NASENI RESEARCH COMMERCIALIZATION GRANT REQUEST

RESEARCH PROJECT TITLE:	Development of Semi-Automated Cashew Nut Sheller and Separator for Improved Production of Commercializeable Cashew kernels
SUMMITTED TO:	National Agency for Science and Engineering Infrastructure (NASENI)
NASENI THEMATIC FOCUS AREA:	Agriculture and Food Manufacturing
IMPLEMENTING INSTITUTION:	National Centre for Agricultural mechanization, Ilorin
PRINCIPAL RESEARCHER:	Engr. Dr. Ozumba, Isaac C.
PROJECT DURATION:	Two (2) Years

EXECUTIVE SUMMARY

The traditional methods used for shelling cashew nuts in Nigeria are labour-intensive, time consuming and hazardous. On the other hand, most of our home-grown mechanical cashew nut shellers do not give satisfactory results in terms of whole kernel recovery percentage which is a critical quality criterion for its acceptability in the international market. There is paucity of appropriate and efficient cashew nut shelling machines in Nigeria since the imported cashew nut shelling machines are not affordable. This challenge has led to low processing, exportation of cashew kernels and lesser foreign earnings from the nation's massive production of raw cashew nuts. Hence, this study seeks to develop an appropriate and efficient cashew nut shelling machine in Nigeria using local and affordable materials to sustainably avert the challenges. The study will cover machine performance evaluation at varying operating conditions and the outcome will be disseminated to promote its adoption by the end users.

1. INTRODUCTION

1.1 Background to the Research

Cashew (*Anacardium occidentale* L.) is a tropical nut tree crop which is a good source of food, income, industrial raw materials and foreign exchange for many countries of Africa, Asia and Latin America. It is held in high esteem in many customs and cultures (Panchbhai *et al.*, 2024). Cultivation and processing activities in cashew provides employment and income generation for women and smallholder farmers in Nigeria (Akinwale, 2000; Topper *et al.,* 2001).

In Nigeria, commercial cultivation of cashew is now more than 60 years and the current cashew trading and exports worth 24 billion naira ($160 million) with over one million people employed in the industry. Products derived from the nuts of the crop include the world's highly delighted

Kernel Nut (KN), Kernel Oil (KO), Cashew Nut Shell Liquid (CNSL), and from the apple of the crop: juice, jam and alcohol among others are derived (Adeigbe *et al.,* 2015; Adeniyi *et al.,* 2025).

Cashew kernel is first among the world's nut snacks because of its nutritional advantages: it has high amount of protein, soluble sugar and rich in polyunsaturated fatty acid that lowers blood cholesterol (Adeigbe *et al.,* 2016). Cashew kernel is widely consumed as roasted, fried, salted or sugared snacks, as material for confectionery, bakery products and as a food ingredient (Alamnie, 2022). It is globally consumed for its desirable nutritional and sensory attributes, being a good source of proteins (20%), carbohydrates (23%), and fats (45%) (Das *et al.,* 2014). Studies have revealed that cashew consumption is linked to lower blood cholesterol levels, cancer and gallstone prevention, improved brain function, and a reduced risk of cardiovascular diseases (Das *et al*., 2025; Gonçalves *et al.,* 2023).

Nigeria is the 6th largest producer of raw cashew nut globally (United Nations Conference on Trade and Development, 2021) but spends huge amount of money annually to ship and process cashew nut abroad. Research and development of low cost and efficient cashew nut processing machines will trigger and promote local and efficient processing, and improve foreign earnings from cashew nut value chain. (Kilanko *et al.,* 2019).

1.2 Statement of the Research Problem

Nigeria is the third largest producer of cashew nut in Africa and the sixth in the world with a production level of 240,000 tonnes annually and yield ranging from 300 – 800 kg/ha (NEPC, 2023) yet, the nation's cashew nut processing industry faces significant challenges in terms of lack of appropriate and efficient shelling machines: low shelling efficiency and whole kernel recovery percentage, high labor costs, and poor kernel quality. The neglect of the cashew industry in favour of crude oil has left Nigeria behind the pack in competing for a global cashew market that worth $1 billion (Chemonics International Inc., 2002).

