American Journal of Engineering Research (AJER)
e-ISSN : 2320-0847 p-ISSN : 2320-0936
Volume-03, Issue-04, pp-230-235
www.ajer.org

Research Paper Open Access

Fabrication and Testing of a Combined Groundnut Roaster and Oil Expeller Machine

Olawale J. Okegbile, Abubakar Mohammed*, Abdulkadir B. Hassan, Osigbodi Obajulu

Department of Mechanical Engineering, Federal University of Technology, Minna, Nigeria

Abstract: - This paper presents the fabrication and testing of a combined groundnut roaster and oil expeller machine. The machine which was fabricated using locally available materials is portable and efficient. The combination of the roasting and expelling units into one single unit led to an efficient and effective production of groundnut oil, because it reduces drudgery, saves time and improves the quality of the oil produced compared to when there are separate units of these operations. The performance evaluation shows that the roasting and expelling efficiencies were 66.9% and 66.7% respectively.

Keywords: *-Roaster, expeller, groundnut, combined machine, fabrication, groundnut oil*

I. INTRODUCTION

Groundnuts are a stable food in many developing countries. Also called peanut, groundnuts are a protein rich tuber that grows well in semi-arid regions. There are two main types of groundnut: the America groundnut (*Arachis hypogea*), and the Africa groundnut, the Bambara nut (*Voandzeia subterranean*). Both are grown in Western Africa as a protein source. Groundnuts also contain sufficient quantity of carbohydrates and fats. The America groundnut grow 30-40cm high and do not spread. The West Africa groundnut is shorter and run along the ground from 30-60cm. Yields of kernels generally range from 0.5-4.0 tons/hec. In the developing countries, where 80 % of the crop is produced, the average yields are around 1 tons/hec [1, 2].

The production of oil from groundnut involves a post processing of groundnut which includes shelling, roasting and pressing. Several groundnuts shelling machines has been fabricated [3, 4]. Roasting reduces moisture content and develops a pleasant flavour which makes the products more acceptable for consumption [5]. Roasting also enhances better extraction as it reduces the oil's viscosity, releases oil from intact cells and reduces the moisture content. The amount of oil produced will be much if it is properly roasted. However, excess heating during roasting results in low nutritional quality of protein. It also reduces the quantity of oil as well as it makes the colour of the oil extracted to be dark [6]. Roasting of groundnut and extraction of oil from it has however been a serious issue to its processing. In some rural parts of the country, roasting and extraction of the oil is achieved by traditional method.Olaniyan A. M. [7] recently carried out the developmentof a manually operated expeller machine for groundnut oil extraction. This machine was designed to be used in rural communities in developing countries like Nigeria. However, using manually operated machine makes the process of extraction very slow, tedious and time consuming considering the present level of production. In order to sustain the increase in oil production from groundnut, there is the need to improve on the technology especially at the rural level. Ajoa et al [8] carried out the development and performance evaluation of groundnut oil expelling machine and stress the need to have a heating chamber incorporated into the expelling machine. Other similar designs have been developed [9, 10].

The problem with these designs is that it is a single unit of oil expelling machine.Machines which could combine roasting of the nut and expelling of the oil from the nut are not commonly available.There is usually a problem when several units of the oil processing operations are separated. The time taken to move the raw materials from one unit to another is sometimes enormous. Apart from that, the labour required to man these separate unit also add to the cost of production. However, if some of these units can be integrated it can generally enhance the efficiency of the entire process. Just recently, Olatunde et al [11] designed and fabricated groundnut roaster cum expeller machine with an efficiency of 41.6% oil extraction. Heat loss in this machine was very high as it was not properly lagged and has heavy gears. Okegbile et al [12] designed a combined groundnut roaster and expeller units within a single machine.The machine will reduce heat loss as it is well lagged and have very few components. This paper present the fabrication and performance evaluation of the combined groundnut roaster and expeller machine.

II. FABRICATION PROCESS

Angle bar

This serves as a base for the entire unit, a holder for the roasting unit and housing for the expeller unit. The angle bar is made up of mild steel. The steel was cut into accurate dimensions and welded using a welding machine to get the required shape and size.

Galvanized steel

This was used mainly for the body of the roasting chamber. Galvanized steel was cut using a cutting machine to get the required shape and size for the hopper, top, sides and bottom of the roasting chamber. Rivets were used to hold the edges together. Galvanized steel was also chosen because some parts needed to be bent without breaking and it is very flexible. The body of the unit was made hollow and filled with foam to serve as an insulating material.

