UNIVERSITY OF NAIROBI

DEPARTMENT OF MECHANICAL & MANUFACTURING ENGINEERING

FINAL YEAR PROJECT

PROJECT NO: SMK 01/2009

<u>DESIGN OF A CROTON SEED DEHUSKER</u>

UNDERTAKEN BY**:**

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PROJECT SUPERVISOR:

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In partial fulfillment of the requirement for the award of the degree of Bachelor of Science in **Mechanical and Manufacturing Engineering** for the year 2008/2009

DECLARATION

We declare that this is our own original work and to the best of our knowledge and has never been presented elsewhere else for academic purposes.

Signature

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This project report has been submitted for examination with my approval as University supervisor for the award of the degree of Bachelor of Science in **Mechanical and Manufacturing Engineering**

………………………………………

Supervisor:

MR.KABUGO

DEDICATION

We would like to dedicate this report to our parents who brought us to this world and have supported us throughout our lives, and to all farmers in Kenya and the world

QUOTE

"The man who will use his skill and constructive imagination to see how much he can give for a dollar, instead of how little he can give for a dollar, is bound to succeed." - Henry Ford

ACKNOWLEDGEMENT

We would like to thank the Almighty God for sustaining us throughout this undertaking and for giving us everything we call ours. Much thanks to our Project supervisor and advisor, Mr. Kabugo who never stopped guiding and inspiring us.

We are especially glad that our Department of Mechanical and Manufacturing Engineering have been kind, supportive in many ways and generous beyond measure.

This project would not have been possible without help from many friends, colleagues, and family. They have been ever so supportive through a very long and bumpy project. They have been supportive in many ways, and Iôm especially glad that all of our family has been patient, kind, and generous beyond the call of duty.

It is our wish also to express our sincere gratitude tour classmates who provided support to us when we needed it most. We couldnôt have done any of this without them.

ABSTRACT

The objective of this was to design a Croton seed Dehusker with optimum performance, high production, high separating capacity, low operation cost and high durability. This project therefore seeks to research, design and develop a machine that is competitive in the market.

The process of making biodiesel is first discussed highlighting the main stages and the need for a dehusking machine.

The characteristics, distribution and uses of both the tree and the seed which we are interested in are discussed in depth.

For the model, various parts are discussed about their functions and how they are to be designed including their dimensions and any special attributes that will allow variety testing based on speed and operation time among other factors.

Various recommendations are then made for future improvements deemed necessary on the project

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INTRODUCTION TO BIODIESEL

Biofuel is any solid, liquid, or gaseous fuel produced from organic (once-living) matter. Biofuel is produced either directly from plants or indirectly from industrial, commercial, domestic, or agricultural wastes. There are three main methods for the development of biofuels: the burning of dry organic wastes (such as household refuse, industrial and agricultural wastes, straw, wood, and peat); the fermentation of wet wastes (such as animal dung) in the absence of oxygen to produce biogas (containing up to 60 percent methane), or the fermentation of sugarcane or corn to produce alcohol and esters; and energy forestry (producing fast-growing wood for fuel).

Biodiesel is produced from a range of plants which include:-

1. Jatropha
2. Croton
3. Sunflower
4. soya
5. Rapeseed
6. Castor
7. Palm
8. Peanut

It is advisable that the biodiesel be produced from non-edible plants such as Jatropha, croton, castor and safflower. This ensures food security and it is cheaper since there is no competition for the oil for food. The various plants have different percentages of oil in their seeds e.g. 32% in croton, 30% in Jatropha. Not all this oil is extracted due to low efficiency of extraction methods. Locally Jatropha, croton, sunflower, and soya are grown in different parts thus they were considered. But since soya and sunflower are edible, not much interest is put on them.

Advantages of biodiesel

1. Produced from sustainable / renewable biological sources
2. Ecofriendly and oxygenated fuel
3. Sulphur-free, less CO, HC, particulate matter and aromatic compounds emissions
4. Income to rural community
5. Fuel properties similar to the conventional fuel
6. Used in existing unmodified diesel engines
7. Reduce expenditure on oil imports
8. Non toxic, biodegradable and safety to handle

Limitations

1. High viscosity
2. Poor atomization-poor volatility
3. Thermal cracking in diesel engines-poor oxidation stability
4. Polymerization in combustion chamber leading to deposits
5. Injection fouling by deposits
6. Fuel line and filter clogging
7. Polymerization of triglycerides in lube oil

These challenges may be solved by:-

1. preheating the oils
2. blending or dilution with other fuels
3. trans-esterification
4. thermal cracking/pyrolysis

Biodiesel production process

The steps followed in the production of biodiesel are:

1. drying
2. dehusking/dehulling/deshelling
3. extraction
4. filtration
5. heating
6. trans-esterification
7. separation/decanting
8. washing

1. Drying

The seeds are dried so as to expel the moisture in them. There are two methods that may be used:-

a) Drying in the sun
b) Using steam

2. Dehusking

This is the removal of the seed shells. A dehusker/sheller is used.

3. Extraction

This is the removal of oil from the seeds. A mechanical expeller or a chemical process may be used.

