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Original Article

Design and Fabrication of a Peanut Roasting Machine for Commercial Use

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Abstract *- A commercial peanut roasting machine PRM was designed and fabricated to solve the breakage problem and improve product hygiene during operation. Evaluating the performance of PRM, some tests were carried out with sun-dried peanuts from the market in Omu-Aran, Nigeria. Some parameters considered for testing were the peanuts' mass, dimensions and moisture content. During the test, a constant speed of 4.55rpm is maintained as the temperature varies between 140°C to 180°C for a duration of 10 mins. The average moisture content of the sun-dried peanut samples is approximately 6% before roasting. According to research, the moisture content of some roasted peanuts is approximately 1%. The average moisture contents of the peanuts after roasting at different temperatures of 140°C, 160°C and 180°C were observed to have reduced from 6% to 1.78%, 1.26% and 0.76%, respectively. The ratios of mass of the unbroken peanuts after roasting to the mass of peanuts fed into the machine were 93%, 94% and 92% at 140°C, 146°C and 180°C, respectively. The results show that the PRM performed optimally within the temperature interval of 160°C - 180°C with a moisture content range of 1.78% - 0.76%. During the experiment, the operating capacity was 6kg/hr (1kg/batch). A healthy diet is a fundamental human right efficiency of the machine has a beneficial roasting efficiency of 91%, 8% seed damage and 1% seed burn. The machine has an impact edge of ± than some of the existing peanut roasting machines.*

Keywords *- Design, Moisture content, Peanuts, Roasting machine efficiency, Temperature.*

1. Introduction

Peanut, scientifically known as "Arachis Hypogaea L." and otherwise called "Groundnut", is arguably the world's most nutritionally packed nut/seed and is an important cash crop. Peanut is a rich source of plant protein known to have its origin in South America. Peanut is very popular and valuable in the world today because of its by-products, e.g. oil, butter, flour and roasted/cooked nuts, with Nigeria ranking third in world peanut production behind India and China, as it produces about 6.8% of the 44 million tons annually. From an industrial standpoint, all peanut products (shell, skin nut, etc.) have numerous uses and applications in manufacturing.

Concentrates of peanuts contain numerous nutrients like proteins, strands, polyphenols, cell reinforcements, minerals and Vitamins that can be useful ingredients in many handled food sources. Recently, a study uncovered that peanuts are an awesome wellspring of mixtures like resveratrol, phenolic acids, flavonoids and phytosterols that block the ingestion of cholesterol from the diet. It is additionally a dependable wellspring of Coenzyme Q10 and contains every one of the 20 amino acids with a liberal measure of arginine. These bioactive mixtures have been perceived for having infection anticipation properties and are thought to advance life span. Processing strategies like roasting and boiling have shown an increase in the convergence of those bioactive mixtures. [2, 15, 23]

There are different types of roasting operations, one among which is the local roasting of peanuts, which is the most prevalent in Nigeria. The local peanuts roasting resulted in an uneven roast because temperature regulation devices were non-existent in the entire setup, exposing the groundnut roasting process to unhygienic conditions.[1, 6, 8] The right to a healthy diet is a fundamental human right. The connection between food security and health should be strengthened to provide a stable community that can foster growth. One way to do this in developing countries is to take advantage of existing local resources to meet the needs of an ever-increasing population.[3, 14, 21]

Ref [4, 5, 7] evaluated the performance of a 36.91kg/hr capacity electromechanical groundnut roasting machine, with results showing that the changes in the temperature, moisture content and machine speed of machine operating parameters affected the machine conveyance efficiency, roasting efficiency, quality efficiency and mechanical damage of the groundnut significantly. The machine performance at optimal temperature intervals was recorded as 150°C - 200°C and the machine speed of 12.8 rpm. It was concluded that the machine has economic advantages over the manual method.

In the study carried out by [16, 19, 24], which involved a focus on the auger-barrel clearance as a means of improving the efficiency of a 1.04 kg/batch peanut roasting machine, a minute amount of peanuts roasted were recorded burnt as a result of uneven distribution of heat over the heating surface due to heat controller malfunction. [19] suggested for future work a focus on uniform heat distribution to reduce peanut loss to burns and a better appearance (color) after roasting. This, therefore, is within the scope of the study that this research focused on.

Ref [16,17,24] modified and optimized a peanut roasting machine and showed that an increase in the machine speed and roasting temperature leads to an increase in the quality performance efficiency of the machine. In contrast, an increase in feed rate would result in a major decrease in the quality performance efficiency of the groundnut.

