



Development of Manually-Operated Groundnut Roasting Machine

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Abstract: Groundnut (*Arachis hypogea*) is one of agricultural product that has wide range of usage to man, animal and industries. It is consume both raw and fried by man and animal, serve as a source of income and a raw material for industries. Groundnut required roasting process to generate oil, bring out characteristic aroma, flavour and a times an acceptable colour for its consumption. In a developing country like Nigeria, this process is done locally. the local method associated with problems and difficulties which make it ineffective, laborious and time consuming, therefore there is need for another improved method. A manually operated Groundnut seed roaster was constructed with the aim of improving on the local methods. It contain Roast chamber, the pulley (which serve as Flywheel) shaft (Agitator), the heating unit (Gas burner and its accessory) and the discharge outlet. The machine after testing shows the frying efficiency of 88.125% with percentages of seed damaged (loss) to be 23.75%. The average and optimum time for roasting was estimated to be in the range of 6 minutes. The machine is inch free and can be operated freely, hence recommended for use.

Keywords: Groundnut, frying, sun drying, roasting, frying-chamber.

1. INTRODUCTION

The groundnut (*Arachis hypogaea*), also called the peanut, is one of the most important food crops in the world, the 6th most important oil seed crop in the world [1]. It is the world's fourth most important source of edible oil and third most important source of vegetable protein [2]. In 2004 groundnuts were grown on 24 million hectares worldwide with a total production of 36 million metric tons. It is estimated that around 65% of the groundnut produced in the world is crushed to extract groundnut oil and the rest is used in making other edible products [3].

Groundnut is a staple food in many developing countries. It is rich in protein, grows well in semi-arid regions; like Nigeria and regarded as valuable cash crop for millions of households in these regions [4]. From 1956 to 1967, groundnut products including cake and oil accounted for about 70% of total Nigeria export earnings, making it the country's most valuable single export crop ahead of other cash crops like cotton, oil palm, cocoa and rubber. Groundnut can be processed into butter, oil, cake, as well as roasted groundnut therefore Groundnut has contributed immensely to the development of the Nation economy

Among the agricultural products that are great value to both man and animals is the groundnut. It serves as raw material for industry. Groundnut oil serves as vegetable oil for human consumption; while groundnut seed cake is being used as part of ingredients in animal and poultry feeds [5]. The wide range of usage of this agricultural product has led to increase in its demand.

The production of oil from groundnut involves a post processing of groundnut which includes shelling, roasting and pressing. Among the problems in processing groundnut is that of roasting the seeds. Roasting reduces moisture content and develops a pleasant flavour which makes the products more acceptable for consumption [6]. Roasting also enhances better extraction of oil 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 [7].

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

Roasting is define as the process of generating characteristic aroma, flavour and colour required by consumers for acceptance of such roasted food [8]. Roasting of food bring about thermal changes in the chemical components at relatively high temperature. This is accomplished by either using a hot air or small metal surface to heat up the material to the required temperature at which the material changes to required colour and according to [9] must be abruptly stopped using cool air to avoid food destruction.

Roasted groundnut is a source of income at the grassroots in Nigeria; it is often prepared traditionally using an open fire with the groundnut mixed with sand or ash to aid the roasting process. This method is unhygienic, inefficient and time-consuming. Consumption of groundnuts as nuts and in the manufacture of peanut butter is based on the use of roasted groundnut kernels. Roasting time has a significant influence on the strength of the odour and flavour according to [10].

The traditional method of roasting makes the process of extraction very slow, tedious and time consuming considering the present level of production. But 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 therefore this machine was designed to be used in rural communities in developing countries like Nigeria

2. MATERIALS AND METHODS

2.1 Materials and Equipment

The material used in fabrication of the roasting machine is stainless steel in order to prevent contamination of groundnut during roasting. The following constructional operations were carried out on the components before the machine was finally built which are marking out and cutting of components, drilling of components, machining of shafts, welding of components, filling and smoothing, assembling of components, and painting.

The following materials and equipment- Mild steel, galvanized stainless, fibre glass, bolt and nut, shaft, revolving pulley, cutting disc, electrode, salt, and spoon used for the fabrication of the machine were secured from Ajegunle market in Osogbo, Osun state while, raw groundnuts were purchased from Owode market, Owode, Ede North local government, Osun State. The materials were selected based on their properties which range from durability, anti-corrosion, heat retention and availability.

