

**DESIGN AND FABRICATION OF A DUAL MECHANIZED CHICKEN PLUCKING
AND YAM POUNDING MACHINE**

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BENIN CITY**

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**A RESEARCH PROJECT SUBMITTED TO THE DEPARTMENT OF
PRODUCTION ENGINEERING, FACULTY OF ENGINEERING, UNIVERSITY OF
BENIN, BENIN CITY, IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD BACHELOR OF ENGINEERING (B.Eng.) DEGREE.**

JULY, 2021

CERTIFICATION

This is to certify that this project was carried by **Erhabor Faith** with matriculation number **ENG1604402** of Production Engineering Department, Faculty of Engineering, University of Benin, Benin City.

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DEDICATION

This project work is dedicated to the ALMIGHTY GOD for his guidance and protection whose loving mercy has kept me this far during the course of this project and to my ever supportive family.

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With utmost sincerity, I say a big thank you to the ALMIGHTY GOD the author, and finisher of my faith, who has always been there for me and who has made me what I am today and also for the success of this project work.

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ABSTRACT

Over the years, feather plucking of birds and pounding of yams of all types and varieties are always done manually without specific attention to the health related challenges associated with such practices. Again, the quality of the processed birds and pounded yam quantity required, were not of interest. Today, the health implications, unit cost of de feathering and pounding, the quality and quantity of processed birds and pounded yam are of interest and paramount importance to farmers. Hence, this work is aimed at designing and manufacturing a dual modernized friendly feather plucking machine and yam pounding machine using locally available materials.

The method adopted for this project work include the selection of appropriate materials, including, mild steel sheet for framing the machine, stainless steel drum carefully manipulated to form the plucking basin and pounding basin. Other locally made materials used for the construction include, tapered plucking fingers made of rubbers, plastic pipes and fittings. Also, the desired electric motor to drive the system using appropriate pulleys and belts were selected using appropriate mathematical models.

Result showed that at an operating speed of 1440 rpm, birds with average weight of 1.5 kg soaked in water for about 85 degrees Celsius for approximately minute were de feathered in 20 seconds and 2 yam piece of 2kg each pounded at 3 minutes. Other results showed that the weight, temperature of the water, the speed of the motor and the duration of soaking of the bird in water and the weight of yam pounded were all important variables to be addressed to enhance the efficiency of the machine and the quality of both dressed birds and yam pounded.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Pounded yam and chicken are one of the common food and meat served in Nigerian occasions. The crude method of processing these foods is laborious, time consuming, and hazardous as the case may be. Hence the need to produce machines capable of enhancing the processing of these foods in a limited time interval and stress free with maximum efficiency becomes very necessary. This machine when developed will enhance the hygienic processing of both yam and chicken for both domestic and commercial consumption, while eliminating the tedious and laborious indigenous process of preparing them.

1.1.1 Yam Pounder

Pounded yam is a common meal in Nigeria, especially within the Yorubas and the Igbos; it is consumed domestically and mostly in many important occasions. Pounded yam is consumed with individual choice of soup such as Ogbono, Ewedu and spinach with Egusi soup. Thus pounded yam is an authentic African food and the presentation of it with Ogbono or Egusi soup to visitors in Igbo and Yoruba lands in Nigeria for example is considered an act of great love and respect. Its medicinal use as a heart stimulant is attributed to its chemical composition, which consists of alkaloids of saponin and sapogenin. The indigenous process of pounding yam is done using a mortar and a pestle, the process is very laborious. It requires physical pounding by one or more people depending on the quantity in the mortar.

In a bid to reduce the labor involved in yam pounding came into being the manufacturing of Habert mixer, Kenwood mixer and hammer mill in early 1975. These intended yam pounders failed due to some limitations in their operational functions. The Habert and Kenwood mixers had almost the same operational principle and they had been identified for poor pounding due to the flapping (moving up and down) of their stirrer or mixer which is keyed to the electric

rotating shaft. Also the mixers had excessive heating problems and as a result, the machine has to be stopped intermittently for cooling purpose, this time needed for cooling makes the machine inefficient since the pounding temperature has to be constant throughout the pounding process in order to obtain a fine textured pounded yam.

1.1.2 Chicken Plucker

Since the restriction of the importation of frozen chicken into the country by the Nigerian government in order to improve the economy of the nation, the demand for a well prepared chicken has been past to the local poultry farmers, who are required to supply a specific amount of chicken on demand. Hence poultry processing plants has been incorporated into the businesses of these poultry farmers in order to comply with the demand on the product, this processing of chicken cannot be done by crude process on a large scale hence there is the introduction of a chicken plucking machine, which do not only help to save time and energy but also make the processing of the chicken free from infection and diseases, also this machines help to prevent injuries due to burnt which are usually associated with the crude means of processing chicken by hand plucking. The machine is able to pluck feathers of chicken of weight ranging from 1.8kg – 4.5kg.

1.2 Problem Encountered

The method usually employed to produce pounded yam is crude and unhygienic. There are many problems associated with manual pounding of yam, which includes; presence of dirt as a result of the wooden nature of the mortar, also the food can be contaminated by sweating during pounding. Also due to the involvement of women in the work force of African countries which was not possible in time past, has completely displaced the concept of full time house wives making it almost impossible for families to prepare pounded yam. Also the number of yam that can be pounded over a specified period of time is quite limited and thereby reducing efficiency of production. With all these aforementioned problems in mind

hence there is need for mechanization of the production of pounded yam in order to improve all round efficiency and hygiene of food production.

Similar problems also persist in the crude plucking of chicken by hand; since the chicken are usually very hot when dipped in hot water and this can cause burns to human hands, also hand plucking may lead to food contamination. Also the number of chicken that can be processed by hand is usually very small compared to the ones that can be processed by a chicken plucker. The skin of the chicken is usually damaged to a larger extent during hand plucking as compared to using a machine.

1.3 Aims

The aim is to design and fabricate a dual mechanized chicken plucking and yam pounding machine.

1.4 Objectives of the Study

The objectives are to:

1. Calculate the probable efficiency of the machine.
2. Determine the time taken to de-feather the bird on the machine as opposed to manual plucking.
3. Determine the scalding temperature at which the feather will be adequately removed from the chicken without any scar.
4. To design and develop a portable electromechanical device which will be more efficient, less time consuming with less human effort and of a greater hygienic processing.
5. To make the beaters detachable for easy maintenance.

1.5 Scope of Research

The design and fabrication is considered with only a prototype commercialization and market feedback is not inclusive in the study. Problem definition is covered in order to realize the

purpose of the research. Literature review of past work on this research work was also examined in order to understand the areas that need improvement. The chicken plucker machine can be used to pluck the feathers of poultry birds such as chicken, turkey etc., it has a capacity of one bird at time and can pluck chicken feathers within a period of 30 seconds to 60 seconds. Also the yam pounding machine can be used to produce pounded yam effectively without contaminating the food and producing a fine textured pounded yam within a short period of time.

1.6 Significance of the Study

The benefit of producing a yam pounding machine and a chicken plucking machine cannot be over emphasized in our ever advancing environment, some of the benefits of these machines are outlined below;

Yam Pounding Machine

1. It saves time and energy usually expended during traditional pounding of yam.
2. It relieves the responsibility of pounding yam only by a certain group of people in the community or family by making it easier for everyone at any age(both old and young) to effectively make pounded yam.
3. It helps to relieve stress involved in pounding yam.
4. It prevents food contamination.
5. It helps to make the food readily available.

Chicken Plucker Machine

1. It reduces food contamination.
2. It prevents damage of the skin of the chicken which is a common characteristic of traditional plucking of chicken feathers.
3. It reduces burns of human hand caused by hot water during traditional plucking of chicken.

4. It requires little or no technical knowhow to pluck chicken feathers.
5. It saves time and energy.
6. It also serves as means of employment to poultry farmers.
7. It helps Nigerians to cope with the importation ban on chicken by making chicken readily available to the public.

CHAPTER TWO

LITERATURE REVIEW

Development of a poultry de-feathering machine is such an economical practice of a mechanized poultry processing plants to replace the removal of poultry feathers by hand for meat preparation, so as to increase the numbers of poultry products processed per day. On the other hand de-feathering or plucking simply means the process of removing feathers from scalded fowls. Therefore, development of a poultry de-feathering machine is planning and building of a mechanical structure that will remove feathers of poultry birds (Jekayinka, 2007).

This work is important in that it will solve the problem of manual plucking of feathers which is often associated with health challenges due to the unhygienic way in which they are handled most times. It is also relevant in the sense that more time, energy and loss of manual labour (man-hour) will be saved thus increasing productivity which in turn increases the profit margin of the firm.

Let us at this point talk a little about some of the component part of a chicken, feathers, scalding, methods of scalding and scalding temperatures for various

2.1 Parts of a Chicken

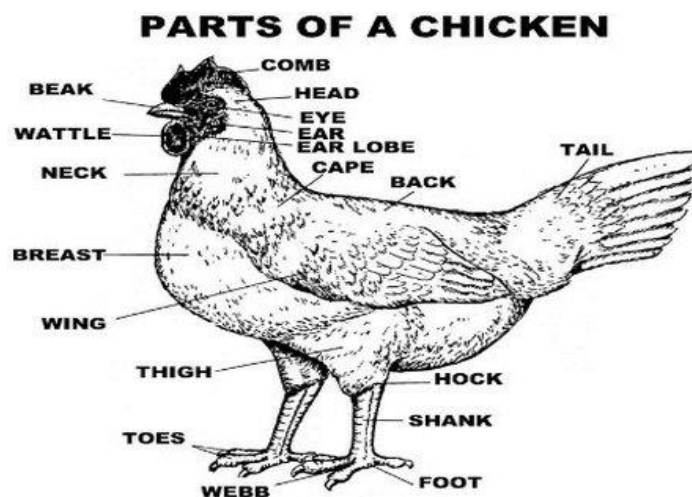


Fig 2.1: Parts of a Chicken

Comb – The comb is a red fleshy appendage on the top of the chicken's head.

Eyes – Chicken have two eyes, one on each side of their head and the eyes should be dark and prominent.

Ear Lobes – Chicken have two ear lobes, one on each side of their head.

Beak – Chicken have an upper and lower beak. The beak is usually a yellowy colour.

Wattles – Chicken have two wattles which hang below the beak. Wattles are fleshy skin and are generally red in colour.

Breast – The breast is at the front of the bird and should be broad and plump.

Wings – Chicken have a set of wing feathers on either side of the body which allow them to fly.

Tail Feathers – The tail feathers are the same colour as the other feathers and point upwards.

Vent – The vent is the external opening referred to as the anus or cloaca. This is the opening which allows the birds to excrete and for the females to lay their eggs.

Hock – The hock is the leg joint which bends in the opposite direction to a human knee.

Shank – The shank is the bird's lower leg. Chicken have two legs which have a scale like appearance.

Toes – Chicken have four toes on each foot. Three of their toes point forward and one faces back for balance.

2.2 Feathers

Feathers cover most of the chicken's body. Most breeds of chickens have bare legs, but some have feathers growing down their legs and even on their toes. Other variations of feathering include *muffs*, puffs of feathers around the ear lobes; *beards*, long, hanging feathers beneath the beak; and *crests* or *topknots*, poofs of feathers on the head that may fall down and cover the eyes. Some breeds of chickens appear fluffy, and some appear smooth and sleek.

Chickens with smooth, sleek feathers are called *hard-feathered*, and birds with loose, fluffy feathers are called *soft-feathered*.

Birds shed their feathers, beginning with the head feathers, once a year, usually in the fall. This shedding period is called the *molt*, and it takes about 7 weeks to complete. The molt period is stressful to chickens.

2.2.1 Types of Feathers

Contour Feathers: Are the outer feathers that form the bird's distinctive shape. They include wing and tail feathers and most of the body feathers.

Down Feathers: Are the layers closest to the body. They provide insulation from cold temperatures. Down feathers lack the barbs and strong central shaft that the outer feathers have, so they remain fluffy. Silkie chickens have body feathers that are as long as the feathers of normal chickens, but their outer feathers also lack barbs, so the Silkie chicken looks furry or fluffy all over.

Feathers also vary according to what part of the chicken they cover. The following list associates these various types of feathers with the chicken's anatomy:

- **On the Neck:** The row of narrow feathers around the neck constitutes the *hackles*. Hackle feathers can stand up when the chicken gets angry. These feathers are often a different colour than the body feathers, and they may be very colourful in male birds. In most male chickens, the hackle feathers are pointed and iridescent. Female hackle feathers have rounded tips and are duller.
- **On the Belly and Midsection:** The belly and remaining body areas of the chicken are covered with small, fluffy feathers. In many cases, the underside of the bird is lighter in colour.

- **On the Wings:** Chickens have three types of feathers on the wings. The top section, closest to the body, consists of small, rounded feathers called *coverts*. The middle feathers are longer and are called *secondaries*. The longest and largest feathers are on the end of the wing and are called *primaries*. Each section overlaps the other just slightly.
- **On the Legs:** Chicken thighs are covered with soft, small feathers. In most breeds, the feathers end halfway down the leg, at the hock joint. In some breeds, however, the legs have fluffy feathers right down to and covering the toes.
- **On the Tail:** Roosters have long, shiny, attractive tail feathers. In many breeds, the top three or four tail feathers are narrower and may arch above the rest of the tail. These are called *sickle feathers*. Hens have tail feathers, too, but they are short and plainly coloured and they don't arch.

2.3 Scalding

Scalding is the process of treating carcasses with hot water or steam to loosen the hair or feather in the follicle to aid their removal (Warriss, 2000). Pork and poultry carcasses are both subjected to a scalding operation during processing. The time and temperature of the heat treatment are primarily determined by the need for efficient removal of the bristles or feathers by the dehairer/defeatherer (Bolton, 2004). Too low a temperature and the hair/feathers will not be loosened; too high a temperature and the skin will be cooked and the hair/feathers will be difficult to remove and there is also a risk of denaturation and shortening of the outermost layer of muscle. The simplest equipment consists of a tank into which the carcass is lowered by a hoist.

