# THE PERFORMANCE OF MULTI – SEED DEHULLING MACHINE UNDER DIFFERENT OPERATIONAL CONDITIONS

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## ABSTRACT

*Dehulling is the removal of the outer coast (testa) from a nut/seed after the kernel has been conditioned. It is a vital in the final processing of nut/seed for human consumption. Traditionally, the removal of the Conditioned outer coast of the legume seed such as cowpea, locust bean and soybean is a tedious activity and it is manually achieved by rubbing the seeds between the palms, stapling of feet on them, by pounding in mortar or use of grinding stone on stony slab and it is commonly carried out by women and children. This process needs to be mechanized to reduce its time consummation and energy intensive as well as to remove its unhealthy and unhygienic practices. The Multi – Seed dehuller that is used for dehulling of wet legume seeds like locust bean, cowpea and soybean was fabricated at National Centre for Agricultural Mechanization, (NCAM), Ilorin with aim of studying its performance under different operational conditions for its effective use by the processors for different leguminous seeds. The legume seeds were conditioned based on their required treatments for dehulling: The required treatments for these seeds are cooking for locust bean and soaking for both cowpea and soy bean. Locust bean was measured in weight of 10 kg each and cooked for 6 hrs, 9 hrs and 12 hrs; cowpea was measured in 5 kg each and soaked for 5 mins, 10 mins and 15 mins while and soybean was measured in 5 kg each and soaked for 6 hrs, 12 hrs and 24 hrs. These legume seeds were weighed in three replicate before dehulling. The conditioned and measured legume seeds were then dehulled at different operating speeds of 150 rpm, 250 rpm and 350 rpm of $3^2$ factorial in randomized block experimental design for each of the legume seeds: locust bean, cowpea and soybean. The highest mean values of dehulling efficiency 89.07%, 99.60% and 98.95% were obtained at 150 rpm for cowpea at 15 mins soaking time, locust bean at 12 hrs cooking time and soybean at 24 hrs soaking time respectively. The highest mean value of cleaning efficiency of 91%, 98% and 99.14% were observed at 15 mins soaking time of cowpea seeds, cooking time of 12 hrs of locust beans and 24 hrs soaking time of soybean seeds accordingly at operating speed of 150 rpm. It is concluded that the operational conditions for wet dehulling of lugumious seeds affect the performance of multi – seed dehuller and it is therefore recommended that the dehuller should be used by the local processing of leguminous seeds in a bid to reduce the drudgery associated with the dehulling of leguminous seeds.*

**KEYWORDS:** Multi-seed, Dehuller, Performance, Operational Conditions.

## 1. INTRODUCTION

Legumes have a remarkable nutritional composition and are rich in proteins it contains low fat but are rich sources of fiber and minerals and its important as sources of energy and protein in many parts of the world over emphasized both in animal and human nutrition. Dehulling of leguminous seeds is required before they can be further be processed into their various products like moimoi, akara (bean cake) and local bean soup obtained from cowpea; fermented locust bean condiment(spies) obtained from locust bean seed; and soy cheese, soymilk obtained from soybean seeds.

Dehulling (removal of the outer coast (testa) from a nut/seed) after the kernel has been conditioned and removed is vital in the final processing of nut/seed for human consumption. Traditionally, the removal of the Conditioned outer coast of the legume seed such as cowpea, locust bean and soybean is achieved manually is by rubbing the seeds between the palms, stapling of feet on them or by pounding in mortar and commonly carried out by women and children. This process is time consuming, energy intensive, unhealthy and unhygienic.

A number of legume seeds dehullers have been developed: Olaoye and Olotu (2017) developed a hydro – separating cowpea dehuller; Ndukwu and Onyenwoke (2014) designed and developed a continuous maize dehulling, cleaning and milling machine; Ogunsola *et al.* (2015) developed a motorized wet soybean dehulling machine and Okunola *et al.* (2019) developed a locust bean dehulling cum washing machine. These dehullers were developed so as to reduce the amount of time and labour required in the traditional manual dehulling of leguminous seeds.Also, Aduba *et al.* (2013) investigated the effects of operational conditions on the performance of the cowpea dehuller/separator.

These dehullers developed and evaluated so far by researchers were leguminous seed specific limiting their functionality for other leguminous seeds. The need to fabricate a multi – seed dehuller and investigate its performance under different operational conditions of dehulling operation using different leguminous seeds become a necessity to allow the designed and fabricated wet dehuller to be able to handle a wide of leguminous seeds.

## 2. MATERIALS AND METHODS

### 2.1 Brief Description of Multi – Seed Dehuller

The Multi – Seed dehuller that is used for dehulling of wet legume seeds like locust bean, cowpea and soybean was fabricated at the National Centre for Agricultural Mechanization, (NCAM), Ilorin, Kwara State. It comprises of two major units which are the dehulling unit and the cleaning unit. The hopper is pyramid in shape and made from mild sheet situated at the top of the auger housing. The dehulling unit consists of shaft worm with a rod which serves as an auger to convey legume seeds during the dehulling process. The dehuller is powered by a 5hp gasoline motor. The dehulling unit operates on the principle of abrasion. The pictorial view of the multi – seed dehuller is shown in Figure 1.

