DESIGN AND FABRICATION OF CONTINUOUS PROCESS GROUNDNUT ROASTER MACHINE

BY

BELLO MUHAMMED

2003/14788EA

DEPARTMENT OF AGRICULTURAL AND BIORESOURCES ENGINEERING

FEDERAL UNIVERSITY OF TECHNOLOGYM MINNA

NIGER STATE.

NOVEMBER 2008.

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BEING A FINAL YEAR PROJECT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF BACHELOR OF ENGINEERING (B. ENG.) AGRICULTURAL AND BIORESOURCES ENGINEERING FEDERAL UNIVERSITY OF TECHNOLOGYM MINNA NIGER STATE.

NOVEMBER 2008.

DECLARATION

I, Bello Muhammed of the Department of Agricultural and Bio-resources Engineering, School of Engineering and Engineering Technology, Federal University of Technology, Minna, hereby declare that this project work has been conducted solely by me under the supervision of Engr. Prof. E.A.S.Ajisegiri. All sources of information have been duly acknowledged.

Bello Muhammed

19-11-2018
Date

CERTIFICATION

This project entitled " Design and fabrication of continuous process groundnut roaster machine" by Bello Muhammed meets the regulations governing the award of Bachelor of Engineering (B. Eng.) of the Federal University of Technology, Minna, and it is approved for its contribution to scientific knowledge and literary presentation.

ENGR. PROF. E.A.S.AJISEGIRI
(SUPERVISOR) DATE

EXTERNAL EXAMINER 19-11-08
DATE

Engr. Dr (Mrs.) Z.D.OSUNDE
HEAD DEPARTMENT OF
AGRICULTURAL AND
BIO-RESOURCES ENGINEERING 25/11/2008
DATE

DEDICATION

This work is whole heartily dedicated to God almighty, the all-sufficient God and the master of the universe who granted me the grace to come this far. I also dedicate this project to the entire members of Bello's family for their love, understanding and support.

ACKNOWLEDGEMENTS

My sincere gratitude goes to Almighty God- the beneficent and merciful for this assistance throughout the course of my studies and His promises to see me through the course of my life in the university. The road would have been so rough and tough than this if not for the assistance of my so many people. I give praises to Almighty for touching the heart of these people to rise to my need and make my university education a reality.

Firstly, I am indebted to my supervisor, Engr. Prof. E.A.S. Ajisegiri who despite his commitment took time, devoted attention, advice and comments made of the completion of this work. I wish to acknowledge my HOD Engr. Dr (Mrs.) Z.D. Osunde. I must also acknowledge Engr. Mustapha Nurudeen for counseling me throughout my stay in the university. Dr. O.Ochuckwu and other lecturers in the department are people to be acknowledged. May God guide them.

Secondary, I am sincerely grateful for the immense contribution my parents, mall. Bello Asuku and Hajia Asmau Bello for their parental care given to me.

I am greatly indebted to my brothers and sisters for their moral, financial and spiritual support. If not God that has destined my education I wouldn't have been someone without their support since the departure of my late father. Among them is Mall. Hassan Umar, who starved and sacrificed other things for my education, may God Almighty rewards him in abundance, Amin. Others are sister Zainab Lawal, who has contributed immensely toward my academic pursuit, Mall Ibrahim (Alhaji), Ibrahim Lawal, Usman, Bros. Yahaya Sulieman and my little sister Mariam Sulieman. May God reward you all, Amin.

My profound gratitude goes to Abdulraheem Abdulrazaki. Engr. Femi Makande. And to Bros Isiaku Abdul (First Bank Plc, Zaria), for their financial assistanceay and elderly advice throughout my educational career. May you reap what you have sowed.

Lastly my sincere appreciation goes to my friends in the university and outside as well as for their financial and spiritual supports. They arre Bello Dolapo Jamiu (a.k.a. Dabello), Dangana S. Nathanael, James O Alabi, Sulieman Salaudeen, Hasanatu Sulieman, Sabdat (Hajia), Michael Odouye (my Distinguish), David Mathew, Mr. Dum, Mr. Dan, Victoria (NIOMCO), and Maliki Steve (home boy). Others are Binta, Tosin, Vancy Nwakwu Izunna, Paul, Jolly and others too numerous to mention. God in His infinite mercy will continue to guide and guard each and every one of us and make our future bright, Amin.

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ABSTRACT

The aim of this work is to design and fabricate continuous process groundnut roaster machine. The machine was designed from locally available materials. This process is made to continue as the groundnut is being fed through the hoppers. From the test carried out on the fabricated machine, the groundnut will travel on the roasting trays inclined at 5° and at a temperature of 160°C. The machine was found to be capable of roasting about 350kg of groundnut in 20 minutes with an efficiency of 51%.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Preamble

Groundnut or peanut, as they are sometimes called originated in Brazil. They are one of the most valuable legumes crops of the tropical and subtropical countries with 25% protein and more than 40% oil. There are two parts of the peanut that are edible, including root and seeds. The roots can be prepared in a variety of ways, like roasting, baking, boiling and drying for flour. The small seeds can be substituted for beams or lentile in soups and stews (Brian, 2005). Africa accounted for 38% of global groundnut area and 25% of production.

Nigeria is a major producer of groundnut for 25% of world export (IFPRI, 1994). In 2004 the country had 3500 hectares cultivated and production of 2750 tonnes (NBS, 2005). Groundnut accounted for 70% of total Nigeria export prior to petroleum oil boom (World Geography of peanut, 2003). Groundnut is widely consumed in Nigeria as roasted or boiled nuts in the western and southern parts of the country (Adebesin et al, 2001). Homogenization of the nuts is a process carried out in the western parts. The process produced a roasted Nigerian groundnut cake called "kulikuli". The results presented by Azizah and Zaiman (1997), suggested that roasting leads to reduction in Insoluble Dietary Fiber (IDF) and Total Dietary Fiber (TDF). CAC (1991) informed that roasting enhances the flavor and the taste of the food in infant formulation. It also said that roasting leads to improved digestibility and reduction in formulate food. The roasting of groundnut with sugar and honey is a new addition just over a decade ago in

Nigeria. It requires little capital for production. However the acceptance by the adult class is still in low ebb, because of some undesirable qualities found in the products. These defects were highlighted and processing method to prevent their economic is investigated and hereby documented.