There is an increasing demand amidst scarcity of quality cashew kernels in Nigeria due to its health benefits for local consumption and export; but there is lack of efficient-modern cashew nut shellers in the nation thus cashew nuts are predominantly processed manually in Nigeria. The practice of processing the nut manually is most challenging since it is labour intensive and hazardous. Consequently, it is noteworthy to remark here that the Nigerian cashew nuts sell at a discount in the world market in the region of 20 to 30% (Oroch, 2005; Topper, 2008).

Several attempts to mechanize cashew nut processing in Nigeria have recorded little success in terms of low whole kernel recovery which is a major problem for the industry (Ogunsina and Bamgboye, 2014) as well as the output capacity. Evidently, Nigeria's local cashew nut processing in 2018 was just 3% (Ricau, 2019). Hence, the need for adequate funding, research and development of appropriate and efficient motorized cashew nut sheller with capacity to simultaneously grade the nuts, shell, scoop the kernels and separate the kernels from the shells cannot be overemphasized.

1.3 Objective of the Research

The main objective of this research is to design, fabricate and carryout the performance evaluation of a semi-automated cashew nut shelling and separation machine as well as popularize the machine to create awareness and drive its commercialization. Research personnels and materials for the research will be sourced locally. See the engineering drawing of the machine in Annex I.

Specific objectives of the research include:

i. To design, develop and evaluate cashew nut shelling machine.
ii. To design, develop and evaluate shelled cashew nut separation machine.
iii. To synchronize the developed shelling and separating units into a semi-automated machine.
iv. To optimize and model all the machines developed to obtain optimal efficiencies.
v. To disseminate the outcome of this study through publications in reputable academic journals, and exhibit at trade and innovation fairs and other avenues for public awareness creation to promote its adoption by processors/ investors.

1.4 Justification of the Research

The outcome of this research in line with some UN SDG goals would:

i. Arrest the drudgery and health hazards associated with traditional methods of shelling cashew nuts,
ii. Create descent jobs for youths to curb youths associated vices and improve their economic wellbeing,
iii. Improve cashew kernel quality by increasing whole kernel recovery percentage to enhance it acceptability in International market,
iv. Provide low-cost, appropriate and affordable shelling machine with separator for adoption in Nigeria,
v. Increase raw cashew nut processing and cashew kernel exports, and
vi. Improve income share of farmers and the nation's foreign earnings from cashew nut value chain for economic development.

2. LITERATURE REVIEW

Nigeria's local cashew nut processing percentage is low and just about 3% (Ricau, 2019). This low output could be attributed to the use of traditional cashew nut processing methods, lack of appropriate indigenously developed technologies and unaffordability of imported technologies in Nigeria. This is also a challenge in other Sub-Saharan African nations. Thus, so much is lost by African farmers through the exportation of cashew nut in raw form. For example, in 2018 the export price of cashew kernels from India to the European Union was about 3.5 times higher than what was paid to cashew farmers in Cote d'Ivoire – a 250% difference in price (UNCTAD, 2021).

Indigenous attempts by researchers such as Ajav (1996), Ojolo and Ogunsina (2007), Kilanko *et al.* (2018) and Ropo *et al.* (2022) to avert this challenge was encouraging, but limited in the aspect of whole cashew kernel recovery and output; hence, the essence of this research.

3. MATERIALS AND METHODS

The research site will be located at the National Centre for Agricultural Mechanization Ilorin on Latitude 8.5°N and Longitude 4.55°E. Materials for fabrication of the machine will be locally sourced from material shops in Ilorin, Nigeria. The selection and procurement of the following materials for fabrication of the machines will be based on their strength, suitability, accessibility and cost effectiveness. Stainless steel electrodes, sheets, rods, fasteners and flat bars shall be procured for the fabrication of food contact components while mild steel electrodes, angle bar, and metal sheets will be used for non-food contact components of the machines. Other materials such as prime mover, v-belt and pulleys will also be purchased.