Figure 1. Pictorial View of Fabricated Multi – Seed Dehuller

## 2.2 Experiment Procedure

Three major legumes seeds such as locust bean, cowpea and soybean were used for this experiment and they were purchased from Ganmo market in Irepodun Local Government Area, Kwara State. The legume seeds were conditioned based on their required conditions for dehulling: locust bean was measured in weight of 10kg each and cooked for 6 hrs, 9 hrs and 12 hrs; cowpea was measured in 5kg each and soaked for 5 mins, 10 mins and 15 mins while and soybean was measured in 5kg each and soaked for 6 hrs, 12 hrs and 24 hrs. These legume seeds were weighed in three replicate before dehulling. The conditioned and measured legume seeds were then dehulled at different operating speeds of 150 rpm, 250 rpm and 350 rpm. The selected operating speed as they were being used by other researchers of $3^2$ factorial in randomized block experimental design for each of the legume seeds: locust bean, cowpea and soybean.

The laboratory apparatus used for this investigation are 10 kg capacity weighing scale, electronic weighing balance of 4000g capacity; model number cL. 201 made by OHAUSin China to measure the weight of the sample, digital photo/contact tachometer of model number DT2236B with accuracy ± (0.05% + 1 digit) made by Bep Edu World in Kondhwa, Pune, Maharashtra, Indian to measure the operating speeds and clock/stop watch to the take time.

At the end of each dehulling operation, the weight of the total conditioned seeds before dehulling operation, weight of sample at cotyledon outlet, weight of cotyledon and weight of hull were measured to the determine the performance parameters of the dehuller such as dehulling efficiency, cleaning efficiency, percentage recovery and performance index of the multi – seeds dehuller for selected conditioned legume seeds.

Analysis of Variance (ANOVA) and New Multiple Duncan Range Test (NMDRT) of IBM SPSS 20.0 statistical package was employed to analyse how the operational conditions affect the performance of the Multi – Seed Dehuller.

## 2.3 Performance Parameter

**Dehulling Efficiency; DE (%):** It is the weight of the cotyledon obtained at the cotyledon outlet over total weight of the both cotyledon and undehulled seed obtained at the cotyledon outlet in percentage. It is expressed as in Equation (1).

$$DE = \frac{W_2}{W_1 - W_4} X100\% \qquad (1)$$

Where;

$W_1$ = Total weight of the samples obtained at the cotyledon outlet, (kg)

$$W_1 = W_2 + W_3 + W_4$$

$W_2$ = Weight of the cotyledon obtained at the cotyledon outlet, (kg)

$W_3$ = Weight of undehulled conditioned seed

$W_4$ = Weight of the hull obtained at the cotyledon outlet, (kg)

**Cleaning Efficiency; CE (%):** It is the weight of the hull removed from cotyledon at the cotyledon outlet. Or weight of hull obtained at the cotyledon outlet over the expected weight of the hull from a given sample of dehulled conditioned leguminous seed in percentage subtracted from 100 as expressed in Equation (2).

$$CE = 100 - [\frac{W_4}{W_6} X100]\% \qquad (2)$$

$W_4$ as defined above

$W_6$ = Expected weight of the hull from a given sample of dehulled conditioned leguminous seed at both cotyledon outlet and hull outlet, (kg)

**Percentage Recovery; PR (%):** It is the weight of cotyledon obtained at the cotyledon outlet of the dehuller over the expected weight of the cotyledon to be recovered after dehulling in percentage. It is expressed as in Equation (3).

$$Percentage\ \text{Recov}ery\ (R_p) = \frac{W_2}{W_5} x100\% \quad (3)$$

$W_2$ = Weight of the cotyledon obtained at the cotyledon outlet, (kg)

$W_5$ =Expected weight of the cotyledon after dehulling, (kg)

**Performance Index (PI):** It is the overall performance of the dehuller in term of its dehulling efficiency, cleaning efficiency and percentage recovery in decimal as expressed in Equation (4).

$$Performance\ Index = 100DE * CE(1 - PR)$$

DE, CE and PR are as defined above are expressed in decimals.

## 3. RESULTS AND DISCUSSION

The fabricated multi – Seed dehuller as shown in Figure 1 was used to investigate the effects of operational conditions on the performance of the dehuller using conditioned leguminous seeds like locust bean, cowpea and soy bean. The performance parameters considered for the investigation were dehulling efficiency, cleaning efficiency, percentage recovery and performance index of the dehuller.

The summary of the performance evaluation of the multi-seed dehuller is presented in Table 1. It was observed that the highest mean values of dehulling efficiency 99.6%, cleaning efficiency 98.82%, percentage recovery 99.2% and performance index 0.99 were obtained at cooking time of 12 hrs and operating speed of 150 rpm when cooked African locust bean was dehulled. Also the lowest mean values of dehulling efficiency 53%, cleaning efficiency 58.08%, percentage recovery 55.83% and performance index 0.54 were obtained at soaking time of 5 mins and operating speed of 350 rpm when soaked cowpea was dehulled.