4. Filtration

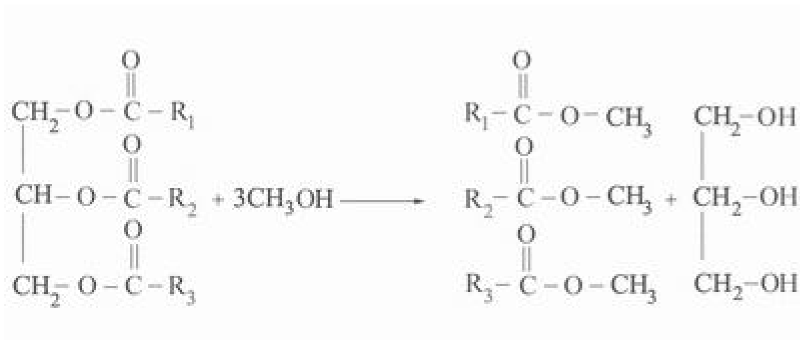
The oil is separated from the other material which is referred to as the cake. This is done using a mechanical press.

5. Heating

The moisture content of the vegetable oil should be less than 0.01%. In the event that the moisture content is above 0.01%, the oil is heated at 120ęC so as to vaporize the water.

6. **Trans-esterification**

This is the process of converting vegetable oil into biodiesel by removing glycerin and other impurities that bring about gumming if vegetable oil is used in diesel engines. The oil is chemically reacted with an alcohol (methanol, ethanol) in the presence of a catalyst (KOH or NaOH) to produce a mixture of methyl esters known as biodiesel and glycerol, which is a high value co-product.



7. **Separation/decanting**

The glycerin may be removed by centrifugation or settling. This glycerin may be used in the cosmetic industry

8. **Washing**

The biodiesel at this stage has traces of glycerin, alcohol and catalyst. Thus it is washed with water so as to remove any of these traces.

CHAPTER ONE: INTRODUCTION

1.1 Overview

The main objective of this project is to access the most valuable part of croton seed and therefore kernel extraction. It is one of the most important aspects of croton seed dehusking process. The cotton seed is crushed and beaten by rotating impact plates (hammers) so that the husks are fractured without damaging the kernels. This process is repeated as many times as possible until the husks and shell separates from the kernel.

Figure 1.1 ripe croton seeds

The chaffs are then separated from the kernel using wind, vibration, water floatation etc. The kernels which are the most important part of the croton seeds should not be damaged at all. This is because they will disable the ease in separation from the husks. This also means the quality of the product of this dehusking process is to achieve one hundred percent undamaged kernel.

The biodiesel industry has the potential for a great future in this country and the entire world as far as production of oil and animal feeds is concerned. However, croton seed production has faced great challenges since they are being cut down for charcoal burning.

1.2 DESIGN PROBLEM

Croton seed has very important properties and materials required in the world today. The worldôs global fuel has gone up and even the oil and petroleum reservoirs are getting depleted. Analysis at the EATEC laboratories in Eldoret, however, showed an average of 32% oil and 18% protein Croton seed like many other seeds has oil which can be extracted through several methods and brought into use to replace or cater for the shortage of the petroleum products such as paraffin, petrol, and diesel, gas etc.

The problem is to minimize lose in the extraction of oil or biodiesel from a croton seed. We therefore here concentrate in the removal of the husks of croton seed. Below is a diagram of a croton seed showing the parts and the most essential parts as far this project is concerned.

At the inner part of the seed the whole unit is divided into quadrants which contain the kernel.

The kernel is the part that contains the oil (biodiesel) .oil is embedded in this part of the seed and hence this part that we shall concentrate on.

Our design problem is therefore to minimize the materials that will absorb this oil when we try to extract it by a mechanical process.

First, like oil extraction by mechanical means or other type of oil e.g. the castor oil seeds, here we look at trying to minimize the chirpy and dust as a result of crushing the seeds and hence minimize the amount of that will be absorbed into them.

We therefore have to design a process by which the machine crashes the seeds through or by impact means. This machine is meant to destroy or damage the bark, husk and the shell without damaging the kernel. The shell and the husks shall therefore be separated from the kernel by either vibration or movement or by floatation using water.

The major areas in this design is to model and test the croton seed dehusker concept I in order to obtain the information that would enable the design and construction of a successful dehusker. Secondly is to design a full scale portable dehusker based on the tests done in the model. We endeavor to design a croton prototype dehusker for small scale production which can be locally manufactured. The dehusker should be portable (mobile) so that it can be transported from one place to another. It should also be cheaper than the available ones because it is meant for small holder farmers, who may not afford other processes e.g. chemical oil extraction method or even the locally available machines that are bulky and too expensive.

The machine should also de-husk the seeds to a high quality and acceptable by the market or even at suitable condition to be processed just like the other similar oil producing seeds of castor oil, maize etc.

1.3 OBJECTIVES OF THE PROJECT

The main objectives of this project are:

To design, develop and test a practical, cheap and reliable dehusker with maximum efficiency possible.

To apply basic engineering principles to ensure that the final product is affordable to small holder farmers.