Equipment, tools, and machines at the workshops and laboratories of the National Centre for Agricultural Mechanization Ilorin will be used for the fabrication activities and laboratory investigations. Equipment such as lathe, milling, drilling, angle grinder, welding, bending, rolling, and gluten machines will be used in the research during fabrication. Equipment such as Universal Testing Machine (TESTOMETRIC-AX model), laboratory oven, angle of repose instrument, digital vernier caliper, digital weighing machine, tachometer, moisture analyser, digital stop watch and plastic bowls will be used during laboratory investigation and, or in machine evaluation process.

2.1 Design of Machine Parts

Each component of the machine will be designed based on the values of relevant physical and mechanical properties obtained in the study. All the shafts will be designed by using ASME Code equation for solid shaft design (Hall *et al.*, 1961), and the power requirement will be determined by the method reported in Ogundipe *et al* (2011), Hibbeler (2011) and Shittu and Ndrika (2012).

2.2 Machine Description

The machine will consist of control panel, hopper, nuts grader, feeding mechanism, cutting blades profiled along the geometry of cashew nut in the shelling mechanisms, plunger-shear mechanism (for scooping), speed reduction gear, belt conveyor, screen separator and 3 electric motors to prime the system. The engineering drawing of the conceptualized machine is presented in Annex I. The working principle of the machine will be impact-shear force principle (Jain and Kumar, 1997; Denin *et al.*, 2020). The machine will have the capacity to simultaneously grade the cashew nuts fed through the hopper into three (3) size categories before moving each category to the cutting mechanism. The mechanism will have an appropriate clearance and knife cutting depth for each category. The plunger on sprocket-chain arrangement will force the nut through a shearing device to crack and scoop the kernels out of the shells for onward separation using two (2) sets of screens.

2.3 Machine Evaluation

During performance evaluation of the machine, moisture level of samples will be adjusted by using the method reported in Solomon and Zewdu (2008) while thermal treatment of samples will be done by adopting the steaming method reported in Ogunsina and Bamigboye (2014). The performance evaluation of the developed machines will be carried out to obtain its shelling efficiency, separation efficiency, percentage whole kernel recovery, machine capacity using Equations 1 – 4 (Chougule and Gunale, 2021) for extension and adoption purposes.

$$\text{Shelling Efficiency} = \frac{Weight\ of\ cashew\ nuts\ shelled}{total\ weight\ of\ cashew\ nuts\ fed} \times 100 \qquad (1)$$

$$\text{Separation Efficiency} = \frac{Weight\ of\ cleaned\ kernels}{Total\ weight\ of\ kernels\ collected} \times 100 \qquad (2)$$

$$\text{Percentage Whole Kernel Recovery} = \frac{Weight\ of\ whole\ kernels\ obtained}{Total\ weight\ of\ kernels\ obtained} \times 100 \qquad (3)$$

$$\text{Machine Capacity} = \frac{Weight\ of\ kernels\ obtained}{Time} \qquad (4)$$

4. RESEARCH GANTT CHART

The research is scheduled to be completed in twenty-four (24) months as presented in the Gantt chart in Table 1.

5. INNOVATION NOVELTY

The novelty of this research will be the development of an efficient machine for simultaneously grading cashew nuts, shelling cashew nuts and separating the shells from the kernels through a new approach: cashew nuts size grading before shelling, use of appropriate calibrated nut cutting knives, selection of cutting depth for each size category, use of appropriate nut cracker and scooper, and separation of kernels from shells.

6. ESTIMATED RESEARCH BUDGET

The estimated budget for the implementation of the research work is **₦41,501,500** (Forty-One Million, Five Hundred and One Thousand, Five Hundred Naira) only. The details are presented in Annex II for ease of reference.

