Development of Simple Polishing Sorghum Machine Abrasive Type Support for Diversification of Food in Lamongan

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Abstract

A common problem encountered in the use of grain sorghum is the milling process before the seeds can be used as food, feed or others. Milling aims to remove layers of sorghum pericarp and testa layer contains tannin from the endosperm. The layer can reduce protein digestibility in the stomach and the feeling of constipation. Institute for Agricultural Technology (BPTP East Java in cooperation with Indonesian Center for Agricultural Engineering Research and Development (ICAERD) Serpong, Banten) have developed a simple sorghum polishing machine with a diesel engine and abrasive stones type with a working capacity of 50-100 kg/hour. The purpose of this activity is to design the prototype machine polishing grain sorghum with the main objectives, namely: (i) Develop a milling system with a stone abrasive; (ii) Produce sorghum with the appearance of an intact form and bright colors. The design of sorghum polishing machine is done with the method and stage activities are divided into: the preparation stage, the stage of fabrication, testing, and reporting stage. The test results showed that the optimum milling capacity (2 × milling) is 100 kg/hour with tannin content of 0.09% and 3-5% broken grains and whiteness reached 44.66% (whole bean and bright appearance).

Keywords: Sorghum; Polishing/Milling Machine; Polishing Capacity; Quality Results

Introduction

Sorghum (Sorghum bicolor) is known as a cereal that contains high carbohydrate and protein as well as prospective substance as a substance of flour and rice. Sorghum is one of the most potent carbohydrate-producing commodities (about 73%) comparable to rice and maize, and even higher protein content (11.2%) than rice (6.8%) that can be developed to support food diversification programs [1,2]. The main difficulty in utilizing sorghum seeds for safe consumption is to remove the tannin content contained in the pericarp of the seeds. The pericarp of sorghum seeds fused strongly with the core of the seed (endosperm) that can be safely consumed. The main way to separate the pericarp part with the core of the seed is by rubbing (abrasion) [3].

The main function of sorghum milling is not only to obtain white (brighter) color from the seeds but also to decrease the tannin (phenol compound) content contained in the pericarp layer of the seed [4,5]. Phenolic compounds in tannins when binding to prolamin (kafirin) by forming complex tannin-protein bond will decrease the digestibility of proteins in the stomach and cause a sense of constipation and bloating [6]. The low content of tannins is generally characterized by the appearance of the bright whitish rice-color of sorghum [7,8]. Low tannin content condition is an indicator of the readiness of sorghum seed to be used for various main ingredients of food and feed [9,10]. For that, it is necessary to make sorghum polishing machine appropriate to efficient and effective. Some sorghum mowing machines that are currently not perfect and still require improvements in the quantity and quality of results [11-13]. This study aims to obtain the appropriate sorghum sorbuce machine by modification of an existing machine.
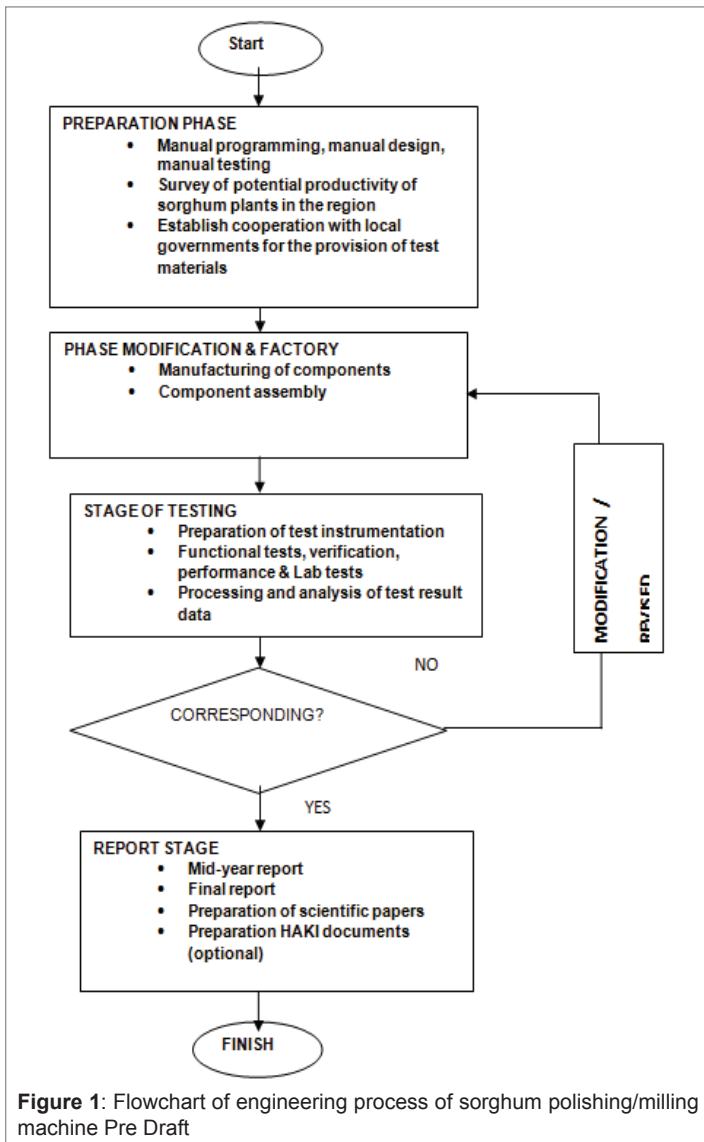
Improvements in the performance and quality of results will be made by modifying existing technologies with the improvement of existing systems and components with more appropriate technology and impacting on better performance and quality of the sosohan. Parameters of quality of sosohan that will be used include; the degree of whiteness, tannin level, amount of damaged/broken sorghum seeds and milling rendemen.

