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Modification and performance evaluation of manually operated groundnut decorticator

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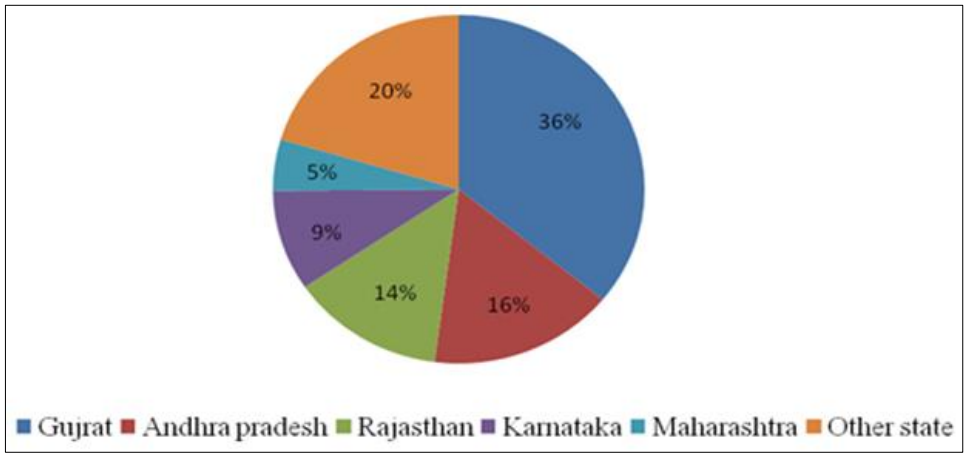
Abstract
The groundnut is one of the major products across the fertile lands of India. But the major problems faced during agriculture are at the stage of processing the products due lack of machines and technologies. Presently, groundnut is decorticated by manually operated groundnut decorticator which consumes more time and less effective. The blower/fan was design and developed to eliminate the limitations in existing groundnut decorticator and to reduce the time consumption for winnowing operation of decorticated groundnut. The Developed groundnut decorticator was tested in laboratory in terms of decorticating capacity, percentage of broken kernel and un-decorticated or partially decorticated kernels, total grain loss, decorticating efficiency and cleaning efficiency. The decorticating capacity of the modified groundnut decorticator was observed in the range of 50.12-53.75 kg/h. The percentage of broken grain and undecorticated or partially decorticated grain in modified decorticator was observed in the range of 13.95-14.80, 0.83-0.91 per cent respectively. The decorticating efficiency and cleaning efficiency of modified groundnut decorticator were observed in the range of 99.11-99.20 and 71.62-77.34 per cent respectively. The total grain loss of modified groundnut decorticated was observed in the range of 19.44-23.56 per cent.

Keywords: Groundnut, groundnut decorticator, decorticating efficiency, cleaning efficiency

1. Introduction
Groundnut (*Arachis hypogeae*) is the most important oilseed crop in the world. It contains 48-50 per cent oil and 26-28 per cent protein. Groundnut is rich source of dietary fibre, minerals and vitamins. It grows best on soils that are well drained, loosely textured and well supplied with calcium, potassium and phosphorous. Over 100 countries worldwide grow groundnut (Pankaj *et al.*, 2018) [4]. In kharif-2018 all India groundnut coverage area was 38,90,000 hectares. The major groundnut growing states in India are Gujarat, Andhra Pradesh, Rajasthan, Karnataka and Maharashtra.



(**Source:** Kharif-2018 Survey of groundnut crop by directorate of economics and statistics, government of India)

Fig 1: Groundnut production in five major states

Decortication is one of the most important post harvest operation in groundnut production process. Decortication basically meant for separation of kernels from the pods.

Groundnut constitutes about 38 per cent of postharvest cost (Butts *et al.*, 2009) [3]. The effectiveness in the decortications process is depends on more shelling capacity with least damage to kernels. Presently, the decortication operation done by manually, by manually operated groundnut decorticator and by motorized groundnut decorticator. The separation of kernel from the pod by manually is quite time consuming, laborious and drudgeries operation. Many farmers are using manually operated groundnut decorticator for removal of the kernel from pods. But in this type of decorticator only decortications process is done, the cleaning operation is not perform by that machine. For cleaning operation winnowing operation is done and it require more time for cleaning.

