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Surface Polishing of Black Mold Affected Sorghum

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A B S T R A C T

Sorghum (*Sorghum bicolour* (L) Moench) is the fifth major cereal crop in the world after wheat, rice, maize and barley. In India the crop is grown of 12.5 million ha. Maharashtra produces 49.82 lack tonnes of sorghum on 55.57 lacks ha., out of which Vidarbha produces 14.08 lack tonnes of sorghum. PKV mini dal mill can be used for polishing of mold affected sorghum with 80 no emery roller and 1200 rpm roller speed at feed rate of 120 kg/h. The combination gave very less black mold rating, hence this combination is considered better for polishing of blackened sorghum. The study revealed that, the 1000 grains mass was slightly reduced from 0.032 to 0.031 kg and hardness was reduced from 6.62 kg to 5.62 kg after polishing mould affected sorghum. The protein content of mold affected sorghum 11.51% was slightly reduced to 11.35 %. whereas carbohydrates content was slightly increased from 71.86 to 72.02 % after polishing. Percent incidence of mycoflora was reduced from 85% to 62% after polishing. It was observed that, there was significantly lower weight in unpolished (4.125 %) and polished sorghum grains (4.37%) when stored in tin container and at par with each other followed by polypropylene bags, gunny bag lined with polyethylene and higher in gunny bags (6.0%) at the end of 4 months. It was observed that, the storage period for unleavened cake (bhakries) prepared from fresh CSH – 9 was 120 days and showed better acceptability. The cost of mold affected sorghum polishing was worked out to be Rs. 35/q. The break even point and payback period is 37 % and 1.40 years respectively. Surface polishing of black mold sorghum by using PKV mini dal mill is techno economically feasible.

Introduction

Sorghum (*Sorghum bicolour* (L) Moench) is the fifth major cereal crop in the world after wheat, rice, maize and barley. In India the crop is grown of 12.5 million ha. Maharashtra produces 49.82 lack tonnes of sorghum on 55.57 lacks ha., out of which Vidarbha produces 14.08 lack tonnes of sorghum.

Generally it seems that wet weather (untimely rains) following flowering and grain development is necessary for grain mold development (Castor and Fredriksen, 1997), which appears black in colour and fetches very low price in the market. The longer the wet period, greater the mold development. The blackening was found to be limited only to the surface layers. The intensity of molding was

variable within a lot of grains of same cultivars. This situation happens to be occurred many a times in our region which lowers the market value of sorghum grain. This mold can be removed to some extent if the grains are polished. A surface demolder / polisher can be developed for this purpose which will remove the surface mold (blackened portion) to some extent and the sorghum grain will fetch better price in the market.0

Scope of work

The blackening of sorghum grain is a common feature happens to be occurred when the untimely rains coincides with flowering to grain development which lowers quality and market price. A gadget needs to be developed for polishing of the blackened sorghum grain which will improve the appearance and thereby increasing the market value.

Initial studies with the cone polisher of rice mill showed satisfactory results. A 5-10 minutes condition times was found to be suitable and passage through two cone polisher gave 7-8 % polishing (Rooney and Sullins, 1999).

Bhatnagar (2004) reported a method using laboratory scale Mc Gill Miller No. 3 and 7 pounds of pressure for polishing of sorghum. The method may be reported as under, cleaned sorghum grains were taken in wire baskets and dipped in water for 30 sec.

The excess of water was drained and grain were conditioned for about 20 minutes with intermittent mixing when the grain began to roll freely subjected to pearling. It was observed that time required for about 15 % of polishing different largely in different varieties and range from 29 sec. for Varadi to 65 sec. for CSH-5. Further it was observed that the broken percentage depended on time of polishing and type of variety used. The grains were first conditioned with 2-3 % moisture for 5-10 min before pearling. During large scale trial, horizontal emery cylinder type polisher gave less breakage than vertical cone polisher (Desikachar, 1982). The sorghum pearled up to 12 % degree of pearling using under runner disc sheller was observed to result in improvement of the chapatti made from it (Sahay and Gandhi, 2005). The ragi pearler procured from Banglore centre, sorghum dehuller, Hyderabad and PKV mini dal mill, Akola was tested for polishing mold affected sorghum by conducting some filler trials. With sorghum dehuller 13.5 m.c.(wb) was found good for polishing. The grain mold was reduced from rating 8-6 only when processed under ragi pearler with various moisture treatment and it is not suitable for polishing of mold affected sorghum.