The water is heated by oil, gas, electricity or an open steam-pipe. Alternatively vertical cabinets utilizing hot-water sprays or steam can be used. Temperatures between 58 and 62 °C

are normally used for 5–6 min for pig carcasses (Gracey et al, 1999), while temperatures of 50–51 °C for 3.5 min are employed for ‘soft’ scalded chicken carcasses destined for chilling, or 56–58 °C for 2–2.5 min for ‘hard’ scalded carcasses destined for freezing (Mountney, 2001).

2.3.1 Methods of Scalding

1. Soft scalding/semi scalding entails scalding for 60 to 180s in water at 50 to 53°C. This method leaves the epidermal layer intact, which is why it is commonly used for young broilers and turkeys but still allows for relatively easy feather removal (Fletcher, 1999). Birds slaughtered for display should be scalded in this way to improve the appearance of the carcass, since water that is too hot will cause the outer layer of skin to loosen or be lost. Such loss also results in the loss of some yellow pigment from the skin.
2. Sub scalding/medium scalding is used for mature birds, and involves using water at 54 to 58°C for 60 to 120 s. The epidermal layer is broken down by this time–temperature combination, and the feathers are usually much easier to remove.
3. Hard scalding/full scalding requires a water temperature above 60°C for 45 to 90 s. This method is faster and eliminates pinfeathers, but the birds tend to dry out and have a less desirable appearance (Mountney, 1989). It is easier to remove the feathers from carcasses scalded at this temperature than from those scalded at lower temperature, but the flesh of such poultry is “doughy” and lifeless and the skin becomes discoloured soon after processing. As a result, the carcass must be kept covered with a packaging material or moist with ice or water. Waterfowl may be scalded at this temperature because it is the only satisfactory way to release feathers, while the skin of waterfowl does not discolour as readily as do other species of poultry (Barbut, 2004).

Careful equipment design is required for meat hygiene. Since 1 g of soil material (e.g., dirt, faecal material) attached to the feathers can contain 10^8 – 10^9 microorganisms, it is important to minimize cross-contamination in this common bath (Mulder and Dorrosteijn, 1977). Maintaining and controlling the temperature is one of the key features to keep bacterial load under control. Another means is the use of a counter flow design (clean water introduced at the exit end of the tank, and water flow towards the entrance where the more contaminated birds are introduced).

Installing a multistage scalding tank system can further reduce contamination problems; this would consist of 2–4 water tanks, where the carcasses are moved from the initial, more contaminated bath, to the cleanest bath at the end. Lillard (1973) reported that when scald water contaminants enter the broiler’s respiratory system during immersion scalding, they can be spread to the circulatory system and to the internal organs, and possibly throughout the entire carcass.

Table 2.1: Common Scalding Times and Temperature for Various Classes of Poultry (Barbut, 2002)

Classes of Poultry	Time	Temperatures
Broilers (hard scald)	90-120 seconds	56-58°C
Broilers (soft scald)	180-220 seconds	50-51°C
Turkeys	50-125 seconds	59-63°C
Quail	30 seconds	53°C
Waterfowl	30-60 seconds	68-82°C

Variables requiring consideration during the scald process step are mechanical, physical, and chemical.

Mechanical variables include counter-current flows and agitation to produce a washing effect. Counter-current systems move water counter to the direction of poultry carcasses at all points. Water enters the system at the point where poultry carcasses exit, and water exits at the point where poultry carcasses enter, producing a dirty-to-clean gradient that continually moves poultry carcasses into cleaner water.

Cleaner water is a relative condition as the amount of dry matter and microorganisms in the scald water increase over time. Physical variables are time and temperature, which influence washing and antimicrobial effects. The chemical variable is pH, which also influences the antimicrobial effect. Immersion scalding is the most common scald technology in use and is best described as dragging carcasses through a tank of hot water (Barbut, 2002). Immersion systems come in single- and multi-stage configurations, incorporating mechanical and physical variables. Single-stage systems provide less washing effect than multi-stage systems. U.S. Poultry processors in the United States prefer a “hard scald” combining shorter scald times and higher scald temperatures. A “hard scald” facilitates removal of the epidermis, which enhances the adhesion of coatings commonly used with fried foods. European poultry processors prefer a “soft scald,” combining longer scald times and lower scald temperatures. A “soft scald” retains much of the epidermis and natural skin colour.

Steam-spray scalding is a less popular alternative. Klose et al. (1971) and Dickens (1989) found that a mixture of steam and air at 50 to 60°C and 137.9kPa pressure applied for approximately two minutes provided a uniform scald of either dry or damp broilers, facilitated feather removal, and yielded carcasses microbiologically equivalent to immersion

systems. Some religious dietary laws prohibit scalding and soak poultry carcasses in cold water.

2.3.2 Various Carcass Scalding Temperatures

The appearance of the dressed bird when sold is largely determined by the temperature of the water in which it was scalded before feather removal. The length of time and numbers of birds that may be processed per hour with specific equipment are also very dependent on the scald temperature. There are three major categories of scald, distinguished by temperature and types of birds. (J. Pitchovsci et al, 1997); (S. Barbut, 2002).

Carcass Scalding at 51°C – 54°C for 45 seconds: Under normal ice storage condition, birds scalded at this temperature will last for just 7-10 days without any discolouration, and they retain their skin colour. However, at this condition it is always difficult to pluck with any type of plucker due to the inadequate scalding temperature. Also, the longer duration required for plucking limit the number of birds the equipment will be able to process within an hour and will not be able to do a thorough job (S. Barbut, 2002). (J. Pitchovsci et al,1997) used scalding temperature of 50-53°C for 60-180 seconds duration for young broiler and young turkey because it does not damage much of the outer layer of the skin, while it still allows for relatively easy removal of the feathers.

Carcass Scalding at 60°C – 62°C for (15-30 seconds duration): This scald does not require as long a time in the picker's mechanism, as the equipment will perform faster and will also do a more thorough cleaning. But the appearance of the bird will last only 4-5 days under refrigeration, (S. Barbut, 2002). (J. Pitchovsci et al, 1997) used 54-58°C for 60-120 seconds for mature birds which can cause the removal of part of the outer skin layer that leaves the skin sticky.

Carcass Scalding at 71°C and above for (10 seconds duration): At this scalding temperature, no hand picking of the remnant pin feathers is necessary. Birds processed at this temperature are white and may start to discolour in as little as 3 days. Thus, the type of scald to be selected is very important in selecting processing equipment, particularly for automated one rather than manual (S. Barbut, 2002). (J. Pitchovsci et al, 1997) reported that poultry scalded at temperature range of 59-61°C for 45-90 seconds duration, has skin discolouration which does not occurred in water flow.

2.4 Existing Chicken Plucking Machine

To this end, search conducted revealed that most researchers in the developed nations of the world had worked in this area extensively. A good example includes Barbut (1998) who in his work estimated the magnitude of the problems associated with poultry processing system. Also, Dickson and Shackelford (1998) investigated the stunning time, scalding time and scalding temperature with respect to feather releasing forces associated with some types of birds. Similarly, Pitchovsci et al. (1997) identified the starting point of breast skin tear during plucking and x-rayed how the problem can be avoided using the best temperature and time merging for soaking of the individual birds.

In the tropical West Africa region, including Nigeria, not much had been done in this research area. However, Adetola et al. (2014) designed and developed a household poultry de-feathering machine for boilers. The paper observed that tearing of the carcass during plucking process is the major problem associated with bird dressing; the paper however added that this problem was taken into account during the design process of the developed machine. In a related work, Jekayinfa (2005) carried out a general energetic analysis of poultry processing operatives with a view of recommending the desired range of operations with respect to the type of birds, temperature range and the soaking time. Also, Adejumo et al. (2013) evaluated a feather plucking machine using two breeds of birds namely Isa brown

and Cockerel at machine speed of 225, 312, 369 and 426 rpm. With a scalding time of 30, 60 and 90 seconds respectively. The result of the work showed that the developed machine performed better when the speed was increased with cockerel having the better plucking result. Also, Adeyinka and Olawale (2015) carried out performance evaluation of chicken de-feathering machine for small scale farmers. The paper observed that it took the machine about 25 seconds to de-feather poultry birds with a machine speed of 300 rpm. However, the paper failed to indicate the specie, type and age of birds that were evaluated.

In a related development, Adetola et al. (2012) considered birds raised in South Western Nigeria with a view to establishing the optimal scalding temperatures of both the exotic and local breeds. The result of their finding showed that for local breeds, the scalding temperature of 80°C – 85°C is adequate, while those of the exotic breed falls between 65°C to 70°C.

Also, Ugwu et al. (2015) carried out optimization and performance evaluation of a developed feather plucking machine. The result obtained in the study showed that at 400 rpm the machine was able to pluck completely at an average time of 22.8 seconds. The paper added that the speed of the machine and the species of poultry birds affects the efficiency of the machines.

In south-western Nigeria, Taniomola et al. (2011) designed and developed a bird de – feathering machine capable of de – feathering 360 mature birds in an hour, irrespective of the type of bird involved. The paper added that the machine recorded about 96 percent when tested with under controlled condition. Elsewhere, Nguyen et al. (2011) investigated the optimal operational parameters for a chicken slaughtering system in Vietnam. The paper recommended an optimal scalding temperature of about 67 degree Celcius and an optimum scalding time of 80 seconds. Again, Irshad and Arun (2013) studied the pathogenic and non-pathogenic micro-organism introduced into the system during scalding. The paper added

that the micro-organism is found in the internal and external surface of the carcass in addition to the ones found in the scalding water. The paper added that it is very important to rinse the birds in warm water so as to remove all traces of blood in the carcass. By so doing, most of the micro-organism will be washed and rendered inactive.

2.4.1 Plucking Feathers with Treadle-Powered Pluckers

The earliest patent found for a feather-plucking machine was issued in 1891 to a Virginia man. This foot treadle-powered device had two rollers that turned in opposite directions. The upper of the two rollers was spring-loaded to press firmly against the lower while allowing it to rise when feathers passed between the rollers. The bird was manipulated on a slanted table and a guard prevented the rollers from catching the fowl's skin. The operator got the rollers turning by working the treadle with his (or, more likely, her) feet and held the bird against those rollers, manipulating it to ensure that all the feathers were removed. It probably wasn't much easier or faster than hand-plucking.

Speaking of hand-plucking, Ernest Hausen comes to mind, who was born July 4, 1877, in Fort Atkinson, Wis. Hausen worked at McMillen's Meat Market in that city and became Fort Atkinson's only world champion when, in 1922, he won the National Chicken Picking Championship, denuding a bird in just 6 seconds. He won the title every year until his death in 1955, even though he competed against both men and machines. His best time, only 4.4 seconds, was set on Jan. 19th, 1939, and is supposedly listed in both *Ripley's Believe it or Not* and the *Guinness Book of World Records*.

2.4.2 The Rise of the Feather-Plucking Machine

In 1903, a patent was awarded for a device that utilized a series of complicated cam and bell crank-driven jaws. These jaws, also powered by a foot treadle, descend to grab a bunch of feathers, give a quick upward movement to jerk them out and withdraw inside a shroud.

There they opened, releasing the feathers, which were caught by the air blast of a fan and moved away from the machine.

The first feather-plucking machine to use a form of rotary rubber fingers was patented in 1906, although the fingers were only the final step in the operation. After manipulating the bird under another complicated set of moving jaws to remove the feathers, “the bird may be held in the path of the rubber flaps upon the ends of the arms of the rotary brush and the down may be easily and quickly wiped from the skin.”

Several other wholly impractical-looking plucking machines were invented during the first decade of the 1900s, including a hand-held gadget that looked a lot like a flexible shaft-powered horse clipper, except it had two corrugated rollers instead of knives. As the machine was passed over the bird’s body, the feathers were raised by a coarse comb and then grabbed by the rollers and yanked from the skin.

A similar hand-held machine used an attached vacuum hose to remove feathers after they had been pulled by rollers. The inventor stated these “well known facts: That fowls that are dry-picked bring better prices on the market than those that are picked wet. That the picking of fowls is very laborious (and) costly. That the down feathers of certain fowls are valuable. That in picking, great care must be taken to prevent tearing the skin.” Of course his invention met all these criteria swiftly and “at small cost.”

2.4.3 Automating De-Feathering

In 1917, machines with two opposing rotary brushes were produced. Each brush had long, semi-stiff bristles. When a bird was lowered between the brushes, the feathers were rubbed off without damage to the skin. In 1924, a device was invented with a series of spinning, flexible rubber fingers against which the bird was held. It was among the first of its kind.

One of the first machines that didn't require the bird to be held and manipulated by an operator during the de-feathering process was patented in 1928 by a Schenectady, N.Y., man. It featured a horizontal cylinder with an inner cylindrical liner that contained rows of longitudinal slots with saw-tooth edges. Closely fitted inside was another cylinder that rotated and also contained longitudinal slots with saw-tooth edges. Finally, inside that cylinder was an auger that also rotated. In operation, an airtight door allowed a bird carcass to be placed into one end of the auger. A vacuum was then introduced into the outer cylinder and the auger and inner cylinder set to rotating. As the bird was tumbled and moved the length of the cylinder by the auger, the feathers were pulled by vacuum through the slots, where they were caught between the saw-tooth edges of the slots in the fixed cylinder and the moving one and jerked from the skin.

By the 1940s birds were hung on conveyors and scalded and run through picking machines without being handled manually. Great improvements in efficiency, automation and sanitation have been made, and today fowl are run through the initial processing at the rate of almost 100 birds per minute, including stunning, killing, bleeding, scalding and de-feathering twice, evisceration, washing a couple of times and immersion of the carcass in a chilling bath.