Recently, great economic importance is attached to the production of groundnut in Nigeria. The production is likely to increase in market demand. However, roasting of this crop has been a serious issue to it's processing and as such, a machine for roasting is not common.

In the old days and still in some rural part of the country, roasting is achieved by traditional method (batch process). This process is very slow, tedious and time consuming with the present level of production. Since the increase in production of groundnut ahs to continue, a small scale farmer has to be provided with means by which their product can be provided with minimum drudgery and cost yet achieved good quality product.

Over the years, continuous process of roasting have introduced into Nigeria (Adebesin et al, 2001), but the major problem has been the roasting efficiency (quality) of the nuts. Yet cost of this imported machine is too exorbitant and hence the machines are out of reach of small scale farmers. The development of such equipment will also reduce the cost of importation of the equipment (Oke et al, 2008).

1.2 Objectives of the study

1. To design and construct continuous groundnut roaster machine, that will increase the roasting rate of groundnut and would incorporate the advantages

of reducing human labour, time wastage, portable, durable, efficient in operation and higher capacity.

2. To design and construct a groundnut roaster machine with locally available materials.

1.3 Statement of the problem

The traditional method of roasting is very slow and tedious which make roasting of groundnut uninteresting and time consuming. The batch process of roasting involves high cost of labour with low roasting efficiency. It is because of these reasons and many more, that a more efficient machine, with time saving and cost efficient is required.

1.4 Justification of the study

The development and introduction of the new processing technology, "continuous process groundnut roaster machine " offers a greater prospects in market for groundnut producers because a high quality and efficient roasting is obtained, thereby increasing the standard of living of the people, in terms of providing technological in processing of groundnut and increasing their income.

Efficient method of roasting will enhance the processing activities and reduce labour intensive, as it is an improved method of roasting groundnut.

1.5 Scope of the problem

The scope of the study is to design, fabricate and test continuous process groundnut roaster machine with view to ascertain it viability and efficiency.

CHAPTER TWO

2 0 LITERATURE REVIEW

2.1 Origin of Groundnut

The origin peanut of ground (Arachis hypogeal L.), originated in South America (Bolivia and adjoining countries) and now grown throughout the tropical and worm temperate region of the world. This crop as grown of European expansion in the sixteenth century and was subsequently taken to Europe, Africa, Asia and the pacific islands. Peanut was introduced to the present south eastern United States during colonial times. Peanut was grown primarily as a garden crop, peanut was used commonly for huge pasture until about 1930 (Adebesin, 2001).

Peanut, important oil and food crops, is currently grown an opportunity 42 million acres world wide. It is the third major oil seed of the world next to Soya beans and cotton (FAO food, 1990). India, china and the United states having been the leading producers for over 25 years and grown about 70% of the world crop. Peanut was ranked ninth in acreage among major raw crops in the United States during 1982 and second in dollars value 1989-1990 was estimated at 1.8 million tons, or about 8% of the world production of 23.2 million tons (FAO food, 1990). In 1983, Georgia, Texas, Alabama, and North Carolina grew 80% of the 1,375,000 acres of peanut in the United States. Virginia, Oklahoma, Florida, South Carolina and New Mexico were the other states with more than 10,000 acres of peanut.

Ground nut is a kind of crop which is mostly grown in warm or tropical climates, with no branches and with compound leaves withy flour leaflets. There is a long petiole with a pulverous (swelling) of the base of the petiole, with a pair or stipules. The bears

two or three seeds inside these have a thick brown testa, and oil globules and starch grains are present in the seed. The seed are very rich in the food values. Although it is grown in all continents over 75% of the total world peanut produce is concentrated only in India, China, and united state of America. Through the tropical groundnut yields are somewhat lower than the world average and hence production in tropical is only about two third of the world total.

Table 2.1 the shown completed analysis

Area(1,000ha) crop	Tropical Africa	Tropical America	Tropical Asia	Total Tropic	World	Tropics as % of world
Yield Ground nut	765	1313	877	848	965	87.9
Production (1000) Ground nut	4636	717	7712	13065	18736	69.7

Ground nut is also found to be a good rich in dietary protein, Vitamins and minerals in many area of the world the recent days, great emphasis as be placed on increasingly the ground nut production in the developing country of a Asia and Africa to meet their demand of edible oil why in the develop world, the emphasis as been on how to standardize or renew technology to process ground nut into a variety of human consumption ground nut is now cultivate through out the world from 36^0N to 36^oS in a range of temperature region from warm temperature to equatorial.

2.2 Seed structure

Seed of cultivated ground nut variety differ in size shape and the colour of their coat. The kernel weight ranges from 0.2 to 1g. The shape of the seed may be almost spherical, elliptical or much elongated or flattered with a length ranges from 10 to 20mm. The colour of the seed coat may be very from dark purple to white passing through different shades of red and rose the embryo consist of two elongated or massive cream cotyledons on upper step axis with young foliage leaves (epicotyls) and a lower stem axis and primary root (radicals) the seed coat testa is thin and papery. It has no palisade cells which has thickness and pitted outer world the race of the testa form a compact layer of the cells immediately benefit the outer epidermis to spongy layer where becomes more squashed.