Mild Steel pipe

Mild steel pipe was used to get the frame of the roasting chamber before galvanized steel was placed on it. The mild steel pipes were cut into dimensions with a hack saw and welded at each end to get the perfect shape and size required.

Aluminium Sheets

Aluminium sheets were used for the roasting trays. Aluminium is a good conductor of heat and is very flexible. The roasting trays were inclined at an angle so as to help the groundnut travel faster when they are vibrated.

Flexible Metal sheets

4 Thin flexible metal sheets were cut using a hack saw and filed to dimension, they were then riveted at four different positions to the tray holder and the main body of the roasting unit.

Vibrator motor

The vibrator motor was initially situated inside the roasting chamber to aid faster vibration of the trays, but while testing, the heat from the chamber caused the coil of the motor to expand and this hampered the vibration. The motor was then moved outside the chamber. A hole was drilled at the edge for insertion of the shaft of the motor to vibrate the trays. An offset was welded to the top of the tray holder and a load was also welded to the end of the motor's shaft, therefore, while rotating, the contact of the load and the offset caused the required vibration of the trays. An attachment was placed on top of the roasting chamber to hold the motor using bolts and nuts. The motoris electrically powered.

Glass

Transparent glass was placed on the side of the roasting chamber to enable visuals of the roasting process. The glass was cut to dimensions using a hack saw and the edges were filed using a file. Rubber was placed between the glass and the metal in order to avoid cracking. A metal frame was riveted on the edges of the glass to prevent it from falling.

Heating Filament

Heating filament was placed at the bottom of the roasting unit. The heating filament heats up the roasting unit to promote an even roast. It is powered by electricity. An Insulator was placed at the end of the filament to avoid shock.

3 inch round pipe

This serves as housing for the auger and the threaded pipe. It is located on the angle bar. It was attached by welding.

Threaded Shaft

This was inserted at one end of the round pipe. It helps push the auger. The handle of the threaded shaft was welded to it using a welding machine.

Auger
This was coiled inserted at the other end of the round pipe. When powered by the motor, it squashes the groundnuts which have been fed into the expelling chamber from the roaster.
The expelling chamber was tied to the frame and had bearings which ensured easy rotation of the parts. A mesh was inserted to filter the oil from cake. The holes were cut using a hack saw. All the edges were filed to accurate dimensions using a flat file. Bolts, nuts and rivets were used to hold parts together where necessary and parts that needed to be placed permanently, such as the edges of the mild steel pipe and edges of the angle frame and base were welded together using a welding machine.

III. OPERATION OF THE MACHINE

3.1 Roasting Unit
The roasting unit consists of the hopper, conveyor trays, vibrator motor, cabinet (casing), lagging materials, bearings, heating filament, frame and exhaust. The hopper serves as an inlet for the roaster and accommodates oil seeds before being transferred into the roaster. The conveyor trays are incorporated in the heating chamber with a vibrator motor attached to it. The continuous roaster moves groundnut through the heating chamber on a conveyor tray by gravity. In this system, the groundnut is agitated to ensure that air passes 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.

3.2 Oil Expelling Unit
The expeller unit extracts the oil contained in the groundnut cells. It is powered by an electric motor through a pulley, belt and a gear box. The screw shaft inside the casing will transport roasted groundnut fed from the roasting unit through the hopper from a larger area to a smaller area of the auger, bringing about increase in pressure which raptures the groundnut oil cells to release the oil. The oil is collected beneath the cylinder, and the cake through the discharge outlet of the casing.