Most of today's plucking machines are too big and expensive for home use, although a handful of small-scale poultry growers have developed machines for picking a few birds.

Various machines have also been developed for de-feathering process which can handle either large or few number of birds. However, their demand and acceptance are different from one continent to the other. Some years ago for instance, Nigerian government banned importation of some poultry processed meat. This step placed a boost on the operation of indigenous poultry industry and allied. (Lucas E.B et al, 2013).

Various machines have also been developed for the de-feathering process which can process large or few numbers of birds (J. Glenn, 1998). However, their demand and acceptance differ regionally.

The Mueller poultry picker (C. B. Mueller Jr, 1951) for instance is electrically powered using a driving pulley mechanism in rotating a cylindrical drum embedded with rubber fingers matrix. The design also incorporates a collection bowl for the plucked feathers.

Gordon (G. W. Brown et al, 1964) however designed the plucker using an electric motor with an extended two pulley shaft attached which allows for counter-rotation of drums. The drum holds the rubber fingers which pluck the feathers upon the rotation of the as seen in figure 5. The fingers assume positions radial to the drums, due to the centrifugal forces on the holders and fingers. The wiping motion of the ribbed surfaces of the fingers removes the feather from the carcass.

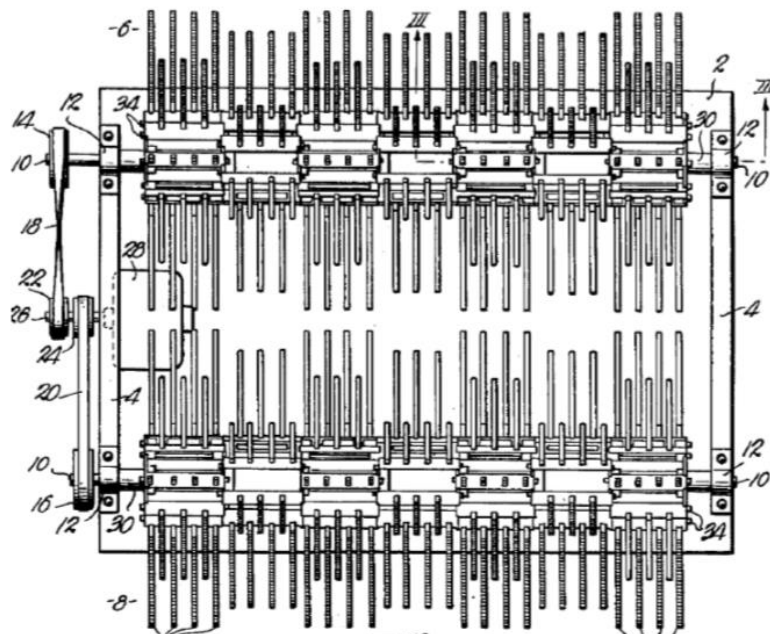


Fig 2.2: Plan view of the Gordon poultry plucker

T F Schlicksupp poultry plucker (T. F. Schlicksupp, 1938) had an advantage over others as it introduced a fan (vacuum) for removal of a plucked feather. The design was also the electric-based rotation of the drive shaft. The fan is in a casing which communicates with the plucking chamber if to draw the feathers from the latter chamber for discharge those through an outlet spout to any desired point. The plucking chamber however used strips of steel, at its outer edge is appreciably wider or thicker than the main portion of the strip and on the periphery or outer portion of the strip, the surface is given a convex curvature, and the sides of the outer portion of the strip are given a concave curvature. This shape of strip provides relatively sharp gripping edges at both sides of the outer portion of the strip to effectively grip the feathers when the convolutions are brought together which, of course, is the contracted condition of the plucker, so as to effectively grip and draw the feathers from the fowl and when the convolutions are separated, the feathers are released which sometimes cause skin tear (J. Pitcovski et al, 1997).

Roy Smith Chicken Plucking Device (R. B. Ford, 1999) introduced a simple motor-driven pulley for the cylindrical picker drum whose surface provided a multiplicity of spaced, transversely disposed of, radially projecting picker elements. The picker elements are soft rubber disc having outwardly presented lip portions that penetrate the feathers by the movement against the birds to uproot the feathers out of the skin. This design, however, does not utilize the pulling action as seen in (C. B. Mueller Jr, 1951); (G. W. Brown et al, 1964).

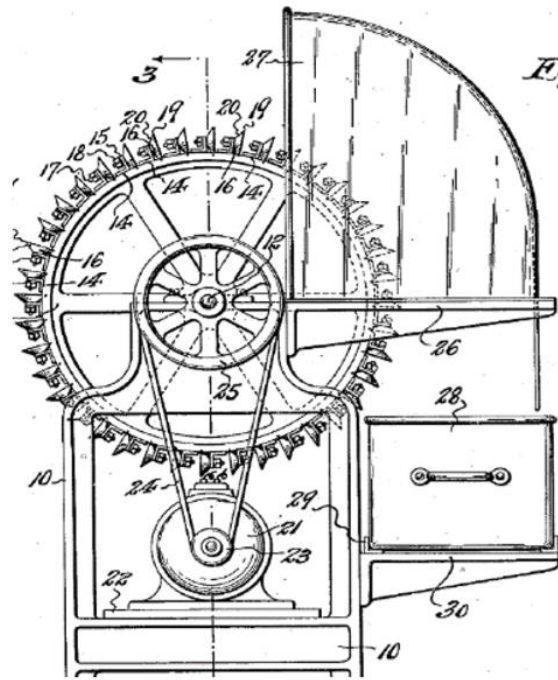


Fig 2.3. Smith plucking apparatus

Raleigh F. Lane prototype (R. F. Lane, 1974) had an electrically driven long shaft attached with rubber fingers at the end, the bird is held and maneuverer manually by the operator for efficient plucking.

The yard bird chicken plucker (ardisam, 2017) also incorporated direct drive connection to the rotating plate. The materials in contact with the chicken were made using stainless steel, and incorporated hose supplied water into the machine.

2.4.4 Development of Chicken Plucking Machine in West Africa and Nigeria

In the tropical West Africa region, including Nigeria, not much had been done in this research area. However, Adetola et al. (2014) designed and developed a household poultry de-feathering machine for boilers. He observed that tearing of the carcass during plucking process is the major problem associated with bird dressing; He however added that this problem was taken into account during the design process of the developed machine.

In a related work, Jekayinfa (2005) carried out a general energetic analysis of poultry processing operatives with a view of recommending the desired range of operations with respect to the type of birds, temperature range and the soaking time.

Also, Adejumo et al. (2013) evaluated a feather plucking machine using two breeds of birds namely Isa brown and Cockerel at machine speed of 225, 312, 369 and 426 rpm. With a scalding time of 30, 60 and 90 seconds respectively. The result of the work showed that the developed machine performed better when the speed was increased with cockerel having the better plucking result.

Also, Adeyinka and Olawale (2015) carried out performance evaluation of chicken de-feathering machine for small scale farmers. They observed that it took the machine about 25 seconds to de-feather poultry birds with a machine speed of 300 rpm. However, they failed to indicate the specie, type and age of birds that were evaluated.

In a related development, Adetola et al. (2012) considered birds raised in South Western Nigeria with a view to establishing the optimal scalding temperatures of both the exotic and local breeds. The result of their finding showed that for local breeds, the scalding temperature of 800C – 850C is adequate, while those of the exotic breed falls between 650C to 700C.

Also, Ugwu et al. (2015) carried out optimization and performance evaluation of a developed feather plucking machine. He showed that at 400 rpm the machine was able to pluck completely at an average time of 22.8 seconds. He added that the speed of the machine and the species of poultry birds affects the efficiency of the machines.

In South-Western Nigeria, Taniomola et al. (2011) designed and developed a bird de – feathering machine capable of de – feathering 360 mature birds in an hour, irrespective of the

type of bird involved. He added that the machine recorded about 96 percent when tested with under controlled condition.

Elsewhere, Nguyen et al. (2011) investigated the optimal operational parameters for a chicken slaughtering system in Vietnam. He recommended an optimal scalding temperature of about 67 degree Celsius and an optimum scalding time of 80 seconds (Ashiedu, F. I. et al, 2018).

On the other hand, one of the oldest recipes known to man is Yam. It has been a major food crop in many of the African/ Caribbean's countries such as Ghana, Ethiopia, Benin Republic and Nigeria in particular. Also, in some other parts of the world such as Brazil, India, Oceania and Latin America; yam is a major source of food. The word "yam" was derived from the Wolof word "n yam" which is a Portuguese name meaning "to taste". Also, in another African language, it means "to eat" e.g. in Hausa "nyam" (Mignouna et al, 2003). This perennial herbaceous crop is of different species such as the white yam (*Dioscorea rotundata*), yellow yam (*Dioscorea cayenensis*), water yam (*Dioscorea alata*) and trifoliate yam (*Dioscorea dumetorum*) (Amusa et al., 2003). The fruit of yam consists of a membranaceous, three-wing capsule. The yam family is mostly of the weak-stemmed vines with large, underground food storage organs-tuber-rhizomes. Yam has found its use in the preparation of steroid hormones by the syntax synthesis of cortisone from yam extract. Also, its lower glycemic index than potatoes products (kay, 1987) accounts for its more sustainable energy and better protection against obesity and diabetes (Walsh, 2003).

According to the food information Network in 2008, it was estimated that the world production of yam in 1993 was at 28.1 million tons in which 96% of this estimate was from the West Africa tropical regions and 71% from Nigeria. This figure was later reviewed in 1998 accounting for about 72.4% of the world total production of 29.6million tones. Also,

according to the Federal Office of Statistics, Nigeria is the world's largest producer of yams having the water yam (*Dioscoreaalarta*) and the yellow yam (*Dioscorearotundata*) as her most cultivated species of yam. Yam, being one of the most sumptuous meals, can be prepared in diverse ways. While the Yoruba tribe may prefer it dried, milled and then made into a slightly solid paste called "Amala", the Igbos prefer cutting the tuber into smaller blocks or bits, boiled and eaten, in order to avoid the tedious nature of pounding the boiled yam which results to bond formation like Nigeria's locally prepared fufu (Akissoe et al, 2003). However, the process of meshing or beating something into pulp or powder with repeated heavy blows is known as pounding. Yam has remained one of the most highly regarded food products in West Africa and particularly Nigeria as virtually all her ethnic groups feed on it; hence its close integration into the socio-cultural, economic and religious aspect of life such as marriage where some tubers of yam are presented to the bride family in accordance to the customs of the people (Odior et al, 2012). Pounded yam production Yam tuber, which is popular in most part of the world is often consumed in Africa. This can be processed into pounded yam for consumption.

Although concentrated in Nigeria, the largest producer of yam in the world, the yam eating zones stretch from western Cote d'Ivoire to Cameroon. This plant is characterized by a great degree of natural genetic diversity adapted to a wide range of production conditions within the region (DEGRAS, 1986). Yam varieties generally achieve high yields (10 to 20 tons per hectare) and many have excellent storage properties in contrast to cassava. They generally have more stringent growing requirements than cassava as concerns both soil quality (high potassium level is needed) and cultivation techniques. Yam growing also has a high cost in terms of plant material. Using the traditional method, up to one-third of the harvest must be retained for use as seed-yam (Pierre-Marie, 1998). Yam has been relatively neglected by agricultural researchers and up to date result that can raise productivity have been far limited

compared to cassava the other major root crop (PierreMarie, 1998). Yam tubers Yams are an excellent source of potassium, with twice the amount as found in a multi-sized banana. They are also a good source of Vitamin C, B6, folate, iron, and magnesium. Yams are high in starch and contain an enzyme, alpha amylase, which converts starch to sugar as the tuber matures, is stored, or when heated.

According to researchers at Brigham Young University, curing yams by storing them at 29 °C (85 °F) for four to six days immediately after harvest, increases the concentration of this enzyme (brighamyounguniversity.com). Curing also appears to heal small surface scratches, decreasing the risk of rotting. Raw yams, like lima beans, contain glycosides, natural chemicals that breakdown into hydrogen cyanide in the stomach or when it is heated. Yam varieties Yams are economically useful plants belonging to the genus *Dioscorea* (Coursey O, 1967). There are many varieties of yam which are differentiated by varying characteristics such as the direction of stem twines (clockwise or counterclockwise), the shape and colour of the leaves, stem and tubers, and the cooking quality of the tubers. The yam tuber is economically the most important part of the plant. The structure is extremely variable, depending on the species. Most yam tubers, however, are cylindrical in shape and the weight of individual tubers range from 200g to 50kg (Asiedu, 1989).

2.4.5 Types of Yam Pounding Machines

The Pounding machine applies either torque or reciprocating force on a piece of solid for the purpose of changing its form from the solid state to a semi-solid nature. There are two types of pounding and they are: Impact (Reciprocating) pounding; rotary (torque) pounding. The impact (reciprocating) pounding modes reciprocate in its operation. The mortar and pestle mode of pounding is classified under this class. The design uses the combination of both rotary and the reciprocating mode of pounding with the rotary mechanism incorporated at the mortar sent. Rotary pounding mode involved the crushing of boiled yam through rotary

twisting force (torque) produced from a motor through pulleys and a propeller shaft connected to the blades. It is on this principle that the existing yam pounders are based.

The Parts of the Yam Pounding Machine: Lightweight materials are necessary for the development of mechanical systems.

The Shaft: The shaft which is made of mild steel was designed to transmit power to the yam beaters in the bowl to perform the yam pounding operation.

Pulley: The primary function of the pulley is to reduce the original speed of the electric motor to the required speed. The material selected for this pulley is mostly cast iron.