At this moisture content the mold was reduced from rating 8-3 with good recovery of whole grains (75.43%) and less broken (4.83%) but, the operation is batch type with no mechanism for separation of broken and insufficient cyclone arrangement for separation of powder. By using PKV mini dal mill even though the amount of whole polished grains collected were on somewhat lower side (64.65%) and broken were on higher side (19.24%) because of existing rough emery no 30 used for dehulling pulses but this is continuous system having all provisions for separating broken and powder and hence can be modified to suite for surface polishing of mold affected sorghum during pearling slight protein loss (0.62%) was observed and reduction of microflora incidence was observed from 16 to 21 % in PKV mini dal mill and sorghum dehuller respectively.

Materials and Methods

Last year various machines viz. ragi pearler, sorghum dehuller and PKV mini dal mill were tested for surface polishing of black sorghum. Considering all factors, this year, it was decided to modify the PKV mini dal mill for surface polishing/demolding of black sorghum grains. This machine is having all operation in one unit such as dehusking, separating husk, powder and brokens also. The machine consists of four units viz. elevator, dehulling unit, separation unit and screw conveyor. (Fig.5.1).It requires two horse power single phase electric motor for complete operation.

Dehulling unit

It consist of an abrasive horizontal conical cylinder rotating in order to achieve smooth flow of grains during dehulling. The cylinder is covered by a metal sieve with a specific clearance. The sieve facilitates the partial separation of husk and powder. The inlet and outlet are provided on sides plates at the top and bottom, respectively, with separates controls by hand wheel and lever.

Separation unit

This unit comprises of the three components viz. blower, sieve unit and cyclone separator. When the dehulled mixture is allowed to fall on the sieve unit, the blower separates the husk and powder from it and passes to the cyclone separator. The mixture of husk and powder falls out from bottom of the cyclone separator and air escapes from top. This unit avoids the dusty atmosphere.

Sieve unit

The four point suspension system is provided to sieve unit resting on main frame with reciprocating motion.

Transmission system

Prime mover supplies power directly to the dehulling unit as it consumes major part. The second belt provides power to the counter shaft, which operates all the other units of dal mill. The whole power transmission is achieved though v-belts and pulleys. The sieve unit reciprocates through connecting rod from eccentric mechanism installed on counter shafts.

The sieve unit was modified by providing sieve of 2 mm diameter aperture. The emery powder of 40, 60 and 80 no was purchased from Agra. Rollers were fabricated by using emery powder 40 no, 60 no and 80 no and by using nylon brush and leather. For changing the speed the existing pulley (127mm diameter) at the end of roller shaft providing 900 rpm was replaced by 90 mm diameter pulley providing 1200 rpm. The hand lever at outlet control was modified by providing screw mechanism for precision control of outlet opening. Various feeler trials (6 trials for each feed rate) were undertaken for maintaining constant feed rates for better polishing.

This was done by feeding 10 kg grains in the hopper and inlet and outlet was kept closed, then the inlet was opened and about 3 kg grains were allowed to pass in the gap between the roller and the sieve (until its full capacity). Then the outlet was opened to such a level so as to maintain the flow rate of 90 kg/h as well as better polishing. Same procedure was adopted for deciding the other feed rates such as 120 kg/h, 150 kg/h and 180 kg/h. The markings were given on inlet controlling mechanism and outlet controlling mechanism for maintaining constant federates of 90 kg/h, 120 kg/h, 150 kg/h and 180kg/h.

The variety of grains sorghum (blackened) used for testing was CSH-9. The sample size was 10 kg for each replication. Before starting the test, the physical properties of the grains such as moisture content, hardness and weights of 1000 grains were observed. For bringing moisture content to the desired level of 13.5%, known amount of water was sprinkled over the grains and kept for conditioning for about 20 minutes.

