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Performance evaluation of a pongamia decorticator

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■ **ABSTRACT :** A study was undertaken to develop a prototype for decortication of pongamia pods. One of the most tedious operations in processing of pongamia pods is the decortication or shelling operation. However, moisture content normally affects the handling and processing, such as decortication/shelling. This study was conducted to determine the effect of moisture content on decortication efficiency of pongamia pods using a rotating corrugated drum and stationary concave plate arrangement. A bulk quantity of well dried pongamia pods was obtained from the local village near Tumkur, Karanataka, and this bulk was divided into two groups namely, graded (A) and ungraded (B) samples. These groups were prepared for conditioning by spraying of ordinary water on pods at room temperature by spreading them in a thin layer. After conditioning, the pods were spread out in a thin layer to dry in natural air for about eight hours, to obtain different level moisture content. Moisture content of each sample was determined by oven drying at 105ºC for 24 h. The moisture content levels were found to be 7.5 and 10 per cent (w.b.) for samples A and B, respectively. The samples were subjected to impact and shearing force while passing through the clearance between concave plate and the corrugated drum. The machine operating at an angular velocity of 250 r.p.m., using two different machine clearances. Data obtained on the percentage of kernel damage, percentage of decortication efficiency and capacity of the machine (kg/h), were statistically analysed. Results showed that moisture content and machine clearance have a significant effect on these performance indices. The most effective performance was obtained at moisture content 7.5 per cent (w.b.), at which means of decorticating efficiency, percentage of kernel damage and capacity for sample A and B were 93.36 per cent, 16.97 per cent, 118.70 kg/h for 8 mm clearance and for 9 mm clearance 84.52 per cent, 14.93 per cent, 122.56 kg/h, respectively. The study further showed that development of pongamia decorticating machine with winnower would eliminate the tediousness of the present manual pod cracking methods.

■ **KEY WORDS :** Pongamia pods, Decortication efficiency, Moisture content, Machine clearance, Capacity, Corrugated drum

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Pongamia (*Pongamia pinnata* L.) is tree borne oil seed (TBO's) belonging to the family Fabaceae. This medium size tree is indigenous to the Indian sub continent and south-east Asia, and has been successfully introduced to humid tropical regions of the world as well as parts of Australia, New Zealand, China and United States (Anonymous, 2007). In India pongamia is having a overall area of about 3 million ha, with the production of 2 lakh MT seeds. The seeds are largely exploited for extraction of non-edible oil commercially known as "Karanja oil" which is well recognized for its fuel, medicinal properties and also used as a lubricant, water-paint binder, pesticide and soap making and tanning industries. The yield of fruit varies from 9 to 90 kg per tree for different age trees. There is no systematic organized collection of seeds. Mature seeds consist of 95 per cent kernel and are reported to contain about 27 per cent oil. The yield of oil is reported to be about 24 to 26.5 per cent if mechanical expellers are used for the recovery, but it is only 18-22 per cent from indigenous village crushers. The crude oil is yellow orange to brown in colour which deepens on standing. It has a bitter taste and disagreeable odour, thus, it is not considered edible.

The decortication is one of the most important post harvest operations that decide the quality of seeds. Generally the pongamia kernels are taken out from the pods by cracking the shell by beating action. By this method the output per man hour is very low, resulting in high cost of shelling and also high human fatigue. Many a time the farmers sell out undecorticated pongamia getting lower returns compared to the decorticated. Mechanical decortication (shelling) using manual and power operated decorticator is in practices, which help in saving time, money and labour. But improper shelling methods cause mechanical damage to seeds. The rupturing of seed coat is a major damage in mechanical decortication, which reduces viability and storability of seeds. Conditioning of pods by reduction of moisture to 10 per cent or less and grading before mechanical decortications are done to keep the percentage of damage of the kernels to a minimum extent.

