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Performance Evaluation of Different Millet Dehullers

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ABSTRACT

Millets often referred to as nutri-cereals due to their rich nutrient content and hold significant promise for enhancing profitability in cultivation through value addition. Traditional dehulling method is associated with significant drudgery, which is considered one of the primary obstacles preventing millets from reaching their full potential. Choosing an appropriate millet dehuller is of utmost importance for processing millets at the village level or for small entrepreneur processing. Dehulling process of kodo millet, foxtail millet, little millet, browntop and barnyard millets was assessed using four different millet dehullers developed at TNAU, CIAE, and a rubber roller sheller. The dehulling efficiency and broken percentage of the millet dehullers were evaluated in single and double passes. Among these dehullers, the CIAE millet mill demonstrated suitability for processing all types of millets. The TNAU double-chamber dehuller proved to be effective for dehulling foxtail and kodo millets, while the TNAU single-chamber dehuller was found suitable for foxtail millets only.

Keywords: *Broken percentage, Dehulling efficiency, Single and double pass dehulling and Value addition*

In India, the cultivation and consumption of millets have been on the rise. Millets are now acknowledged as crucial alternatives to major cereals, helping to address global food shortages and cater to the needs of growing populations in both developing and developed nations (Kumar *et al.*, 2016). In recent times, there has been a notable increase in the consumption of millet foods due to growing health consciousness among people. The industrial processing methods for millets are not as advanced and well-developed as those used for wheat and rice (FAO, 2012). Consequently, by implementing value-added strategies and adopting suitable processing technologies, millet grains can be incorporated into the creation of numerous value-added and health-oriented food products from millets. This, in turn, could lead to a surge in demand from sizeable urban populations and non-traditional millet consumers.

Processing of millets plays a crucial role in reducing the presence of anti-nutritional factors, thereby enhancing the bioaccessibility of nutrients in these grains. The production and processing of minor millets face limitations due to the lack of suitable primary processing methods, semi-processed raw materials, and appropriate value addition technologies. De-hulling of millets, which involves removing the husk, is particularly challenging because of their small size and the presence of husk. Without proper husk removal, the grains cannot reach their full potential (Mal *et al.*, 2010). Traditionally, women have been engaged in this arduous and inefficient task, which is both unpleasant and labor-intensive. Therefore, there is a need to identify a de-huller that can effectively process the minor millets and contribute to unlocking the full potential of these grains. Very few researchers studied the milling performance of the millet dehullers.

Double stage millet dehuller for foxtail, browntop, little and barnyard millets, whereas, Balasubramanian *et al.* (2020) employed CIAE millet mill on raw and parboiled millets. There were no consistent results arrived by them. Therefore, the present study is undertaken to assess the performance of different millet dehullers. The objective of the present study is to determine the efficiency and effectiveness, with the ultimate goal of recommending a suitable machine to farmers and small entrepreneurs for millet processing. This recommendation aims to provide them with a valuable tool to enhance the processing of millets and promote their utilization in various food products.

MATERIAL AND METHODS

Fresh raw materials of foxtail millet, brown top millets, barnyard millet and kodo millets from local farmers and little millets from Agricultural Research Station, Podalakur, Andhra Pradesh were procured for evaluation studies.

Moisture Content

Moisture content of kodo millet, foxtail millet, little millet, browntop and barnyard millets was determined on triplicate sample by hot air-oven drying method by placing about 15 g of sample at 130 °C for 72-96 h (Sahay and Singh, 2001). The moisture content on wet basis (w.b.) was calculated using Eq. 1. and moisture content on dry basis (w.b.) was calculated using Eq. 2.

$$\text{Moisture content (w.b.)\%} = \frac{W_w}{W_w + W_d} \times 100 \qquad \text{Eq. (1)}$$

$$\text{Moisture content (d.b.)\%} = \frac{W_w}{W_d} \times 100 \qquad \text{Eq. (2)}$$

where, Ww = Weight of water (moisture), g

Wd = Weight of bone dry material, g

Each sample of 10 kg foxtail millet, brown top millet, barnya

was processed single and double passes in the TNAU single-chamber and double-chamber centrifugal dehuller and CIAE millet mill and whereas millets was processed in single pass in case rubber roll sheller (Model: NB10, make: Nandi Agro Products, Hyderabad) (Fig. 1) and the machine was operated as per the specifications of the manufacturers and tested for their performance. Millet grains were subjected to two passes in order to get maximum dehulling efficiency.