The following treatments were considered for testing PKV mini dal mill for polishing of mold affected sorghum by using PKV mini dal mill.

Moisture content (w.b.) of sorghum grain: 13.5%

Rollers used for polishing

R1- 40 no emery roller
R2- 60 no emery roller
R3- 80 no emery roller
R4- Nylon brush roller
R5- Leather roller

Speeds Used for polishing

S1 - 900 rpm

S2- 1200 rpm

Feed rates used for polishing

F1- 90 kg/h
F2- 120 kg/h
F3- 150 kg/h
F4- 180 kg/h
Replications: 3

After the test was over the whole polished grains, broken and powder were measured for each replication. The mold rating of whole polished grains was also observed. Data was statistically analyzed by using analysis of variance by one way classification.

The percent incidence of mycoflora, protein and carbohydrate content, was observed for whole polished grains and mold affected grains. The mycoflora, was observed by standard blotter paper method. The protein content was determined by micro Kjehldal's method and carbohydrates were determined by Flame photometric method.

After analyzing the data statistically and finding out the best treatment the polishing of the 150 kg grains was carried out by using parameters of the best treatment. Polished and unpolished grains were stored in various packaging materials.

In order to observe the shelf life of polished and mold affected grains (unpolished), the storage experiment was laid in FCRD replicated thrice. Four kilogram grains were used for each treatment. The treatment details are as under.

Grains

B1- Polished grains
B2- Unpolished grains

Containers

A1- Gunny bag
A2- Gunny bag lined with polyethylene
A3- Polypropylene
A4- Tin Container

The observations were taken at every 15 days interval to examine weight loss, hardness, moisture content, protein and carbohydrates of grains by taking sample of 50 g.1000 grain weight was taken at the initial and final stage of storage.

To observe the quality of the stored grains, unleavened breads (Bhakaries) prepared from mold affected sorghum (A), freshly polished sorghum (B),stored polished sorghum (C) and fresh CSH-9 (non blackened)(D) were served to judges with chutneys for organoleptic testing. Before that, the physical properties of flour viz. kneading quality, rolling quality, baking quality and keeping quality were determined. The data was analyzed by using analysis of variance technique – one way classification.

Results and Discussion

The variety of mold affected grain sorghum used for polishing was CSH -9. The physical properties of the grain sorghum are shown in Table 1.The 1000 grain mass was 0.0322 kg at 9.6 % moisture content (w.b.) and the hardness of the grain was 5.62 kg, at 9.6 % moisture content (w.b.). The mold rating scale given in Table 2 was used for determining the mold rating of whole grains. The test results of polishing of mold affected sorghum by using PKV mini dal mill using various treatments are shown in Table 3 to 12.

Roller

Table 3 shows effect of different rollers on mold rating, whole grain, broken and husk and powder. Maximum removal of mold (3.33) was due to roller R3 (Emery No 80), It was significantly better than any other roller and was followed by roller R2 (Emery No 60) and roller R1 (Emery no 40) respectively. The R4 (nylon brush roller) and R5 (leather roller) could not remove sufficient mold (Table 3). As regards the effect of roller with respect to whole grains, maximum quantity of whole grains

were observed in R4 (nylon brush roller) and R5 (leather roller), which were at par. However both of these rollers cannot be considered for polishing point of view, as it was observed that these rollers were unable to remove the mold and mold rating is very important quality parameter for analyzing the polishing of blackened sorghum grains. These were followed by roller R2 (Emery No 60) and roller R3 (emery no 80) both being at par with each other and significantly better than roller R1 (emery No 40).

As regards the broken grains due to different rollers, minimum broken grains were observed in R4 (nylon brush roller) and R5 (leather roller) both being at par with each other. These were followed by roller R2 (emery No 60) and R3 (emery No 80). Significantly maximum broken grains were observed by using R1 (emery No 40). Similar trend was observed for husk & powder. Significantly minimum husk and powder was observed by using roller R4 (Nylon brush roller) followed by R5 (Leather brush roller).