Table 1: Research work implementation Gantt chart

Activities	Duration in Years and Months																							
	First Year												Second Year											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Literature search and review																								
Determination of engineering properties of raw and pre-treated nuts																								
Designing, drawing and simulation of the machine																								
Procurement of fabrication materials																								
Fabrication of the machine																								
Testing of the machine and adjustment																								
Data analysis																								
Writing and publication of outcome																								
Dissemination of research outcome																								

7. RESEARCH TEAM

The research team comprise a Principal Researcher and the other five members. The list of the members is presented in Annex III.

8. RELEVANT EXISTING PUBLICATION

A pre-liminary study leading to the clarity of the research problem and the conceptual design of the machine in this proposal has been published in AgriMech peer review journal (https://doi.org/10.63749/agrimech.5.1.1005u). The published paper has been attached for ease of reference.

9. PROPOSAL ENDORSEMENT

This proposal is endorsed by:

Engr. Dr. Kamal, A. R. FNSE, FNIAE
NCAM Executive Director/CEO

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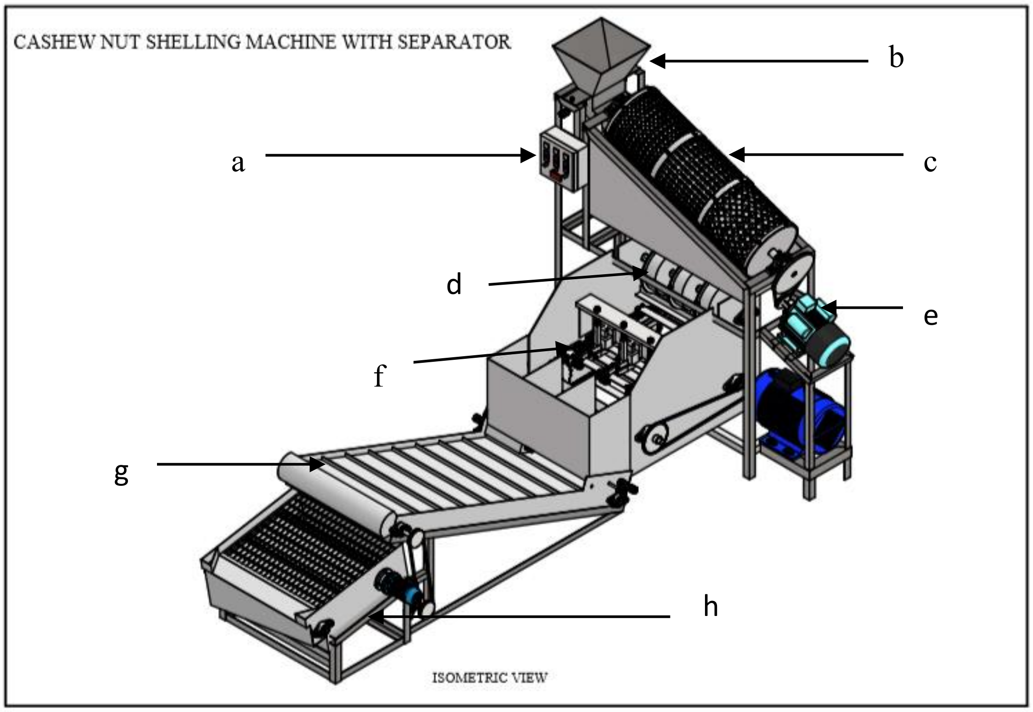
ANNEX I
Isometric Engineering Drawing of the Machine



Key: a = Control panel, b = hopper, c = nut grader, d = nut pre-cutter, e = electric motor, f = chain-sprocket mechanism, g = belt conveyor, and h = separator unit