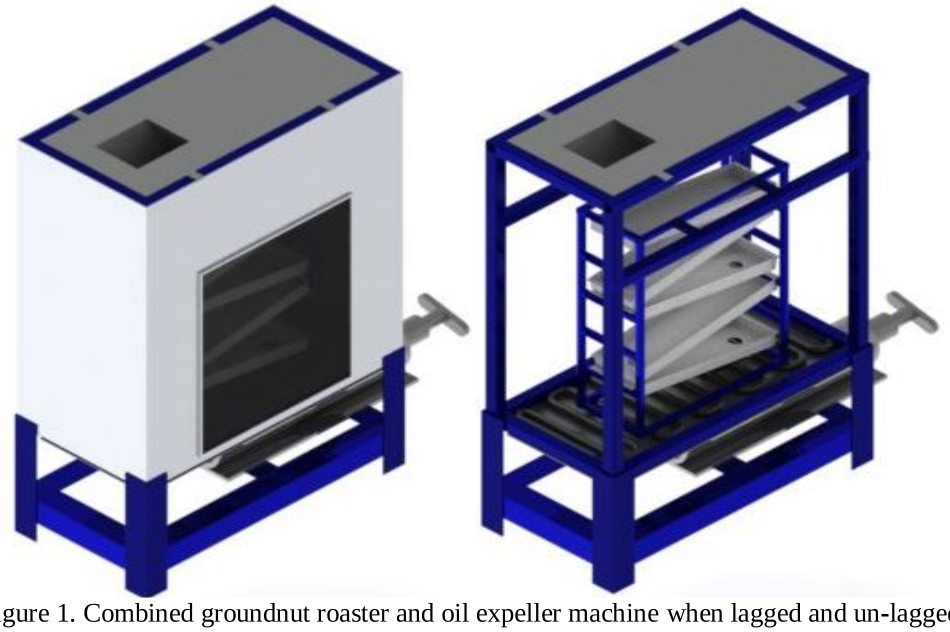

Figure 1. Combined groundnut roaster and oil expeller machine when lagged and un-lagged

IV. COMPONENT DESCRIPTION OF THE MACHINE

4.1 Features of Roasting Unit
Hopper
The hopper serves the purpose of feeding the groundnut into the machine. It has dimensions of 180mm by 200mm at the top and 80mm by 120mm at the bottom. It is embedded in the casing of the roasting unit and is made of mild steel material.

Conveyor trays
The conveyor trays are made of aluminium sheet to enhance good heat conduction and resist corrosion. Each tray has a dimension of 600mm by 150mm.

Casing
The casing has three openings in which one is for the hopper, another for the exit and the third for the discharger. The casing houses the trays, vibrators, heating filaments with a dimension of height by breath by length of 650mm by 300mm by 700mm respectively. It was lagged so as to reduce heat loss. At the bottom of the casing is the collector channel for the exit of the roasted groundnut. The casing was made of mild steel to reduce heat loss.

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

Lagging Materials
This serves the purpose of preventing heat loss to the environment. It helps to retain the temperature within the heating chamber it is made of foam.

Flexible Metal Sheets
The metal sheets are flexible supports which serve as a damper to allow flexible connection between the tray holder and the main body of the unit.

Vibrator Motor
The vibrator motor serves the purpose of agitating the groundnut as they conveyed by the tray. This is to ensure that air passes through the individual kernels so as to promote an even roast. It has small electric motor and an unbalanced mass of 1.4kg.

Heating Filament
This is located in the roasting chamber of the groundnut roaster. It serves the purpose of supplying the heat needed to roast the groundnut. It is made of composite material. A heating filament of 1800Watts was selected.

4.2 Features of the Oil Expelling Unit
Electric Motor
This is the prime mover that provides the power required. It provides the rotational motion and power needed to rotate the shaft transmitted by the belt. The remaining components of the expeller are also powered by the motor. The selection was based on the power analysis made. An electric motor of 5HP was selected.

Oil Extractor Barrel
The oil extractor barrel houses the shaft that carries the conveyor. It has two openings; one for collecting the groundnut from the roaster and the other for the discharge. Mild steel was selected for the fabrication of the casing because it is easy to harden and to temper, and it can withstand shock and vibration. The dimensions of the casing were selected to be length 350mm and a diameter of 65mm and 55mm at the big end and small end respectively. The perforated bottom of the casing collects and drains the oil by force of gravity downward. The diameter of the perforated holes was selected to be 3mm.

Expeller Shaft
The expeller shaft serves as a conveyor, transporting groundnut (roasted) fed the tapered end where it is pressed. It is made of mild steel. It is supported by two bearings which are selected based on the calculation on the bearing. The total length of the screw is 300mm and the total length of the shaft is 450mm. Mild steel was selected because of its ability to withstand shock and impact load. It was also selected because it is easily forged and welded.

Discharge outlet
The discharge outlet is forced open at a given pressure. Steel was used in fabricating the discharge outlet because of its ability to withstand shock and vibration. From literature, the maximum pressure which a continuous expeller can discharge cake when oil would have been fully extracted is 13.6Mpa [13].

Gear Box
This is a speed reduction mechanism that serves the purpose of reducing the speed of the motor to that expected to operate the shaft. The gear box is made of composite materials.

Control Lever
This is used in adjusting the shaft while expelling the oil from the kernel. It is made of mild steel so as to withstand high pressure.