Tables 2 - 5 are the results of Analysis of Variance conducted and it was discovered from the ANOVA results that the operational conditions of operating speed and seed treatment of soaking and cooking times had significant effects on the performance parameters of the dehuller at $p \leq 0.05$ as indicated in the Tables 2 – 5. The levels of the operational conditions that cause how they affect the performance of the dehuller are shown in NDMRT Tables 6 and 7 which show that all levels of the operational conditions were significantly different from each other at $p \leq 0.05$. Figures 2 – 12 further show how the operational conditions affect the performance parameters of the dehuller

Table 1. Summary Performance Parameters of Multi-Seed Dehulling Machine

| Operating Speed (rpm) | Seed | Seed Treatment | Time Spent | Performance Parameters | | | |
|---|---|---|---|---|---|---|---|
| | | | | Dehulling Efficiency (%) | Cleaning Efficiency (%) | Percentage Recovery (%) | Performance Index |
| 150 | CP | Soaking in Min | 5 | 71 | 76.19 | 73.59 | 0.72 |
| | | | 10 | 81.82 | 79.87 | 80.84 | 0.79 |
| | | | 15 | 89.07 | 91.06 | 90.07 | 0.88 |
| 250 | | | 5 | 58.81 | 66.18 | 62.49 | 0.61 |
| | | | 10 | 69.63 | 71.86 | 70.74 | 0.69 |
| | | | 15 | 76.89 | 81.05 | 78.97 | 0.77 |
| 350 | | | 5 | 53.57 | 58.08 | 55.83 | 0.54 |
| | | | 10 | 64.4 | 65.77 | 62.71 | 0.63 |
| | | | 15 | 71.66 | 76.96 | 74.31 | 0.73 |
| 150 | LB | Cooking in Hr. | 6 | 75.01 | 77.05 | 76.03 | 0.76 |
| | | | 9 | 96.28 | 95.3 | 95.79 | 0.95 |
| | | | 12 | 99.6 | 98.82 | 99.21 | 0.99 |
| 250 | | | 6 | 65.93 | 65.14 | 65.54 | 0.65 |
| | | | 9 | 90.12 | 85.82 | 87.97 | 0.88 |
| | | | 12 | 95.31 | 93.1 | 94.21 | 0.94 |
| 350 | | | 6 | 64.36 | 60.98 | 62.67 | 0.62 |
| | | | 9 | 76.89 | 78.91 | 77.9 | 0.77 |
| | | | 12 | 92.2 | 85.13 | 88.67 | 0.88 |
| 150 | SB | Soaking in Hr. | 6 | 79.69 | 83.37 | 91.6 | 0.85 |
| | | | 12 | 94.33 | 93.99 | 96.36 | 0.95 |
| | | | 24 | 98.95 | 99.14 | 95.8 | 0.98 |
| 250 | | | 6 | 69.3 | 78.17 | 84.66 | 0.77 |
| | | | 12 | 80.95 | 81.39 | 95.45 | 0.86 |
| | | | 24 | 94.6 | 85.76 | 99.27 | 0.94 |
| 350 | | | 6 | 54.25 | 61.26 | 84.58 | 0.67 |
| | | | 12 | 77.67 | 72.42 | 97.23 | 0.82 |
| | | | 24 | 88.75 | 86.96 | 98.06 | 0.91 |

Values are means of three replicates. CP = Cowpea;
LB = Locust Bean; SB = Soy Bean

Table 2. Analysis of Variance (ANOVA) for Dehulling Efficiency for Different Legumious Seeds

| Seed | Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| CP | OS | 1438.113 | 2 | 719.057 | 79.347 | .000 |
| | ST | 1489.751 | 2 | 744.876 | 82.196 | .000 |
| | OS * ST | .000 | 4 | 4.391E-005 | .000 | 1.000 |
| | Error | 163.119 | 18 | 9.062 | | |
| | Total | 138282.427 | 27 | | | |
| LB | OS | 685.407 | 2 | 342.704 | 660.929 | .000 |
| | ST | 3523.630 | 2 | 1761.815 | 3397.786 | .000 |
| | OS * ST | 168.593 | 4 | 42.148 | 81.286 | .000 |
| | Error | 9.333 | 18 | .519 | | |
| | Total | 195067.000 | 27 | | | |
| SB | OS | 1370.437 | 2 | 685.219 | 461.820 | .000 |
| | ST | 3191.596 | 2 | 1595.798 | 1075.528 | .000 |
| | OS * ST | 235.745 | 4 | 58.936 | 39.722 | .000 |
| | Error | 26.707 | 18 | 1.484 | | |
| | Total | 186598.309 | 27 | | | |

*Significant at p≤0.01; **Significant at p≤0.05: CP = Cowpea; LB = Locust Bean; SB = Soy Bean; OS = Operating Speed, ST = Seed Treatment

Table 3. Analysis of Variance (ANOVA) for Cleaning Efficiency for Different Legumious Seeds

| Seed | Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| CP | OS | 1088.066 | 2 | 544.033 | 2186.971 | .000 |
| | ST | 1216.875 | 2 | 608.438 | 2445.872 | .000 |
| | OS * ST | 21.333 | 4 | 5.333 | 21.440 | .000 |
| | Error | 4.478 | 18 | .249 | | |
| | Total | 150633.140 | 27 | | | |
| LB | OS | 1083.185 | 2 | 541.593 | 356.659 | .000 |
| | ST | 3033.852 | 2 | 1516.926 | 998.951 | .000 |
| | OS * ST | 33.259 | 4 | 8.315 | 5.476 | .005 |
| | Error | 27.333 | 18 | 1.519 | | |
| | Total | 187040.000 | 27 | | | |
| SB | OS | 1567.100 | 2 | 783.550 | 1281.877 | .000 |
| | ST | 1204.324 | 2 | 602.162 | 985.129 | .000 |
| | OS * ST | 268.035 | 4 | 67.009 | 109.625 | .000 |
| | Error | 11.003 | 18 | .611 | | |
| | Total | 186806.212 | 27 | | | |

