At present the process of breaking cocoa pods is done manually and crudely by the use of wood and cutlass. This is an arduous task, apart from the large labour requirement and time consumed during the operation. The cutlass damages the beans, resulting to increased losses leading to reduced profit. The strenuous task causes the frequent weakness and sickness of the labour and farmer resulting in low standard of their health (Vejesit and Salohkhe, 2004). Cocoa pod breaking and bean separation are done manually and need more labour. Manual chopping could increase the number of damage beans resulting in fungal attack (Wood and Lss, 1985).

In recent years, few researches have been carried out to develop a mechanical cocoa pod breaker. The mechanical method of breaking cocoa pods will reduce fatigue for the farmers and the labours and thereby encouraging people to be engaged in farming. Also the losses usually occur during the manual breaking of the pods with wood and cutlass will be reduced which enhances profit for the farmers. The time required in breaking pods using the manual method will be reduced by mechanical method. The saved time can be used to perform another form of operation thereby increasing production. The large labour required during manual method results in high cost of production due to salary paid and problem of supervision. The mechanical method will bring about low labour requirement and reduced problem of supervision.

Considering the benefits, cocoa production and processing must be mechanized and properly improved to aid profits and reduce losses. Hence an attempt was made at Kelappaji College of Agricultural Engineering and Technology, Tavanur, to develop a cocoa pod breaker with the following objectives.

1. Determination of engineering properties of cocoa pod.
2. Development of a mechanical cocoa pod breaker.
3. Performance evaluation of cocoa pod breaker in terms of capacity and efficiency

Review of literature

CHAPTER II

REVIEW OF LITERATURE

This chapter presents a brief review of work done by earlier researchers related to the engineering properties of cocoa and its pod breaking mechanism.

2.1 Cocoa

The cocoa tree (*Theobroma cacao)*, is indigenous to South America. It is originated in the foothills of the Andes and Orinoco basins of South America. Later on, the cultivation is spread to other countries viz., Central America, Mexico, West Africa and South East Asia, where the climatic condition is ideal (Ardhana and Fleet, 2003). Chocolate was introduced to Europe by the Spaniards, and became a popular beverage by the mid-17th century. They also introduced the cacao tree into the West Indies and the Philippines. It was also introduced into the rest of Asia and West Africa by Europeans. In the Gold Coast, modern Ghana, cocoa was introduced by an African, Tetteh Quarshie. The cacao plant was first given its botanical name by Swedish natural scientist Carl Linnaeus in his original classification of the plant kingdom, who called it *Theobroma* (food of the gods) *cacao* (Anon., 2012). It thrives in tropical climates 20º north and south of the equator. Being a tropical crop, it grows very well in areas with an average rainfall of 1250-3000 mm per annum and a dry season of not more than 3 months. It requires high humidity, often 70-100% and varying soil conditions. Cocoa is more sensitive to soil moisture stress than other tropical crops but is also sensitive to water-logging. It is either cultivated by seeds or vegetative by budding or grafting. The trees are relatively small, 12-15 m in height and are often sheltered by intercropping plants such as banana. The cocoa tree starts bearing pods after two to three years (Cook, 1982; Beckett, 2008; Beckett, 2009). The fruit is fully grown after 143 days and the process of ripening starts. Maturity is attained after 170 days as indicated by the colour of the pod walls. Harvesting is done twice a year. On an average a fruit is 180-200 mm long and weighs about 400-500g.

2.1.1 Cocoa Production

Nine countries are reputed to be the world’s largest cocoa bean producers. Table 2.1 shows the production estimates for the year 2012-13.

Table 2.1 World Production of cocoa bean (thousand tonnes)

Country/ Continent	Production	Percentage
Africa	**2823**	**71.9**
Cameroon	225	
Cote d'Ivoire	1449	
Ghana	835	
Nigeria	225	
Others	89	
America	**622**	**15.8**
Brazil	185	
Ecuador	192	
Others	245	
Asia and Oceania	**484**	**12.3**
Indonesia	410	
Papua New Guinea	37	
others	37	
World total	**3929**	**100**

Source: ICCO Quarterly Bulletin of Cocoa Statistics, Vol. XL, No. 2, Cocoa year 2013/14 Published 30-05-2014

2.1.2 Varieties of Cocoa

The three large and distinct groups within the species *cacao* are *Criollo, Forastero* and *Trinitario*.

2.1.2.1 *Criollo*

It is native to Central America and considered the best flavoured cocoa. This variety has white to pale yellow cotyledon. Some types produce a jorquette, while others do not. The variety is also characterized by slender trees, green pods or pods coloured by anthocyanin pigments. Leaves are relatively smaller and more oval than the other types. The seed is cylindrical (in cross section) and plumb. It weighs around one gram and is covered with sweet mucilage. Pods are soft, easy to break, and do not have the woody layer found in other varieties. Immature pod colour ranges from pale green to red. On fermentation and drying the cotyledon colour turns light brown.It is very susceptible to most pests and diseases of cocoa.

It produces the best quality chocolate. With proper attention and care, the yield can be enhanced high as 1.0 – 1.5 t/ha. (Adewumi, 1997).

2.1.2.2 *Forastero*

Forastero is native to Venezuela and Northern Amazon Basin. It is commercially grown in Brazil, Central America, the Caribbeans and West Africa. The group is characterized by green pods, absence of anthocyanin pigmentation, thick pericarp, strongly lignified mesocarp, plump but slightly flattened purple beans. The trees are vigorous, with leaves larger than those of c*riollo*. *Forastero* is noted for its precocity, superior growth vigour, and high bean yields as well as appreciable and tolerance to West African virus strains. (Adewumi, 1997).

2.1.2.3 *Trinitario*

Trinitario is a product of hybridization between criollo and forastero has its origin in Trinidad. It show a range of characteristics possessed by both criollo and forastero. The trees are generally vigorous with a variable reaction to pests and diseases. Pods are green or pigmented. Beans colour varies from light to very dark purple. Most of the present cocoa on farmers' fields in Nigeria and indeed many parts of West Africa seem to be hybrid types. The most useful and valuable part of the crop is the bean. The highest percentages of cocoa beans produced in the developing countries are exported. The exported beans are processed abroad and the end products are imported back to the developing countries at a relatively high cost (Adewumi, 1997).

2.1.3 Propagation

Cocoa is grown from seed or propagated from upright stem cuttings possessing 2 to 5 leaves and including 1 to 2 buds. The cutting should be taken early in the morning and the leaves cut to about half their length and then dipped in a rooting hormone and placed in a small container filled with moist, clean, well-draining, soil media. The cutting should then be covered with a polyethylene bag and placed in a warm but shaded area. The soil should be kept moist but not overly wet. Rooting should take place in about 4 weeks, during which time the bag may be slowly opened. Once the plant is fully rooted and growing, it may be moved repeatedly to increasing light levels. Cocoa may also be propagated by marcottage (air-layering) and budding and grafting (Jonathan *et al.*, 2012).

2.1.4 Structure and biochemical composition of cocoa pod and bean

Cocoa bean is generally termed as protein rich, because it contains 11% protein, which is high when compared to other bean. Also the fat content is so high, which leads the production of rich cocoa butter and such fat rich products. The cocoa beans, which are embedded in a mucilaginous pulp inside the pods have two important parts namely seed coat or testa and the kernel or cotyledon. Seed cotyledon is the material in which characteristic flavour and aroma are produced during processing of the fruits while testa constitutes 10-14% of seed weight and has little utility value. Cotyledon accounting for 86-90 per cent of the seed is processed into a variety of products. The chemical composition of cocoa bean is shown in Table 2.2.

