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Design and development of double head dehuller and its performance testing using selected minor millets

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ABSTRACT

A double head dehuller was designed and developed and its performance evaluation was done using selected minor millets of barnyard, brown top, kodo, proso and foxtail millet. The main components of the machine included hopper of 5kg capacity, a double grain crushing chamber, an outlet grain chute, blower for husk aspirator, a cyclone outlet for husk separation and a prime mover motor of 3hp power. The machine was operated both at no load and load condition for calibration and determination of capacity and efficiency. Under load condition, it was operated for 15 minutes and the husk and dehulled grain were collected separately. In double pass dehulling the hull removal is more compared to single pass dehulling, it is in the order of barnyard millet ≤ brown top millet ≤ kodo millet ≤ proso millet ≤ foxtail millet. In double pass, the minimum dehulling percentage is 18.2% and maximum hull removal is 22.9%. Approximately in double pass, 10% more of hull removal than in single pass dehulling. Total yield ranged between 77.1 % to 81.8%. With the foxtail millet the dehulling efficiency was 64.07%, head millet recovery was 95.21%, broken grain recovery was 4.79%, dehuller performance index was 61, capacity of the double head dehuller is 96.4kg/h and husk recovery is 31.12%. With the barn - yard millet, the dehulling efficiency was 38.27%, head grain recovery was 88.98%, broken grain recovery was 11.02%, dehuller performance index was 34.05%, capacity was 74kg/h and husk recovered is 51.35%. Three replications for both single pass and double pass dehulling were made separately and the average values were taken. Then the values were tested for its statistical significance using SPSS software and it was found to be significant at 5% level of significance ($p \leq 0.05$). The statistical analysis was done using SPSS 16.0 software.

Key words: *Dehuller, Minor millets, Efficiency, Yield, Double pass, Performance index*

Introduction

Millets are very difficult to dehusk especially in minor millets since the husk is intact with the grain, hence machines are to be specially designed for dehusking the grain. Dehulling is usually done to remove the outer husk layer so that the grain becomes palatable and easy to digest during consumption and this helps in increasing the marketability of the millet grain. Millets are nutritious food and they are rich in phytochemicals, fibre and minerals. There is an immense potential to process millet grains into value-added foods and beverages (Devi *et al.,* 2011). The millets are of two types, major millets and minor millets. Major millets include sorghum, bajra and ragi. Minor millets include little millet, proso

(*[1]Scientist (ss) (AS&PE), [2]Principal Scientist (Agril. Econ.), [3]Research Scholar, [4]Former Director, [5]Retd. Professor, [6]Director) millet, barnyard millet, foxtail millet and kodo millet. Husk is fibrous in nature and can be utilized after removal from the grain. This dehulling can be done by centrifugal forward curved action and by impact action.

The grains hits the centrifugal disc inside and the husk, the outer layer gets removed and gets collected in a separate cyclone separator and there the swirling action of the air generated by the blower, speed is set in such a way that only husk gets separated to a separate outlet chute. Approximately 20% of the grain is husk. Since the double head dehuller has 2 circular discs and the grain after gets dehulled from the first disc, hits the second disk and further the dehusking takes place. The double head dehuller consists of 5 kg capacity hopper, a double grain crushing chamber, an outlet grain chute, blower for husk aspirator, a cyclone outlet for husk separation and a prime mover motor of 3hp power. The hopper dimensions are 420 mm X300 mm X75 mm mounted on a frame of dimension, 40X 40 mm, square table, Fig. 9 & 10 represents double head de -huller, line diagram and its side view.

Materials and Methods

Freshly harvested selected minor millets of Foxtail millet, Proso millet, Barnyard millet, Kodo millet and little millet were taken from gubba storage. The millets were cleaned with cleaner cum destoner cum aspirator. Then the cleaned millets were tested for its moisture content in hot air oven method. Then a measured amount of cleaned millets is taken for dehulling in double head dehuller for all minor millets, proso, little, barnyard, foxtail and kodo millet for de-hulling. The analysis was done by using SPSS 16 version software. Now the dehulling efficiency, percentage broken grains and head rice recovery, after each pass was calculated below using equations.

$$\text{(1) Dehulling efficiency} = \frac{\text{weight of total hulled grain (head grain + broken grain)} \times 100}{\text{weight of grain fed into the dehuller hopper}}$$

$$\text{(2) Head grain recovery} = \frac{\text{weight of total hulled head grain} \times 100}{\text{weight of total hulled grain (head grain + broken grain)}}$$

$$\text{(3) Broken grain} = \frac{\text{weight of total hulled broken grain} \times 100}{\text{weight of total hulled grain (head grain+broken grain)}}$$

$$\text{(4) Dehuller performance index} = \frac{\text{dehulling efficiency} \times \text{head rice recovery}}{100}$$

$$\text{(5) Unhulled grain} = \frac{\text{Weight of the unhulled grain}}{\text{Input weight of the millet grain}} \times 100$$

$$\text{(6) Capacity} = \frac{\text{Weight of grain fed into the dehuller hopper kg/h}}{\text{Time taken to dehull grain}}$$

(7) Dehulling Index (η) The dehulling index was calculated using the following equation:

$$\eta = [(mk + mh) - (mud + mb)] / mi \quad (20)$$

The dehulling index may vary from a maximum value of +1 to a minimum of- 1. A value of +1 indicates that the entire original grain sample is completely dehulled into two fractions of grain (mb) and husk (mh) with no fines and undehulled grains. A value of - 1 indicates that the dehulling is not complete, thus the broken grains (mf) and /or not dehulled (muh) at all (Ikebudu *et al.,* 2000)

(8) Degree of dehulling (Mh) The degree of hull removal is the ratio of mass of hull removed during dehulling to the initial mass of sample used for the dehulling process.