*Significant at p≤0.01; **Significant at p≤0.05: CP = Cowpea; LB = Locust Bean; SB = Soy Bean; OS = Operating Speed, ST = Seed Treatment

Table 4. Analysis of Variance (ANOVA) for Percentage Recovery for Different Legumious Seeds

| Seed | Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| CP | OS | 1253.511 | 2 | 626.755 | 314.899 | .000 |
| | ST | 1322.912 | 2 | 661.456 | 332.334 | .000 |
| | OS * ST | 5.360 | 4 | 1.340 | .673 | .619 |
| | Error | 35.826 | 18 | 1.990 | | |
| | Total | 144288.690 | 27 | | | |
| LB | OS | 877.306 | 2 | 438.653 | 684.485 | .000 |
| | ST | 3258.253 | 2 | 1629.127 | 2542.129 | .000 |
| | OS * ST | 69.096 | 4 | 17.274 | 26.955 | .000 |
| | Error | 11.535 | 18 | .641 | | |
| | Total | 190713.221 | 27 | | | |
| SB | OS | 8.927 | 2 | 4.463 | 1.998 | .165 |
| | ST | 643.550 | 2 | 321.775 | 144.016 | .000 |
| | OS * ST | 123.138 | 4 | 30.784 | 13.778 | .000 |
| | Error | 40.217 | 18 | 2.234 | | |
| | Total | 238274.472 | 27 | | | |

*Significant at p≤0.01; **Significant at p≤0.05: CP = Cowpea; LB = Locust Bean; SB = Soy Bean; OS = Operating Speed, ST = Seed Treatment

Table 5. Analysis of Variance (ANOVA) for Performance Index for Different Legumious Seeds

| Seed | Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| CP | OS | .125 | 2 | .063 | 314.899 | .000 |
| | ST | .132 | 2 | .066 | 332.334 | .000 |
| | OS * ST | .001 | 4 | .000 | .673 | .619 |
| | Error | .004 | 18 | .000 | | |
| | Total | 13.784 | 27 | | | |
| LB | OS | .088 | 2 | .044 | 684.485 | .000 |
| | ST | .326 | 2 | .163 | 2542.129 | .000 |
| | OS * ST | .007 | 4 | .002 | 26.955 | .000 |
| | Error | .001 | 18 | 6.409E-005 | | |
| | Total | 18.862 | 27 | | | |
| SB | OS | .070 | 2 | .035 | 460.877 | .000 |
| | ST | .148 | 2 | .074 | 975.851 | .000 |
| | OS * ST | .012 | 4 | .003 | 38.758 | .000 |
| | Error | .001 | 18 | 7.603E-005 | | |
| | Total | 20.252 | 27 | | | |

*Significant at p≤0.01; **Significant at p≤0.05: CP = Cowpea; LB = Locust Bean; SB = Soy Bean; OS = Operating Speed, ST = Seed Treatment

### 3.1 Effect of Operating Speeds on the Performance of the Multi Seed Dehuller

The operating speed of multi – seed dehuller had significant effect on the performance parameters of dehuller such as dehulling efficiency, cleaning efficiency, percentage recovery and performance index as indicated in Tables 2 - 5. It also showed that all the level of the operating speeds of the dehuller were significantly different from each other $p \geq 0.5$ for all the three conditioned leguminous seeds; cowpea, locust bean and soy bean used to investigate the performance of multi – seed dehuller. It confirmed the result of the research conducted by Aduba *et al.* (2013) who investigated the effects of operating speed on the performance of the cowpea dehuller/separator.

It was observed from Table 6 that there was decrease in the dehulling efficiency of the dehuller as the level of operating speed of the dehuller increases this findings was in contrast to Babatunde, (1995) that stated the dehulling of cowpea is more efficient as the operating speed of the dehuller increases. Olaoye and Olotu, (2017) report showed some level of agreement with some varieties of cowpea seeds used in their investigation. This was also confirmed by Etoamaihe and Ndubueze (2010) who reported that dehulling efficiency of dehuller increases as the operating speed of the dehuller decreases when bread fruit was used for the investigation. Figures 2, 3 and 4 further revealed the decrease in dehulling efficiency of dehuller as its operating speed increases with the use of cowpea, locust bean and soybean seeds.

The highest mean values of dehulling efficiency 80.63%, 95.35% and 90.99% were obtained at operating speed of 150rpm for cowpea, locust bean and soybean respectively while their least mean values of dehulling efficiency 63.21%, 78.00% and 73.56% were obtained at 350rpm. This might be that the increase in operating speed of the dehuller reduces the resident time of conditioned seeds inside the dehulling chamber which would not allow complete removal of the hull from cotyledon before it pushes out hence decreases the dehulling efficiency of the dehuller.

