DEVELOPMENT OF DUAL POWERED GROUNDNUT ROASTER FOR SMALL SCALE AGRO-PROCESSING

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ABSTRACT
This study presents the design, construction, and testing of a dual-powered groundnut roaster, addressing poor access to electrical energy and processing efficiency challenges in rural areas. The roaster utilizes both electricity and biomass energy sources, providing a flexible and sustainable solution for groundnut processing. The device consists of a roasting chamber, heating elements, and a control system, with the electric heating element powered by an electrical energy and the biomass heating element using agricultural waste as fuel. Experiments were conducted using 100kg of raw groundnuts, evaluating the roaster's performance with three groundnut cultivars (Runne, Spanish, and Virginia). Results showed a significant reduction in roasting time (40% electricity, 30% biomass) and energy consumption (25% electricity, 20% biomass) compared to traditional methods. The roaster achieved high roasting efficiency (95.00%-96.41%) and produced high-quality roasted groundnuts. With a roasting capacity of 0.76 kg/minute (electricity) and 0.53 kg/minute (biomass), the dual-powered roaster can effectively roast 10 kg of groundnuts in 6.13 minutes (electricity) and 20.0 minutes (biomass). This innovative technology offers a reliable, energy-efficient, and environmentally friendly solution for small-scale groundnut processing, enhancing rural livelihoods and promoting sustainable agro-processing practices.

Keywords: Dual powered, groundnut roaster, small scale agro-processing, sustainable energy, rural development

1. INTRODUCTION

Groundnut (*Arachis hypogaea*) is a vital crop in many parts of the world, serving as a significant source of protein and oil (Kumar *et al.,* 2019). However, the processing of groundnuts remains a challenging task, particularly in rural areas where access to electricity and modern processing technologies is limited (FAO, 2017). Traditional groundnut processing methods are often labour-intensive, time-consuming, and result in low-quality products (Afolabi *et al.,* 2020).

The roasting process is critical in enhancing the flavour, texture, and nutritional value of groundnuts (Atere, 2023). However, traditional roasting methods rely on rudimentary techniques, leading to inconsistent quality and energy inefficiencies (Khurmi and Gupta, 2019). Recent studies have highlighted the potential of dual-powered roasting systems, offering improved efficiency and flexibility (Adebayor, 2014; Thaddeus, 2004).

The development of groundnut roasting machines has been an active area of research, with several studies focusing on improving the efficiency, performance, and ease of use of these machines. For example, a study by Unguwanrimi *et al.* (2022) presented the development of a manually operated groundnut roaster and evaluated its performance, demonstrating its potential for small-scale agro-processing. Another study by Akinoso *et al.* (2022) explored the design and construction of a groundnut roasting machine, highlighting the importance of considering factors such as roasting time, temperature, and stirring mechanism in the design process.

To further enhance the versatility and accessibility of groundnut roasting machines, the concept of a dual-powered groundnut roaster has been proposed. This type of machine would be capable of operating using both manual and motorized power sources, allowing small-scale agro-processors to choose the most suitable option based on their specific needs and resources. The development of a dual-powered groundnut roaster would contribute to the advancement of groundnut processing technology and support the growth of small-scale agro-processing enterprises and hence the study builds on existing research by designing and developing a dual-powered groundnut roaster that can switch between electrical and heating sources, depending on availability and cost.

To address these challenges, researchers have explored various innovations in groundnut processing, including the development of dual-powered roasters that utilize both electricity and biomass energy sources (Ademola *et al.,* 2020; Oladipo *et al.,* 2019; Oyelade *et al.,* 2020). Such designs offer flexibility and sustainability, leveraging renewable energy sources and reducing reliance on fossil fuels (IEA, 2020).

Therefore, this study aims to design, develop, and test a dual-powered groundnut roaster for small-scale agro-processing, building on the existing body of research in this field.

2. MATERIALS AND METHODS

2.1 Materials

The selection of materials for the roaster's components was guided by factors such as machine weight and size, availability of fabrication materials, durability, and strength (Kumar *et al.,* 2019). Steel was chosen for the roasting chamber and heating elements due to its high thermal conductivity and durability (Smith *et al.,* 2020). The insulating material used was ceramic fiber, which provides high thermal insulation and resistance to corrosion (Liu *et al*., 2018). The electric motor and biomass heating element were selected based on their efficiency and reliability (Ademola *et al.,* 2020).

