AGRICULTURAL SCIENCES JOURNAL VOL(2026)8-(1): 43-63

Agricultural Sciences Journal
Available online at http://asj.mnsuam.edu.pk/index.php
ISSN 2707-9716 Print
ISSN 2707-9724 Online
https://doi.org/10.56520/asj.v8i1.578

Review Article

SUSTAINABLE MECHANIZATION OF GROUNDNUT DECORTICATION: A COMPREHENSIVE REVIEW OF ENGINEERING INNOVATIONS, PERFORMANCE OPTIMIZATION AND POSTHARVEST LOSS REDUCTION

Muhammad Sami Ullah[1], Zia Ul Haq[1*], Muhammad John Raza[1], Muhammad Adnan Islam[2], Syed Mudassir Raza[1], Aksar Ali Khan[2], Abu Saad[2], Ahmad Waqas[3], Javed Iqbal[4], Muhammad Abdullah[1]

[1]*Department of Farm Machinery and Precision Engineering, Faculty of Agricultural Engineering and Technology, Pir Mehr Ali Shah Arid Agriculture University, 46300, Rawalpindi, Pakistan.*
[2]*College of Biosystems Engineering and Food Science, Zhejiang University, 310058, Hangzhou, China.*
[3]*Department of Farm Machinery and Power, Faculty of Agricultural Engineering and Technology, University of Agriculture Faisalabad, 03802, Pakistan.*
[4]*Barani Agricultural Research Institute, Chakwal, 48800, Pakistan.*

**Corresponding Authors: zia.ch@uaar.edu.pk*

Abstract

Groundnut is the sixth most important oilseed crop with a wide range of applications in the food, light and chemical industries. In developing countries, the unavailability of post-harvest processing machinery results in the kernel price being twice that of the pod, which is a major challenge to achieve its potential yield. Mechanized shelling is necessary for post-harvest processing and for producing quality products. An effective way to improve the quality of products is by reducing the kernel damage percentage during decortication. Therefore, the research on reducing the kernel damage percentage has a significant effect in mechanized peanut-shelling. Despite the existing technology in Pakistan not compatible with the high-quality shelling requirements of farmers and industry, as Pakistan is the 5th largest groundnut producer in the world. This review focuses on the transition between manual to mechanized operations such as the use of cost-effective pedal, dual, and motor-operated decorticators. It comprises the influence of design variables such as machine speed, clearance and the moisture content on the machine shelling efficiency and kernel damage percentage. This manuscript also offers a roadmap towards sustainable mechanization by overcoming technical barriers and socio-economic limitations to improve productivity and minimize post-harvest losses. It is expected to provide a reference for effectively reducing kernel damage percentage, improving the quality of shelled kernels and promoting the sustainable development of groundnut decortication.

Keywords: *Groundnut Decorticator, Efficiency, Kernel Quality, Loss Reduction, Moisture Content.*

(Received: 25-Feb-2026 Accepted: 08-May-2026) Cite as: Ullah. M. S., U., U. H. Zia., J. R. Muhammad., A. I. Muhammad., M. R. Syed., A. K. Aksar., S. Abu., W. Ahmad., I. Javed., A. Muhammad. 2026. Sustainable mechanization of groundnut decortication: a comprehensive review of engineering innovations, performance optimization and postharvest loss reduction. Agric. Sci. J. 8(1): 43-63.

1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important oil-seed and cash crop, commonly known as peanut (Husain *et al*., 2024). In oil seed crops it lies on the sixth position globally on the bases of production (darshan *et al*., 2018). It provides a substantial amount of oil (43-55%) and protein (25-28%) for human consumption (Ejiko *et al*., 2015). The major producer of peanuts are West African countries, who have increased their production by 53% in the past 25 years (Delhagen, in 2003). This reflects the inspiration as well as the interest of growers in groundnut production (Karthik *et al*., 2018). Groundnut is cultivated in more than

100 countries around the world (Ravindra *et al*., 2008), with developing countries providing about 94% of total production (Ugwuoke *et al*., 2014). In Africa, Nigeria is the major groundnut producing country. In 2008, among nations including Gambia, Togo, and Ghana, Nigeria represented 51% of groundnut production in the West African region and 31% in Africa (Ajeigbe *et al*., 2015).

In Pakistan, groundnut is grown in rain-fed areas, including districts Chakwal, Jhelum Attock, Rawalpindi, Swabi, Karak, and Sanghar. Groundnuts are grown at 94 thousand hectares, with an anticipated yield of 1.1 tons/ha and a total output of 101 thousand tons. The Pothwar region of Pakistan majorly contributes (82.8%) to the production of groundnut. During harvesting, groundnut losses may range from 10-30% depending on the soil texture, moisture level, groundnut variety, and time of harvesting. The early and late sowing activities have resulted in a very poor average yield of groundnuts in Pakistan. The main factors that are affecting groundnut productivity are exceptional environmental conditions and low input use by farmers. A long, hot climate with ideal rainfall of 500mm and a range of temperature between 25-30°C are the requirements for appropriate growth of groundnut (Ali and Ali 2020).

Good drainage soils with loose texture, and enough minerals, especially potassium, calcium, and phosphorus are best for groundnuts production (Bharath *et al*., 2020). It is a vital source in both industrial and health due to the presence of essential nutrients including vitamins, oil antioxidants, fiber, protein, and minerals (Shalini *et al*., 2016). Peanuts are a valuable commercial crop that can be found in many tropical as well as subtropical regions worldwide, including Thailand. On average, Thailand is producing 30,695 tons of peanuts on 14601.92 hectare of land, with an average yield of about 2102 kg per hectare (Acharya, 2022). The existing groundnut harvesting field machines are a huge constraint in the groundnut supply chain even after harvest. Typical peanut threshers used with conventional tractors often combine standard quality pods with immature or damaged pods, and field debris like mud, clouds and stones. This un-automated separation directly affects the purity of the yield collected, directly affecting the market classification and economic value of the yield for the growers (Saad *et al*., 2026).

2. NEED OF GROUNDNUT MECHANIZATION

Historically, the groundnut fields were prepared by bullock-drawn tillage implements, sown by drills, or grown manually with small tools or hoes, harvested, striping, and pods collected. Several factors prevent the farming community from adopting modern agricultural technology. Normally farmers in undeveloped countries are hesitant to adopt new technologies. Different technological interventions were made by different researchers in terms of seedbed preparation, sowing, intercultural, plant protection, harvesting and threshing, oil extraction, and butter making to avoid the challenges involved with the traditional method (Saad *et al*., 2024).

Farmers perform exhausting manual tasks like planting crops, harvesting, and threshing/processing. These repetitive jobs cause extreme physical strain and tiredness. This back-breaking labor is often referred to as drudgery. Modern farming still lacks simple tools to make these jobs easier (Khambalkar, 2012). Timely execution of harvesting operations is critical and essential to enhance the efficiency of groundnut production and prevent field spoilage. The traditional methods of lifting, manual rigid digging blades, are essentially manual, time consuming and physically strenuous for farm workers. In addition, the primitive harvesting practices can cause excessive mechanical damage and inadequate soil separation of the sub-surface pods leading to significant post-harvest field losses, up to 30 percent of the total production (Husain *et al*., 2024).

The deployment of agricultural machinery to automate agricultural tasks is called automation in agriculture. The productivity of farm workers increases when automation in agriculture takes place through better operational timeliness, higher quality of jobs, and reduction in drudgery and cost of labor. Agriculture has been much more mechanized in recent times. Farmers use mechanical equipment very often for nearly all kinds of agricultural tasks, including irrigation, plant protection, threshing, and sowing. Tools improve efficiency at the workplace (Singh, 2018).

Primary tillage operations are necessary for groundnut production system. The use of primary tillage equipment is necessary to break and pulverize the compacted soil up to a depth of 30-45 cm and to give a soft, crumbly soil base tilth for proper plant growth (Krishnaprabu, 2019). Farmer sell peanuts pods at local markets and middlemen sell pods to processors. Processors remove shells and sell the kernels. Peanut and kernel price change with seasons. A kilogram of kernels costs about twice as much as a pod. Therefore, the processors and middlemen keep most of the profit. Farmers earn little but could earn more if they sell decorticated kernels (Rajurkar *et al*., 2005).