Groundnuts are produced in the farms largely in the south-east and mid-south region of the nation. The main issue regarding groundnut is to remove its shell. The manually operated groundnut decorticator (Fig. 2) is widely used in all over in India, mainly in rural region. This decorticator shell the groundnut but the hull is also mixed with the kernels, for this the winnowing operation done to remove the hull from the kernel it require more time and labour. The manually operated groundnut decorticator has no adjustment of cleaning. It require more time for cleaning. To overcome this problem modification in existing manually operated groundnut decorticator is necessary. The entire modification includes the design of blower for this decorticator, which able to separate the hull from kernels.

Fig 2: Existing manually operated groundnut decorticator

2. Material and Methods

2.1 Design of blower

a) Terminal velocity of husk

The following formula is used to calculate terminal velocity of husk (Akindele *et al.*, 2017).

$$v = \sqrt{\frac{2 \times m \times g}{p \times A \times C}} \quad \text{------ (1)}$$

Where
V = Terminal velocity of husk, (m/s)
m = mass of groundnut husk, (g)
g = acceleration due to gravity, (m/s^2)
p = density, (kg/m^3)
C= drag coefficient

b) Air flow rate of blower

The following formula is used to calculate air flow rate of blower (Akindele *et al.*, 2017).

$$Q = V \times A_d \quad \text{------ (2)}$$

Where
V is the velocity of flow in m/sec.
A_d is the area of the discharge duct in mm^2.

$$V = \sqrt{p \times 2g} \quad \text{------ (3)}$$

Where
p - Dynamic pressure of the blower
g - Acceleration due to gravity (9.81 m/s^2)
Hence the diameter of blower is 300 mm, and blower opening diameter is 65 mm, which is mounted on metallic frame having height 215 mm from ground surface, width and length 240 mm. It is operated with DC motor of 0.5 hp with 2800 RPM. Motor works on 240 Volt. Was selected for modification purpose.

c) Discharge chute

The discharge chute is of rectangular shape having dimension 510×270 mm, and inclined at angle 85^o from main frame.

d) Air Chest

Design of air chest

The air chest is trapezoidal shape with the specification 500 mm top width, 90 mm bottom width and 540 mm height. Fig. 3 shows the Modified manually operated groundnut decorticator. Table 1 shows the specifications of modified groundnut decorticator. Fig. 4 shows the isometric and sectional views of modified groundnut decorticator.

Table 1: Specification of modified groundnut decorticator

Sr. No.	Name of component	Material	Specification (mm)
1.	Main frame	MS angle	500×450×600
2.	Concave sieve	MS angle	825 × 275
3.	Decorticating leaver	MS plate	750 × 40
4.	Connecting rod	MS angle	L = 280, D = 25
5.	Decorticating beaters	Cast iron	200 × 50
6.	Air chest	MS sheet	L = 400, W = 500, H = 540
7.	Blower	Cast iron	D=300
8.	Discharge chute	MS sheet	510 × 270