ANNEX II
Estimated Research Budget

S/N	Description	Quantity	Unit Cost, ₦	Amount, ₦
A.	**Materials for machine development**			
1.	Prime movers (geared electric motor)	3	750,000	2,250,000
2.	Food grade stainless steel metal sheet (2 mm thick, full sheet),	6	415,000	2,490,000
3.	Stainless steel rods (Ø30 mm, full length)	2	400,000	800,000
4.	Stainless steel rods (Ø25 mm, full length)	1	300,000	300,000
5.	Stainless steel rods (Ø5 mm, full length)	4	100,000	400,000
6.	Stainless steel flat bar (10 mm thick, full length)	2	190,000	380,000
7.	Stainless steel net (2 mm thick, full length)	2	390,000	780,000
8.	MS angle iron (45x45x5 mm, full length)	15	230,000	3,450,000
9.	MS metal sheet (5 mm, full length)	2	340,000	680,000
10.	Stainless steel electrode (gauge 12, full pack)	5	55,000	275,000
11.	MS Electrode (gauge 10, full pack)	15	16,000	240,000
12.	Pulleys (pieces)	5	50,000	250,000
13.	V-belts (pieces)	5	1,000	5,000
14.	Block bearing (pieces)	18	7,000	126,000
15.	Bolt and nuts (pieces)	300	200	60,000
16.	Flat and spring washers (pieces)	300	100	30,000
17.	Sprockets (pieces)	7	7,000	49,000
18.	Speed reduction box (pieces)	2	350,000	700,000
19.	Conveyor	3	301,000	903,000
20.	Chain (pieces)	4	5,000	20,000
21.	Control panel	1	1,200,000	1,200,000

22.	Painting (Lump)	1	150,000	150,000
23.	Fabrication workmanship and diesel	1	950,000	950,000
	Sub-total			**16,488,000**
B.	**Supplies / Consumables**			
24.	Raw Cashew Nut (in 100 kg bags)	5	320,000	1,600,000
25.	Electricity Bill payment	Lump	1,000,000	1,000,000
26.	Cutting disc (in pieces)	24	3,000	72,000
27.	Grinding disc (in pieces)	10	3,000	30,000
	Sub-Total			**2,702,000**
C.	**Others / Miscellaneous**			
28.	Drawing and Report writing	Lump	400,000	400,000
29.	Printing and binding	3	250,000	750,000
30.	Paper publication	3	720,000	2,160,000
	Sub-Total			**3,310,000**
D.	**Personnel Cost (conference attendance/ others)**			
31.	Principal Researcher's and Institution allowance	1	3,000,000	3,000,000
32.	Conferences and Exhibitions participation	3	2,000,500	6,001,500
33.	Other Team Members allowances	6	1,500,000	9,000,000
34.	Craftsmen allowances	4	200,000	800,000
35.	Data analyst allowance	1	200,000	200,000
	Sub-Total			**19,001,500**
	TOTAL COST			**41,501,500**

ANNEX III
Research Team

S/N	Name	Rank	Highest Qualification	Area of specialization	Organization
1.	Engr. Dr. Isaac Chinedu OZUMBA **(Principal Investigator)**	Director of Engineering	PhD	Agricultural and Biosystem Engineering	National Centre for Agricultural Mechanization, Ilorin, Nigeria.
2.	Prof. Fatai Bukola AKANDE	Professor	PhD	Farm Power & Machinery	Ladoke Akintola University of Technology (LAUTECH) Ogbomoso
3.	Prof. Folorunso Adegboyega OLA	Professor	PhD	Farm power & Machinery	Ladoke Akintola University of Technology (LAUTECH) Ogbomoso
4.	Engr. Terhemba IORPEV	Principal Research Officer	M.Eng.	Crop Processing & Storage	National Centre for Agricultural Mechanization, Ilorin, Nigeria.
5.	Prof. Olalekan David ADENIYI	Professor	PhD	Energy & Environmental Engineering,	Federal University of Technology, Minna
6.	Engr. Sinatu Juliet AYOBAMIDELE	Lecturer I	M. Tech.	Farm power and Machinery	Department of Agriculture, Faculty of Agricultural Science, University of Ilesha, Nigeria.
7.	Mr. Richard Oluwadamilare ODETUNDE	Research Assistant	B. Tech.	Farm Power and Machinery	Ladoke Akintola University of Technology (LAUTECH) Ogbomoso