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A Comparative Study of Postharvest Processing Methods for Little Millet (*Panicum Miliare* L.)

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ABSTRACT. *Minor millets are important food crops of a large group of people in rural, tribal and hilly areas in India. Presence of husk and bran over the edible endosperm is the major processing problem. This is usually removed by hand pounding, since mechanical dehusking or polishing units suitable for processing little millet are not available yet. Therefore, a study was undertaken on "Postharvest processing methods for little millet" using two types of mills and different pretreatment interventions. Rubber roll sheller and abrasive grain polisher (Mill-1) yielded little millet brown rice with 62.2% head rice yield, 3.8% of broken with 66.2% dehusking efficiency. The dehusking efficiency was significantly higher in direct boiling in water for 20 min and sun drying (T_5). Head rice yield using Mill-1 ranged from 67.0 to 73.0 % and 48.7 to 67.9 % in provender mill (Mill-2). The mean milling efficiency values varied from 44.8–57.8%. Among the treatments, T_5 recorded significantly highest milling efficiency (60.6%). Treatments such as parboiling, steaming and application of 2% lime (Calcium oxide) solution showed differences in dehusking efficiency. The cost incurred to convert one kilogram of little millet into rice in Indian rupees was Rs. 0.23 and Rs. 8.65 in Mill-1 and Mill-2 respectively. It can be concluded that pretreatment of little millet is a must for complete removal of husk. Provender mill had more advantages as it can be used for milling of other cereals and millets cost effectively. To reduce milling losses and to bring good returns, little millet should be parboiled and dried before milling.*

INTRODUCTION

Small millets or minor millets are important food crops for a large group of people in rural, tribal and hilly areas in India. Millets have minor importance in developed countries, but the most important staple food for millions of people in the semi-arid tropics of Asia and Africa (Rai, 2000). Millet crops have sustained the lives of the poorest people in the world and will continue to do so in the foreseeable future. India is the largest producer of many kinds of millets, which include sorghum, pearl millet, finger millet, and other small millets like little millet and foxtail millet. Small millets are predominantly rain fed crops with a total area of 4.00 million hectares with the production of 3.6 million tonnes in India (Anonymous, 2006).

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Improvements in production, availability, storage, utilization and consumption of these food crops will significantly contribute to the household food security and nutrition of the inhabitants of these areas. Among small millets, little millet (*Panicum miliare* L.) is grown throughout India. Little millet has unique nutritional properties, which are superior to rice and wheat in certain constituents. This millet is a good source of phosphorus, iron, and protein (7-12%) and the amino acid profile is well balanced. It contains about 65 % carbohydrate, a good proportion of which is in the form of non-starchy polysaccharides and dietary fiber (Menon, 2004). With all these benefits, it has husk and bran over the edible endosperm. The husk and bran are separated traditionally by hand pounding which involves laborious operations and drudgery since mechanical dehusking or polishing units suitable for processing of little millet are not yet available. Further, preconditioning is an essential requirement for effective dehusking of majority of small millets. Considering several disadvantages associated with traditional methods of dehusking of little millet, this study was conducted for developing postharvest processing methods for little millet to obtain good quality rice.

MATERIALS AND METHODS

The little millet was procured in bulk from the All India Coordinated Small Millets Improvement Project, GKVK Campus, Bangalore. Initially little millet was milled using Rubber roll sheller without any pretreatment to obtain brown rice and known quantity of brown rice was polished (5%) by rice polishing machine and used as raw milled rice for comparison of milling and rice quality (Tippeswamy, 2006).

The effect of hydrothermal treatments on dehulling efficiency of little millet grain was studied. Before dehulling, following pre-treatments were given for the grains. The experiment was conducted with three replicates.

