

ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2026): 4.97
IJAFS 2026; 8(11): 25-30
www.agriculturaljournals.com
Received: 28-08-2026
Accepted: 22-10-2026
Published: 03-11-2026

RK Vishwakarma
ICAR-Central Institute of Post Harvest Engineering and Technology, Ludhiana, Punjab , India

Chandan Solanki
ICAR-Central Institute of Post Harvest Engineering and Technology, Ludhiana, Punjab, India

Corresponding Author:
Chandan Solanki
ICAR-Central Institute of Post Harvest Engineering and Technology, Ludhiana, Punjab, India

Development of process protocol for efficient dehulling of millets and producing refined millet flour

RK Vishwakarma[1], Chandan Solanki[2]

DOI: https://www.doi.org/10.33545/2664844X.2026.v8.i11a.89368

Abstract
Millets are nutrient-dense, climate-resilient coarse cereals that offer significant health benefits; however, their wider industrial and household utilization is often limited by tough, fibrous outer seed coats and a lack of standardized post-harvest processing. This study presents a standardized, optimized process protocol designed to achieve high-efficiency dehulling of millets while minimizing nutrient loss and endosperm breakage. Moisture conditioning and mechanical abrasive milling parameters were systematically evaluated to maximize dehulling efficiency i.e., 86%, head-grain recovery, and separation of the fibrous pericarp. The dehulled grains were subsequently subjected to multi-stage dry milling and classification to produce fine, refined millet flour with uniform particle size distribution, improved dispersibility, and enhanced functional attributes. The developed processing approach provides a scalable, energy-efficient framework for grain millers to manufacture high-quality millet flours suitable for ready-to-eat products, composite baked goods, and extended-shelf-life functional foods.

Keywords: Millets, Dehulling, Abrasive milling, Refined flour, Process optimization, Functional properties, Post-harvest processing

Introduction

Usually, millet seeds have four parts namely hull, bran, germ and endosperm. The hull contains mainly indigestible fibers. The bran covers the endosperm whereas the germ ia very small and located on the central side at the base of the grain. Bran and germ are rich in oil and hence affect the storage quality of millets. Desikachar (1977) [1] reviewed the processing of sorghum and millet for food uses, including pearling or debranning, preparation of chapattis, dosa (a pancake from fermented batter), vermicelli or noodles, flaking for soft cooking and popping or puffing of millets.

Jain *et al.* (1997) [2] studied physical properties of pearl millet. Purushothaman *et al.* (1996) [3] analysed the chemical composition and nutritive value of little millet. Visvanathan *et al.* (1990) [4] studied angle of repose for sorghum, pearl millet, finger millet, Kodo millet, foxtail millet and little millet and observed linear increase with increasing moisture content, and bulk density decreased linearly for all the grains. Baryeh (2002) [5] studied physical and mechanical properties of various millets. Yanez *et al.* (1991) [6] studied chemical and physical characteristics of proso millet starches. The starch digestibility of millet was like that of maize. Ravindran (1991) [7] dehulled common millet (*Panicum miliaceum*), finger millet (*Eleusine coracana*) and foxtail millet and examined for proximate composition (moisture, crude protein, crude fat, crude fibre, ash, carbohydrate), minerals (K, Na, Mg, Ca, P, Mn, Zn, Cu, Fe, Ca:P ratio), phytic acid, and water-soluble and total oxalates. The results indicated that, as a source of protein, carbohydrate and minerals, the millets are comparable or superior to other common cereals. Mean protein contents in common, finger and foxtail millets were, resp., 14.4, 9.8 and 15.9%. Oxalate contents were low, but high phytic acid levels (0.45-0.70 g/100 g) were found. Devittori *et al.* (2000) [8] extracted oil from proso millet bran (with supercritical CO_2.

In the process of converting millets into number of products, they undergo number of unit operations like dehulling, pearling, grinding, mixing, extrusion, baking, packaging, transportation etc. In the process of dehulling and pearling, it is necessary to remove the hull, bran and germ to increase the shelf life of the dehulled grain and flour. Usually dehulling of millets is done with abrasive mills. Adeyemi (1983) [9] milled sorghum using Buehler mill. Francisco *et al.* (1982) [10] dehulled pearl millet and sorghum in laboratory abrasive mill. Neither millet nor sorghum de-germed during dehulling. Fractionation of sorghum produced 10-14% bran (fines and flakes), 5-43% broken (small and large), 41-84% whole grain. Malleshi *et al.* (1981) [11] studied the suitability of roller flour mill, hammer mill and plate grinder for obtaining refined flour from malted ragi. Lorenz *et. al.* (1980) dehulled proso millet with barley pearler. Perten (1977) [12] showed that wheat milling technology could be utilized for millet and sorghum milling. Kotlyar *et al.* (1973) [13] optimized machine parameters for husking of Saratovskoe 853 millet grain using small rubber rollers and based on findings, a GDF laboratory husking machine was developed. Gurusiddappa (2003) [14] obtained a US