$$Mh = mh/mi$$

(9) Effectiveness of dehulling (Ed) Effectiveness of dehulling is the ratio between the mass of the material remaining undehulled and the initial mass of material taken for dehulling.

$$Ed = mud/mi$$

(10) Quality of dehulling (Qd) It can be calculated as ratio between the weight of dehulled kernel (both broken and whole) and initial weight of material taken for dehulling.

$$Qd = mk / mi$$

(11) Coefficient of dehulling (Cdh) This can be calculated using the following equation:

$$Cdh = 100[1 - (Yb + Ed + Yf)]$$

(12) Cleaning Efficiency (Ce) This can be calculated using the following equation:

$$Ce = mw/mk$$

Results and Discussion

The single head vertical dehuller has a feed hopper of 250 kg/h capacity, a dehulling chamber consisting of impeller blades, separating chamber to separate the husk dehulled and the dehulled millet rice. (Fig. 1). The selected millets taken for study include foxtail millet and barnyard millet. 50kg of the sample were thoroughly cleaned using the destoner cum grader cum aspirator. Then the cleaned grains were weighed and fed into the feed hopper of the single head dehuller and subjected to dehulling. The time for dehulling was noted and then partial feeding with the feed roller adjustment was made. Then the dehulled millet grains were subjected to separation in the separation chamber and dehusked hull were separated using a blower and the blower speed was adjusted so that millet husk was separated and the dehulled millets were collected through the separate outlet. A 1hp electric motor with 1440 rpm and single phase power supply was fitted to the machine as prime mover. The capacity of the dehuller and efficiency of the dehulling was calculated using a known weight of the millet grain fed into the machine. The machine was operated both at no load and load condition for calibration and determination of capacity and efficiency. The machine at no load condition had less vibration and noise hence recommended for load condition. Under load condition, it was operated for 15 minutes and the husk and dehulled grain were collected and separately. The dehulled whole millets were subjected to separation, using respective sieves in grader cum aspirator. The separator was used to separate the whole millets, brokens and husk and weighed separately.

The different parts of double head dehuller include baffle, base support material, bearing, belt, belt length, blower, casing, crushing chamber, cyclone separator, dehulling disc, electrical connection, frame, L angle frame, motor details, nut, bolt and studs, outlet chute, overall dimension, pulley, drive, pulley, driven, shaft details, steel hopper, teflon pipe hose and variable frequency drive (Fig. 9).

Fig. 1. Single head dehuller

The main components of the machine included hopper of 5kg capacity, a double grain crushing chamber, an outlet grain chute, blower for husk aspirator, a cyclone outlet for husk separation and a prime mover motor of 3hp power. The power from the electric motor is transmitted to the rotating shaft of the dehulling machine by means of V-belts and pulleys. Under load condition, it was operated for 15 minutes and the husk and dehulled grain were collected separately.

50 kgs of millet grains are cleaned in destoner cum grader cum aspirator. The cleaned grains are fed into the hopper of dehuller, then after machine is started with hopper opened partially. The dehuller is run for 15 minutes with continuous feeding of grain into the hopper (Kept track on weight of grains operated during 15 mins). Then the dehuller is stopped and then take the weights of the hulled grains and husk collected at the respect outlets. The hulled grains collected were separated into head rice and brokens using respective sieves in grader cum aspirator.

In double pass dehulling the hull removal is more compared to single pass dehulling, it is in the order of barnyard millet ≤ brown top millet ≤ kodo millet ≤ proso millet ≤ foxtail millet. Fig. 5 represents performance characteristics of single and double head dehuller of small millets. In double pass, the minimum dehulling percentage is 18.2% and maximum hull removal is 22.9%. Fig. 4 represents performance characteristics; dehull η, HRR, BRR, Capacity, PI and UHRR of double head dehuller of small millets separately. Approximately in double pass, 10% more of hull removal than in single pass dehulling. Table 1 represents yield and capacity of small millets in double head dehuller in first pass. Total yield ranged between 77.1% to 81.8%. Fig. 2 & 3 represents yield and capacity of small millets in double head dehuller single head dehuller in first and second pass of dehulling. Table 2 represents yield and capacity of small millets in double head dehuller second pass.

Table 1. Yield and capacity of small millets in double head dehuller in first pass

SN.	Type of millet	Yield,(%)	Capacity, kg/h
1	Foxtail millet	63.00	98.00
2	Proso millet	65.00	26.00
3	Barnyard millet	80.00	40.00
4	Kodo millet	66.00	24.00
5	Little millet	96.00	32.00
6	Browntop	92.00	60.00
	average	77.00	46.67
	minimum	63.00	24.00
	maximum	96.00	98.00
	sem	28.30	11.60
	sd	14.53	5.93
	cv	18.87	12.71