Fig 3: Modified manually operated groundnut decorticator

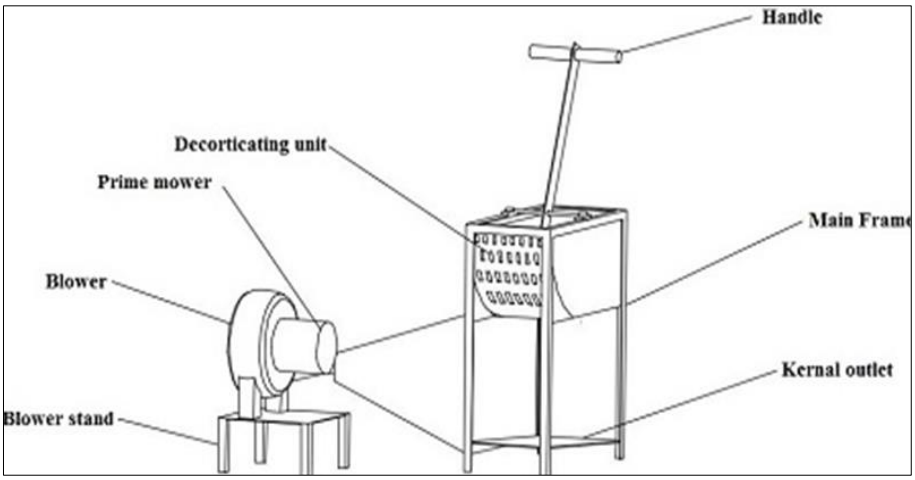


Fig 4(a): Isometric view of modified manually operated groundnut decorticator

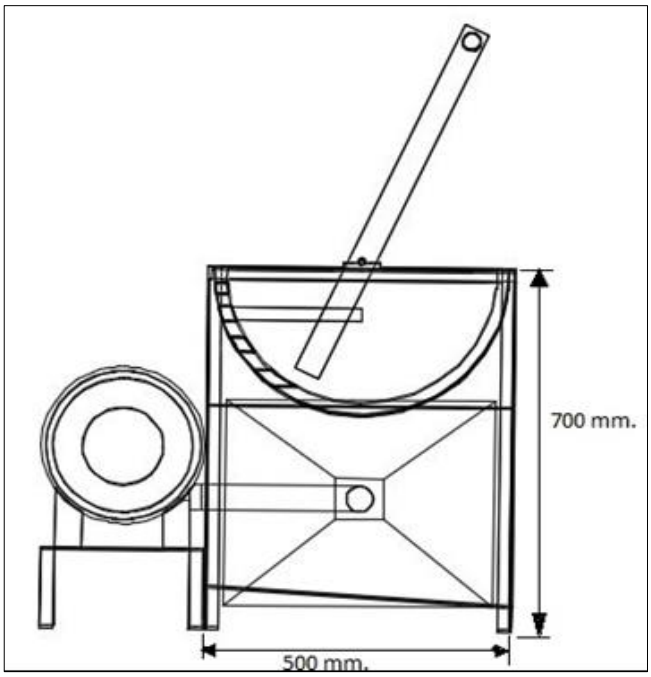


Fig 4(b): Side View

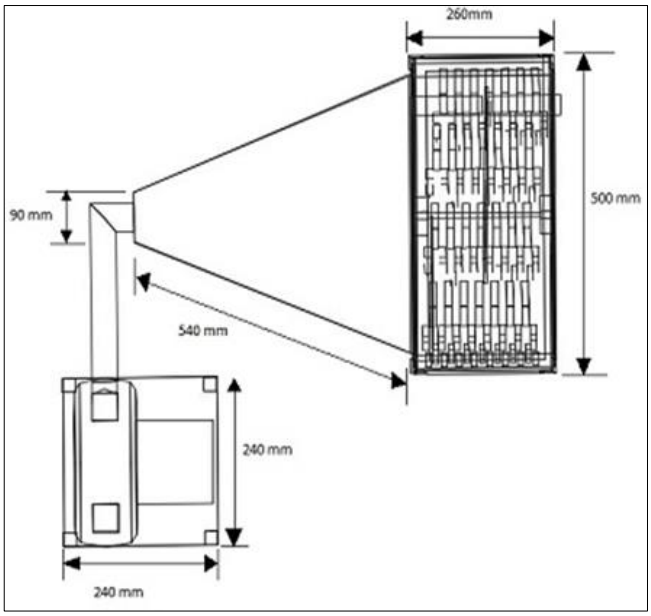


Fig 4(c): Top View

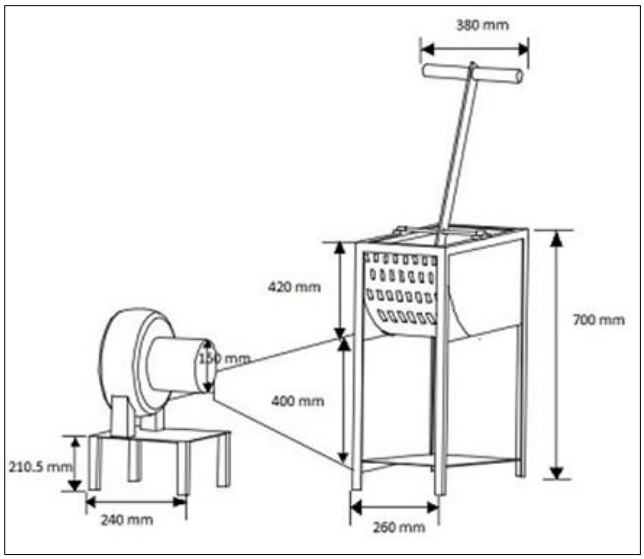


Fig 4(d): Isometric view

2.2 Performance evaluation of modified manually operated groundnut decorticator

The performance of groundnut decorticator was carried for dry groundnut pods. Before decorticating the moisture content of pods was determined. The decorticating operation was perform in batch. The amount of pods decorticated per hour, damage percentage, decorticating efficiency was determined by formulae given below. The following crop parameter was recorded.