26648458, 2026, 8(11), Downloaded from https://www.doi.org/10.33545/2664844X.2026.v8.i11a.89368 by International Journal of Agriculture and Food Science on [03/11/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License

patent for process of decorticating finger millet using abrasive mill. Lazaro *et al.* (2000) [15] used NaOH for bebranning sorghum and millets. Besides these, several other scientists had worked on milling of millets using abrasive type of milling mechanism.

Materials and methods

Materials

The minor millets namely proso, barnyard, kodo, little, and foxtail millets were procured from AICRP on Minor Millets, ANGRAU, Hyderabad. The millets were cleaned, graded and packed into metal bins for further experiments.

Methods

Pre-conditioning of millets

The cleaned and graded minor millet seeds (using conventional air screen cleaner and grader) were taken for the study. Then the seed moisture content of the seeds was determined. The moisture content of the seed was adjusted to 10% (d.b.) prior to dehulling. Thereafter the seeds were dehulled immediately using differential speed rubber roll dehulling machine with varying machine parameters as per the experimental plan.

Dehulling of millets

` Differential speed rubber roll dehulling machine was used for dehulling the pre-conditioned seeds. It consists of two rubber-coated rolls placed in which the clearance between rollers can be changed as per requirement. The rolls are spring loaded to avoid any breakage during dehulling. A sample of 200 g was used for dehulling and experiments were replicated twice. After dehulling operation, a sample of about 10 g was drawn and fractionated in unhulled seed, dehulled seed, broken and hull. The dehulling efficiency of the machine was calculated using the following equation.

$$\eta = \left(1 - \frac{U_h}{T_h}\right)\left(\frac{F_p}{F_p + B_r + P_o}\right) \times 100 \quad (1)$$

Where

η: Dehulling efficiency, %

B_r: Weight of broken grains, g

F_p: Weight of finished product (weight of dehulled grains + splits), g

P_o: Weight of powder, g

T_h: Total weight of grains used for dehulling, g

U_h: Weight of unhulled grains, g

Pearling of dehulled millets

Conical shape horizontal rice polisher was used for polishing the dehulled millet grains. This machine was adopted for the polishing. The diameter of polishing roller was less at feed end whereas it was more at the outlet end, thus formed conical shape. Depending upon degree of polish required, the time of pearling and outlet clearance can be changed.

Experimental plan for dehulling

For dehulling experiments, the millets were first conditioned to desired moisture level. Then the seeds were fed to the rubber roll sheller at uniform flow rate of 100 kg/h. The experimental plan for the dehulling experiments was as given below.

Dehulling method: After the pre-conditioning and tempering of the samples to required time, the millets were dehulled using differential speed rubber roll dehulling machine (also called rubber roll sheller). The experimental plan followed for the dehulling was as given below Table 1.

The data analysis was carried out by using the Statistca 6 software. The differences between the mean values of characteristics of millets were tested for significance using *t*-test.

Table 1. Experimental plan for the dehulling of millets

S. No.	Variables/ parameters	Level (s)	Description
1.	Millets	1	One variety of each millet
2.	Clearance between rollers	5	0.25, 0.50, 0.75, 1.00 and 1.25 mm
3.	Differential speed	1	2:1
4.	Speed of first roller	1	1046 rpm
5.	Speed of second roller	1	523 rpm
6.	Sample size	1	200 g
7.	Replications	2	

Results and discussion

The dehulling and bran removal from minor millets is one of the challenging works, particularly when all components are expected to come separately for further uses. To achieve the objectives, five minor millets were taken for the study. Some physical properties relevant to the machine development and adoption were studied for two millets. The dehulling study was done for all five millets selected for the study. Polishing of all five millets were done. The results of the study are presented below.

