FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 6 No. 1, March, 2022, pp 93 - 101
DOI: https://doi.org/10.33003/fjs-2022-0601-847

DESIGN, CONSTRUCTION AND PERFORMANCE EVALUATION OF GROUNDNUT DECORTICATOR

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ABSTRACT

Appropriate and efficient technology is desired to obtain clean groundnut kernels for further processing such as edible oil extraction and for meeting international export standard. An existing groundnut decorticator was modified and a proto-type was constructed to decorticate groundnut in-shell with minimum kernel damage. The modified decorticator was tested with Samnut 14 groundnut variety at 20 mm concave clearance. The groundnuts in-shell was graded into three grades (grades I, II and III) while screen apertures of 8, 10 and 12 mm were used at 8, 10 and 20 % moisture levels using three replications in a complete randomized design. The components of the decorticator include the hopper, frame, decorticating drum, main shaft, blower, pulleys, belt, bearings and a 5 kW electric motor. Results obtained showed a high decorticating efficiency of 94.66% of clean kernels at 10% moisture content was obtained from grade III samples using 8 mm screen aperture. The least kernel bruises and splits of 2.08 and 1.37%, respectively were recorded at 8% moisture level and 12 mm aperture from grade II samples. These results reduced the high incidence of *aflatoxin* contamination on the decorticated kernels, thus increasing the kernel's value as well as making it less carcinogenic.

Keywords: Groundnut in-shell, Decorticator, Screen Aperture, Moisture Content, Kernel Quality

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is one of the world's principal oil-seed crops that is rich in protein and has a high energy value. Groundnut is also an important food crop in many areas of semi-arid tropics (FAO, 1994). It is cultivated for its kernels, oil and hay for livestock (Nigam *et. al.*, 1999). Improvements in groundnut productivity and processing for a qualitative output are also crucial because of its potential to regain and increase export earnings. Growth in agriculture has generally been linked to development in other sectors which invariably contributes to poverty alleviation (Khan, 1999). Like most developing countries, majority of the rural dwellers in Nigeria depends on agriculture. In order to reduce poverty, agricultural sector must be revitalized. This would increase rural employment, trade and purchasing power for smallholder farming families, strengthen the economic capacity of rural women and improve household nutrition. It thus plays a key role in the agriculture-dependent economies of West Africa where its marketing and trade served as the major sources of employment, income and foreign exchange (Rai *et al.,* 1993; Revoredo and Fletcher, 2002; Ntare *et al.*, 2008).

Production of groundnut in Nigeria started in 1912 (Ntare *et al.,* 2008). It has immensely contributed to the economic development of Nigeria being one of the most popular commercial crops. Nigeria was at one time the leading exporter of groundnut in the world. Until 1969, Nigeria was the third largest exporter of groundnut in the world after India and China. However, Nigeria lost out and is currently not listed among the major exporters due to production and marketing problems (NAERLS, 2016). That notwithstanding, groundnut sector provided the basis for the agro-industrial development and contributed significantly to the commercialization and integration of the national rural sectors (Ntare *et al.*, 2007). However, groundnuts exported into Europe during the years of bumper harvests in Nigeria and other Sub-Saharan African countries (SSA) was done majorly in-shell because of high incidence of aflatoxin contamination on decorticated kernels is carcinogenesis. *Aflatoxin* is associated with bruises and breakages of kernels. This reduced the net profit of both the farmer and produce agent. The cost of export also increases because of the space needed to ship the produce. Kernel quality as a method of measuring marketability is very essential in successful agricultural production as poor quality produce is characterized by gradual decline in value and vigour (Hartmann *et al.,* 1990). A good quality kernel has high economic value, better germination and free from disease and insect attack.

The greatest potential for providing clean decorticated kernels is by means of establishing and adapting suitable home-processing equipment in order to improve the kernels quality by reducing bruises and breakages to meet the standards of the importing countries and in turn serves as leverage for creating jobs for the teaming unemployed youth. Groundnuts exported from West Africa during bumper harvest were majorly done in-shell because it did not meet the standards of the importing countries. This could be largely due to low efficiency of processing equipment in terms of the quality of their output and the technology of using the equipment. Popular groundnut varieties that are characterized with soft and irregular pods and kernels present substantial problems in maintaining acceptable levels of kernel quality (Pinson *et al.*, 1991). It was observed that most of the equipment used in the processing of groundnut have been generally designed without taking into cognizant the physical properties of their pods and kernels (Olajide and Igbeka, 2003; Razari *et al*., 2007). Decorticated kernels from such equipment have bruises, cracks and breakages that reduce their qualities. Bruise downgrades and devalues kernels quality; thus reducing its economic value. Consequently, the problems of establishing specific decorticating parameters for a particular grade of groundnut with a view to minimizing kernel damage has not been overcome. The aim of this study was, therefore, to investigate the factors that that affects high quality kernel recovery for decorticating in-shell groundnut at different moisture contents and screen apertures.