2.2 Design Analysis

1) **Determination of the volume of Roasting chamber:** The volume of roasting chamber (V_c) was determined using equation 1 and based on 5 kg of groundnut per batch and putting into consideration 50% filling of fresh groundnut (True density=619Kgm³ [8])

$$V_c = \frac{V_b}{50\%} m^3 \tag{1}$$

Where,

$$V_b = \frac{\text{Mass of groundnut}}{\text{Bulk density of groundnut}} \tag{2}$$

$$V_c = \frac{5Kg}{619Kg} \times \frac{100}{50} m^3 = 0.01615m^3$$

Therefore, required volume of roasting chamber = 0.01615m³

2) **Determination of the roasting chamber diameter:** Lower surface ratio to the heating surface is required for effective heat transfer, this translates to a larger diameter to height ratio, and hence 160.0 mm was chosen for the height. Therefore, the roasting chamber diameter was determined using equation 3;

$$D_c = 2 \sqrt{\frac{V_c}{\pi h}} \tag{3}$$

$$D_c = 2 \sqrt{\frac{0.01615}{3.142 \times 0.160}} = 0.505$$

Therefore, the diameter for the roasting chamber = 0.5m

3) **Determination of the weight and volume of paddle:** The volume of paddle is determined using equation 4 as described by [7, 8];

$$V_p = (l_p \times b_p \times h_p) \tag{4}$$

The volume of 4 paddles is given as:

$$V_p = 4 \times (0.300 \times 0.065 \times 0.05)$$

$$V_p = 0.0000256 m^3$$

Where the paddle length is selected as 0.300 m, paddle breadth is 0.065 and the height is 0.05m.

The density of the wood, $\rho = 0.980g/cm^3 = 980 kg/m^3$

Total weight of paddle is determined using equation 5 [9];

$$\begin{aligned}
 W_p &= \rho \times V \times g \\
 &= 980 \text{ kg/m}^3 \times 0.0000256 \text{ m}^3 \times 9.8 \text{ m/s}^2 \\
 &= 0.246 \text{ N}
 \end{aligned}$$

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4) Determination of the weight of materials to be processed: The maximum weight of the material to be processed is calculated using equation 6 [9], for 6 kg mass of fresh groundnut.

$$\begin{aligned}
 \text{Weight} &= \text{Mass} \times \text{Acceleration due to gravity} \\
 &= 6 \text{ kg} \times 9.8 \text{ m/s}^2 \\
 &= 58.8 \text{ N}
 \end{aligned}$$

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5) Description of the Fabricated Machine: The major components of the machine are Frying chamber, the pulley (which serve as Flywheel) shaft (Agitator), the heating unit (Gas burner and its accessory) and the discharge outlet. The Roasting chamber is made up of welded metal sheets together with a flat metal sheet used for closure and outlet of the seed. It contains bearing in which the agitator passed through. Agitator upper end is fixed with the Pulley which serve the purpose of ensuring the continuous rotation of the agitator due to its weight while at the lower end a stirrer is fixed which is made with the semicircular plate for stirring the seed as it is roasting. The gas burner is placed at the bottom of the roasting chamber. It supply heat through the hose connected to gas cylinder to the chamber (Figure 1-3).

6) Testing and Evaluation: Performance Evaluation of the machine was done using 200 grams of groundnut, while the performance criteria considered were the comparison with local method using dry rate and product mechanical damage.

- a. **Drying Rate:** 200 grams of groundnut was roasted locally using earthen pot and salt as base while firewood remains as the source of heat. Also another 200 grams was roasted using fabricated Roaster. The weight of the groundnut is measured at intervals of 5 minutes for both methods to determine the drying rate and the maximum temperature for both method is maintained at 60°C.
- b. **Product Mechanical Damaged:** Four test were carried out. In each test, 200g of groundnut seed were fed into the roast chamber and the gas were fired to supply heat. At interval the agitator was rotated, providing the stirring effects. After ten (10) minutes, the machine was stopped and roasted seed were separated from damaged one and weighed. The test were repeated with the same grams of seed for the remaining test with varying time interval of seven (7), five (5) and two (2) minutes. The roasted groundnut was separated from the non-roasted or partially roasted ones and weighed. The efficiency of the roasting unit was calculated using Equation 7;

$$\text{Frying Efficiency} = \frac{W_f}{W_t} \times 100$$

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Where, W_f = Weight of frying seed and W_t = Total weight of the seed