The endosperm is a single layer of cell containing oil deoplets and possibly alumnae grains. The epicotyls consist of three buds has four foliage leaves while each of the cotyledomary laterals may has one or more leaves thus, at the embryo stage, six to eight leaves are found differentiate. Peanut pod consist of twenty six percent shells and in 44 to 80% kernel. Cotyledons contribute about 72% seed coat 4%, while the germ about 3% the pod weight (Chavan J.K, 1990).

Table 2.2 Shown how ground nut is been produced.

Country	Area 1000 (ha)	Yield (Kg/ha)	Production (1000 tons)
INDIA	7,429	833	6,186
NIGERIA	600	867	526
BRAZIL	283	1488	421

In Nigeria and the north part of country where many variety are grown seeds are sown from mid- march to mid- may in manure pit and again sown last September to mid-December it is largely produce in this part of the country compare to the eastern and the western because of the less rainfall in the area (Weather chart F.O.S 1993).

2.3 Types of groundnut

Although ground nut come in a varieties which include the following: Runners, Virginia, Spanish and Valencia. Each of the ground nut types in distinctive in size, flavor, and nutritional composition within each basic type of groundnut there are several varieties seeds and production purpose which varieties contain district characteristics which allow a producer to select the product that is the best suited for each region and market.

2.3.1 Runner

Runner have become the dominant types due to the introduction in the early 1970 of a new runner variety, the flow-runner, which was responsible for spectacular increase the ground nut yields. Runner have rapidly gained wide acceptance because of the attractive uniform kernel size. Fifty- four percent of the runners are grown used for butter. Runners are grown mainly in Georgia, Alabama, Florida, Texas and Oklahoma.

2.3.2 Virginia

Virginias have the largest kernels and account for most of the groundnuts roasted and processed in- the- shell. When shelled, the larger kernels are sold as snack groundnut. Virginias are mainly grown in south eastern Virginia and northern eastern and northern Carolina.

2.3.3 Spanish

Spanish –type groundnuts have smaller kernels covered with a reddish-brown skin. They are used predominantly in peanut candies, with significant quantity used for snack nuts and peanut butter. They have higher oil content than the other types of groundnuts, which is advantageous when crushing for oil. They are primarily grown in Oklahoma and Texas.

2.3.4 Valencia

Valencia's usually have three or more small kernels to a pod and are covered in a bright- red skin. They are very sweet groundnuts and are usually roasted and sold in- the-shell. They are also excellent for fresh used as boiled groundnuts. New Mexico is the primary producer of Valencia groundnuts.

2.4 Processing of Groundnuts

2.4.1 Processing Condition

For optimum roasting of groundnut of good quality, the processing condition based on experimental finding and test carried out should be observed (Simon, 1982).

i. Roasting should be stirred continuously to prevent burning.

ii. The average charring temperature should maintain between. 170-120°C for 45 minutes for a maximum roasting.

iii. The use of warm water sugar should be applied, because it hasting roasting and thereby prevent boiling or soaking of seeds.

2.4.2 Traditional Processing Method

Locally, the roasting of groundnut and its products (raw or fried cake) is an important source of income for women in rural areas of Nigeria and Africa as a whole.

Though there may be regional variation in processing groundnut it almost the same (Khan etal, 1983).

i. Groundnut are harvested manually

ii. Harvested groundnut kernels are soaked in water with 4% salt (Nacl) for 12 hours.

iii. The soaked kernels are dried and roasted with sand.

iv. Roasted groundnut kernels are packed.