Dehulling Efficiency

In each trial, all the millet grains were passed one time (single pass) or two times (double pass) consecutively and the dehulling efficiency after each pass was calculated using Eq. 3. Experiments were repeated thrice.

$$\text{Dehulling efficiency} = \frac{\text{Weight of dehulled whole millet rice (kg)}}{\text{Total weight of millets (kg)}} \times 100 \qquad \text{Eq. (3)}$$

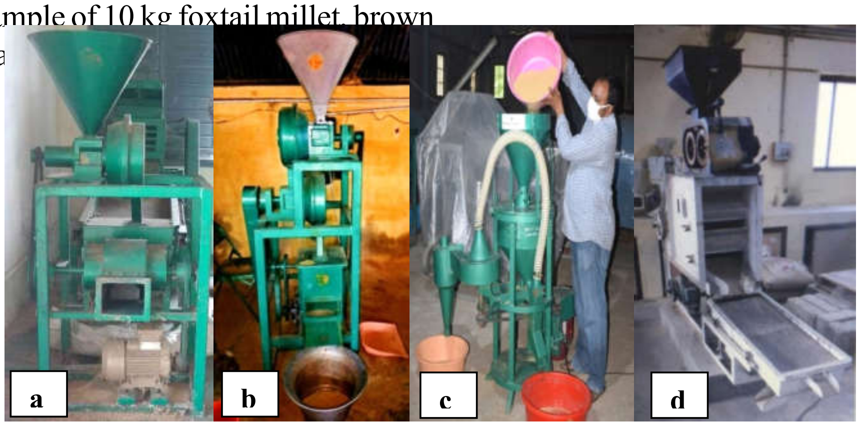

Fig. 1 TNAU single chamber centrifugal de-huller (a), TNAU double chamber centrifugal de-huller (b), CIAE millet mill (c) and Rubber roll sheller (d)

Broken Rice Percentage

In each trial, after each pass the percentage broken grains was calculated using Eq. 4.

$$\text{Broken rice percentage} = \frac{\text{Weight of broken millet rice (kg)}}{\text{Total weight of millets (kg)}} \times 100 \qquad \text{Eq. (4)}$$

RESULTS AND DISCUSSION

Moisture content of raw kodo millet, foxtail millet, little millet, browntop and barnyard millets was determined and given in Table 1. Performance of the all the millet dehullers was conducted at the mentioned moisture contents present in the millets.

Table 1 Moisture content of millets

Type of millets	MC, % w.b.	MC, % d.b.
Foxtail	12.21±0.19	13.91±0.19
Barnyard	12.23±0.11	13.93±0.11
Kodo	12.00±0.10	13.64±0.10
Little	11.58±0.12	13.09±0.12
Browntop	10.68±0.04	11.96±0.04

Performance Evaluation of Millet Dehullers

Performance Evaluation of TNAU Single-chamber Dehuller

Dehulling efficiency and brokens obtained from the single-pass and double-pass of the TNAU single-chamber dehuller are provided in Table 2.

Table 2 Performance of TNAU single-chamber centrifugal dehuller for millets

Type of millets	Single-pass		Double-pass	
	Dehulling efficiency (%)	Broken percentage (%)	Dehulling efficiency(%)	Broken percentage (%)
Foxtail	91.14±0.28	6.25±0.04	98.86±0.04	15.17 ±0.01
Brown top	14.27±0.43	5.66± 0.08	19.74 ±0.14	27.78±0.14
Barnyard	25.14±0.05	5.93±0.05	32.46±0.18	38.13±0.30
Kodo	16.70±0.23	0.00±0.00	50.89±0.17	22.17±0.09
Little	24.84 ±0.07	18.16±0.03	31.57±0.04	35.10± 0.19

Maximum dehulling efficiency of 91.14% and 98.86% was obtained in foxtail millet in single- and double-pass, respectively. In the case of brown top and kodo millets, minimum dehulling efficiency was noticed in single-pass. But, in double-pass operation, brown top and little millets obtained minimum dehulling efficiency.