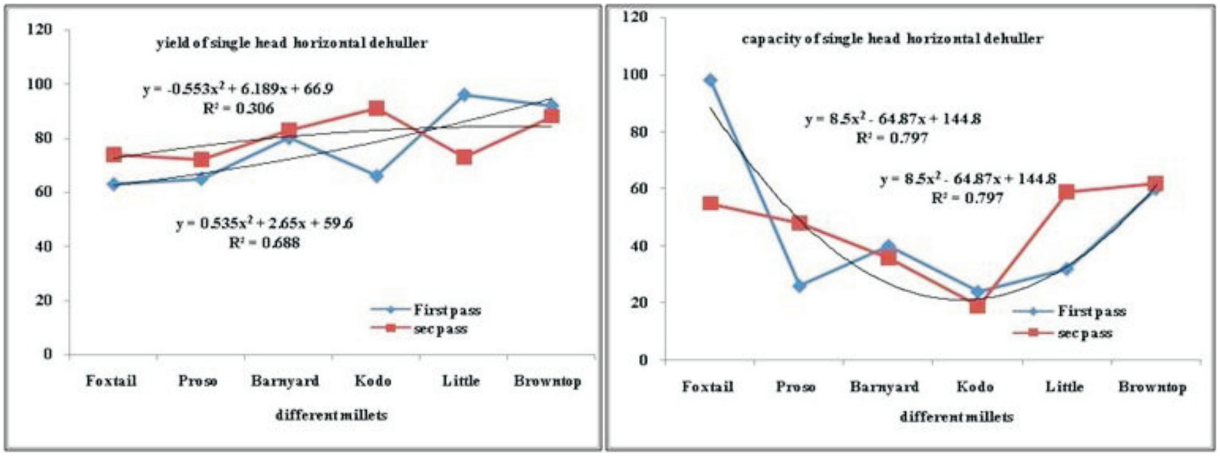

Fig. 2. Yield and capacity of small millets in single head dehuller

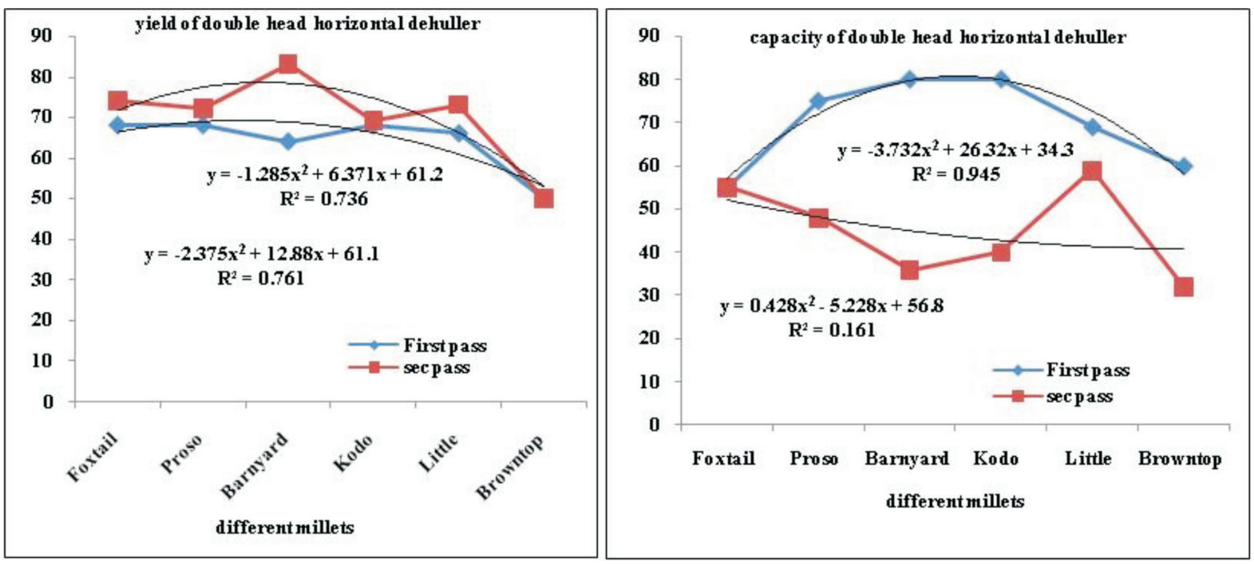

Fig. 3. Yield and capacity of small millets in double head dehuller

Table 2. Yield and capacity of small millets in double head dehuller second pass

SN.	Type of millet	Yield (%)	Capacity, kg/h
1	Foxtail millet	74.00	55.00
2	Proso millet	72.00	48.00
3	Barnyard millet	83.00	36.00
4	Kodo millet	69.00	40.00
5	Little millet	73.00	59.00
6	Browntop	50.00	32.00
	average	70.17	45.00
	Minimum	50.00	32.00
	Maximum	83.00	59.00
	Sem	4.47	4.40
	Sd	10.94	10.77
	Cv	6.37	9.78

Table 3. Yield and capacity of small millets in single head

SlN.	Type of millet	Yield, (%)	Capacity, kg/h
1	Foxtail millet	68.00	55.00
2	Proso millet	68.00	75.00
3	Barnyard millet	64.00	80.00
4	Kodo millet	68.00	80.00
5	Little millet	66.00	69.00
6	Browntop	68.00	60.00
	average	67.00	69.83
	Minimum	64.00	55.00
	Maximum	68.00	80.00
	Sem	0.68	4.28
	Sd	1.67	10.50
	Cv	2.49	15.04

Approximately in double pass, 10% more of hull removal than in single pass dehulling. Total yield ranged between 77.1% to 81.8%. Fig. 7 represents performance characteristics of double head dehuller of small millets With the foxtail millet the dehulling efficiency was 64.1%, head millet recovery was 95.21%, broken grain recovery was 4.8%, dehuller performance index was 61, capacity of the double head dehuller is 96.4 kg/h, husk recovery is 31.12%. Fig.10 represents performance characteristics of proso millet using design expert software 12 version. Dehulling operation was performed in double pass for the buckwheat grains at optimized parameters of the machine to analyze the dehulling effi-