Table 6 showed that there was increase in the cleaning efficiency of the dehuller as the level of operating speed of the dehuller increases and all the level of operating speeds were significantly different $p \geq 0.5$. This was in line with the study conducted by Olaoye and Olotu (2017) that indicated high values of cleaning efficiency of dehulled cowpea at high operating speed of the dehuller. Figures 5, 6 and 7 also revealed an increase in cleaning efficiencies as the operating speed of dehuller increases for all the seeds used.

The least mean values of cleaning efficiency 66.44%, 75% and 73.55% were obtained at operating speed of 150rpm for cowpea, locust bean and soybean respectively while their highest mean values of cleaning efficiency 82.37%, 90.44% and 92.17% were obtained at 350 rpm. The increase in the cleaning efficiency of the dehuller as the operating speed increases could be that the hulls which are considered to be lighter were able to discharge easier and faster as the operating speed increases making the dehuller to produce more unclean cotyledon at lower operating speed.

The decrease in the percentage recovery of the dehulled leguminous seeds was observed as the operating speed of the dehuller increases for all the leguminous seeds used for the investigation as shown in Table 3.6 and indicated in Figures 8, 9 and 10 for cowpea, locust bean and soybean seeds. It mean that the highest mean values of percentage recovery of dehulled leguminous seeds were obtained at operating speed of 150 rpm while their least mean values were obtained at operating speed of 350 rpm.

The same trend of percentage recovery of leguminous seeds was seen with the performance index of the multi – seed dehuller which mean that as the operating speed of the dehuller increases the performance index of the dehuller decreases with it as indicated in Table 6 and shown in Figures 11, 12 and 13.

Table 6. Effect of Operating Speed on Performance Parameters of the Multi –Seed Dehuller using NDMRT for Three Conditioned Legumious Seeds

| S/N | Performance Parameters | Operating Speed (rpm) | Conditioned Legumious Seeds | | |
|---|---|---|---|---|---|
| | | | Cowpea Bean | Locust Bean | Soy Bean |
| 1 | Dehulling Efficiency (%) | 150 | $80.63_a$ | $95.33_a$ | $90.99_a$ |
| | | 250 | $68.44_b$ | $83.78_b$ | $81.61_b$ |
| | | 350 | $63.21_c$ | $78.00_c$ | $73.56_c$ |
| 2 | Cleaning Efficiency (%) | 150 | $66.94_a$ | $75.00_a$ | $73.55_a$ |
| | | 250 | $73.03_b$ | $81.44_b$ | $81.78_b$ |
| | | 350 | $82.37_c$ | $90.44_c$ | $92.17_c$ |
| 3 | Percentage Recovery (%) | 150 | $81.50_a$ | $90.35_a$ | $94.59_a$ |
| | | 250 | $70.74_b$ | $82.57_b$ | $93.46_b$ |
| | | 350 | $65.07_c$ | $76.41_c$ | $93.29_c$ |
| 4 | Performance Index (%) | 150 | $80.21_a$ | $90.01_a$ | $93.11_a$ |
| | | 250 | $69.07_b$ | $82.30_b$ | $86.09_b$ |
| | | 350 | $63.19_c$ | $76.10_c$ | $80.17_c$ |
| | Significant | | 1.000 | | |

Mean with different letters on the same column are significantly different from each other

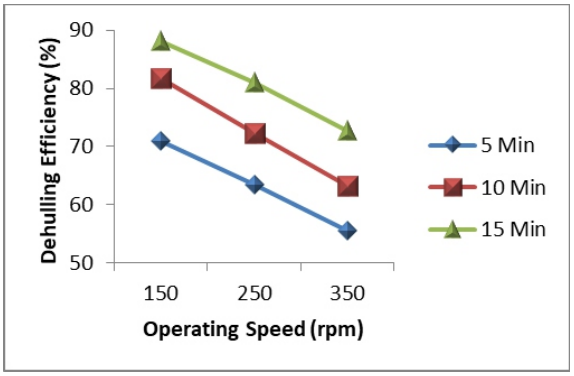


Figure 2. Effect of Operating Speed on Dehulling Efficiency of Multi – Seed Dehuller with Cowpea Seeds

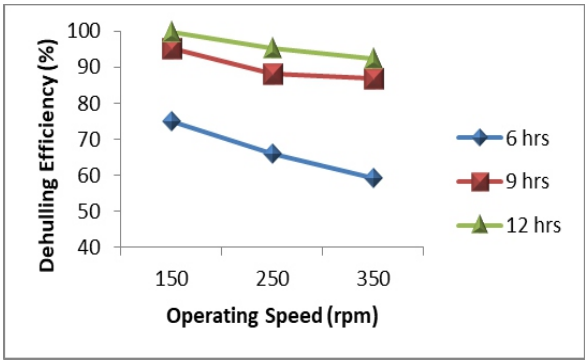


Figure 3. Effect of Operating Speed on Dehulling Efficiency of Multi – Seed Dehuller with Locust Bean Seeds