Table 2.2 Bio- chemical composition of cocoa bean (Rohan,1963)

Composition	% of beans On dry wt.basis	Constituent	% of beans on dry wt.basis
Cotyledon	89.63	Glucose	0.30
Shell	9.69	Starch	6.10
Germ	0.77	Pectins	2.25
Total fat	55.05	Fibre	2.09
Water	3.65	Cellulose	1.92
Ash	2.63	Pentosans	1.27
Total nitrogen	2.28	Mucilage gum	0.38
Protein nitrogen	1.50	Tannins	7.54

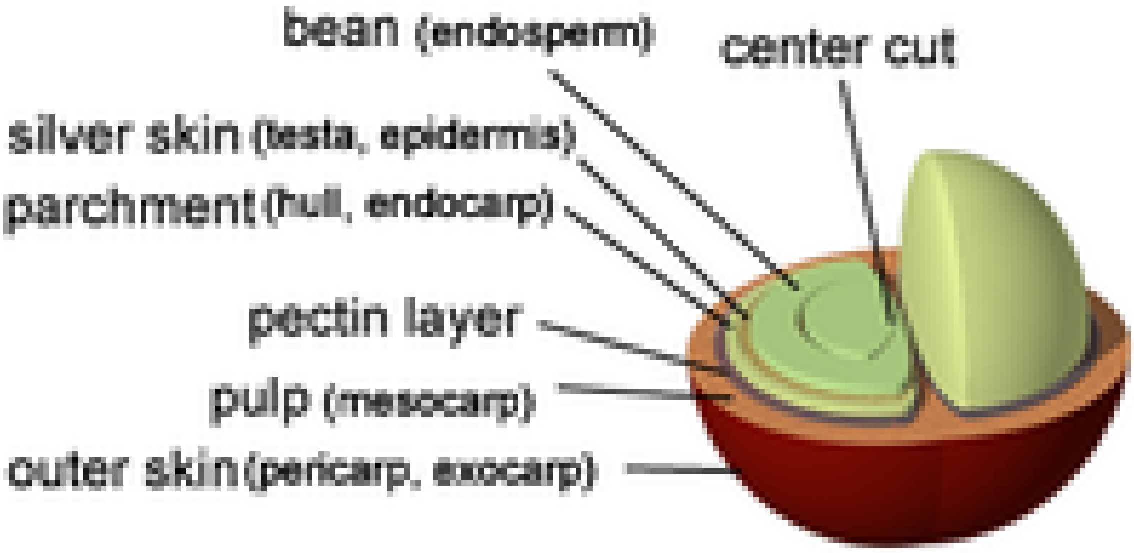

Plate 2.1: structure of cocoa pod (Adzimah, S.K *et.al*)

2.1.5 Harvesting

First step in the processing of cocoa beans is harvesting of the pods. Ripe pods are easy to identify by the colour of pods. Forestero turns from green to yellow when ripe. The ripening process is slow, and a mature pod will remain suitable for harvesting for two or three weeks. Unripe pods will not undergo fermentation, and over ripe pods often become dry (Barclays Bank, 1970*)*.

2.2 Engineering Properties

The knowledge of physical, thermal and mechanical properties of biological materials play an important role in the design of farm equipments (Mohsenin, 1986).

2.2.1 Physical properties

Physical properties viz., length, width, volume, density, surface area, weight etc are important for the design of new equipments or determining the behavior of a product. (Sahay and Singh, 1994).

2.2.1.1 *Size*

Aviara *et al.* (2007) reported that for designing and developing the extraction mechanisms physical properties such as major and minor semi-axial dimensions, thickness of the epicarp and mesocarp, fruit volume and mass, pod, pulp and seed masses, pod-fruit, pulp-fruit and seed-fruit mass ratios and true and bulk densities of fruits are important.

Adewumi *et al*.(2006) investigated the physical properties of F_3 Amazon fresh cocoa pods. The mean diameter and length of cocoa pod were 7.83 and 16.04 cm, respectively (Table 2.3).

Table 2.3 Size of whole pod of cocoa (Adewumi, B *et.al)*

Parameter	Pod maximum Diameter (cm)	Pod Length (cm)
Frequency	50	50
Range (cm)	6.16-9.60	11.25-20.20
Mean (cm)	7.83	16.04
Standard Deviation	1.07	2.40

2.2.1.2 *Mass and volume*

The average bulk density and mass density of F_3 Amazon cocoa pod was 456 kg/m^3 and 793 kg/m^3, respectively(Bamgboye and Ojoh, 2004).

Adewumi *et al*.(2006) analysed the whole cocoa pod to find the percentage weight of various components of three varieties viz., Amezonia, Amelondo and hybrids. It was found that, the pods of hybrid variety weighed more than Amezonia and Amelondo. However, the husk of hybrid variey weighs lesser than other two varieties (Table 2.4).

Table 2.4 Percentage weight of various components of wet Cocoa Pods (Adewumi, B *et.al)*

Variety of cocoa	Mass(kg)	Components of wet cocoa pod (%)		
	Pod	Husk	Bean	Placenta
Amezonia	0.4	70.00	27.00	3.00
Amelonado	0.37	74.51	24.93	.56
Hybrid	0.48	66.30	21.3	3.12

2.2.2 Mechanical properties

The breaking of pods is a size reduction process, which aims at extracting the beans from the pod. The forces involved in breaking the cocoa pods could be compressive, impact or shearing forces depending on the type of machine and process (Andu *et al.,* 2004; Adewumi *et al.,* 2006).

Maduako and Faborode (1994) reported that the maximum shear force required to rupture a fresh pod husk ranged from 570 to 860 N and the corresponding shear strength varied from 242 to 357 kN/m^2 at 95 per cent confidence level for all four varieties of cocoa and the pooled data gave a correlation coefficient of 0.274 and 0.208, respectively for maximum shear load and shear strength versus husk thickness. They concluded that the shear properties correlated poorly with husk thickness.

Aviara *et al*. (2007) reported that impact strength, bio-yield and rupture points and compressive and rupture strengths, as well as the modulus of stiffness and modulus of elasticity of the cocoa fruits were higher at the longitudinal loading orientation than at the lateral.