To develop a mobile dehusker which reduces the cost of production by removal of the parts such as the shell and the husk from all over the field and hence avoid the stationary type which has always been the collection and carrying of the seeds hence wastage of time and money as the transportation of materials that are unnecessary.

To achieve or realize a product whose performance reflects the expectations of the farmer.

To design a machine that will produce kernels of acceptable quality to the next process or acceptable to the market.

CHAPTER TWO

2.1 Croton seed

Croton seed is a spherical seed with lines of weakness on the outer shell or husk. Each fruit contains 3 ellipsoid-ovoid or oblong-ellipsoid seeds. When the seed is ripe, it falls down from the plant/tree where it dries naturally. The volume of the seed reduces by about 20% on the drying up and release of the seed bark coat. The Croton nut is inedible, and therefore cannot directly affect edible oil prices.

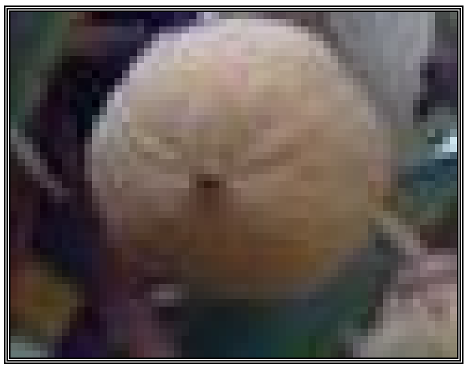


Figure 2.1 Croton showing detailed parts

The size of the seed depends on;

- the species plant(type of the plant)
- climatic condition of the geographical location where the plant is cultivated
- the amount of rain received in a season
- the type of soil, etc

When seeds are ripe, they dry up and the bark coat cracks

Thickness of the bark coat 1.6 ± 0.6 mm

Approximate measurements 2.2 - 2.4 cm long and 1.2 - 1.4 cm wide

Thickness of the husk 1.2±0.2 mm volume of the whole (raw) seed

Approximate volume of the husk

Approximate volume of the shells

Total approximate volume of the husks and the inner shell

The approximate volume of the kernels (done experimentally)

2.1.1 Impact Characteristics of the seed.

This is to be determined on the first testing of this model. The speed of the hammer axle will determine impact force that will act on the seed. This will be achieved through the use different pulley speeds and motor speeds.

Figure 2.2 croton plants at Uhuru Park Nairobi

2.2 Theory of croton plant and its products

The binomial nomenclature is ***Croton megalocarpus,*** **Family*: Euphorbiaceae*** Other Common Names are**:** Mlalai, Muhande (Tanzania), Mukinduri (Kikuyu ï Kenya) Otwet (Kipsigis-Kenya) and Otonwet (Tugen ï Kenya), Muuti (Meru), muthulu (kamba-kenya).

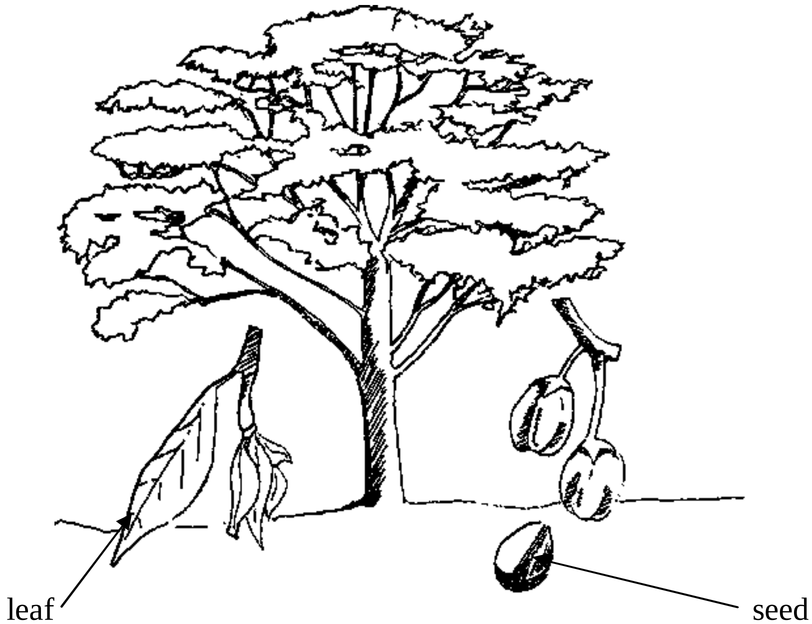
Figure 2.3 croton leaves after heavy rains

2.2.1 Distribution

Occurs in tropical East Africa, with an altitudinal range of 4,000 to 6,700 ft; used as a shade tree in coffee plantations.

2.2.2 The Tree.

May reach a height of 30m; with a clear cylindrical hole 12 to 18m in length, free of buttresses; with trunk diameters of 0.6m to 1.2m.



2.3 The Wood.

2.3.1 General Characteristics:

Heartwood yellowish to brownish gray, sometimes with dark brown to black streaks near the center of the log; sapwood not clearly differentiated. Texture medium; grain straight; unpleasant smell when freshly cut; dry sawdust irritating to nose and throat.

2.3.2 Weight

Basic specific gravity (oven dry weight/green volume) =0.57; air-dry density 44 pcf.