The focus of this study is to streamline energy utilization using temperature regulation/control, increase the quality of peanuts produced by ensuring an even roast as well as reduced nut breakage and improve the working conditions engaged in the process of roasting peanuts. Implementing all these with materials easily acquired from local markets.

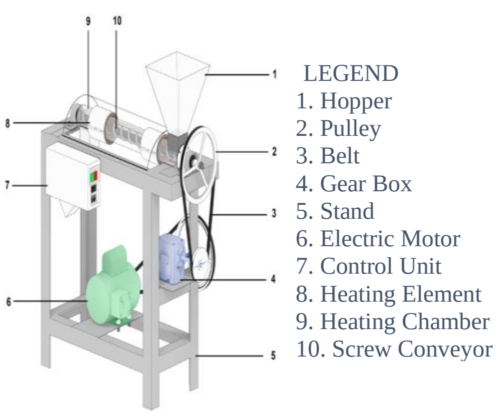

Fig. 1 Labelled peanut roaster machine

2. Development of Machine Components

The raw groundnuts used in the roasting were purchased from the Omu-Aran, Kwara State, Nigeria market. The solid component materials used to fabricate the machine parts (see Figure 1) are stainless steel and mild steel. Other materials and instruments used include a thermocouple, temperature control unit, digital weighing scale, stopwatch, moisture analyzer, mica heater bands and electric motor.

2.1. Mainframe

The mainframe serves as the structural frame for all other components and is constructed using mild steel (angle bars of size 25mm by 25mm), having a dimension frame of 650mm by 300mm by 700mm.

2.1.1. Roasting Chamber and Auger Conveyor

This cylindrical component is fabricated (see Figure 2) using a stainless steel tube with a diameter of 70mm, thickness of 3mm and length of 600mm. It houses a stainless steel auger conveyor having a pitch of 45mm, a blade radius of 25mm and a rod with a length of 730mm.

Fig. 2 Roasting chamber and auger conveyor

Gear System

A gearbox unit is used to reduce speed for the motor with a step-down ratio of 40:1 and then transmits the reduced speed through the pulleys and belts to the shaft in the heating chamber.

Speed Reduction

An electric motor of 1400rpm is utilized for the experiment; however, all the nuts will be crushed and/or uncooked at this speed, hence the need for speed reduction. The electric motor is connected to a pulley via the gear unit (see Figure 3) to reduce and transmit motion.

Driven pulley = 220mm
Driving pulley = 80mm
Reduction ratio = $\frac{220}{8} = 2.75$
Operating speed is given as
$\frac{1400}{2.75} = 509.1\ rpm$

The pulleys transmit a speed of 509.1 rpm onto the gearbox shaft; the gearbox having a reduction factor of 40 further reduces the speed.

Gearbox reduction factor = 40
Operating speed is given as

$$\frac{509.1}{40} = 12.73\ rpm$$

The gearbox's output shaft is connected to another pulley pair, which transmits motion to the conveyor shaft.
Driven pulley = 280mm
Driving pulley = 100mm

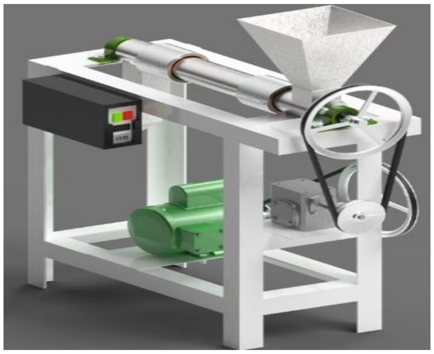

Fig. 3 Driving assembly

Reduction ratio = $\frac{280}{100} = 2.8$

Final operating speed is given as

$$\frac{12.73}{2.8} = 4.55\ rpm$$

$$\frac{4.55}{60} = 0.076\ m/s$$

Pulley System

This consists of two pairs of V-belt pulleys for the transmission of power, Table 1.