T-1: Little millet brown rice (Rubber roll sheller)
T-2: Raw milled rice (Control) (Rubber roll sheller and abrasive grain polisher)
T-3: Germination for 18 hours and Sun drying
T-4: Application of 2% lime water (Calcium Oxide) for 2 hours and Sun drying
T-5: Direct boiling in water for 20 min and Sun drying
T-6: Soaking in water for 10 min and Steaming at 1 kg/cm^2 for 15 min and Sun drying
T-7: Direct feeding to the pearler
T-8: Whole grains
T-9: Popped little millet

(T-7 to T-9 samples were used for analyses of nutrients and to study the extent of nutrient losses in comparison with other treatments)

Rubber roll sheller and abrasive grain polisher-mill No. 1 and (Plate 1) Provender mill-mill No. 2 (Plate 2) were used for dehusking of millet. Effect of pearling was studied using millet pearling machine. Output obtained was the mixture of broken, bran, and husk. Husked and unhusked grains which were separated manually into different fractions were weighed.

The following observations were recorded and converted into percentages. The weights of all the test samples used for milling were 5 kg and data was calculated by the following indices:

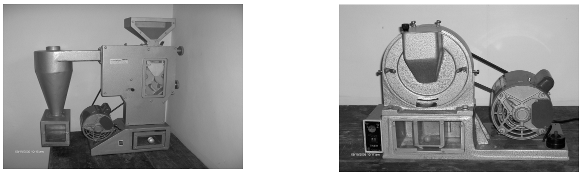

Plate 1. Dehusking of little millet using rubber roll sheller with abrasive grain polisher

$$\text{Dehusking efficiency \%} = \frac{A}{B} \times 100 \qquad \text{Brokens \%} = \frac{D}{A} \times 100$$

$$\text{Head grain yield \%} = \frac{C}{A} \times 100 \qquad \text{Milling efficiency \%} = \frac{E \times F}{100}$$

Where,
A - Weight of milled grains (head grain and broken) (kg)
B - Weight of grains fed to machine (kg)
C - Weight of head grains (kg) (round and clean dehusked grains)
D - Weight of broken grains (kg)
E - Dehusking efficiency
F - Head rice yield

Proximate composition (Nutritive values) of processed little millet rice, pearled grains, popped grains and whole grains was carried out using AOAC (1980) procedure and results were used for discussion.

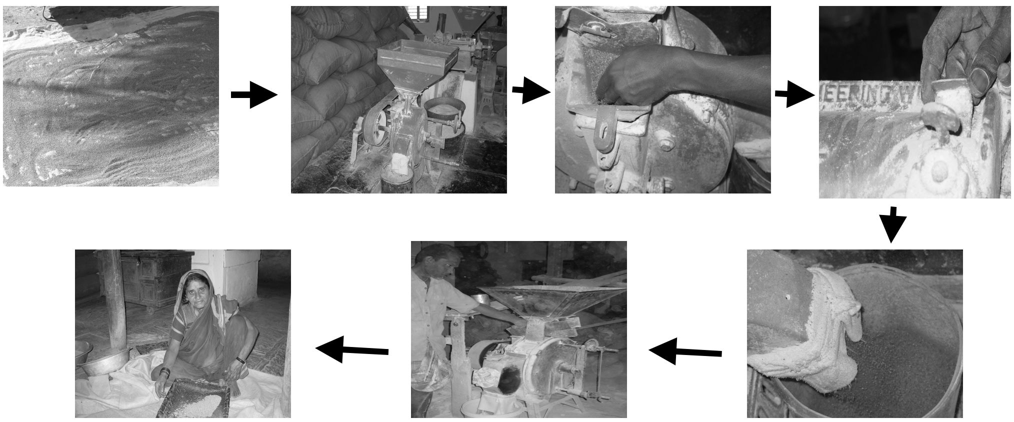

Plate 2. Dehusking of little millet in provender mill and manual separation

The economics for dehusking of little millet grain through dehusking machines and cost incurred to convert one kg of little millet grains (with different pre-treatments) to rice was determined taking into account the fixed and variable costs by adopting the procedure given by Babu *et al.* (1999). Statistical analyses were conducted for significance testing at P≤ 0.05% to find out differences among the processing methods.