2.3.3 Mechanical Properties

Moisture content (%)	Bending strength psi	Maximum crashing strength psi
Green 50%	11,500	6,600
12%	14,000	7,500

Janka side hardness 1,300 lb for green material and 1,350 lb for dry.

2.3.4 Drying and Shrinkage

Rather difficult to season without warping and checking. Kiln schedule T3-C2 is suggested for 4/4 stock and T3-C1 for 8/4. No data available on shrinkage values. Movement in service is large.

2.3.5 Working Properties of the wood

- easy to saw
- moderately difficult to machine but planes to a smooth lustrous surface

Good gluing and finishing characteristics

However dust may be irritating to mucous membranes.

Durability: Vulnerable to attack by decay and stain fungi and liable to termite attack.

Preservation: Reported to be readily treatable by pressure systems.

Uses: General construction, heavy-duty flooring.

2.4 PLANTATION AND DISTRIBUTION OF CROTON MEGALOCARPUS

Production figures for croton seeds are not available. Egli & Kalinganire (1988) report that in Rwanda it flowers and produces fruits every two years, while evidence from Kenya suggests that this species produces fruits every year. Potential seed production for a tree is still unknown but it is generally described as `abundant'. Preliminary observations, however, indicate that 25 kg of seeds per tree per year is feasible.

There seems to be large variability in the major components of seed production (frequency of flowering, number of flower spikes, and number of female flowers per flower spike (1-5), fruit diameter (1.7 and 3.8 cm), and seeds per fruit (1-4), seed weight (0.67 and 1.18 g). This indicates that significant improvements in seed yield could be achieved through selection and breeding of new varieties. The effects of management on seed production are not known, but different pruning regimes could also benefit seed production, as flower buds are borne at the end of branchlets.

Propagation of this species is by seed which germinate readily within about 10 days. Contrary to reports that seeds lose viability fast because of the high oil content, germination percentages can be as high as 80% after one year storage in a plastic container. No reports are available on vegetative propagation of *C. megalocarpus.*

C. megalocarpus (i.e., `croton with the big seeds') is a hardy and fast-growing tree (table 3) that can reach 35 m or more in height. It usually forms a flattish crown and has horizontal layers of branches. Young plants thrive well even in harsh climatic conditions, and it is not browsed by livestock nor attacked by termites.

Region	Altitude (m)	Age (years)	Height (m)
Rwanda, Rwerere area	2300	2	3.1
Rwanda, Rangiro area	1900	5	11.7
Rwanda, Ruhande area	1750	43	20.2
Kenya, Maseno area	1500	1	1.7
Burundi, Karuzi area	1620	0.5	0.7

Table 2.1 Growth characteristics of *Croton megalocarpus* in East Africa

The poultry feed tree is characterized by its multipurpose functions on the farm. Because seeds are available and propagation simple, it is often planted to demarcate boundaries where it plays roles as a live fence, a windbreak, and reduces soil and water erosion. Younger trees coppice well after pruning, so this species is often used as a hedge around home compounds or fields. In the Kenyan coffee-based land-use system of Embu District, for instance, more than 10% of the farms have croton hedges, with an average length of 70 meters. However, when managed as a hedge this species is unlikely to produce fruits.

Older trees have been reported to be competitive with crops. The species is therefore often confined to certain niches on the farm such as roadside boundaries, woodlots and paddocks. In grazing areas crotons are valued as shade trees for animals. As a shade tree croton can even be found on home compounds, in markets and at bus stops along the road. Where trees are grown within crop areas the annual extensive leaf fall combined with high levels of nitrogen and phosphorus in the leaves give it potential to improve soil fertility and serve as a source of mulch in, for instance, coffee plantations.

Products obtained from *C. megalocarpus* are timber, building poles and fuel wood, while first-class charcoal can be made out of the wood of this species. The well- dried nuts are reported to be used in some areas together with charcoal in cooking stoves. Nut shells could be used as mulch in vegetable gardens (one 30-litre bucket can cover an area of 2.25 m^2) and as a component of potting mixtures for plants. The croton flowers are bee forage while the seeds, bark and leaves of the tree are reported to have medicinal value including medication for poultry.

In the Embu area, on the slopes of Mount Kenya, *C. megalocarpus* has been found on 40% of the farms at an average density of about 15 trees per farm (excluding trees managed as a hedge). The majority of farms (84%) had between 1 and 10 trees, while 11% contained between 50 and 100 trees. An estimate of the total number of croton trees on farms in the coffee-based land-use system of this area (ca 400 km^2) gives a figure of more than 160 000 trees.

2.5 HARVESTING AND STORAGE OF CROTON

In Kenya crotons seeds are harvested once in a year. However, it has been reported that in other countries e.g. Rwanda, croton seeds are harvested twice per annum. Crotons are harvested manually and since the trees are tall a ladder is used to climb. The seeds are handpicking from the tree while those which fall off the tree before harvesting time are also collected from the ground. The seeds which have been handpicked are green and full of moisture and therefore drying is essential before storage. Drying is done by spreading under the sun. a moisture content of 13.8 is acceptable for storage purposes. Prior to dehusking process, an extra drying is recommended in order to increase the impact characteristics.