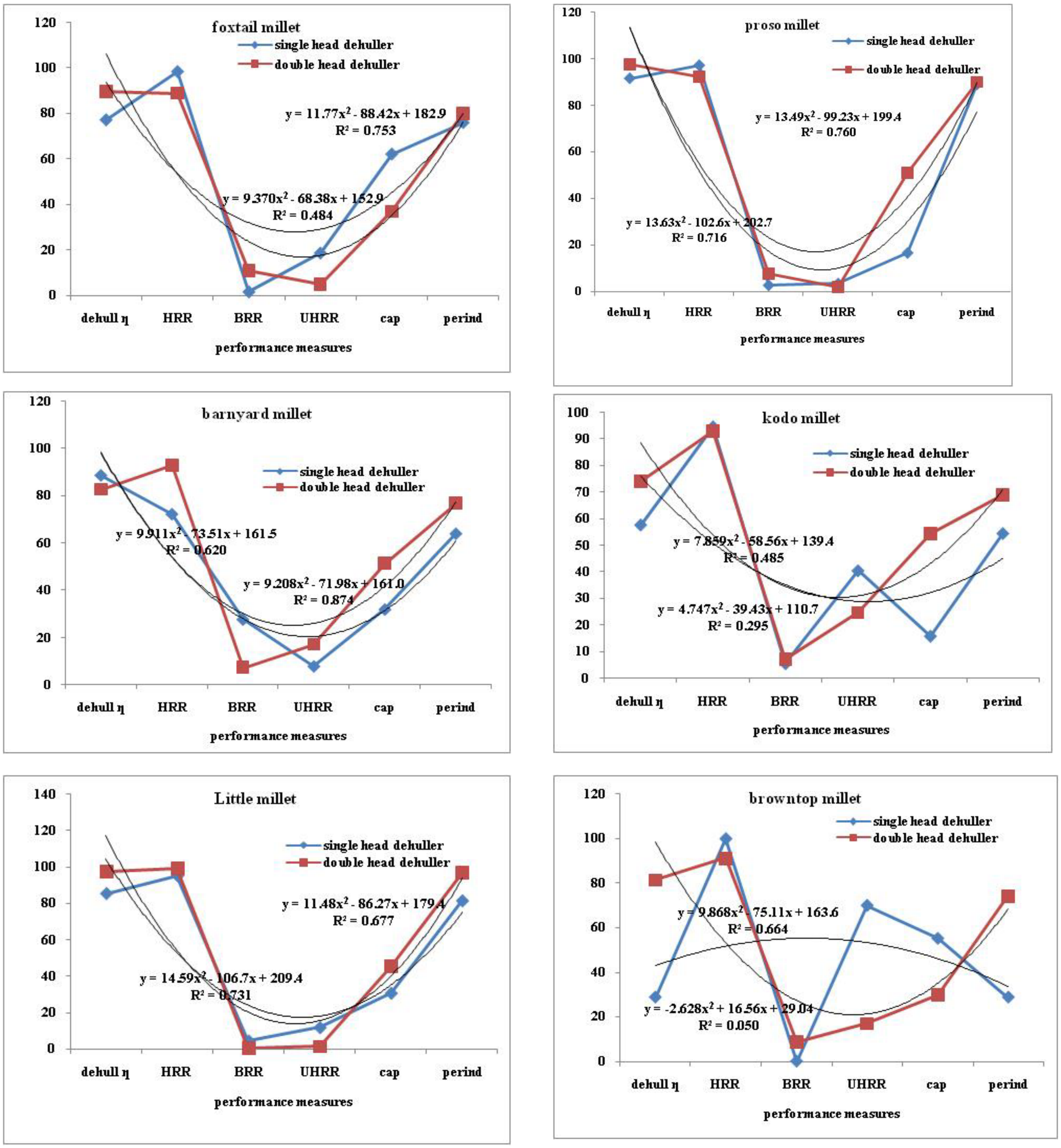

Fig. 4. Performance characteristics, dehull η, HRR, BRR, Capacity, PI and UHRR of double head dehuller of small millets.

ciency and percent of broken kernel in double pass and it was found, the dehulling efficiency and percent of broken kernel were 74.52% and 10.28% respectively (Chandan Solanki, 2018). This coincided with our findings of millet double stage dehulling of 77.1% and brokens of 4.79%. Table 5 represents performance characteristics of single head dehulling of minor millets. The abrasive method of dehulling grains are found to cause high dehulling losses by crushing the seeds (Lazaro *et al.,* 2014; Singh *et al.,* 2010). Moreover, the grains get polished during abrasion leading to the loss of nutrients by the removal of the bran layers, that is not the case with impact hullers (Malathi *et al.,* 2014). Table 6 represents performance characteristics of double head dehulling of minor millets.