Manual groundnut decortication is a tough labor-intensive and time-consuming process using a lot of energy with less output. Therefore, the research on development of mechanize decorticators is essential to save time, energy and efforts (Arundas *et al*., 2021). Shelling is essential for separating kernel from hull to enable oil extraction. This process allows each part of the groundnut to be utilized effectively. It is necessary steps for all further post-harvest handling and storage (Nyaanga *et al*., 2003). Shelling can primarily be performed manually or decorticator. Hand shelling involves pressing the pod between the thumb and the first finger to force out the kernel. It is the most widely used method in Kenya's farmers. However, hand shelling minimizes the breakage of kernels, it is labor-intensive, energy-consuming and may cause "sore thumb syndrome" when large quantities are handled. A decorticator is a device used to separate the hull from the kernels for them to be further processed, stored, or consumed as foodstuff. The device significantly reduces labor costs associated with decortications, cleaning, and preparing groundnuts for added value processing (Kinyanjui *et al*., 2011).

Improve the performance of a manually operated groundnut decorticator. Shelling of groundnut pods with manual decorticators in Kenya is characterized by high kernel breakages as well as low shelling efficiency. Consequently, farmers receive little cash because of low price of broken kernels, and much time is wasted in the tedious shelling process. To address this challenge, factors that influence the effectiveness of manually driven groundnut decorticators were identified. Two manual decorticators were evaluated, and one was modified to enhance its functional performance. (Gitau *et al.*, 2013).

Manual shelling has been a source of income for many groundnut growers. This is usually done by matching groundnut or beating a bag of groundnuts with sticks. This is a time-consuming and arduous process. It is inefficient since it causes considerable groundnut losses. Machines, on the other hand, are required for mechanical shelling, but due to their size and cost, these methods are still rarely used. Kernels are extracted from groundnut pods by impact action, stripping, rubbing, or an amalgamation of these methods. The most frequent way of shelling is to shatter the pods and extract the kernel by pushing the groundnut between the index and thumb (Ugwuoke *et al*., 2014). In addition to the mechanical harvesting of groundnut pods by digging and threshing, there are significant handicaps for manual collection in the fields. The hand picking of pods greatly adds to the manpower requirements and operational time of the field, making the harvested crop vulnerable to the vagaries of the weather and fungal contamination. Hence, the shift from manual to tractor mounted pod collecting machine is essential to utilize field labor optimally, to reduce the overall cost of operation and to clear the fields quickly to avoid post-harvest crop deterioration (Nasir *et al*., 2023).

Every step is important, and the industry is employing techniques to mechanize every aspect of production to make it more economical, efficient, and sustainable (khan *et al*., 2024). Since it gives ready-to-use seeds that could be suitable for industrial purposes and are more convenient for storage and transportation, handling peanuts, especially shelling and seed coat removal, is crucial to adding value to them. Farmers still employ time-consuming labor-intensive manual shelling which is not sufficient for large-scale production (bakoye *et al*., 2017). As such, the implication of this constraint has prompted the development of mechanical shellers to enhance production through reduced labor costs and effectiveness, mainly among small-scale farmers (Sirichumpan *et al*., 2015). Manual groundnut shelling is labor intensive and therefore slows down post-harvest supply chain. Manual operations are slow as well as result in a lot of kernel breakage, reducing the market value of the crop. Further, due to seasonal high production, the manual process is insufficient, resulting in major storage issues which allow mold growth and spoiling of the product. This necessitates a shift to an efficient mechanical handling method to avoid the loss of the crop.

3. GROUNDNUT DECORTICATION SYSTEMS AND METHODS

In Asia and Africa, the groundnut is still cultivated and processed using traditional methods. The common technique involves sun-drying the pods before manually shelling by friction from hands and feet, trampling, or striking with tools. Sometimes farmers beat the pods in bags or on mats to break the shells, following which they manually remove the kernels from the debris (Engels, 2011). These time-consuming, labor-intensive methods limit the number of groundnuts that can be processed each day. In addition, these methods are often poorly controlled, leading to a large proportion of broken kernels; these have a seriously adverse effect on market value. Research has shown that in conventional methods kernel breakage of more than 15-20% are noted (Tang *et al*., 2024). Furthermore, supporting post-shelling operations such as winnowing and sorting are also normally required for traditional methods, increasing the overall labor requirements. These methods continue despite limitations due to several factors. These include minimal financial investment, limited access to modern technology, and deeply ingrained cultural traditions (Adefila *et al*., 2024).

Conventional groundnut decortication techniques involve manual shelling raw equipment, which are laborious, costly, and cause significant kernel damage. This method is associated with inconsistent output quality, a large percentage of damaged and broken kernels, and a higher aflatoxin risk (Pinson *et al*., 1991). These methods failed to meet international quality standard for export (FAO, 1994). Use a hand-operated groundnut decorticator, to shell groundnut pods and separate kernels. It consists of a handle and an oscillating unit with a sieve at the bottom. The oscillation unit has several hard rubbers or casts iron lined assemblies installed. The shells are removed by rubbing the groundnut pods against the fixed perforated concave sieve an oscillating unit. The perforated concave sieve allows the decorative shells and kernels to fall. At the base of the machine, the kernel and shells are gathered and manually separated. Concave sieves are also changeable depending on the size of the pod, and clearance between the concave and oscillating unit can be adjusted (Krishnaprabu, 2019).

Decorticating and the quality of extracted kernels can be significantly improved with changes in moisture levels and grading. For instance, for Grade III groundnuts (medium sized kernel with 10-12% moisture content), a screen aperture size of 8 mm at 10-12% moisture content was able to yield approximately 95% clean kernel recovery with minimum splitting and bruising. This is a huge improvement compared with conventional techniques, which often result in larger damage and lower recovery rates (Saleh *et al*., 2022). Modern decorticators are also designed with features such as detachable sieves, trapezoidal hoppers for better pod flow, and adjustable concave clearances for improved use and flexibility to various groundnut types. Along with saving processing time and increasing efficiency, these technological developments reduce post-harvest losses, improve kernel safety by reducing aflatoxin threats, and increase the economic value of the produce for exporters and small farmers (Saleh *et al*., 2022). On the other hand, mechanized decortication uses electrical and physical machinery for shelling groundnut. It can further be divided into pedal-powered machines, manually operated machines with revolving parts, and motorized shellers that are driven by diesel or electric motors. Other than ensuring more consistent shelling outcomes, mechanized systems have demonstrated appreciable gains in terms of processing speed and reduction of human fatigue (Thaddaeus, 2024).

4. IMPROVING GROUNDNUT MARKETABILITY THROUGH ADVANCED DECORTICATION

Groundnut decortication is a relatively complicated process that consumes a significant amount of energy, which consequently results in lower productions outputs. Many publicly available decorticators that are manually operated fall into this category. Therefore, it was planned and envisioned that such a machine would be developed that requires even less labor with even less energy (Arundas *et al*., 2021). The design improvement in manually operated groundnut decorticator implies that farmers would be able to get more kernel with less breakage percentage, resultantly increasing the farmer profit (Gitau *et al*., 2013). Groundnut decorticators can make processing efficient, reduce manpower, and encourage farmer's production. Small groundnut decorticators are popular due to low cost, portability and local adaptability (Idogho *et al*., 2025, Ekpechi *et al*., 2025). In order to improve price and ease of maintenance, these machines frequently use locally available materials for manufacturing, and they can operate manually, pedal-powered, or motorized (Franco *et al*., 2023). The performance of these machines varies greatly depending on design factors, operation conditions, and the morphological characteristics of the groundnut pods, despite the existence of several experiments and commercialized variants (GAJANAN, 2017).

Advanced technological interventions and design refinements have made shelling machinery more powerful and user-friendly, enhancing its overall functionality. These include the development of adjustable clearance mechanisms that allow tuning of the machine for different sizes of pods and levels of moisture for efficient shelling with minimum mechanical damage. The cleaning integrated with blowers and sieves has greatly improved shelling percentage. Increased attention to ergonomic design, especially for women, who in most communities are the primary processors, has resulted in the development of portable, battery-operated decorticators that reduce physical strain and are easier to operate. The appropriateness of the machines for rural environments has also been enhanced using locally sourced and renewable materials for fabrication, which reduces costs and ensures spare part availability (Sikha, 2024). Despite the evident advantages, several problems are preventing use of modern decortication equipment widely in developing countries, particularly in poor countries. Small-scale farmers cannot afford motorized systems because of the high initial capital cost. In rural and off-grid areas, relying on a continual supply of fuel or energy is quite serious issue. Operating and maintaining such equipment frequently requires a minimum level of technical expertise. Prolonged downtime can result from inadequate readily available repair services and spare parts. In addition, groundnut species, pod sizes, and moisture content differ, machines need to be flexible, which may not be possible with standard designs. Therefore, the choice of decorticator for specific situations needs great consideration of local socioeconomic variables, energy availability, technical support infrastructure, and technical performance (Nwankwo *et al*., 2023).