The Yam Beaters: The yam beaters are two blades made of stainless-steel material and they are the main components that do the real pounding of the yam. These are two bars designed and joined together at angle 90° to each other at the center and they rotate together through angle 360° while pounding the cooked slices of yam.

The Bowl: The bowl consists of the yam beaters which perform the pounding operation in a chamber of the bowl. It is made of stainless-steel material with a volume of 0.018 m^3 .

The Frame: The frame forms the housing of the whole components, including the electric motor. It has to be rigid to withstand all the forces generated in the components during the pounding operation.

2.4.6 Effect of Healthy Yam Processing

Jimoh, et al., (2008) presented an analysis of the medicinal effect of healthy carbohydrate processing. The effect of yam processing was studied, and it is discovered to have an effect on the glycemic response to white yam (*Dioscorea rotunda*) meals. Postprandial glycemic response to food can be affected by the method of food preparation. The effect of processing on yam, a staple food in Nigeria, was studied in 24 healthy nondiabetic Nigerians. The

postprandial glycaemic indices of peak plasma glucose (PPG), maximum increase in plasma glucose (MIPG), 2-hour postprandial plasma glucose level (2HPPG), incremental area under glucose curve (IAUGC) and glycaemic index (GI) were determined for boiled yam, pounded yam and yam flour (amala) after eating a measured amount of 50 g of digestible carbohydrate as recommended by FAO/WHO. Despite undergoing more processing, food prepared from yam flour showed better postprandial glycaemic response indices as compared with other study foods. Yam flour submitted to more processing showed better indices than the other yam-based product compared. Yam based products, particularly yam flour, can be recommended for diabetic Nigerians as a substitute to eating monotonous beans-based products.

The above analysis shows that well-processed yam can be a good supplement in the fight against widespread diabetes. After thorough examination and analysis, this project aims to provide this project presents the processing of yam to produce pounded yam using a pounding machine an alternative to the pounded yam from yam flour. In order to facilitate the processing of yam for consumption, a yam pounding machine is been developed using mainly some locally sourced materials. This project thus looks at the use of stainless steel to produce the parts that will have direct contact with the yam using the rotary motion of the yam beaters that will produce the normal crushing and turning as well as mixing in order to get the local texture of the pounded yam.

2.5 Existing Yam Pounding Machine

Among the researchers that have worked on Yam Pounders are Makanjuola, (1974); Raji and Oriola, (2007); Odior and Orsarh, (2008); Ayodeji and Abioye, (2011); Olaoye and Oyewole, (2012); just to mention few names.

At present there exists different makes of yam pounding machine. One type cooks and pounds while another pounds only. The problem associated with them is that they are expensive to operate and acquire.

en.wikipedia.com records that some earlier African designers designed a pounding machine, but it had the local pestle and the local mortar, it was just that the reciprocating motion was mechanized; other work has been the use of hydraulic press and rotating bowl to provide the necessary turning and mixing.



Fig 2.4: Early African pounding machine (en.wikipedia.com)

2.5.1 Panasonic Yam Pounder for Fufu Production

This yam pounder is always cool, retro yam pounder from National – now Panasonic. It was developed in 1963. It does a mean pounding job, but it is very hard to find. It also has a tendency to over-pound so the product comes out a little soft to the touch. But when it is left for a few minutes it hardens right up to proper “okele” texture. The machine was successful though over-pounds “fufu” the other paste product form cassava but was not able to produce the required texture of pounded yam (Toyosi O. C, 2016).

2.5.1.1 Short Comings

- It was very hard to find and now in extinction.
- It only pounds fufu and cannot pound our desired pounded yam.
- It over pounds the fufu.
- Its product is always too soft to touch and has to be left for few minutes before solidifying which makes the desired fufu cold.



Figure 2.5: Panasonic Yam Pounder (panasonic.com)

2.5.2 Yam Pounding Machine by Makanjuola (1974)

A machine for pounding yams and similar foods was developed by Makanjuola (1974) at the Department of Agricultural Engineering of University of Ile - Ife in Nigeria. It is capable of producing enough 'fufu' for eight adults in 45 seconds (UNIFEM, 1993).

2.5.3 Yam Pounding Machine by Herbert and Kenwood

In 1975, Herbert and Kenwood mixing machines were introduced into the market for use. This however, gave rise to the conception and development of the yam pounding machine. The Herbert and Kenwood mixers were not originally designed for yam but gradually faded away due to its inefficiency in operation such as longer time in meshing operation and overheating of the machine which had to be stopped intermittently for cooling and the non-

homogeneity in bond formation after meshing. Hence, the above argument ascertains that both the Herbert and Kenwood mixers were not originally designed for yam pounding but potatoes meshing as their mode of operation is similar (TISR, 2008). Also, these mixers have the following deficiencies on the pounded yam;

- i. Hardness of the yam after pounding.
- ii. Presence of much un-pounded yam seedlings.
- iii. Not compatible enough.

In 1980, some final year students of Obafemi Awolowo University took up the challenge to research and develop a yam pounding machine having studied the problems of the Herbert and Kenwood meshing machine. To their credit a design blue print was made and sent to Japan, and the first ever yam pounding machine was then fabricated and imported into the country but this machine was faced with the problem of its high cost, making it affordable to only the rich.

However, some of these above mentioned deficiencies were improved on by Odior in 2008 where he designed another pounding machine capable of producing a better homogeneous bond yam.

2.5.4 Yam Pounding Machine by Odior and Orsarh

Odior and Orsarh, (2008) designed a pounding machine that beats using the process of cutting to pieces as well as crushing and turning to produce the natural taste.

The yam pounding machine was designed and developed to hygienically process yam and it was designed to pound from kilograms to kilograms weight of cooked yams for both domestic and commercial consumption. The machine consists of the following major components: the shaft, pulleys, belt, bearings, electric motor, yam beaters, bowl and the

frame. The yam beaters or blades were located on the upper edge of the shaft which was connected to the electric motor via a V – belt and pulley system. During the pounding operation, the slices of already cooked yam are loaded into the pot-like pounding chamber and covered with the pounding chamber cover. The electric motor transmits power through the V - belt to shaft, as the shaft rotates it actuates the yam beaters, which start pounding the yams in the yam pounding chamber. The pot or pounding chamber bears the bigger pulley so as to reduce the speed of the electric motor to a desired pounding speed of 100 rpm.

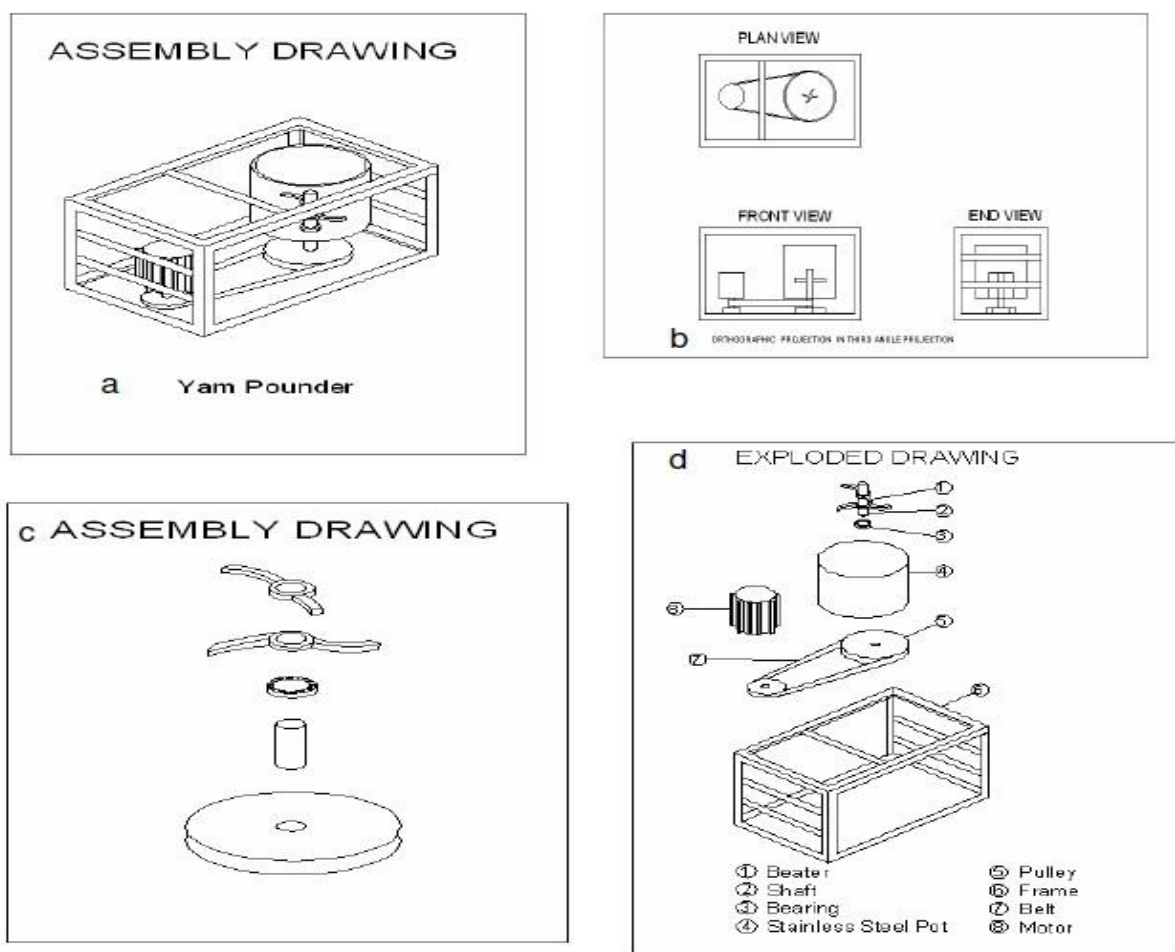


Figure 2.6: Component Elements of the Yam Pounding Machine (TISR, 2008)

2.5.4.1 Short Comings

- i. The shaft was made from mild steel; mild steel is not friendly to health when consumed, the persistent usage of the machine through the rotation of the shaft will lead to wear of the mild steel which will allow the fallen fillings mix with the yam in

process, this when consumed overtime leads to build up of material inside the body and at the end results to cancer.

- ii. There was no air vent and the heat produced by the electric motor has no exit vane, so it had to be stop intermittently like by the early generation pounding machine.
- iii. The speed of 100 rpm was not enough to pound the yam to the required texture.

2.5.5 Yam Pounding Machine by Osueke

After a period of two years, Osueke in 2010 improved on the design made by Odior by incorporating a steaming chamber inside the pounding machine. This design of his in 2010 consists of mainly two chambers which were made of stainless steel and shafts. One of the chambers is used for cooking while the other chamber is used for the pounding. Though this design tends to be good as two operations were being accomplished with the machine but the problem of overheating continues and even higher than those of Herbert and Kenwood mixer irrespective of the number of vents introduced for cooling. However, this machine gives a better quality product at a higher speed but the cost of production or manufacturing was high hence its high cost of purchase. Also, a particular species of yam was known to pound well with this machine that is the water yam. Likewise, the bulky nature of the machine makes its portability a mirage.

2.5.5.1 Short Comings

- Overheating problem continued.
- High cost of production and manufacturing.
- High cost of Purchase.
- Only a particular species of yam was known to pound well with this machine that is the water yam.
- The bulky nature of the machine.

After considering all these shortcomings, in this design, the above mentioned challenges were been eliminated by eliminating the cooking chamber thereby overcoming the issue of overheating, operating the machine at a moderate speed and as a result increases the life span or durability of the machine. Also, improvement in the quantity and quality of yam pounded in less time which was one of the major problems of the Herbert and Kenwood mixers. Hence, these improvements make the machine suitable for commercial and domestic use. Also, to put a margin between the advantages and disadvantages of the machine usage, the protective electric motor device (fuse) considering the fluctuating and inconsistent power supply thereby increasing its reliability.

Finally, the simplicity in its manufacturability is an added advantage as it tends to provide job for the young and unemployed production engineers/ technologists as the raw materials are readily and locally available. This will to a great extent reduce unemployment.

Limitations

One of the outstanding limitations of this work is its inability to pound all varieties of yam. It can only pound two varieties namely:

- White yam (*Dioscorea rotundata*)
- Water yam (*Dioscorea alata*)

CHAPTER THREE

DESIGN METHODOLOGY AND ANALYSIS

3.1 Materials and Methods

The design was targeted towards achieving the following: producing good and quality dual component machine for defeathered chicken and pounder yam, high probable efficiency, availability of raw materials and cost of the machine.

3.2 Material Selection Technique

Selection of materials depends on many features such as the intensity and type of stress to which the components are subjected to, whether it is flexible or rigid or it is to experience high temperature or corrosive action and how it leads itself to processes of manufacture, i.e. forging, machine etc. Therefore, the designer selection will be influenced the following factors:

1. Strength
2. Weight
3. Appearance
4. Manufacture
5. Cost of Production.

These will also determine the variation between success and failure of the machine. We can further classify the above factor into four main classes:

- a. Service Requirements.
- b. Construction Requirements.
- c. Economic Requirements.
- d. Maintenance Requirements.

3.2.1 Service Requirements

Before a material is chosen for construction, it must possess some distinct properties which it exhibits when put to play. These properties are generally referred to as the service requirement. Some of these properties which should be appreciable while the material is in service are:

- a) Toughness.
- b) Hardness.
- c) Strength.
- d) Stiffness.
- e) Resistance to corrosion.
- f) Conductivity and heat resistance.

3.2.2 Fabrication Requirement

For fabrication process, a material must possess some distinct properties; these are mainly forge-ability, malleability, ductility and weld-ability. Materials undergoing forge-ability are heated to a temperature close to its melting point then shaped to desired structure. For malleability, it's required that the material should be made into a sheet like form while ductility requires the material to be drawn into a wire form. Finally, weld-ability can be described as the ability of the material to be easily welded. Therefore, the materials must be able to be joined by the process of welding.

