Functional Testing of Sorghum Grading Machine

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Abstract. Sorghum seeds form some varieties are range from 2 to 4 mm in size and containing the outer skin/husk about 30 percent. Parallel with tampering of cortex/husk sorghum seeds, also needs exfoliation process. In order of husk exfoliation process can be done equally, it’s required grading/sorting of sorghum seeds and tampering process be spread evenly. Tampering purposes to remove sorghum’s pericarp and tesla coating that contains tannin on endosperm section. This section able to reduce protein digestibility inside the human body and causes constipation. Center for Agricultural Engineering Research and Development (BBP Mektan) developed Sorghum grading machine with pneumatic type with work capacity 400 kg/hour. The aims of this study were : (i) to sorting sorghum seeds evenly (ii) to produce clean sorghum seeds. The testing of grading machine performance, includes: preparation, fabrication and modification, functional and performance test, and reporting. Sorting/grading machine use diesel motor driving force 6.5 HP and the dimension of the machine are 1610 x 1280 x 1820 mm. The capacity of sorting/grading machine able to achieve 400 kg/hour with the efficiency of sorghum’s seed uniformity around 86.25%.

1. Introduction

Sorghum is one of the crops which is being prioritized the cultivation in Lamongan district and East Flores district as a local foodstuff that supports food security. East Java is one of the areas of sorghum’s seed production centre, which is around 4.180 tons/ha in 2012, but decrease to 3898 tons/ha in 2013, and increase in 2014 (Diperta, 2016). By August 2014, wide area of sorghum’s land reached ± 509 ha, which is 450 ha of rice fields and 59 ha other than rice fields with productivity around 6 tons/Ha (Anonim, 2014).

According to the Office of Communications and Informatics East Java Province, potential land for sorghum achieve 10 K ha, but the realization is still recorded 950 ha, so, there is still a great potential for sorghum need to be developed. From the sorghum area in East Java, domination around 500 ha located in Lamongan district and the rest spread to other areas (www.lamongan.go.id). In Lamongan district, sorghum production centre in Babat sub-district. Data by 2013 showed that the highest of sorghum’s seed production in East Java located in Lamongan district, which reaches 1673 tons. The second production potential is Pasuruan district with 1.111 tons, other districts are : Pacitan (36 tons), Banyuwangi (35 tons), Probolinggo (81 tons), Bangkalan (60 tons), Sampang (212 tons) and Sumenep (690 tons).

In East Java, most of the year there is harvest of sorghum, however, the great harvest moment in May (Banyuwangi, Pasuruan and Sumenep), and October (Lamongan) (Diperta, 2016), average of Sorghum’s seed national production around 5217 tons (Director General of Food Crops, 2016). Sorghum
from Lamongan is KD-4 varieties, which is local varieties and cultivated a long time ago from generation to generation of farmers.

These commodities became the mainstay of farmers during the dry season due to the plant is resistant to underwater conditions. But until now the utilization of sorghum for food has not been maximized and still limited for both feed and industrial purposes. In fact, the nutritional value of sorghum is not inferior to rice as staple food. The chemical composition of sorghum contains many proteins (8-12%), equivalent to wheat, while rice only reaches (6-10%), and its fat content (2-6%) is higher than rice (0.5-1.5%). One obstacle in the utilization of sorghum as food is the high content of tannins that reach 40,79 mg/100 g (USDA, 2009). The high content of tannin, besides affecting the taste (bitter/"sepet"), also antibacterial that can interfere with the process of mineral absorption by the body (Adiandri et al., 2014).

KD4 varieties of sorghum seeds are 2-4 mm in size and contain about 30 percent leather/husk. In the process of removing the skin/husk of sorghum seeds then exfoliated this husk. Therefore, the process of peel husk can be done even when it is necessary grading process/sorting of sorghum seeds so that the seeds obtained sorghum uniform and more perfect of tampering process. Tampering process aims to remove the pericarp layer of sorghum and tesla layer that containing tannin from the endosperm that can decrease the digestibility of protein inside the human body and causes constipation too. Center for Agricultural Engineering Research and Development (BBP Mektan) developed Sorghum grading machine with pneumatic type with work capacity 200 kg/hour. By using a grading machine/grading of sorghum’s seed, expected to improve the uniformity of the tampering process result and able to increase tampering capacity.