Dehulling of Millets

Effect of roller clearance and moisture content on dehulling efficiency

Proso millet: The samples of 5, 10, 15 and 20% moisture content were prepared as described above. The dehulling of the proso millet grain was done at four roller clearances (1.5, 1.25, 1.0, 0.75 and 0.50 mm). Samples of 200g grain were taken for the dehulling study. The results are shown in Fig 1.

It can be observed from Fig. 1 that Maximum dehulling efficiency (94%) of the grain was observed at 10% moisture content. The Dehulling efficiency decreased with increase in moisture content above 10%. The maximum dehulling of the grain was observed at 0.75 mm roller clearance. Lower dehulling efficiency at 0.5 mm roller clearance was observed due to breakage of grain and clogging of the machine.

26648458, 2026, 8(11), Downloaded from https://www.doi.org/10.33545/2664844X.2026.v8.i11a.89368 by International Journal of Agriculture and Food Science on [03/11/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License

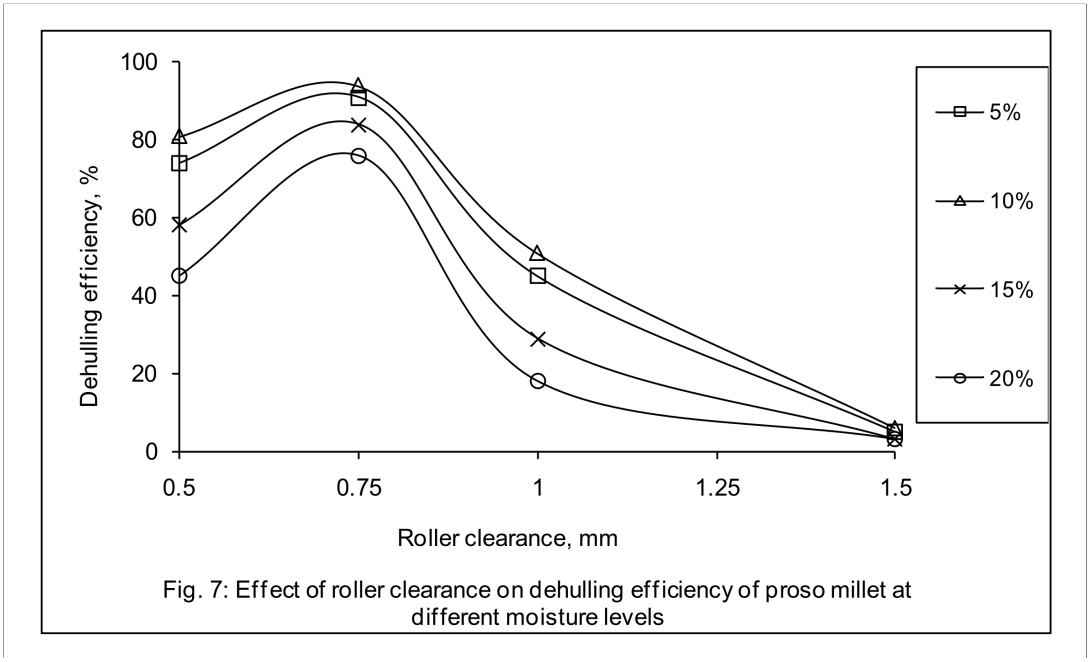


Figure 1. *Effect of roller clearance on dehulling efficiency of proso millet at different moisture levels*

Barnyard millet: The samples of 5, 10, 15 and 20% moisture content were prepared as described above. The dehulling of the grain was done at four roller clearances (1.5, 1.0, 0.75 and 0.50 mm). Samples of 200g grain were taken for the dehulling study. The results are shown in Fig 2.

It can be observed from Fig 8 that Maximum dehulling efficiency (93%) of the grain was observed at 10% moisture content. The Dehulling efficiency decreased with increase in moisture content above 10%. The maximum dehulling of the grain was observed at 0.75 mm roller clearance. Lower dehulling efficiency at 0.5 mm roller clearance was observed due to breakage of grain and clogging of the machine.