Significantly maximum husk and powder was observed in Roller R1 (emery No 40). There was no significant difference existed between roller R2 (emery No 60) and roller R3 (emery No 80) indicating superiority of roller R3 (emery no 80) over others as it has reduced the mold rating to sufficient extent.

Feed rate

Among the various feed rates tested for the polishing of mold affected sorghum, minimum feed rate of 90 Kg/h was effective in polishing the grains thereby reducing the mold rating to sufficient extent and was significantly better than rest of all the feed rates followed by 120 kg/h, 150 kg/h and 180 kg/h (Table 4).

In case of whole grains significantly highest whole grains were observed at 180 kg /h and was followed by 150 kg/h, 120kg/h and 90 kg/h. Thus, as the feed rate was reduced the amount of whole grains obtained after polishing was also reduced. This was because of the more retention time period of grains between roller and sieve. In case of less feed rate, exposure of grains to the rollers for more time resulting in more breakage and thereby reducing the whole grains.

Significantly minimum broken grains were observed in 180 kg/h feed rate, followed by 150 kg/h, 120kg/h and 90 kg/h. Thus as the feed rate was decreased the brokens were increased for the same reason given before. Likewise significantly minimum husk and powder was observed at 180 kg/h than any other feed rate.

Speed

As shown in Table 7, speed of 1200 rpm has shown significantly less mold rating (good polishing) than in 900 rpm. This was because the grains were exposed for more number of times to the roller surface resulting in less mold rating (better polishing). As regards the whole grains, maximum grains were observed at speed of 900 rpm than 1200 rpm. The brokens and husk and powder were observed minimum at 900 rpm for the same reason given before.

Interaction effect of roller and feed rate

As regard the effect of roller and feed rate (Table 7) on the mold, minimum mold rating (2.67%) i.e. better polishing was observed by using roller R3 with feed rate 90 kg/h and 120 kg/h with no significant difference and was significantly better than any other roller and feed rate.
As regard the quantity of polished whole grains, no significant difference was observed with feed rate 150kg/h and 180 kg/h for nylon brush roller and it was at par with leather roller for same feed rate and was significantly better than any other roller and feed rate. However by using these two rollers (R4 & R5) and these two feed rates (F3 & F4), the mold rating (6) is not reduced to acceptable range which indicates polishing is not good and hence this combination of rollers and feed rate is not useful.

The significantly minimum quantity of broken

grains was observed at feed rate 180 kg/h and for leather roller (R5). It was at par for same feed rate with nylon brush roller (R4) and was significantly lower than any other roller and feed rate. But even though the quantity of brokens obtained by using above combination is less, the mold rating is not reduced to much extent and retains 6 only, which indicates very less polishing and hence the combination is not useful.

Significantly minimum quantity of husk and powder was observed with 90, 120, 150 and 180 kg/h for nylon brush roller and was at par with the same feed rate for leather roller and it was significantly better than any other roller. But using these combination mold rating is not reduced to much extent hence these combination cannot be considered better for polishing black mold sorghum.

Interaction effect of roller and speed

The minimum mold was observed on polished whole grains at the speed of 1200 rpm and for roller with 80 no emery and it was minimum and was significantly better than any other roller and feed rate (Table 7).

As regard the quantity of whole grains, the maximum whole grains were observed at nylon brush roller and 900 rpm speed and was significantly better than any other roller and speed. But in this combination the mold rating (6) is not reduced to much extent and hence the combination is not suitable for polishing of blackened sorghum grains. The minimum quantity of brokens were observed at nylon brush roller at 900 rpm speed and significantly better than any other roller and speed. But in this combination the mold rating (6) is not reduced to much extent and hence the combination is not suitable for polishing of blackened sorghum grains. The similar trend was observed as regard husk and powder which is not suitable for polishing of black sorghum for the same reason stated above.

Interaction effect of feed rate and speed

The minimum mold (4.6) was observed at 90 kg/h and 120 kg/h at 1200 rpm and was significantly better than other feed rates and speeds (Table 8). Thus by using these two feed rate and 1200 rpm speed, the polishing of mold affected sorghum was better.