Figure 2.3 sacks of dried croton seeds

2.6 DEHUSKING PROCESS OF CROTON SEEDS

Dry croton seeds have a bark coat which is easily removable. This coat is usually broken to dust which then can be blown away so as to remain with the husk coat only. The husk coat is usually symmetrical with two center points. Lines of weaknesses joining the two center points run across the surface of the husks forming six similar shells.

The lines of weaknesses are important during dehusking process. They ease the breaking of the husk releasing the kernels which is the most important part of the croton seed. The crushing of the above is achieved by impact.

The two center points can also be used in the process of dehusking. A force is applied on the two centers which easily crushes the seed into sub shells which then releases the kernels without damaging them. This is an ideal approach and is not possible because it is not easy to locate the centers on the seed surfaces. Similarly, exerting forces on a point is complex and time consuming process.

It is preferable to use the impact approach in our design. The seeds are fed into the dehusking machine through the feed tray. They are impacted on the hammer blades and then guided down to the base. The hammer blades collect and accelerate them to the upper impact surface. This is repeated severally until the kernels are released from their shells and husks.

Figure 2.4: kernels and husks after dehusking process

The chaps are then separated from the kernel using wind, vibration, water floatation etc. The kernels which are the most important part of the croton seeds should not be damaged at all. This is because they will disable the ease in separation from the husks. This also means the quality of the product of this dehusking process is to achieve one hundred percent undamaged kernel.

CHAPTER THREE

3.1 USES OF CROTON PLANT AND ITS PRODUCTS

There are two main uses of croton megalocarpus seed and its products. These are production of oil, and for poultry/animal nutrition. Other uses are medicinal purposes, the production of charcoal, wood fuel and for carpentry and construction purposes.

3.1.1 Oil production

These seeds contain oil and protein, believed to be 30 and 50% respectively (Teel 1994). Analysis at the EATEC laboratories in Eldoret, however, showed an average of 32% oil and 18% protein. Croton oil is also reported to be a powerful cathartic, occasionally used in medicine (anon. 1958).

Figure 3.1 croton megalocarpus seed oil

3.1.2 Poultry nutrition

Because poultry are monogastric, they are unable to manufacture essential amino acids or the B vitamins, and they cannot exist on high-fibred diets. The diet of birds must contain the materials essential for the processes of maintenance, production and reproduction. The essential nutrients can be grouped as water, carbohydrate, fats and oils, protein (amino acids), vitamins and minerals.

The energy in the diet, necessary for production (meat, eggs) and for the maintenance of vital functions and body temperature, is largely in the form of carbohydrates; fat and amino acids are also required.

The synthesis of protein in the body tissues requires an adequate supply of about 20 different amino acids, 10 of which cannot be synthesized by the bird and must therefore be provided in the diet.

Foodstuffs commonly used in poultry diets in the tropics can be classified into five broad classes:

- cereals and cereal by-products (maize, sorghum, millets, wheat, rice, maize bran, wheat bran, rice bran)
- other energy foods (cassava, sugar, molasses)
- animal proteins (fish meal, meat and bone meal, feather meal, blood meal)
- plant proteins (soya bean, groundnut, cottonseed, sunflower seed, linseed)
- mineral supplements

Foods containing high levels of protein (e.g., soya beans, groundnuts, sunflower seeds) are expensive to purchase, while energy foods (e.g., cereal by-products) are often plentiful and relatively cheap. The seed is incorporated in poultry feeds, as its protein content is high (50%).

The most commonly used animal protein for poultry diets is fish meal. It is a high-quality protein food rich in all the essential amino acids, but fish meal is in limited supply in most developing countries.

The high and increasing prices for animal feed have compelled researchers in developing countries to direct their attention to non-conventional feeds, with particular emphasis on protein substitutes.

In Kenya, however, a real breakthrough has been made in identifying a local poultry feed supplement. The Kenya Wood fuel and Agro forestry Programme (KWAP), implemented by

ETC Kenya Consultants, has in close collaboration with farmers, identified some indigenous knowledge on a species that can be named the `poultry feed tree'.

3.1.2.1 The potential of the croton seeds in animal nutrition

The seeds of the poultry feed tree, *Croton megalocarpus* Hutch. (Euphorbiaceae), are reportedly eaten by birds and squirrels (Noad & Birnie 1989) and can be used for poultry (Nicholson 1992). These seeds contain oil and protein, believed to be 30 and 50% respectively (Teel 1994). Analysis at the EATEC laboratories in Eldoret, however, showed an average of 32% oil and 18% protein. Croton oil is also reported to be a powerful cathartic, occasionally used in medicine (anon. 1958).

C. megalocarpus is indigenous to East Africa. Its range is the semi-arid and sub humid highlands, at altitudes between 1200 and 2450 m, with an annual rainfall of about 800 to 1600 mm and average annual temperatures varying between 11 and 26^{o}C. Trees of this species are found in forests and often on farms, where they play a major role as boundary markers, windbreaks, shade trees and fuel wood producers.