2.3 Equipment for cocoa pod breaking

The breaking of pods is a size reduction process, which aims at extracting the beans from the pod. The forces involved in breaking the cocoa pods could be compressive, impact or shearing forces depending on the type of machine and process (Audu *et al., 2004;* Vejesit and Salohkhe,2004; Adewumi *et al., 2006).*

At present, the process of breaking cocoa pods is largely done manually using wood and cutlass. This is an arduous task, apart from the large labour requirement and time consumed during the operation and the damage on the beans. The manual processes and some machines that have been developed have been found to cause damages to the beans, making some of them unsuitable for fermentation, thereby resulting in losses (Bamgboye, *2003).* The man-hours required for this manual operation vary and depend on crop factors such as variety and workers attitude and supervision (Opeke, 1987*).*

In Nigeria, the first cocoa pod breaker was constructed at the *Cocoa Research Institute of Nigeria (CRIN)* as reported in Jabagun (1965). Mechanical cocoa pod breaker was designed and built by Messrs Christy and Norris Limited of England, was tested at Cadbury Brothers Cocoa plantation at Ikiliwindi, Cameroon (Are and Gwynee-Jove, 1974).Two people are required to operate the machine; one feeds the cocoa pods into the machine while the other collects the beans. It breaks the pods by means of a revolving ribbed wooden cone mounted vertically inside a ribbed cylindrical metal drum. The pods fed into the hopper move into the shelling section by gravity. The beans pass through the meshes into a collecting wooden box, while the shell fragments drop out at the open end of the rotary sieve (Fig 2.2)

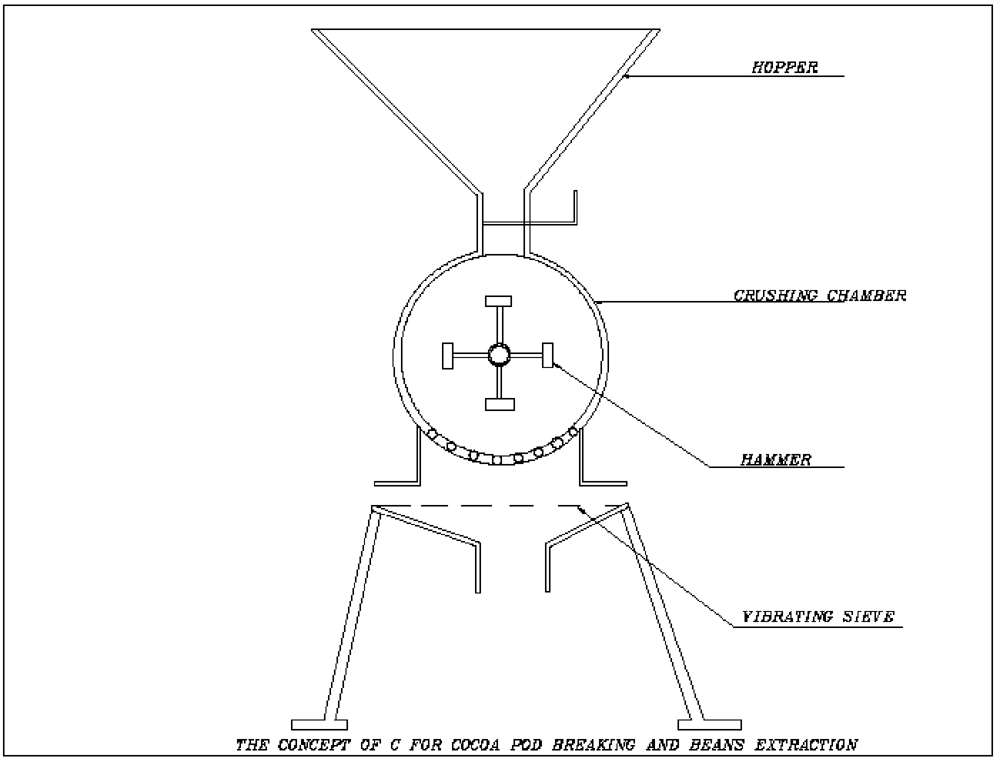

Plate 2.2 Machine designed and built by Messrs Christy and Norris Limited of England (1974*)*

Zinke machine consists of several rotary jaws or toothed rollers for cocoa bean extraction (Faborode and Oladosun, 1991). This machine has the problem of crushing the husks further into tiny portions, which mix with the wet beans and this poses a problem during separation.

In 1991, Faborode and Oladosun designed, fabricated and tested machine to break Cocoa pod and extract the wet beans. It consists of a hopper, metering plates, hammer and reciprocating sieve. The hammer breaks the pods while the vibrating sieve separates the husk. The beans are then collected through the discharge tube (Fig 2.3).

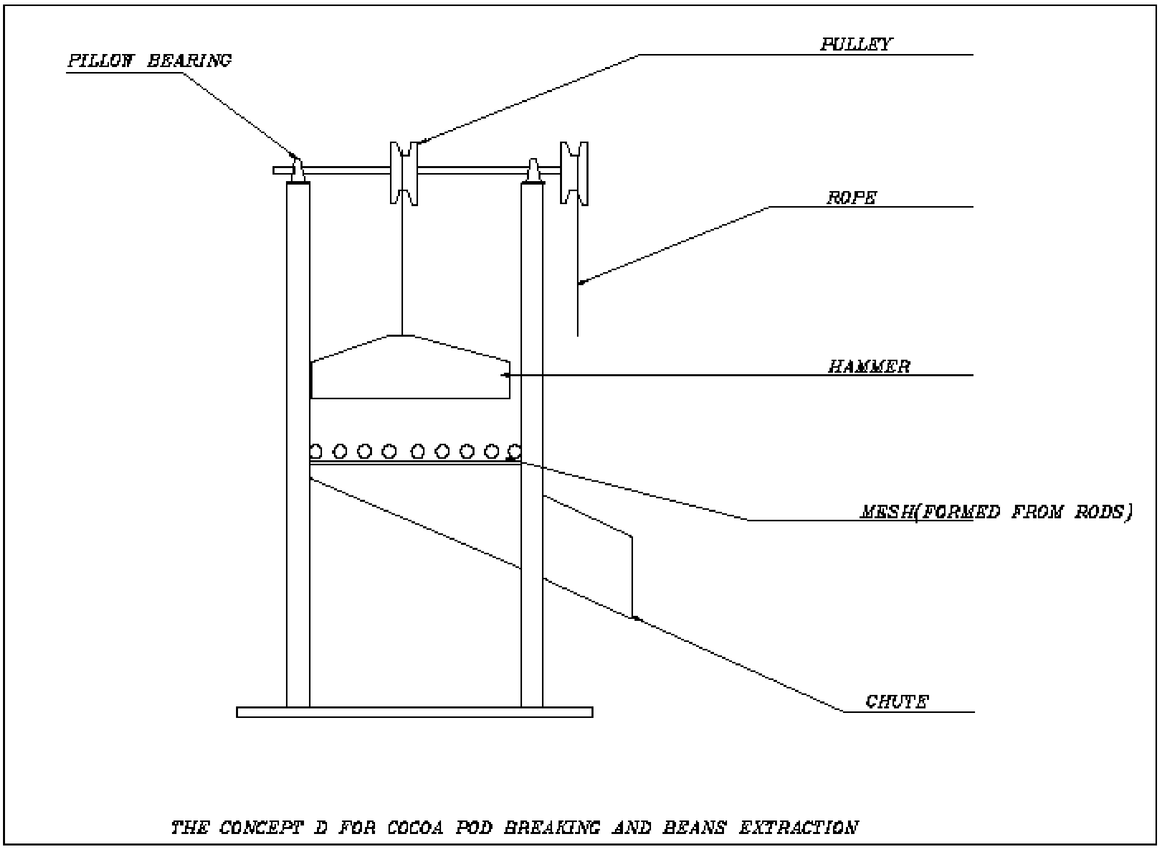

Plate. 2.3 Cocoa pod breaker and bean extraction machine (Faborode and Oladosun, 1991)

Adewumi and Fatusin (2006) designed, fabricated and tested a manually operated machine for breaking cocoa pods and extracting the beans. This machine consists of the frame, the hammer, shafts, rope, bearings, pulleys, rail, catch tray or collector and covers. The frame holds the other major components in position. In this machine, the hammer is dropped several times until the pod breaks (at heights 22 to 68 cm) using 1 to 5 whole pods.