Based on these considerations, it is necessary to modify and develop sorghum mowing stones and material carrier screw to the wastage portion, so that the material flow rate can be increased and the rock capacity at each slump can be better, and the repetition of the milling becomes less and is expected only once repeat. The uniformity of the material to be muddled can improve the efficiency of milling. So that the activity of Sorghum Disposal Machine Capacity of 100 kg/Hour to Support Food Diversification needs to be done as a refinement of activity in the previous year.

Materials and Methods

This study was carried between March to December 2016. Location planning, design, manufacturing of sorghum polishing machinery, functional testing and verification and performance test was conducted at BPTP Jatim and Laboratory of Engineering BBP Serpong Agriculture Mechanization. While the laboratory testing was conducted at Post Harvest BB Laboratory. The main engineering materials for the manufacture of sorghum milling machines include: stone abrasive, diesel engine, blower, iron plate, elbow iron, pulley and belt and other supporting components. While the test material used was sorghum from KD4 variety. The equipment that were used consists of; a set of supporting tools for manufacturing activities (drilling machines, lathe, welding, cutting, bending, grinding, etc.), and a set of test equipment (meter, scales, stopwatch, Tachometer, moisture tester, whiteness tester, Measuring cups and others). The development and modification of sorghum sorbing machine is done by the method and activity stage which is divided into: preparation stage, modification and manufacturing stage, testing phase, and reporting stage. Figure 1 shows the flow chart of the methodology (Figures 1 and 2).

Figure 1: Flowchart of engineering process of sorghum polishing/milling machine Pre Draft

Figure 2: Sorghum Polishing/Milling Machine
Figure 2 is a perspective view of an entire simple sorghum polishing machine consisting of the main frame (1), sorghum exit (2), abrasive stones and Sieve (3), Hopper (4), As (5), Pulley (6), Diesel engine (7), The skin exit/the bran of sorghum (8)

Figure 3: Sorghum polishing machine capacity of 100 kg/hour

Results and Discussion

Sorrow sorbot machine capacity of 100 kg/hour as a whole has dimensions p × l × t is 1350 × 80 × 1350 mm with 8.5 hp diesel engine driving power. Soros sorbing machine capacity of 100 kg/hour consists of several major components of the milling unit and supporting components of the framework and propulsion (Figure 3).

Major unit components

Millstone design: Abrasive stones are a major component in the design of prototype submitter machines. The abrasive stones used in the wastage unit are abrasive stones that have specific dimensions and axle holes. Abrasive stones for prototype submersion machines in the previous year which has a diameter of 253 mm, a length of 270 mm yields less than optimal reprobing capacity with repetition of up to 4 times to obtain sorghum seeds with safe tannin content (<0.5%). In order to improve the efficiency (reduce the amount of repeat polishing), better and more optimal capacity than one time. Abrasive stones used in the polishing unit is abrasive stones with a diameter of 203 mm, 20 mm thick and which can meet the length of space penyosoh (240 mm) and easily obtained as shown in table 1.