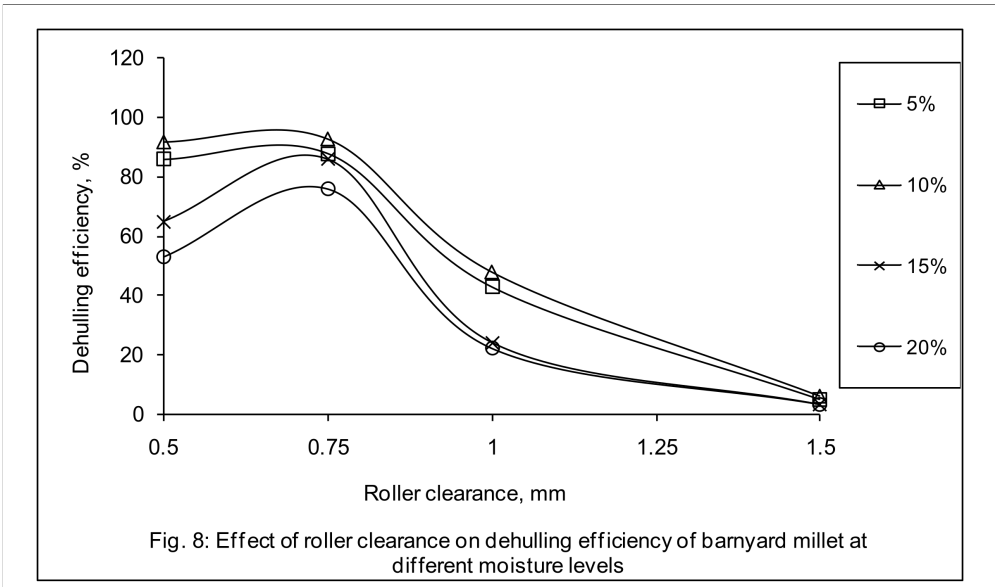


Figure 2. *Effect of roller clearance on dehulling efficiency of barnyard millet at different moisture levels*

Kodo millet: The samples of 5, 10 and 15% moisture content were prepared as described above. The dehulling of the grain was done at four roller clearances (1.5, 1.0, 0.75 and 0.50 mm). Samples of 200g grain were taken for the dehulling study. The results are shown in Fig 3.

It can be observed from Fig. 9 that Maximum dehulling efficiency (89%) of the grain was observed at 10% moisture content. The Dehulling efficiency decreased with increase in moisture content above 10%. The maximum dehulling of the grain was observed at 0.50 mm roller clearance. The kodo grain has two layers of hull and hence the dehulling efficiency is less than proso and barnyard millets.

26648458, 2026, 8(11), Downloaded from https://www.doi.org/10.33545/26648458.2026.v8.i11a.89368 by International Journal of Agriculture and Food Science on [03/11/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License

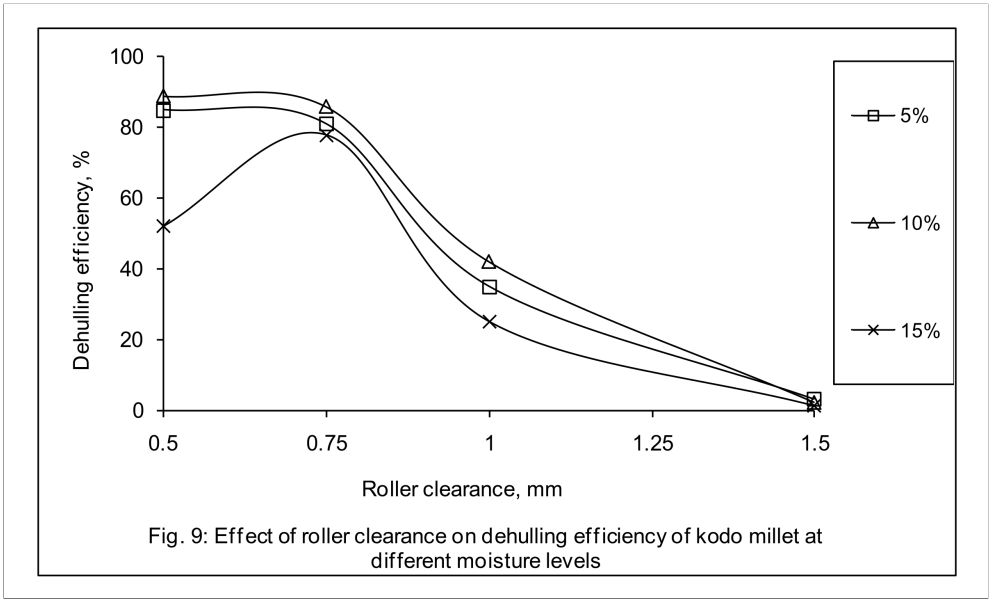


Figure 3. *Effect of roller clearance on dehulling efficiency of kodo millet at different moisture levels*

Little millet: The samples of 5, 10 and 15% moisture content were prepared and dehulled at four roller clearances (0.75, 0.50, 0.25 and 0.10 mm). Samples of 200g grain were taken for the dehulling study. The results are shown in Fig 4.