RESULTS AND DISCUSSION

Results of dehusking trials are presented in Table 1, since brown rice and pearled grains were milled separately without any pretreatments; results of those two samples are presented in a separate table.

Brown rice (%)

Between two milling techniques tested for little millet (raw material) to get brown rice, Mill No. 1 (rubber roll sheller and abrasive grain polisher) yielded brown rice with 62.2% head rice yield, 3.8% of broken yield and dehusking efficiency was 66.2% (Table 1), while Mill No. 2 (provender mill) did not produce any little millet brown rice. The procedure followed to obtain brown and polished raw milled rice is given below.

Pearled rice (%)

Little millets were fed to pearler (T_7) and results revealed that the dehusking efficiency of pearling machine was very high (89.1 %). The head rice yield was 68.4% and broken yield was 23.5%.

Dehusking efficiency (%)

Table 1 depicts the effects of processing on little millet such as, dehusking efficiency, head rice yield, broken yield and milling efficiency of pre treated samples in comparison with raw milled rice and whole grains. Only treatments 2 to treatment 6 were compared since they were milled in both the mills.

Table 1. Effects of processing on little millet

Mills / Processing methods	Dehusking efficiency (%)		Head rice yield (%)		Broken yield (%)	
	Mill-1	Mill-2	Mill-1	Mill-2	Mill-1	Mill-2
T_2	74.8	80.7	67.0	48.7	6.3	15.8
T_3	77.9	83.6	68.3	54.3	9.1	17.5
T_4	78.9	83.4	69.0	59.8	8.4	19.0
T_5	83.0	83.8	73.0	65.5	6.8	15.9
T_6	82.0	81.1	70.4	67.9	5.4	14.4
Mean	**79.3**	**82.5**	**70.0**	**59.2**	**7.2**	**16.5**

(P≤ 0.05)
Mill 1 = Rubber roll sheller and abrasive grain polisher, **Mill 2** = Provender mill

T_2: Raw milled rice (Control), **T_3:** Germination for 18 hours and Sun drying, **T_4:** Application of 2% lime water (Calcium Oxide) for 2 hours and Sun drying, **T_5**: Direct boiling in water for 20 min and Sun drying and **T_6:** Soaking in water for 10min and Steaming at 1 kg/cm^2 for 15 min and Sun drying

Irrespective of the mills, the dehusking efficiency was significantly higher (83.0%) in direct boiling in water for 20 min and sun drying (T_5) followed by soaking in water for 10 min and steaming at 1 kg / cm^2 for 15 min and sun drying (T_6) (81.6). Between the two mills tested, Mill No. 2 (provender mill) had significantly higher dehusking efficiency (82.5%). The dehusking efficiency was found significant in Mill No. 2 (provender mill) with the range of 80.7 to 83.8%.

Head rice yield (%)

The head rice yield using Mill No. 1 (rubber roll sheller and abrasive grain polisher) varied from 67.0 to 73.0%. However with Mill No. 2 (provender mill), it varied form 48.7 to 67.9%. Among the pretreatments, direct boiling in water for 20 min followed by sun drying (T_5) followed by soaking in water for 10 min and steaming at 1 kg / cm^2 for 15 min and sun drying (T_6) were found to be comparable with each other yielding 69.3 and 69.2% respectively. Mill No. 1 (rubber roll sheller and abrasive grain polisher) yielded maximum head rice yield (69.6%).

Broken yield (%)

The mean values for broken yield varied from 9.8 – 13.7%. Mill No. 1 (rubber roll sheller and abrasive grain polisher) yielded significantly lesser broken yield with the mean values of 7.2. Among all the treatments, soaking in water for 10 min and steaming at 1 kg / cm^2 for 15 min followed by sun drying (T_6) (9.8%) proved as the best method for reducing the broken rice during milling.