The design considerations of the length of the abrasive stone structure are based on the length of the contact between the sorghum and the stone surface so as not to cause excessive heat effects on the sorghum seeds. The occurrence of excessive heat in the seeds due to the friction between the surface of the sorghum with abrasive stone resulted in the occurrence of sorghum seed meltion (surface of the seed will melt). The gelatinization effect will cause the smooth bran/bran to be attached to the sorghum seeds, on the stone surface, and can clog the concave filter holes that inhibit the rate of bran/bran output. The thickness (length) of the stone becomes the durability factor against the pressure received a stone from various directions when penyosohan take place, the thicker the stone the lower the possibility of broken (split) or damage. Based on Mwasaru et al. [4], abrasive roughness is used to muffle high tannin sorghum seeds between mesh 24 (840 μm diameter) 46 (484 μm in diameter), whereas abrasive stones used for machining components 2016 have mesh 46.

The working process to unite some abrasive rocks, then the hole in the middle of a stone that has a metal wall can be made a spi hole that serves as a stone lock so that the rock does not shift. To form a slump stone with a length of about 240 mm, then an abrasive stone with a diameter of 203 mm, and a length of 20 mm should be put together in series into a series.
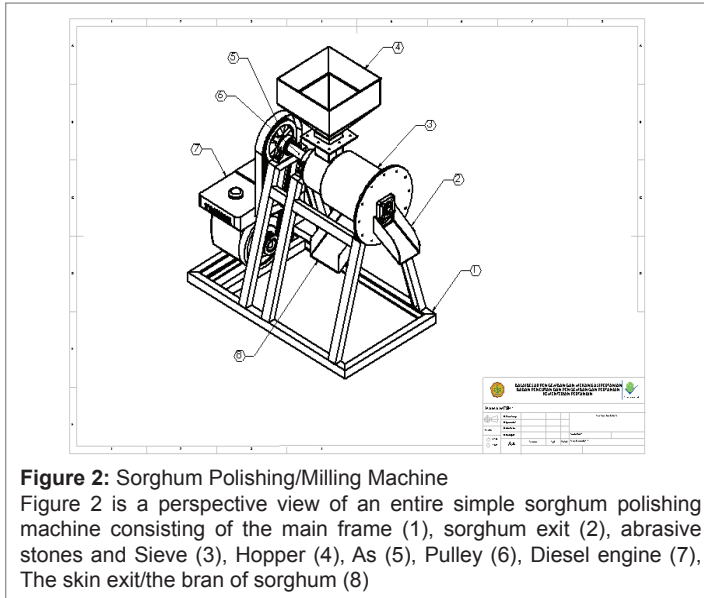
Table 1: Specification of Abrasive Stone

Rock weight per piece (kg)	1,3
Diameter of stone (mm)	203
Shaft Diameter (mm)	76
Rock length (mm)	20

Based on the above abrasive stone specifications the length of the slab stone required for the design unit of 2016 is determined by comparing the length of the track or the field of sorghum seed contact on the abrasive stone. The wider field of contact will accelerate the peeling process of the skin of sorghum seeds so as to speed up the process of milling. From the calculation results obtained abrasive stone length required 240 mm which means abrasive stone required with the above specifications as many as 12 pieces, so the overall abrasive length of 240 mm.

In the previous year with a shorter stone length to produce sorghum sosum by doing 4-5 times penyosohan, it is expected that this year's design has a longer trajectory length will result in sorghum performed a maximum of 3 times penyosohan. With the length of the trajectory is expected sorghum seeds will experience optimal penyosohan so as to increase the value of efficiency of milling.

The scratch filter design (konkaf) has a rectangular oblique perforated hole with a length of 14 mm, the width of 1.2 mm and a spacing between holes 2 mm. The perforated hole has a slope of 45° to the spindle shaft (Figure 4). The filter design is divided into two parts in order to facilitate maintenance, cleaning, and when replacing abrasive stones.

Design capacity of the milling unit: The theoretical capacity calculation was achieved by calculating the volume of screw/auger capable of carrying sorghum seeds at 850 rpm and the ratio of sorghum seed compression into the trough room and by considering the value of bulk density. From the calculation results obtained the theoretical capacity of 100.5 kg/hour? The value has met the targeted capacity of 100 kg/hour. The result of the design calculation is then poured into the shape of the drawing unit design as shown in figure 5.