As regard the whole grains, the significantly maximum quantity of whole grains were observed at 180 kg/h and 900 rpm and was significantly better over others, but using this combination, the polishing is not better (mold rating is 4) hence the combination is not suitable for polishing black mold sorghum.

The significantly minimum brokens were observed at feed rates 180 kg/h (F4) and was at par with 150 kg/h (F3) at 900 rpm and was better than any other feed rate, but in this case also, the mold rating is 5.4 and 5.2 which indicates no better polishing and hence the combination is not suitable.

The lowest husk and powder was observed at feed rate 180 kg /h at 900 rpm and was significantly better than others. But by using this combination also polishing is not done to much extent and hence the combination is not suitable.

Interaction of roller, feed rate and speed

Table 9 depicting three factor interaction means, showing effect of roller, feed rate and speed on mold rating of polished whole grains. The minimum mold (2.33) was observed at R3S2F1 & R3S2F2 and was significantly better than rest of all. Hence the polishing of blackened sorghum by using this combination is better. But as the similar extent of polishing is done by using the grater feed rate F2 (120kg/h), the capacity of polishing is increased as compared to feed rate 90 kg/h (F1). Thus by using the combination R3S2F2 i.e roller with emery no 80, feed rate 120kg/h and speed of roller 1200 rpm, the blackened sorghum can be better polished reducing mold rating to the tune of 2.33.

The highest quantity of polished whole grains were observed at R4F4S1 (9.754) and followed by R4F3S1 (9.7139) and significantly better than rest of

all (Table 10). But since the mold rating by using these combination is not reduced to much extent these combinations are not useful. The combination at which we get very less mold rating gives the polished grains to the tune of 8.5016 and 8.5603, by using R3F1S2and R3F2S2 respectively. Thus more amount of polished whole grains are getting by using combination R3F2S2 hence this combination can be considered as better combination for polishing of mold affected sorghum grains.

The minimum brokens were observed at R5F4S2 (0.1276) and was significantly better over rest of all combinations (Table 11). But using this combination, the mold rating is 6 which indicates polishing is not done to sufficient extent. The combination by which we are getting very less mold rating i.e. R3F1S2 and R3F2S2 gives the broken to the tune of 0.5943 and 0.5876 which are less hence this combination can be considered better for polishing of blackened sorghum.

The minimum husk and powder (Table 12) was observed at R4F4S1 and was at par with R4F4S2, R4F3S1, R4F3S2, R4F2S1 R4F2S2, R5F2S1, R5F3S1,R5F4S1and R5F4S2 was significantly better over rest of combination. But since the mold rating by using this combination is not reduced to much extent, these combinations are not useful.

The combination by using which we are getting very less and similar mold rating gives husk and powder to the tune of 0.6493 and 0.6006 here it indicates that even though the mold rating is reduced to similar extent but since the amount of husk and powder is less by using R3F2S2(0.6006) as compared to R3F2S1(0.6493) the combination of R3S2F2 can be considered better for polishing of mold affected sorghum.

The data in Table 11 revealed that the 1000 grains mass was slightly reduced from 0.032 to 0.031 kg and hardness was reduced from 6.62 kg to 5.62 kg after polishing mould affected sorghum. The protein content of mold affected sorghum (11.51%) was slightly reduced to 11.35 %. whereas carbohydrates content was slightly increased from 71.86 to 72.02 % after polishing. Various organisms such as *Curvularia lunata, Fusarium. spp., Alternaria-alternata, Aspergillus spp., Phoma. spp., Dreschlera spp*. were observed on the moldy grains. Percent incidence of mycoflora was reduced from 85% to 62% after polishing.

The data presented in Table 11 showed the effect of various storage containers on moisture content of polished & mold affected sorghum during storage. It was observed that the moisture content of the stored grains decreased slightly with the storage period due to evaporation. It was also revealed from the table that, the moisture content in the Tin container was significantly higher than rest of the containers where as the moisture content of rest of the containers were lower and at par with each other having slightly decreasing trend. i.e. tin containers, polypropylene, gunny bag lined with polyethylene and gunny bag.