The few reports on the use of croton seeds as poultry feed are restricted to the Nyeri and Kakamega areas of central and western Kenya respectively. In all cases the seeds are fed as seasonally available supplements to the diet of scavenging poultry flocks. Little is known about feeding ratios and productivity of these birds.

Preliminary results of experiments by KWAP with ground croton seeds partially replacing commercial chick and layers mash show that up to 50% of commercial feed in the diet of highly productive hybrid layers can be substituted by croton seed meal, with no adverse effects on production or hatchability of eggs. Additionally, a 10 to 15% saving in food consumption was observed when croton seed meal was included in the diet.

In the case of chicks, feeds were formulated using commercial feeds and croton seed meal. One-day-old layer chicks were fed on a 10% croton seed diet, and the level of croton in the feed was gradually increased to 25% for one-week-old chicks and maintained at that level. Feed intake, feed efficiency, body weight gain and growth rate of the chicks over a 12-week period were very satisfactory (table 3.2). Birds slaughtered after this experimental period did not show any internal abnormalities.

Week	Croton seed in diet (%)	Food conversion ratio (%)	Weekly growth rate (g)
1	10-20	50	26
2-4	25	26	48.5
5-12	25	22	117.5

Table 3.2. Growth of layer chicks fed with croton seed meal in the diet

3.1.3 Other uses

Fuel: Well-dried nuts are reportedly used in some areas together with charcoal in cooking stoves. The tree is also utilized for firewood.

Apiculture: This species produces a dark-ambered honey with strong flavor.

Timber: Wood is of medium weight, hard, termite-resistant and strong; it is used for timber and building poles.

Medicine: Seed contains up to 32% oils, which have been used favorably as medicine. Bark decoction is used as a remedy for worms and whooping cough.

Shade or shelter: C. megalocarpus forms a flat crown and has horizontal layers of branches, which make it useful in providing light shade and serving as a windbreak.

Soil improver: Leaves have high levels of nitrogen and phosphorus and serve as a source of mulch, for instance, in coffee plantations.

Ornamental: Its conspicuous flowers make it suitable as an ornamental.

Boundary or barrier or support: As the species is not browsed by livestock, it is often used as a live hedge.

CHAPTER FOUR

DESIGN OF THE MODEL

4.1 Description of parts

4.1.1 Cover Shell

It consists of hammer blades, end cover plates, pillow blocks and a shaft. The cylinder is made of two parts which can easily be opened through use of hinges. The other side is to be locked using bolts. The upper part consists of a **173mm** outside diameter semicircular cylinder. The lower part consists of a **153mm** outside diameter semicircular cylinder. The thickness of the material is **3mm.** The cylinder can also be made by rolling a plate to the specified dimensions.

The center shaft is to be machined from common shaft materials available. Based on the cost, mild steel was chosen as the preferred choice. The dimensions of the shaft are 25mm diameter and 600mm length.

The pillow blocks are made of cast iron. They should be slid over the shaft during assembly and bolted to the stand.

4.1.2 Drive and coupling System

A belt drive system was chosen to allow the drive system to slip without burning out the motor as opposed to a chain drive. The engine pulley diameter was chosen as 6 inches while the beater drum pulley was chosen as 8 inches. This gives a gear ratio of 1: 1.333 and the approximate belt length was chosen to be 56 inches. A V-belt was chosen for coupling the power system and the beater drum.

The pulleys used in this design have several diameters so as to allow ease of changing the belt so as to vary the speed during testing. It should be noted though that the machine has to be stopped before changing the belts.

The criterion used in the selection of the V-belt is as below:-

Belt section	Width, inches (a)	Thickness inches (b)	Minimum sheave diameter	Hp range, one or more belts.
A	$\frac{1}{2}$	$\frac{11}{32}$	3.0	0.25 - 10
B	$\frac{21}{32}$	$\frac{7}{16}$	5.4	1 - 25
C	$\frac{7}{8}$	$\frac{17}{32}$	9.0	15 - 100

Since our source of power is a 5.5 horsepower engine, then the belt section B is chosen.

Let,

C ï Centre distance between the center axle and the motor. (440mm)= 17.32 inches.

L_p -pitch length of the belt

D ï center shaft pulley diameter (8 inches)

d ï Engine pulley diameter (6 inches)

Then the following formulae are used for the calculation of the belt pitch length required,

$$L_p = 2C + \frac{\pi(D+d)}{2} + \frac{(D-d)^2}{4C}$$

L_P= (2x17.32) + (πx14/2) + (2/4x17.32) = 56.69 inches.

From the standard belt sizes, the closest size to the above calculated value is **56 inches** which is then chosen as the size of belt required for this design.

4.1.3 Hammer Plates

The hammers are made from cast iron of **70mm by 2mm thickness** and a **290mm length.** The hammers are used to sweep the base of the shell and thus they have a clearance of only **5mm** so as to make sure they get all the seeds. A phosphor-bronze alloy may also be used. These plates are held by mild steel bar of **37mm by 4mm thickness** welded onto an 8mm outside diameter cylindrical bar. The hammer plate holders are 290mm long with 20mm indentions on both sides to give room for the side plate and the bolts

4.1.4 Chute

This is the point from which the dehusked seeds will be taken from the beater drum. It is made up of 2mm thick hot rolled iron sheets to specifications as provided in the design drawings. This is designed in such a way that the products will easily be ejected during dehusking. This can be done by sliding the lower retaining slide.