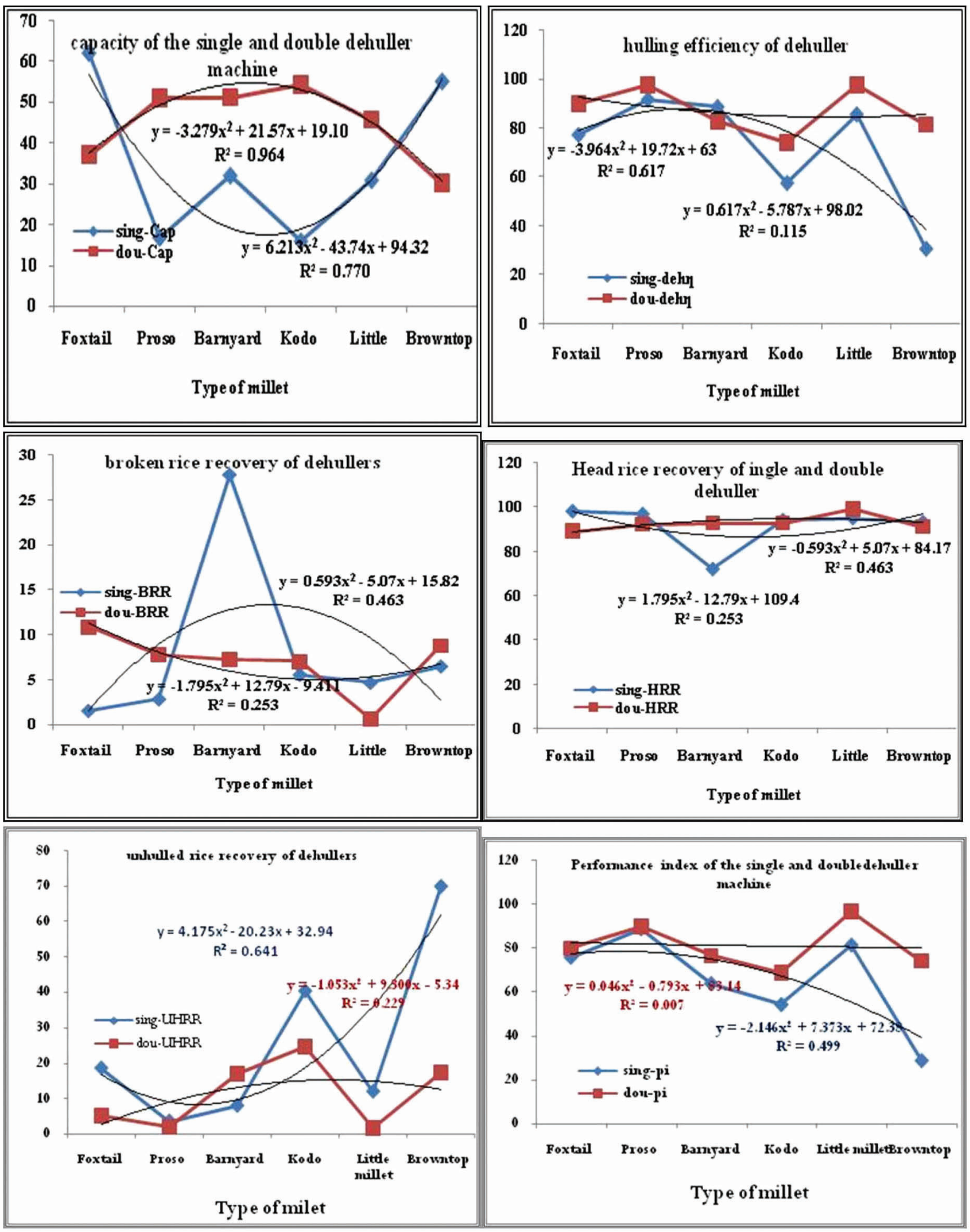

Fig. 5. Performance characteristics of single and double head dehuller of small millets