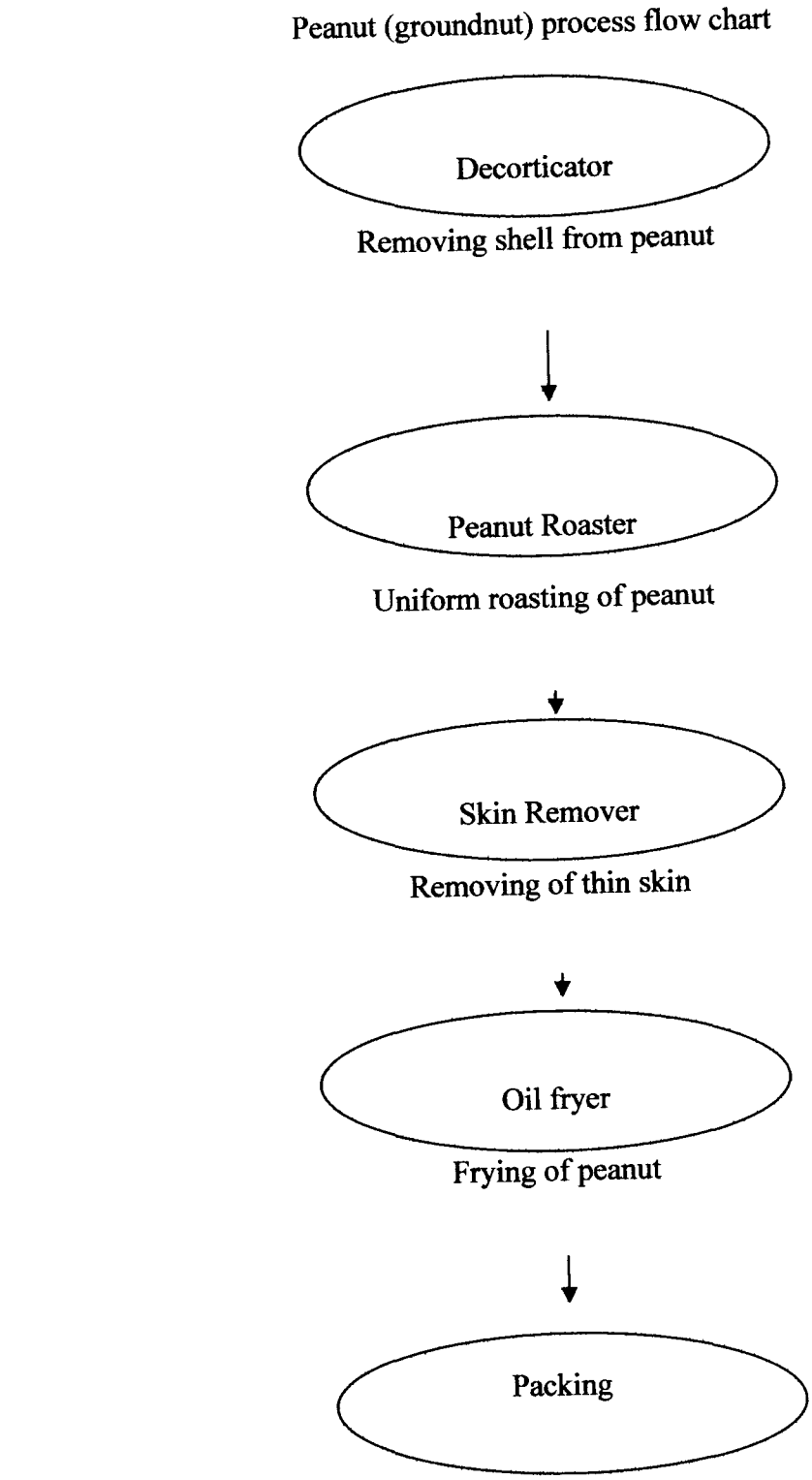


Fig. 2.1 peanut (groundnut) flow chart

2.5 Groundnut product and their uses

Groundnut crops are grown extensively and utilized in the production of oil and meal derived from the residue after oil extraction. The nuts are eaten raw, lightly roasted or boiled, some times salted or made into paste which is known as peanut butter. The leaves of the plant are used as vegetable in soups. The oil is used for cooking and may be used for margarine, vegetable glee, soap making, cosmetic products, pharmaceutical products and emulsions for insecticides. Being reach in protein, it is adopted in making baby food, and is extensively used in livestock feeds (groundnut cake) (Allen. J.S, 1989).

2.6 Moisture Content requirement

Harvesting is manually followed by mechanical drying. Moisture in groundnuts is usually kept below 12 percent to prevent aflatoxin molds from growing. This low moisture content is difficult to achieve under field conditions without over drying vines and stems, which reduces combines efficiency (less foreign material is separated from the pods). On- farm dryers usually consist of either storage trailers with air channels along the floor or storage bins with air vents. Fans bellows heated air (approximately 35^0C (95^0F) through the air channels and up through groundnuts. Groundnuts are dried to moisture of roughly 7 to 10 percent before roasting (Harries, 1988).

2.6.1 Various Method of Reducing Moisture

2.6.2 Sun Drying

Drying done in open sunlight is weather temperature and relatively humidity dependent. Sun drying may be successfully in a hot, dry climate what would take 6 to 10 hours to dry using another method such as solar drying, oven drying etc may take 3 to 5

days in sun. The groundnut then moved into a shade to complete the dry when it is two – third dry

2.6.3 Solar Drying

Solar dry is modification of sun drying in which the sun rays are collected inside the specially designed unit with adequate ventilation for removal of moisture air. The temperature in the unit is usually 20 to 30 degrees higher than in open sun light, which result in shorter drying times. Solar drying has many advantages over sun drying. Lack of control over the weather is the main problem with both methods.

2.6.4 Oven Drying

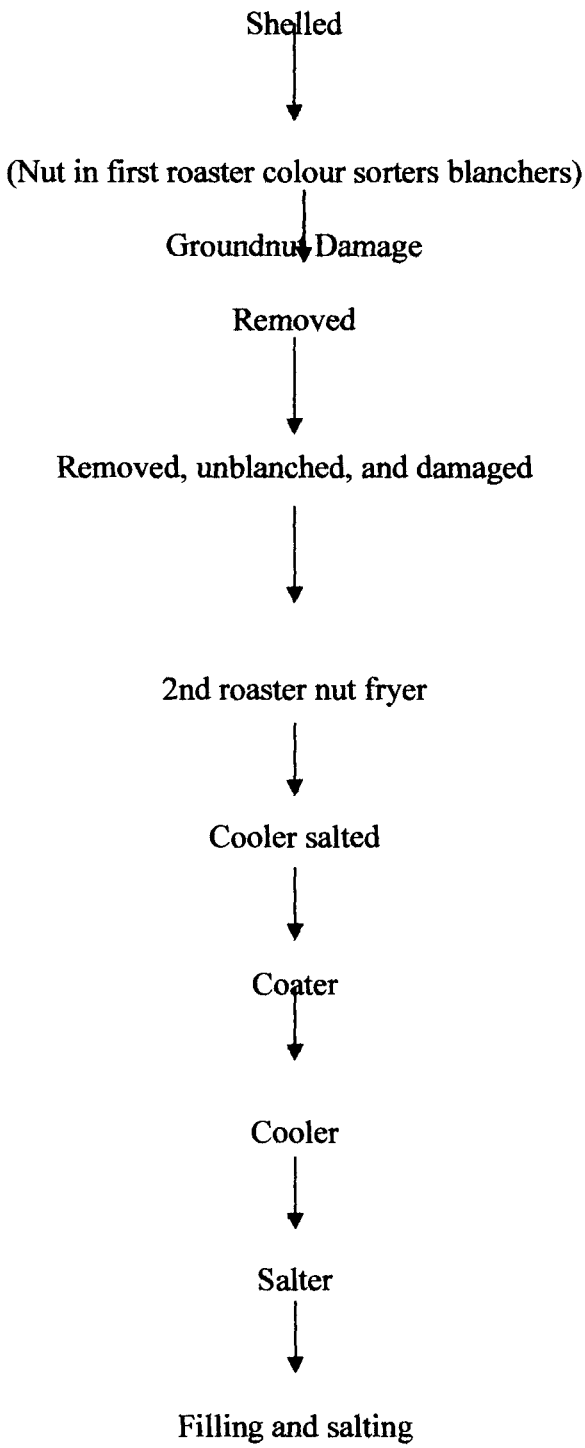
This is usually a good choice if only 20 to 40 kg of produce is to be dried at a time on a small- scale drying. Disadvantages are the cost of the energy and having the oven on constantly. Oven drying take 2 or 3 times longer than a dehydrator. The groundnut may be turned occasionally to assure even drying by shifting the trays every half hour.