2.2.1 Crop parameters

a. Name of the crop
b. Variety of crop
c. Grain hull ratio

The grain hull ratio is calculated by following formula

$$\text{Grain hull ratio} = \frac{\text{Total weight of hull}}{\text{Total weight of clean grain}} \times 100 \text{ ---------- (4)}$$

d. Length of pod

The length of pods were calculated by using venire caliper as shown in Fig. 5.

e. Diameter of pod
The diameter of pods were calculated by using venire caliper as shown in Fig. 6.

f. Length of kernels
The length of kernels were calculated by using venire caliper as shown in Fig. 7.

g. Diameter of kernels
The diameter of kernels were calculated by using venire caliper as shown in Fig. 8.

h. Moisture content of kernel (per cent)
Moisture content of kernel is determined by oven drying method as described in ASABE (1982) standards. The groundnut kernels were put inside the oven at 105 ^{0}C for 24 hours for determination of moisture content. Before putting the kernel inside the oven, the weight of the kernel is taken. Then after 24 hours, the dried kernel is taken out of the oven and weighted again. The moisture content of the groundnut kernel is calculated.
Moisture content is calculated by using following formulae (Dr. J. Sahay, Element of Agricultural Engineering)

$$\text{MC wet basis (wb)} = \frac{\text{Weight of moist kernels} - \text{Weight of dry kernels}}{\text{Weight of total kernels}} \times 100 \text{ ….. (5)}$$

$$\text{MC dry basis (db)} = \frac{\text{Weight of moist kernels} - \text{Weight of dry kernels}}{\text{Weight of total kernels}} \times 100 \text{ ------- (6)}$$

i. Moisture content of hull (per cent)
For determination of moisture content of hull same procedure was adopted as described in ASABE (1982) standards.

$$\text{MC wet basis (wb)} = \frac{\text{Weight of moist hull} - \text{Weight of dry hull}}{\text{Weight of total kernels}} \times 100 \text{ --------- (7)}$$

$$\text{MC dry basis (db)} = \frac{\text{Weight of moist hull} - \text{Weight of dry hull}}{\text{Weight of total hull}} \times 100 \text{ ---------- (8)}$$

Fig 5: Measurement of length of pod

Fig 6: Measurement of diameter of pod

Fig 7: Measurement of length of kernel

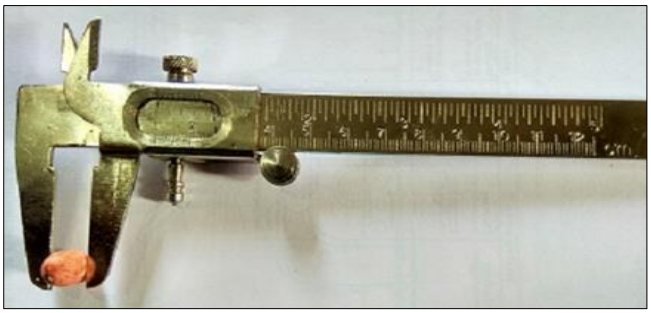


Fig 8: Measurement of diameter of kernel

2.3 Performance parameters of modified manually operated groundnut decorticator
The performance of modified manually operated groundnut decorticator was carried for groundnut. The capacity of decorticator, percentage of broken grains, percentage of undecorticated and partially decorticated grain, percentage of clean grain obtained at chaff, percentage of sieve loss, total grain loss, cleaning efficiency and decorticating efficiency was determined by formulae given below.

a) Capacity of decorticator (kg/h)
The Capacity of decorticator is calculated by using following formula (Groundnut Decorticator Test code 11473: 2002)

$$\text{Capacity of decorticator } \left(\frac{\text{kg}}{\text{h}}\right) = \frac{\text{Total quantity of groundnut fed}}{\text{Time}} \text{ …… (9)}$$

Percent of broken grain
The percent of broken grain is calculated by following formula (Groundnut Decorticator Test code 11473:2002).