3.2.3 Economic Requirement

This is about the most important factor for the material selection because it determines the total cost of production which in turn affects the price of the product or retail cost and consumer choice. If the total cost of production is high, variably the price of the finished product will also be high. When the price of a product is high, consumers will seek for

alternative cheap but similar goods. Bearing in mind that the two aims of production is, satisfying consumer wants and needs and also to make maximum profit, as a producer, one must judiciously select relatively cheap but reliable and appropriate materials for production. This will reduce the overhead cost of production therefore making it cheap in respect to other similar materials. Then we can comfortably harmonize the cost of production with the real price. One of the major considerations in engineering design is to design machines that are reliable, cost effective and the ability of the machine solving human problem. This was one our consideration in this project work.

3.3 Machine Components of the Machine

These are unit components of the machine that are assembled together to form the entire machine. The machine components include; the machine structural frame, trough, blade or impeller, pulleys, Belt, Rubber Fingers, pounding basin, bearings, shaft and the electric motor which was selected.

3.4 Design Factor

This refers to some characteristics which affects or influence the design of the machine or perhaps some of the components. However, out of the numerous factors that affected the design, only one or few will turn out to be the major factors and the minors ignored as they would have little or no effect in the design. These factors or characteristics are;

- i. Thermal conductivity of the material.
- ii. Strength of the materials used.
- iii. Overall weight of the machine in order to achieve its portability and machine size.
- iv. Ease of maintenance.
- v. Noise and vibration.
- vi. Resistance to corrosion attack.

vii. Finishing.

3.5 Detailed Design Description of the Plucking Component of the Machine

For the experimental aspect of the work, a poultry de-feathering machine was developed and evaluated. Material used for the construction of the de-feathering machine was locally-available materials majorly mild steel. The materials needed were selected based on availability, mechanical properties and relative cost. Stainless Steel was preferred because it is widely available, strong, and easy to fabricate. The defeathering component consists of three identifiable assemblies with their functional components. These are **Base Unit** (top plate, cross member, coupling, electric motor, pulley and belt), **Housing Unit** (frame cover, the drum, drum support, bolt and nut, rubber fingers and bearing) and the **Over-Hanged Unit** (crank rod, handle and rope). Factors considered in the design of the component in other for it to be suitable for eatery and household use (e.g. cutleries, machine and kitchen tools) are safety, portability, low cost of production, production capacity, durability of fabrication materials, materials availability, ease of alteration, finishing, reliability and ease of operation. The machine is able to pluck feathers from chicken of weight up to 1.8 - 4.5kg.

3.6 Machine Fabrication for the Plucking Component

The fabrication sequence of the plucking component is as follows: construction of frame, installation of electric motor, erection of bearings/sheave on shaft, fabrication of stainless steel plucker basin, fixing of Rubber Pluckers, installation of water hose, finishing and painting.

3.7 Design Dimension for the Machine

Scalded birds are conveyed manually without delay to the de-feathering Component. The component consists of an electric motor transmitting torque to the sheave by a belt. Torque is transmitted to shaft supported by two bearing assembly. The shaft drives the plucker plate

rotating against a stationary frustum basin consisting protruding rubber pluckers as well as the plucker plate. Rubber pluckers get a grip on the feathers as the plate is rotating against the basin, thus removing the feathers from the birds while the carcass are conveyed through this section.

The frame of the machine is of over-all dimension 580 X 580 X 580mm for both the plucking component and the pounding component. The frame was being constructed in such a way that it would provide support for the electric motor, shaft, pulley, belt, and bearings. The electric motor of capacity **1.5kW, 1440rpm** by capacity was installed to provide adequate setting. A sheave of **70mm** nominal diameter was fixed on the shaft of the motor which would transmit power to the shaft through the belt. The motor was being attached to the frame by using Hex head bolt and nut. The shaft of diameter **20mm** and length **595mm** was erected vertically at the centre of the main frame supported by two bearings and brazed at the top and bottom of the frame. Attached to the shaft is a driven sheave of diameter **210mm** which reduces the actual speed of the electric motor because it is greater than the sheave of the motor. The rubber plucker plate or the Yam beater was then joined to the walls of the basins. The plate or beater was joined to the shaft end by using hexagonal bolt. The plucker basin is a frustum of a cone which has a top diameter of 508mm, bottom diameter of 400mm and a height of 450mm. The basin was developed from Stainless Steel. The top and the bottom of the basin are concentric with the rubber plucker plate. Holes of diameter 23mm was drilled on the plate which was used to hold the rubber Pluckers. Also, holes of diameter 23mm were being drilled on galvanized steel plate of diameter 320mm, thickness 1.4mm.

As well, the pounding basin is a cylinder which has a top and bottom diameter of 280mm, and a height of 184mm alongside a steel thickness of 10mm. The basin was developed from Stainless Steel. The top and the bottom of the basin are concentric with the beater. A hole of

diameter 25mm was drilled through the bottom of the basin for the entry of the shaft. The beater was of length 190mm and width 20mm.

3.8 Materials Selection for the Machine

The choices of the material and component used here are based on the consideration of the following factors, cost analysis of the material, durability of the materials, availability of the materials, properties of the material such as; physical properties, thermal properties, relative properties, chemical properties and mechanical properties.

Table 3.1: Materials Used and Selection Criteria

S/N	MATERIALS USED	SELECTION CRITERIA
1.	Stainless Steel	It has a very high resistance to corrosion, Workability
2.	Angle bar	It is very rugged and easily to fabricate.
3.	Pipe	It is rugged and easily to fabricate.
4.	Electric Motor	To transmit the torque, with aid of V-belt.
5.	Water pump	To wash the chicken and to discharge the plucked feather.
6.	Plucker rubber	To pluck the feather.
7.	Bolt and nut	It is used to couple the drum and frame together
8.	Paint	To enhance the resistance to corrosion

3.9 Construction Technique of the Machine

The following operation sequences were undertaken in the fabrication of the dual component machine, measurement and marking out, cutting of material, welding, grinding, and drilling operation. And the following tools were used: Hack saw, Scriber, Try-square, Measuring tape, Welding Machine, Grinding Machine and Drilling Machine.

Operation Sequence includes:

Measurement and Marking Out: The measurements were used according to the design specification and the marking out was done accordingly.

Cutting of Materials: Sheet metal (stainless plate) of 10mm thickness, sheet metal (mild steel) 10mm thickness and angle iron were marked out according to the dimension. The cutting operation was carried out manually using shearing machine to cut angle bar, pipe and shaft while hand cutting machine is used to cut sheet metal manually.

Welding Operation: All materials being cut out were joined by the use of arc welding machine.

Grinding Operation: Contours on the welded joints of the work piece were smoothed using grinding machine. It is the operation in which all welded area and rough surfaces are slightly grinded for smooth and aesthetes surface finishing. The welded joint were slightly grinded, because too much of grinding will weaken the strength of the bond.

Drilling Operation: The drum, rotating plate and the base of the machine were drilled accordingly, using drilling machine with (21mm) drill bit.

3.10 Description of Part of the Plucking Component of the Machine

The part of the machine includes the Outer drum, Static finger, Dynamic finger, Upside down finger, the Finger plate, Bearing, Main Frame, Output Chute, Electric motor, Main shaft, Driven Pulley, Driving pulley, V-Belt, Foot adjuster and Water reservoir.

3.11 Principle of Operation of the Plucking Component

Chicken de-feathering component is a machine designed by using an electric motor. Electric motor drives the dynamic finger studded on the rotating plate at a certain speed. Transmission power from the electric motor to the rotating plate is using v-belt transmission. Driver pulley mounted on the electric motor and the driven pulley mounted on the main shaft. Main shaft

rotating on a vertical axis direction and moving the rotating plate directly. This principle distinguishes between vertical and horizontal retraction system. Chicken will be processed placed on a finger plate. In the rotating plate has been installed dynamic finger made of rubber with a screw shape that serves to bind the chicken feathers. When the rotating plate rotates at a certain speed, the chicken will come round and is likely to be thrown into the drum wall due to centrifugal force. Chicken feathers tied in dynamic finger will be regardless of chicken when the chicken thrown into the drum wall. In the drum wall studded with finger rubber that will bind chicken feathers when chicken thrown into the drum wall. Chicken will fall back to dynamic finger due to gravitational forces. Chicken feathers tied in static finger will fall into finger plate.

3.12 Parts and Operation of Yam Pounding Component

The yam pounding Component is designed and developed to hygienically process yam and it is designed to pound variable weight of cooked yams for domestic consumption. The machine consists of the following major components: the shaft, bearings, automatic gear electric motor, yam beater, bowl and the frame.

The yam beater or blade is located on the upper edge of the shaft which is connected directly to the electric motor system. During the pounding operation, the slices of already cooked yam is loaded into the pot-like pounding chamber and covered with the pounding chamber cover. The electric motor transmits power directly to the shaft through its armature section, as the shaft rotates it actuates the yam beater, which starts pounding the yams in the yam pounding chamber. The pot or pounding chamber bears the shaft and the beaters. The operational stages in yam pounding include; washing the yam tuber, peeling, slicing, parboiling and pounding using the pounding machine before packing the pounded yam as shown in Figure 7 (Toyosi Craig, 2011).

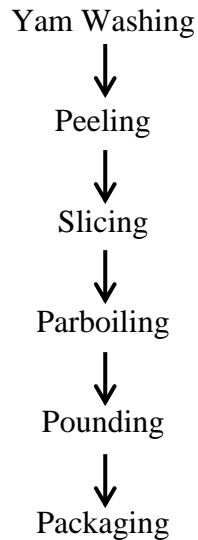


Figure 3.1: Flow diagram for Yam Pounding (Odior and Orsarh, 2010)

3.12.1 Yam Beaters

The yam beaters are two blades made of stainless steel material and they are the main components for pounding of the yam. These are two bars crafted, designed and joined together at angle 180° to each other at the centre and they rotate together through angle 360° while pounding the cooked slices of yam. The Beaters are attached to the connecting rod with a circular portion.

3.12.2 Pounding Bowl

The pounding bowl is a stainless steel structured bowl which consists of the yam beaters which perform the pounding operation in a chamber of the bowl.

3.12.3 Machine Frame

The machine frame forms the housing of the whole components, excluding the pounding bowl and the beaters which are located on top the frame. It has to be rigid to withstand all the forces generated in the components during the pounding operation. It was constructed using the angle bar.

3.13 Design Calculations of the Machine

Certain calculations were made on certain parameters so as to make correct choices in selecting them. Design calculations were carried out on the following: Sheave (Pulley), Belt, Shaft, Yam Beater, and Plucker Basin.

3.13.1 Sheave System

The sheave system comprises of two sheaves. The bigger, being the driven, is mounted on the shaft and the smaller sheave, the driver, is mounted on the electric motor. Since the diameter of the sheave on the motor is smaller, then there is reduction in speed (rpm) on transmission to the larger sheave attached to the shaft. The speed of the motor is 1440 rpm. In order to calculate the speed that would be transmitted to the shaft, the following analyses were been carried out:

$$N_1 D_1 = N_2 D_2 \quad (3.1)$$

Where:

N_1 = Speed of the motor, 1440 rpm,

D_1 = Diameter of the motor sheave, 70 mm,

N_2 = Speed of the shaft/shaft sheave,

D_2 = Diameter of the shaft sheave, 210 mm

$$N_2 = \frac{N_1 D_1}{D_2}$$

$$N_2 = 1440 \times \frac{70}{210}$$

$$N_2 = 100,800/210 = 480 \text{ rpm}$$

Therefore, the speed that the motor will transmit to the shaft/shaft sheave through the belt is 480 rpm.

3.13.2 Belt Design and Selection

A belt and pulley system was used to transmit the power and torque from electric motor section to both the plucking chamber and the yam pounding section.

$$b = 12\text{mm}, t = 8\text{mm}, w/l = 1.06$$

D_1 = diameter of driving pulley, 70mm

D_2 = Diameter of driven pulley, 210mm.

$$P_{\text{belt}} = 1250\text{kg/m}^3$$

$$P = 746 \text{ Watts.}$$

Rotational Speed of driver pulley, $N_1 = 1440\text{rpm}$

$$S_s = 3.0\text{MPa}$$

$$\mu = 0.25$$

Groove angle of pulley = $30^\circ = 2\beta$

Length of belt,

$$L = \frac{\pi(D_1 + D_2)}{2} + 2C + \left(\frac{(D_1 + D_2)^2}{4C} \right) \quad (3.2)$$

But C = Unknown

$$C = \max\left(\frac{3D_1}{2} + \frac{D_2}{2}\right) \quad (3.3)$$

$$= \max\left(\frac{3 \times 70}{2} + \frac{210}{2}\right) = \mathbf{210\text{mm.}}$$

We use a centre distance of 250mm.

$$L = \frac{\pi(70+210)}{2} + 2 \times 250 + \left(\frac{(70+210)^2}{4 \times 250} \right) = \mathbf{1018\text{mm}}$$

A standard belt is then chosen as the nearest match is 1026 mm which is type **A43 belt**.