Table 1. Pulley system

	Position	Driving Pulley (Dia)	Driving Pulley (Dia)
1	Motor to Gearbox Transmission	80mm	220mm
2	Gearbox to Shaft Transmission	100mm	280mm

Torque

As stated by Khurmi and Gupta (2005),

$$\tau = \frac{P \times 60}{2\pi N} \quad (1)$$

Where,

P = Electric motor power.
N = Pulley speed.

$$\tau = \frac{0.75 \quad \times 1000 \ \times 60}{2\pi \ \times 35} = 204.62\ N.m$$

Load Propulsion

$$v = \frac{S \times N}{60} \quad (2)$$

Where,

S = screw pitch
N = speed of the shaft

$$v = \frac{0.045 \times 4.55}{60} = 3.4\ \times\ 10^{-3}\ m/s$$

Heating Element

Two mica heating bands (see Figure 4), with a combined power rating of 640W with dimensions 70mm x 20mm x 125mm, are wrapped around the roasting chamber.

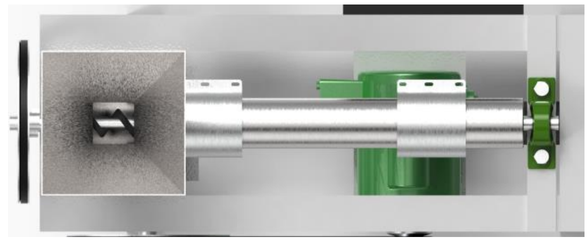

Fig. 4 Mica heating bands

Inlet (Hopper) and Outlet Openings

The inlet opening consists solely of a stainless steel hopper with dimensions 200mm x 200mm (upper face) and 60mm x 60mm (lower face), spanning a height of 200mm. The outlet comprises a 30° stainless steel elbow of diameter 70mm.

Hopper Volume

$$V = \frac{1}{3}\ h(A_1 + \sqrt{A_1}A_2 + A_2) \quad (3)$$

Where,

A_1 = Area of feed section
A_2 = Area of compression section
H = perpendicular distance between A_1 and A_2

$h = 200mm$
$A_1 = L^2 = (200^2)mm^2$
$A_2 = L^2 = (60^2)mm^2$

$$V = \frac{1}{3}\ 200(200^2 + \sqrt{200^2\ x}\ 60^2 + 60^2)$$

$V = 3{,}706{,}666.667mm^3$= 0.0037$m^3$

3. Materials and Methods

3.1. Principle of Operation

The target of this project is to streamline energy utilization by means of temperature regulation/control and to increase the quality of peanuts produced by ensuring an even roast as well as reduced nut breakage. This prototype is powered by an electric motor, Figure 3, which transmits the rotational effect via the gear unit. [13][12] The process continues through a conveyor of uniform pitch containing nuts fed in through the hopper, transporting the nuts to the heating chamber for roasting, after which the roasted peanuts are expelled at the outlet. Two heating elements at both ends heat up the heating chamber. It is regulated by a temperature control unit, ensuring the working temperature is maintained throughout the experimental process. [9,10, 20,22]

3.1.1 Design Procedure

Highlighted below are the designs of several components of the peanut roasting machine. First is the machine specification, Table 2.

Volume of the Roasting Chamber

$$V = \pi r^2 h$$

Where,
r = radius of the chamber

Table 2. Machine specifications

S.No	Machine Name	Peanut Roaster
1	Purpose	Peanut Roaster
2	Mode of operation	Batch type
3	Overall dimension	650 × 300 × 700
4	Roasting chamber Diameter Length	70mm 630mm
5	Electric Unit Power Rating	1 hp single-phase motor
6	Working speed	1400 rpm
7	Capacity (kg/batch)	1 kg/batch
8	Floor area	650 × 300

h = height of chamber
$r = 35mm$
$h = 600mm$

$$V = \pi \times 35^2 \times 600$$
$$= 2.30907 \times 10^6 mm^3$$
$$= 0.0023 m^3$$

Capacity of the Roasting Chamber

The bulk density of unshelled peanuts is given as 336 kg/m^3 (Liu X. 2021)

Therefore, the capacity of the heating chamber is given as

$$M = \rho \times V$$

Where,
ρ = Bulk density of peanut
V = Volume of the heating chamber

$$M = 336 \times 0.0023 = 1.24\ kg$$

Power Transmission Electric Motor

This is the primary source of power. The motor used has a rating of

Power (P) : 1hp
Speed : 1400 rpm
Phase : single
Frequency : 50 Hz
Voltage : 220v

Power required

$$P = \frac{Q}{t} \quad (4)$$

Where,
Q = quantity of heat required to roast
t = time required for roast

But,
$Q = Mc(T_2 - T_1)$
M = mass of peanut = 1 kg
c = specific heat capacity = 2.3 KJ/kg/K
T_2 = final temperature
T_1 = initial temperature

$$Q = 2.3\ (180 - 25) = 356.5\ KJ$$

$$P = \frac{Q}{t} = \frac{356.5\ (KJ)}{600\ (s)} = 0.5942\ KW = 0.6\ KW$$

Groundnut seed's Physical Properties at Different Moisture Levels

The primary peanut sample moisture content was found to be about 6%, and the dimensions of random nuts were recorded, Figure 8, to keep track of dimensional changes after roasting, ergo, at a different moisture content. [22,26,27] After roasting, a trend of a slight decrease in dimension was observed on examination of random nuts, Table 3.