5. TO ANALYZE PERFORMANCE PARAMETERS AND ECONOMIC FEASIBILITY

However, important technical parameters like shelling efficiency, breakage of kernel, input rate, cleaning efficiency, and power requirements are used to rate the performance of small groundnut decorticators. The applicability of a decorticator for use in a rural processing environment and small-scale farmer can be directly affected by these conditions (Nwankwo *et al*., 2023). Manual decorticators would ideally provide a shelling efficiency of 60-85%, with a kernel breakage rate exceeding 10% and a throughput rate of 10-25 kg/hr. These decorticators are not very productive, hence not economically viable even with low costs of operation due to ease of manufacturing (Otieno, 2009). Pedal-operated decorticators offer better performance compared to conventional decorticators with 75-90% shelling efficiency, 5-10% kernel breakage, and 40-80 kg/hr throughput rate. This machine reduces costs, manual labor, and is appropriate for remote setting (Shejole *et al*., 2017).

Motorized groundnut sheller with 54% efficiency and shelling rate 66 kg/hr has a steep upfront cost making it impractical for small, individual farmers (Igira, 2018). These decorticators are seen as economically viable due to their high performance and efficiency. However, the high capital costs of fuel/energy, as well as lack of know-how, are major threats to their economic viability (Nwankwo *et al*., 2023). Factors such as costs of fabrication, spare parts supply, operational costs, and market demand contribute to economic sustainability. This sustainability can be ensured by the fact that processing machines composed of locally fabricated components are relatively cheaper and easier to maintain (Fannou *et al*., 2020). This suggests that a pedal-operated decorticator machine with a moderate processing rate and low processing costs was found to be economical for small-scale farmers. On the other hand, even with motorized technology, it would not be economically feasible for those with irregular power supply and small processing capacities (Shejole *et al*., 2017).

The development and performance test of a propeller peanut sheller that can benefit farmers with limited manpower by increasing shelling speed and reducing losses in shelling. Two major parameters considered in this research were rotor speed (RS) and concave clearance (CC). Performance evaluation of the sheller used grain breakage rate (GB) and shelling efficiency (SE) measured in percentage. Findings indicated that for a speed of 550 rpm of the RS, a shelling efficiency of 88.05% with a GB rate of 9.70% was obtained. Furthermore, for a GB rate of 10.94% and a SE of 87.98%, the value of CC was set as 10 mm. Also, as per economic studies, processing a minimum of 29,803.21 kg of peanuts every year would help in achieving a payback period of 0.82 years, that is, 9.84 months (Pachanawan, *et al*., 2025). Operational success of equipment used for groundnut processing should be determined by the analysis of performance data for different systems. The main parameters that are used to measure this success are throughput capacity, kernel damage and shelling efficiency. The three measurements are compared directly in Table 1 for the three types of decortications: manual, pedal powered, and motorized.

Table. 1: Performance Matrix of Different Groundnut Decortication Systems

Decortication System Type	**Throughput Capacity (kg/h)**	**Kernel Damage (%)**	**Decortication Efficiency (%)**	**Reference**
Manual Hand Shelling	10-15	<1.5	100	Desai *et al*., (2024)
Pedal-Operated System	50-95	3.0-4.8	74.3-87.5	Mishra *et al*., (2009)
Diesel / Motor Operated	150-400	5.0-8.2	95.0-98.6	Helmy *et al*., (2012)

6. GROUNDNUT PODS FACTORS FOR MECHANICAL AND PHYSICAL PROPERTIES

The different varieties of groundnuts have different characteristics the number of kernels and each pod, and their sizes. In this experiment four varieties were selected including Runner, Virginia, Spanish, and Valencia. (Shoko and Mushiri, 2015). The size of groundnuts was measured by estimating the average of the radial measurement, that is, the small, medium, and large size of groundnuts. The outcome of this investigation showed that larger varieties give better efficiency in shelling (Akcali *et al*., 2006). The suitability of different groundnut varieties for mechanical harvests and decortication is based on specific mechanical and physical properties. Groundnut varieties differ in pod size/length and thickness, shape, and the strength of attachment between pods and stems. Different groundnuts, for example, with thick shells, may require more energy for decortication. However, these varieties may be useful in preventing breakage during mechanical harvests compared to conventional harvests that result in high loss levels due to traditional handling and preservation methods (Bako *et al*., 2015). The process of decortication depends on several pods’ varieties, moisture content, pod size, shell hardness and pods geometry. Pods with high moisture are flexible and hard to separate while pods with low moisture become more brittle and break easily, causing broken kernels. So, moisture affects how pods behave during shelling. It should be noted that these variables affect the geometry of pods, which includes size and shape (Azmoodeh *et al*., 2014). Mechanical properties such as the toughness and compression strength of the pods would affect shelling device designs and determine energy requirements for efficient decortication. Parameters for optimization based on these properties would allow for a reduction in mechanical damage and improve rates for kernel recovery (Hu *et al*., 2018).

7. TYPES OF DECORTICATION SYSTEMS: PRINCIPLE, CAPACITY, EFFICIENCY, ENERGY REQUIREMENTS

Manually operated groundnut decorticator consists of a hopper, a semi-cylindrical concave sieve and an oscillating sector driven by a handle. Groundnut pods are fed into the hopper, where they cascade down into the gap between the oscillating sector and the concave sieve. The shearing action produced by the moving sector and sieve removes the shell from the kernel. The major aspect of this modification is the addition of a blower system, which will automatically carry out the separation between the lightweight hulls and the kernels, and so no longer require manual winnowing. Performance parameters of manually groundnut decorticator were observed for the pods feeding rate of 50.12-53.75 kg/h. The percentage of broken kernel, partially decorticated pod and decorticating efficiency was observed in the range of 13.95-14.80, 0.83-0.91 and 99.11-99.20 respectively. The details of the performance parameters of existing groundnut decorticator are shown in Table 2 (Kadlag *et al*., 2022).

Table. 2: Performance Parameters of the manually Groundnut Decorticator

Sr. No.	Parameters	Range
1	Capacity of the decorticator (kg/h)	50.12-53.75
2	Broken kernel (%)	13.95-14.80
3	Decorticated and partially decorticated pod (%)	0.83-0.91
4	Clean grain obtained at chaff (%)	4.65-7.85
5	Sieve loss (%)	0
6	Total grain loss (%)	19.442-23.567
7	Decorticating efficiency (%)	99.11-99.20
8	Cleaning efficiency (%)	71.62-77.34

Table. 3: Trial for pedal operated groundnut decorticator

Sr. No.	Total Weight of Groundnut (kg) [Q_t]	Weight of Decorticated Groundnut (kg) [Q_s]	Weight of Undamaged Groundnut (kg) [Q_u]	Weight of Damaged Groundnut (kg) [Q_d]	Time Taken for Operation (sec) [T_m]
1	2.0	1.184	1.074	0.110	147
2	2.0	1.182	1.072	0.112	145
3	2.0	1.181	1.070	0.114	142

8. PEDAL-OPERATED GROUNDNUT DECORTICATOR

it is observed that farmers preferred using a pedal-operated groundnut decorticator machine rather than a hand-operated. The pedal operated groundnut decorticator machine uses no energy, reducing production cost. Moreover, it saves labor and time, enabling higher output in a short period because it requires no skilled operation and runs continuously. Sample is bought from market, and sun-dried for one day to remove moisture. The sample contains groundnuts to be decorated with some adhered oil. The data for three replications were noted. In trial table 3 following parameters are mentions Total weight of groundnut in kg (Q_t), Weight of decorticated groundnut in kg (Q_s), Weight of undamaged groundnut in kg (Q_u), Weight of damaged groundnut in kg (Q_d) and Time to decorticating operation in sec (T_m). The result of this trail shows time saving, money and increase efficiency by using pedal operated groundnut decorticator machine. In this experiment 2kg of groundnut pods were processed with output of 1.184kg of kernels or decayed seeds (Shejole *et al*., 2017).