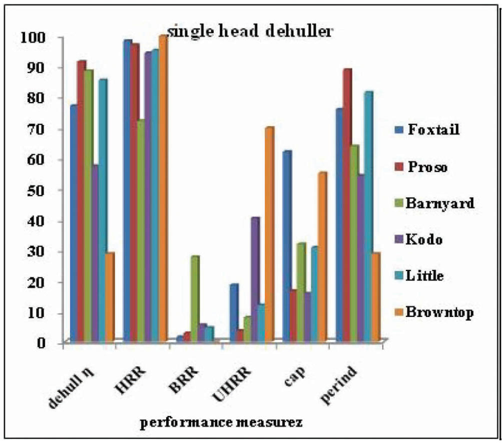

Fig. 6. Performance characteristics of single head dehuller of small millets

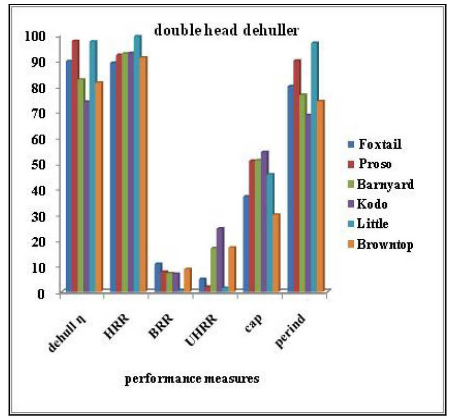

Fig. 7. Performance characteristics of double head dehuller of small millets

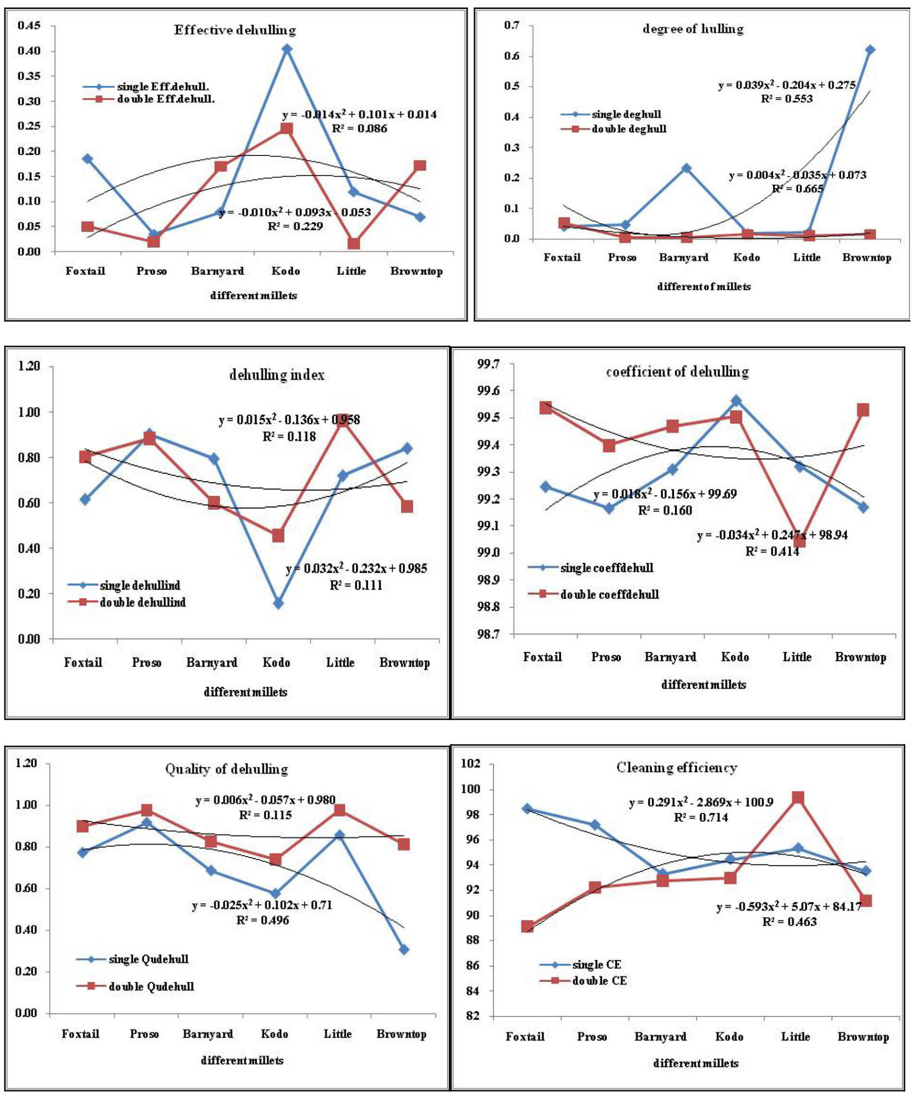

Fig. 6a. Performance characteristics of single and double head dehulling of minor millets

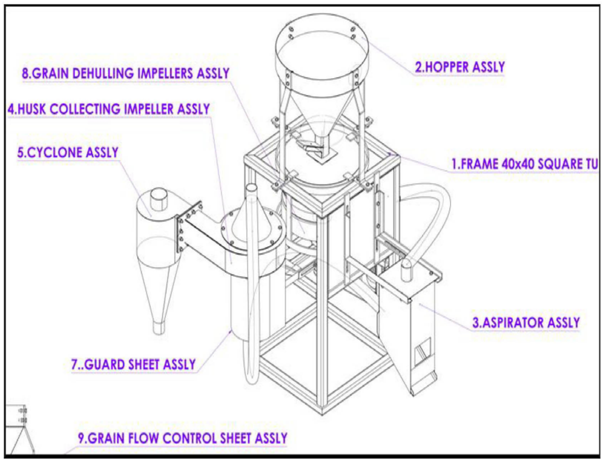

Fig. 8. Double Head Dehuller, line diagram

Fig. 9. Double Head Dehuller, side view

Table 4. Yield and capacity of small millets in single head dehuller in second pass

SN.	Type of millet	Yield, (%)	Capacity, kg/h
1	Foxtail millet	74.00	55.00
2	Proso millet	72.00	48.00
3	Barnyard millet	83.00	36.00
4	Kodo millet	91.00	19.00
5	Little millet	73.00	59.00
6	Browntop	88.00	62.00
	average	80.17	46.50
	Minimum	72.00	19.00
	Maximum	91.00	62.00
	Sem	16.36	6.68
	Sd	8.28	3.38
	Cv	10.33	7.27

dehuller in first pass

The average effective dehulling is double head is more than single head by 26.67%, degree of dehulling is 88.24% more in single head than in double head dehuller, Fig. 6a represents performance characteristics of single and double head dehulling of minor millets, dehulling index is 5.83% more in double head than in single head, coefficient of dehulling in double head is 0.12% more than that of single head dehulling, quality of dehulling in double head dehulling of minor millets is 21.30% more than in single head dehulling, cleaning efficiency is 2.56% more in single head dehulling than in double head dehulling of minor millets (Table 6a & 6b).

In foxtail millet the yield in double head dehuller in first pass 8.11% more than in first pass, the capacity is same both in first pass and second pass. In proso millet in first pass, 5.55% yield is more in double pass than in single pass, in capacity 36.49% more in first pass than in second pass. In barnyard

Table 5. Performance characteristics of single head dehulling of minor millets

SN.	Type of millet	Dehull ´	HRR	BRR	UHRR	Cap	perind
1	Foxtail millet:	77.20	98.45	1.55	18.60	62.18	76.00
2	Proso millet:	91.60	97.16	2.84	3.60	16.71	89.00
3	Barnyard millet:	88.60	72.23	27.77	8.00	32.00	64.00
4	Kodo millet:	57.60	94.44	5.56	40.40	15.84	54.40
5	Little millet:	85.60	95.33	4.67	12.00	30.86	81.60
6	Browntop	28.80	100.00	0.00	70.00	55.20	28.80
	average	71.57	92.94	7.07	25.43	35.47	65.63
	min	28.80	72.23	0.00	3.60	15.84	28.80
	max	91.60	100.00	27.77	70.00	62.18	89.00
	sd	24.27	10.34	10.34	25.40	19.36	21.88
	sem	9.91	4.22	4.22	10.40	7.90	8.93
	cv	33.91	11.13	146.36	99.87	54.59	33.34