2.7 Method of Roasting Groundnut

Roasting impacts the typical flavor many people associate with groundnuts. During roasting ammonia acids and carbohydrates reacts to produce tetrahydrofuran derivatives. Roasting also dry the groundnuts further and causes them to turn blown as groundnut oil stains the groundnut cell walls. Groundnuts seeds are roasted using vegetable oil with or without salt (1-4%) by applying dry heat, or on sand an even distribution of heat. The dry roasted groundnut is useful in preparation of peanut butter, confectionary or bakery products. After roasting, the testa are removed and the dried cotyledons are consumed. Roasting reduces moisture content and develops a pleasant

flavor which makes the products more acceptable for consumptions. However, excess heating during roasting results in low nutritional quality of protein (Harris, 1988).

The large- scale roasting involve the following steps:



2.7.1 Various Method of Roasting groundnut

2.7.2 Drum Roasting

Drum roasting have conventional window on its side. It makes sense to any cook who simmers their sauces slowly, or faithfully oils their cast iron, that a drum roast will be inherently better. After all, it is slower, transferring heat to the groundnut seeds by conduction (contact with the hot drum metal) and convection- radiance (warm air passing through the drum). That is perfect blend of stovetop pan cooking and gas oven cooking techniques. And commercial drum roaster is big, attractive, expensive and old-world-European-looking machines. Home roasters generally to small shops perhaps thinking that drum roasting is the technique of choice among the cognoscenti.

2.7.3 Air Roasting

Air roasting has less intrinsic charm, unless you are really into hair dryers. But the roast is easy to observe, the process is clean because there is no effluence from atmospheric gas burners, and some variables of the drum process (bean variability and ambient temperature) are less of a factor.

In commercial world of quality conscious groundnut roasters you are going to see drum roasting as the dominant techniques. Only the sivetz roaster is available for small scale quality air roasting. It is a great machine, but consumes a lot of power, is noisy and fire-prone without good maintenance and has little aesthetic value. It's a ballsy move to start a new roasting shop without a sivetz roaster are not many sensible people (well ones who don't want lose their life savings in a business start-up) will go to that route.

On large scale end of thing, factory roasters have a better mix of air and drum roaster installed, but this doesn't bode well for the reputation of air machines. Big buns like the throughput of air roasting which boasts as low as 3.5 minutes in huge quantities.

2.7.4 Macro wave roaster Groundnuts

For those who may want to get the roasting done a little quicker, you may want to give this method a terrier. Roasting in the macro wave certainly would not be the most traditional way, but it is effective, the only thing in this method you have to shell the groundnut, unshelled will not work well in this method.

2.7.5 Batch Roaster

These are the advantage of adjusting for different moisture content of groundnut lots from storage. Batch roasters are typically natural gas-fried revolving ovens (drum-shaped). The rotation of the oven continuously stirs the nuts to produce oven roast. Oven temperatures are approximately 430^0C (800^0C), and ground nuts vary with temperature raised to approximately 160^0C (320^0F) for 40 to 60 minutes. Actual temperatures and time vary with condition of the groundnut batch and the desire end characteristics.

2.7.6 Continuous Roaster

Continuous dry roasters vary considerably in type. Continuous roasting reduces labour, ensure steady flow of groundnut for other process (packaging), candy production, peanut butter production etc and decreases spillage. Continuous roasters may move peanut through an oven on a conveyor or by gravity feed. In one type of roaster groundnut are fed by a conveyor into a stream of counter current hot air that roasts the groundnuts.

In this system, the groundnuts are agitated to ensure that air passes around the individual kernels to promote an even roast (Dennis. R. 1981)

CHAPTER THREE

3.0 MATERIAL AND METOHDS

3.1 DESIGN CONSIDERATION AND MATERIAL SELECTION

Considering that economy is the basis of any good design. The materials to be used were carefully selected so that it serves the specific purpose for which it is meant, while at the same time are economical.

In designing the continuous groundnut roasting machine, the basic factors considered include choice of material, their availability and cost these factors are of primary consideration, materials were chosen based on their properties (Solomon, 1994).

In selecting materials to achieve the main objective of a design, factors such as the cost of materials, availability, durability amount of labour properties of materials must be taken into consideration. One should not be wholly sacrificed in order to achieve the other.

The properties of the materials must include resistance to corrosion to avoid contamination.

Materials like stainless steel, brass, grey cast iron have better advantages over others but for availability and economic reasons, galvanized mild steel and aluminum were chosen.

The availability of the material within the locality will reduce the constructional cost and hence will make the price comparatively low, making it affordable. The design features of each of the parts are discussed below.

3.1.1 Hopper

The hopper serves the purpose of feeding the groundnut into the machine. It has dimensions of 200mm by 250mm and an opening of 50mm by 150mm. which is channeled to vibrating trays.

3.1.2 Vibrating trays

The vibrating trays are made of gauge 24 aluminum sheet to enhance good heat conduction and resist corrosion; the trays are of the dimension 1000mm by 120mm by20mm.