$$\text{Pc} = \frac{\text{qc}}{\text{Gt}} \times 100 \text{ ---- (10)}$$

Where
Pc = Percent of cracked/broken grains (kg)
qc = Quantity of cracked grain obtained (kg)
Gt = Total grain received at grain outlet (kg)

b) Percentage of undecorticated or partially decorticated grain
The percentage of undecorticated or partially decorticated grains are calculated by following formula, (Groundnut Decorticator Test code 11473: 2002)

$$\text{Pu} = \frac{\text{qu}}{\text{Gt}} \times 100 \text{ ---------- (11)}$$

Where
Pu = Percentage undecorticated and partially decorticated grain
Qu =Quantity undecorticated and partially decorticated of grain obtained from chaff (kg)
Gt = Total grain received at grain outlet (kg)

c) Total grain loss (%)
Total grain loss is determined by following equation,

Total grain loss *TL* (%) = *Pu* + *Pc* ---------- (12)

d) Decorticating efficiency (%)
The decorticating efficiency is the fraction of pods decorticated to the pods fed by weight as percentage. (Groundnut Decorticator Test code 11473:2002).

e) Percentage of clean grain obtained at chaff
The percentage of clean grain obtained at chaff is calculate using following formula, **(**Groundnut Decorticator Test code 11473:2002)

$$Pl = \frac{ql}{Gt} \times 100 \quad \text{---------- (13)}$$

Where
Pl = Percentage of clean grain obtained at chaff outlet, (per cent)
ql = Quantity of clean grain obtained at chaff outlet (kg)

f) Percentage of sieve loss
The percentage sieve loss is calculated by using formula given in test code. (Groundnut Decorticator Test code 11473:2002)

$$Ps = \frac{qa}{Gt} \times 100 \quad \text{---------- (14)}$$

Where
Ps = Percentage of sieve loss (per cent)
qa = Clean grain at sieve over flow + sieve under flow + stuck grain (kg)

g) Total grain loss (per cent)
Total grain loss is determined by following equation,

Total grain loss TL (%) = Pu + Pc + Pl + Ps ---------- (15)

h) Decorticating efficiency (per cent)
The decorticating efficiency is the fraction of pods decorticated to the pods fed by weight as percentage. (Groundnut Decorticator Test code 11473:2002).

i) Cleaning efficiency
The cleaning efficiency was calculated by following formula,

$$CE = \frac{Gc}{Gt} \times 100 \quad \text{..... (16)}$$

Where
Gc = clear seed received at grain outlet (kg)
Gt = Total grain received at grain outlet (kg)

Fig 10: Performance evaluation of modified manually operated groundnut decorticator

Fig 11: Fraction of clean grain, broken grain, hull and undecorticated pods

3. Result and discussion
Different experiments were conducted in the laboratory to evaluate the performance of the modified groundnut decorticator.

3.1 Performance evaluation of modified manually operated groundnut decorticator
The crop parameters considered are kernel-hull ratio, length of pod and diameter of pod also the length and diameter of kernels. The crop parameters are shown in Table 2. The kernel-hull ratio of selected samples were in the range of 3.66-3.78.The length and diameters of pods was observed in the range of 19.21-28.35 and 12.15-15.20 respectively. The length and diameter of kernel was observed in the range 13.15-15.31 and 5.38-7.53 respectively. The moisture content of kernel and hull of selected sample were in the range of 8.46-9.24 and 10.09-11.23 respectively.
The capacity of groundnut decorticator was observed in the range of 50.12 - 53.75 kg/h. The percentage of broken kernel, undecorticated and 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 is shown in Table 3.

Table 2: Details of selected crop parameters

Sr. No.	Parameters	Range
1.	Name of crop	Groundnut
2.	Varity of crop	CO-6
3.	Kernel- hull ratio	3.66-3.78
4.	Length of pods, mm	19.21-28.35
5.	Diameter of pods, mm	12.15-15.20
6.	Length of kernels, mm	13.15-15.31
7.	Diameter of kernels, mm	5.38-7.53
8.	Moisture content of kernel, %	8.46-9.24
9.	Moisture content of hull, %	10.09-11.23

Table 3: Details of performance parameters of manually operated modified 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.	Undecorticated 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

4. Conclusions

Decortications is one of the important post-harvest operations in groundnut production process. Traditional shelling methods do not support large- scale shelling of groundnut, especially for commercial purposes. This practice usually takes a lot of time; causes great damage to kernels and does not separates kernels from the husk. Hence this study was initiated to modify and evaluate groundnut decorticator that would be affordable by farmers and decrease damage and loss of groundnut kernel during decorticating. Manually operated decorticators have no facility to separate kernels and husks hence consume more time and labour cost for separation of husk by traditional winnowing method. Whereas modified groundnut decorticator with blower have these facilities and also affordable to the most of the marginal and small farmers due to their low cost of construction.

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