Materials and Methods

CHAPTER 3

MATERIALS AND METHODS

This chapter describes the various engineering properties required to develop cocoa pod breaker. It also include the methodology for fabrication and evaluation procedure for cocoa pod breaker

3.1 Raw material procurement

Matured cocoa fruit were procured from the Cadbury unit of Kerala Agricultural University. Materials for the construction of machine were purchased from M/s Royal hardware and mill stores, Coimbatore. Good quality cocoa pods of medium size were sorted out from cracked ones and were used in this study.

Plate 3.1 Cocoa fruit

3.2 Study of Existing Method for Cocoa Pod Breaking

Prior to the development of cocoa pod breaker a survey was conducted in Malappuram and adjacent districts namely, Wayanad and Palakkad to study the existing method used for the breaking of cocoa pods.

3.3 Determination of Engineering Properties of Cocoa Pod

Prior to the design and development of cocoa pod breaker, the physical, mechanical and frictional properties of cocoa pod were studied. Matured cocoa pods, having a moisture content of around 70 per cent were graded based on their size were used for determination of properties. The engineering properties of cocoa pod viz., size, shape, volume, density, angle of repose and compressive force were determined based on the standard methods as explained in the following section.

3.3.1 Physical properties

3.3.1.1 Determination of moisture content

Moisture content was determined as per *AOAC method (1984).* About 5 to 10 g of cocoa husk (whole pod in case of pod moisture content) was weighed accurately and dried in a hot air oven at 105°C. The sample was dried to constant weight which took about 20 hours. The moisture content was expressed as percentage.

$$\text{Moisture content (\% w.b)} = \frac{Initial\ weight - final\ weight}{Initial\ weight} \times 100 \qquad \text{.... (3.1)}$$

3.3.1.2 Determination of cocoa pod size

From the samples, 10 numbers of cocoa pod were selected at random for the determination of pod size. The length of the pod was measured along its longitudinal axis and diameter was measured along its lateral axis. The geometric mean diameter of the pod was calculated using the formula suggested by Sharifi *et al.* (2007).

$$D_{gm} = (ab^2)^{1/3} \qquad \text{.... (3.2)}$$

3.3.1.3 Determination of cocoa mass

Mass of individual pod and seed were determined by selecting 10 numbers of samples at random using an electronic balance and the mean value was taken.

3.3.1.4 Determination of volume

Volume of cocoa pod was determined by platform scale method (Mohsenin, 1986). The cocoa pod was completely immersed in water using a sinker rod without touching the sides or bottom of the beaker by the pods. Volume was measured as the ratio of the displaced water by the sample to the density of water

$$\text{Volume } (m^3) = \frac{Weight\ of\ water\ displaced\ (kg)}{Density\ of\ water(\frac{kg}{m3})} \qquad \text{...3.1}$$

3.3.1.5 Determination of bulk density

An empty carton box of pre-determined volume was filled with cocoa pods and the bulk weight was measured. The bulk density (ρ_b) was calculated by using the equation given below. The experiment was replicated ten times and the mean value was recorded.

$$\text{Density (kg/m}^3\text{)} = \frac{Weight\ of\ cocoa\ (kg)}{Volume\ of\ cocoa\ (m3)} \quad \ldots 3.2$$

3.3.2 Mechanical Properties

3.3.2.1 Compression Test

Rupture test helps in determining the force required to break the cocoa pod. The rupture force was measured using Universal Testing Machine as shown in plate 3.2.

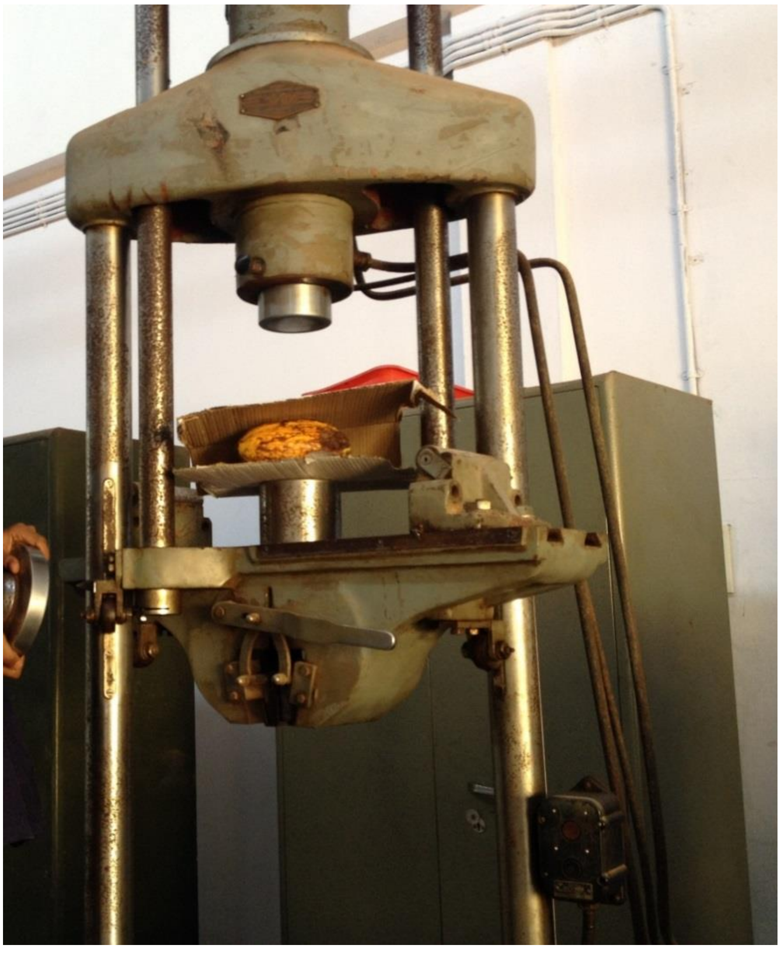

Plate 3.2 Universal Testing Machine

Ten cocoa pods were randomly selected from each grade were compressed longitudinally by using the UTM. The pods were aligned to the compression unit of UTM in such a way that no bending stress was created. The load cell and compression rate of the machine was set at 50 kg and 5 mm/min, respectively. Each pod was compressed between the parallel plates and the deformation force was noted.

3.3.3 Frictional Properties

3.3.3.1 Determination of coefficient of friction

Coefficient of friction may be defined as the frictional forces acting between surfaces of contact and sample at rest. The apparatus used for the determination of co-efficient of friction of cocoa pod consisted of a frictionless pulley fitted on frame, a bottomless rectangular, a loading pan, and test surface. Tied one end of the cocoa using a thread and placed on the test surface and weight were added on loading pan until the cocoa pod began to slide. The weight of the pod and the weights added on the pan represent the normal force (N) and lateral force (F), respectively (Sahay and Singh, 2010). The co-efficient of static friction was calculated as given below.

