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ORIGINAL ARTICLE

Design, Development and Performance Testing of Hand Operated Groundnut Decorticator

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ABSTRACT

In Lake Tana, Ethiopia, influx of nutrients has resulted in excessive growth of water hyacinth (WH) in the last decades, which has also caused economic and environmental problems. Although enormous labor and financial resources used to control this overgrowth, these were still not enough to suppress the excessive growth of WH. This study examines the design, development and performance evaluation of a wooden groundnut decorticator designed for small-scale rural farmers. Groundnut, a vital legume crop, is widely cultivated in tropical regions, offering significant nutritional and economic value. However, traditional hand-shelling methods in Ethiopia are inefficient, labor-intensive, and lead to health issues like "sore thumb syndrome." The objective of this research is to design, develop prototype and performance test of groundnut decorticator. The decorticator was constructed using timber, wire mesh, and paddle mechanism that operated manually for shelling the groundnuts. Performance tests were conducted using various input amounts (1, 1.5, and 2 kg), and key parameters such as shelling percentage, damage percentage, unshelled nuts, and shelling efficiency were recorded. Results showed an average shelling percentage of 92%, the damage rate of 4%, and efficiency of 15 kg/hr, which is higher than traditional hand-shelling of 3 kg/hr (from experts' opinion).

The findings indicate that moderate input quantities of groundnuts yield the best balance of shelling performance. The wooden decorticator, constructed from affordable, local materials, presents a valuable tool for rural farmers, saving time, reducing labor, and enhancing productivity. Further modifications could explore motorization for larger-scale use.

Keywords: Groundnut, Decorticator, groundnut Decorticator, performance test, Shelling efficiency, Shelling Percentage.

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1. INTRODUCTION

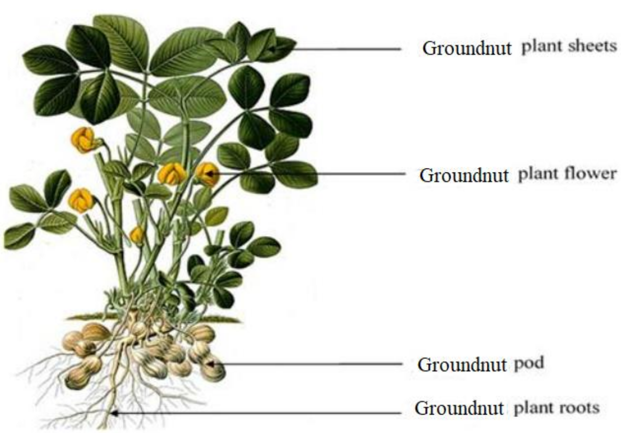
1.1BACKGROUND AND JUSTIFICATION

The groundnut, also known as peanut, is a significant legume crop in tropical and semi-arid tropical regions, where it serves as a key source of vegetable protein and edible oil. Groundnut is one of the world's leading food, cash, and rotational crops and cultivated throughout the world. It is among the most important foods in international trade.

Groundnut kernels are composed of 47-53% oil and 25-36% protein The crop is grown between latitudes 40ºN and 40ºS. As a self-pollinating plant, its flowers bloom above ground, and after fertilization, the pegs penetrate the soil where seed-filled pods develop underground. Groundnut yields differ widely, in the USA producing about 3500 kg/ha, South America 2500 kg/ha to less than 800 kg/ha Africa (Prasad et al., 2010).

Groundnut unshelled seed production and productivity in the world during 2006 is 47,768,244 tonnes and 2148.66 kg/ha, while in Africa this figure was 8,967,410 tonnes and 1019.43 kg/ha and in Ethiopia it was 34,529 tonnes and 1228.18 kg/ha (FAO, 2008).