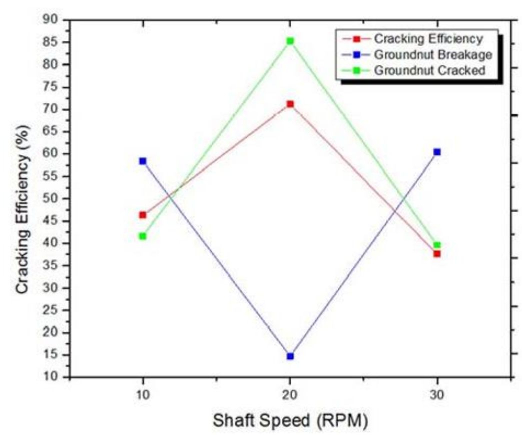
9. DUAL-OPERATED GROUNDNUT DECORTICATOR

Dual-operated groundnut decorticator in different conditions with the special emphasis on the effect of shaft speed and moisture level. Machines work best at 20 rpm shaft speed with dry pods (0% moisture) whereby they can attain maximum cracking efficiency of 71.2 percent and a cracked rate of 85.3 percent with minimum kernel breakage. However, once the moisture content reaches 5.1% and 9.3%, the efficiency reduces and the rates of breakage soar high especially when the speed increases. The following three graphs clearly depict these trends and the correlation between speed, efficiency and the level of moisture and are explained in detail in the following three graphs: Graph (a) for dry pods, Graph (b) for 5.1% moisture, and Graph (c) for 9.3% moisture content (Larson *et al*., 2017).

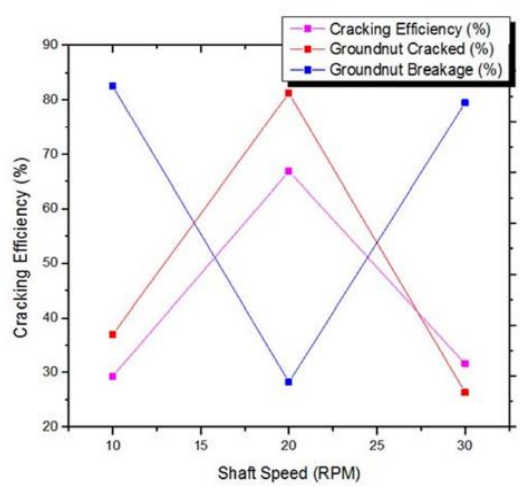
Graph (a): Performance with 0% Moisture Content (Dry) The machine was the most successful when the groundnut pods were fully dry. The highest efficiency was noted to be the shaft speed at 20 rpm. The cracking efficiency at this rate was 71.2 percent and 85.3 percent of the pods were cracked. Most importantly, the breakage of the kernels had been the lowest at this speed (14.7 percent). The machine's highest cracking efficiency was observed at rotor speed of 20 rpm while this value decreases at 10 and 30 rpm.

Graph (b): The decortication process was repeated at 5.1 percent moisture content. Performance of the machine started to decrease with the increase of the moisture level in comparison with dry pods. There was a 66.9 percent cracking efficiency at the optimal speed of 20 rpm. Nevertheless, at very high speeds (10 rpm and 30 rpm), the rate of increase in breakage was rapid and was around 80 percent. This demonstrates that with a small amount of moisture the pods are more susceptible to any damage in case of high-speed mechanical collisions.

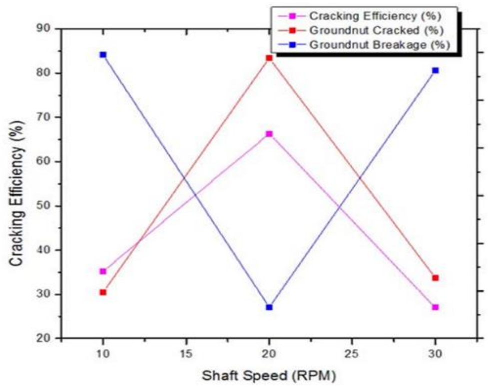
Graph (c): Performance of machine at 9.3% moisture content: this graph showed the lowest peak performance of 66.3 percent at 20 rpm. The reason is that the more moisture the shells are the harder and more flexible they are and then they consume more energy to break. The breakage was very high at low (10 rpm) speed (69.5 %). Also, at this level of moisture the machine began to slip, and this was another factor that lowered the quality and consistency of the output.



(a) Moisture content of 0% (d.b.)



(b) Moisture content of 5.1% (d.b.)



(c) Moisture content of 9.3% (d.b.)

10. MOTORIZED DECORTICATORS

Motorized groundnut sheller machine is a semi-automatized machine that aims at substituting manual labor consuming time with more efficient and cheap solutions to serve the small-scale farmers. The machine uses an electric motor with 1hp power, and it works on the principle of shearing and blowing. Groundnuts pods are loaded in a hopper and crushed between a rotating roll shaft and a stationary semicircular net. This operation serves the effect of peeling the peanuts and the shells apart, with the help of a blower, to hurl off the light shells, and the heavy ones fall below. The testing data shows that the machine has a high throughput capacity of 130.5 kg/hr and shelling efficiency of 81.2 % and requires a maximum of 22.4 seconds to process a 1 kg sample. The machine is much more cost-effective and faster compared to the traditional hand-decocting process. The results of the testing process indicate that the use of the groundnut decorticator will save time and money. According to the experimental results 1 kg of raw groundnut processing gives 0.812 kg of shelled seeds. This efficient ratio increases with higher amounts 5 kg input would yield approximately 4 kg of seeds and a 50kg input would yield an approximated 40kg of produce (Table 4). The machine operates continuously to produce a high volume of output within a very short period which has an efficiency of 81.2 % in shelling with minimum wastage (Raghtate and Handa, 2014).

Table 4: Trial for Motorized groundnut decorticator

Sr. No.	Total Wt. (Q_t) (kg)	Wt. Shelled (Q_s) (kg)	Wt. Undamaged (Q_u) (kg)	Wt. Damaged (Q_d) (kg)	Time (T_m) (sec)
1	1	0.83	0.645	0.185	23
2	1	0.81	0.655	0.155	21
3	1	0.80	0.640	0.160	20
4	1	0.82	0.650	0.170	25
5	1	0.80	0.655	0.145	23
Total	**5**	**4.06**	**3.245**	**0.815**	**112**
Mean	**1**	**0.812**	**0.649**	**0.163**	**22.4**

Motorized groundnut decorticators, also referred to as shellers or threshers, operate on the principle of mechanical impact and friction to separate kernels from pods. These machineries usually consist of a stationary concave sieve and a rotating drum (beating cylinder). The pods are put into a hopper and then go through a crushing or threshing chamber, where the shells split open as a result of revolving beaters rubbing or beating the pods against the concave surface. A blower or sieve device, which uses airflow or vibration to remove lighter chaffs and debris, is frequently used to help separate kernels from shell fragments. Compared with traditional methods involving decortication with foot pedals, it is less laborious and more efficient (Saad *et al*., 2024).

11. KERNEL DAMAGE AND QUALITY ASSESSMENT

Kernel damage during shelling, such as bruising and splitting, negatively affects the marketability, storage potential, and safety of the final product. Hand-operated decorticators frequently produce breakage rates above 10–15% (Gitau *et al*., 2013). On the flip side, with optimal processing, motorized decorticators can maintain breakage at 5%, while pedaled ones reduce breakage to 5-10%. The literature examined indicates that different decorticator designs and operational conditions result in dramatically varying kernel breaking rates (Adenigba and Sedara, 2021). Kernel quality depends on physical integrity, cleanliness, and bring from contaminants like aflatoxin. Moisture and screen size are the main things that affect kernel damage. Screen size of 8 mm with 10% moisture would generate 94.66% clean kernels with negligible splitting and bruising at 1.37% and 2.08%, respectively, on Grade III groundnuts. It was suggested that at 20% or more, kernel shell and damage increases (Saleh *et al*., 2022). Wet cereals and oilseeds can cause mold growth, mite infestations, and sprouting (Armitage and Wontner-Smith, 2008). Conversely, over drying grain before or during storage leads to poor quality, energy waste, and splitting and cracking. So, it's important to control the moisture level (Rai *et al*., 2005). Mechanical damage, apart from reducing the size and appearance of the corn kernels, also poses a risk of aflatoxins, which are hazards and a major constraint on world trade. Kernel damage is reduced, and overall quality is enhanced by effective decorticators with regulated impact and friction mechanisms, such as tapered studs, rubber-padded blades, or adjustable concave clearances. Moreover, another crucial component of quality evaluation is cleaning efficiency, or the capacity to extract kernels from shells and debris. Machines with integrated blowers or aspiration systems, achieve cleaning efficiencies above 85%, ensuring higher kernel purity (Gana *et al*., 2022).