3.1.3 Casing

The casing had openings in which one is for the hopper and the other for the discharger. The casing houses the trays, vibrator, heating filaments.

At the bottom of the casing is the collector channel for the exit of roasted groundnut.

3.1.4 Discharge outlet

The discharge outlet is located at the base of the casing for the discharge of the roasted groundnut.

3.2.0 DRY ROASTING

Dry roasting is either a batch or continuous process. Batch roasters offer the advantage of adjusting for different moisture contents of groundnut lots from storage. Batch roasters are typically natural gas-fired revolving ovens (drum-shaped). The rotation of the oven continuously stirs the peanuts to produce an even roast. Oven temperatures are approximately 430°C (800°F) and peanut temperature is raised to approximately 160°C

(320°F) for 40 to 60 min. Actual roasting temperatures and times vary with the condition of the peanut batch and the desired end characteristics.

Continuous dry roasters vary considerably in type. Continuous roasting reduces labor, ensures a steady flow of groundnut for other processes (packaging, candy production, peanut butter production, etc.), and decreases spillage.

The continuous roaster move groundnut through oven on a conveyor tray by gravity feed. In this system, the groundnut is agitated to ensure that air passes around the individual kernels to promote an even roast.

The downhill movement of groundnut is due to the force of gravity and is resisted by friction. The forces of gravity and friction are in balance at the ***angle of repose*** which is the maximum slope angle that unconsolidated materials can maintain. At angles steeper than the angle of repose friction is not sufficient to counter gravity and mass wasting (sliding) occurs. At angles less than the angle of repose gravity cannot overcome friction and groundnut may accumulate to form steeper slopes.

Gravity, Friction

Consider the case pictured below of a block on an inclined plane. The block is attracted straight downward (toward the center of the Earth) by the force of gravity (f_g). In the case of the inclined plane, a certain amount of the gravitational force is applied perpendicular to the plane (f_n, normal force) and a certain amount is applied parallel to the plane (f_s, shear force). The normal force acts to increase friction and stick the block to the plane. The shear force acts to pull the block down the plane.

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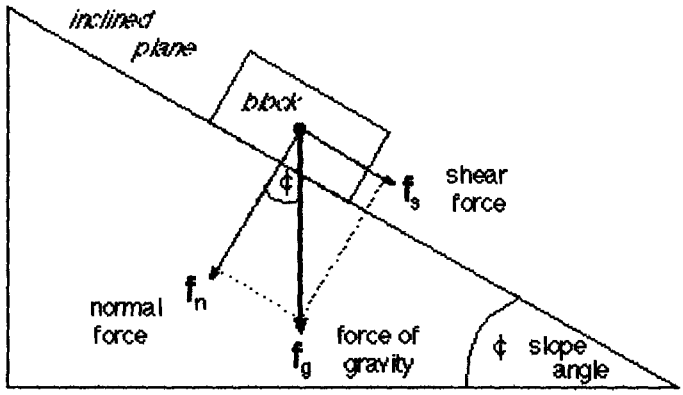

That component of shear force and normal force derived from the downward gravitational force are dependent on the angle of slope.

(shear force) = (force of gravity) x (sin (slope angle))

$$F_s = F_g \times \sin\phi$$

(normal force) = (force of gravity) x (cos (slope angle))

$$F_n = F_g \times \cos\phi$$

In English Units the force of gravity is simply the weight of an object in pounds. In most problems we are interested in the force acting over a given area of the plane (like pounds per square inch). This is called the ***stress***.

Stress = Force / Area

The shear and normal stresses are therefore simply the shear and normal forces divided by the area of contact between the block and the inclined plane.

Since the area between the block and the inclined plane are the same when considering both the shear and normal stress, the ratio of the shear to normal stresses is the same as the ratio of the shear to normal forces.

Now most importantly relating the shear stress, cohesion (do they stick together even with no forces applied?), normal stress, and friction. Notice in the equations below how the normal stress works hand in hand with friction.

At the angle of repose:

(shear stress) = (cohesion) + (coefficient of friction) x (normal stress)

$$\sigma_s = c + \mu\sigma_n$$

in cohesionless substances:

(shear stress) = (coefficient of friction) x (normal stress)

$$\sigma_s = \mu\sigma_n$$

or restated:

(coefficient of friction) = (shear stress) / (normal stress)

$$\mu = \frac{\sigma_s}{\sigma_n}$$

The coefficient of friction is related to the friction between particles and depends on the characteristics of the material (e.g., is it rough or smooth, rounded or blocky):

(coefficient of friction) = tan (angle of internal friction)

$$\mu = \tan\phi$$

and in the case of unconsolidated materials:

(angle of internal friction) = (angle of repose) = inverse tan ((shear stress) / (normal stress))

$$\phi = \tan^{-1}\left(\frac{\sigma_s}{\sigma_n}\right)$$

(Chapters 4 and 6 [Rahn])

Density of shelled groundnut is 641kg/m^3 (Le Système International d'Unités)

Angle of repose =30^0

Coefficient of friction =0.4

(Agric/industrial division of Chief Industries, Inc.)

3.3 POWER REQUIREMENT

The power requirement for the continuous groundnut roasting machine can be subdivided into two.

a. Power required roasts the groundnut.

b. Power required to agitating the trays.

The summation of these separate power requirements gives the total power required by the groundnut roasting machine.