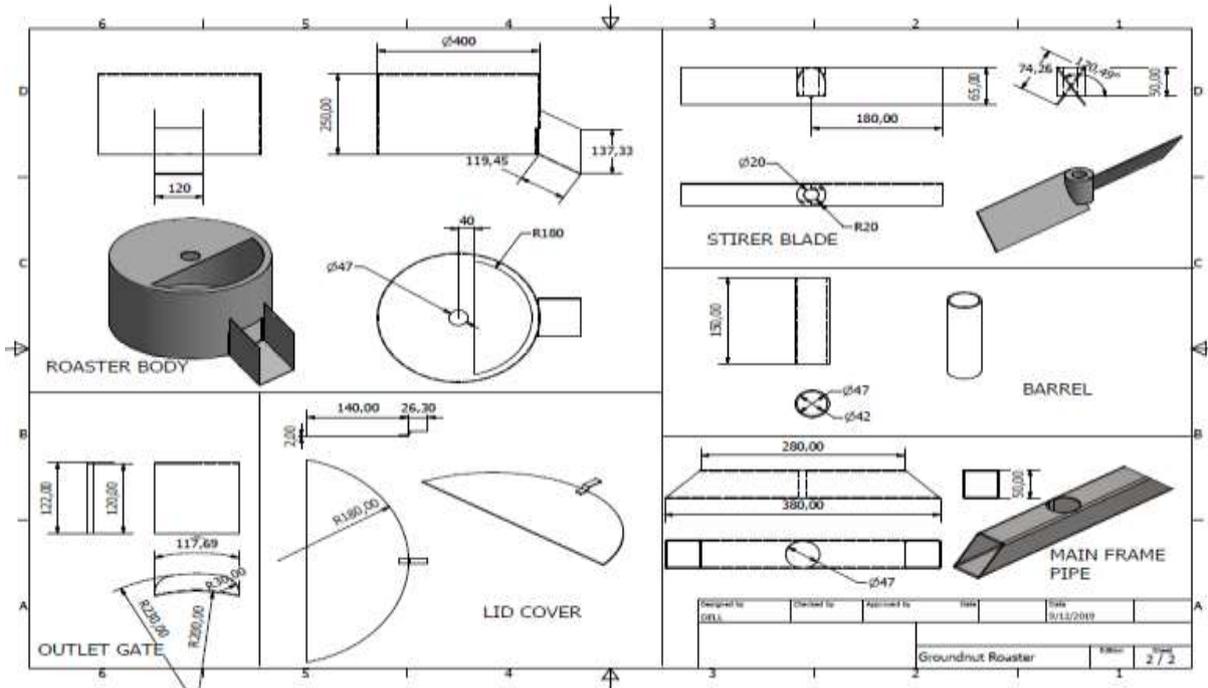


Figure 1: Part drawing of a groundnut roasting machine

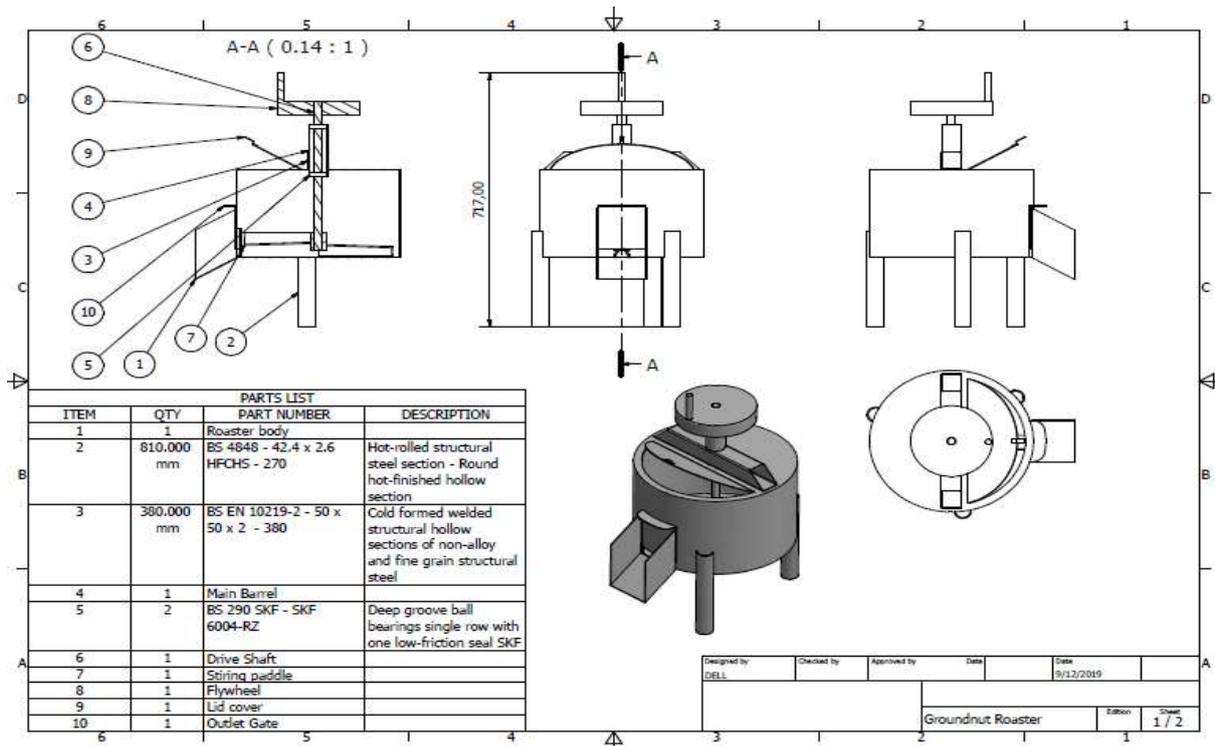


Figure 2: Isometric drawing of a groundnut roasting machine



Figure 3: Groundnut roasting machine

3. RESULTS AND DISCUSSIONS

3.1 Result

Table 1 and 2 below shows the result of the performance criteria considered which the comparisons are with local method using dry rate and product mechanical damage.

1) Drying Rate

From table 1 above, it was observed that the drying rate is higher when using the fabricated roaster compared to the local method and according to Olawale et.al dryness has positive impact on the aroma produced during the roasting process despite that the heat must be regulated to minimize damaged to the seed.

Table 1: Showing the weight and % drying rate of the groundnut using local method and fabricated machine

Time (min)	Weight of Groundnut using Local method of Roasting (kg)	Weight of Groundnut using fabricated roaster (Kg)	% drying using Local method of Roasting (kg)	% drying using fabricated roaster (Kg)
0	5.50	5.50	0.00	0.00
5	5.36	5.10	02.55	7.27
10	5.28	4.80	04.00	12.72
15	5.12	4.32	06.91	21.45
20	4.70	4.12	14.55	25.00
25	4.51	3.90	18.00	29.09

2) **Product Mechanical Damage**