Performance Evaluation of TNAU Double Chamber Dehuller

Dehulling efficiency and brokens obtained from the single-pass and double-pass of the TNAU double-chamber dehuller are given in Table 3.

Table 3 Performance of TNAU double-chamber centrifugal dehuller for millets

Type of millets	Single-pass		Double-pass	
	Dehulling efficiency (%)	Broken percentage (%)	Dehulling efficiency (%)	Broken percentage (%)
Foxtail	97.17±0.33	1.90±0.26	98.92±0.41	42.36±0.31
Barnyard	47.54±0.51	14.52±0.63	51.06±0.65	45.55±0.72
Kodo	63.57±0.61	08.20±0.56	67.07±0.80	50.11±0.49
Little	37.92±0.46	19.47±0.11	41.61±0.55	52.34±0.21
Browntop	18.43±0.24	05.18±0.34	32.92±0.29	56.32±0.36

Dehulling efficiency of TNAU double-chamber centrifugal dehuller showed improvement in all the minor millets when used in a single-pass compared to the TNAU single-chamber centrifugal dehuller. However, when operated in a double pass, the broken percentage increased significantly. The maximum dehulling efficiency of 99.17% was achieved in the single-pass mode using the TNAU double-chamber centrifugal dehuller. Therefore, it is recommended to opt for the single-pass dehulling method for foxtail millets in the TNAU double-chamber centrifugal dehuller to achieve better performance.

Performance Evaluation of CIAE Millet Mill

Dehulling efficiency and brokens per cent of five types of millets obtained from the single-pass and double-pass of CIAE millet mill are provided in Table 4.

Table 4 Performance of CIAE mill for millets

Type of millets	Single-pass		Double-pass	
	Dehulling efficiency (%)	Brokens percentage (%)	Dehulling efficiency (%)	Brokens percentage (%)
Foxtail	94.65±0.28	0.65±0.04	97.60±0.04	7.55±0.01
Brown top	93.68±0.43	1.68± 0.08	94.50±0.14	10.90±0.14
Barnyard	77.40±0.05	3.03±0.05	84.64±0.18	5.44±0.30
Kodo	74.75±0.23	4.25±0.05	95.13±0.17	5.63±0.09
Little	92.12±0.07	3.12±0.03	96.60±0.04	6.32± 0.19

Dehulling efficiency of the CIAE millet mill improved in double-pass when compared to its single-pass mode. However, the broken percentage in double-pass also increased in comparison to the single-pass operation of the same mill. On the other hand, when the CIAE millet mill was operated in double-pass mode, the broken percentage decreased compared to the double-pass operation of the TNAU double-chamber dehuller. As a result, it is advisable to choose the double-pass dehulling method for all minor millets when using the CIAE millet mill to achieve better performance.

Performance of rubber roll sheller on millets dehulling

Dehulling efficiency and brokens per cent of five types of millets obtained from the single-pass of rubber roll sheller are given in Table 5.

Table 5 Performance of rubber roll sheller for millets

Type of millets	Single-pass	
	Dehulling efficiency (%)	Broken percentage (%)
Foxtail	64.77±0.76	4.72±1.42
Barnyard	27.95±0.44	2.92±0.15
Kodo	14.66±0.11	0.47±0.43
Little	47.61±0.19	7.48±0.05
Browntop	44.51±0.03	18.33±2.43

With the exception of foxtail millets, the dehulling efficiency of other minor millets is less than 50% when using a rubber roll sheller. Moreover, even for foxtail millets, the dehulling efficiency in a rubber roller sheller is lower than that achieved with the other three millet dehullers. Therefore, conducting milling operations in a rubber roll sheller is not recommended due to the low dehulling efficiency across all minor millets.