Tension on tight side of belt T_1 :

$$\mathbf{T_1 = btS_s} \quad (3.4)$$

$$T_1 = 0.012 \times 0.008 \times 3.0 \times 10^6 = \mathbf{288N}.$$

3.13.3 Angle of Wrap

$$\theta_1 = 180 - 2\alpha,$$

$$\theta_2 = 180 + 2\alpha \quad (3.5)$$

$$\mathbf{\sin \alpha = \left[\frac{d_2 - d_1}{2C} \right]} \quad (3.6)$$

$$= \left[\frac{210 - 70}{2 \times 250} \right] = 0.28.$$

$$\alpha = \text{Sin-1}(0.28) \ 16.260^\circ$$

$$\theta_1 = 180 - 2(16.260) = \mathbf{147.48^\circ}$$
 and

$$\theta_2 = 180 + 2(16.260) = \mathbf{212.52^\circ}.$$

Tension on slack Side of belt T_2 :

To evaluate the tension on the slack side, we use the relationship:

$$2.3 \log \left(\frac{T_1}{T_2} \right) = \mu \theta_1 \text{cosec} \beta \quad (3.7)$$

$$2.3 \log \left(\frac{T_1}{T_2} \right) = 0.25 \times 147.4 \times \frac{\pi}{180} \text{cosec } (15)$$

$$\mathbf{T_2 = 23.94N}$$

$$T_1 = 288N, T_2 = 23.94N.$$

Power transmitted through the belt:

$$\mathbf{P = (T_1 - T_2) V} \quad (3.8)$$

$$= (T_1 - T_2) \frac{\pi DN}{60}$$

$$= (288 - 23.94) \frac{\pi \times 1440 \times 70}{60}$$

$$= 1392.969 \text{ Watts.}$$

Bearing Design and Selection

The single row deep groove ball bearing was chosen because of its high load carrying capacity and suitability for high running speed. Considering the diameter of the shaft which is 25mm, a bearing of bore 25mm was then used for this calculation. The specific static load rating or capacity C_o (Arvid, 1945)

$$C_o = \frac{1}{5} \times k_o \times i \times z \cos \alpha D_w^2 \quad (3.9)$$

Where:

C_o = Specific Static Load rating or Capacity = 10kN

K_o = Factor depending on the type of bearing. = 12.3

D_w = Diameter of the ball

α = Nominal angle of contact = 0

i = Number of rows of ball in any one bearing = 1

z = Number of balls per row in the groove = 6

$$K_o = \frac{Q_{max}}{D_w^2} \quad (3.10)$$

Q_{max} = Maximum bearing load.

And the above data (Budynas et al, 2008) the ball diameter can be calculated

$$\begin{aligned} D_w &= \sqrt{\left(\frac{C_o \times 5}{K_o \times i \times z \cos \alpha} \right)} \quad (3.11) \\ &= \sqrt{\left(\frac{10 \times 10^3 \times 5}{12.3 \times 1 \times 6 \cos 0} \right)} \\ &= \sqrt{677.5067751} \\ &= \mathbf{26.02896mm} \end{aligned}$$

Then the maximum bearing load Q_{\max} becomes:

$$K_o = \frac{Q_{\max}}{D_w^2}$$

$$Q_{\max} = K_o \times D_w^2$$

$$= 12.3 \times 677.5067751$$

$$= \mathbf{8333.333N}$$

A bearing of 6206, which is of an inner diameter of 25mm and outer diameter of 55mm, then was chosen. The bearing number interpreted as 200 means a light bearing of bore that is inner diameter of $05 \times 5 = 25\text{mm}$. Also, in the selection of this bearing, the radial load of which the bearing can carry was put into consideration. However, for the ball lubrication, grease is used at low and medium speed when the temperature is not over 20°C while oil is used at higher speed. Hence, for this design, grease is regarded as the most satisfactory lubricant.

3.13.4 Yam Beater Design

Evaluation of forces acting on the beater

$L = \text{Length} = 200 \text{ mm}; 0.200 \text{ m}$

$W = \text{Width} = 30 \text{ mm}; 0.03 \text{ m}$

$T = \text{Thickness} = 5 \text{ mm}; 0.005\text{m}$

$$V = L \times W \times T$$

$$V = 0.200 \times 0.03 \times 0.005 = 0.00003 \text{ m}^3$$

Beater Material: Stainless Steel, Density of Stainless Steel: $\rho = 7500\text{kg/m}^3$ (BSSA, 2009)

Weight of beater:

$$\text{Mass (M)} = (\text{Density} \times \text{Volume}) \tag{3.12}$$

$$M = 7500 \times 0.00003 = \mathbf{0.225kg}$$

$$\text{Weight (W}_b) = \text{mass} \times g \ (g = 9.81)$$

$$0.225 \times 9.81 = \mathbf{2.207 N}$$

$W_1=W_2$ = the weight of two pounding blade (because they are of the same material and same size)

$$F_1 = W_1 = \mathbf{2.207 N}$$

(F1 and F2 being the respective forces at point 1 and point 2)

Area of beater surface in contact with yam:

$$A = \frac{1}{2}(a + b)h = \frac{1}{2}(0.03+0.026)*0.08=\mathbf{0.0024 m^2} \quad (3.13)$$

Volume occupied by beater:

$$V = At = 0.0024 \times 0.005 = \mathbf{0.000012 m^3} \quad (3.14)$$

Effect of yam on the beater:

Osueke C.O, 2010, experimented and determined the density to be 1250kg/m³ and 1950kg/m³, before and after boiling respectively.

A piece of Yam with dimensions L=40mm, B=40mm, H=40mm is used for this analysis.

$$\text{Volume of yam piece} = (40/1000)^3 = 0.0000064\text{m}^3$$

Density of boiled yam: 1950kg/m³

Mass of the piece of yam:

$$\rho \times v = 1950 \times 0.000064 = \mathbf{0.1248\text{kg}}$$

There can be a maximum of two (2) pieces of yam on the beater, hence

$$\text{Mass of 2 pieces of yam} = 2 \times 0.1248 = \mathbf{0.2496\text{kg}}$$

$$\text{Weight of 2 pieces of yam} = 0.2496 \times 9.81 = \mathbf{2.449\text{N}}$$

Total weight of beater with yam on it:

$$\text{Total weight} = \text{weight of beater} + \text{weight of 2 pieces of yam}$$

$$\text{Total weight} = 0.942 + 2.449 = \mathbf{3.391\text{N}}$$

Determination of crushing pressure and force acting on beaters surface

$$P = \frac{F}{A}; F = P_y \times A \quad (3.15)$$

$$P_y = \rho_b gh \quad (3.16)$$

Where P_y = Crushing Pressure, h = height of the yam.

The machine is designed to pound an average of tuber of Yam. Experimentally, a tuber was cut into pieces of 40mm cube, into a total of 44pieces.

$$P_y = 1950 \times 9.81 \times 0.04 = \mathbf{765.18N/m^2}$$

$$F = 765.18 \times 0.0024 = \mathbf{18364N}$$

To crush 22 pieces of yam by RHS of beater; $F = 1.8364 \times 22 = \mathbf{40.4008N}$

Turning Effect and Power Requirement:

Torque Computation:

$$F = T \times D \quad (3.17)$$

Where T = Torque, F = Force, D = Distance from centre of pivot

Torque from weight of beater with yam weight inclusive

$$T = 3.391 \times (0.04 + 0.0125) = \mathbf{0.177975Nm}$$

Torque from force acting on the surface of the beater

$$T = 40.4008 \times (0.04 + 0.0125) = \mathbf{2.121Nm}$$

$$\text{Torque of RHS of beater} = 0.177975 + 2.121 = \mathbf{2.299Nm}$$

$$\text{Total Torque of beater} = 2 \times 2.299 = \mathbf{4.598Nm}$$

Power Requirement:

This is given as:

$$\text{Power (P)} = \frac{2\pi NT}{60} \quad (3.18)$$

Where N = speed of revolution and T = Torque

Using a speed reduction factor of 1:31; $N = \frac{\text{Motor Speed}}{3} = \frac{1440}{3} = \mathbf{480rpm}$.

$$P = \frac{2 \times \pi \times 480 \times 4.598}{60} = \mathbf{231.121 \text{ Watts.}}$$

Hence considering the factor of safety 1.5, the minimum power requirement for the design; $=231.121 \times 1.5=346.681$ Therefore, based on the above calculations an electric motor of 1 hp with speed 1440 rpm, phase 3 and voltage of 440 V was chosen.

Analysis of the Shaft Design:

The structure screwed shaft can be designed for strength, rigidity and stiffness as considered for most shaft members. If these are to be considered as necessitated in our work, one or all of the followings has to be put into consideration:

- a. If the Shaft is subjected to a twisting moment or torque only.
- b. If it is subjected to bending moment only.
- c. If it is subjected to fluctuating loads.
- d. If it is subjected to combined twisting and bending moments.
- e. If it is subjected to axial loads in addition to combined torsion and bending loads.

In designing shaft on the basis of strength, shaft subjected to axial loads in addition to combine torsion and bending loads was taken into consideration (Khurmi R.S et al, 2006). Consideration was given to the axial load (F) which comprises the plate that was being attached to the shaft, likewise the weight of the chicken to be de-feathered.

Since mild steel is used for the shaft, maximum shear stress theory is used for the design of shaft diameter and it is stated below according to J. K. Gupter, 2008;

$$D^3 = \frac{16}{\pi S_s} \sqrt{(K_b M_b)^2 + (K_t M_t)^2} \quad (3.19)$$

Where;

K_b = combined shock and fatigue factor applied to bending moment;

K_t = combined shock and fatigue factor applied to torsional moment;

M_b = Bending moment (Nm);

M_t = Torsional moment (Nm)

S_s = Allowable shear stress

Plucking Drum: The drum was made up of plastic of about 1mm thick, the diameter of the drum is 508 mm and length 450 mm. The area of the drum is calculated as follows:

The diameter of the de-feathering drum is 508 mm = 0.508 m.

The length of the de-feathering drum is 450 mm = 0.45 m

$$\begin{aligned} \text{Area of the defeathering drum} &= \pi dl & (3.20) \\ &= \pi \times 0.508 \times 0.45 \\ &= \mathbf{0.718 \text{ m}^2}. \end{aligned}$$

Frame: The frame is made of wood for it to be rigid and it takes rectangular shape of length 580 mm and breadth 580 mm.

$$\begin{aligned} \text{Area of frame} &= \text{Length} \times \text{Breath} & (3.21) \\ \text{Length} &= 580\text{mm} = 0.58 \text{ m} \\ \text{Breath} &= 580\text{mm} = 0.58 \text{ m} \\ &= 0.58 \times 0.58 \\ &= \mathbf{0.3364 \text{ m}^2} \end{aligned}$$

Rotating Plate: The rotating plate was made from a stainless steel of 1.4 mm thick; it takes a circular shape of diameter 360 mm. To calculate the area of the rotating plate, the following analysis was been carried out:

$$\begin{aligned} \text{Area} &= \pi d^2 = 3.142 \times (0.36)^2 & (3.22) \\ &= 3.142 \times (0.1296) \\ &= \mathbf{0.407 \text{ m}^2} \end{aligned}$$

Volume of plucking chamber: The volume of the plucking chamber was determined using this equation according to (Adetola S.O et al, 2012),

$$V = \frac{1}{3} (R^2 - r^2) \pi h \quad (3.23)$$

Where:

V = Volume of the frustum;

R = Radius of the upper opening = 0.508m;

r = Radius of the lower opening = 0.40m;

h = height of the drum = 0.5m.

Volume of the plucking chamber = **0.05135 m³**

Hopper capacity: The plucking chamber capacity is determined from the equation according to (O. Eric, et al, 1982).

$$P_c = \rho V \quad (3.24)$$

Where,

ρ = Density of chicken sample = 1150 kg/m³;

V = Volume of plucking chamber = 0.05135 m³

Plucking chamber capacity, P_c = **59.053 kg**.

Force Required for Feather Removal: The force required for feather removal F_c is determined from the equation according to [J. K. Gupter, 2008].

$$F_c = M\omega^2 r \quad (3.25)$$

Where:

M = Mass of the rotating plate = 0.7kg;

ω = Angular velocity of the pulley = 124 rpm

r = Radius of the pulley = 0.105m;

The force required to remove the feather, F_c = **12.393 N**.

Shear Failure Analysis of the Defeathering Chamber: The shear stress of the de-feathering chamber is determined by the equation below according to V. B. Bhandari, 1994;

$$\tau = \frac{16Mt}{\pi d^3} \quad (3.26)$$

$$M_t = WR \quad (3.27)$$

W = Weight of the chamber = 56.60 N;

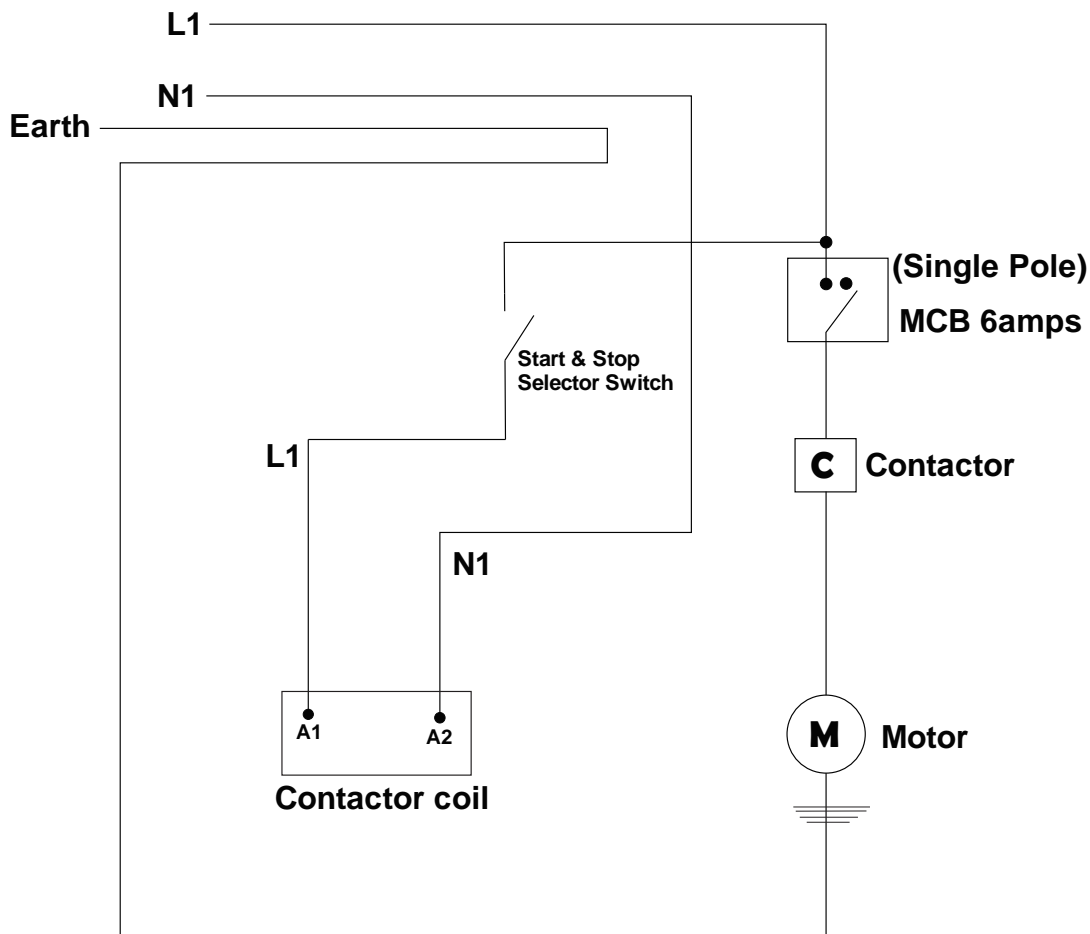
R = Mean diameter of the Chamber = 0.454 m

$M_t = 25.696 \text{ Nm}$;

$\tau = 1398.518 \text{ N/m}^2$

Electrical System

The electrical system comprises of a wiring of the machine and its components parts, the electric motor, circuit breaker, the timer, and their interconnections with each other.