MATERIAL AND METHODS

The groundnut decorticator used for this study was designed and constructed. Its features were a combination of the proven features of the NCAM and IAR decorticators. The modifications considered include: replacing the fixed net-like arranged iron rod bars sieve of the NCAM decorticator with a removable oblong-shape sieve slots; a decortication unit that consists of six decorticating bars made up of flat plates with tapered studs similar to IAR decorticator replacing the NCAM decorticator shaft that has spikes made of rod bars along its functional length; and an IAR trapezoidal frustum hopper type as against NCAM rectangular tray-like hopper. In the design and choice of materials for the decorticator, due considerations were given to ease of transportation, affordability for the farmer or processor to procure. Table 1 shows the summary of design specifications of the NCAM, IAR and the modified decorticators.

Description of the Modified Groundnut Decorticator

The constructed groundnut decorticator used for the study consists of the hopper, frame, decorticating drum, drum housing, main shaft, blower, pulleys, belt, bearings and a 5 kW electric motor (Figure 1). The detailed description of the modified parts of the decorticator is given below:

Table 1: Summary of the design specifications of NCAM, IAR and the modified decorticators

S/N	Component	Decorticator		
		IAR	NCAM	Modified
1	Sieve	Fixed net-like iron bars	Fixed oblong-shape sieve slots	Removable oblong-shape sieve slots
2	Decorticating drum	Flat plates with tapered studs	Spikes rods	Flat plates with tapered studs
3	Hopper	Trapezoidal frustum	Rectangular tray-like	Rectangular tray-like
4	Concave	Fixed	Fixed	Adjustable

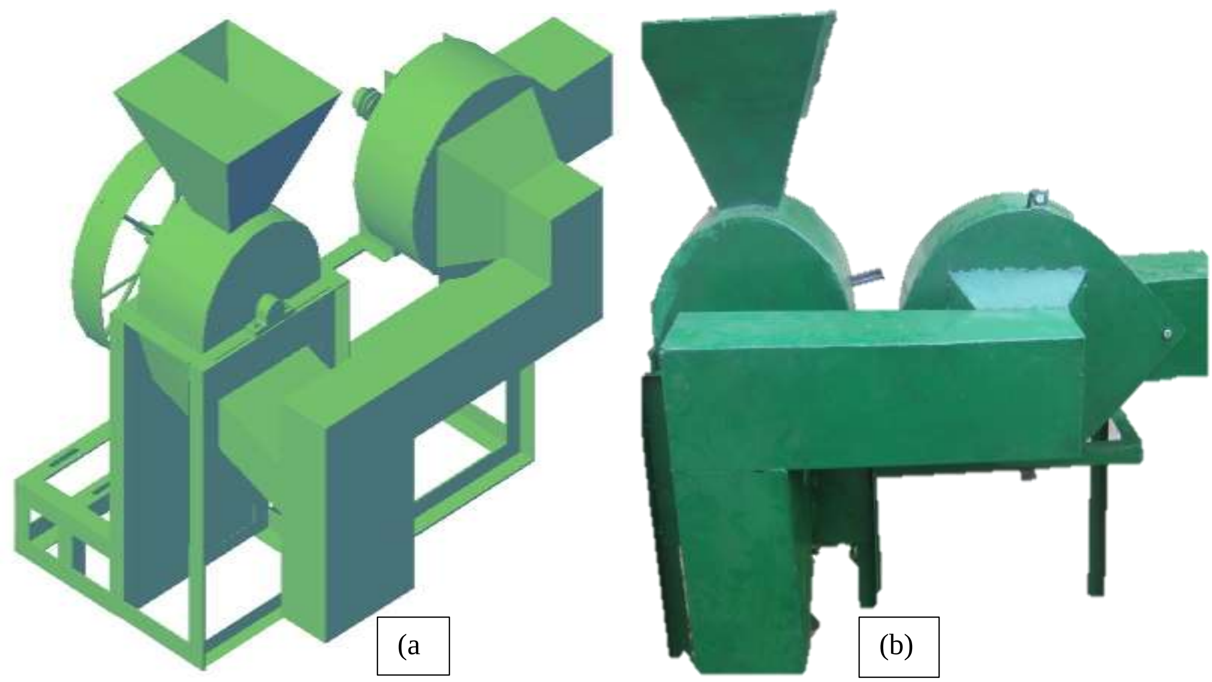


Figure 1: (a) Pictorial View and (b) Constructed modified groundnut decorticator

Frame - The frame of the decorticator was constructed from angle iron of 50 x 50 x 5 mm. It supports the entire arrangement of other components and also serves as the prime mover seat. It has a total length of 1.16 m and a maximum height of 850 mm. The decortication and blower chambers are joined to the frame by arc welding while the main shaft, blower shaft, decorticating drum cover and blower cover are bolted together for easy packaging and transportation.