Table 3. Nut dimension before and after roasting

S.NO	Nut length before roasting (mm)	Nut width before roasting (mm)	Nut length after roasting (mm)	Nut width after roasting (mm)
1	12.5	7.4	12.2	7
2	12.6	7.6	12.5	7.5
3	14	7.9	13.6	7.7
4	14	7.9	13.9	8.1
5	14.3	8	14.2	8.2
6	14.5	8.2	14.7	8.4
7	14.7	8.4	14.9	8.5
8	15.3	8.5	15.1	8.6
9	15.3	8.5	15.1	8.6
10	15.5	8.6	15.2	8.8
11	16	8.9	15.9	8.9
12	16	8.9	15.9	9
13	16.5	9.2	16	9
14	16.6	9.1	16	9
15	17	9.4	16.1	9.3

Table 4. Time taken to achieve the required temperature

Sl.no	Temperature (°c)	Time taken (sec)	Time taken (min)
1	140	572	9.53
2	150	638	10.63
3	160	685	11.42
4	170	745	12.42
5	180	807	13.45
6	190	868	14.47
7	200	930	15.5

Moisture Content

Before roasting, the moisture content of peanuts already on sale in a regular market was found to be approximately 1%. [25,28] After roasting, a moisture content analysis (see Figure 9) was carried out on the peanuts roasted at various temperatures (140°C, 160°C, 180°C), Table 4.

Performance Evaluation

i. Roasting Efficiency, (Er%)

$$E_r = \frac{W_r}{W_t} \times 100 \quad (5)$$

Where:

Wr = Weight of the roasted groundnut seed not damaged (kg)

Wt = Total weight of groundnut seed roasted (kg)

At 140°c, Figure 5.

$$E_r = \frac{0.932}{1} \times 100 = 93.2\%$$

At 160°c, Figure 6.

$$E_r = \frac{0.944}{1} \times 100 = 94.4\%$$

At 180°c, Figure 7.

$$E_r = \frac{0.908}{1} \times 100 = 90.8\%$$

ii. Percentage Seed loss, (Ei%)

$$E_i = \frac{W_d}{W_t} \times 100$$

Where:

W_d = Weight of the over-roasted groundnut (damaged seed) (kg)

Wt = Total weight of groundnut seed roasted (kg)

At 180°c

$$E_i = \frac{0.012}{1} \times 100 = 1.2\%$$

Procedure

- 5kg of peanut was manually selected to eliminate the presence of foreign bodies and rotten and broken nuts to achieve an ideal output.
- The moisture content of the peanuts was gotten using a moisture analyser (AND Mx-50)
- Peanuts were separated into 5 batches of 1kg.
- The peanuts were roasted at intervals of 140°C, 160°C and 180°C.
- Readings for the initial and final mass of roasted peanuts were taken.
- Moisture analysis of output was carried out using AND Mx-50 moisture analyzer (see Figure 9).

Output was manually sorted to separate broken nuts from unbroken and charred nuts.

4. Results and Discussion

4.1. Efficiency Analysis of Peanut Roasting (Ei %)

This experiment targeted quality roasting and consumption of peanuts by the general public. Therefore, the final peanut product must have an efficient appearance that showcases the machine's efficiency. Some experimentally based literatures studied as a guide to achieving our study aim reported the following efficiency comparison. Conclusions from various authors, for example, [4] gave the best roasting efficiency of 84.04% while the temperature increases to 200^0C. Also, [5] shows that the roasting efficiency ranges between 92 – 93%. These are progressive results where the Author reports two different roasting methods, which means the efficiency is unstable. The experiment conducted by [16] also gave a progressive result of the roasting efficiency as 55.15 – 76.50% with a roasting temperature of 120^0C. It was observed that [19] did three different experiments on peanut roasting but reported the following roasting efficiencies: 68.9%, 71.2% and 85.6%.