It can be observed from Fig that Maximum dehulling efficiency (86%) of the grain was observed at 10% moisture content. The Dehulling efficiency decreased with increase in moisture content above 10%. The maximum dehulling of the grain was observed at 0.10 mm roller clearance. It was not possible to decrease the clearance between the rollers beyond this to avoid the friction between rollers.

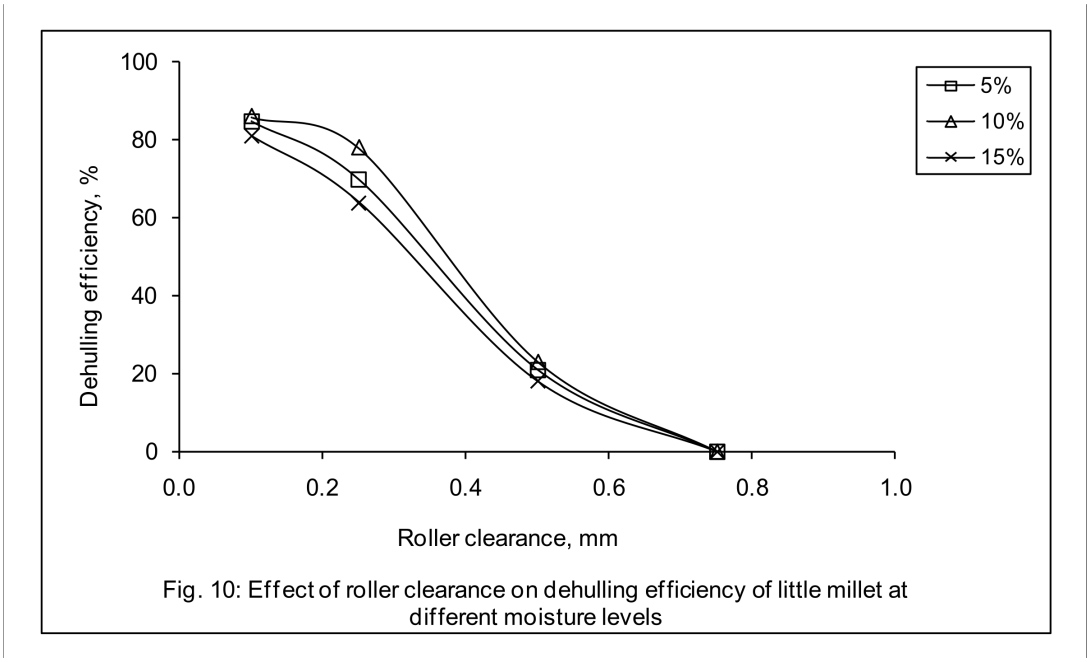


Figure 4. *Effect of roller clearance on dehulling efficiency of little millet at different moisture levels*

Barnyard millet: The samples of 5, 10 and 15% moisture content were prepared and dehulling of the grain was done at four roller clearances (1.05, 0.75, 0.50 and 0.25 mm). Samples of 200g grain were taken for the dehulling study. The results are shown in Fig 5.

It can be observed from Fig that Maximum dehulling efficiency (88%) of the grain was observed at 10% moisture content. The Dehulling efficiency decreased with increase in moisture content above 10%. The maximum dehulling of the grain was observed at 0.25 mm roller clearance. To avoid the friction between rubber rollers, the clearance was not reduced beyond this limit (the size of grains varied widely and hence clearance less than 0.25 mm was not achieved).

Dehulling Process

All five minor millets namely foxtail millet, little millet, proso millet, barnyard millet and kodo millet were tested for their dehulling using differential speed double roll dehulling machine. The millets were first cleaned and graded (using any conventional air screen cleaner and grader).

In the step the moisture content of the millets were adjusted to a predetermined level (9-11%, w.b.) by sprinkling the water on its surface and keeping the seeds for a predetermined time (4-6 h). This pretreatment toughened the hull and loosens it from the rest of the seed contained within.