With uniform sorghum’s seed and similar size, it will occur a perfect process of tampering, because there is no longer sorghum’s seed with a smaller size that not able to proceed for tampering because it escapes from the tampering part. Related to that, it is necessary to apply the machine of cleaning and sieving/sorting/grading of sorghum’s seed and able to support the better result of tampering process, uniformity and equally with the higher whiteness level and lowers tannin level.

2. Materials and methods
This study was carried out from March until November 2018. Location planning, design, manufacturing machinery, functional testing was done in Engineering Laboratory BBP Mektan, Serpong. While the verification and performance test and field test was conducted at Likotuden village, East Flores district, East Nusa Tenggara. The main engineering materials for the manufacture of sorting machine/sorghum’s seed grading were: screen/sieve with diameter 3, 4 and 5 mm, diesel motor 6,5 HP, iron plate, iron elbow, pulley, belt, and their supporting components. While the test material used was sorghum from KD4 variety. The equipment used consists of a set of supporting tools for manufacturing activities (drilling machine, lathe, welding, cutting, bending, grinding, and others), a set of equipment test (meter, scales, stopwatch, Tachometer, moisture tester, measuring cup and others). The development activity of the sorting machine/grading of sorghum seeds is done by method and activity stage which is divided into: preparation stage, pre-design stage, design, fabrication, testing phase, and reporting stage. Flow chart methodology is presented in Figure 1.

2.1. Pre Draft
The uniformity of the sorghum seed is required before the mucking is done to obtain optimal capacity for the work of the tamper. Uniformity of the size of the sorghum seed will affect the length and decrease the quality of milling result. Therefore it is necessary to add a sorting tool/grading to obtain the value of material uniformity.
Figure 1. Flow chart of the process engineering of sorghum seed sieving machine
2.2. Sorting Machine Design / Grading Sorghum Seeds

The function of the sorting machine/grading of sorghum seeds is mainly to separate the sorghum seeds by size so that the seeds obtained are uniform, besides it also serves to separate intact seeds with other impurities such as crowns and stems sorghum and soil and hard rocks that are still elbowed at the time of harvest. This is to avoid the occurrence of blockages in holes polishing concaf and worsening rocks friction due to friction with hard rock. In addition, the function of sorting/grading also can be used to separate the bran/bran that is still mixed with sorghum seed tamper. This sieve design uses a 5 mm (5 mm) perforated plate and 4 mm size (for seed size ± 3 mm) and size 2 mm (to separate the bran). The sieving design has an eccentric type that is driven using a diesel motor with a power of 6.5 HP.

Figure 2. Grading machine design/sorting of sorghum
Figure 3. Detailed design of grading machine / pneumatic seed grain sorting of front, rear and three-dimensional design

3. Results and discussion
Sorting machine/grading of the sorghum seeds pneumatic system as a whole has dimensions p x l x t = 1225 mm x 1217.5 mm x 2315 mm with a propulsion of 6.5 hp diesel motor. This sorghum seed sieving machine consists of the main components of the sieving unit, blower unit, overall engine framework and engine driver 6.5 HP diesel engine.
Figure 4. Sorting machine/sorting/grading of sorghum seed capacity 400 kg/hour

A sorghum seed sorting machine is designed to get sorghum seeds of uniform size. The size of varied sorghum will be difficult in tampering because the seeds are larger will be lost first while the smaller has not been fooled. When the large sorghum has collapsed along with the small sorghum then the great sorghum will still be dumped again with the small sorghum, so it will decrease the yield and prolong the timing.

Sieve was made up of the main frame made of 40 x 40 mm elbow, sieve from 1.5 mm 1.5mm diesel, 6.5 hp diesel engine, pulley and V belt to transmit power. The size of the perforated plate was determined based on the mean value of the dimensions of the sorghum seed and the dimensional measurements were performed by taking samples of 100 seeds randomly (Figure 5). So as to obtain the size of perforated plate with 5 mm hole size for sorghum size ± 4 mm (grade 4) and 4 mm hole size for sorghum grade ± 3 mm (grade 3). In addition to functioning as a separator of sorghum seeds, this sieve can also as a separator sorghum still mixed with bran / “bekatul”. The perforated plate used to separate sorghum with bran using 2 mm holes size. Perforated plates are made knockdown and fitted with bolts to be modified in accordance with the desired rendering. The overall dimensions of the sorting machine are 1610 x 1280 x 1820 mm.
A sorghum seed sorting machine is designed to get sorghum seeds of uniform size. The varying size of sorghum will be difficult in milling because the larger seeds will fall out first while the smaller ones have not been muddled. When the large sorghum has been eroded along with the small sorghum then the great sorghum will still be lost again with the small sorghum, so it will decrease the yield and increase the length of tamper time. Sieve was made up of the main frame made of 40 x 40 mm elbow, sieve from 1.5 mm 1.5 mm diesel, 5.5 hp, pulley and V belt to transmit power. The overall dimensions of the sorting machine are 1610 x 1280 x 1820 mm.