The result obtained by [25] indicated that the roasting efficiency of the machine was 70%. During the period of our experiment, other literatures reported an advanced method of peanut roasting, Infrared (IR) radiation, to achieve a reasonable result. Their conclusions show that the roasting efficiency of this method is in the range of 80% to 90%; again, this is a dynamic result. [11] From the above comparisons, therefore, we can draw a conclusion that Figure 10, with a roasting efficiency of 91%, has an impact edge of ± than some of the existing peanut roasting machines.

4.1.1. Results of the Performance Evaluation

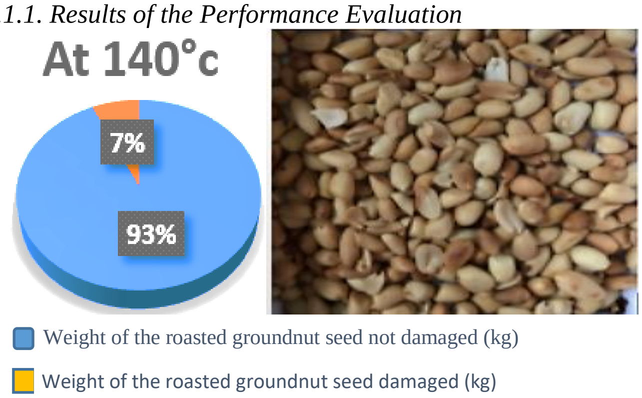