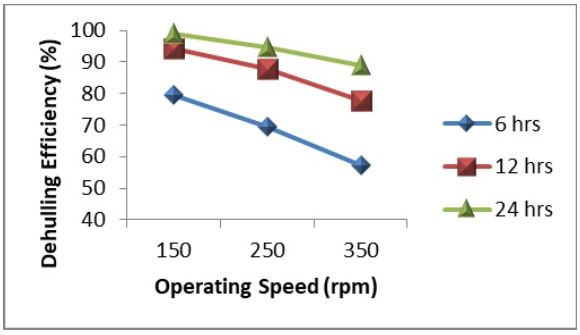


Figure 4. Effect of Operating Speed on Dehulling Efficiency of Multi – Seed Dehuller with Soybean Seeds

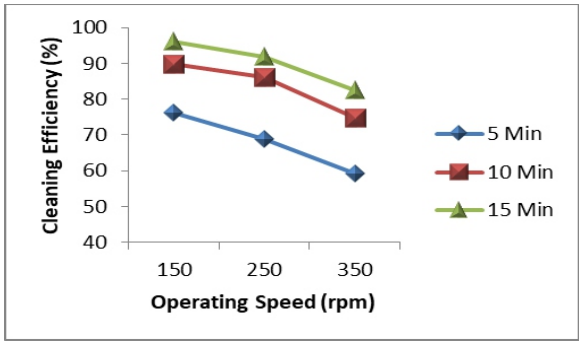


Figure 5. Effect of Operating Speed on Cleaning Efficiency of Multi – Seed Dehuller with Cowpea Seeds

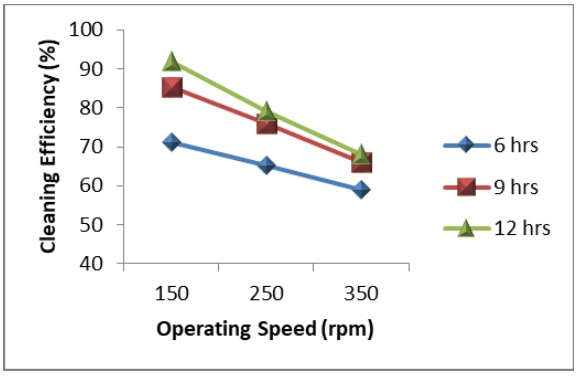


Figure 6. Effect of Operating Speed on Cleaning Efficiency of Multi – Seed Dehuller with Locust Bean Seeds

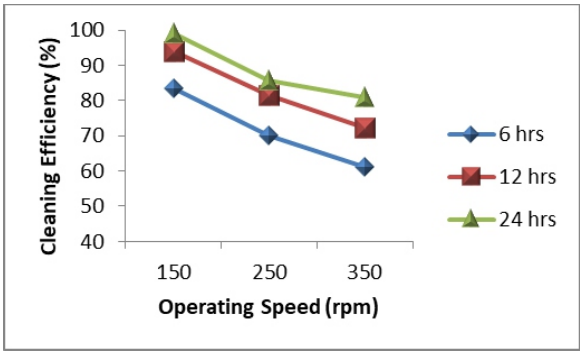


Figure 7. Effect of Operating Speed on Cleaning Efficiency of Multi – Seed Dehuller with Soybean Seeds