Pulley and Belt Drive
These components will serve the purpose of transmitting power from the pulley attached to the electric motor to that attached to the gear box. The rim of the drive pulley was V-grooved, and the belt was equally wedged sectioned (v-belt).

V. TESTING AND PERFORMANCE EVALUATION

The testing and performance evaluation of the fabricated machine is made up of a roasting unit and an expelling unit. The evaluation of the efficiencies of each unit is determined using equations (1) to (3) below.
The efficiency of the roaster is given as:

$$\eta_r = \frac{G_o}{G_i} \times 100 \quad \textbf{(1)}$$

The efficiency of the oil expeller unit is given as:

$$\eta_e = \frac{Q_E}{Q_T} \times 100 \quad \textbf{(2)}$$

The total quantity of oil in groundnut is given as:

$$Q_T = 45\% \times G_o \quad \textbf{(3)}$$

Where, η_r is the efficiency of the roaster (%), G_o is the quantity of roasted groundnut (kg), G_i is the quantity of groundnut fed into the hopper (kg), η_e is the efficiency of the oil expeller (%), Q_E is the quantity of oil extracted (kg) and Q_T is the total quantity of oil in groundnut (kg).

5.1 Testing Roasting and Expelling Units

5kg of groundnut was fed into the machine through the hopper to the conveyor trays which transport the groundnut through the roaster. The groundnut spends 30 minutes travelling in the roaster which is at temperature of 90^0C and is discharged through the discharge outlet at the bottom of the casing into the expelling unit. Before transferring into the expelling unit, the roasted groundnut was separated from the unroasted or partially roasted ones and weighed. The efficiency of the roasting unit was calculated using equation (1) above.
The roasted groundnut was poured into the expeller through the collector from the roaster in order to push it into the casing. The roasted groundnut was gradually conveyed to the tapered end by the rotating screw auger where it was pressed due to the built-up pressure. The pressed discharger opens to discharge the cake and oil was drained through the perforation on the casing. The oil was collected through the oil collecting trough directly into a container and weighed. The efficiency of the expelling unit was determined using equation (2) above. The procedure was repeated for 10kg and 15kg of groundnut.

5.2 Results and Discussion

The results of the roasting and expelling units are shown in Figures 2 and 3 below. The roasting unit gave an efficiency of 66.9%. This value of efficiency must have been due to heat lost by the heating filament. The groundnut spends 20 minutes travelling through the roasting chamber at which the groundnut was roasted satisfactorily. The temperature of the roasting chamber was 60°C. A total of 30kg of groundnut was fed through the hopper; 20kg was completely roasted while 10kg was partially roasted. The expelling unit had an efficiency of 66.7%. A pressure of $13.6 \times 10^6 N/m^2$ was exerted by the expeller, in which 6kg of oil was expelled within 10 minutes. The low efficiency of the roasting unit was as a result of heat loss through the walls of the roaster. If the machine is properly handled, it is a great prospect to our growing economy, thereby making roasting of groundnut less tedious.

