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A Comparative Performance Evaluation of an Existing and a Modified Groundnut Seed Roasting Machines

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Abstract

Groundnut seed roasting is a critical step in the processing for oil extraction, snack nuts, confectionaries and peanuts for roasting. Roasting enhances oil extraction processes as it reduces the oil's viscosity, releases oil from intact cells and reduces the moisture content. A comparative performance evaluation of an existing and a modified groundnut seed roasting machines was carried out and reported in this study. A Completely Randomized Design (CRD) was used where roasting efficiency, percentage of groundnut seed loss and fuel consumption rate were used as performance indicators, for the two machines investigated (existing and modified machines). Two groundnut seeds varieties (*Manipintar* and *Ex-Dakar*) and three turning speeds (30, 50 and 70 rpm) were used as independent variables. The combination of the independent variables resulted to a total of twelve (12) experimental treatments, thus with three replications carried out on each treatment a total of thirty-six (36) experiments were conducted. For the existing and modified roasting machine, results obtained revealed that 91.20% and 98.80%; 12.40% and 1.20%; and 1.90 kg/hr and 1.20 kg/hr were achieved as roasting efficiency; percentage of groundnut seed loss; and fuel consumption rate, respectively. It was established that the effects of using different roasting machine model and turning speeds are significant on roasting efficiency, while variety is not significant on roasting efficiency. For percentage of groundnut seed loss for the different machine models was highly significant, while variety and turning speed with their interaction are not significant. The interactions on the effects of using different machine model, variety of groundnut seed used and turning speed were highly significant on fuel consumption rate.

Keywords: Roasting efficiency, percentage of seed loss, turning speed, groundnut, performance.

Introduction

Groundnut, (*Arachis hypogeal*) also called peanut is a vital nutritional food in many developing countries. Among the agricultural products that are of great value to both man and animals is groundnut. It serves as raw material for industry. Groundnut oil also as vegetable oil for human consumption and groundnut seed cake is being used as part of ingredients in animal and poultry feeds. Groundnut is a protein rich legumes that grows well in semi-arid regions. There are two main types of groundnut: the America groundnut (*Arachis hypogeal*), and the African groundnut, the Bambara nut (*voandzeia subterranean*) (Ajao, *et al.*, 2009; Hommons, 1994). Both are grown in western Africa as a protein source. Groundnuts also contain sufficient quantity of carbohydrates and fats. The America groundnut grow 30-40 cm high and do not spread. The West Africa groundnut is shorter and run along the ground from 30-60 cm high with a yields of kernels range from 0.5-40 tons/ha (Ajao, *et al.*, 2009). In most developing countries, 80% of crops yields were around 1 tons/ha (Ajao, *et al.*, 2009). The production of oil from groundnut entails a postharvest processing of groundnut which includes shelling, roasting and pressing (Mohammed and Hassan, 2012). Roasting is defined as the process of generating characteristics aroma, flavour and colour required by consumers for acceptance of such roasted food (Ola, *et al.*, 2001). Roasting of food bring about thermal changes in the chemical components of relatively high temperature. This is accomplished by both using a hot air or small metal surface to heat up the material to the required temperature of which the material changes to required colour (Maduakoj, *et al.*, 2006). During roasting, amino acids and carbohydrates react to produce tetrahydrofaran derivatives. Roasting also dries the peanuts further and changes its colour to brown as peanut oil stains the peanut cell walls (Ola, *et al.*, 2001). Mohammed and Hassan, (2012) also reported that groundnuts roasting reduces moisture content and develops a pleasant flavour which makes the products more acceptable for consumption.

Dry roasting represents the most significant form of processing in Nigeria. Among the problems in processing agricultural materials is that of roasting the seeds. Most oil seeds and nuts are roasted using heat to liquefy the oil in the crop cells and facilitate the release of oil during extraction that is you can roast peanut in the shell by spreading them on a shallow baking pan, one or two layers deep, and taking them into a 350^{o} oven for 26 to 30 minute, turning them occasionally. The amount of oil produced will be much if it is properly roasted (Ajao, *et al.*, 2009). Eke and Maigida, (1995) reported that 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. Roasting of groundnut operation in Nigeria is mostly traditionally done using different pots such as clay pots, aluminium pot, on open fire until they are

brown (Manta and Ajisegiri, 2007). This method is ineffective, time consuming and laborious. Olaniyan, (2010) also reported that roasting of groundnut and extraction of oil in Nigeria have been a serious issue in some rural parts of the country, where the roasting and the extraction of the oil are achieved by traditional method. Therefore, Manta and Ajisegiri, (2007) suggested the use of infrared heating in groundnut seed roasting operation to improve on the traditional techniques. Abdulsalam, (2013) developed a manually operated roasting machine that handled groundnut seed roasting operation more effectively than the traditional methods. Result revealed that the machine has the roasting efficiency of 66.2%. Lawan, (2015) modified the machine developed by Abdulsalam, (2013), in order to improve on its performance. Therefore, this paper presents a comparative performance evaluation of the two (existing and modified) roasting machines to ascertain the level of improvement achieved.