12. TECHNOLOGICAL INNOVATION

Manual operations are slow, exhausting, and low quality, it can't keep up with modern farming demands. For these reasons, a compatible peanut shelling machine is required to replace traditional shellers and manual labor. A groundnut shelling machine that mimics the manual peeling process has been developed. The peanut shelling machine's frame, feeding mechanism, pneumatic gripper, and peanut shelling enabling mechanism to make up its mechanical structure (Sun *et al*., 2017). Motorized shelling and decortication equipment that increase productivity and minimize labor are examples of post-harvest improvements. An affordable and effective shelling option is provided by a groundnut sheller made for small farmers (Raghtate and Handa, 2014). This is the application of electrically and mechanically powered equipment like electric motors and gasoline engines. They supply the energy needed for shelling, either by converting electrical energy from an electric motor or mechanical energy from a gasoline oil. This method shells the same tons of groundnuts faster than manual methods. Shelling machines that rotate and reciprocate are used in the mechanical approach (Walke *et al*., 2017). The inclusion of renewable energy (RE) into groundnut processing machinery can be a green solution to reduce the operating cost for the farmers in the rural areas. Smallholder farming communities are often without reliable electricity supply and high cost of diesel fuel, rendering the use of conventional motorized shellers challenging. Recent designs include low duty DC motors and solar PV system/battery backup. The decorticators are solar powered, offering a consistent and environmentally friendly solution, reducing carbon emissions, and supporting small farms' productivity.

13. WEAR-RESISTANT MATERIALS AND DESIGN IMPROVEMENTS

The machine's frame and structural elements are usually made of cast iron or mild steel, which offer strength and durability but are prone to wear and corrosion over time. To survive constant abrasive action, alternative devices mentioned in the literature, such power-operated decorticators, frequently include interchangeable sieves and hardened steel pegs. Two essential wear-prone parts are the oscillating sector and perforated sieve. Cast iron peg assemblies are utilized in hand-operated models, however they can wear out more quickly and cause more kernel damage. This is improved by the pedal-operated design, which uses a quick-return mechanism with rubberized contact points to preserve the kernel and lessen mechanical wear on the impact surfaces and sieve (Shejole *et al*., 2017). There is need of strong design and material selections since the machine is meant for small-scale farmers to provide them with equipment that is dependable and low in maintenance. Other related studies on agricultural machinery have added that further enhancements may involve making concave bars and drum blades-considered as high-wear parts-from composite materials or hardened steel (Liao *et al*., 2024). The design of the propeller-type peanut sheller takes several factors into consideration to achieve gains in performance and durability, most especially by material selection and structural optimization. Importance of a design improvement that can reduce losses and enhance efficiency, ensuring its long life, even though the wear-resistant materials are not mentioned. For instance, the feeding chute modification is suggested so that the scattering of peanuts would be reduced to lessen the wear of the machine parts and material loss. Furthermore, in reducing mechanical stress and potential wear in shelling, the propeller-type drum and concave rod are designed to match the peanut pod longitudinal cracking. Moreover, optimization, which is possible with concave clearance and rotor speed, makes it adjustable regarding peanut size and moisture content, minimizing excessive friction that leads to material deterioration through time (Pachanawan *et al*., 2025).

14. SOCIO-ECONOMIC

Mechanized groundnut decortication is one feasible method of enhancing efficiency, reducing labor costs, and increasing the throughput capacity. These machines are of affordable cost, ease of portability, and potential for fabrication to suit local conditions (Idogho *et al*., 2025). Testing their performance is a must to be informed about their technical feasibility and, hence, to guide this development process towards better systems. In addition to this, evaluative terms have now been extended to encompass functional design and operational simplicity, all in the interest of user-friendliness, especially for women and older persons who often process groundnuts (Ezechukwu *et al*., 2025). People used old methods to remove shell from groundnut, because modern machines are expensive. Family does the work by hand, usually women and children. This manual work takes a lot of time and physical effort. The manual decorticator adds to the heavy work hold that women already bear in both household duties and farm responsibilities (Adefila *et al*., 2024).

Groundnut decortication was also shown to enhance the qualitative value of its product, that is, by raising kernel quality. When process conditions were appropriately highlighted regarding grade, moisture content, and screen aperture. Its ability to restore and boost export revenue makes it essential. These advancements also ensure the viability of its production where it is essential to their economies that rely heavily on agriculture. This will enhance household nutrition, boost women's economic potential, and have an impact on rural employment, trade, and smallholder farming. Additionally, it will boost these nations' foreign exchange and net revenue (Saleh *et al*., 2022). Smallholders often do not have access or cannot afford post-harvest processing equipment such as shellers, graders, and butter-making machines. On-farm grading systems are lacking because Farmers need to use human sorting, which is bulky, irregular, and less competitive in the market (Easackha *et al*., 2020). Moving from manual hand-shelling to small-scale mechanical shellers brings major economic and social benefits to smallholder farmers. Manual shelling is extremely tedious and labor intensive and creates a tremendous workload on farmers, particularly women. The introduction of simple and low-cost shelling machines will aid in removing this hard labor and minimizing post-harvest losses. It enables farming families to process their produce far quicker, obtain a better market price for their clean kernels and enhance the food security of the region.

15. COST-BENEFIT ANALYSIS FOR SMALLHOLDERS AND REDUCTION IN LABOR AND POST-HARVEST LOSSES

One of the crucial post-harvest procedures in the groundnut production process is decortication. Large-scale groundnut shelling, particularly for commercial purposes, is not supported by conventional shelling techniques. This method typically takes a long time, damages the kernels severely, and fails to remove the kernels from the hull. To reduce damage and loss of groundnut kernel during decorticating. This study was started to modify and assess groundnut decorticators that farmers could afford. Manually operated decorticators lack the capacity to separate kernels from hull, the traditional winnowing process of hull removal requires more time and labor. However, because of their low construction costs, modified groundnut decorticators with blowers have these features and are also reasonably priced for many marginal and small farmers (Kadlag *et al*., 2022). One of the major problems in groundnut production is the unavailability of affordable groundnut processing machinery, more specifically groundnut Sheller. The groundnut Sheller machines available in the market today are too big, expensive, and unsuitable for residential purposes. The machine will be fabricated using locally available raw materials. The major components of the machine include the hopper, crushing chamber, separating chamber, and blower. The various activities involved in this project include design, fabrication, and assembly of components (Ravindra *et al*., 2008).

The main objective of this study is to create a portable groundnut decorticator. Hand-operated groundnut decorticating machine with a high cost-benefit ratio of 1:28.6 and an output of roughly 40-42 kg/hour, the shelling process required 1.5 minutes each kilogram. Additionally, this prototype's unique design enhances efficiency and lessens all reasons. In addition to being lightweight and simple to use and maintain, the machine's spare components may be found nearby. It is very economical to use, inexpensive to buy, and very simple to maintain. Diesels or electricity are not needed. It doesn't require any expertise. Regular shelling can be used by small and marginal farmers to plant groundnuts. This is useful equipment that they can use at any given time which suits them, whether it be during the day or at nighttime. The decortication method is very cheap; labor is quite minimal and can even be operated with one person (Sikha, 2024). For smallholder farmers, investing in low-cost groundnut shelling machinery presents a clear economic advantage. Manually operated groundnut sheller is an affordable alternative to expensive electric or motorized decorticators, reducing upfront investment and operational costs. This resulted in a shelling efficiency of their machine to be 81.2%, enabling farmers to process higher volumes without necessarily the use of expensive machinery or labor (Mungle *et al*., 2022). The design and fabrication of a groundnut sheller machine demonstrated its affordability for farmers. The production costs of the machine were minimized by making use of easily available materials and simple fabrication methods. Due to reduced labor costs and increased speed of processing, the research provided evidence that shelling efficiency was much higher compared to manual methods. However, the payback period was very short, hence a feasible investment by smallholders who cannot afford expensive machinery. Similarly, it has been documented that the utilization of small-scale decorticators makes the technology feasible and viable since it reduces both initial capital investment in the machines and recurring costs such as maintenance and electricity (Bharath *et al*., 2020). There is a direct reduction in labor costs and post-harvest losses due to improved groundnut processing technology adoption. Reported that while a small-scale motorized decorticator reduced hardship by 90%, the use of a motorized groundnut stripper reduced drudgery by 41% compared to traditional manual methods. Farm women can do duties more quickly and effectively because to this significant decrease in physical strain (Desai *et al*., 2024). Furthermore, according to, their pedal-operated sheller reduced seed damage and enhanced output quality, thereby addressing post-harvest losses that sometimes arise during manual shelling. These machines also lessen losses from combining shells and kernels by using semi-automated separation mechanisms (such as blowers and sieves), improving product quality and market value (Mungle *et al*., 2022).