Hence if

P_T = total power

Pr = Power required to roast the groundnut

Pv = Power required vibrate trays

: - Total power (P_T) = Pr +Pv

3.3.1 Power to roast groundnut

Heat required for roasting (Q)

The required temperature to roast groundnut is 160^0 C

From the equation

$Q = hA \times \Delta T$

Where

h = heat transfer coefficient

A = cross sectional area

ΔT= change in temperature of groundnut =160^0 C

$$h = \frac{k}{\Delta x}$$

k= thermal conductivity of aluminum=237 W/mK

Δx =material thickness. 0.4mm

$$h = \frac{237}{0.4 \times 10^{-3}} = 592500 \text{ W/K}$$

A= length ×breadth of roasting tray

A = 600mm ×120mm

A = 72000mm^2 =0.072m^2

$$Q = 592500 \times 0.072 \times 160 = 6825600$$

$$P = \frac{W}{T}$$

$$P = \frac{6825600}{3600} = 1896 watt$$

3.3.2 Power required to vibrate trays

Vibrator frequency

Given that vibrator motor rpm =1600rev/min

$$\omega = \frac{2\pi N}{60} = \frac{2\pi \times 1600}{60} = 167.55 rad/s$$

$$f = \frac{\omega}{2\pi} = \frac{167.55}{2\pi} = 26.58 Hz$$

Pv = Power required to vibrate trays

$$P_r = Mr\omega$$

where

M=vibrator mass =1.4 Kg

r = radius of mass = 2cm = 0.02m

$P_r = 1.4 \times 0.02 \times 167.55 = 4.6914$ watt

Total power required by groundnut roaster

$P_T = 1896 + 4.6914 = 1900.69$Watt

Heating filament selection

From the results obtained in the power requirement Nichrome heating filament of 2000watt rating was selected for the design.

Vibrator motor selection

A 100watt A.C motor was chosen for the tray vibrator.

3.4 VELOCITY OF GROUNDNUT (V)

$$V = \frac{S}{T}$$

V= velocity mm/sec

S = distance traveled = 6meters (6000mm)

T = processing time = 12min (720 seconds)

$$V = \frac{6000}{720} = 8.33 mm/s$$

3.5 LENGTH OF CONVEYOR TRAY (L)

$$L = \frac{S}{n}$$

S = distance traveled = 6000mm

n = number of trays = 10

$$L = \frac{6000}{10} = 600 mm$$

3.5.1 Angle of inclination of conveyor trays (θi)

$$\theta i = \frac{\phi}{6}$$

ϕ = Angle of repose = 30^0

$$\theta i = \frac{30}{6} = 5^o$$

3.6 SPRING DESIGN ANALYSIS

A helical spring is a spiral wound wire with a constant coil diameter and uniform pitch. The most common form of helical spring is the compression spring but tension springs are also widely used. . Helical springs are generally made from round wire which, it is comparatively rare for springs to be made from square or rectangular sections. The strength of the steel used is one of the most important criteria to consider in designing springs.

F = Force exerted on spring = 56 N

$D_{Standing}$ = Free length of spring

$D_{Deflected}$= Length of spring with force applied

k = spring constant determined by experiment or calculation Equation

Force (F) = k ($D_{Standing}$ - $D_{Deflected}$)

Where

C = Spring Index D/d

d = wire diameter (m)

D = Spring diameter (m)

D^i = Spring inside diameter (m)

D^{il} = Spring inside diameter (loaded) (m)

E = Young's Modulus (N/m^2)

F = Axial Force (N)

G = Modulus of Rigidity (N/m^2)

K_d = Traverse Shear Factor = (C + 0,5)/C

K_W = Wahl Factor = [(4C-1)/(4C+5)}]+ (0,615/C)

L = length (m)

L_0 = Free Length (m)

L_s = Solid Length (m)

n_t = Total number of coils

n_a = Number of active coils

p = pitch (m)

y = distance from neutral axis to outer fibre of wire (m)

τ = shear stress (N/m^2)

τ_{max} = Max shear stress (N/m^2)

θ = Deflection (radians)

Meters (m) have been shown as the units of length in all of the variables above for consistency

3.6.1 Spring Index

The spring index (C) for helical springs in a measure of coil curvature.

$$C = \frac{D}{d}$$

$$= \frac{24}{3} = 8$$

Spring index (C) =8

3.6.2 Spring Constant

The spring constant k is function of the spring geometry and the spring material's shear modulus G,

$G = 80 \times 10^9 \text{ N/m}^2$

D =24mm = 0.024m

d = 3mm = 0.003m

n_a = 8 coils

$$k = \frac{Gd^4}{8D^3 n_a} = \frac{80 \times 10^9 \times 0.003^4}{8 \times 0.024^3 \times 8} = 7324.2$$

and D is the mean diameter of the spring (measured from the centers of the wire cross-sections),

3.6.3 Spring Stress Values

For General purpose springs a maximum stress value of 40% of the steel tensile stress may be used. However the stress levels are related to the duty and material condition.

Consider a compression spring under an axial force F. If a section through a single wire is taken it can be seen that, to maintain equilibrium of forces, the wire transmits a pure shear load F and also to a torque of Fr.

$$K_d = \frac{C+0.5}{C} = \frac{8.5}{8} = 1.0625$$

$$\tau_{max} = \frac{8 \times 50 \times 0.024 \times 1.0625}{\pi \times 0.003^3} = 120250401.4 \text{ N/m}^2$$

The curvature of the helical spring actually results in higher shear stresses on the inner surfaces of the spring than indicated by the formula above. A curvature correction factor has been determined (attributed to A.M.Wahl). This (Wahl) factor K_w is shown as follows.

$$K_w = \frac{4\times8-1}{4\times8-4} + \frac{0.615}{8} = 1.206$$

This factor includes the traverse shear distribution factor K_d.. The formula for maximum shear stress now becomes.

$$\tau_{max} = \frac{8\times50\times0.024\times1.206}{\pi\times0.003^3} = 136491279.2 \text{ N/m}^2$$

3.6.4 Spring resonant frequency

$$f_{res} = \frac{1}{2}\sqrt{\frac{k}{M}}$$

Where k is the spring constant from above and M is the spring mass. The spring mass M was found by weighing the spring,

$$= \frac{1}{2}\sqrt{\frac{7324.2}{0.12}} = 123.53Hz$$

CHAPTER FOUR

4.0 TEST, RESULTS AND DISCUSSION OF ERSULTS

4.1 MODE OF OPERATION OF THE MACHINE

The groundnut roasting machine is electrically powered. The groundnut is fed into the machine through the hopper and to the trays which transport the groundnut through the roaster. The groundnut spend 20 minutes traveling through the roaster at which time the groundnut gets satisfactorily roasted and is discharged through the discharge outlet at the bottom of the casing.