3.1. Functional Testing Results

The grader machine functional test was performed using sorghum varieties KD-4, this test to observe if the size of the perforated plate is in accordance with the characteristics of sorghum seed (dimensions), speed and sieving eccentric movement adjusted to the required electric motors. Based on the test results, sieve has been able to separate sorghum into two grades of grade 4 for those who did not pass the 4 mm perforated plate and grade 3 for the 4 mm perforated plate. The eccentric force velocity has been adjusted to the material flow rate in a particular incline and the force of gravity of 400 kg/hour

In functional testing using sorghum KD-4 varieties also obtained grade 4 and grade 3 sorghum. In grade 3 there was 7% sorghum that has dimensions of more than 4 mm, due to sorghum passing through the hole in longitudinal position on the high side. From random measurements on 100 seeds obtained on average for length, width and height respectively 3.27 mm, 2.66 mm and 3.7 mm and sorghum seed sieving efficiency of KD4 grade 3 varieties of 93%. In sorghum of KD-4 grade 4 variant there is 20% sorghum which has a dimension less than 4 mm in the sense of efficiency of grade 4 sieving sorghum KD4 varieties 80%. The efficiency was smaller because this is due to sorghum not direct contact with the perforated plate, this constraint can be overcome by extending the seed time above the perforated plate so that the possibility of direct contact with the perforated plate is longer and the deviation result can be reduced. Although no sorghum seeds are retained on a perforated plate with a hole size of 5 mm but this plate is used to separate the panicle stalk, husks and other impurities that participate in the sorghum seeds so that sorghum seeds enter into the waste hopper is clean and does not inhibit the process of mucking. In general, the sorghum sieving machine has been able to function well and can separate the sorghum seeds in grade 3 and 4 mm with an overall average efficiency of 86.25% (Table 1). The capacity of the average sieving machine was 232.55 kg/hr as shown in Table 2. While the picture of sorghum seed after the sortation, seen in Figure 6, Figure 7 and Figure 8.
### Table 1. The efficiency of sorting machine sorting/grading of sorghum seeds

| No | Variety | Grade sorghum seeds | Efficiency |
|----|---------|----------------------|------------|
|    |         | pcs  | %  | pcs  | %  | %  |
| I  | Kawai  | 3 mm | 4 mm |       |      |
| 1  | Grade 3 mm | 76   | 76  | 24   | 24  | 76  |
| 2  | Grade 4 mm | 4    | 4   | 96   | 96  | 96  |
| II | KD4    | 3 mm | 4 mm |       |      |
| 1  | Grade 3 mm | 93   | 93  | 7    | 7   | 93  |
| 2  | Grade 4 mm | 20   | 20  | 80   | 80  | 80  |
|    | Efficiency average |     |     |      |     | 86.25 |

#### Figure 6. Sequencing/grading result of sorghum seeds for grade I (> 4 mm)

#### Figure 7. Sequencing/grading of sorghum seeds for grade II (3 - 4 mm)
Figure 8. Sequencing / grading of sorghum seeds for grade III (< 3 mm)

| Repeating No. | Sorting time (minute) | Rotation Speed (rpm) | Weight of material (kg) | Variety | Capacity Kg/hour |
|---------------|-----------------------|----------------------|-------------------------|---------|-----------------|
| 1             | 2,95                  | 504                  | 20 20                   | KD-4    | 406,78          |
| 2             | 3,01                  | 505                  | 20 18,18 1,8            | KD-4    | 398,67          |
| Average       |                       |                      | 20 18,18 1,8            | KD-4    | **402,73**      |

4. Conclusion
Overall, the grading machine of sorghum seeds has been properly able to separate the sorghum seeds with the capacity of 400 kg/hour and the grading efficiency for KD4 sorghum varieties reach 86.25%.

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