16. CHALLENGES AND LIMITATIONS

Design and operation of automatic groundnut decorticators are intended to increase efficiency; technical issues such machine blockage and maintenance requirements can arise. In the automatic groundnut decorticator, the semi-circular net and roller shaft assembly are critical components where clogging may occur, especially when processing groundnuts with high moisture content or irregular pod sizes. Improper adjustment or accumulation of shell debris can lead to blockages and reduced throughput (Darshan *et al*., 2018). Small-scale users often struggle with the maintenance of moving parts such as belts, pulleys, and bearings in manually operated and motorized decorticators. Their study on drudgery-reducing technologies found that training programs on basic troubleshooting and lubrication significantly improved machine performance. They recommended designing machines with easily accessible components and using corrosion-resistant materials to reduce maintenance frequency in humid or dusty environments (Desai *et al*., 2024).

Hand-operated concave or semi-rotary shellers, which process only 60-80 kg per hour, are examples of locally made groundnut shelling equipment that frequently need a large amount of effort and time. Particularly when dealing with different pod sizes and moisture levels, these devices are prone to clogging. Even though electrically powered shellers with upgraded parts (hopper, separation chamber, crushing chamber, blower) have more capacity, their uptake is still restricted because of maintenance issues and the requirement for locally sourced replacement parts (Bharath *et al*., 2020). For manual decorticators to maximize shelling efficiency and avoid clogging, sieve size and clearance adjustments are essential. They found that using an 11 mm sieve with a 16 mm clearance decreased blockages and kernel damage (Gitau *et al*., 2013). In relation to motorized decorticators, another issue on clogging is revealed that showed material accumulation in the shelling chamber could be attributed to incorrect settings of CC and/or insufficient feeding rate, especially during processing with uneven size pods. To provide continuous flow and avoid jamming of crops, the study recommends that adjustment of rotor speed and concave gaps should consider the size of pods and moisture content in real time (Pachanawan *et al*., 2025). The study says that to prevent the occurrence of obstructions and maintain operational efficiency, cleaning of the crushing chamber and the sieve routinely is very essential (Adwal *et al*., 2017). Even after mechanical improvements, mechanical blockage and excessive wear of components are big technical challenges in day-to-day operation. Clogging usually occurs when feeding wet pods or varieties that have thick fibrous hulls which become entangled between the rotor and concave screen. Ongoing rubbing also erodes the rubbing surfaces, changing the factory set clearance, and slowly decreasing efficiency. The creation of materials that are more resistant to abrasion and harder will require the operators to have less downtime and fewer repair costs.

17. FUTURE DIRECTIONS

This is the creation of affordable, versatile, and locally adaptable machinery for farmers in the future. To ensure farmers can do single product grading for value addition with reduced post-harvest losses, the review highlighted the inexpensive grading and sorting technologies that can be combined with threshing equipment (Easackha *et al*., 2020). There is also much room for innovation in compact and energy-efficient small-scale peanut butter makers and decorticators, among other processing equipment, to improve value addition at farm level (Moyana and Mushiri, 2018). These machines will be affordable, long-lasting, and appropriate for the socioeconomic conditions prevailing within most groundnut-producing nations when the local manufacture and participatory design of such machines are considered first (Saad *et al*., 2024). To improve sustainability and accessibility in off-grid areas, future innovations are urged to investigate alternate power sources, such as solar energy (Adetola *et al*., 2022). To improve operational accuracy and lower losses, one important path is the integration of smart and precise agriculture technology, such as the broader use of autopilot systems for digging and sowing operations (Zerbato *et al*., 2019). Additionally, a promising area to increase germination rates and resource usage efficiency under varied climatic conditions is the development of sensor-based planters that allow site-specific water and seed placement. To support sustainable agricultural practices and facilitate data-driven decision-making, future research should also concentrate on IoT-enabled monitoring systems for real-time data collecting on crop health, soil moisture, and performance of machinery (Anitha and Kumar, 2022).

Agriculture is the main source of income for a substantial section of the world's population. This machine will be used extensively and is adaptable. This solar operated decorticator makes it easier for farmers to make money from their crops to save labor expenses, boost operational effectiveness, and decrease physical effort (Ravindra *et al*., 2008). Future research should aim to develop a smart adaptive shelling system which can adapt to various varieties of groundnut. Most machines have the concave clearance adjusted manually to accommodate the various sizes of pods and this adjustment can be prone to errors and broken kernels. If it were possible to install simple sensors to measure the moisture and shell thickness of the grain in real time, machines could automatically change their rotors' speed. These smart controls in conjunction with low-cost manufacturing will be essential for the next generation of decorticators.

18. CONCLUSION

To increase farm productivity, it is necessary to modernize groundnut decortication as manual shelling is no longer viable as it is expensive, labor-intensive as well as physically challenging to the workers' health. The only solution is the shift to mechanical systems to satisfy the increasing demand in the world and guarantee maximum efficiency with the strict optimization of such parameters as the speed of the cylinder, the quantity of moisture, and shelling clearance. The development of motorized and solar-powered decorticators is beneficial for large farmers while it is challenging to the small-scale farmers due to its high initial and operational cost. Though they have challenges like machine wear and high initial costs, these technologies are more accessible and sustainable to implement as the government provides supportive policies, and indigenous materials are introduced. This will eventually lead to improvement in the economic status of smallholders and ensure that the global groundnut value chain is efficient and profitable.

19. GROUNDNUT BREEDING AND MACHINERY INTEGRATION

Standardized large-scale production depends on a clear understanding of peanut physical properties. Scientists must investigate how these properties correlate with shelling damage to reduce losses. Collaboration with breeders is essential to develop uniform and disease-resistant varieties. These new varieties should be specifically optimized for mechanized processing from the start. Furthermore, integrating shelling suitability into variety appraisal is a vital step. Practical verification of these varieties will ultimately enhance overall industrial performance and processing efficiency.

20. OPTIMIZATION OF SHELLING PROCESSES AND KEY PARAMETERS

Optimizing the entire peanut-shelling assembly line is crucial for maintaining high food safety and seed quality. This process requires significant improvements in moisture control, drying, and storage techniques. It is also important to tailor shelling processes to specific end-uses, such as oil production or food processing. By refining machine parameters like cylinder speed and sieve spacing, kernel damage can be minimized. This detailed approach ensures a more robust and reliable industry chain.

21. INNOVATION, SMART MATERIALS AND TECHNOLOGIES

Low efficiency and high levels of breakage are also a cause of major problems that need higher investment in R&D. Academia and industry should start collaborative work to enhance the theoretical knowledge of mechanical behavior of peanuts. Researchers are supposed to modify the high-end foreign technologies to fit in the small-scale, as well as super-large-scale, processing plants. The key to success in the future is innovation in intelligent and environmentally friendly manufacturing. The innovations will aid in developing popular international brands in the market. It will open the international footprint of the peanut-shelling industry, which will be expanded by strengthening technical base.

22. DESIGN A SOCIALIZED SERVICE SYSTEM FITTING PAKISTAN GROUNDNUT PRODUCTION CHARACTERISTICS

Socialized system of the service sector which is led by the government gives a chance to small-scale farmers to concentrate on cultivation. Besides it, large-scale procurement, professional storage and mechanization shelling can be consumed by centralized stations. This is a systemized system that strives to introduce standardized quality throughout the board. It also introduces an equitable trading system to modernize the industrial chain and the overall processing productivity.