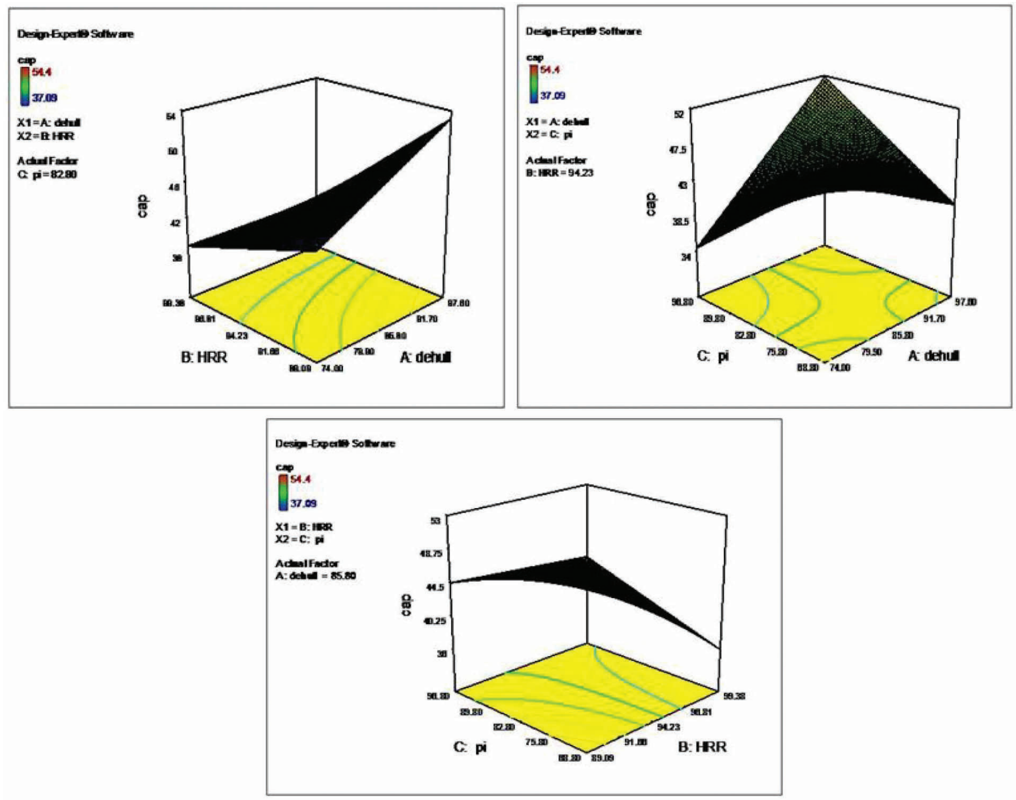

Fig. 10. Performance characteristics of proso millet using design expert software 12 version

millet, 22.89% more yield is found in second pass than in first pass, capacity is 55% more in first pass than in second pass. In kodo millet, 1.45% more yield is in second pass than in single pass, capacity is 59% more in first pass than in second. In little millet, 9.59% yield is more in second pass than in first pass, capacity is 14.49% more in first pass than in second. In browntop millet, 26.47% more in first pass than in second pass,46.67% capacity is more in first pass than in second pass in double head horizontal dehuller. In average of yield in first pass is 4.52% less in first pass than in double pass, 35.56% capacity is more in first pass than in second pass.

In foxtail millet the yield is 14.86% more in second pass than in first pass, 43.85% more capacity is found in first pass than in second pass dehulling. Table 4 represents yield and capacity of small millets in single head dehuller in second pass. In proso

Table 5a. Performance characteristics of single head dehulling of minor millets

S.No.	Type of millet	Eff.dehull.	Deghull	Dehullind	Coeffdehull	Qualidehull	Clean Eff.
1	Foxtail	0.19	0.04	0.62	99.25	77.20	98.45
2	Proso	0.04	0.05	0.90	99.17	91.60	97.16
3	Barnyard	0.08	0.23	0.79	99.31	68.60	93.29
4	Kodo	0.40	0.02	0.16	99.56	57.60	94.44
5	Little	0.12	0.02	0.72	99.32	85.60	95.33
6	Browntop	0.07	0.62	0.84	99.17	30.80	93.51
	average	**0.15**	**0.17**	**0.67**	**99.30**	**68.57**	**95.36**
	minimum	0.04	0.02	0.16	99.17	30.80	93.29
	maximum	0.40	0.62	0.90	99.56	91.60	98.45
	SD	0.13	0.24	0.27	0.15	22.10	2.06
	SEM	0.06	0.10	0.11	0.06	9.02	0.84
	cv	87.05	144.24	40.18	0.15	32.23	2.16

millet, the yield is 9.72% more in second pass than in first pass, in capacity, 45.23% more in second pass than in first pass dehulling. In barnyard millet, the yield is 3.61% more in second pass than in first pass, in capacity 10% more in first pass than in second pass dehulling. In kodo millet, the yield is 27.47% more in second pass than in first pass, in capacity it is 20.83% more in first pass than in second pass. Fig. 6 represents performance characteristics of single head dehuller of small millets. In little millet, the yield is 23.96% more in first pass than in second pass, in capacity is 45.76% more in second pass than in first pass. In brown top millet, the yield is 4.35% more in first pass than in second pass in capacity it is found that 3.23% more in second pass than in single pass dehulling. In average yield among selected minor millets, 3.95% more in second pass than in single pass and 0.36% more in first pass than the second pass dehulling. Table 3 represents yield and capacity of small millets in single head dehuller in first pass.

In single head dehulling of minor millets in foxtail millet the dehulling efficiency is 14.03% more than that of double head dehulling of minor millets. In head rice recovery in foxtail millet, 9.51% more in double head than in single head dehulling. In broken rice recovery in foxtail millet, 85.79% make in single head than in double head dehulling. The unhulled rice recovery in foxtail millet, single head dehulling is 73.12% more than in double head dehulling of minor millets. In capacity of single head dehulling is 40.35% more in double head dehulling than in single head dehulling of minor millets. The performance index of foxtail millet single head dehulling is 5% more than in double head dehulling of minor millets.

The dehulling efficiency of foxtail millet, 89.80% ±9.47 using double stage dehuller for dehulling of minor millets coincided with the TNAU single chamber dehuller for a dehulling efficiency of 91.14%±0.28. The broken percentage of barnyard millet using double head dehulling of minor millets

Table 6. Performance characteristics of double head dehulling of minor millets

S.No.	Type of millet	dehull ´	HRR	BRR	UHRR	Cap	per ind
1	Foxtail	89.80	89.09	10.91	5.00	37.09	80.00
2	Proso	97.60	92.21	7.79	2.00	51.00	90.00
3	Barnyard	82.60	92.74	7.26	17.00	51.20	76.60
4	Kodo	74.00	92.97	7.03	24.60	54.40	68.80
5	Little	97.40	99.38	0.62	1.60	45.69	96.80
6	Browntop	81.40	91.15	8.85	17.20	30.00	74.20
	average	87.13	92.92	7.08	11.23	44.90	81.07
	min	74.00	89.09	0.62	1.60	30.00	68.80
	max	97.60	99.38	10.91	24.60	54.40	96.80
	sd	9.47	3.47	3.47	9.64	9.50	10.45
	sem	3.86	1.42	1.42	3.93	3.88	4.27
	cv	10.87	3.73	49.03	85.82	21.16	12.89