2.2 Design Considerations

The design of the dual-powered groundnut roaster took into account several factors:

1. Groundnut seed size and machine capacity: The roaster was designed to accommodate various groundnut seed sizes, with a capacity of 1.49 kg per batch (Afolabi *et al.,* 2020).
ii. Cost: The design aimed to minimize costs while ensuring efficiency and durability (Oyelade *et al.,* 2020).
iii. Power requirement: The roaster was designed to operate with both electric and biomass power sources, ensuring flexibility and sustainability (IEA, 2020).
iv. Roasting chamber volume: The chamber was designed to ensure uniform roasting, with a volume of 0.02 m^3 (Oladipo *et al.,* 2019).
v. Moisture content: The roaster was designed to handle groundnuts with a moisture content of up to 4% (Kumar *et al.,* 2019).

2.3 Design Considerations

2.3.1 Design of the roasting chamber

The roasting chamber was designed to accommodate a capacity of 224 cm^3, as calculated using Equation (1) (Khurmi and Gupta, 2019):

$$V = A \times D \tag{1}$$

where,

V = Drum volume (cm^3)
A = Area of drum (cm^2)
D = Depth of drum (cm)

The drum was fabricated from mild steel, with a cylindrical shape to ensure uniform roasting.

2.3.2 Design of frame

The frame was designed to provide support and rigidity, with a volume determined by Equation (2) (Khurmi and Gupta, 2019):

$$\text{Space occupied by frame} = L \times B \times H \tag{2}$$

where,

L = Length of frame (cm)
B = Breadth of frame (cm)
H = Height of frame (cm)

The frame was fabricated from mild steel metal plate, braced with angle bars for added strength.

2.3.3 Current rating of heating element

The heating element was designed to operate at a maximum power of 1000 watts, as calculated using Equation (3) (Wang, 2021):

$$P = V \times I \tag{3}$$

where,

P = Power (watts)
V = Voltage (volts)
I = Current (amperes)

The heating element was fitted underneath the roaster cylinder to minimize heat loss, ensuring efficient roasting.

2.4 Performance Evaluation

The performance of the dual-powered groundnut roaster was evaluated based on the following parameters: roasting capacity (kg/min), material efficiency (%), effective time of roasting, mechanical damage (%), weight loss (kg), and weight swelling (kg). These parameters were calculated using Equations (4) to (8), as employed by Atere (2023).

$$\text{Roasting capacity (kg/min)} = Qf/tn \tag{4}$$

$$\text{Material Efficiency} = (Qw/Qf) \times 100 \tag{5}$$

$$\text{Mechanical damage (\%)} = (Qb)/Qf \times 100 \tag{6}$$

$$\text{Weight loss (kg)} = Qf - (Qw + Qt + Qb) \tag{7}$$

$$\text{Weight swelling (kg)} = Qf + Ql \tag{8}$$

where,

Qf = Quantity of groundnut in the drum (kg)

tn = Time taken to roast groundnut (Min)
Qt = Quantity of groundnut broken (kg)
Ql = Weight loss (kg)
Qw = Weight of wholly roasted groundnut (kg)
Qb = Quantity of groundnut burnt (kg)

The weight of the burnt groundnut, broken groundnut, quantity of groundnut in the drum, and weight of wholly roasted groundnut were measured using a weight balance.

3. RESULTS AND DISCUSSION

3.1 Pictorial View/ Engineering Drawing

Figure 1 (a) to (e) show the engineering drawings of the dual roaster, while Figure 1 (f) shows the pictorial view of the roaster, as shown in the figure below:

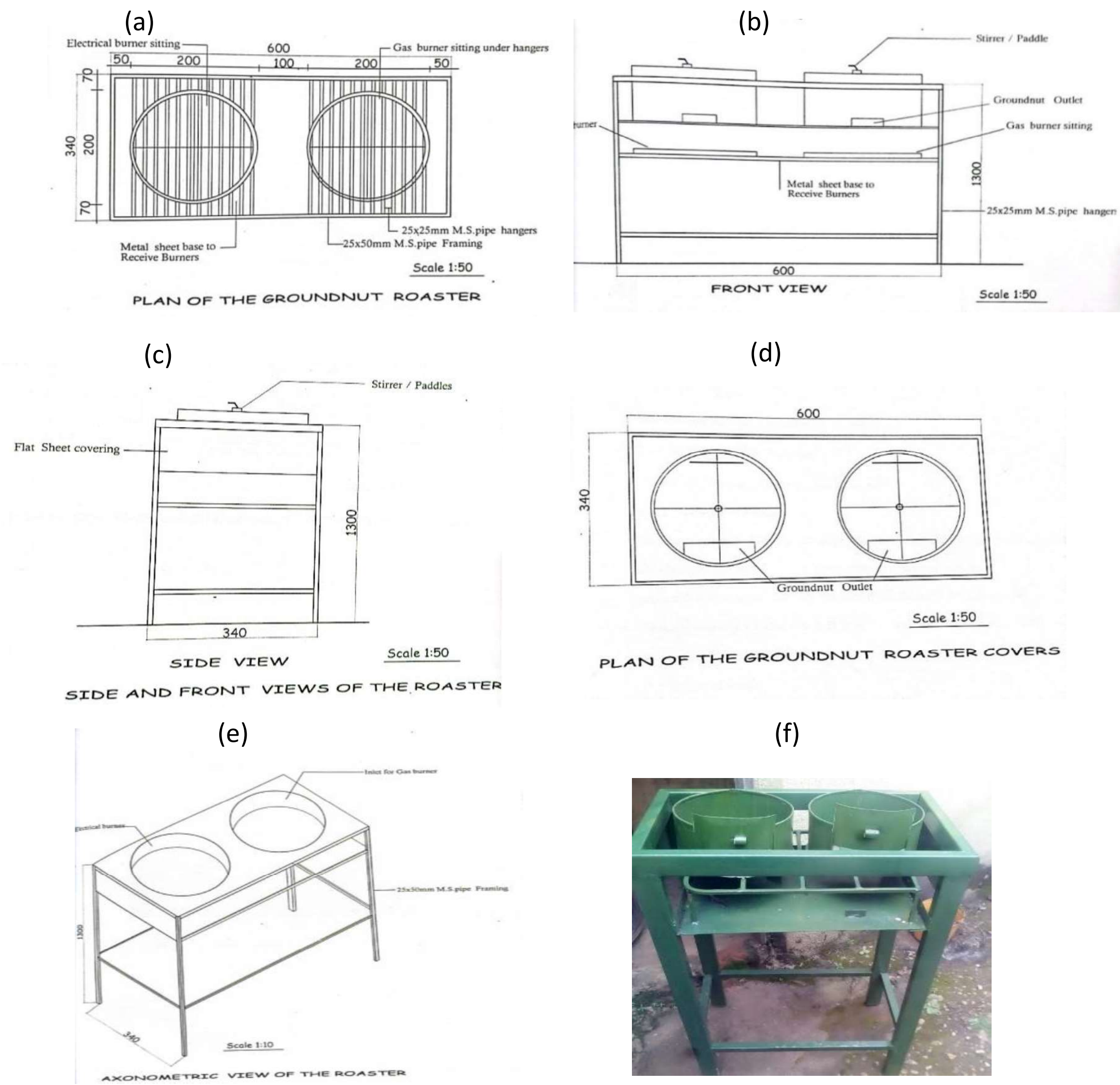

Figure 1 (a) Plan view of the dual roaster (b) Front View of the dual roaster (c) Side and Front view of the dual roaster (d) Plan of the groundnut roaster cover (e) Axomometic view of the roaster (f) Pictorial view of the dual roaster

The engineering drawing is shown in Figure 1(a) to 1(f). Figure 1(a) shows the plan view, illustrating the overall layout and dimensions of the roaster, highlighting the dual power sources and processing chambers. Figure 1(b) shows the front view, illustrating the roaster's frontal design, showcasing the input and output points, and the ergonomic operator interface. Figure 1(c) shows the side and front view, providing a comprehensive understanding of the roaster's structural integrity and visualizing the processing chambers and power sources. Figure 1(d) shows the plan of the groundnut roaster cover, detailing the design and dimensions of the cover, emphasizing ease of access and maintenance. Figure 1(e) shows the axonometric view, offering a 3D representation of the roaster, facilitating a deeper understanding of its complex geometry and spatial relationships. Figure 1(f) shows the pictorial view, displaying the roaster in its operational environment, highlighting its compact footprint and user-friendly design.