Pradhan *et al.* (2008) evaluated some moisture dependent physical properties of pongamia kernel. The physical properties of karanja kernel were evaluated as a function of moisture content in the range of 8.56 to 22.22 per cent (d.b.). Arora and Sehgal (1987) investigated the effect moisture content on physical properties of some important varities of four oil seeds, namely: gobi sarson, toria, raya and linseed. According to Akani *et al.* (2000) research is concentrated only on the agronomic aspect, while the processing aspects have been neglected. The pod of groundnut is very hard and the cracking methods are still traditional. These cracking methods vary from locality to locality depending on the quantity produced. Some communities use mortar and pestle to cursh the dry pods. Some beat them with sticks on flat ground; others use stones to crush pods on the flat grounds. These methods have the disadvantage of damaging the seeds, and are slow. Pinson *et al.* (1991) worked on the decortication of tropical oilseeds and edible nuts. The recovery of seed kernels from balanites nuts, cashew nuts, cotton seeds, macadamia nuts and sunflower seeds was described.

■ METHODOLOGY

A bulk quantity of pongamia pods was purchased from a local farmer in Chikkadalwata, Tumkur, Karnataka. The pods were cleaned and sampled for experiment. The moisture content of the pods was varied using the method USDA (1970) then the bulk quantity of the pods were spreaded in a thin layer for conditioning by spraying ordinary water at room temperature. Another bulk quantity of pods was retained at the stable storage moisture content as a control sample. After conditioning the pods were spread out in a thin layer to dry in natural air for about eight hours. The pods were then sealed in marked polyethylene bags and stored in that condition for a further 24 hrs. This enabled stable and uniform moisture content of the pods to be achieved in the bags. The moisture content of each sample was determined using the method described by USDA (1970).

Fig. A shows the orthographic drawing of the pongamia pod decorticating machine. The machine consists of mild steel (M.S.) frame, hopper, MS drum in the corrugated form and a concave plate made of alluminium. The drum diameter is 170 mm and length of 150 mm. the MS flat measuring 12 mm width and 3 mm thick was welded together all along the circumference of the drum in a corrugated form. The pitch between the two corrugation were maintained at 20 mm. A stationary concave plate of length 190 mm was mounted parallel to the drum. The clearance could be easily adjusted between the drum and the stationary concave plate by moving the concave plate. The shaft of the drum is made to

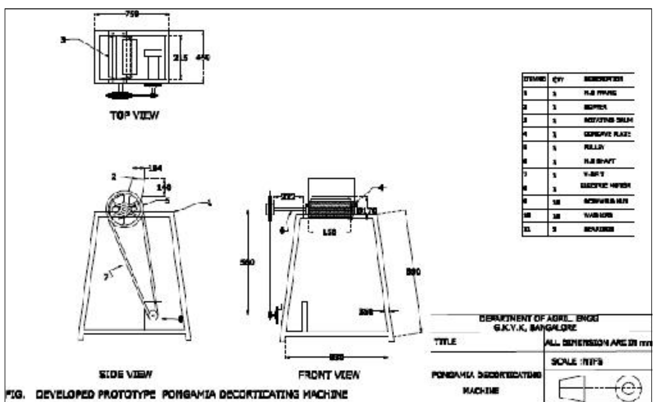

Fig. A : Orthographic drawing and parts list of the pongamia decorticating machine

rotate by means of V-groove pulley. Hopper is having the dimension of 140 × 104 mm. The pods were fed from the top of the hopper to pass through the clearance between drum and concave plate. The kernels were separated from the pods due to the shearing and impact forces. A variable speed motor is selected to carry out the decortication process at 250 r.p.m., through a belt and pulley system.

To carry out the performance tests, 100 pods were randomly selected and weighed in case of both sample A and B. These pods were poured into the hopper while the pods flow control was completely closed. The main power supply was switched on; as the drum attained the operating speed, the pod flow control was opened to allow the pods to flow into the eye or clearance between the concave plate and corrugated drum. These pods were carefully collected after going through the unit, and the weight of shelled pods in grams (N_1), weight of total pods fed in grams (N_{TP}), weight of total kernels in grams (N_{TK}) weight of broken kernels (N_2) and Time (T) were determined and recorded.

Each of these tests was replicated five times for each of the evaluated machine clearance and the performance of the decorticator was evaluated on the basis of the following indices.