Materials and Methods / Methodology

Materials Used in the Study

The following instruments and equipment were used during the conduct of this study;

i. Weighing balance, ii. Stop watch, iii. Existing and modified groundnut roasting machines, iv. Charcoal, v. Tachometer vii. Moisture analyzer viii. Thermometer

Description of the Existing and the Modified Roasting Machines

Description of the existing machine

The machine has a handle as a driving mechanism, a drum roasting chamber of 0.066 m^3. The roaster is covered with circular trough at two ends which carry shafts onto this shaft are attached paddles for stirring the material being roasted and a handle for turning the shaft. The support consists of frame with covers on three sides. Apart from carrying the roasting chamber, it houses the heat source (charcoal burner) right below the roasting chamber for heating the drum**.** After accomplishing the roasting operation, an exit gate can be open which allows the roasted groundnut seeds out. Plate 1 shows the existing roasting machine.

Description of the modified roasting machine

The modified roasting machine consists of a roasting chamber on top of the roaster stove, and a stirring shaft with blades attached inside the chamber can be operated manually by the crank handle attached. After accomplishing the roasting operation, an exit gate can be open which allows the roasted groundnut seeds out. Plate 2 shows the modified roasting machine.

Performance Evaluation of Groundnut Seed Roasting Machines

Sample preparation

A total of 100 kg of groundnut seeds, 50 kg each for the two varieties (*Manipintar* and *Ex-Dakar*) was used for the comparative analysis. Thereafter, dirt, foreign materials and immature seeds were removed (Plates 3 and 4). Moisture analyzer was used to determine the moisture content and found to be 2.34% and 2.51% dry basis for *Manipintar* (*Mai Bargo*) and *Ex-Dakar*, respectively.

Experimental design and layout

The experiment was conducted using 2 X 2 X 3 factorial in a completely randomized design (CRD). Two (2) groundnut seed roasting machines: (Existing = M_1 and Modified = M_2). Two (2) varieties of groundnut seeds (V_1 = *Manipintar* and V_2 = *Ex-Dakar*) and three (3) different turning speeds (S_1 = 30 rpm, S_2 = 50 rpm and S_3 = 70 rpm) were used. These give a total of twelve (12) treatments. Each of these treatments was subjected to three (3) replications, thus making the number of experiments conducted to be thirty six (36). Draw lot method was adopted as reported by Gomez and Gomez, (1983) to achieve an unbiased sequence of conducting the experiments.

Experimental procedure

The evaluation of the machines was carried out in the Department of Agricultural and Environmental Engineering Workshop. The Charcoal was measured and filled into trapezoidal tray and it was ignited. A free turning speed of rotation test was first carried out on the machine to see how it functioned with empty Chamber. The turning speed of rotation was measured using the tachometer to be 30 rpm and ensured it was maintained. Afterwards the machine was tested again under full load, with 5.0 kg of groundnut seed poured into the chamber. The groundnut seed was rotated in the roaster chamber for 30 minutes roasting time and then discharged through the discharged outlet. The turning speed of rotation was adjusted to 50 and 70 rpm respectively. The same procedure was used. The roasting time was determined using stopwatch. The groundnut seed was weighed after roasting using weighing balance and the roasted groundnut was separated from unroasted, broking and over roasted groundnut and reweighed and recorded. The quantity of fuel used was determined by obtaining the difference in weight of charcoal before ignition and after the roasting.

Computation of Performance Parameters

The parameters used in evaluating the two roasting machines were:

Roasting Efficiency, (Er%)

$$E_r = \frac{W_r}{W_t} X\ 100 \qquad (1)$$ (Abdulrahman, 2011)

where:

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

Wt = Total weight of groundnut seed roasted (kg)

2.6.2 Percentage Seed Loss, (E_l%)

$$E_l = \frac{W_d}{W_t} X\ 100 \qquad (2)$$ (Abdulrahman, 2011)

where:

Wd = Weight of the over roasted groundnut (damage seed) (kg)

Wt = Total weight of groundnut seed roasted (kg)

Fuel Consumption Rate, (kg/hr)

$$F_{cr} = \frac{F_c}{T_e} \qquad (3)$$ (Abdulrahman, 2011)

where:

Fc = Fuel consumed during the roasting process (kg)

Te = Effective roasting time (hr)

Results and Discussion

Performance of the Existing and Modified Roasting Machines

Table 1 presents the mean values obtained for roasting efficiency, percentage seed loss and fuel consumption rate for each experimental treatment.