.

$$\text{Coefficient of friction } (\mu) = \tan^{-1}\left(\frac{F}{N}\right) \qquad \ldots 3.3$$

Where,

F - Frictional force, kg

N - Normal force, kg

μ - coefficient of friction

3.3.3.2 Determination of Angle of repose

The angle of repose was determined by filling method. Cocoa pods were filled in a box and lifting up the box gradually, allowing the samples to form a heap on the surface. Angle of repose was measured using the formula given below. The experiment was repeated 10 times and the mean value was noted.

$$\Theta = \tan^{-1}(H/r) \qquad \ldots 3.4$$

Where,

H- height of the heap, cm

r- radius of the heap, cm

3.4 Development of Cocoa Pod Breaker cum bean extractor

Cocoa pod breaker cum bean extractor was developed and fabricated in the Kelappaji College of Agricultural engineering and Technology, Tavanur workshop. It consists of hopper, metallic rollers, chute, rotating cylindrical strainers, frame, prime mover and pulley

3.4.1 Cocoa pod breaker

3.4.1.1 Hopper

It is the one of the main component of the machine. It helps to feed the cocoa to the roller assembly. The dimension of the hopper was optimized based on the length and diameter of the cocoa pod. The hopper was made of 14 SWG thick mild steel sheet with 45^0 inclination towards the horizontal to facilitate easy feeding. It was rectangular in shape and was mounted over the roller assembly. Top dimension of hopper was 28 cm × 10 cm.

Plate 3.3 Feed hopper

3.4.1.2 Rollers

Two corrugated mild steel rollers of dimension 30 cm length and 8cm diameter were used for breaking of cocoa pods. The rollers were rotating in opposite direction at a speed of 390 rpm.

One of the rollers was fixed while other was adjustable to obtain desired clearance between the rollers based on the size of the cocoa bean

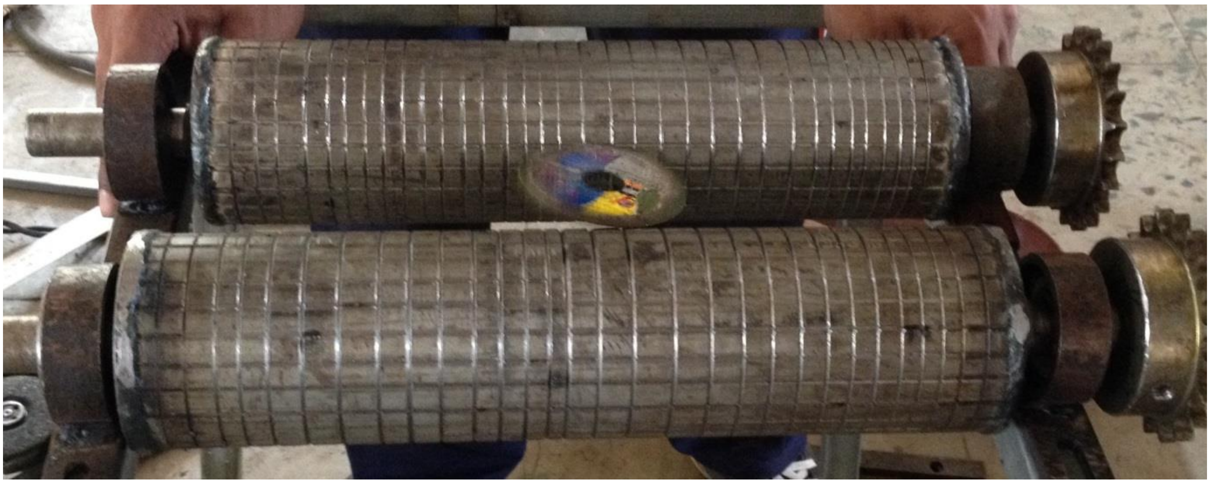

Plate 3.4 Rollers

3.4.1.3 Discharge Chute

Chute is made up of 2mm MS sheet with 30^0 inclinations towards horizontal to facilitate easy discharge. The broken pod slides downward through the chute into the strainer

3.4.1.4 Frame

The frame supports the entire machine component to perform. It was fabricated using GI square section. The units' viz., feeding unit, roller, chute, motor etc. were mounted on frame. Main frame was mounted with transportation provision and bear static and dynamic loads during operation and transportation.

3.4.1.5 Motor specification

1 hp motor at a speed of 1420 rpm was used as prime mover for operation. The speed was reduced to 350 rpm by employing belt and pulley arrangement. The diameter of drive and driven pulley used in this study were 2 inch and 8 inch, respectively. V belt of 42 inch was used for power transmission.

3.4.2 Bean extracting mechanism

3.4.2.1 Cylindrical drum strainers

Cylindrical drum strainer was fabricated to separate bean from broken pod. It composed of square mesh of 25 mm x 25 mm. The diameter and length of strainer was 30cm and 36 cm respectively.

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Plate 3.5 Strainer

3.4.3 Operation of cocoa pod breaker cum bean extractor

Cocoa fruit was fed manually in to breaker unit through hopper. Gap between the rollers was set so as the cocoa kernels were not damage during the pod breaking process. Tangential force of the roller pushed the cocoa pod towards the gap resulted in breakage. Cocoa pod, kernels and placenta then discharged to strainer through chute. Rotation of strainer separated the cocoa kernels from cocoa pod and placenta, and passed through the pores of the strainer. It was then collected and could be directly send for fermentation process. The broken pods were remained above the strainer and got separated.

Plate 3.6 Cocoa pod breaker cum bean extractor

3.5 Performance Evaluation of the Machine

Matured cocoa beans procured from Cadbury unit of Kerala Agricultural University were used for conducting the experiment. The gap between the rollers of the machine was adjusted according to medium size cocoa pods. Testing was done at roller speed of 350 rpm. Performance of the machine was evaluated in terms of capacity, percent bean damage, percent bean recovery and machine efficiency. (Adewumi and Fatusin, 2006)

3.5.1. Capacity

3.5.1.1 Capacity of breaking unit

Capacity is defined as the ratio of total weight of cocoa taken for breaking to the total time taken for breaking. It is expressed in kilogram per hour

$$\text{Capacity} = \frac{Wp}{t} \qquad \ldots 3.5$$

where,

W_p = mass of the cocoa pod fed in to the machine (kg)

T =Time taken for breaking (h)

The cocoa of different size were weighed separately and the total time taken for extraction was recorded

3.5.1.2 Capacity of extracting unit

The capacity is the ratio total weight of the broken cocoa pod in the strainer and the time taken for the bean extraction.

$$\text{Capacity} = \frac{Wb}{t} \qquad \ldots 3.6$$

Where,

W_b = mass of the cocoa bean extracted (kg)

T =Time taken for bean extraction (h)

3.5.2. Percent bean damage

Percent bean damage was calculated as the ratio of number of damaged beans to the total number of beans.

Per cent bean damage, B = $\frac{Nd}{N}$ …3.7

Where,

N_d = number of damaged beans

N = total number of beans

3.5.3 Percent bean recovery

Per cent bean recovery was calculated as the ratio of amount of beans extracted to the total number of beans.

Per cent bean recovery = $\frac{Be}{Be+Bw}$ ...3.8

Where,

B_e = Amount of beans extracted

B_w = Amount of beans collected from husk waste

3.5.4 Machine efficiency

Machine efficiency was calculated as the ratio of number of pods broken to the number of pods fed into the machine.

η = $\frac{Nb}{N}$ …3.9

Where,

N_b = number of damaged beans

N = total number of beans.

Results and Discussion

CHAPTER 4

RESULTS AND DISCUSSION

This chapter deals with the results of the experiment carried out to evaluate the performance of cocoa pod breaker cum bean extractor.