Cylinder filter: The filter cylinder is made of a perforated plate having a thickness of 1 mm with a beveled oblique hole profile (14 × 1.2 mm) so that the bran or bran of the slaughtering result is expected to pass through the hole. The filter cylinder design is made into two parts in order to be more easily removed during checking of rock conditions as well as other problems that may arise during milling, without opening the chassis of the output.
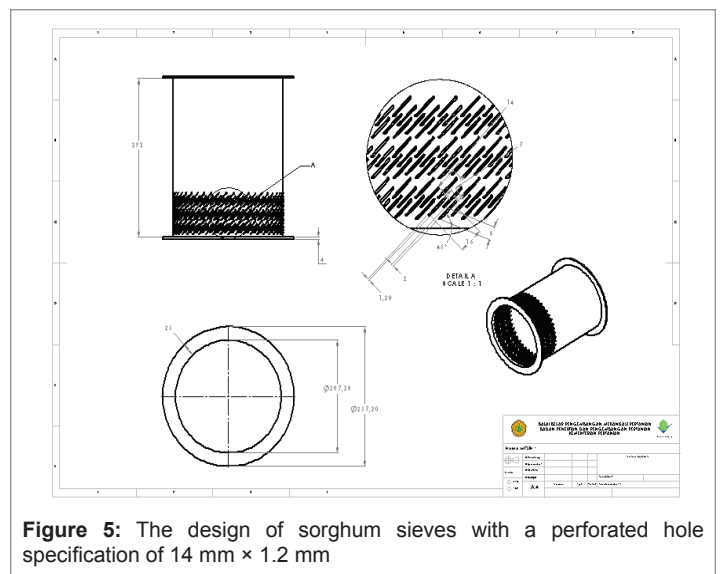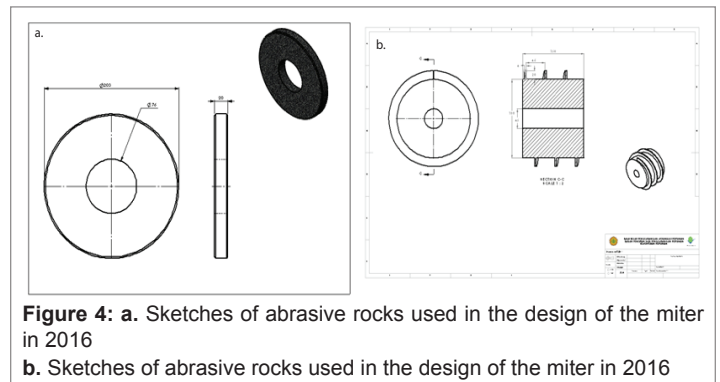
Main frame and drivers

The main frame design is based on several things as parameters, including the dimensions and weights of all the mucker unit components, the space required by the bran hoppers and the consideration of the wastage unit balance when it operates in relation to the spinning and shaft spindle generated. For balance, the main frame that has a sleek and tall shape is designed together with the engine seat frame, the separator unit. To reduce vibration during operation then the bottom of the frame is installed bolts plant (dynabolt). The main frame design drawing and engine holder are shown in figure 5.

The driving force requirement is calculated from the power requirements for the wastage unit. Calculation of the driving force based on the torque that occurs with the desired engine speed. From the calculation results obtained power for the milling unit of 8.5 HP.

Results of performance testing

Sorghum disposal machine capacity 100 kg/hour: From the results of the performance test of the sorghum sorbing machine, the capacity

Figure 4: a. Sketches of abrasive rocks used in the design of the miter in 2016
b. Sketches of abrasive rocks used in the design of the miter in 2016

Figure 5: The design of sorghum sieves with a perforated hole specification of 14 mm × 1.2 mm

reached up to the first figure of 100 kg/hour (Table 2). This milling can be done up to two replications with optimum yield quality at 100 kg/hour. If penyosohan done continuously above 100 kg and after two replication the quality of the result of sosohan become decrease. Comparison of the quality of the results can be seen in figure 6. This is due to the factor of bran or bran is still out with sorghum which resulted in the sorghum that has been completely covered by bran and cause the color becomes not bright.

Based on the observations at the performance test, if the test material inserted into the hopper is less than 100 kg and twice repetition, the sorghum seeds can be perfectly absorbed and not mixed with bran (Figure 7a). However, after reaching 100 kg above, in the middle of the process of milling the sorghum began to mix with bran (Figure 7b) or about 85% cleanliness level.