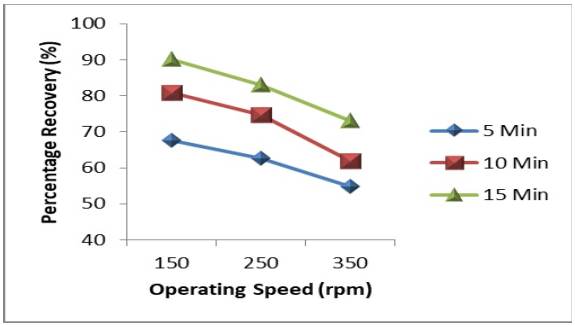


Figure 8. Effect of Operating Speed on Percentage Recovery of Cowpea Seeds

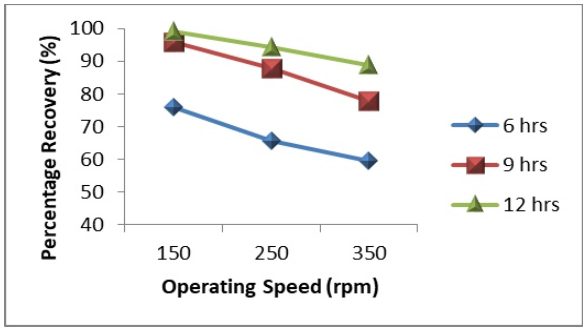


Figure 9. Effect of Operating Speed on Percentage Recovery of Locust Bean Seeds

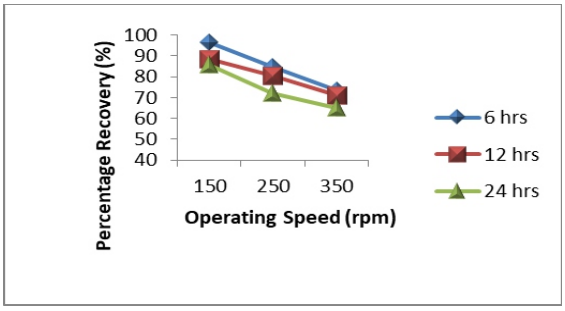


Figure 10. Effect of Operating Speed on Percentage Recovery of Soybean Seeds

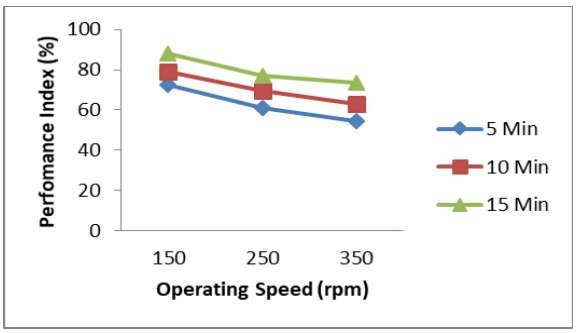


Figure 11. Effect of Operating Speed on Performance Index of Multi – Seed Dehuller with Cowpea Seeds

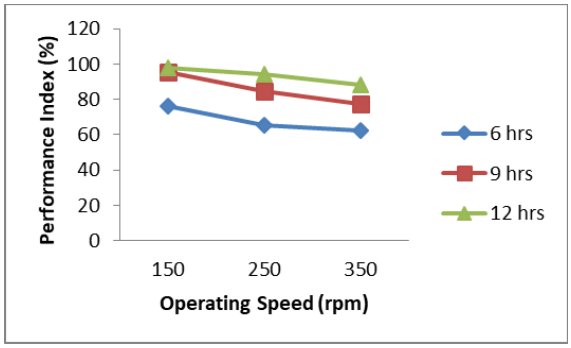


Figure 12. Effect of Operating Speed on Performance Index of Multi – Seed Dehuller with Locust Bean Seeds

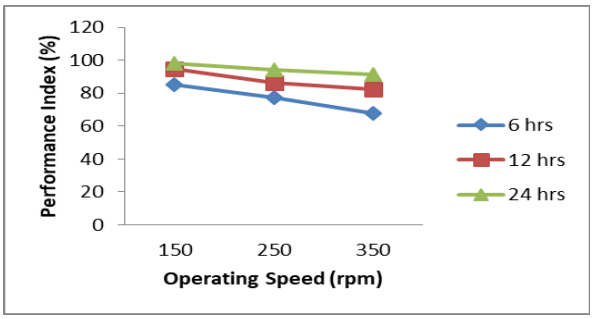


Figure 13. Effect of Operating Speed on Performance Index of Multi – Seed Dehuller with Soybean Seeds

### 3.2 Effect of Seed Treatment Time of Legumious Seeds on the Performance of the Multi Seed Dehuller

Tables 2 – 5 showed that the seed treatment times of the leguminous seeds used had significant effect on the performance parameters of the dehuller $p \geq 0.5$ for all the three conditioned leguminous seeds; cowpea, locust bean and soy bean used to investigate the performance of multi – seed dehuller in term of its dehulling efficiency, cleaning efficiency, percentage recovery and performance index of the dehuller. Table 7 also depicted that all level of the seed treatment times of cowpea, soybean and locust bean were significantly different from each other $p \geq 0.5$ as also report by Aduba *et al.* (2013) who investigated the effects of operational conditions on the performance of the cowpea dehuller/separator. This mean they did not have similar effect on the performance of the dehuller.

Table 7 revealed that as the soaking times of cowpea and soybean seeds as well as the cooking time of locust bean as indicated as seed treatment times increase the performance parameters of the dehuller as they increase.

It was observed from Table 7 that there was increase in the dehulling efficiency of the dehuller as the levels of seed treatment times of the leguminous seeds increase this findings was in line with Ogunigbo *et al.* (2018) who reported an increase in dehulling efficiency a dehuller as soaking time of the cowpea increases and Okunola *et al.*(2019) that studied the effects of boiling time on dehulling efficiency of locust bean dehuller and reported that dehulling efficiency increased with the boiling time of the locust bean seeds. The same trend was reported by Mahalle *et al*. (2010). Figures 2, 3 and 4 further revealed the increase in dehulling efficiency of dehuller as the seed treatment times increase with the use of cowpea, locust bean and soybean seeds. The highest and the least mean values of dehulling efficiencies of 94.09% and 67.75% were obtained at soaking time of 24 hrs and 6 hrs of soybean respectively. This might that the time the seeds were soaked or cooked prior to dehulling operation allows the hulls of the seeds to get soften and the more time they spent during the treatment the more they are being soften as a result more of the hull were detached.

The least mean value of dehulling efficiency 61.13% was obtained at 5mins soaking time of cowpea seeds while the highest mean value of dehulling efficiency of 79.21% was observed at 15mins soaking time of cowpea seeds. The highest mean value of 95.78% was obtained at cooking time of 12 hrs of locust beans while the 6 hrs cooking time of locust bean gave the least mean value of dehulling efficiency 68.56%.

Table 7 showed that there was increase in the cleaning efficiency of the dehuller as the level of seed treatments of the cowpea, locust bean and soybean seeds increases and all the level of seed treatments were significantly different $p \geq 0.5$. Figures 5, 6 and 7 also revealed an increase in cleaning efficiencies as the seed treatment times increases for all the seeds used. This could be that increase in quantity of hull that were removed from its cotyledon during the dehulling operation as a result of time spent during the treatment were easily float away and discharge at the hull outlet.