4.2 TESTING

After fabrication, performance test was carried out on the roaster. This was aimed at assessing the performance and the degree to which the machine could roast out from groundnut roaster.

4.3 DETERMINATION OF EFFICIENCY

Total number of groundnut fed to the hopper = input = 410 pieces

Total number of groundnut completely roasted = output =210 pieces

Total number of groundnut partially roasted = 208 pieces

Efficiency = (output/input) x 100%

= (210/410) x 100% = 51.2% ≈ 51%

4.4 DISCUSSION OF RESULT

The input and output of groundnut fed gave an efficiency of the machine as 51%. This value of efficiency must have been due to heat lost by the heating element and velocity.

The result of the velocity which was 8.33mm/s indicated that it is sufficiently required for the groundnut to travel in 20 minutes before it is completely roasted.

Both the efficiency and the value of the velocity indicated that the machine is satisfactory for its minimum requirements.

4.5 COST ANALYSIS

The Cost of the project is represented by three basic unit costs which are:

(a)Material cost

(b) Labor cost

(c) Overhead cost

4.5.1 DIRECT LABOUR COST

Direct labor cost is the cost of working with some of the machines in the workshop for the fabrication of product. The direct labor cost consist the cost of drilling and riveting of frames and welding of structural members. For the fabrication of the project, the direct labor cost was 40% of material cost

4.5.2 DIRECT MATERIAL COST

Direct material cost is the cost of materials that can be identified in the finishing product. The cost estimates of materials used for the fabrication of the roaster are tabulated in table 4.1

TABLE 4.1 MATERIAL COST

S/N	DESCRIPTION	QTY	UNIT COST	TOTAL COS
1	Square pipe 3/4 inch x 3/4inch	3	700	2100
2	Aluminum sheet	2 sheet	2000	4000
3	Heating filament	2	1000	2000
4	Galvanized	½ sheet	3000	3000
5	Electric motor	1	1000	1000
6	Spring	6	100	600
7	Paint	1litre	1000	1000
8	rivets	60	5	300
9	Thinner	1bottle	100	100
10	Cable	1	300	300
11	Plug	1	100	100
15	Polyutheryne foam	½ sheet	1250	1250
	TOTAL			15,750

Material cost =₦ 15,750

Labor = 40% of material cost

= ₦ 6,300

4.5.3 OVERHEAD COST

This is the sum of indirect material cost of indirect labour cost. This is the total cost of fabricating the product which cannot be identified in the project. The overhead cost was ₦2000.

4.5.4 TOTAL COST

Total cost is the sum of the direct labour cost, direct material cost and overhead cost. For the fabrication of the machine, the total cost is as follows:

TABLE 4.2 TOTAL COST ESTIMATE

Description	cost (₦)
Direct material cost	₦15,750
Direct labor cost	₦6,300
Overhead cost	₦ 2,000
TOTAL COST	**₦24,050**

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSIONS

A performance test was carried out on the fabricated continuous process groundnut roaster machine and the roasting efficiency was 51.0%. However, there was a loss of heat through the wall of the roaster. If the machine is carefully handled, it is a great prospect to our growing economy, thereby making roasting of groundnut less tedious. This machine can be used anywhere irrespective of location or settlement areas including household and commercial places.

It can be concluded, therefore that the performance of the fabricated roaster machine is satisfactory as accessed from the result obtained above which shows that the roaster temperature of 160°C for hrs is satisfactory.

5.2 RECOMMENDATION

The result obtained after testing continuous groundnut roaster machine fulfills the following recommendations for more efficient model;

i. To maintain a steady power and cost of electricity, charcoal can be incorporated as an alternative source of heat.

ii. The efficiency can be improved upon by proper adjustment of the angle of repose of the roasting trays.

iii. The heat and the speed should be improved for an efficient roasting.

REFERENCES

Adebesin A.A. et al, 2001, Microbiological Quality of some Groundnut Products Hawked In Buachi, Nigerian city. T. Food Tech. Afri; 6: 53-55.

Asuedu J.J. (1989), processing tropical crops a technological approach. Macmillan press, London.

Azizah A.H and Zaiman H. (1997), Effect of processing on dietary fiber contents of selected legumes and cereals. Mal. J. Nutri; 3:131-136

Brian Quin (2005): Exploring the native groundnut, The Rhexia Prairie chapter, Florida Natural Plan/Society.

Codex Alimentarius Commission (CAC); (1991): Guideline on Formulated supplementary food older infants and young children, CAC/GL 08-1991.

FAO (1990): Food and Agricultural Organization production year book room, vol. 35.

Hrris and Vonleosecke (1988): Nutritional Evaluation of food processing, supported by WHO/USA, PFU Khan.

IFPRI (1994): Trade passion and Regionalism in African countries. The case of groundnut exporters' research report 97.

Khan, L.M and Hanna M.A (1983): Express of oil from seeds.

National Bureau of Statistics (NBS) (2005): The Nigerian statistical fact sheets on Economic and Social Development.

Simon Rsedoums LTD (1982): Plant and equipment for the oil and proteins Industries. Hull England pp 68-75.

Solomon A. (1994): Appropriate technology, journal, vol. 21 No1.

World Geography of the peanut (2003):