It is easy to grow, because it withstands drought to some extent and so a choice crop for dry farming. It is soil erosion resistant crop, and being a legume crop, it can fix atmospheric nitrogen, thus maintains soil fertility. All parts of this plant can be commercially used. The plant stalks are fed to cattle in the form of green, dried and silage. Groundnut shell, haulms, and hay are good fodder. Groundnut cake is a good feed for livestock and it is also used as manure. Groundnut can be consumed in many ways and various forms. Primarily used as a vegetable cooking oil. Kernels are used directly as food or snacks for human consumption. A large number of food products are prepared from groundnuts - Boiled nuts, roasted nuts, salted nuts, groundnut milk, groundnut yogurt, groundnut bars, groundnut butter, groundnut cheese, and bakery products etc. It is an important cash crop of rain-fed areas.



(a) **(b)**

Figure 1. (a) Groundnut plant and (b) groundnut pods and seeds

Different decorticating machines have been developed and tested in different parts of the world. For example, Asuako L. et al., (2017) deisined and manufacture an dual operated groundnut Decorticator a feed rate of 25kg/hr in Nigerai? They found that the performance efficiency of 32% . similarly, A. N. Gitau. Et al., 2013 d, from Kenya developed manually operated groundnut decorticator with a feed rate of 30 kg/hr and obtained maximum shelling efficiency of 88.73% can be achieved with percent damage of 4% ,

In Ethiopia shelling groundnut in smallholder sector is predominantly done by hand. While hand shelling keeps the rate of kernel breakage low, it is labour intensive and leads to "sore thumb syndrome" when large quantities of groundnuts are handled. The low productivity (1-3 kg/hour) of hand shelling puts enormous pressure on farmers, because they need to shell their groundnuts before the marketing season ends. It is, therefore, important to search for a simple, efficient, low-cost machine to replace hand shelling. Thus, objective of the study is to construct and test the performance of wooden groundnut decorticator for the small-scale rural groundnut producing farmers.

2. MATERIAL AND METHODS

2.1 MATERIALS USED

The materials used for constructing the decorticator include timber, pegs, wire mesh and nails, Two halve circle timbers of each 1m diameter, 2cm thickness , with openings of 2cm diameter at about 10cm below from the center of the radius of the circle (horizontal edge) of circle timber; paddle (handle) with 80cm length, 4cm width, 3cm thickness and 2cm diameter opening at 50cm, from the top; a wire mesh with opening size of $1cm^2$; four wooden legs with length 80cm, thickness 3cm, and 4cm width.

The other mataerials used of the podes were weighting balance to measure the weight and callipers to measure their length. The axial length of the pods ranged from 20mm – 26mm, and width ranged 8mm – 16mm .

2.2 CONSTRUCTION OF THE DECORTICATOR

The groundnut decorticator was constructed at Bahir Dar TVET woodwork shop. The components were joined in such a way that the two half circle timbers are connected at a width of 20cm to each other using pieces of timber of 25cm length and 1cm thickness and nail at an interval of 25cm on the circular side of the two half circle timbers and forming a volume of halve circle. Then the four legs made of wood of 80cm length and 4x4cm width and 2cm thickness were attached with nails to the two half circles to be used as stand. Then the wire mesh is attached to the lower side (on the half circle side) using nail. The paddle (handle) was placed between the two half circle timbers such that a pipe was inserted from one side of the timber through the paddle to the other end of the timber. The bottom end of the paddle was connected with threshing unit of the paddle with bolt and nuts with 1cm clearance from the wire mesh in a way that it can be lowered and raised to adjust the clearance against the wire meshbased on the size of the groundnuts to reduce kernel breakage. Pegs of 1cmx1cm with 1cm thickness were attached to the bottom surface of the threshing unit.

2.3 OPERATION PROCEDURE

Before shelling can proceed, the groundnuts should be air dried as local trend to lower moisture content. The decorticator is operated by one person, moving the handle of the decorticator back and forth. Groundnut was placed in the decorticator and the paddle wwas pushed against the resistance provided by the pods, thereby shelling them. The broken shells and kernels fall through the wire mesh into a container placed under the base.