Single-pass comparison of millet dehulling efficiency and broken percentage of different millet dehullers are given below Table 6.

Table 6 Single-pass comparison of millet dehulling efficiency and broken percentage of millet dehullers evaluated

Type of millets	TNAU single-chamber dehuller		TNAU double-chamber dehuller		CIAE millet mill		Rubber roll sheller	
	Dehulling efficiency (%)	Broken percentage (%)	Dehulling efficiency (%)	Broken percentage (%)	Dehulling efficiency (%)	Broken percentage (%)	Dehulling efficiency (%)	Broken percentage (%)
Foxtail	91.14±0.28	6.25±0.04	97.17±0.33	1.90±0.26	94.65±0.28	0.65±0.04	64.77±0.76	4.72±1.42
Browntop	14.27±0.43	5.66± 0.08	47.54±0.51	14.52±0.63	93.68±0.43	1.68± 0.08	27.95±0.44	2.92±0.15
Barnyard	25.14±0.05	5.93±0.05	63.57±0.61	8.20±0.56	77.40±0.05	3.03±0.05	14.66±0.11	0.47±0.43
Kodo	16.70±0.23	0.00±0.00	37.92±0.46	19.47±0.11	74.75±0.23	4.25±0.05	47.61±0.19	7.48±0.05
Little	24.84±0.07	18.16±0.03	18.43±0.24	5.18±0.34	92.12±0.07	3.12±0.03	44.51±0.03	18.33±2.43

Among all the millet dehullers, the TNAU double chamber dehuller achieved the highest dehulling efficiency (99.17%) for foxtail millets in a single pass comparison. However, for other millet varieties, the CIAE millet mill achieved the maximum dehulling efficiency.

Double-pass comparison of millet dehulling efficiency and broken percentage of different millet dehullers (except rubber roll sheller) are provided in Table 7.

Table 7 Double-pass comparison of millet dehulling efficiency and broken percentage of millet dehullers evaluated

Type of millets	TNAU single-chamber dehuller		TNAU double-chamber dehuller		CIAE millet mill	
	Dehulling efficiency (%)	Broken percentage (%)	Dehulling efficiency (%)	Broken percentage (%)	Dehulling efficiency (%)	Broken percentage (%)
Foxtail	98.86±0.04	15.17 ±0.01	98.92±0.41	42.36±0.31	97.60±0.04	7.55±0.01
Browntop	19.74 ±0.14	27.78±0.14	51.06±0.65	45.55±0.72	94.50±0.14	10.90±0.14
Barnyard	32.46±0.18	38.13±0.30	67.07±0.80	50.11±0.49	84.64±0.18	5.44±0.30
Kodo	50.89±0.17	22.17±0.09	41.61±0.55	52.34±0.21	95.13±0.17	5.63±0.09
Little	31.57±0.04	35.10± 0.19	32.92±0.29	56.32±0.36	96.60±0.04	6.32± 0.19

Among all the millet dehullers, the TNAU single and double chamber dehullers achieved the highest dehulling efficiency (98.86% and 99.17%) for foxtail millets in a single pass comparison. However, for other millet varieties, the CIAE millet mill achieved the maximum dehulling efficiency.

Balasubramanian *et al*. (2020) conducted performance of CIAE millet mill on raw and parboiled millets and found the overall dehulling efficiency of raw millet ranged from 83.95-69.76% and parboiled millets 85.15-72.07%. Efficiency obtained in the present study is much higher than their studies.

Performance evaluation studies were conducted for the foxtail, barnyard, kodo, little and browntop millets with TNAU single-chamber and double-chamber, CIAE millet mill and rubber roll Sheller with single-pass and double-passes. Among the dehullers, CIAE millet mill is found suitable for all millets, TNAU double-chamber dehuller is suitable for foxtail and kodo millets and TNAU single-chamber dehuller is suitable for foxtail millets only. The dehulling of the machines was ef-ficient compared to the traditional methods. However, the effectiveness of the machines are said to be dependent on the uniformity, size and moisture content of the millet grains.

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