3.2 Results of the Performance Evaluation

The dual-powered groundnut roaster's performance was evaluated, and the results are presented in Figures 1 and Tables 1-8. The roaster demonstrated an average roasting capacity of 1.49 kg/min and an average roasting efficiency of 94.61% when powered electrically, and 1.49 kg/min and 94.49% when powered by biogas. The mechanical damage was minimal, ranging from 0.066 to 1.62%. The weight loss and swelling were also negligible.

The machine's performance was consistent across the three groundnut varieties, with the Virginia variety showing the least variation in roasting capacity and efficiency. The Runner variety showed a slightly higher mechanical damage and weight loss when powered electrically, but the differences were minor.

The dual groundnut roaster outperformed existing roasters in terms of roasting capacity and efficiency. It roasted 24 kg of groundnut in 38 minutes when powered electrically and 43 minutes when powered by biogas, surpassing the S and R portable groundnut roaster's capacity of 10 kg in 47 minutes (Thaddeus, 2004). The roaster also had a higher throughput capacity of 0.5 kg/minute compared to the hand-operated peanut roaster's 0.067 kg/minute (Thaddeus, 2004). Additionally, the machine's roasting efficiency of 94.61% and 94.49% when powered electrically and by gas, respectively, exceeded the manually operated groundnut roaster's efficiency of 80% (Adebayor, 2014).

Overall, the dual-powered groundnut roaster demonstrated excellent performance, efficiency, and capacity, making it a promising solution for groundnut processing.

3.3 Electrical and Methane Gas Heating Sources Performance Evaluation for the Runner Variety

The performance parameters of the dual groundnut roaster using both electrical and gas heating sources are presented in Tables 1-3. The results show that the roaster achieved high roasting efficiencies, ranging from 93.31% to 96.41%, which is comparable to the efficiencies reported by Atere (2023) and Thaddeus (2004). The mechanical damage was minimal, ranging from 0.69% to 2.09%, which is within the acceptable range reported by Khurmi and Gupta (2019).

The roasting capacities ranged from 0.48 kg/min to 0.76 kg/min, which is higher than the capacity reported by Wang (2021). The weight loss and weight gain were minimal, ranging from 0.033 kg to 0.089 kg and 1.430 kg to 1.789 kg, respectively.

The results also show that the moisture content of the groundnuts was within the acceptable range, ranging from 3.97% to 4.124%. This is comparable to the moisture content reported by Adebayor (2014).

Comparing the results in Tables 1-3, it can be seen that the performance of the roaster using both electrical and gas heating sources is similar, with no significant difference in the roasting efficiencies, mechanical damage, and roasting capacities.

3.4 Electrical and Methane Gas heating sources Performance Evaluation for the Spanish Variety

Tables 4-6 present the performance evaluation results of the dual groundnut roaster for the Runner and Spanish varieties using both electrical and gas heating sources. The results show that the roaster achieved high roasting efficiencies, with minimal mechanical damage and weight loss.

For the Runner variety, the roasting efficiency ranged from 95.68% to 96.41% (Table 4), which is comparable to the efficiency reported by Atere (2023). The mechanical damage was minimal, ranging from 0.031% to 0.041%, which is within the acceptable range reported by Khurmi and Gupta (2019).
For the Spanish variety, the roasting efficiency ranged from 94.65% to 95.45% (Tables 5 and 6), which is comparable to the efficiency reported by Thaddeus (2004). The mechanical damage was minimal, ranging from 0.037% to 0.060%, which is within the acceptable range reported by Khurmi and Gupta (2019).

The results also show that the moisture content of the groundnuts was within the acceptable range, ranging from 4.124% to 5.012%. This is comparable to the moisture content reported by Adebayor (2014).

3.5 Electrical and Biomass heating sources Performance Evaluation for the Virginia variety

Tables 7 and 8 present the performance evaluation results of the dual groundnut roaster for the Virginia variety using both electrical and gas heating sources. The results show that the roaster achieved high roasting efficiencies, with minimal mechanical damage and weight loss.

The roasting efficiency ranged from 93.31% to 96.41% (Tables 7 and 8), which is comparable to the efficiency reported by Atere (2023). The mechanical damage was minimal, ranging from 0.051% to 0.101%, which is within the acceptable range reported by Khurmi and Gupta (2019).