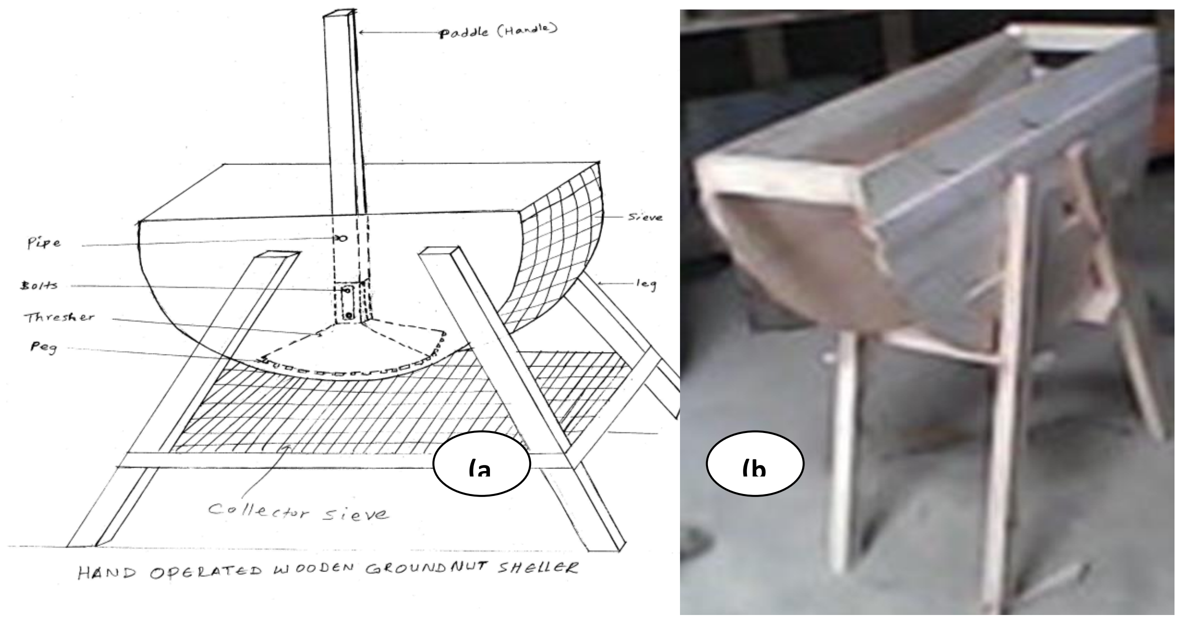


Fig 1: (a) Drawing for groundnut decorticator, (b) photo of the groundnut decorticator during construction

Atotal of 20kg of groundnut pods was bought for this purpose. The decorticator was filled with feed rate of 1, 1.5 and 2 kg of unshelled groundnut pods with specific moisture content and shelled until the decorticator is empty and the total time (t) spent to finish was determined. The feed rates were determined to make the shelling easier for children and women. The weight of pods that were completely shelled and unbroken (W_1), completely shelled but broken (W_2), and unshelled pods (W_3) were determined at the end of each run. At a combination of each of the above conditions, the test was replicated three times and the data was collected as follows.

Once these data were collected (table-1), then the performance of the decorticator was evaluated on the basis of the following indexes. The average weights were taken to evaluate the machine's performance.

1. **Shelling percentage (S_p)** and **efficiency (S_e):** This is the percentage of total shelled groundnuts (both unbroken[W1] and broken [W2]) relative to the weight of input (Wt).

   $S_p = (W_1+W_2)/W_t * 100$

   $Se = (W_1+W_2)/t$, where t is the shelling time

2. **Unshelled percentage (Su):** This represents the percentage of groundnuts that remain unshelled after the process.

   Su = 1 - Sp:

3. **Percentage damage(P_d):** This is the percentage of broken shelled groundnuts(W2) relative to the input weight(Wt)

$P_d = W_2 / W_t * 100$

3. RESULT AND DISCUSSION

3.1 PERFORMANCE TEST AND EVALUATION

Once these data were collected (table-1), then the performance of the decorticator was evaluated on the basis of the following indexes. The average weights were taken to evaluate the machine's performance.