Hopper - The feed hopper is that part of the decorticator through which groundnut in-shell are fed to the decorticator drum. A permissible vertical height of 380 mm was determined so that a man of average height can load the pods. The bottom width is 140 mm to allow easy down flow of pods into the drum. It is a trapezoidal frustum, with a square top of 410 mm having both ends opened as against the rectangular tray shape in the NCAM version that restricts free flow of pods. The upper part of the hopper was covered half-way by a sheet of metal to prevent splitting the pods due to impact force of the decorticating drum. The material for the hopper is galvanised steel plate. It is chosen because of its ability to be forged with ease and its greater strength gives it a desirable advantage. It also resists corrosion.

Decortication Drum Housing **-** The decortication drum has two main components: the upper part is a half drum made of galvanised metal sheet folded such that it serves as guide for the groundnut in-shell being processed and as a protective cover for operator; the lower part of the housing serve as collector of the shelled mix. It also houses the screen and decorticating shaft arrangement. It has a length of 400 mm and a diameter of 410 mm.

Decortication Drum **-** The decortication drum rotates and thus does the decortication process by rubbing action (Plate 1). It is referred to as the decortication unit. It is cylindrical in shape and has a diameter of 370 mm. The decortication unit consist of 6 flat shelling bars fitted at equal distance with tapered pegs of 10 mm length and 13 mm diameter spirally arranged with which it rubs the materials against the screen while it rotates. The bars are made from cast iron in order to minimise contamination due to corrosion. Each bar is 210 mm long and 50 mm wide with 16 pegs on 2 rows. The drum is mounted on the main shaft via two 25 mm diameter support bearings. This was in contrast with the NCAM design that was equipped with spikes rod and bars along the functional length of the shaft with which it rubs the material against the screen.

Screen **-** The screen was a slot/capsule-like perforated metal with apertures allowing only the shelled mix material to pass through as recommended by Singh (1993) and Sudjad *et al.* (2005). It was fastened to the housing with bolt and nuts instead. The oblong-shaped screen aperture has a diameter range between 8 – 12 mm. For this design, the concave clearance determined was 20 mm based on the impressive results of some pre-decortication tests and the physical sizes of the groundnut pods measured. The detailed engineering of the modified decorticator is shown in Appendix I.

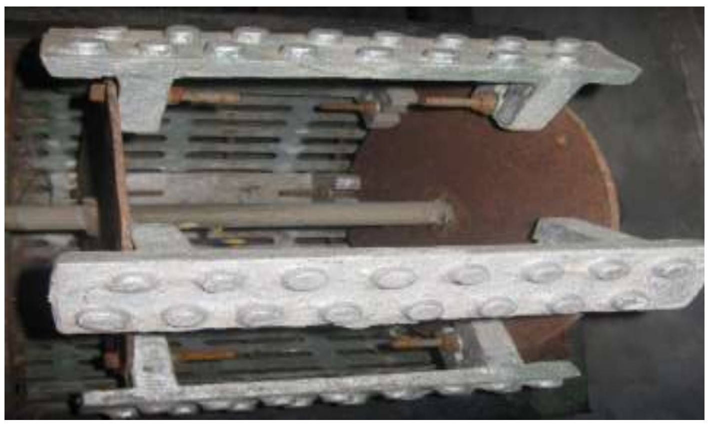


Plate 1: Screen and decortication drum of the modified decorticator

Experimental Methodology

The groundnut in-shell was graded into three different grades according to its geometric size with the aid of a developed grader. Each grade from the three varieties was then subjected to three moisture regimes (8, 10 and 20 %) and was decorticated with all the three screens (8, 10 and 12 mm) constructed. The initial decorticating trials for each variety were conducted with ungraded samples of all the grades at the chosen moisture content regimes to serve as control. All decortications were replicated three times in order to minimize error. The measured parameters studied were clean, bruised and split kernels and the process conditions (factors of interest) employed are grading, moisture content and screen apertures. These factors were varied at various levels and their effects on the quality of the clean kernels were studied and measured. For the grading system, the levels considered were; grade I, grade II and grade III. Moisture content was varied at 8, 10 and 20 % while screen apertures were also varied at 8, 10 and 12 mm. The study was aimed at improving the quality of kernels that would be produced from the modified groundnut decorticator.

Samples of the selected groundnut in-shell were decorticated with the developed decorticator. Analyses of the results were determined by weight of the decorticated samples. These values were converted into output percentages for ease of comparison in order to draw conclusions. Samples of the output were separated by hand into 4 categories: clean (undamaged) kernels, bruised kernels, split/broken kernels and un-decorticated pods.

Performance Tests of the Groundnut Decorticator

Tests were conducted to evaluate the performance of the groundnut decorticator following the procedure outlined by Oluwole *et al*. (2004). To avoid bias and allow fairness to all the trials such that results obtained should not be by chance, the quantity of in-shell per decortications trial was pegged at 1000 g. This was fed into the hopper by hand. The prime mover was put on to supply power and set the working components of the decorticator in motion. Pods were discharged into the decorticator and decorticated until the hopper was emptied. Preliminary tests showed that good results could be obtained with the concave clearance of 20 mm. Therefore, this clearance was maintained throughout the performance tests. The chosen clearance was in agreement with Omran *et al.* (2005) Oluwole *et al*. (2004) and Khan (1990) who found that clearance levels when optimizing the operating parameters for a model machine to thresh groundnut maintaining the concave clearance between 20 – 30 mm. Three screen apertures used have diameters of 8, 10 and 12 mm. These were determined based on the physical sizes of the groundnut variety used.