4.1.5 Hopper

This is welded on to the top part of the cover shell. Below it is a sliding retaining plate that is opened only when the seeds are to be put into the drum.

4.2 Bill of materials

1.	stand	1	Fabricated from mild steel angle bars of 40mm by 40mm by 3mm thickness
2.	shaft	1	Mild steel solid cylindrical shafts of about 600mm
3.	Beater drum	1	Circular hot rolled iron sheet section: Lower half: 304mm outside diameter, 3mm thickness,300mm in length. Upper half: 346mm outside diameter, 3mm thickness, 300mm in length.

			A horizontal distance of 3mm is put between the centers of the two circles Cover sides thickness is 2mm
4.	Hammer plates	4	Bars of 70mm by 2mm sectional dimensions, equal lengths of 290mm.
5.	Hammer plate holders	4	Mild steel bars of 37mm by 4mm cross sectional dimensions welded into 8mm outside diameter cylindrical bars. the unit is 290mm long with 20mm indentions on both sides
6.	End plate hammer holders	2	Mil steel plates of 5mm thickness,25mm inside diameter, 80mm outside diameter with four 30mm by 30mm projections of which each has 7mm diameter hole drilled to hold the hammer plate holders
7.	Beater drum side cover	1	Hot rolled iron sheet, 3mm thickness. Developed as per design drawings.
8.	Pulley	2	These are chosen from the standard sizes available in the market according to the calculations as shown above.
9.	belt	1	It is used as calculated above
10.	Chute	1	Hot rolled iron sheet,100mm by 50mm by 2mm thickness. developed as per design drawings.
11.	hopper	2	Hot rolled iron sheet,120mm by 100mm by 2mm thickness and 96mm depth. developed as per design drawings
12.	Electric motor	1	Approximately 5 horse power

4.3 Weight considerations

The weight of the dehusker was estimated by calculating the volume of the parts and using the density of the material used in construction to approximate the mass and hence the weight. Density of mild steel is 7860kg/m^3 and acceleration due to gravity is 9.81m/s^2.

The angle bars used to construct the frame are 40mmx40mmx3mm. Therefore the weight of the frame of the modified prototype is given by;

Weight of the proposed frame of the design;

Weight = (volume x density) 9.81

$= (1.59 \times 10^{-3} \times 7860)\ 9.81$

$= 122.68N$

Mass = 12.5 kg

The weight of other parts and components are calculated below.

The cover shell

Weight = (volume x density) 9.81

$= (2.1616 \times 10^{-3} \times 7860)\ 9.81$

$=166.67N$

Mass = 17kg

Hammers and holders

Weight = (volume x density) 9.81

$= (3.887 \times 10^{-4} \times 7860)\ 9.81$

$= 30.086N$

Mass = 3.056kg

The hopper

Weight = (volume x density) 9.81

= $(4.0 \times 10^{-5} \times 7860)\ 9.81$

= 3.0843N

Mass = 0.3144 kg

***The chute*.**

Weight = (volume x density) 9.81

= $1.132 \times 10^{-4} \times 7860)\ 9.81$

= 8.728N

Mass = 0.89 kg

Pillow blocks.

Mass = 2 x1.5 kg

3.0kg

Weight = 29.43N

shaft.

Weight = (volume x density) 9.81

= $(2.95\times 10^{-5} \times 7860)\ 9.81$

=22.71N

Mass = 2.815 kg

Motor

The mass of the I.C engine to be used is given as;

Mass = 6 Kg

Weight = (6 x 9.81)

=58.86N

The total weight of the machine is given by;

Total weight = (122.68+166.67+30.086+3.0843+8.728+29.43+22.71+58.86) N

= 999.6036N

Total mass= 999.6036N ÷ 9.81

=101.896 Kg

4.4 Power requirement

The source of power can either be a motor powered by electricity, human -powered or by the use of an internal combustion engine. This design is based on the electricity-powered motor as it is to be used for testing after which it may be improved to be human ï powered or internal combustion powered as it may be used in the rural areas where there is no electricity.

Since it has not been tested, it can be assumed that the power required to dehusk one kilogram of the croton seeds will be measured by multiplying the power rating of the motor used and the time used to dehusk one batch of 1 kilogram completely.

4.5 Operational description

The dehusker works as follows:

a. The operator pours a certain amount of croton seeds in to the hopper and opens the upper retaining slide. The seeds will pour into the drum.

b. The setting of the pulleys is done so as to set the speed of the hammers

c. The machine operator turns on the motor

d. The already rotating dehusker hammer blades then come into contact with the seeds thus putting them on an angular path. At the top of the drum, the seeds move tangentially, hitting the top part of the drum and hence are dehusked. They then fall down to the lower bottom of the drum.

e. After sometime of running, the operator stops the machine, opens the lower retaining slide and the dehusked seeds together with the husks are removed via the chute into a reservoir.