Immediately after the end of the treatment period, the seed is dehulled immediately using a machine based on compression and shear mechanism. Differential speed roller dehulling machine is used for dehulling the pretreated seed. It consists of two rolls placed at a clear

26648458, 2026, 8(1), Downloaded from https://www.doi.org/10.33545/26648458.2026.v8.i1a.89368 by International Journal of Agriculture and Food Science on [03/11/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License

ance of about 0.1-0.75 mm, which may vary according to the seed size. The rolls are spring loaded to avoid the breakage of the endosperm during dehulling. Compression and shear causes dehulling of the seed because bond between the hull and cotyledon becomes weak after pretreatment. The hull is removed from the dehulled lot using aspirator. The optimum moisture range and roller clearance for dehulling the millets is given in Table 2.

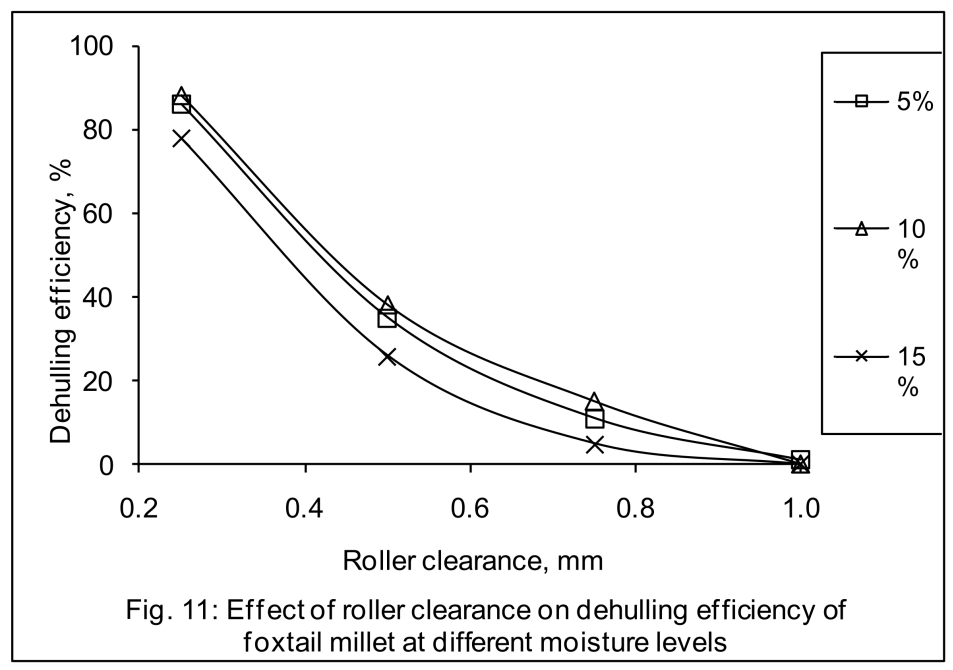


Figure 5. *Effect of roller clearance on dehulling efficiency of foxtail millet at different moisture levels*

Table 2. Optimum roller clearance and moisture content range for dehulling millets

Millet Name	Moisture range, % (w.b.)	Roller clearance, mm	Dehulling efficiency, %
Proso millet	5-10	0.5-0.75	91-94
Barnyard millet	5-10	0.5-0.75	90-96
Kodo millet	5-10	0.25-0.5	88-95
Foxtail millet	5-10	0.25-0.5	86-93
Little millet	5-10	< 0.25, >0.1	85-95

The dehulled seeds are then separated using any conventional grader. Dehulled seeds are dried to bring moisture content to 10%. The bran and germ remains intact during dehulling and hence only hull is removed.

Dehulled millet seeds are then polished using abrasive type of polishing machine. Rice polisher was evaluated for polishing the dehulled millets. The time required for polishing ranged from 10-30 seconds depending upon the degree of polish required. The polishing time also depends upon extent of bran removal to be achieved. A time of 15 seconds is sufficient to remove all the bran from the dehulled millets using emery of 36 grade in the abrasive mill. In case complete white grain is required, the polishing time may be increased to 20-25 seconds. All germ and bran was removed in this process. The bran and germ was separated using blower.

The polished millet seeds can then be ground to fine powder using burr mill. In this, the polished grain can be fed to the burr mill at a feed rate recommended by the manufacturer for specific machine settings. The grinding is done in a way that temperature of the flour does not increase much to avoid any loss of nutrients. Refined millet flour of required particle size is obtained after grinding.

The process flow diagram for dehulling these minor millets is as follows.