Samples of groundnuts in-shell were decorticated. The variety used was Samnut 10. Decortication tests were conducted at the initial moisture content of 8 %, 10 and 20 % (wb). At a combination of each of the above conditions, the test was replicated three times. Assumption was made that three replications would give sufficient mean data for analyses. Analyses by weight of clean kernels, bruised kernels, split/broken kernels, un-decorticated pods and shells were done for each decorticated sample at the end of each run.

RESULTS AND DISCUSSION

Plate 2 shows the products of the decortication of the three grades of the groundnut in-shell using 8, 10 and 12 mm screen apertures and 8, 10 and 20 % moisture levels, respectively; being samples of the output separated manually into 4 categories of clean kernels, bruised kernels, split/broken kernels and un-decorticated pods.

Plate 2: Classification of the product of groundnut decortication

Performance Evaluation of the Modified Groundnut Decorticator

The results of the decortication obtained revealed that Samnut 14 had the highest percentages of clean kernels of 94.66 % at 10 % moisture content and 8 mm screen aperture for grade III (Figure 2). When moisture level was raised to 10 and 20 % to increase the swelling ability and smallest aperture of 8 mm was used, it was observed that the recovery of clean kernels decreases. This performance could possibly be attributed the differences in physical properties of individual groundnut varieties such as irregularity of kernels shapes, thickness of the shell and uniformity and strength of kernels as observed by Pinson *et al.* (1991). This observation was also reported by Baughman (2007); Franz *et al.*, (2000); Sharma *et al*. (1995) who discovered that wetting of agricultural produce was associated with increase in volume that could result in high bruises when decorticating at higher moisture content, thus reducing the rate of clean kernel recovery. However, recovery of clean kernels increase with increase in screen aperture for grades II and III samples at 20% moisture level.

This trend could be attributed to the fact that the pod sizes of this grade are smaller, the rate of undecorated pods increased as the screen aperture increase. The rate of kernel damage was, however, observed to increase with increase in moisture level for grade III. It was similarly observed that the percentages of clean kernels recorded while decorticating grade III samples could be adjudged good because they lies within the acceptable range of 50 – 80 % recommended by Jambunathan, (1991) even as the variety and moisture levels he used were not ascertained. The variation in moisture contents and screen apertures where the highest percentages of 94.66 % clean kernels were recorded could be attributed to the variation in kernel diameters of the groundnut variety studied. The DMRT on Table 2 also shows that screen aperture had significant effects on the rate of kernel's bruise for grade and III samples.

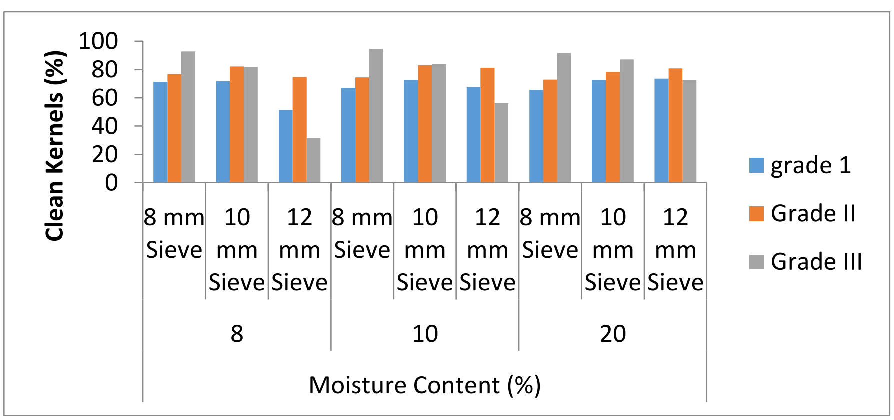


Figure 2: Mean percentage of clean Kernels at 8, 10 and 20 % Moisture content

Table 2: Duncan Multiple Range Test on the effects of screen aperture on bruised kernels for ungraded, grades I and II groundnut in-shell at the three moisture content regimes

Grade	Screen Aperture (mm)	N	Subset		
			1	2	3
Ungraded	12	27	14.5137		
	10	27		16.6237	
	8	27			24.1293
	Sig.		1.000	1.000	1.000
I	12	18	12.9983		
	10	18		17.9867	
	8	18			21.8678
	Sig.		1.000	1.000	1.000
II	12	27	11.6930		
	10	27		16.0211	
	8	27			17.5356
	Sig.		1.000	1.000	1.000

It was also observed that Samnut 14 that had the least mean pod diameter (Table 3) could perform better at smaller screen apertures while larger percentages would pass un-decorticated if larger screen were used, hence, the need to raise its moisture level. This finding was also in agreement with previous observations (Camargo *et al*., 1989; ICRISAT, 1994; Sharma *et al*., 1995; Ezzatollah *et al*., 2009; DAFF, 2010; Ndjeunga *et al.,* 2010) that while smaller pods sizes tends to pass through the screens, un-decorticated pods that are relatively bigger in sizes would be crushed and/or bruised when the sieve size is smaller.