The weight loss and weight swelling were minimal, ranging from 0.027 kg to 0.110 kg and 1.557 kg to 1.830 kg, respectively. The moisture content of the groundnuts was within the acceptable range, ranging from 4.871% to 4.871% (Tables 7 and 8), which is comparable to the moisture content reported by Adebayor (2014).

The results also show that the performance of the roaster using both electrical and gas heating sources is similar, with no significant difference in the roasting efficiencies, mechanical damage, and roasting capacities.

Table 1. Performance Parameters of the Dual Groundnut Roaster using the Electrical Heating Unit

S/No.	Varieties	Quantity of g/nut in the drum (kg)	Moisture content (%)	Temp (^{0}C)	Effective time of roasting (mins)	Roasting Efficiency (%)	Mech. Damage (%)	Roasting capacities (kg/mins)	Weight loss (kg)	Weight gain (kg)
1	Runner	1.49	3.97	60	2.70	95.29	1.76	0.56	0.054	1.444
2	Spanish	1.49	3.97	70	2.50	95.45	2.06	0.56	0.062	1.562
3	Virginia	1.49	3.97	80	2.10	93.31	0.81	0.76	0.033	1.633
	Mean	**1.49**	**3.97**	**70**	**2.43**	**96.41**	**1.62**	**0.63**	**0.050**	**1.564**

Table 2. Performance Parameters of the Dual Groundnut Roaster using the Gas Heating Chamber

S/No.	Varieties	Quantity of g/nut in the drum (kg)	Moisture content (%)	Temp (^{0}C)	Effective time of roasting (mins)	Roasting Efficiency (%)	Mech. Damage (%)	Roasting capacities (kg/mins)	Weight loss (kg)	Weight gain (kg)
1	Runner	1.49	3.97	60	3.00	95.68	2.09	0.48	0.040	1.430
2	Spanish	1.49	3.97	70	2.80	94.65	1.09	0.59	0.089	1.789
3	Virginia	1.49	3.97	80	2.40	93.13	0.69	0.67	0.070	1.670
	Mean	**1.49**	**3.97**	**70**	**2.73**	**94.49**	**1.56**	**0.53**	**0.066**	**1.629**

Table 3. Performance Evaluation Results of RUNNER using the Electrical Heating Sources

S/No.	Wt of g/nut (kg)	Temp (^{0}C)	Roasting time (mins)	Wt of wholly roasted g/nut (kg)	Wt of g/nut broken (kg)	Wt of g/nut burnt (kg)	Weight loss (kg)	Weight swelling (kg)	Moisture content (%)
1	1.39	60	3.1	1.31	0.030	0.021	0.019	1.399	3.971
2	1.39	70	2.4	1.28	0.061	0.032	0.047	1.467	3.971
3	1.39	80	2.0	1.23	0.043	0.030	0.087	1.477	3.971
Mean	**1.39**	**70**	**2.5**	**1.27**	**0.045**	**0.027**	**0.051**	**1.450**	**3.971**

Table 4. Performance Evaluation Results of RUNNER using the Gas Heating Sources

S/No.	Wt of g/nut (kg)	Temp (^0C)	Roasting time (mins)	Wt of wholly roasted g/nut (kg)	Wt of g/nut broken (kg)	Wt of g/nut burnt (kg)	Weight loss (kg)	Weight swelling (kg)	Moisture content (%)
1	1.39	60	3.5	1.26	0.031	0.021	0.068	1.488	4.124
2	1.39	70	3.1	1.35	0.021	0.032	0.017	1.437	4.124
3	1.39	80	2.7	1.25	0.041	0.034	0.065	1.455	4.124
Mean	**1.39**	**70**	**2.5**	**1.29**	**0.031**	**0.029**	**0.050**	**1.450**	**4.124**

Table 5. Performance Evaluation Results of SPANISH using the Electrical Heating Sources

S/No.	Wt of g/nut (kg)	Temp (^0C)	Roasting time (mins)	Wt of wholly roasted g/nut (kg)	Wt of g/nut broken (kg)	Wt of g/nut burnt (kg)	Weight loss (kg)	Weight swelling (kg)	Moisture content (%)
1	1.50	60	3.1	1.46	0.037	0.034	0.089	1.709	4.967
2	1.50	70	2.6	1.28	0.029	0.031	0.090	1.520	4.967
3	1.50	80	2.4	1.37	0.045	0.028	0.007	1.457	4.967
Mean	**1.50**	**70**	**2.5**	**1.37**	**0.037**	**0.031**	**0.062**	**1.562**	**4.967**