Milling efficiency (%)

The mean milling efficiency values varied from 44.8 to 57.8% of which, Mill No. 1 (rubber roll sheller and abrasive grain polisher) had significantly higher milling efficiency (55.2%) (Table 2). Among the treatments direct boiling in water for 20 min and Sun drying (T_5) recorded significantly higher (57.8%) milling efficiency and control (T_2) gave least milling efficiency (44.9%). Between two mills tested direct boiling in water for 20 min and Sun drying (T_5) found to be the most suitable treatment for increased efficiency of milling.

Table 2. Milling efficiency of pretreated little millet

Processing methods	Milling efficiency (%)	
	Mill-1	Mill-2
T_2	50.1	39.4
T_3	53.2	45.4
T_4	54.5	49.8
T_5	60.6	54.9
T_6	57.7	55.1
Mean	**55.24**	**48.93**

Mill 1 = Rubber roll sheller and abrasive grain polisher, **Mill 2** = Provender mill

T_2: Raw milled rice (Control), **T_3:** Germination for 18 hours and Sun drying, **T_4:** Application of 2% lime water (Calcium Oxide) for 2 hours and Sun drying, **T_5**: Direct boiling in water for 20 min and Sun drying and **T_6:** Soaking in water for 10min and Steaming at 1 kg/cm^2 for 15 min and Sun drying

Popping of little millet

There was not much influence of treatments on popping and percentage variation was very marginal. Therefore, popped grains were used only for selected analyses. Consumption of millets is decreasing due to non availability of processed, ready-to-prepare millets (Anonymous, 2006). Therefore, little millet was pretreated before milling and to make milling easier and cost effective, commercially available existing provender mills (Mill No. 2) were used for dehusking of little millet, since dehusking is a major problem in most of the cereals. Pre-treating of millets before milling is a common practice adopted by the villagers in millet growing areas.

Brown rice was obtained using rubber roll sheller without polishing. However, provender mill did not yield brown rice. The reason for this might be due to lesser gaps between emery stones, greater speed, higher capacity of the machine and pressure exerted during milling of brown rice. Whereas, rubber roll sheller had better controlling options with average weight and pressure which allowed grains to lose only outer husk not the bran layers and prevented micro nutrient losses. Moreover rubber roll sheller had separate abrasive grain polisher. Similar findings with reference to foxtail millet were reported by Tippeswamy (2006). However, little millet without any pretreatments fed to pearler and obtained bright coloured rice. But, pearling of grains resulted in significant loss of nutrients (Table 3) such as, loss of protein(9.80 g), fat(2.87 g), ash(0.98 g), and specially crude fibre(0.49) and carbohydrate content(62.25 g) in pearled grains when compared to whole grain, popped grain and other treatments. However, numerical differences were noticed among the other treatments. This may be due to force applied during pearling process. Pearling essentially transforms brown rice into white by removing the outer layer pericarp (Shams-ud-din and Bhattacharya, 1978). However, pearling of little millet is not recommended except for preparation of specific low fibre diets for infant formulas.

Table 3. Proximate composition of processed little millet rice and whole grain per 100g

Treatments	Moisture (%)	Protein (g)	Fat (g)	Ash (g)	Crude Fibre (g)	Carbohydrate (g)	Energy (kcal)
T_1	9.30	10.63	5.09	1.95	1.00	66.95	368.13
T_2	9.63	10.56	5.05	1.39	1.13	72.24	376.65
T_3	9.51	10.07	4.41	1.35	0.96	73.70	374.77
T_4	9.20	10.02	3.89	1.37	0.80	74.94	373.79
T_5	10.01	10.00	4.51	1.98	0.97	72.53	370.71
T_6	9.98	10.54	4.29	1.73	0.86	72.60	370.77
T_7	9.05	9.80	2.87	0.98	0.49	76.59	372.27
T_8	11.38	12.49	4.80	4.78	8.72	62.25	332.26
T_9	5.77	10.15	4.04	2.40	1.28	74.02	382.41
F value	*	*	*	*	*	*	*
SEm (0.05)	0.05	0.02	0.02	0.02	0.02	0.67	0.05
C D (0.05)	0.17	0.06	0.05	0.06	0.06	2.14	0.16