Table 3: Means and standard deviations of lengths and widths of Samnut 14 and two common varieties of groundnut in-shell

Groundnut Variety	Parameter	Pod		Kernel	
		Mean	**Standard Deviation**	**Mean**	**Standard Deviation**
Samnut 10	Length	33.22	5.97	14.52	1.24
	Width	14.34	1.45	8.96	0.83
Samnut 14	Length	25.89	2.00	11.40	1.03
	Width	13.44	0.78	7.90	0.53
Samnut 18	Length	30.01	1.97	14.63	2.10
	Width	15.11	0.82	8.87	1.10

For bruised kernel, the results shows that more kernels are bruised at higher levels of moisture levels. Kernels decorticated from grade I at 20 % moisture level had the highest bruised kernel of 17.44 % (Figure 3). The results further shows slight increase in splitting of the kernels when moisture content increases thus reducing its quality and packaging/marketability (Figure 4); but progressively decrease with increase in aperture size in of the most samples decorticated. Similar trends were noticed with respect to kernel bruise (Figure 3) as reported by Saiedirad *et al.* (2008). This was because as the groundnut in-shell diameter become progressively larger than the screen apertures, the greater the possibility of obtaining a relatively higher percentage of bruised and split kernels This conclusion is consistent with the findings of Konak *et al*. (2002) who reported higher cracks and bruises in chick pea seeds when moisture content increases. It was also found that kernels became more sensitive to cracking at higher moisture content causing the rate of bruising and splitting to increase. Altuntaş and Yildiz (2007) conducted a similar study on the effects of the moisture content on some physical and mechanical properties of grains (*Vicia faba* L.) and reported that as the moisture content increase grains cracking increases. Hoki and Tomita (1987) and Liu *et al*. (2009) reported a decrease in rate of seed breakages for soybean with decrease in the moisture content, which is true for the present work too. Therefore, to minimize bruised and split kernels, lower moisture level of 8 – 10 % will be appropriate.

The results on the effects of grading, moisture content and screen aperture on the clean, bruised and split kernels using Samnut 14 as presented in Table 4 was significant at 5 % level. This implies that the process parameters employed significantly affect the efficiency of clean, bruise and split kernels at 5 % level. It can, therefore, be concluded from the foregoing that the efficiency of either of the measured parameters along the levels of process parameters differ significantly from one level to another.

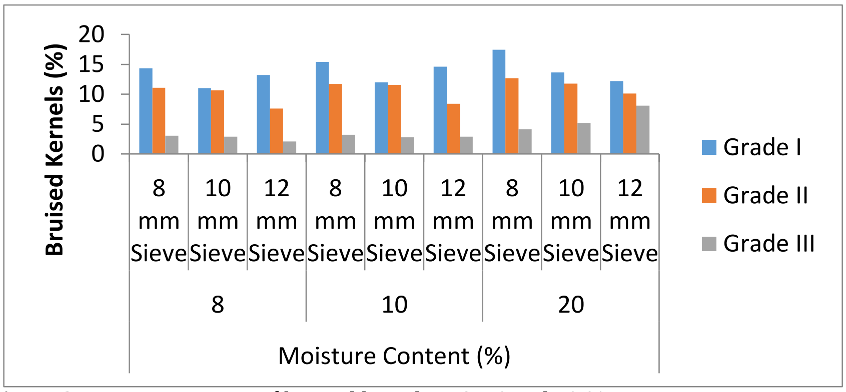


Figure 3: Mean percentage of bruised kernels at 8, 10 and 20 % Moisture content

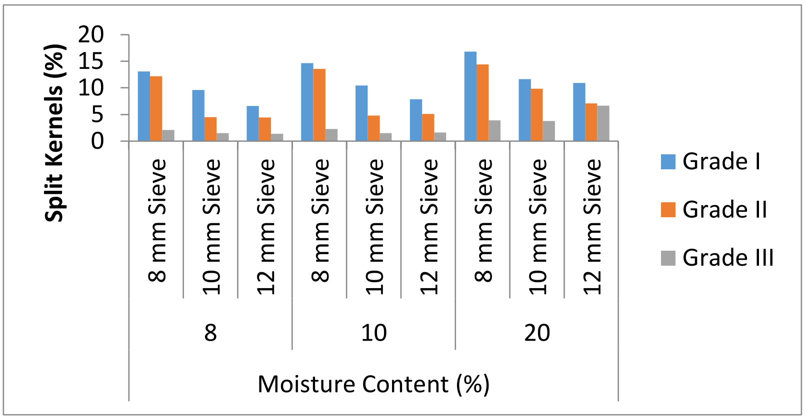


Figure 4: Mean percentage of split kernels at 8, 10 and 20 % Moisture Content

Table 4: Effect of Grading, Moisture Content and Screen Aperture on Clean, Bruised and Split Kernel using Samnut 14