Table 1 The table below shows the performance of the machine using different performance indicators

Trials	Amount added (Wt)(Kg)	Replication	Average Shelled (Kg)			Average					
			Shelled unbroken (W1) (Kg)	Shelled but broken (W2) (Kg)	Total shelled (W1+W2) (Kg)	Weight of Unshelled (W3) (Kg)	Shelling Time (minute)	Shelling percentage (S_p) = $(W1+W2)/W_t*100$	Unshelled percentage S_u= 1 -	Percentage damage (Pd) = W2/Wt*100%	Shelling efficiency (S_e): S_e = $(W_1+W_2)/t$ (Kg/hr)
1	1	3	0.83	0.13	0.96	0.05	3	96	5	13	19
2	1.5	3	1.39	0.02	1.41	0.09	5	94	6	1	17
3	2	3	1.76	0.02	1.78	0.22	9	89	11	1	12
Average	**1.5**	**3**	**1.33**	**0.06**	**1.38**	**0.12**	**5.67**	**92**	**8**	**4**	**15**

This table provides a detailed analysis of the performance of groundnut shelling over three trials, focusing on the weight added, the calculated metrics including shelling percentage, unshelled percentage, damage percentage, and shelling efficiency. The key findings regarding the efficiency and effectiveness of shelling groundnuts across different input quantities are as follows:

Shelling Percentage: On average, 92% of the groundnuts were successfully shelled, with a slight decrease in shelling percentage as the input weight increased. This suggests that while the shelling process is generally effective, its efficiency diminishes slightly with larger amounts of groundnuts.

Unshelled Percentage: A small but notable percentage of groundnuts (8% on average) remained unshelled, with higher unshelled percentages observed as the input weight increased. This indicates that larger batches lead to a slightly less effective shelling process.

Percentage Damage: The percentage of broken (damaged) nuts was relatively low, averaging 4%. Trial 1 had the highest percentage of broken nuts (13%), likely due to the smaller batch allowed fast movement of the paddle which inturn may have increased breakage while reducing the shelling time . In contrast, Trials 2 and 3 showed only 1% breakage, reflecting a more careful process when handling larger quantities.

Shelling Efficiency: The shelling efficiency, measured in kg/hr, decreased as the input weight increased. Trial 1 had the highest efficiency at 19 kg/hr, while Trial 3, with the largest input weight, had the lowest efficiency at 12 kg/hr. This indicates that the shelling process becomes slower and less efficient as the quantity of groundnuts increases.

The average shelling efficiency of the machine was determined to be 15kg/hr while manual shelling is about 3kg/hr. Therefore, this machine is beneficial for farmers in two way; the first benefit is that it is constructed from locally available materials at least cost and the other benefit is that it saves the time that would be lost shelling the nuts. It also highly reduces the work load of women and children as shelling is considered to be women and children's work.

Generally, the results suggest that for optimal shelling performance, moderate input quantities (around 1–1.5 kg) yield the best balance between high shelling percentage, low damage, and high efficiency. Larger input quantities tend to decrease both the shelling percentage and efficiency, while increasing the unshelled and damaged nut percentages.

4. CONCLUSION AND RECOMMENDATION

4.1CONCLUSIONS

The groundnut shelling experiment highlights several key trends regarding shelling efficiency and effectiveness across different input weights. The average shelling percentage was 92%, with a slight decrease as the input weight increased, suggesting that larger quantities result in slightly less effective shelling. The unshelled percentage averaged 8%, which increased with the input weight, indicating reduced efficiency for larger batches. Damage to nuts was minimal, averaging 4%, with Trial 1 exhibiting the highest damage (13%), likely due to the faster shelling process for smaller batches. Shelling efficiency, measured, decreased as the input weight increased, from 19 kg/hr in Trial 1 to 12 kg/hr in Trial 3. This suggests that the shelling process becomes slower and less efficient with larger input quantities. The machine's efficiency of 15 kg/hr, compared to the manual rate of 3 kg/hr, offers many benefits to farmers, including reduced time spent shelling and alleviating the workload, especially for women and children who traditionally perform the task.

Overall, the results indicate that moderate input quantities (around 1–1.5 kg) provide the best balance of shelling percentage, minimal damage, and high efficiency. Larger quantities reduce shelling effectiveness and efficiency while increasing the unshelled and damaged nut percentages.

4.2 RECOMMENDATION

This machine is mainly designed to be used at household level but for large farms further research is needed to modify it in to motorized machine.

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