Table.1 Physical properties of mold affected grain sorghum (Variety :CSH-9)

Moisture content , %	9.6
1000 grain mass, kg	0.032
Hardness, kg	5.62

Table.2 Mold rating scale

Mold rating	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Mold, %	0	1-10	11-20	21-30	31-40	41-50	51-60	61-75	> 75

Table.3 Means ratings for selected characters of mold affected sorghum as *influenced by different rollers*

Rollers/parameters	R1	R2	R3	R4	R5	SE_D	CD 5 %
Mold	5.375	4.041	3.333	9.611	9.541	0.064	0.126
Whole grains	8.633	9.040	8.954	9.611	9.541	0.044	0.086
Brokens	0.550	0.293	0.414	0.200	0.037	0.021	0.042
Husk and powder	0.661	0.401	0.422	0.092	0.161	0.021	0.041

Table.4 Mean ratings for selected characters of mold affected sorghum as influenced by different feed rates

Feed rate/parameters	F1	F2	F3	F4	SE_D	CD 5 %
Mold	4.633	4.700	5.066	5.400	0.577	0.113
Whole grains	8.906	9.073	9.238	9.406	0.039	0.077
Broken	0.440	0.360	0.301	0.227	0.1940	0.038
Husk and powder	0.458	0.382	0.313	0.236	0.019	0.037

Table.5 Mean ratings for selected characters of mold affected sorghum as influenced by different speeds

Speed/parameters	S1	S2	SE_D	CD 5 %
Mold	5.016	4.883	0.040	0.078
Whole grains	9.392	8.920	0.028	0.054
Brokens	0.233	0.431	0.013	0.026
Husk and powder	0.218	0.477	0.013	0.026

Table.6 Two factor interaction means showing effect of roller and speed on polishing parameters of mold affected sorghum

Roller/ speed	Mold rating		Whole grains		Brokens		Husk and powder	
	S1	S2	S1	S2	S1	S2	S 1	S2
R1	5.5	5.2	9.256	8.010	0.241	0.859	0.303	1.019
R2	4.082	4	9.221	8.859	0.242	0.344	0.301	0.501
R3	3.5	3.166	9.249	8.658	0.280	0.548	0.303	0.542
R4	6	6	9.690	9.533	0.163	0.236	0.086	0.081
R5	6	6	9.543	9.538	0.239	0.168	0.081	0.224
SE +-	0.091		0.026		0.030		0.030	
$CD_{5\%}$	0.178		0.122		0.060		0.059	

Table.7 Two factor interaction means showing effect of feed rate and speed on polishing parameters of mold affected sorghum

Feed rate/speed	Mold rating		Whole grains		Broken		Husk and powder	
	S1	S2	S1	S2	S1	S2	S 1	S2
F1	4.666	4.6	9.189	8.623	0.317	0.563	0.295	0.620
F2	4.8	4.6	9.300	8.846	0.251	0.468	0.242	0.523
F3	5.2	4.93	9.454	9.022	0.206	0.397	0.207	0.419
F4	5.4	5.4	9.625	9.186	0.157	0.296	0.128	0.345
SE+_	0.081		0.056		0.027		0.027	
CD $_{5\%}$	0.160		0.109		0.053		0.053	

Table.8 Three factor interaction means showing effect of roller, feed rate and speed on mold rating of polished whole grains

Feed rate	F1		F2		F3		F4	
Roller/speed	S1	S2	S1	S2	S1	S2	S1	S2
R1	5	5	5	5	6	5	6	6
R2	3.33	3.667	4	3.667	4	3.667	5	5
R3	3	2.33	3	2.333	4	4	4	4
R4	6	6	6	6	6	6	6	6
R5	6	6	6	6	6	6	6	6
SE+_	0.182							
CD $_{5\%}$	0.357							

Table.9 Three factor interaction means showing effect of roller, feed rate and speed on quantity of polished whole grains