Fig. 5 Performance evaluation at 140°C and peanuts color change after roasting

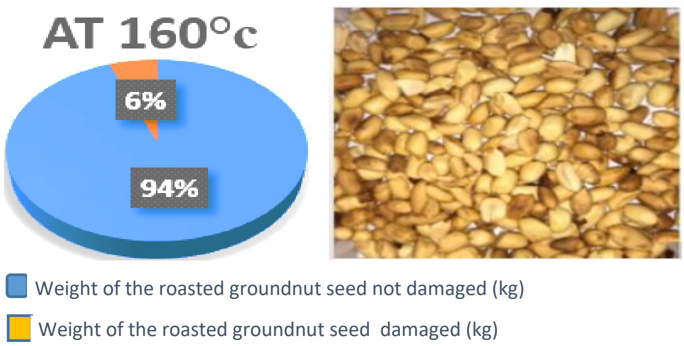

Fig. 6 Performance evaluation at 160°C and peanuts color change after roasting

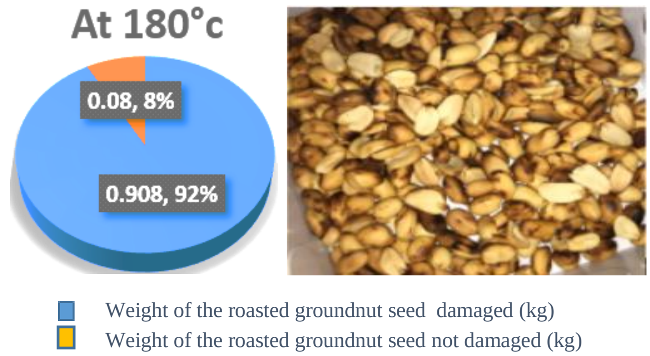

Fig. 7 Performance evaluation at 180°C and peanuts color change after roasting

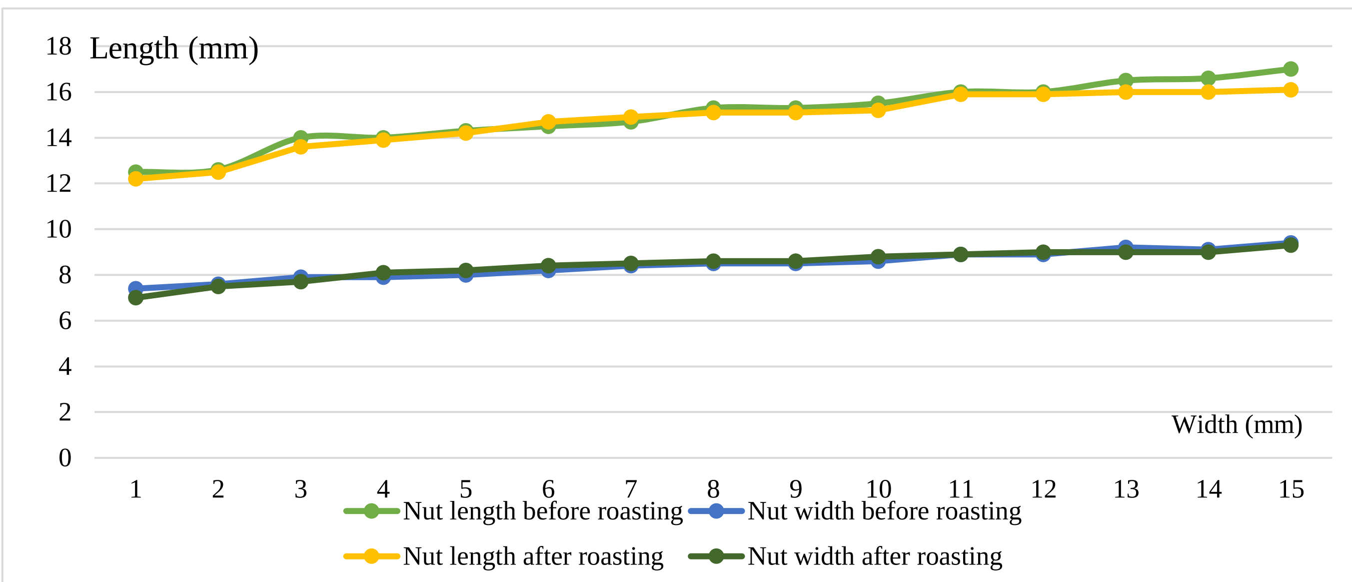

Fig. 8 Dimensional trend due to reduced moisture content (Table 3)

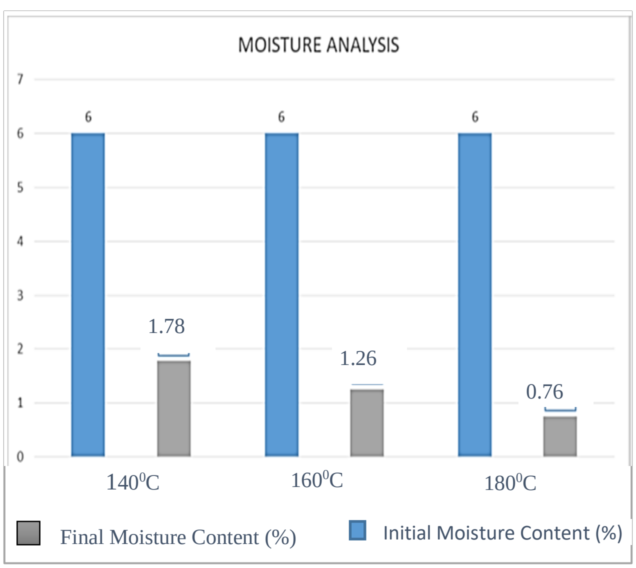

Fig. 9 Peanuts moisture content before and after roasting

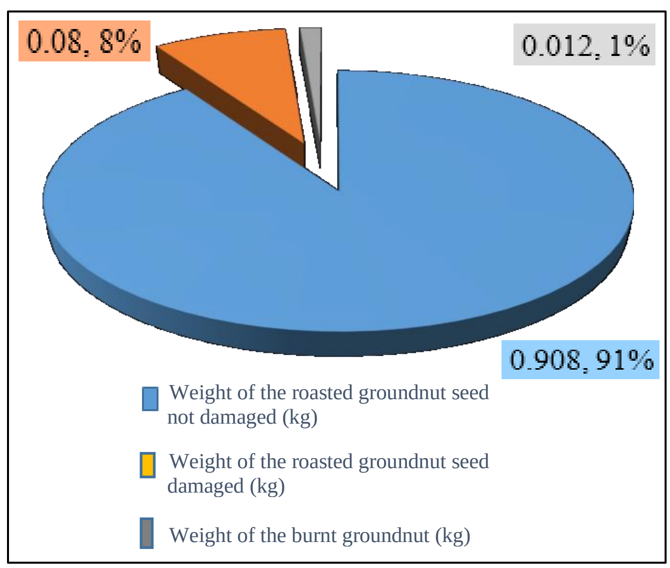

Fig. 10 Efficiency analysis of the roasted seed (Ei %)