Testing of the dehusker to determine if any other hazards exist as well as the amount of time it takes for the cylinder to stop following full speed operation can only be done during field testing and the results obtained can dictate the necessity of additional braking system.

4.6 Design review

The model design is to be assembled and tested in order to determine the speed, effectiveness and time of croton seed dehusking.. To enhance performance of the machine, the de-husked seeds were studied and adjustments made until the seeds have the desired characteristics i.e. quality. The outer husk which is the overall seed enclosure should be fully removed hence exposing and releasing all of the kernels. The result of the model test is to enable us analyze the impact characteristics of the croton seed which shall be the major basis when designing the prototype.

When evaluating the components directly associated with de-husking, the main variables of interest are the rotational speed, time, feed rate and clearance between the hammers and enclosing surface. The speed affected how many times the hammer blades contacted the seed as it was fed through the machine. The speed of the hammer axle was calculated after determining the speed of the motor. Assuming that motor is running at full speed the rated speed can then be used to determine the hammer axle speed. However in real life motors operate at speeds lower than the rated speed, in that case speed of the motor can be measured using a tachometer.

The speed of the hammer axle is a major component of both the pitch parameter and the power parameter. Changing the speed to accommodate one parameter affects the other. Speed was also dependent on the gearing used in the drive train. Varying the speed required purchasing and installing new pulleys. The desired value of pitch was not precisely determined. Initial estimates of appropriate pitch must be evaluated using trial and error. Rotational speed and feed rate both affect the pitch. Both variables can only be adjusted by using different sized pulleys.

There should be consideration on the clearance between the cover shield and the hammer blades so that the seeds will not be crashed to dust. It is therefore recommendable to design for adjustability of clearance between the cover shield and the hammer the blades strip the skin cleanly while not cutting into the fibers far enough to damage them. This was accomplished by moving the breast plate rather than lengthening the blades. Clearance was one of the only components of the power equation that was easily variable. For that reason, determining the ideal power through experimental testing was dependent on clearance.

The main concern for the casing was its strength and vibration. Strength can be achieved by using the correct material specifications. Sheet metal should tested for the for noise vibration while the machine is in operation. The performance of the mobility feature is dependent on the ability of an average person to move the dehusker without assistance. The safety component had no effect on the performance of the dehusker but it is vital to the overall design. The safety features will be added late in the construction or testing phases so that other components can first be accurately tested.

CHAPTER FIVE

SAFETY AND MAINTENANCE

5.1 SAFETY

Safety is a feature that should be put into great consideration in the design of any engineering component. This is important in avoiding injuries to humans and damage to the machine. Croton seed dehusker is non-exception since it has moving parts which if left unguarded can trap loose clothing of the operator thus causing serious injury. Due to this all pulleys and belts on the final design should have tailored guards.

It is also advisable for the machine operator to wear protective gear especially gloves overalls and goggles during the operation of the machine. This will help in protecting the operator from dust which is irritating and uncomfortable when it gets into our breathing system.

In order avoid machine damage; always use it for the intended purpose only. Foreign materials such as metallic objects can damage the hammer blades and therefore should never be introduced into the machine. Feeding must be regulated so as to avoid overloading hence preventing machine damage.

Defects such as cracks will always exist in any material. Vibration causes crack growth; care must therefore be taken during the machine operation to make sure that its standing on stable ground. If this is overlooked the machine is bound to vibrate during operation and the safety of the machine will be at the stake.

Unauthorized persons should not operate the machine and the machine should be kept in a safe place when not in use.

Daily cleaning after work should be. Plain water can easily be used for this purpose. The machine should also be protected from direct sunlight and rainfall by storing it under a shade when not in use which can damage the motor.

5.2 MAINTENANCE

The operator should ensure that all moving parts including the bearings, wheels bearings, bolts and nuts and other rotating components are regularly lubricated to avoid wearing and rusting of parts and thus generally reducing the cost of replacement. The machine should be regularly cleaned after every dayǒs operation. The collecting bin should always be emptied and cleaned after use.

Loose bolts and nuts should be tightened on the hammer axle and other parts of the machine. Any worn out parts should be replaced.

CHAPTER SIX

6.1 *CONCLUSION AND RECOMMENDATIONS*

This design is to be improved to be able to incorporate a variety of improvements, this includes:

- Enhancements to manufacturability, the design were demonstrated as having high manufacturability through simple design. This is confirmed by the availability of the manufacturing processes used in Kenya.
- weight and portability
- Safety and ease of use.
- There is need for an extensive testing was not realized due to time limits, it was recommended that future design teams assigned to this project should test the variable parameters available in this design model, including using different time periods, hammer axle speeds achieve by employing variety pulley ratios. Some elements should be tested during construction and assembly. The elements relating to the dehusking process including proper clearance values for the hammers should be installed late into the design after field testing. The drive system itself should be given higher priority early on in the conceptual stages.
- Vibration throughout the machine was well dampened through natural damping thus allowing relatively smooth operation. Through the design process, a greater knowledge of designing for manufacturability was attained. Future revisions to the design will include installation of safety guarding and a kill switch as well as testing and optimizing the compliment of adjustable settings. The project will be continued by the University of Nairobi student engineers.

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APPENDICES