The roaster efficiency appears to be generally high in the range of 75.00 to 97.50% at four different level of roasting groundnut seeds in the chamber. Seed losses (EI), was observed but at a low level in the range of 2.5 to 25% at an average time interval of six minutes, 176.25 grams of groundnut seed roasted while 23.75 grams were damaged which put average efficiency at 88.125%. One of the distinguishing features of the roaster is that instead of using conventional firewood as the source of energy, gas (LPG) was used.

Table 2: Performance evaluation parameters of Groundnut seed roaster

S/N	Weight of Groundnut Seed (g)	Weight of fried Groundnut Seed (g)	Weight of damaged Groundnut Seed (g)	Time (min)	Fryer Efficiency
1	200	150	50	10	75
2	200	175	25	7	87.5
3	200	185	15	5	92.5
4	200	195	5	2	97.5
		176.25	23.75	6	88.13

4. CONCLUSION

The groundnut seed roaster constructed during this investigation was observed to roast groundnut seeds at faster rate than the traditional method of using fire wood which is very tedious and exposes the health of rural women to great danger. The drying required was observed to be lighter, because the moisture content required for frying is the moisture content require for the safe storage and preservation of groundnut seeds. In other to improve on this machine the following suggestions are made-

- i. For effective and maximum roasting, groundnut should be dried in sun before roasting.
- ii. More research on other groundnut seed varieties should be carried out to predict the temperature and moisture content at which roasting would be very effective.

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