Table 6b. Performance characteristics of double head dehulling of minor millets

S.No.	Type of millet	Effec.dehull.	Degreehulling	Dehullind	Coeff.dehull	Qualidehull	CleanEff.
1	Foxtail	0.05	0.05	0.80	99.54	89.80	89.09
2	Proso	0.02	0.004	0.88	99.40	97.60	92.21
3	Barnyard	0.17	0.004	0.60	99.47	82.60	92.74
4	Kodo	0.25	0.01	0.46	99.51	74.00	92.97
5	Little	0.02	0.01	0.96	99.05	97.40	99.38
6	Browntop	0.17	0.01	0.58	99.53	81.40	91.15
	average	**0.11**	**0.02**	**0.71**	**99.42**	**87.13**	**92.92**
	minimum	0.02	0.004	0.46	99.05	74.00	89.09
	maximum	0.25	0.05	0.96	99.54	97.60	99.38
	SD	0.10	0.02	0.19	0.18	9.47	3.47
	SEM	0.04	0.007	0.08	0.08	3.86	1.42
	cv	85.46	110.20	26.59	0.18	10.87	3.73

is 7.26%±3.47 coincided with that of TNAU double chambered dehuller with the brokens percentage of 8.20±0.56. In kodo millet the dehulling efficiency using TNAU single chamber dehuller is 50.89%±0.17 and this coincided that with the findings of 57.60±24.27 using single head dehuller of dehulling of millets (Vasudeva *et al.,* 2022). The raw minor millets dehulled in double stage dehuller had an efficiency range of 74-97.6% that coincided with the findings of Balasubramanian *et al*., 2020 for an dehulling efficiency range of 69.76%-83.95%.

The dehulling efficiency in proso millet is 6.15% more in single head dehulling than in double head dehulling. The head rice recovery in proso millet is 5.09% is more in double head dehulling than in single head dehulling. The broken rice recovery in proso millet is 63.54% single head dehulling than in double head dehulling. The unhulled rice recovery in proso millet is 44.44% more in double head dehulling than in single head dehulling. The capacity of proso millet is 67.24% more in single head dehulling than in double head dehulling. The performance index of double head dehulling is 1% less than that of single head dehulling.

In barnyard millet, the dehulling efficiency 6.77% more than that of single head dehulling in double head dehulling. In head rice recovery, 22.16% more in barnyard millet in double head dehulling than in single head dehulling. In barnyard millet, 73.86% broken rice recovery is more in double head de - hulling of minor millets. In barnyard millets, 52.94% more in unhulled rice recovery in double head dehulling than in single head dehulling. In barnyard millets, 16.45% performance index is more double head dehulling than in single head dehulling of minor millets.

In kodo millets, 22.16% the dehulling efficiency is more in single head dehulling than in double head dehulling of minor millets. In kodo millets, head rice recovery is 1.56% more in double head dehulling of minor millet than in single head dehulling. In broken rice recovery is 20.91% more in single head dehulling of minor millets than in double head dehulling. In unhulled rice recovery in kodo millet, 35.59% more in double head dehulling than in single head dehulling. In capacity in kodo millet,70.98% more in single head dehulling of minor millets than in double head dehulling. In performance index, in single head dehulling 20.93% more in single head dehulling than in double head dehulling of minor millets.

In little millet, dehulling efficiency is 12.11% more in single head dehulling than in double head dehulling. In head rice recovery in little millet more in single head dehulling than that of double head dehulling of minor millets. In broken rice recovery in little millet, 86.72% is more in double head dehulling than single head dehulling of minor millets. In capacity of little millet dehulling it is found that 32.46% more in single head dehulling than at double head dehulling in minor millets. In performance index in little millets, dehulling it is seen that 15.70% more in single head dehulling than that in double head dehulling.

In browntop dehulling of minor millet, 64.78% more in single head dehulling than in double head dehulling in dehulling efficiency. In browntop dehulling the head rice recovery in single pass dehulling 9.71% less in single head dehulling than in double head dehulling. In brown top millets dehulling the broken rice recovery is 8.85% more in single head dehulling than in double head dehulling. In browntop millets, unhulled rice recovery is 75.43% more in double head dehulling than in single head dehulling. In browntop millets, the capacity is 45.65% more in double head dehulling than in single head dehulling. In browntop millets, 61.19% more in performance index in double head dehulling than in single head dehulling.

In average dehulling efficiency, 17.86% more in single head dehulling than in double head dehulling. In average head rice recovery, 2% increase in double head dehulling than in single head dehulling. In broken rice recovery, 0.14% more in double head dehulling than that in single head dehulling. The average unhulled rice recovery is 55.86% more in double head dehulling than in single head dehulling. The average capacity is 21% more in single head dehulling than in double head dehulling. In average performance index, 19.05% more in single head dehulling than in double head dehulling.

Conclusion

The millets are difficult to process owing to its smaller size and hence different processing machines for processing of small millets is very essential. For small millets dehulling is very difficult and this type of double pass dehuller provides better dehulling for small millets with improved head rice recovery. Since millets has many layers, it is difficult to dehull especially in kodo millet, hence this double head dehuller design is found to be suitable for more effective dehulling than single dehuller that can be used with single pass and second pass of dehulling, Among the minor millets that were selected for dehulling the little millet and proso millet has better dehulling efficiency with a pronounced effect on capacity of the dehuller. This dehulling gadget is much useful for using the underutilized minor millets owing to its smaller size and poses difficulty with existing dehulling machineries that is used for other crops, the grain may become unfit for human consumption and can be used only for animal and bird feeds without using dehuller machines for dehulling.

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