Based on the results of the proximate analysis, from several treatments and replications, it was found that the fat content and tannin content experienced a significant decrease occurred in the second (optimum sosoh condition). The result of proximate analysis can be seen in table 3.

The result of laboratory analysis of whiteness test, KD-4 sorghum varieties which are boosted by 2 × optimum obtained an average value of 36.4-46.6% (Table 4, Figures 8 and 9). This shows that with the value of whiteness there is a decrease in tannin content in the sorghum seed. There is a relationship between the value of whiteness with tannin content, where the higher the value of whiteness the lower the tannin content [11].

Thus the milling of sorghum seeds as much as twice obtained the value of whiteness and tannin content in accordance with consumption needs.

The results of physical analysis of sorghum seeds show that the process of milling on sorghum seeds can be done well. This can be seen in table 5 where the percentage of whole seeds averaged 91.16%-94.40% and seeds broke about 3-6%. This is in accordance with the main objective of mucking that is obtaining sorghum seeds sosoh with the percentage of seeds breaks 3-6% (Table 6).

Based on table 7, sorghum polishing machine is able to reduce the tannin content in accordance with consumption needs and 3-5% broken seeds with a maximum of 2 times penyosohan. But there are some weaknesses in the design of this penyosohan machine is that if penyosohan has lasted long and a lot of about 100 kg to the top, the results of the perfect is still mixed with bran or bran that come out simultaneously. Various modifications have been made and still continue to be done on the component parts of the absorption unit with the addition of high pressure air blowing unit on the inside of the cylinder that serves to press the bran out the filter.
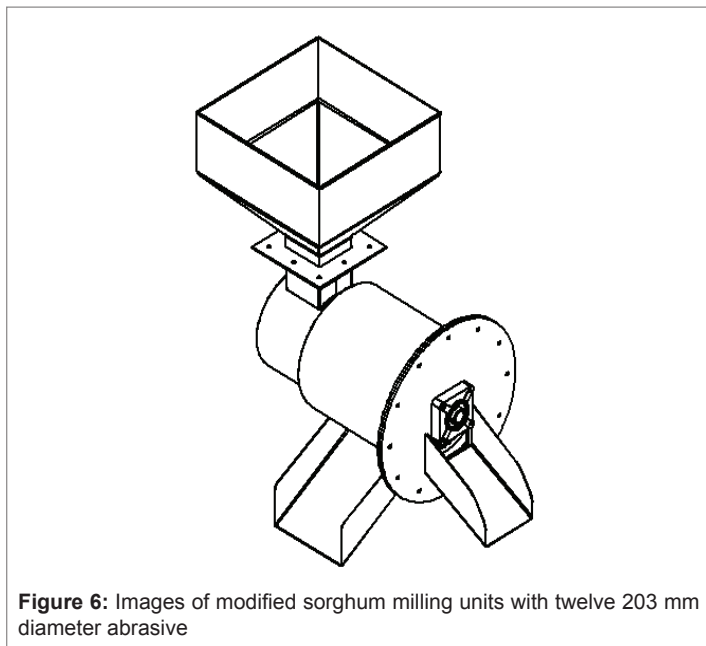
Table 2: Result of performance test of sorghum polishing machine

No.	Varieties	Treatment	Speed of Shaft spindle (rpm)		Speed of blower (rpm)		Material weight (kg)		Disposal Time (minute)	Capacity (kg/hour)
			before	after	before	after	in	Out		
1	KD-4	Polish 1x	763	735	3105	3050	100	60	60	100
2	KD-4	Polish 2x	741	733	3100	3047	60	50	60	50

Table 3: Proximate test results of Sorghum Seeds Before and After Milling

No.	Varieties	Treatment	Analysis (%)				
			Water Level	Fat Level	Protein Level	Carbohydrate	Tannin
1	KD4	First Material	9,87	2,52	7,67	76,73	1,44
2	KD4	Optimum Polish	5,99	0,46	5,82	86,13	0,09

Figure 6: Images of modified sorghum milling units with twelve 203 mm diameter abrasive

Figure 7 (a,b): Sorghum seed absorption is optimal and not yet optimal

Figure 8: Early sorghum seed var. wonogiri and sorghum seed polishing yields 1 × and 2 ×