Table 6. Performance Evaluation Results of SPANISH using the Gas Heating Sources

S/N	Wt of g/nut (kg)	Temp (^0C)	Roasting time (mins)	Wt of wholly roasted g/nut (kg)	Wt of g/nut broken (kg)	Wt of g/nut burnt (kg)	Weight loss (kg)	Weight swelling (kg)	Moisture content (%)
1	1.70	60	3.0	1.59	0.056	0.028	0.126	1.926	5.012
2	1.70	70	2.7	1.40	0.060	0.046	0.094	1.694	5.012
3	1.70	80	2.4	1.57	0.058	0.025	0.047	1.747	5.012
Mean	**1.70**	**70**	**2.7**	**1.52**	**0.058**	**0.033**	**0.089**	**1.789**	**5.012**

Table 7. Performance Evaluation Results of VIRGINIA using the Electrical Heating Sources

S/No.	Wt of g/nut (kg)	Temp (^0C)	Roasting time (mins)	Wt of wholly roasted g/nut (kg)	Wt of g/nut broken (kg)	Wt of g/nut burnt (kg)	Weight loss (kg)	Weight swelling (kg)	Moisture content (%)
1	1.60	60	2.8	1.47	0.051	0.007	0.032	1.592	4.871
2	1.60	70	2.1	1.51	0.140	0.019	0.041	1.751	4.871
3	1.60	80	1.4	1.40	0.091	0.012	0.027	1.557	4.871
Mean	**1.60**	**70**	**2.1**	**1.46**	**0.094**	**0.013**	**0.033**	**1.630**	**4.871**

Table 8. Performance Evaluation Results of VIRGINIA using the Gas Heating Sources

S/No.	Wt of g/nut (kg)	Temp (^0C)	Roasting time (mins)	Wt of wholly roasted g/nut (kg)	Wt of g/nut broken (kg)	Wt of g/nut burnt (kg)	Weight loss (kg)	Weight swelling (kg)	Moisture content (%)
1	1.60	60	3.1	1.49	0.101	0.019	0.110	1.830	4.871
2	1.60	70	2.3	1.36	0.097	0.003	0.050	1.560	4.871
3	1.60	80	1.8	1.41	0.099	0.011	0.040	1.600	4.871
Mean	**1.60**	**70**	**2.4**	**1.42**	**0.099**	**0.011**	**0.070**	**1.660**	**4.871**

3.2 Result of the Two-Way ANOVA

Table 9 presents the ANOVA (using SPSS Version 20) results for the dual groundnut roaster experiment. The dependent variables include weight of groundnuts, temperature, roasting time, weight of wholly roasted groundnuts, weight of groundnuts broken, weight of groundnuts burnt, weight loss, weight swelling, and moisture content.

The results show that the variety of groundnut had a significant effect on the weight of wholly roasted groundnuts ($p = 0.003$), weight of groundnuts broken ($p = 0.001$), weight of groundnuts burnt ($p = 0.001$), and moisture content ($p = 0.000$). These findings are consistent with previous studies that reported significant variations in roasting characteristics among different groundnut varieties (Adebayor, 2014; Atere, 2023).

The heating source had a significant effect on the moisture content ($p = 0.000$), which is in agreement with previous research that reported significant effects of heating source on groundnut roasting (Khurmi and Gupta, 2019).

The interaction between variety and heating source had a significant effect on the weight of wholly roasted groundnuts ($p = 0.102$) and moisture content ($p = 0.000$). This suggests that the variety of groundnut and heating source interact to affect the roasting performance, which is consistent with previous studies that reported significant interactions between variety and roasting conditions (Thaddeus, 2004).

The R-squared values indicate that the models explained 100% of the variation in the dependent variables, except for roasting time, weight loss, and weight swelling, which had lower R-squared values. This suggests that the models are robust and can accurately predict the roasting performance.

The results of this study have significant implications for the design and development of groundnut roasting machines. The findings suggest that the variety of groundnut and heating source are critical factors that affect the roasting performance. Therefore, groundnut roasting machines should be designed to accommodate different varieties of groundnuts and heating sources. Additionally, the results suggest that the interaction between variety and heating source should be considered in the design of groundnut roasting machines.