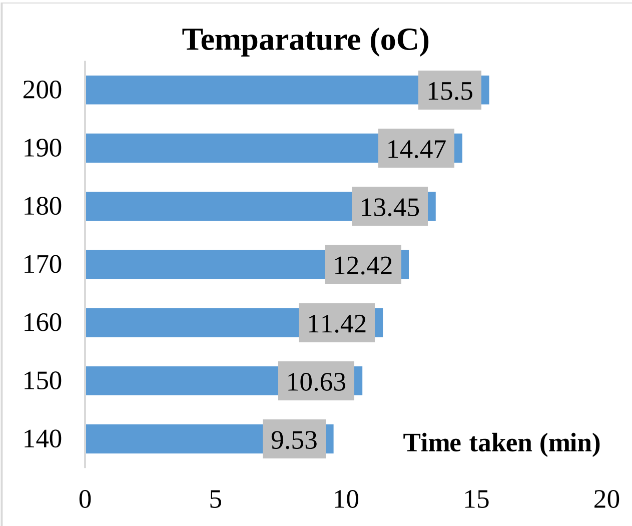

Fig. 11 Experimental working temperature ^{0}C. (Table 4)

From the experiment carried out, the following are recommended:

1. There is a need to increase the length of the roasting chamber to enable the roasted peanuts to come out easily before the roasting time is complete, even though the speed was reduced from 1400rpm to 5rpm.

2. Bulk feeding of the peanuts into the hopper chokes the auger conveyor and, therefore, increases the breakage ratio. Also, proper insulation should be introduced to keep heat loss at the barest minimum.

3. A plausible conclusion of the performance efficiency (see Figure 10) shows that the peanut roasting machine is moderately high compared to literature-based results and thus scalable for commercial use.

This study contributes to the Sustainable Development Goals 2 and 3 (Zero hunger and good health and well-being) set up by the United Nations General Assembly.

5. Conclusion

Data from the test result shows that the developed peanut roasting machine maintained a high level of efficiency in terms of the moisture content of the peanut after roasting, even-roasting and reduction of the broken nuts (see Figure 9). The efficiency was achieved (see Figure 10) due to the improvement of the auger conveyor and the introduction of the temperature regulator (see Figure 11). This peanut roasting machine is easy and safe to operate and can be easily scaled up for an easy fit for producing roasted peanuts on a large scale. Based on the results obtained from the tests performed on the peanut roasting machine, a reasonable conclusion can be made that the best temperature for roasting peanuts ranges from 160°C - 180°C with a moisture content range of 1.78% - 0.76%. During the experiment, the operating capacity was 6kg/hr (1kg/batch).

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References

[1] Aaron N. Adazabra, G. Viruthagiri, and R. Ravisankar "Cleaner Production in the Shea Industry via the Recovery of Spent Shea Waste for Reuse in the Construction Sector," *Journal of Cleaner Production*, vol. 122, pp. 335-344, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[2] M. S. Abubakar, A. A. Sadiq, and I. Law, "A Comparative Performance Evaluation of an Existing and a Modified Groundnut Seed Roasting Machines," *Journal of Dryland Agriculture*, pp. 125-135, 2017. [Google Scholar] [Publisher Link]

[3] M. B. Achu et al., "Nutritive Value of Some Cucurbitaceae Oilseeds from Different Regions in Cameroon," *African Journal of Biotechnology*, vol. 4, no. 11, pp. 1329–1334, 2005. [Google Scholar] [Publisher Link]

[4] A. M. Akintade, O. J. Olukunle, and J. Isa, *Performance Evaluation of an Electromechanical Groundnut Roasting Machine* vol. 8, no. 2, pp. 96–104, 2014. [Google Scholar] [Publisher Link]

[5] Alao Adeyinka Idowu et al., "Design, Fabrication and Evaluation of Electrically-operated Groundnut Roasting Machine," *American Journal of Engineering and Technology Management*, vol. 5, no. 3, pp. 48-55, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[6] R. Ali, "*Design and Development of a Continuous Solar Roaster (CSR) for the Processing of Agricultural Products,*" PhD Thesis, Department of Farm Machinery and Power, Faculty of Agricultural Engineering & Technology. University of Agriculture, Faisalabad, Pakistan, 2019.