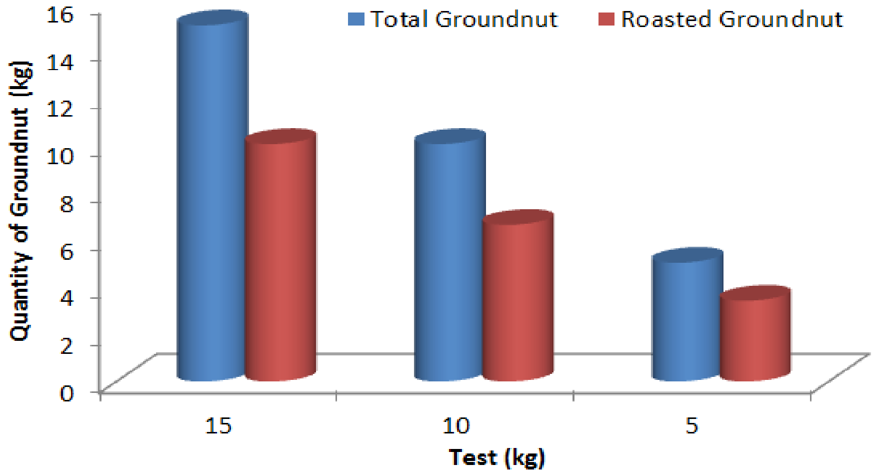

Figure 2. Groundnut Roaster

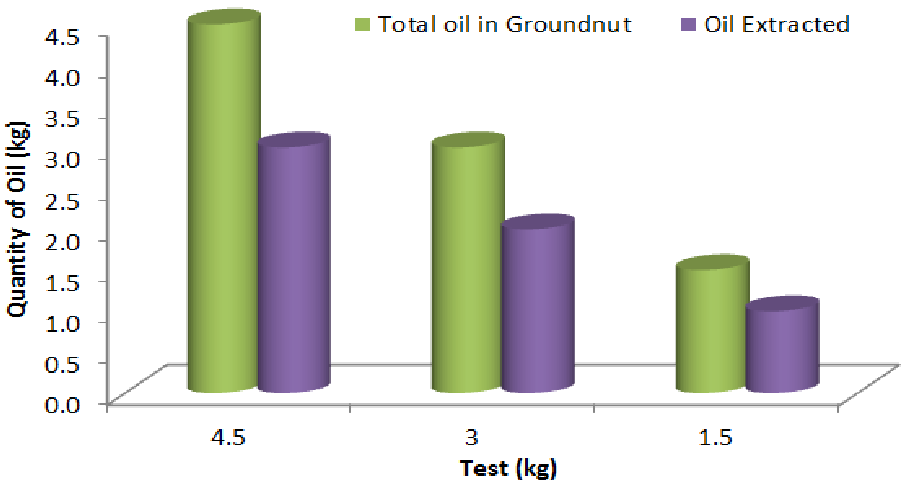

Figure 3. Groundnut Oil extraction

VI. CONCLUSION

The unit operations involved in extracting groundnut oil was combined and a performance test was carried out on the fabricated machine. Efficiencies of 66.9% and 66.7% were recorded for the roasting and expelling units respectively. The combination of the roasting and expelling units into one single unit led to an efficient and effective production of groundnut oil because it reduced drudgery, saved time and improved the quality of the oil produced compared to when there are separate units of this operation. The average performance efficiency of the machine is 66.8%.

REFERENCES

[1]. Shankarappa T., Robert E. R. and Virginia N. (2003). World geography of groundnut: distribution, production, use and trade.

[2]. Hommons, R. O. (1994): The origin and History of groundnut, In: Smart, J. (Ed), The Groundnut crop; A scientific Basis for Improvement. New York, U.S.A. Chapman and Hall, pp: 56-78.

[3]. Mohammed A., Hassan A. B. (2012). Design and Evaluation of a Motorized and Manually Operated Groundnut Shelling Machine, International Journal of Emerging Trends in Engineering and Development, Vol. 4 (2):673-682.

[4]. MaduakoJ. N., Saidu, M., Matthias, P., Vanke, I. (2006). Testing of an Engine-Powered groundnut shelling machine. Journal of Agricultural Engineering and Technology, 14: 29-37.

[5]. Asiedu, J. J. (1988): Processing Tropical Crops, a technological approach, London Macmillan press.

[6]. Gerald L. (2009). The application of fluid mixers in edible oil processing. Available at www.emimixers.com.

[7]. Olaniyan, A. M. (2010). Development of a manually operated expeller for groundnut oil extraction in rural Nigerian communities. Asia-Pacific Journal of Rural Development, 20 (1),185-201.

[8]. Ajao K. R., Ajimotokan H. A. and Olaomi J. (2009). Development and performance evaluation of a groundnut oil expelling machine, New York science journal, Vol. 2(6):76-79.

[9]. Manta I.H and Ajisegiri A.O (2007). Design and Fabrication of a Cottage Groundnut Oil Expeller.Journal of Humanities, science and Technology (JOHSAT), Niger State Polytechnic, Zungeru.Vol.2 (1):131-136.

[10]. Idah, P. A. Manta, I. H. and Akin A. (1996). Development of continuous cottage groundnut oil expeller. Proc. of the NSAE Vol. 18. pp 318 – 321.

[11]. Olatunde O. B., E. A. Ajav, Fatukasi S.O. (2014). Design and Fabrication of Groundnut (ArachisHypogaea) Roaster cum Expeller, International Journal of Science and Technology, Vol. 3(3):177-184

[12]. Okegbile O. J., Hassan A. B., Mohammed A., Obajulu O. (2014). Design of a combined groundnut roaster and oil expeller machine, International Journal of Science and Engineering Investigations, Vol. 3 (26): *in press.*

[13]. Purseglove, J.W. (1984). Tropical Crops. Dicotyledons. Volumes 1 and 2. English Language Book Society and Longmans, London.