21. REFERENCES

Adefila, A., Ajayi, O., Toromade, A., and Sam-Bulya, N. 2024. Integrating traditional knowledge with modern agricultural practices: A sociocultural framework for sustainable development. W. J. Bio. Pharm. Health. Sci. 20:125-135.

Adenigba, A., and Sedara, A. 2021. Design, fabrication, and performance evaluation of groundnut dehulling and separating machine. Turk. J. Agri. Engin. Res. 2(1), Article 1.

Adetola, O. A., Akinniti, O. E., and Olukunle, E. A. 2022. Development and performance evaluation of a groundnut shelling machine. Intern. J. Engin. Sci. Appli. 6(3):85–94.

Adwal, R., Ghadge, R., Awad, S., and Khare, G. N. 2017. A review on design and fabrication of groundnut shelling and separating machine. Intern. Res. J. Engin. Techn. (IRJET). 4(10):1403-1406.

Ajeigbe, H., Waliyar, F., Echekwu, C., Ayuba, K., Motagi, B., Eniayeju, D., and Inuwa, A. 2015. A farmer's guide to groundnut production in Nigeria.

Akcali ID, Ince A and Guzel E 2006. Selected physical properties of groundnuts. Intern. J. Food. Prop. 9(1):25-37.

Ali, B., and Ali, Q. 2020. Evaluation of optimum sowing dates for newly developed lines of groundnut in Rainfed areas of northern Punjab. Evaluation, 5(1).

Anitha, G., and Kumar, A. A. 2022. Mini tractor-mounted sensor-based aqua groundnut planter. Agricultural Mechanization in Asia, Africa and Latin America, 53(1):22.

Armitage D and Wontner-Smith T 2008. Grain moisture-guidelines for measurement. HGCA-Funded Project, Caledonia House 223 Petronville Road London NI9HY. 2008.

Arundas, S. V. Jogdand, R. K. Naik, V. M. Victor and Sambhu Singh. 2021. Development of Pedal Operated Groundnut Decorticator. Int. J. Curr. Microbiol. App. Sci. 10(2):3352-3358.

Arya, S. S., Salve, A. R., and Chauhan, S. 2016. Peanuts as functional food: A review. J. Food Sci. Techn. 53(1):31–41.

Azmoodeh, M., Abdollahpoor, S., and Navid, H. 2014. Comparing of peanut harvesting loss in mechanical and manual methods. Intern. J. Adv. Bio. Biom. Res. 2(5):1475–1483.

B. K. Kinyanjui, A. N. Gitau and M. K. Mang'oli, "Power Development Planning Model in East Africa. 2011. J. Strat. Plan. Ene. Envi. 31(1):43-55.

Bako, T., Bayero, H., and Ezekiel, A. M. 2015. Performance evaluation of a tractor mounted groundnuts harvester. Innovative Systems Design and Engineering, 4(2):70–81.

Believe O Idogho, Ifeanyichukwu U Onyenanu, Kennedy C Owuama, Ashimedua C Ndubisi, Chukwunwendu E. Ilochonwu 2025. Optimization of a Sustainable Virgin Coconut Oil Extraction Machine for Rural Communities. J. Food. Tech. Nutr. Sci. SRC/JFTNS-275.

Bharath, K. V., Priyanka, C., A, S. K., Sharu, S., and Subashree, S. 2020. (August). Design and Fabrication of Groundnut Pod Separator. Intern. J. Sci. Engin. Res. (IJ0SER,) 8(8):6-9.

D. M. Nyaanga, M. C. Chemelil, P. K. Kimani, W. K. Kirui and S. K. Musimba, "Development and

Evaluation of a Portable Hand Operated Groundnut Sheller," The KSAE International Conference, 27-28 November 2003.

Darshan, G. C. P., Venkatagiri, H. A., and Govindarej, A. J. 2018. Automatic groundnut decorticator. Open Access Intern. J. Sci. Engin. 3(7):16-21.

Delhagen W, Hussam S, Mohdramli R and Alexander Y 2003. A Low-cost groundnut sheller for use in developing nations. Final Application for IDEAS. 2003.

Desai, R., Chitagubbi, G., and Salunke, R. 2024. Impact of mechanization in groundnut production system for drudgery reduction and to enhance farm income. Ind. J. Ext. Educ. 24(2):51-58.

Easackha, A., Geetha, R., and Amutha, C. M. R. 2020. Standardization of Sieve Size for Grading of Sesame Seeds (*Sesamum indicum* L.) Var. TMV-7. Intern. J. Curr. Microbio. Appl. Sci. 9(7):850-855.

Ejiko S, Adu J. and Osayomi P. 2015. Design and Fabrication of groundnut shelling machine. GRIN Verlag, Munich.

Ekpechi, D. A., Obiukwu, O. O., Nwankwo, E. I., and Okpalaku-Nath, V. C. 2023. Experimental study of the thermal and mechanical properties of epoxy-reinforced composites. J. Appl. Phy. Sci. Inter. 15(1):6-16.

Ekpechi, D. A., Obiukwu, O. O., Opara, U. V., Emeziem, V. C., Nwankwo, E. I., Ezeaku, N. I., Ozuruoha, E. N., Oluwadare, O. E., Ayo-Akano, H. O., and Opkalaku-nath, V. C. 2025. Evaluation of Key Performance Factors and Recommendation of Optimization Strategies of a Power Generation Company. Engineering Science & Technology, 52-68.

Engels, J. 2011. Groundnut Grower's Guide for Mozambique: Production, Harvesting and Post-harvest Handling. Hawthorn, Australia. 58.

Ezechukwu, V. C., Braide, T. K., Onyenanu, I. U., Ayadinuno, G., Agwaziam, J. O., and Ojinekeya, C. O. 2025. Structural simulation analysis of the developed hybrid of aluminum composites and carbon nanotube brake disc. Intern. J. Appl. Natu. Sci. 3(1):18-28.

Fannou, J. -L. C., Semassou, G. C., Chegnimonhan, K. V., Sonoudouto, G., Degan, G., Sanya, E. A., and Houndekpondji, G. (2020). Design and manufacture of a groundnut sheller. J. Experi. Agri. Intern. 42(7):66-75.

FAO. (1994). General conclusions and recommendations of expert consultation on fats and oils in human nutrition. Food and Agriculture Organization.

Franco, W., Marchis, V., and Pozzi, M. 2023. Foot-Powered Machines, a Functional Taxonomy in the Age of Sustainability. Machines, 11(9), Article 9.

Gamal E, Radwan S, ElAmir M and ElGamal R 2009. Investigating the effects of moisture content on some properties of groundnut by the aid of digital image analysis. Food and Bio Products Processing, 87:273-281.

Gana, I. M., Ojo, O. O., Pius, U. B., and Ajagbe, O. T. 2022. Development of a groundnut decorticator with an aspiration cleaner. Intern. J. Vet. Sci. Agri. Res. 4(1):15-23.

Gitau, A. N., Mboya, P., Njoroge, B. N. K., and Mburu, M. 2013. Optimizing the performance of a manually operated groundnut (Arachis hypogaea) decorticator. Open J. Optimization, 2(1), Article 1.

Gitau, A. N., Mwithiga, G., and Kimani, S. T. 2013. Optimization of a mechanical groundnut decorticator. J. Engin. Appl. Sci. 8(2):112-119.

Helmy, M. A., Mitrroi, A., Abdallah, S. E., and Basiouny, M. A. 2012. Modification and evaluation of a reciprocating machine for shelling peanut. Misr J.