A single line control diagram of the electrical system of the machine

CHAPTER FOUR

RESULT AND DISCUSSION

The fabricated machine was tested with electricity.

4.1 For the Chicken Plucking Chamber

After the fabrication and construction of the machine chamber, various tests were done, and results taken for running time. For a successful de feathering, the bird must be scalded in the right temperature to avoid damage to the skin of the birds during de feathering.

Table 4.1: Time and Weight Analysis

Test No	Initial weight (kg)	Final weight (kg)	Weight of feather removed (kg)	Time (sec)
1.	1.60	1.47	0.13	45
2.	1.60	1.49	0.13	40
3.	1.56	1.40	0.16	30

From Table 4.1 the average feather removal time was estimated as 38.3 Seconds. This value indicated that the removal rate for this design is approximately 94birds/h. However, this value absolutely depends on the operator's judgment or satisfaction since the birds are rotating at high speed, and it therefore becomes difficult to adequately observe when all feathers have been removed. The type of bird also affects the removal rate as this value applies to chicken. From (B. Bhandari, 1994) study, manually feather removal rate was estimated at 12birds/h. This therefore highlights the advantage of this design as an average output rate of 94birds/h was achieved. The machine was designed to accommodate one birds per process. From physical observation, with low scalding temperatures it becomes difficult to completely remove the feathers hence higher motor speed is required to reduce scalding time. Similarly, for higher scalding temperatures, there is a risk of the skin being cooked. This in turn makes feather removal difficult as the feather appeared to cut out parchment of

skin tissue from the chicken. The optimum temperature required to achieve acceptable results however depends on the type of bird being processed. For the locally bred chicken, substantial plucking force difference was noticed between 75°C and 80°C while for temperatures greater than 80°C, the required plucking force remained fairly constant. For Exotic birds, the optimum recorded temperature ranged between 65°C to 75°C. After testing, improvements were made to the current design. First, rotating parts were adjusted for the reduction of noise and vibrations in parts such as the belts. To achieve this, dampers were installed on the motor, Alignment of shaft was done, and the bearings were all replaced.

4.1.1 Efficiency of the Chicken Plucking Chamber

The efficiency of the machine was determined by using TABLE 4.2.

Table 4.2: Determination of the Efficiency of the Chicken Plucking Chamber

S/N	Initial Mass m_i	Final Mass m_f	Efficiency = $\frac{m_f}{m_i} \times 100$
1.	0.270	0.246	91.11
2.	0.300	0.26	86.67
3.	0.262	0.246	93.89

$$\text{Average Efficiency} = \frac{93.89+86.67+91.11}{3}$$

$$\text{Average Efficiency} = 90.557\%$$

4.1.2 Notes on Efficiency

Different values of efficiency for the three trials made are significantly high. However, the last trial is exceptionally higher than each of the other two trials all because of one or two adjustments in the construction noted during the first two trials. The machine will continue to produce in replicate at higher efficiency consistently.

4.2 For the Yam Pounding Chamber

The constructed yam pounding machine was tested by pounding two different types of cooked yams with the machine. Yam of weight 2kg was used and cut into small sizes.

Each yam specimen was washed, peeled, cut into small slices and cooked for a period of about 45 minutes. The cooked yam slices were then packed into the bowl or pounding chamber of the machine. The machine was then operated to pound the cooked yam slices for a stipulated time which was not the same for the different yam specimens. Test for hardness was conducted on each specimen to know if it was necessary to add water to the pounded yam, in order to achieve a desired texture. The test results are presented in Table 1.

Table 4.3: Test results on different yam specimens

S/N	Yam Specimen	Pounding Time (Min)	Test For Hardness Time (Min)	Total pounding time (min)	Quality
1.	White yam	4	1	5	Starchy
2.	Water yam	2	1	3	Semi – starchy.

*Test for hardness: manually stopping the machine and feeling the pounded yam texture with hands.

It was however observed that while the water yam took a period of 2minutes for pounding and 1 minute for hardness testing, the white yam took a period of 3minutes for pounding and 1 minute for hardness testing. It was also observed that the fabricated machine chamber also eliminates the tedious and laborious indigenous process of preparing pounded yam.

4.2.1 Efficiency of the Yam Pounding Chamber

The optimum pounding efficiency of the machine was observed to be 94.90% at the feed rate of 2 kg of cooked yam and pounding time of 1.7 minutes respectively. (Adebayo AA et al,

2014) reported threshing efficiency of 93% at feed rate of 1.8kg/min using electric motor as power for the pounding machine. These higher value of 94.90% can be attributed to high horse power of the prime mover driving the beaters in the pounding chamber.

Table 4.4: Determination of the Efficiency of the Yam Pounding Component

S/N	Initial Mass m_i	Final mass m_f	Efficiency = $\frac{m_f}{m_i} \times 100$
1.	0.204	0.180	88.24
2.	0.255	0.242	94.90

$$\text{Average Efficiency} = \frac{88.24+94.90}{2}$$

$$\text{Average Efficiency} = 91.57\%$$

The total Efficiency of the machine becomes the mean of the average efficiency of plucking chamber and average efficiency of pounding chamber.

$$\text{Total Efficiency} = \frac{90.557 + 91.57}{2}$$

$$\text{Total Efficiency} = 91.064\%$$

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

A locally made dual mechanized chicken plucking and yam pounding machine with an efficiency of 91 % has been conceived, designed and manufactured, to replace the crude method of manually removing birds' feather and pounding yam under the most unhygienic conditions. It is our view that the major users of this machine will find it easy and convenient since it requires no special training for the intended users. This undoubtedly will boost production, increase profit margin and ultimately increase productivity most especially now that the Federal Government of Nigeria is more interested in commercial agricultural practices than ever.

For the plucking part, the machine was able to achieve a clean de-feathering of a single bird at a time and within average of three minutes per bird. Temperature monitoring and control is very importance in scalding operation as it poses some safety challenges and a determinant for quality of scalded bird. Temperature of water for the de-feathering obtained of the chickens shows that scalding free of damage on the skin is economically achieved at lower temperature for exotic breed compared to local chicken of the same weight hence a reduce processing time and risk. Cost of production of the machine as well as cost of processing the bird is relatively reduced compared with existing de-feathering machines but with reduced production capacity. It is proved that the unit price of scalded bird can be reduced using the locally made scalding machine and thereby guarantee the safety of local processing farmer. This study therefore suggests that full support of agricultural business by government especially in areas where risk factors are high is very necessary to enhance sustenance of food and agricultural produce in the country. Such supports include the establishment of food processing and agricultural implement fabrication shops capable of manufacturing homemade

equipment both at small and large scale, provision of farmer friendly loan scheme and continue the education of poultry farmers.

For the Yam Pounding part, on the other hand, pounded yam is a staple food in West Africa, it is consumed by all tribes especially in Nigeria. The indigenous process of producing pounded yam is very laborious. It requires physical pounding by two or more matured persons, depending on the quantity and the type of mortars and pestles.

As a result, a mechanical yam pounding machine was developed in this project and can serve for domestic pounded yam processing. The machine presents a more hygienic process of pounded yam making. It also eliminates the laborious indigenous ways of pounding yam.

The production of these machines offers an incredible opportunity for pounded yam making in large quantities in few minutes as compared to the hours that would have otherwise been wasted. The cost of labour would also be reduced if the machine is adopted in canteens and restaurants.

5.2 Recommendations

Based on findings of this study, the following are recommended:

1. Further studies should be done on how to run the machine using solar power.
2. Further studies should be done on how to modify the machine to de-feather other poultry birds; e.g. turkey.

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APPENDICES



1 Inch stainless steel sheet



1 Inch Mild Steel Sheet



Stainless Steel Electrode



Driving and Driven Pulley



Bearings



Unmachined Stainless Steel Shaft



Cutting the steel to size



Rolling the Stainless Steel Sheet



After Rolling



Machine Casing



Plucker basin on casing



Holes drilled for the Rubber Fingers



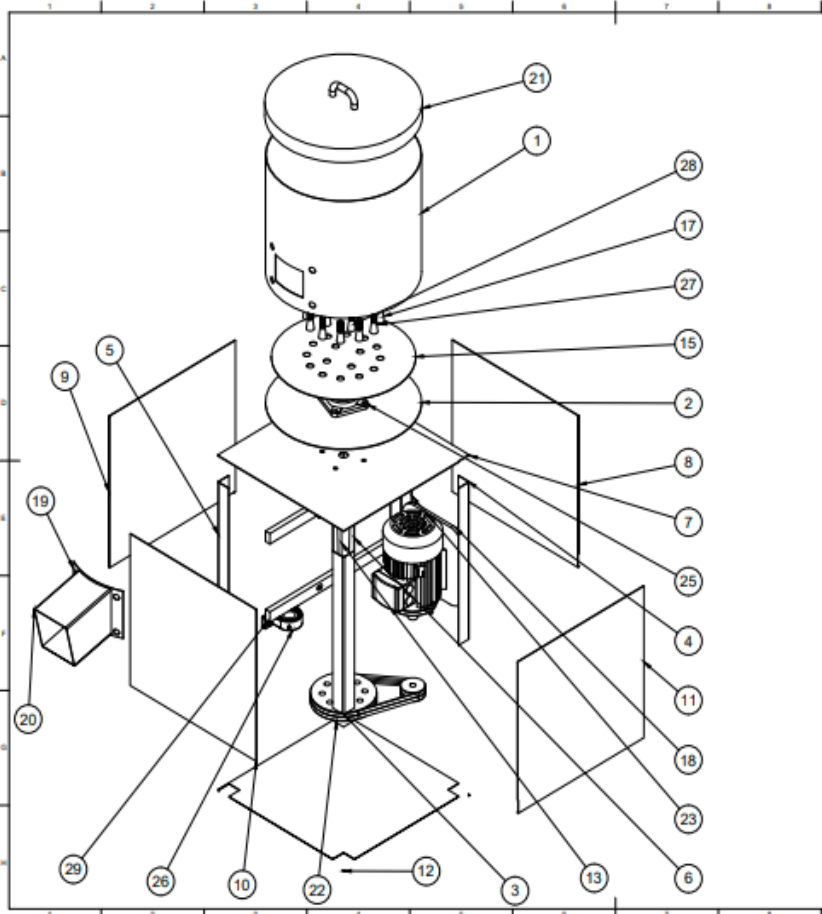
Holes drilled on the Rotating Plate for the Rubber Fingers



Fixing Rubber Fingers into basin

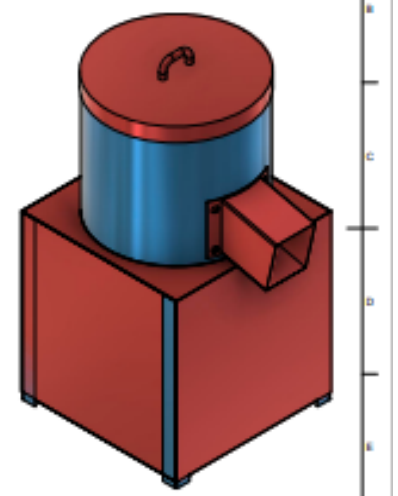
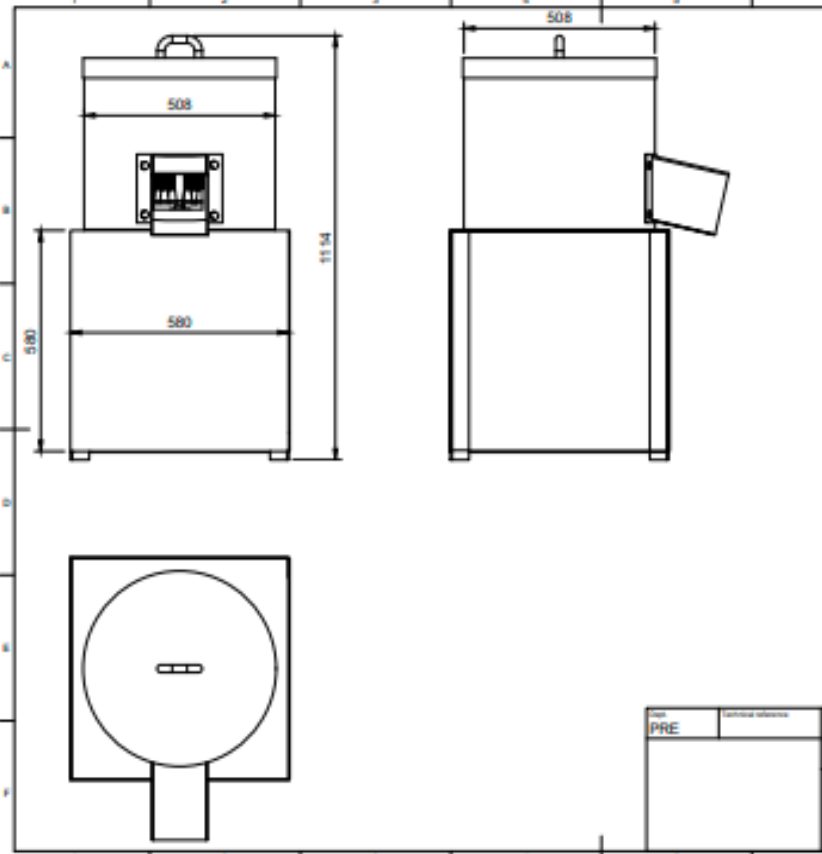