4.1 Study of Existing Method for Cocoa Pod Breaking

From the survey conducted in three districts of Kerala, it was found that, no mechanical cocoa pod breaker had been developed so far. Cocoa pod breaking and bean separation were still done manually using wood and sickle.

4.2 Engineering properties

The result of physical, mechanical and frictional properties of cocoa pod are presented and described in the following section.

4.2.1 Physical properties

The physical properties of coca pod viz., moisture content, length, diameter, volume, mass, bulk density and sphericity were investigated to facilitate the development of cocoa pod breaker

4.2.1.1 Moisture content of cocoa pod and beans

The average moisture content of fresh coca pod and bean are tabulated in table 4.2. The average moisture content of cocoa pod and bean was 81.45 and 40.24 per cent (wb) respectively. Similar results were reported by Nyadanu *et al.*(2011).

Table 4.1 Moisture content of cocoa pod and bean

Sl.no	**particulars**	**Moisture content (% wb)**
1	Cocoa pod	81.45
2	Cocoa bean	40.24

4.2.1.2 Determination of cocoa pod size

The cocoa pods were sorted in to three sizes small, medium, large and the physical properties viz., length and diameter of cocoa pod were measured and are shown in Table 4.3. The average length of small, medium and large was measured as 126.6, 157.4 and 177.3 mm, respectively. Similarly, the geometric mean diameters of the pods were 74.2, 85.1 and 97.6 mm, respectively. Adewumi *et al.* (2006) investigated the physical properties of three varieties of cocoa viz., *Criollo*, *Forastero* and *Trinitario*. It was reported that the average length and diameter of three varieties of cocoa were 112.5, 166, 202 mm and 61.6, 72 and 96 mm.

Table 4.2 Size distribution of cocoa pod

Parameter	Pod diameter, D_{gm} (cm)			Pod length (cm)		
	Small	Medium	Large	Small	Medium	Large
Frequency	5	5	5	5	5	5
Minimum	7.2	8.3	9.7	12.3	14.9	17
Maximum	8.1	8.8	10.4	13.7	16.7	19.5
Mean	7.42	8.5	9.76	12.66	15.74	17.73

4.2.1.3 Mass of Pod

The average mass of cocoa pod is presented in Table 4.3. From the table, it is observed that the mass of pod varied from 200, 350 and 542 g, respectively for small, medium and large size cocoa pods.

Table 4.3 Weight of the cocoa sample

sample	Weight(g)		
	Small	Medium	Large
1	200	320	320
2	180	270	270
3	180	280	280
4	180	310	310
5	180	310	310
6	240	330	330
7	190	330	330
8	230	330	330
9	250	320	320
10	170	350	350
Mean	200	315	542

Adzimah and Asiam (2010) studied the physical properties of three cocoa varieties viz., *Criollo*, *Forastero* and *Trinitario*. They reported that weight of pod increased with increase in pod size. The average weights of cocoa pods were 400, 370 and 480 g, respectively for *Criollo*, *Forastero* and *Trinitario*.

The average bulk density of small, medium and large cocoa pods was 653.2, 618.7 and 698.7 kg/m^3 respectively. Similarly, the corresponding volumes of cocoa pods were 308, 511 and 776 cm^3, respectively. Similar results were observed in case of *Criollo* variety of cocoa (Adewumi *et.al.,* 2006).

Table 4.5 Bulk density and volume of cocoa pods

Sample	Bulk density (kg/m^3)			Volume (m^3)		
	Small	Medium	Large	Small	Medium	Large
1	625	561.40	681.8	3.2×10^{-4}	5.7×10^{-4}	8.8×10^{-4}
2	642.86	562.5	618.56	2.8×10^{-4}	4.8×10^{-4}	9.7×10^{-4}
3	782.61	583.33	610.39	2.3×10^{-4}	4.8×10^{-4}	7.7×10^{-4}
4	562.5	584.91	777.78	3.2×10^{-4}	5.3×10^{-4}	6.3×10^{-4}
5	514.28	596.15	652.78	3.5×10^{-4}	5.2×10^{-4}	7.2×10^{-4}
6	685.714	634.61	781.25	3.5×10^{-4}	5.2×10^{-4}	6.4×10^{-4}
7	678.57	600	620.25	2.8×10^{-4}	5.5x10-4	7.4×10^{-4}
8	718.75	687.5	774.65	3.2×10^{-4}	4.8×10^{-4}	7.1×10^{-4}
9	735.29	615.38	722.89	3.4×10^{-4}	5.2×10^{-4}	8.3×10^{-4}
10	586.21	760.87	747.13	2.9×10^{-4}	4.6×10^{-4}	8.7×10^{-4}
Mean	653.1784	618.665	698.748	3.08×10^{-4}	5.11x10-4	7.76×10^{-4}

4.2.2 Mechanical and Frictional Properties

The results of mechanical and frictional properties are shown in table 4.7. The compression load of cocoa pod increased with increase in pod size. The average compression load for small, medium and large was 6.1, 6.6 and 7.5 kg force, respectively. Similarly, the average coefficient of friction and angle of repose were0.23, 0.35, 0.31 and 18.7, 17.4, 14.5°, respectively for small, medium and large size cocoa pods..

Table 4.6 Mechanical and frictional properties of cocoa pod

Properties	Small	Medium	Large
Compression test (kg)	6.1	6.6	7.5
Coefficient of friction (Mild steel sheet)	.23	.35	.31
Angle of repose (^{0})	18.7	17.4	14.5

4.3 Performance evaluation of the developed Cocoa Pod Breaker

The performance of equipment is the basic criteria to evaluate its ability. The performance of the developed cocoa pod breaker cum bean extractor was evaluated based on its capacity, percentage bean damage, and percentage bean recovery and machine efficiency.

4.3.1 Time taken for cocoa pod breaking and bean separation

The results of average time taken for breaking 5medium size pods of cocoa using manual and mechanical methods are presented in Table 4.7. It is observed that the average time required for breaking 5 cocoa pods using pod breaker was 20 s where as in manual method was 30 sec. Similarly the time required to separate the bean was around 31 s for cocoa pod breaker against 55s for manual method. Results showed that the total time required to break the pod and bean extraction is relatively low form mechanical method than manual method.

Table 4.7 Performance of manual and mechanical pod breaker

Sl no.	Method	No. of pods	Time taken (sec)	
			Pod breaker	Bean separator

1	Manual	5	30	55
2	Mechanical	5	20	31

4.3.2 Performance of developed cocoa pod breaker cum bean extractor

The overall capacity of the developed machine and manual method was found to be 327.6 and 216 kg/hr. Similarly the bean damage per cent, bean recovery per cent and overall efficiency of the machine was estimated as 0.4, 75.6 and 87.4 per cent, respectively. The bean damage recorded during testing was less than 1 per cent, which enhanced the product quality.

Table 4.8 Performance evaluation of pod breaker cum bean extractor.