T_1: Little millet brown rice, **T_2:** Raw milled rice (Control), **T_3:** Germination for 18 hours and Sun drying, **T_4:** Application of 2% lime water (Calcium Oxide) for 2 hours and Sun drying, **T_5**: Direct boiling in water for 20 min and Sun drying and **T_6:** Soaking in water for 10min and Steaming at 1 kg/cm^2 for 15 min and Sun drying, **T_7:** Direct feeding in the pearler, **T_8:** Whole grain and **T_9:** Popped little millet

Though provender mill had yielded comparatively lower milling efficiency than rubber roll sheller, it had more advantages with little adjustment of gap between emery stones to achieve desired degree of dehusking and polishing. This needs more skill by the operator. Though rubber roll sheller was found to be the best mill for milling of little millet, it is basically designed for milling of paddy. Small size of little millet grain is another aspect, which hinders the dehusking efficiency in rubber roll sheller.

Pretreatment of little millet had very good impact on dehusking when compared to raw grains. Treatments such as parboiling (T_5), steaming (T_6) and application of 2% lime (Calcium Oxide) solution (T_4) clearly showed difference in dehusking. Since, parboiling and steam application weakens the structure of starch granules by disrupting the hydrogen bonds and promotes hydration. Irreversible swelling of the starch granules was ensured due to pretreatment. This phenomenon significantly reduces the number of broken during milling as reported by Araullo *et al.* (1985).

Broken yield of rice was the major problem of milling which accounts to approximately 20% of total milled rice in commercial provender mill. Among the pretreatments, application of 2% limewater and sun drying yielded significantly highest broken rice yield (T_4). However, soaking in water for 10 min and steaming at 1 kg/cm^2 and sun drying (T_6) yielded significantly less brokens. This may be due to partial gelatinization of starch, which becomes harder on drying and making the grains stronger to withstand milling stress. These results are in line with findings of Arora *et al*. (1973). Researcher reported that the key characters of material for milling quality were the size, form and structure of the grain, outer layer and endosperm hardness. Milling losses could be reduced with increase in steaming temperature and duration. Findings of present investigations are agreeing with the findings of Malleshi and Desikachar (1985). Doesthale *et al.* (1979) concluded that milling and polishing of rice grain brings about considerable losses of nutrients and the extent depends on the degree of milling i.e.1-15 %.

Economics

The machine cost of provender mill in Indian Rupees was Rs. 20000 (included the material and motor cost) and rubber roll sheller and abrasive grain polisher was Rs. 17890. The cost incurred to convert one kilogram of little millet into rice was worked out to be Rs. 0.2 and Rs. 8.6 respectively.

The total operational cost of the provender mill for milling little millet was Rs. 68.4 /h including fixed cost of Rs. 2.9/h and variable cost of Rs. 65.4/h. However in rubber roll sheller and abrasive grain polisher, Rs. 43.2 /h was total operational cost which included fixed cost of Rs. 3.5/h and variable cost of Rs. 39.7/h. The cost economics of dehusking of little millet was calculated using rubber roll sheller and abrasive grain polisher just to compare the quality of output since, the machine is used for research purpose only and if similar machinery is developed, definitely it will help the food processors and the consumer.

CONCLUSIONS

Pretreatment of little millet is a must for complete removal of husk and polishing, packing and labeling of processed little millet which will generate little income to farm families. Hence there is scope for marketing of ready -to- use little millet rice. Cost involved in converting one kilogram of little millet to raw milled rice using provender mill was the lowest and provender mill had more advantages compared to rubber roll sheller, as it can be used for milling of other cereals and millets such as jowar, pearl millet, little millet and foxtail millet. Little millet should be pretreated with heat application before milling to reduce milling losses and bring good returns.

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