[7] Ali Raza et al., "Development and Experimental Results of a Thermal Oil Based Roasting System for Decentralized Processing of Groundnuts," *Applied Science*, vol. 9, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[8] Anthony Agyei-Agyemang et al., "Numerical Modeling of a Hot Plate Stove for Peanut Roasting," *Journal of Engineering*, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[9] Anthony J. Robinson et al., "Heat and Mass Transfer for a Small Diameter Thermosyphon with Low Fill Ratio," *International Journal of Thermofluids*, vol. 1-2, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[10] Farzad Mohebbi, and Ben Evans, "Simultaneous Estimation of Heat Flux and Heat Transfer Coefficient in Irregular Geometries Made of Functionally Graded Materials," *International Journal of Thermofluids*, vol. 1-2, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[11] Hadi Bagheri, "Application of Infrared Heating for Roasting Nuts," *Journal of Food Quality*, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[12] H. U. Kabri, B. A. Ankidawa, and J. Elson, "Modification and Performance Evaluation of a Manually Operated Drum Groundnut Roaster," *Savannah Journal of Agriculture*, vol. 1, no. 2, pp. 88–93, 2006. [Google Scholar] [Publisher Link]

[13] RS Khurmi, and JK Gupta, *A Textbook of Machine Design*, S. Chand Publishing, 2005. [Google Scholar] [Publisher Link]

[14] J. N. Maduako et al., "Testing of an Engine-Power Groundnut Shelling Machine," *Journal of Agricultural Engineering and Technology*, vol. 14, pp. 29-37, 2006. [Google Scholar] [Publisher Link]

[15] A. Mohammed, and A. B. Hassan, "Design and Evaluation of Motorized and Manually Operated Groundnut Shelling Machine," *International Journal of Energy Trends in Engineering and Development*, vol. 4, no. 2, pp. 673-682, 2012. [Google Scholar]

[16] A. Musa et al., "Modification and Optimization of Groundnut (Arachis hypogaea) Roasting Machine," *Journal of Scientific Research and Reports*, vol. 26, no. 5, pp. 71–83, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[17] Oladeji Akanni Ogunwole, "Design, Fabrication and Testing of A (Manually and Electrically Operated) Roasted Groundnut Decorticating Machine," *Food Science and Quality Management*, vol. 14, 2013. [Google Scholar] [Publisher Link]

[18] J. O. Olawale et al., "Fabrication and Testing of a Combined Groundnut Roaster and Oil Expeller Machine," *American Journal of Engineering Research*, vol. 3, no. 4, pp. 230-235, 2014. [Google Scholar]

[19] A. A. Oluwo, and D. T. Idowu, Improving the Efficiency of a Peanut Roasting Machine via Screw-barrel Clearance, pp. 396–408, 2021.

[20] Sagar Paneliya et al., "Systematic Investigation on Fluid Flow and Heat Transfer Characteristic of a Tube Equipped with Variable Pitch Twisted Tape," *International Journal of Thermofluids*, vol. 1-2, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[21] Samuel Kofi Tulashie et al., "Design of Shea Nut Rotary Roasting Machine Used for Shea Butter Production in Ghana," *International Journal of Thermofluids*, vol. 1-2, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[22] A.A.P. Susastriawan et al., "Design and Fabrication of Roller Type Pelletizing Machine Equipped with a Steam Injector for Production of Buoyant Fish Feed," *SSRG International Journal of Mechanical Engineering*, vol. 8, no. 10, pp. 13-16, 2021. [CrossRef] [Publisher Link]

[23] [Online]. Available: https://peanut-institute.com/peanut-products

[24] Vanessa Rose L. Meana, Nazer Sarapeo P. Kimkiman, and Alvin C. Dulay, "Design, Fabrication, and Performance Evaluation of a Batch-Type Fluidized Bed Coffee Roaster for Smallscale Coffee Growers," *Mountain Journal of Science and Interdisciplinary Research*, vol. 79, no. 2, 2019. [Google Scholar] [Publisher Link]

[25] A. M. Olaniyan, O. R. Karim, and E. O. Eromosele, "Design and Development a Smallscale Peanut Roaster," *The Journal of the Association of Professional Engineers of Trinidad and Tobago*, vol. 45, no. 2, pp. 34–39, 2017. [Google Scholar]

[26] J. N. Maduako, and M. Hamman, "Determination of Some Physical Properties of Three Groundnut Varieties," *Nigerian Journal of Technology*, vol. 24, no. 2, pp. 159–280, 2004. [Google Scholar] [Publisher Link]

[27] Ikechukwu Celestine Ugwuoke et al., "Design and Development of Manually Operated Roasted Groundnut Seeds Peeling Machine," *International Journal of Recent Development in Engineering and Technology*, vol. 2, no. 4, pp. 30–33, 2014. [Google Scholar] [Publisher Link]

[28] A. A. Shehu et al., "Design and Fabrication of Shea Nut Steam Roaster," *International Journal of Scientific Research Engineering and Technology*, vol. 6, no. 11, pp. 1113–1121, 2017. [Google Scholar]