Source	Dependent Variable	Sum of Squares	df	Mean Square	F	Sig.
M	Clean Kernel	668.706	2	334.353	660.147	0.001*
	Bruised Kernel	64.155	2	32.077	125.394	0.001*
	Split Kernel	158.978	2	79.489	265.286	0.001*
G	Clean Kernel	1485.523	2	742.761	1466.509	0.001*
	Bruised Kernel	1402.964	2	701.482	2742.174	0.001*
	Split Kernel	1032.098	2	516.049	1722.262	0.001*
S	Clean Kernel	3266.062	2	1633.031	3224.258	0.001*
	Bruised Kernel	38.147	2	19.074	74.561	0.001*
	Split Kernel	328.431	2	164.215	548.052	0.001*
M * G	Clean Kernel	560.773	4	140.193	276.798	0.001*
	Bruised Kernel	15.434	4	3.858	15.083	0.001*
	Split Kernel	2.715	4	0.679	2.265	0.074#
M * S	Clean Kernel	1889.219	4	472.305	932.519	0.001*
	Bruised Kernel	0.937	4	0.234	0.916	0.4610
	Split Kernel	10.601	4	2.650	8.845	0.001*
G * S	Clean Kernel	4812.109	4	1203.027	2375.258	0.001*
	Bruised Kernel	75.871	4	18.968	74.148	0.001*
	Split Kernel	201.585	4	50.396	168.192	0.001*

M * G * S	Clean Kernel	449.688	8	56.211	110.983	0.001*
	Bruised Kernel	46.262	8	5.783	22.605	0.001*
	Split Kernel	26.059	8	3.257	10.871	0.001*
Error	Clean Kernel	27.350	54	0.506		
	Bruised Kernel	13.814	54	0.256		
	Split Kernel	16.180	54	0.300		
Total	Clean Kernel	13159.430	80			
	Bruised Kernel	1657.584	80			
	Split Kernel	1776.647	80			

M=Moisture Content, G=Grading, S=Screen Aperture, *significant at $p \leq 0.05$, #significant at $p \leq 0.10$

CONCLUSION

A groundnut decorticator has been modified for higher efficiency. The results of the decortication from Samnut 14 variety tested showed that 94.66 % clean kernels was obtained at 8% moisture content and 8 mm screen aperture. Decortication of groundnut with due emphasis of process conditions (grade, moisture content and screen aperture) was seen to have improved the qualitative value of its output (increase kernel quality and reduce bruised and split kernels). It is crucial because of its potential to regain and increase export earnings. Such improvements also guarantee sustainability of its production in Nigeria and many producing countries where it plays a key role in their agriculture-dependent economies. This will impact on rural employment, trade and purchasing power for smallholder farming families, strengthen the economic capacity of women and improve household nutrition. It will also increase the net income and foreign exchange of such countries.

REFERENCES

Altuntaş E., Yildiz M. (2007): Effect of moisture content on some physical and mechanical properties of faba bean (*Vicia faba* L.) grains. *Journal of Food Engineering*, 78: 174–183.

Baughman, T. (2007). Texas Peanut Production Guide. Texas Agri-Life Extension Pub. B 1514. College Station, Texas A. & University.

Camargo, C.P., Bragantini, C. and Monares, P. (1989). Seed Production Systems for small farmers; a non-commercial perspective. CIAT, Cali, Columbia.

DAFF (Department of Agriculture, Forestry and Fisheries), (2010); Plant Production Private Bag X250 PRETORIA 0001. DPP@daff.gov.za 12th September, 2012.

Echekwu, C.A and Emeka, I. (2005). Groundnut, endowing, the groundnut/rediscovery programme in Nigeria. Opah mission Abuja p 18

Ezzatollah, A. A., Yousef A. and Saeid A. (2009); Study of Performance Parameters of Threshing Unit in a Single Plant Thresher, *American Journal of Agricultural and Biological Sciences* 4 (2): 92-96.

FAO (1994). General conclusions and recommendations of expert consultation on fats and oils In Human nutrition. F.A.O: Rome

FAOSTAT (2010). Agricultural Statistics Database, 2010, (www.fao.org). Accessed 17th October, 2012

Franz, A., Jorn B., Udo, C., Petra, H., Joachim, M., and Christine S. (2000): Organic Farming in the Tropics and Subtropics: Exemplary Description of 20 Crops – Peanuts; Naturland e.V., Kleinhaderner Weg 1, 82166 Grafelfing Germany. P 22 – 24.

Hartmann, H. T., Kester, D. E and Davies, F. T. (1990). Plant propagation principles and practices. 5th Edn. Publisher-Prentice Hall international Inc. pp. 55-73.