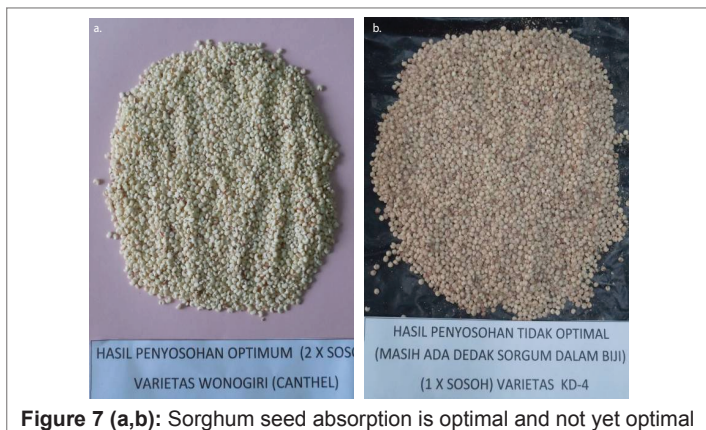**Figure 9:** Early sorghum seed var. KD4 and sorghum seed polishing yields 1 × and 2 ×

Table 4: Whiteness test results

No.	Sample	Whiteness (%)
I	**Var. wonogiri awal**	**18,00**
1	Sosoh 1 ×	29,40
2	Sosoh 2 ×	37,00
3	Sosoh 2 × Optimum	46,66
II	**Varietas KD4 awal**	**20,00**
1	Sosoh 1 ×	27,47
2	Sosoh 2 ×	32,06
3	Sosoh 2 × Optimum	36,60

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Table 5: Physical analysis of sorghum seeds resulting from milling

No.	Sample	Bobot Awal	Sorgum						Kotoran	
			Utuh		Pecah		Tanpa Lembaga			
			gr	(%)	gr	(%)	gr	(%)	gr	(%)
I	**Var. wonogiri awal**	25,00	24,30	97,20	0,10	0,40	0,15	0,60	0,45	1,80
1	Sosoh 1 ×	25,00	24,37	97,48	0,15	0,60	0,45	1,80	0,07	0,28
2	Sosoh 2 ×	25,00	23,05	92,20	1,13	4,52	1,05	4,20	0,07	0,28
3	Sosoh 2 × Optimum	25,00	22,79	91,16	1,13	4,52	1,03	4,12	0,07	0,28
II	**Varietas KD4 awal**	25,00	24,60	98,40	0,30	1,20	0,00	0,00	0,10	0,40
1	Sosoh 1 ×	25,00	23,80	95,20	0,90	3,60	0,30	1,20	0,00	0,00
2	Sosoh 2 ×	25,00	22,90	91,60	1,50	6,00	0,60	2,40	0,00	0,00
3	Sosoh 2 × Optimum	25,00	23,60	94,40	0,80	3,20	0,60	2,40	0,10	0,40

Table 6: Physical analysis of sorghum seeds resulting from milling repeat

No.	Sample	Initial Weight	Sorgum			Dirt
			Intact	Broken	Without Institution	
			gr	gr	gr	gr
1	2 × Optimum polishing b	25,00	23,60	0,80	0,60	0,10
2	1 × Optimum polishing/Initial repeat	25,00	21,80	2,60	0,40	0,20
3	1 × Optimum polishing b	25,00	23,80	0,90	0,30	0,00
4	2 × Optimum polishing a	25,00	22,90	1,50	0,60	0,00

Table 7: Comparison of quality of sorghum seeds at the level of milling

No.	Parameter	Polish 1 time	Polish 2 time
1.	Capacity (kg/hour)	100	50
2.	Tannin Level (%)	1,05	0,09
3.	Whiteness (%)	28,90 (less bright)	46,66 (bright)
4.	Whole Seed (%)	95,2-97,0	91,6-92,2
5.	Broken Seed (%)	0,6-3,6	3,52-6,0
6.	Rendemen (%)	79,20	80

Conclusion and Recommendations

Overall sorghum polishing machine capacity of 100 kg/hour has been able to polish the sorghum seeds with 1 (one) repetition time so that the capacity to reach 100 kg/hour. If the milling is done optimum (twice polishing) capacity 50 kg/hour with the quality of whole seeds average 91.16%-94.40% and seeds broke about 3-6% and whiteness value 46.66% (sunny) to the level Tannin averaged 0.09%.

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