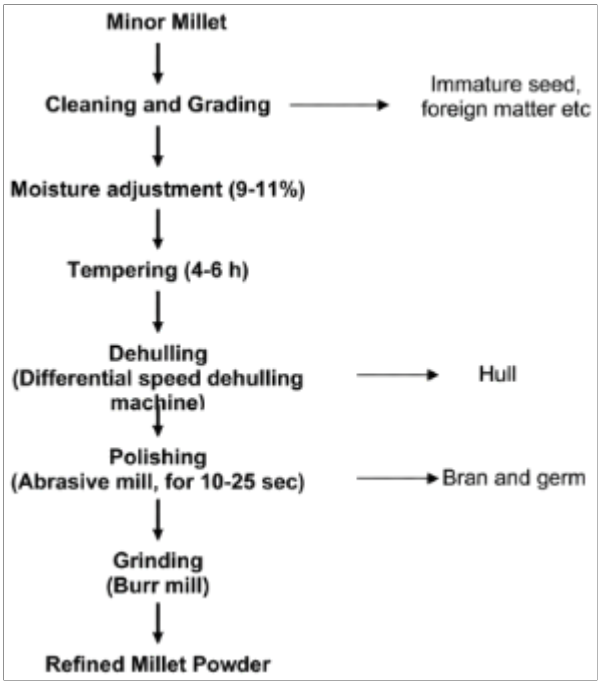


Figure 6. Process flow diagram for production of refined flour from minor millets

26648458, 2026, 8(11), Downloaded from https://www.doi.org/10.33545/26648458.2026.v8.i11a.89368 by International Journal of Agriculture and Food Science on [03/11/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License

Conclusion

Dehulling and pearling of minor millets is one of the problems for its judicious utilization for human consumption. In this project, the physical properties of two minor millets were determined for development of process for dehulling and pearling. A pilot scale millet mill of 100 kg/h throughput capacity (including dehuller, and pearler) was developed and installed at CIPHET, Abohar. The pilot plant was evaluated for dehulling and pearling minor millets namely proso, barnyard, kodo, little, and foxtail millets. The minimum dehulling efficiency of 86% was observed with least losses in the form of broken and powder. The plant is capable of pearling barley, sorghum and bajra also.