Hoki M., Tomita K. (1987): Moisture effects on mechanical strength of soybeans. Bulletin of The Faculty of Agriculture, Mie University, Tsu, 51: 103–110.

ICRISAT (1994): Sustainable Groundnut Production in Southern and Eastern Africa. Proceedings of a Workshop 5-7 Jul. 1994, Mbabane, Swaziland.

Jambunathan, R. (1991). Groundnut quality characteristics. Uses of tropical grain legumes. Proceedings of a consultants meeting 27-30 Mar 1989, ICRISAT Centre, India.

Khan, A. U. (1990). Dual–model all crop threshers. *Agricultural Mechanization in Asia, Africa and Latin America*. 21(4): PP: [11-14].

Konak M., Carman K., Aydin C. (2002): Physical properties of chick pea seeds. *Biosystem Engineering*, 82: 73–78.

Liu, X.Y.; Cai, P.D.; Bai, W.D.; Qian, M. (2009). Peanut Processing Status and its Research Progress. Academic Periodic of Farm Products Processing (175) 115-118.

Ndjeunga, J., A. Ibro, B.R. Ntare Y Cisse and M.. Zarafi, A (2010). Groundnut trends and market prospects in West and Central Africa. ICRISAT Unpublished Report.

Ntare, B. R, Ndjeunga J, Waliyar F, Kodio O, Echekwu C. A, Kapran I, Da Sylva A, DialloA. T, Amadou, A., Bissala, H. Y and Sako, K. (2007). Farmer Participatory Evaluation and Dissemination of Improved Groundnut Varieties in West Africa. International Crops Research Institute for the Semi-Arid Tropics. P 36.

Ntare, B.R, Diallo, AT, Ndjeunga, J. and Waliyar, F. (2008). Groundnut Seed production Manual. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). p 1 – 20

Oluwole, F, Aviara, N. and Haque, M. (2007). Effect of Moisture Content and Impact Energy on the Crackability of Sheanut. Agricultural Engineering International: *the CIGR journal*. Manuscript FP 07 002 Vol. IX.

Omran, M. A, Omer M. E. E and Hassan I. M. (2005). Modification and Performance Evaluation of Multicrop Thresher: *Journal of Science Technology*, Volume 6 (2) 1-18

Pinson, G.S., Melville, D.J. and Cox, D.R.S. (1991) Decortication of tropical oilseeds and edible nuts (*National Resource Institute of University of Greenwich Bulletin No. 42*). [Working Paper] p 24 – 27. http://gala.gre.ac.uk/11073

Rai, M; Barghouti, S. E. Cromwell. A.J., Pritch, , R.D (1993). Market-led oilseeds Development in South Asia - an Indian experience. World-Bank-Technical-Paper. 1993, No. (204) 121 - 134. Washington, DC; USA

Revoredo, C. L. and Fletcher, S. M. (2002); "World Peanut Market: An Overview of the Past 30 Years" University of Georgia Research Bulletin, Number 437, May 2002.

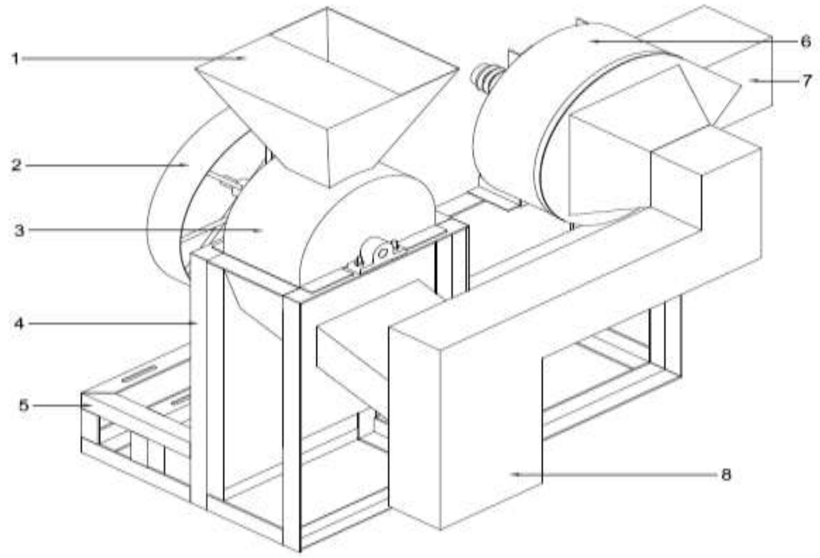
Sharma, S.B., Mehan, V.K, Ramraj, V.M. and Reddy, D.D.R. (1995). Preliminary investigation of a `Peg Drying` problem of groundnut, *International Arachis Newsletter*, 15, p 45-46.