Sl No.	Bean damage %	Bean recovery %	Overall efficiency %
1.	0	76	88
2.	0	80	90
3.	1	74	86.5
4.	0	73	86.5
5.	1	75	87
Total	0.4	75.6	87.4

Summary and Conclusions

CHAPTER 5

SUMMARY AND CONCLUSIONS

Cocoa (*Theobroma cacao*) is a tropical crop and native to Amazon region of South America. It grows in tropical environment within 15-20° latitude from equator. The primary cocoa growing regions are Africa, Asia and Latin America.*(www.worldcocoafoundation.com).* The global production of cocoa during 2012-13 was 4.1 MT. In India, cocoa is mainly grown in Kerala, Karnataka, Andhra Pradesh and Tamil Nadu. Kerala state is the largest producer of cocoa in India with an annual production of around 8,673 metric tonnes from an area of 12,759 ha . India has exported 15,962 million tonnes of cocoa products to the world worth of Rs 571 crores during the year 2013-2014*(www.apeda.gov.in).* Cocoa is the main raw material in the production of chocolates, cosmetics, health drinks, pharmaceuticals etc. It contains about 50 per cent fat which is useful in the production of candle, soap, ointments etc. (Opeke, 1987). Cocoa butter is also used in the production of pharmaceutical products. The beans are ground into powder for making beverages, chocolates, ice cream, soft drinks, cakes, biscuits, flavoring agents and other confectionaries. Cocoa husks can be hydrolyzed to produce fermentable sugar. Cocoa cake is used as part of feed ingredients for poultry, pig, sheep, goat, cattle and fish after removing the theobromine.

At present the process of breaking cocoa pods is done manually and crudely by the use of wood and cutlass. This is a strenuous task, apart from the large labour requirement and time consumed during the operation. The cutlass damages the beans, resulting to increased losses leading to reduced profit. Hence, cocoa production and processing must be mechanized and properly improved to aid profits and reduce losses. Hence an attempt was made to develop a cocoa pod breaker.

Before the fabrication of machine, the engineering properties of cocoa viz., physical, mechanical and frictional properties of fresh cocoa pod were determined. Physical properties studied were size, shape, mass and density. The mechanical and frictional properties viz., compression test, angle of repose and co-efficient of friction were determined as per the standard procedures.

The cocoa pods were sorted in to three sizes small, medium, large and the physical, mechanical and frictional properties of cocoa pod were measured. The average moisture content of cocoa pod and bean was 81.45 and 40.24 per cent (wb) respectively. The average length of small, medium and large was estimated at 126.6, 157.4 and 177.3 mm, respectively. Similarly, the corresponding geometric mean diameters of the pods were 74.2, 85.1 and 97.6 mm, respectively. The mass values were 200, 350 and 542 g, respectively for small, medium and large size cocoa pods. The average volume of small, medium and large cocoa pods were 308, 511 and 776 cm^3, respectively. Similarly, the corresponding densities were 653.2, 618.7 and 698.7 kg/m^3 respectively. The average compression load for small, medium and large was 6.1, 6.6 and 7.5 kg force, respectively. Similarly, the average coefficient of friction and angle of repose were 0.23, 0.35, 0.31 and 18.7, 17.4, 14.5°, respectively for small, medium and large size cocoa pods.

The developed cocoa pod breaker cum bean extractor had two main parts- 1) Cocoa pod breaker and 2) Cocoa bean extractor. Cocoa pod breaker consists of two rollers in which each roller was reverse rotated. The gap between the rollers was set based on the size of the cocoa pods fed. Bean extractor consists of a rotational strainer which helps to separate beans from the broken cocoa pod. Gap between the rollers was adjusted so that the pod should break properly, whereas no damage occurred to cocoa kernels during the process. Cocoa fruit was fed manually in to pod breaker unit through hopper. The tangential force of the roller pushed the cocoa pod towards the gap resulted in breakage. Broken cocoa pod, kernels and placenta then discharged to the strainer through chute. Strainer separated the cocoa kernels from cocoa pod and discharged through strainer outlet. The broken pods were remained above the strainer.

Performance of the machine was evaluated in terms of capacity, percent bean damage, and percent bean recovery and machine efficiency. The average time required to break 5 cocoa pods using pod breaker was 20 s where as in manual method was 30 sec. Similarly the time required to separate the bean was around 31 s for cocoa pod breaker against 55s for manual method. The cocoa pod breaker had a maximum capacity of 327 kg/hr at a motor speed of 350 rpm whereas in manual method the capacity was 216 kg/hr. Similarly the bean damage per cent, bean recovery per cent and overall efficiency of the machine was estimated at 0.4, 75.6 and 87.4 per cent, respectively. The bean damage recorded during testing was less than 1 per cent. The developed cocoa pod breaker cum bean extractor may enhance the quality of cocoa products to a great extent. The machine developed is simple and easy to maintain. The drudgery and much time involved in the process of breaking the cocoa pods manually could be overcome with the help of the machine.

References

REFERENCES

Adewumi, B.A. 1997. Cocoa bean processing and drying equipment for small and medium scale industries. A paper presented at a conference titled 'The Role of Science and Technology in the Development of Small/Medium Scale Industries in Nigeria'. Organized by the Centre for Research and Development, Ondo State University, Ado-Ekiti, pp: 17.

Adewumi, B.A. 1997. Relationship between the angle of repose and related parameters for granulated agriculture materials. *Appl. Trop. Agric*. 2(2): 114-119.

Adewumi, B.A. 1998. Status of cocoa processing industry in Nigeria. Proceeding of the 20th Annual Conference and General Meeting of the Nigerian Society of Agricultural Engineers, Lagos Nigeria, 20: 175-187.

Adewumi, B.A. 2000. Design and testing of a manually operated cashew decorticator. *Nigerian J. Tree Crop Res*., 4(2): 10-17.

Adewumi, B.A. and Ayodele,O.R. 1997. Design and construction of a device for the determination of static and dynamic angle of repose of granular agricultural materials. *Nigerian J. Tech. Edu.*, 24(1): 101-106.

Adewumi, B.A. and Fatusin, A.B. 2006. Design, Fabrication and testing of an impact-type hand operated Cocoa Pod breaker. Agr. Eng. *Int. CIGRE journal Manuscript PM* 06 022:22(1) 8.

Adewumi, B.A., Ademosun, O.C, and Ogunlowo, A.S. 2006. Design, fabrication and preliminary testing of a thresher-cleaner for legume. *J. Food Sci. Technol*. 44(3): 414-420.

Adeyanju, S.A., Oguntuga, D.B.A., Ilori, J.O., and Adegbola, A.A. 1975. Cocoa husk in maintenance rations for sheep and goats in the tropic. Nutr. Rep.

AOAC. 1984,. Official Methods of Analysis, Association of Official Analytical Chemists, (4th Ed.), Washington, D.C. USA.

Are, L. A., and Gwynne-Jones, D. R. G. 1974. Cacao in West Africa. Chapter 10: Harvesting and processing of Cocoa. IBADAN, Oxford University Press, Oxford, England. Baker, D. M., Tomlins, K. I. and Gay, C. (1994). Survey of Ghanaian cocoa farmer fermentation practices and their influence on cocoa flavour. Food Chem. 51: 425-31.

Audu, I., Oloso, A.O., and Umar, B. 2004. Development of a concentric cylinder locust dehuller. CIGR-Ejournal PM 04 003, Vol: 6.

Bamgboye, A. I. 2003. Effect of some physical properties of cocoa bean on post harvest delay on its compressive and impact rupture. Discovery and Innovations 15(3): 137-141.

Bamgboye, A. I., and Odima Ojoh. 2004. Design Parameters for Cocoa Pod Breaker. Beer, P and Johnson, O. Mechanics of materials Mceram Hill Book Company Newyork.

Barclays Bank DCO,1970. Cocoa. Well Hall Press Ltd, London, England.