References

1. Desikachar HSR. Processing of sorghum and millets for versatile food uses in India. Tropical Products Institute Conference Papers. 1977:41-45.
2. Jain RK, Bal S. Properties of pearl millet. Journal of Agricultural Engineering Research. 1997;66(2):85-91.
3. Purushothaman MR, Natanam R. Chemical composition and nutritive value of little millet (*Panicum miliare*). Indian Veterinary Journal. 1996;73(4):410-413.
4. Visvanathan R, Varadharaju N, Gothandapani L, Sreenarayanan VV. Effect of moisture content on angle of repose and bulk density of selected food grains. Journal of Food Science and Technology. 1990;27(3):133-135.
5. Baryeh EA. Physical properties of millet. J Food Engineering. 2002;51(1):39-46.
6. Yanez GA, Walker CE, Nelson LA. Some chemical and physical properties of proso millet (*Panicum milliaceum*) starch. Journal of Cereal Science. 1991;13(3):299-305.
7. Ravindran G. Studies on millets: proximate composition, mineral composition, and phytate and oxalate contents. Food Chemistry. 1991;39(1):99-107.
8. Devittori C, Gumy D, Kusy A, Colarow L, Bertoli C, Lambelet P. Supercritical fluid extraction of oil from millet bran. Journal of the American Oil Chemists' Society. 2000;77(6):573-579.
9. Adeyemi IA. Dry milling od sorghum for ogi manufacture. J of Cereal Science. 1983;1(3):221-227.
10. Fransisco A de, Shepherd AD, Hoseney RC, Varriano ME. Decorticating pearl millet and grain sorghum in a laboratory abrasive mill. Cereal Chemistry. 1982;59(1):1-5.
11. Malleshi NG, Desikachar HSR. Studies on the suitability of roller flour mill, hammer mill and plate grinder for obtaining a refined flour from malted ragi (*Eleusine coracana*). J. Food Science and Technology. 1981;18(2):37-39.
12. Perten H. Specific characteristics fo millet and sorghum milling. Tropical Products Institute Conference Papers. 1977:47-51.
13. Kotlyar LI, Goikhenberg BI. Optimization of millet husking using small rubber rollers. Izvestiya Vysshikh Uchebnykh Zavedenii, Pishchevaya Tekhnologiya. 1973;5:117-121.
14. Gurusiddappa MN. Decorticated finger millet (*Eleusine coracana*) and a process for preparing decorticated finger millet. US Patent No. 2003/0185951 A1. 2003.
15. Lazaro EL, Favier JF. Alkali debranning of sorghum and millet. Cereal Chemitry. 2000;77(6):717-720.
16. Babatunde AO, Manyasa E. Millets. In Pseudocereals and Less Common Cereals, Grain Properties and Utilization Potential, Belton PS, Taylor JRN, eds. Springer-Verlag Berlin Heidelberg, New York; 2002:177-218.
17. Lorenz K, Dilsaver W, Bates L. Proso millets: Milling characteristics, proximate composition, nutritive value of flours. Cereal Chmeistry. n.d.;57(1):16-20.
18. Malleshi NG, Hadimani NA. Nutritional and technological characteristics of small millets and preparation of value added products from them. In: Advances in Small Millets, Riley KW, Gupta SC, Seetharam A, Mushonga JN, eds. New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.; 1993:271-287.
19. Rao MV. The small millets: their importance, present status and outlook. In: Advances in small millets, Riley KW, Gupta SC, Seetharam A, Mushonga JN, eds. New Delhi: Oxford and IBH Publishing Co. Pvt. Ltd.; 1989:271-287.
20. Subramanian S, Viswanathan R. Bulk density and friction coefficients of selected minor millet grains and flours. J. Food Engineering. 2007;81:118-126.
21. Carman K. Some physical properties of lentil grains. Journal of Agricultural Engineering Research. 1996;63(2):87-92.
22. Deshpande SD, Bal S, Ojha TP. Physical properties of soybean. Journal of Agricultural Engineering Research. 1993;56(2):89-98.
23. Mohsenin NN. Physical properties of plant and animal materials. New York: Gordon and Breach Science Publishers Inc.; 1970.
24. Curray JK. Analysis of sphericity and roundness of quartz grain. MS dissertation, Pennsylvania State University, University Park, PA. 1951.
25. Mohsenin NN. Physical properties of food and agricultural materials. New York: Gordon and Breach Science Inc.; 1981.
26. Tunde-Akintunde TY, Akintubde BO. Some physical properties of sesame seed. Biosystems Engineering. 2004;88(1):127-129.
27. IS: 4333 (Part II). Food grains, Determination of 1000-kernel weight on as-is (w.b.) basis. New Delhi (India): Bureau of Indian Standards; 1968.
28. Rahman S. Food Properties Handbook. Boca Raton, Florida: CRC Press LLC; 1995.
29. Singh KK, Goswami TK. Physical properties of cumin seed. Journal of Agricultural Engineering Research. 1996;64(2):93-98.
30. Gupta RK, Das SK. Physical properties of sunflower seed. Journal of Agricultural Engineering Research. 1997;66:1-8.
31. Sablani SS. Physical and thermal properties of cereal grains. In: Chakraverty A, Mujumdar AS, Raghavan GSV, Ramaswami HS, editors. Handbook of Postharvest Technology. New York: Marcel Dekker Inc.; 2003:17-40.
32. Thompson RA, Issacs GW. Porosity determination of grains and seeds with air comparison pycnometer. Transactions of ASAE. 1967;10:693-696.
33. Paksoy M, Aydin A. Some physical properties of edible squash (*Cucurbita pepo* L.). Journal of Food Engineering. 2004;65:225-231.
34. Fraser BM, Verma SS, Muir WE. Some physical properties of fababeans. Journal of Agricultural Engineering Research. 1978;23:53-57.
35. Dutta SK, Nema VK, Bhardwaj RJ. Physical properties of gram. Journal of Agricultural Engineering Research. 1988;39:259-268.
36. Suthar SH, Das SK. Moisture sorption isotherms for Karingda (*Citrullus lanatus* Thumb) seed kernel and hull. Journal of Food Process Engineering. 1997;20:349-366.

How to cite this article: Vishwakarma R, Solanki C. Development of process protocol for efficient dehulling of millets and producing refined millet flour. *International Journal of Agriculture and Food Science*. 2026;8(11):25-30. doi: https://www.doi.org/10.33545/2664844X.2026.v8.i11a.89368

2664844X, 2026, 8(11), Downloaded from https://www.doi.org/10.33545/2664844X.2026.v8.i11a.89368 by International Journal of Agriculture and Food Science on [03/11/2026]. See the Terms and Conditions (https://www.agriculturaljournals.com) for rules of use; OA articles are governed by the applicable Creative Commons License