Results revealed that maximum roasting efficiency of 98.80% was achieved with the modified roasting machine, *Manipintar* variety and 30 rpm turning speed. Minimum percentage seed loss of 1.20% was also achieved with the modified roasting machine, *Ex-Dakar* variety and 50 rpm turning speed. More so, minimum fuel consumption rate of 1.20 kg/hr was achieved using the modified roasting machine, *Ex-Dakar* variety and 30 rpm turning speed.

Comparative Analysis of the Performance of Existing and Modified Roasting Machines

Roasting Efficiency

Table 2 presents the result of the performance evaluation parameters which were subjected to analysis of variance (ANOVA). The effects of differences in machine model used, variety of groundnut seeds used, turning speed and their interactions. The effects of using different machine models were found to be highly significant (significant at 1% probability level), while the effects of variety on roasting efficiency was not significant. The effects of the roasting turning speeds were found to be significant. The effects of the interactions were significant on the roasting efficiency except the interaction of machine model and variety of groundnut seeds used. These results obtained were further analyzed to find the least significant difference (LSD) (Table 3).

From the Table 3, it can be seen that the best roasting efficiency was achieved with the modified model of the roasting machine, *manipintar* variety and 50 rpm turning speed. This revealed that there was improvement on the roasting efficiency between the modified and existing models of the groundnut seed roasting machine. The result obtained is in agreement with that of Ajao, *et al.*, (2009), this was because their machine has a roasting unit with higher very of roasting efficiency.

Percentage of Groundnut Seed Loss

Table 2 presents the effects of differences in machine model used, variety of groundnut seeds used, turning speed and their interactions. The effects of using different machine models were found to be highly significant (significant at 1% probability level), while the effects of variety and the turning speed and all the interaction on roasting efficiency was not significant. This revealed that the modified model of the roasting machine minimizes the percentage of groundnut seed losses when compared to the existing machine. This findings is similar to one reported by Ola *et al.*, (2001) and Olaniyan (2010). Also in the paper they reported turning speed had no significant effect on the groundnut seed loss.

Fuel Consumption Rate

Table 2 presents the effects of differences in machine model used, variety of groundnut seeds used, turning speed and their interactions. All the main effects and their interactions were found to be highly significant (significant at 1%

probability level). These results obtained were further analyzed to find the least significant difference (LSD). Table 4 presents the least significant difference.

From the Table 4, the minimum fuel consumption rate is achieved with the modified model of the roasting machine. This has indicated improvement achieved on the modified machine. It has also been shown that as turning speed increases, fuel consumption rate also increases. But the best fuel consumption was achieved with 30 rpm turning speed. This agrees with the results of the work of Ola, *et al.*, (2001). Because they reported that turning speed directly effect on the fuel consumption of their machine.

Conclusion

The following conclusions were made:

The performances of the two (existing and modified) groundnut seeds roasting machines were evaluated in terms of; roasting efficiency, percentage seed loss, and fuel consumption rate. The results obtained from the comparative analysis carried out revealed that the best roasting efficiency (98.80%), least percentage of groundnut seeds loss (1.20%) and least fuel consumption rate (1.20 kg/hr) were achieved with the modified model of groundnut seed roasting machine. Therefore, the modifications carried out on the existing groundnut seeds roasting machine resulted in significant improvements in terms of roasting efficiency, percentage of groundnut seed loss and fuel consumption rate.

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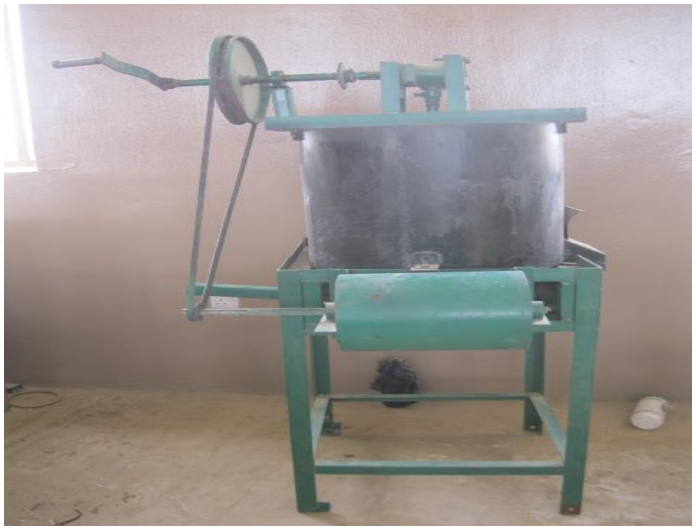