Camu, N., De-Winter, T., Addo, S. K., Takrama, J. S., Bernaert, H., and De -Vuyst, L. 2008. Fermentation of cocoa beans: influence of microbial activities and polyphenol concentrations on the flavour of chocolate. *J. Sci. Food Agric*. 88: 2288-2297.

Faborode, M. O., and Oladosun, G. A. 1991. Development of a cocoa pod processing machine.The Nigerian Engineers. 26(4): 26-31.Int., 2: 351-357.

Hansen,C.E., Olmo, M. D., and Burri, C.1998. Enzyme activities in cocoa beans during fermentation. *J. Sci. Food Agric*. 77: 273-81.

ICCO,2012. Quarterly Bulletin of Cocoa Statistics, 38(3). Cocoa year 2011/12. (http://www.icco.org).

International Standard Organisation, 1972. Table of Standard, 2291-1972(E).

Jabagun, J.A. 1965. A mechanised cocoa pod sheller. *Nigeria Aqua. J.*, 2(1): 44-45.

Jonathan, H. C., Carlos, F. B., and Gene, J. 2012. Cocoa (Chocolate Bean) Growing in the Florida Home Landscape.

Khurmi, R..S., and Gupta, J.K. 2005. A Textbook of Machine Design. First Multicolour Edn., Eurasia Publishing House Ltd., 7361, Ram Nagar, New Delhi-110055, pp: 16-50. ISBN: 81-219-25 31-1.

Mossu, G.,1992. Cocoa. Chapter 6: Harvesting and preparation of commercial cocoa. The Macmillan press ltd. London, U. K. Nan,Y. S, Li, Q. Y. Feng, X., and Qiang, W. Z. (2010). Analysis on microclimate variation of plastic greenhouse in spring under different conditions of meteorology. Res. of Agric. Modernization. 31(2): 254-256.

Oke, D. O., and Omotayo, K. F.2012. Effects of hermetic storage on artificially- dried cocoa beans stored in hot-sealed plastic bags. *Wudpecker J. Agric*. Res. 1(11): 454 – 458.

Opeke, L.K. 1987. Tropical Tree Crops. John and Sons, Clichester, pp: 108-119.

Potty, V. H.,1979. Food industries. The Chemical Engineering Development Centre, Indian Institute of Technology, Madras, pp.11.69-11.90.

Rohan, T.A.,1963. Processing of Raw Cocoa for the Market. Food and Agricultural Organization of United Nations, Rome.

Sahay, K.M., and Singh, K.K.2001. Engineering properties of agricultural materials. *Unit operation of agricultural processing.*Vikas publication pvt lmd., pp. 6-18.

Sunilkumar, K., Pushpalatha, P. B., and Amma, S. P. K., 2008. Quality of cocoa beans in small scale processing as influenced by methods of drying and season. *Environ. Ecol.* 26(3): 1001-1005.

Takrama, J. F., and Adomako, D.1996: Raw cocoa processing in Ghana. Cocoa research institute of Ghana, New Tafo, Ghana.

Thompson, S.S., Miller, K. B., and Lopez, A. S. (2001. Cocoa and coffee. *Food Microbiol. Fundamentals and frontiers*. ASM Press, Washington, D.C., pp. 721-733.

Vejesit, A., and Salokhe, V. 2004. Studies on machinecrop parameters of an axial flow thresher for threshing soy bean. *CIGR-Ejournal*, Vol: 6.

Wills, B.A. 1981. Mineral Processing Technology. 2nd Edn, Pub. Pergamon Press, New York, pp: 252-255.

Wood, G. A. R., and Lass, R. A., 1985. Cocoa. (4th Ed.). Longman Group Limited, London, United Kingdom.

Ziegleder, G. 1991. Composition of flavour extracts of raw and roasted cocoas. Z. Lebensm. Unters. Forsch., 192: 521-525.

DEVELOPMENT AND PERFORMANCE EVALUATION OF COCOA POD BREAKER CUM BEAN EXTRACTOR

By

ARUN JOSHY (2011-06-003)

GEETHU.S (2011-06-007)

KRISHNENDU K.M (2011-06-009)

NIKHIL C.S (2011-06-010)

ABSTRACT OF PROJECT REPORT

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TAVANUR, MALAPPURAM - 679 573

ABSTRACT

Cocoa *(Theobroma cacao)* is a commercial plantation crop in India. It is mainly cultivated in Kerala, Andhra Pradesh, Karnataka and Tamil Nadu as an intercrop with arecanut or coconut. Cocoa is the main raw material in the production of chocolates, cosmetics, health drinks, pharmaceuticals etc. It contains about 50 per cent fat which is useful in the production of candle, soap, ointments etc. The processing of cocoa involves the breaking of pods, extraction, fermentation, drying, dehulling and winnowing of the beans; and the production of value added products like cocoa butter, beverage and cake. Cocoa pod consists of three main components viz.,crust pod, cocoa bean and placenta. The cocoa beans which are embedded in a mucilaginous pulp inside the pod consist of two parts- seed coat and seed cotyledon. Seed cotyledon is the material in which characteristic flavour and aroma produced during fermentation.

At present, cocoa pod breaking and bean extraction from crust pod are done manually by using machete or sickle and need many workers. Manual chopping could increase the number of damage bean which leads to fungal attack. In order to eliminate the drudgery involved in manual cocoa pod breaking, avoid injury to workers, increase efficiency and to ensure high quality products, an attempt was made to develop a cocoa pod breaker cum bean extractor. Before the fabrication of machine, the engineering properties of cocoa viz., physical, mechanical and frictional properties of fresh cocoa pod were determined. Physical properties studied were size, shape, mass and density. The mechanical and frictional properties viz., compression test, angle of repose and co-efficient of friction were determined as per the standard procedures. The developed cocoa pod breaker cum bean extractor had two main parts- 1) Cocoa pod breaker and 2) Cocoa bean extractor. Cocoa pod breaker consists of two rollers in which each roller was reverse rotated. The gap between the rollers was set based on the size of the cocoa pods fed. Bean extractor consists of a rotational strainer which help to separate beans from the broken cocoa pod.Gap between the rollers was adjusted so that the pod should break properly, whereas no damage occurred to cocoa kernels during the process. Cocoa fruit was fed manually in to pod breaker unit through hopper. The tangential force of the roller pushed the cocoa pod towards the gap resulted in breakage. Broken cocoa pod, kernels and placenta then discharged to the strainer through chute. Strainer separated the

cocoa kernels from cocoa pod and discharged through strainer outlet. The broken pods were remained above the strainer.

Performance of the machine was evaluated in terms of capacity, percent bean damage, percent bean recovery and machine efficiency. The average time required to break 5 cocoa pods using pod breaker was 20 s where as in manual method was 30 sec. Similarly the time required to separate the bean was around 31 s for cocoa pod breaker against 55 sec for manual method. The cocoa pod breaker had a maximum capacity of 327 kg/hr at a motor speed of 350 rpm whereas in manual method the capacity was 216 kg/hr. Similarly the bean damage per cent, bean recovery per cent and overall efficiency of the machine was estimated at 0.4, 75.6 and 87.4 per cent, respectively. The bean damage recorded during testing was less than 1 per cent. The developed cocoa pod breaker cum bean extractor may enhance the quality of cocoa products to a great extent. Also it avoids the risk and danger exposed during the process of splitting the cocoa pods manually.