Final Frame work for the machine

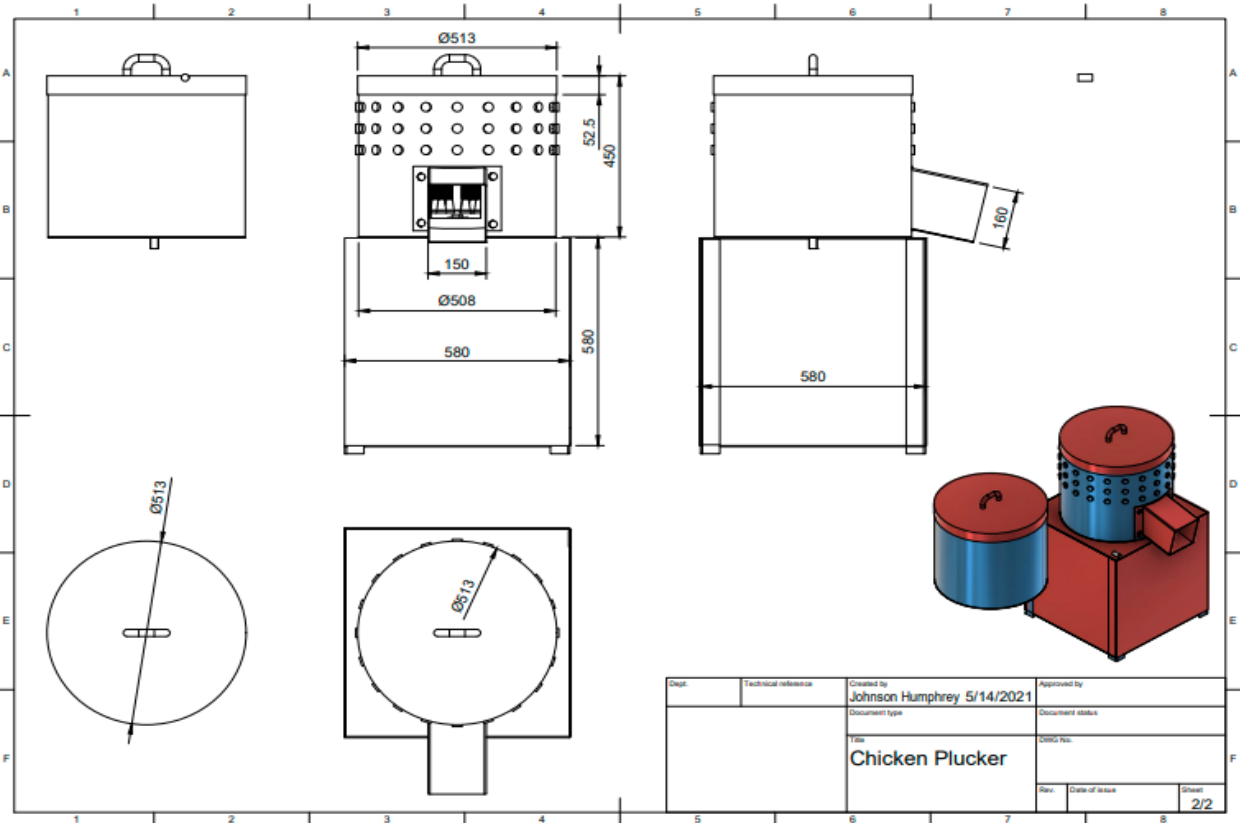
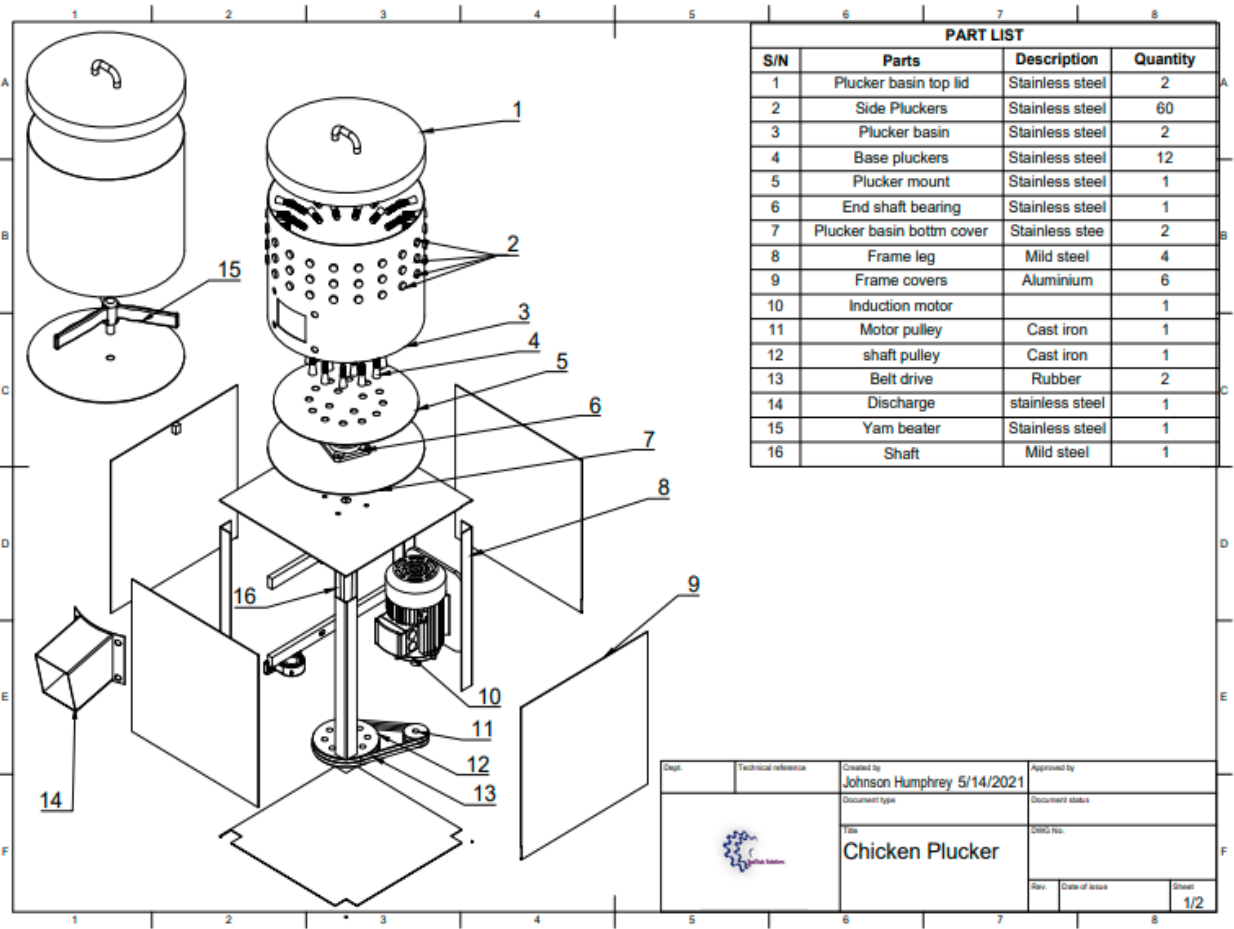


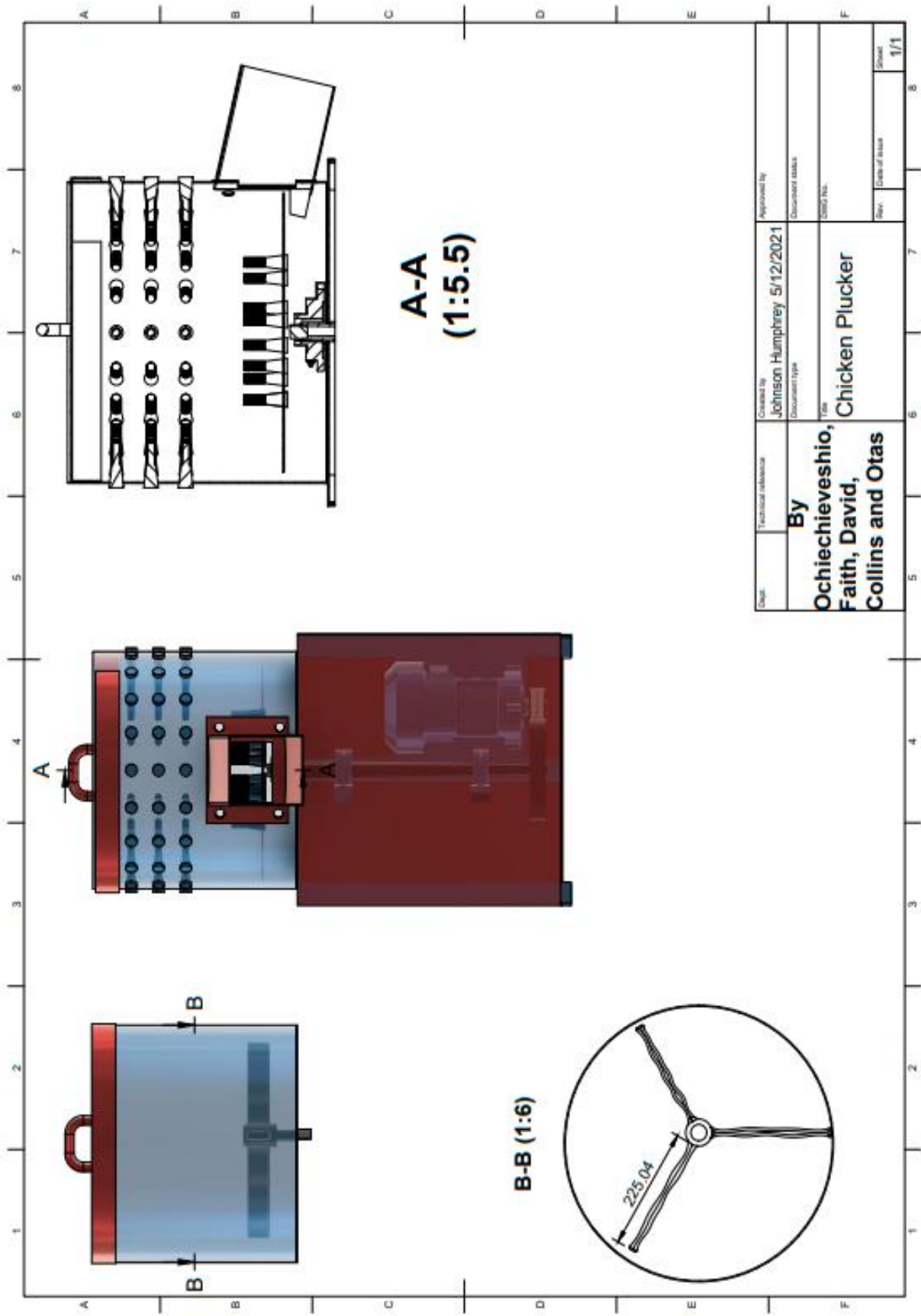
Parts List				
Item	Qty	Part Number	Description	Material
1	1		Top Basin	Steel
2	1		Bottom Basin cover	Steel
3	1		Frame	Steel
4	1		Frame 2	Steel
5	1		Frame 3	Steel
6	1		Frame 4	Steel
7	1		Top frame cover	Steel
8	1		Side cover 1	Steel
9	1		Side cover 2	Steel
10	1		Side cover 3	Steel
11	1		Side cover 4	Steel
12	1		Bottom cover	Steel
13	1		Shaft	Steel
14	1		Shaft key	Steel
15	1		Plucker plate	Steel
16	4		Component16	Steel
17	12		Plucker	Steel
18	1		Motor Assembly v4	Steel
19	1		Discharge assembly	Steel
20	1		Discharge	Steel
21	1		Top Basin lid	Steel
22	1		Belt design for chicken plucker v1	Steel
23	1		Component3(Mirror v3)(Mirror) (1)	Steel
24	1		Bearing v3	Steel
25	1		End shaft bearing v1	Steel
26	1		Bearing v3 (1)	Steel
27	1		Plucker (1)	Steel
28	4		Plucker (2)	Steel
29	1		Bearing v3 (1) (1)	Steel

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Chicken Plucker		001	
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Chicken Plucker		001	
			2/2





**A-A
(1:5.5)**

B-B (1:6)

Design	Technical reference	Created by	Approved by
	By	Johnson Humphrey, 5/12/2021	
	Ochiechievshio,	Document type	Document status
	Faith, David,	Year	2020 No.
	Collins and Otas	Chicken Plucker	
		Rev.	Date of issue
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