Plate 1 – An Existing Groundnut Seed Roasting Machine (Abdulsalam, 2013)

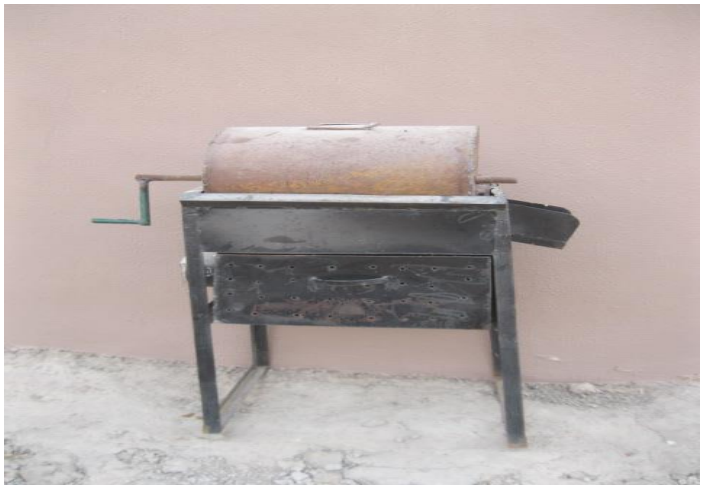

Plate 2 - A Modified Groundnut Seed Roasting Machine (Lawan, 2015)

Plate 3 - *Manipintar* (*Mai bargo*) Groundnut Seed Variety

Plate 4 - *Ex-Dakar* Groundnut Seed Variety

Table 1 - Mean Values of the Performance Parameters for each Experimental Treatment

S/N	Treatment	Er (%)	E_l (%)	Fcr (kg/hr)
1	$M_1V_1S_1$	91.20	10.60	1.96
2	$M_1V_1S_2$	92.00	12.40	1.86
3	$M_1V_1S_3$	95.60	12.40	1.86
4	$M_1V_2S_1$	91.60	11.20	1.90
5	$M_1V_2S_2$	93.60	12.40	1.84
6	$M_1V_2S_3$	94.64	12.80	1.84
7	$M_2V_1S_1$	98.80	2.45	1.20
8	$M_2V_1S_2$	96.40	1.40	1.82
9	$M_2V_1S_3$	95.60	12.40	1.86
10	$M_2V_2S_1$	97.80	2.45	1.40
11	$M_2V_2S_2$	97.80	1.20	1.75
12	$M_2V_2S_3$	97.40	4.40	1.86

Note: M = machine model, V = groundnut variety, S = turning speed

Table 2 - Analysis of Variance for Roasting efficiency, Percentage seed loss and Fuel consumption rate

Sources of variation	Degree of freedom	Pr>F		
		Roasting efficiency, Er (%)	Percentage seed loss, E_l (%)	Fuel Consumption rate, Fcr (kg/hr)
Replication	2	0.0910^{NS}	0.1107^{NS}	0.0125^{*}
Machine Model, M	1	$<.0001^{**}$	$<.0001^{**}$	$<.0001^{**}$
Variety, *V*	1	0.54336^{NS}	0.7023^{NS}	$<.0001^{**}$
Turning Speed, S	2	0.0474^{*}	0.3319^{NS}	$<.0001^{**}$
Interactions:				$<.0001^{**}$
M*V	1	0.6834^{NS}	0.2397^{NS}	$<.0001^{**}$
M*S	2	0.0046^{**}	0.4631^{NS}	$<.0001^{**}$
V*S	1	0.0384^{*}	0.1222^{NS}	$<.0002^{**}$
M*V*S	2	0.0011^{**}	0.4188^{NS}	$<.0001^{**}$

NS = Not significant, * = Significant at 5% probability level, and ** = Significant at 1% probability level, (Highly significant).

Table 3 - Least Significant Difference of Roasting Efficiency for Main Effects

Independent Variables	Mean Roasting Efficiency (%)	LSD
Existing machine	93.59	B
Modified machine	97.46	A
Manipintar variety	95.56	A
Ex-Dakar variety	95.48	B
30 rpm	95.18	B
50 rpm	96.03	A
70 rpm	95.35	B

Table 4 - Least Significant Difference of Fuel Consumption Rate for Main Effects

Independent Variables	Mean Fuel Consumption Rate (kg/hr)	LSD
Existing machine	1.88	A
Modified machine	1.61	B
Manipintar variety	1.67	B
Ex-Dakar variety	1.84	A
30 rpm	1.64	C
50 rpm	1.73	B
70 rpm	1.86	A