Saiedirad M.H., Tabatabaeefar A., Borghei A., Mirsalehi M., Badii F., Ghasemi Varnamkhasti M. (2008): Effects of moisture content, seed size, loading rate and seed orientation on force and energy required for fracturing cumin seed (*Cuminum cyminum* Linn.) under quasi-static loading. *Journal of Food Engineering*, 86: 565–572.

Singh, G. (1993). Development of a unique groundnut decorticator. *Agricultural Mechanization in Asia , Africa and Latin America*, 24(1): 55-64.

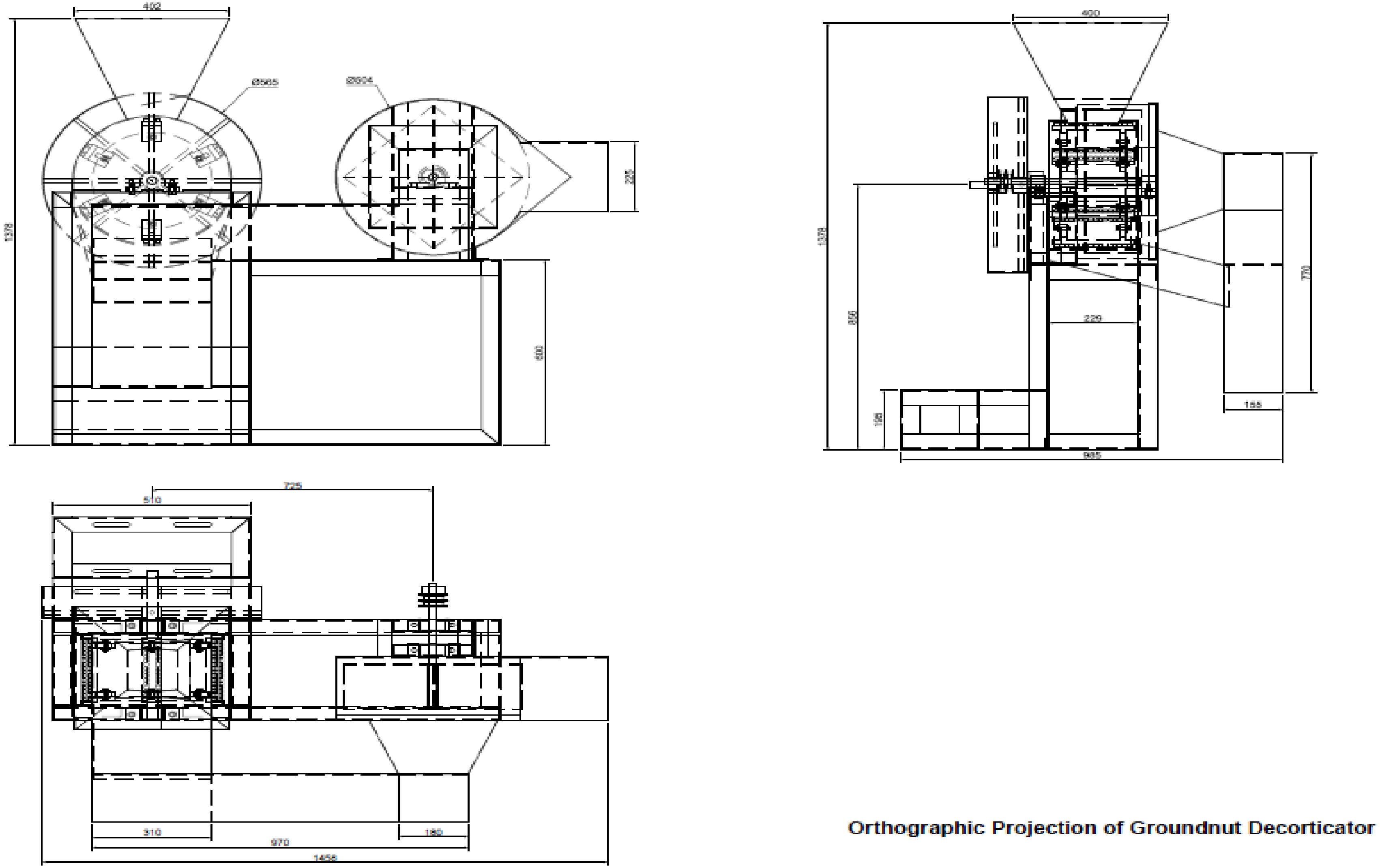
Somposh S., Somnuk C. and Vilas M. S. (2005). Effect of Concave Hole Size, Concave Clearance and Drum Speed on Rasp-Bar Drum Performance for Threshing Sunflower. *gricultural Mechanization in Asia, Africa and Latin America*, Vol.36, No.1, pp 52 – 60.

APPENDIX 1
Isometric view of the Modified Groundnut Decorticator



Isometric View of Groundnut Decorticator

Key:
1 - Hopper
2 - Pulley
3 - Decorticator Chamber
4 - Frame
5 - prime-mover Seat
6 - Suction Fan Housing
7 - Shell Outlet
8 - Kernel Outlet



Orthographic projection of the Modified Groundnut Decorticator