Feed rate	F1		F2		F3		F4	
Roller/speed	S1	S2	S1	S2	S1	S2	S1	S2
R1	9.004	7.475	9.020	7.751	9.340	8.226	9.663	8.588
R2	9.026	8.474	9.093	8.795	9.183	8.906	9.582	9.259
R3	8.929	8.501	9.185	8.560	9.410	8.763	9.474	8.807
R4	9.644	9.336	9.648	9.534	9.713	9.612	9.754	9.649
R5	9.342	9.331	9.554	9.593	9.623	9.604	9.654	9.626
SE +_	0.125							
CD $_{5\%}$	0.245							

Table.10 Three factor interaction means showing effect of roller, feed rate and speed on quantity of broken

Feed rate	F1		F2		F3		F4	
Roller/speed	S1	S2	S1	S2	S1	S2	S1	S2
R1	0.336	1.192	0.267	0.970	0.195	0.698	0.164	0.575
R2	0.300	0.495	0.270	0.365	0.253	0.330	0.147	0.186
R3	0.416	0.594	0.321	0.587	0.211	0.574	0.174	0.435
R4	0.182	0.345	0.172	0.228	0.151	0.217	0.146	0.156
R5	0.352	0.191	0.228	0.188	0.218	0.166	0.156	0.127
SE+ _	0.615							
CD $_{5\%}$	0.120							

Table.11 Three factor interaction means showing effect of roller, feed rate and speed on husk & powder

Feed rate	F1		F2		F3		F4	
Roller/speed	S1	S2	S1	S2	S1	S2	S1	S2
R1	0.399	1.333	0.395	1.141	0.227	0.833	0.142	0.769
R2	0.400	0.680	0.346	0.546	0.326	0.480	0.133	0.300
R3	0.441	0.649	0.282	0.600	0.257	0.498	0.230	0.422
R4	0.133	0.125	0.086	0.102	0.082	0.094	0.064	0.071
R5	0.125	0.316	0.102	0.225	0.094	0.194	0.071	0.164
SE+ -	0.021							
CD 5%	0.042							

Table.12 Physical properties , protein, carbohydrates and percent incidence of mycoflora observed in grains before and after polishing

Particulars	1000grain mass, kg	Hardness, kg	Protein,%	Carbohydrates,%	Mycoflora,%
Blackened sorghum	0.032	6.62	11.51	71.86	85
Polished sorghum	0.031	5.62	11.35	72.02	62

Table.13 Physical properties of the flour

Sr. No	Parameters	Mold affected sorghum	Freshly polished sorghum	Stored polished sorghum	CSH-9
1	Kneading quality	Less sticky	Less sticky	Less sticky	**sticky**
2	Rolling Quality	Poor	Very good	Good	**Very good**
3	Baking quality	Poor	Very good	Good	**Very Good**
4	**Keeping quality**	**Poor**	**Very good**	**Good**	**Very good**

Table.14 Mean consumer index for unleavened cake (Bhakari)

Judges	Mold affected sorghum	Freshly polished sorghum	Stored polished sorghum	CSH-9
1	0.575	0.875	0.825	**0.90**
2	0.55	0.875	0.80	**0.850**
3	0.625	0.925	0.80	**0.875**
4	0.65	0.85	0.80	**0.875**
5	0.625	0.875	0.75	**0.875**
6	0.575	0.925	0.775	**0.925**
7	0.55	0.95	0.80	**0.975**
8	0.575	0.85	0.775	**0.925**
9	0.60	0.875	0.825	**0.90**
10	**0.675**	**0.850**	**0.80**	**0.90**

Table.15 Analysis of variance of consumer index

Parameters	Mold affected sorghum	Freshly polished sorghum	Stored polished sorghum	CSH-9
Treatment means	0.60	0.885	0.795	**0.9**
SE(M)	**0.0155**			
CD(M)	**0.0327**			
CV %	**4.384**			

Fig.1 PKV mini dal mill

The meteorological observations during storage period was recorded and presented in the Table 11 which shows increase in temperature as storage period advances.