Agri. Engin. 29(2):605–624.
Hu, Z. C., Lv, X. L., Peng, B. L., Wu, F., and Yu, Z. Y. 2018. Optimization of the working performance of half-feeding peanut picking device based on response surface methodology. INMATEH Agricultural Engineering, 54(1):5.
Husain, M., Haq, Z. U., Mahmood, H. S., Jahanzaib, M., Islam, M. A., Niazi, B. M. K., Ali, M. M., Saad, A., Khan, A. A., and Nawaz, Q. 2024. Performance Evaluation of Precision Groundnut Digger-Inverter. Agric. Sci. J. 6(2):17–26.
Igira, E. 2018. Design and fabrication of a motorized groundnut shelling machine [Master's thesis, Busitema University].
Karthik, G., Balashankar, D., Rambabu, G., Nagabhushanam, B., Akhil, L., and Naidu, A. 2018. Design and fabrication of groundnut pods and shell stripper. Inten. J. Engin. Trends. Techn. 58(2):60-64.
Khambalkar, V. P.; Suman, Ritesh; Rathod; C. V. and Gangde; C. N. 2012. Assessment and requirement of farm mechanization: A case study. Indian Res. J. Ext. Edu., 12 (3):84-91.
Khan, A. A., Zia-Ul-haq, Asam, H. M., Khan, M. A., Zeeshan, A., Qamar, S., and Saad, A. 2024. Performance Evaluation of Half-Feed Rice Combine Harvester. Proceedings of the Pakistan Academy of Sciences: Part A, 61(1):81–88.
Krishnaprabu, S. 2019. Primary, I Mechanization Tools in Groundnut Cultivation. Vol. 1, edition 1.
Larson, E. A., Yamba, P., Akayeti, A., and Adu-Gyamfi, S. 2017. Design, manufacture and performance evaluation of an effective dual operated groundnut decorticator with blower. Intern. J. Mecha. Engin. Applica. 5(2):107-111.
Mishra, Soni and Mangla Mishra, A., Soni, R., and Mangla, J. 2009. Development of a low cost peanut decorticator for use in developing countries [Conference paper]. Synergy and Technical Development, Gödöllő, Hungary.
Moyana, B., and Mushiri, T. 2018. Design of an automated peanut butter making machine in developing countries. Proceedings of the International Conference on Industrial Engineering and Operations Management Pretoria / Johannesburg, South Africa, October 29-November 1:2018.
Nasir, A., Zia-Ul-Haq, Yasin, M., Iqbal, T., Ansar, M., Yaseen, G., Karim, F., Mirani, A. L., Saad, A., and Zaman, M. A. U. 2023. Testing of tractor mounted groundnut pods collector and its comparison with traditional method. Pure and Applied Biology, 12(1):342-348.
Nwankwo, E. I., Onyegirim, S. N. K., Owuama, K. C., and Onyenanu, I. U. 2025. Traditional vs. Modern Coconut Oil Extraction: A Systematic Review of Practices and Outcomes. IPS J. Engin. Techn. 1(2), Article 2.
Nwankwo, E. I., Onyenanu, I. U., and Utu, O. 2023. Performance evaluation of small-scale groundnut decorticators: A comprehensive review. Proceedings of the W. Intern. Conf. African Research and Development Studies, 32(2):85–102.
Nwankwo, E., Onyenanu, I., and Nwobi-Okoye, C. 2025. Bio-Based Brake Pads: A Review of Natural Fillers and Their Performance Characteristics. Intern. J. Appli. Natur. Scie. 3:81-97.
Nyaanga D. M., Chemeli M. C., and Wambua R. M. 2007. Development and testing of a portable hand-operated groundnut sheller. Egerton Journal, 7(5):117-130.
O. N. Bakoye, I. B. Baoua, H. Seyni, L. Amadou, L. L. Murdock, and D. Baributsa. 2017. "Quality of maize for sale in markets in Benin and Niger," J.

Stored Products Res. 71, 1: 99-105.

Otieno, P. M. 2009. Optimizing the performance of a manually operated groundnut (Arachis hypogaea) decorticator [PhD Thesis, University of Nairobi, Kenya].

Pachanawan, A., Doungpoueng, K., Muenkaew, P., Rayanasuk, K., & Srila, M. 2025. Design and performance evaluation of a propeller-based peanut sheller: efficiency and Economic Feasibility Analysis. Engin. J. 29(10):15-23.

Pinson, G. S., Melville, D. J., and Cox, D. R. S. 1991. Decortication of tropical oilseeds and edible nuts (National Resource Institute Bulletin No. 42). University of Greenwich.

Q. Sun, C. Wang, Z. Wang, Y. Zhao, and C. Bao 2017. "Design and Experiment of a Peanut Shelling Machine," Agricultural Research. 6(3):304-311.

Raghtate, A. S., and Handa, C. C. 2014. Design and fabrication of groundnut sheller machine. IJIRST – Intern. J. Inno. Res. Sci. Techn. 1(7):38–45.

Rai A. K, Kottayi S. and Murty S. N. 2005. A low-cost field usable portable grain moisture meter with direct display of moisture (%). Afri. J. Sci. Techn. Science and Engineering Series, 6(1):97–104.

Rajurkar, K. T., B. K. Joshi, B. D. Sherkar and H. P. Singh 2005. Post-Harvest Profile of Groundnut, Agricultural Marketing Information Network-AGMARKNET Report, Department of Agriculture and Cooperation, Government of India

Ravindra, A., Rohit, G., Saurav, A., and Khare, G. N. 2008. A review on design and fabrication of groundnut shelling and separating machine. Intern. Res. J. Engin. Techn. 4(10):1403-1406.

Reshma Kadlag, Pranav Pawase, Jagdish Khurdal and Narayan Gatkal 2022. Modification and performance evaluation of manually operated groundnut decorticator. The Pharma Innov. J. 11(2):36-41.

Saad, A., Haq, Z. U., Iqbal, T., Ansar, M., Alam, T., Islam, M. A., Ahmad, I., and Khan, A. A. 2026. Development and performance evaluation of peanut threshing machine. J. Tek. Agri. Faculty. 23(2):613–624.

Saad, A., Zia-Ul-Haq, Raza, S. M., Islam, M. A., Ahmad, I., Butt, S. J., Hussain, M., Sheraz, K., Khan, A. A., and Alam, T. 2024. Prospects and scope of groundnut mechanization: A review. J. Agri. Food, 5(1):53-68.

Saleh, A., Fashina, A. B., and Akande, F. B. 2022. Design, construction and performance evaluation of groundnut decorticator. FUDMA J. Sci. 6(1):93–101.

Shalini S, Akshata R, Chauhan S. Peanuts as functional food: a review. J. Food. Sci. Technol. 2016;53(1):31-41.

Shejole, K. M., Borkar, N. B., & Bobade, A. M. 2017. Design and fabrication of pedal operated groundnut decorticator machine. Intern. J. Modern Engin. Res. (IJMER), 7(3):12–15.

Shoko A. Z., and Mushiri, T. 2015. Design of an automated powered peanut shelling. Internet. 2021.

Sikha, S. L. 2024. Fabrication of a portable groundnut decorticating machine for domestic purposes. Available at ssrn 4990891.

Singh, Alka; Yadav, Rakesh Kumar and Singh, Dhananjai 2018. Efficacy of improved tools for farm women toward drudgery reduction and efficiency enhancement. Indian Res. J. Ext. Edu., 18 (3):32-37.

Sirichumpan, W., Idhipong, S., Sirichumpan, W., and Supama, Y. 2015. Research and development on Peanut. Department of Agriculture, Thailand.

Tang, H., Zhu, G., Wang, Z., Xu, W., Xu, C., & Wang, J. 2024. Prediction method for maize kernel impact breakage based on high-speed camera and FEM. Powder Technology, 444, 120002.

Thaddaeus, J. 2024. Development and optimization of palm nut cracking and separating machine. J. Res. Engin. Appl. Sci. 9(1).

Ugwuoke I. C., Okegbile O. J., and Ikechukwu, I. B. 2014. Design and fabrication of groundnut shelling and separating machine. Intern. J. Engin. Sci. Inven. 3(4):60-66.

W. Liao, H. Xie, Z. Hu, J. Wang, M. Liu, J. An, H. Wei, and H. Zhang. 2024. "Peanut-Shelling Technologies and Equipment: A Review of Recent Developments," Agriculture. 14(7):1-26.

Walke T, Gadge P, Gohate G and Banpurkar R. 2017. Design and fabrication of groundnut sheller machine. Intern. Res. J. Engin. Techn. 4(3):1606–1610.

Zerbato, C., Furlani, C. E., Oliveira, M. F. D., Voltarelli, M. A., Tavares, T. D. O., and Carneiro, F. M. 2019. Quality of mechanical peanut sowing and digging using autopilot. Revista Brasileira de Engenharia Agrícola e Ambiental, 23:630–637.