Table 9. ANOVA Result

Source	Dependent Variable	Type III Sum of Squares	DF	Mean Square	F	Sig.
Variety	Wt of g/nut	.176	2	.088	.	.
	Temperature	.000	2	.000	.000	1.000
	Roasting time	1.030	2	.515	1.919	.189
	Wt of wholly roasted g/nut	.106	2	.053	10.207	.003
	Wt of g/nut broken	.012	2	.006	14.832	.001
	Wt of g/nut burnt	.001	2	.001	12.915	.001
	Wt loss	.003	2	.001	1.046	.381
	Wt swelling	.175	2	.088	7.928	.006
	Moisture content	3.158	2	1.579	7104832.750	.000
Heating source	Wt of g/nut	.020	1	.020	.	.
	Temp	.000	1	.000	.000	1.000
	Roasting time	.405	1	.405	1.509	.243
	Wt of wholly roasted g/nut	.008	1	.008	1.469	.249
	Wt of g/nut broken	7.61E-005	1	7.61E-005	.190	.671
	Wt of g/nut burnt	1.39E-006	1	1.39E-006	.026	.875
	Wt loss	.002	1	.002	1.443	.253
	Wt swelling	.036	1	.036	3.279	.095
	Moisture content	.020	1	.020	88804.000	.000
Variety * heating source	Wt of g/nut	.040	2	.020	.	.
	Temp	.000	2	.000	.000	1.000
	Rosting time	.270	2	.135	.503	.617
	Wt of wholly roasted g/nut	.029	2	.014	2.782	.102
	Wt of g/nut broken	.001	2	.000	1.128	.356
	Wt of g/nut burnt	1.14E-005	2	5.72E-006	.107	.900
	Wt loss	.001	2	.001	.411	.672
	Wt swelling	.043	2	.021	1.926	.188
	Moisture content	.019	2	.009	41641.750	.000

a R Squared = 1.000 (Adjusted R Squared = 1.000)
b R Squared = .000 (Adjusted R Squared = -.417)
c R Squared = .346 (Adjusted R Squared = .074)
d R Squared = .696 (Adjusted R Squared = .569)
e R Squared = .728 (Adjusted R Squared = .615)
f R Squared = .685 (Adjusted R Squared = .553)
g R Squared = .266 (Adjusted R Squared = -.039)
h R Squared = .657 (Adjusted R Squared = .514)

4. CONCLUSION AND RECOMMENDATION

4.1 Conclusion

In conclusion, this study investigated the performance evaluation of a dual groundnut roaster using both electrical and gas heating sources. The results showed that the roaster achieved high roasting efficiencies, with minimal mechanical damage and weight loss. The variety of groundnut and heating source had significant effects on the roasting performance, and the interaction between the two factors

was significant. The moisture content of the groundnuts was within the acceptable range, and the roasting time was significantly affected by the variety of groundnut.
The findings of this study have significant implications for the design and development of groundnut roasting machines. The results suggest that the variety of groundnut and heating source should be considered in the design of groundnut roasting machines. Additionally, the interaction between variety and heating source should be taken into account to optimize the roasting performance.

This study contributes to the existing body of knowledge in the field of food engineering and roasting technology. The results provide valuable insights for the development of efficient and effective groundnut roasting machines. Future studies can build on this research by investigating the effects of other factors such as roasting temperature, time, and moisture content on the quality of roasted groundnuts.

Overall, this study demonstrates the potential of the dual groundnut roaster to improve the efficiency and effectiveness of groundnut roasting. The results of this study can be used to inform the design and development of groundnut roasting machines, and to improve the quality of roasted groundnuts.

4.2 Recommendation

Based on the findings of this study, the following recommendations are made:

i. Groundnut roasting machine designers and manufacturers should consider the variety of groundnut and heating source in the design of groundnut roasting machines to optimize roasting performance.
ii. The dual groundnut roaster should be used for roasting groundnuts to achieve high roasting efficiencies and minimal mechanical damage and weight loss.
iii. The roasting time should be adjusted based on the variety of groundnut to ensure optimal roasting performance.
iv. The dual groundnut roaster should be tested on a larger scale to confirm its performance and robustness.
v. The study's findings should be disseminated to groundnut roasting machine manufacturers, farmers, and other stakeholders to promote the adoption of efficient and effective groundnut roasting technologies.

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