– Decortication / shelling efficiency,

$$= (N_1 / N_{TP})\ 100, \qquad (1)$$

– Percentage of kernel damage,

$$= (N_2 / N_{TK})\ 100, \qquad (2)$$

– Capacity (kg/h),

$$= (N_2 / T), \qquad (3)$$

These results were statistically analysed using t-test to evaluate the effect of moisture content on the performance indices of the decorticator (Panse and Sukhatma, 1985).

■ RESULTS AND DISCUSSION

The initial moisture content of pod was found to be 7.5 per cent (w.b.). The moisture level was obtained after conditioning the pods was 10 per cent (w.b.). The investigations were carried out at the above moisture levels to determine the effect of moisture content on the decorticating efficiency of pongamia pods.

The results of the performance test analyses are presented in Tables 1, 2, 3 and 4. It can be seen from Table 1, that moisture content, machine clearance and interaction between moisture content and machine clearances significantly affected the decortication efficiency, percentage of kernel damage and capacity at 5 per cent level of significance.

Table 1 : F-ratio for the results of performance test *denotes statistically significant difference at 5 per cent level

Sources of variation	Decortications efficiency (%) (E_D)	Kernel damage (%) (D_K)	Capacity (C) (kg/h)
Moisture content(M)	0.19*	0.09*	0.06*
Machine clearance(Mc)	0.26*	0.07*	0.08*
Interaction (Moisture content and machine clearance)	0.16*	0.09*	0.12*

* indicates significance of value at P=0.05

Table 2 : Effect of moisture content on performance indicators

Moisture content (%) (w.b.)	Decortication efficiency (%) (E_D)	Kernel damage (%) (D_K)	Capacity (C) (kg/h)
7.5	93.36	16.97	118.70
10	90.11	13.49	118.47

Table 3 : Effect of machine clearance on performance indicators

Machine clearance (mm)	Decortications efficiency (%) (E_D)	Kernel damage (%) (D_K)	Capacity (C) (kg/h)
8	93.36	16.97	118.70
9	84.52	14.93	122.56

Table 4 : Effect of interaction between moisture content and machine clearance

Moisture content (%) × Machine clearance (mm)	Decortication Efficiency (%) (E_D)	Kernel damage (%) (D_K)	Capacity (C) (kg/h)
M_1C_1	93.36	16.97	118.70
M_2C_2	84.52	14.93	122.56
M_2C_1	90.11	13.49	118.47
M_2C_2	81.74	11.08	122.43

Table 2 shows the result of applying CRD to the means of moisture content on the performance indicators. It can be seen from Table 2 that decortication efficiency (E_D), kernel damage (D_K) and capacity (C) decreased with increase in moisture content. This is because at low moisture levels, pongamia pods are brittle, which makes them susceptible to mechanical damage.

Table 3, shows the results of applying CRD to means of machine clearance on the performance indicators. It can be seen from this table that the 8 mm machine clearance gave the highest average decortication efficiency (93.36%), followed by 9 mm machine clearance (84.52%). Similar findings were reported by Odigboh (1979) and Oluwole *et al.* (2004) in the performance evaluation of an egusi (melon) shelling machine and performance evaluation of a sheanut cracker, respectively.

The result of applying CRD to the means of interaction between moisture content and machine clearance is presented in Table 4. These results showed that interaction between moisture content and machine clearances statistically affected all the performance indicators at 5 per cent level of significance. The 8 mm machine clearance gave the best decortication efficiency at both investigated moisture contents, with the mean highest of 93.36 per cent at moisture content of 7.5 per cent (w.b.). However, the percentage of kernels damage was 16.97 per cent and capacity was 118.70 kg./h, at this moisture content. The 9 mm machine clearance gave the lowest decortication efficiency at two investigated moisture content, with the least of 81.74 per cent at moisture content of 10 per cent (w.b.). However, the percentage of kernel damage was 11.08 per cent and capacity was 122.43 kg/h, at this moisture content.

Conclusion :

- Moisture content of pongamia pods statistically affected the performance indicators at 5 per cent level of significance.
- Machine clearance significantly affected the performance indicators at 5 per cent level of significance.
- Decortication efficiency and percentage of kernel damage decreased with increase of moisture content.
- The machine clearance of 8 mm gave the best decortication efficiency, followed by the 9 mm machine clearance.

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