The hardness of grains was decreased with increase in storage period (Table 11). It can be correlated with reduction in moisture content during storage. This was confirmed by the results quoted by Rana *et al.*, (2004). It was observed that the hardness of the grains stored in the tin containers was significantly high than that of the other containers. It was also observed that unpolished grains had higher hardness than that of the polished grains and it can be attributed to the fact that, as the thickness of the pericarp of grain reduces due to polishing, grains become more brittle and is confirmed by Greenwell and Schofield (1986). The hardness of the grains stored in polypropylene bag, gunny bag lined with polyethylene and gunny bag was found in decreasing trend.

The average 1000 grains weight was found reduced in each case of storage container at the end of 120 days storage period (Table 11). As shown in Table 12 significantly lower weight loss was observed in unpolished (4.125 %) and polished grains (4.37%) stored in tin container and at par with each other followed by polypropylene bags, gunny bag lined with polyethylene and higher in gunny bags (6.0%) at the end of 4 months. This can be attributed that mold attack on kernel can lead to decrease in kernel weight Thus tin container was found better for storing polished sorghum grains. It was also

observed that the weight loss was rapidly increased after 2.5 months storage period due to grain weathering, pericarp degradation and reduction in moisture content. Thus farmer may sale his produce up to two months of storage or more as and when required.

It was observed that there is no significant difference in the protein content and carbohydrates with increase in storage period (Table 11).

After 120 days the storage experiments was concluded and the organoleptic testing of the unleavened cakes (Bhakries) prepared from polished and unpolished sorghum of best treatment (tin container) was carried out. The properties of the flour prepared from mold affected sorghum (A), freshly polished sorghum (B), stored polished sorghum (120 days)(C) and fresh hybrid sorghum CSH-9(D) were determined and presented in Table 21. It was observed that the rolling, baking and keeping quality of fresh sorghum CSH-9 was similar to that of freshly polished sorghum followed by stored polished sorghum. The flour prepared from mold affected sorghum was having poor baking, keeping and rolling quality. The unleavened bread prepared from it was found breaking at many places.

The mean score values given by panel of 10 judges were computed. The consumer index was calculated and presented in Table 13. From this table it revealed that the higher consumer index was found for unleavened cake (bhakri) prepared from CSH-9 followed by freshly polished sorghum, stored polished sorghum and lowest for mold affected sorghum.

The analysis of variance is presented in the Table 14. It is clear from the table that the higher acceptability of the unleavened cake (bhakries) prepared from fresh CSH – 9 is at par with the bhakaries prepared from the freshly polished sorghum followed by stored polished sorghum (120 days).

The economic analysis of PKV mini dal mill (modified) used for polishing of mold affected sorghum shows that, the cost of mold affected sorghum polishing was worked out to be Rs. 35/q. There is net profit of Rs. 23981/-per annum assuming 60 working days. The break even point and payback period is 37 % and 1.40 years respectively. Thus the technology is technically feasible and economically viable.

PKV mini dal mill can be used for polishing of mold affected sorghum with 80 no emery roller and 1200 rpm roller speed at feed rate of 120 kg/h.

The study revealed that, the 1000 grains mass was slightly reduced from 0.032 to 0.031 kg and hardness was reduced from 6.62 kg to 5.62 kg after polishing mould affected sorghum. The protein content of mold affected sorghum 11.51% was slightly reduced to 11.35 %. Whereas carbohydrates content was slightly increased from 71.86 to 72.02 % after polishing. Percent incidence of mycoflora was reduced from 85% to 62% after polishing. There was significantly lower weight in unpolished (4.125 %) and polished sorghum grains (4.37%) when stored in tin container and at par with each other followed by polypropylene bags, gunny bag lined with polyethylene and higher in gunny bags (6.0%) at the end of 4 months.

It was observed that, the storage period for unleavened cake (bhakries) prepared from fresh CSH – 9 was 120 days and showed better acceptability.

The cost of mold affected sorghum polishing was worked out to be Rs. 35/q. The break even point and pay back period is 37 % and 1.40 years respectively. Surface polishing of black mold sorghum by using PKV mini dal mill is techno economically feasible.

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