The least mean values of cleaning efficiency 66.82%, 67.67% and 74.27% were obtained at seed conditions of 5 mins soaking time for cowpea, 6 hrs cooking time for locust bean and 6 hrs soaking time for soybean respectively while their highest mean values of the cleaning efficiency 83.02%, 92.44% and 90.62% were obtained at their 15 mins soaking time, 12 hrs cooking time and 24 hrs soaking time for cowpea, locust bean and soybean seeds respectively.

The increase in the percentage recovery of the dehulled leguminous seeds was observed as the seed conditions of cowpea seed increases from 5 mins to 15 mins soaking time, locust bean seed increases from 6 hrS to 12 hrs cooking time but soybean seed gave a conflicting result as shown in Table 7 and indicated in Figures 8, 9 and 10. This could be that the soybean seeds were over soaked as such some of the soaked seeds were broken and washed away with hull during the dehuling operation. The highest mean values of percentage recovery 81.11% of dehulled cowpea seeds was obtained at seed conditions of 15 mins soaking time for cowpea, 94.03% percentage recovery at 12 hrs cooking time for locust bean and 96.35% percentage recovery at 12 hrs soaking time for soybean. Their least mean values of the percentage recovery of 63.97%, 68.08% and 78.05% were obtained at 5 mins soaking time of cowpea seeds, 6 hrs cooking time of locust bean seeds and 24 hrs soaking time of soybean seeds respectively.

The same trend of dehulling efficiency of dehuller was seen with the performance index of the multi – seed dehuller which mean that as the seed conditions of the leguminous seeds increase the performance index of the dehuller increases with it as indicated in Table 7 and shown in Figures 11, 12 and 13. The highest mean values of

dehuuller performance index of 79.13%, 94.22% and 94.16% were observed at the cowpea soaking time of 15 mins, locust bean cooking time of 12 hrs and soybean soaking time of 24 hrs respectively. The least values of performance index of 62.44%, 68.01% and 76.09% were observed at 5 mins soaking time of cowpea seeds, 6 hrs cooking time of locust bean seeds and 12 hrs soaking time of soybean seeds respectively.

Table 7. Effect of Seed Conditions on Performance Parameters of the Multi –Seed Dehuller using NDMRT for Three Conditioned Legumious Seeds

| S/N | Conditioned Legumious Seed | Seed Treatment | Time Spent | Performance Parameter | | | |
|---|---|---|---|---|---|---|---|
| | | | | Dehulling Efficiency (%) | Cleaning Efficiency (%) | Percentage Recovery (%) | Performance Index (%) |
| 1 | Cowpea | Soaking (min) | 5 | $61.13_a$ | $66.82_a$ | $63.97_a$ | $62.44_a$ |
| | | | 10 | $71.95_b$ | $72.50_b$ | $72.22_b$ | $70.05_b$ |
| | | | 15 | $79.21_c$ | $83.02_c$ | $81.11_c$ | $79.13_c$ |
| 2 | Locust Bean | Cooking (hr) | 6 | $68.56_a$ | $67.67_a$ | $68.08_a$ | $68.01_a$ |
| | | | 9 | $87.78_b$ | $86.78_b$ | $87.23_b$ | $87.30_b$ |
| | | | 12 | $95.78_c$ | $92.44_c$ | $94.03_c$ | $94.22_c$ |
| 3 | Soy Bean | Soaking (hr) | 6 | $67.75_a$ | $74.27_a$ | $86.95_a$ | $76.09_a$ |
| | | | 12 | $84.32_b$ | $82.60_b$ | $96.35_b$ | $88.33_b$ |
| | | | 24 | $94.09_c$ | $90.62_c$ | $78.05_c$ | $94.16_c$ |
| | Significant | | | | 1.000 | | |

Mean with different letters on the same are significantly different from each other

## 4. CONCLUSION

The performance of the fabricated multi – seed dehuller was evaluated and it was discovered that the highest mean values of dehulling efficiency 99.6%, cleaning efficiency 98.82%, percentage recovery 99.2% and performance index 0.99 were obtained at cooking time of 12 hr and operating speed of 150 rpm when cooked African locust bean was dehulled. Also the lowest mean values of dehulling efficiency 53%, cleaning efficiency 58.08%, percentage recovery 55.83% and performance index 0.54 were obtained at soaking time of 5 mins and operating speed of 350 rpm when soaked cowpea was dehulled. It was also observed from the investigation that as the operational conditions for wet dehulling of these lugumious seeds increase or decrease the performance of the dehuller as well increases or decreases. The NDMRT was employed and it gave highest mean values of dehulling efficiency 80.63%, 95.35% and 90.99% at 150 rpm for cowpea, locust bean and soybean respectively. Also, NDMRT results for leguminous seeds treatments gave the highest mean value of dehulling efficiency of 79.21%, 95.78% and 94.09% at 15mins soaking time of cowpea seeds, cooking time of 12 hrs of locust beans and 24 hrs soaking time of soybean seeds accordingly. The multi–seed dehuller performed well on all leguminous seeds used and it is recommended for use by the local processing of leguminous seeds of cowpea seeds into bean cake or moinmoin, locust bean seeds into locust condiment and soybean seeds into soycheese, flour or milk.

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