Community scale Small Millet Processing

A Training Manual

M. Karthikeyan, Dwijendra Nath Guru & P. Saravanan

Small Millet Foundation,
A division of DHAN Foundation

-

Millet processing unit run by Mr. Janagan, Rasipuram, Tamil Nadu

Millet processing unit run by COW AMRIT ORGANICS, Adoni, Andhra Pradesh

Content

Preface		iii
Chapter 1:	Introduction to Community scale Small Millet Processing (CSMP)	1
Chapter 2:	Assessing Quality of Small Millet Grains	5
Chapter 3:	Steps involved in CSMP	8
Chapter 4:	Machines and Tools used in a CSMP	12
Chapter 5:	Pre-hulling Cleaning and Grading in CSMP	18
Chapter 6:	Hulling and Post Hulling Operations in CSMP	21
Chapter 7:	Products of CSMP	25
Chapter 8:	Pest Management and Quality Control in CSMP	28
Chapter 9:	Maintenance and Basic Repair of CSMP Machines	34
Chapter 10:	Summary and Conclusion	36

Acronyms

CSMP	Community scale Small Millet Processing
GAC	Global Affairs Canada
IDRC	International Development Research Centre, Canada
MOTG	Materials Other Than Grains
NGO	Non-Governmental Organisation
RPM	Rotations per minute
SMF	Small Millet Foundation
SMPU	Small Millet Processing Unit
VFD	Variable Frequency Drive

Preface

This manual is an outcome of learning from two action research projects namely,
i) Revalorizing Small Millets in Rainfed Regions of South Asia (RESMISA) project and
ii) Scaling up Small Millet Post-harvest and Nutritious Food Products Project implemented between 2011-18 by DHAN Foundation and its Indian and Canadian partners. As part of these projects, DHAN Foundation had an opportunity to work in depth along with Tamil Nadu Agricultural University, Mc Gill University, processors and experts on i) assessing the existing small millet processing equipment, ii) improving them, iii) developing new equipment, iv) field testing the improved equipment with farming community and enterprises and v) building capacity of entrepreneurs, operators and NGOs on effectively operating these machines. These engagements brought to the fore the enormous need for scaling up decentralized processing of small millets as a first step for mainstreaming them in the food and cropping systems. Since then, DHAN Foundation has been spearheading various initiatives in this direction. In this endeavor, it was found that new entrants to small millet processing find it very difficult to access relevant information and inadequate capacity of the operators and supervisors is hampering the establishment and viability of Small Millet Processing Enterprises (SMPEs). To meet these requirements, DHAN Foundation has brought out ***Guidelines for Setting up a Small Millet Processing Unit*** and an ***Audio Visual Training Manual on Community scale Small Millet Processing*** in English and Hindi languages. Building on these earlier efforts, Small Millet Foundation (SMF), a division of DHAN Foundation, has brought out a detailed training manual on ***Community scale Small Millet Processing*** as a compliment to the above-mentioned two resources.

This detailed manual is intended to be a quick primer for operators, entrepreneurs, supervisors and community leaders on what goes into converting small millets to their edible forms and to run the Small Millet Processing Enterprises effectively. SMF hopes that this manual will encourage setting up of small millet processing and value addition enterprises in the rural areas by the entrepreneurs, community organisations and other agencies. It is also expected that this manual will be help various millet promoting agencies like Millet Missions of state and central Governments and NGOs in building the capacity of entrepreneurs they have been supporting to establish local processing units.

We thank all the processors, experts, colleagues and farming community members, who were our co-learners and whose glad involvement made this manual possible. We profusely thank IDRC and Global Affairs Canada for their generous financial support for the RESMISA project and Small Millet Scaling up Project, which resulted in this training manual.

M. Karthikeyan
Chief Executive & Programme Leader,
Small Millet Foundation, A division of DHAN Foundation

Community scale Small Millet Processing

A Training Manual

Chapter 1: Introduction to Community scale Small Millet Processing (CSMP)

Importance of small millets

Small millets are a neglected subset of millets, grown mostly under rainfed conditions. In the Indian context, sorghum and pearl millets constitute major millets and finger, kodo, little, foxtail, proso, barnyard and browntop millets constitute 'small millets' (see Figure 1). Small millets are an often-overlooked staple food for millions living in the harshest, food-insecure regions of India. Small millets offer better nutrition with various micronutrients like vitamin B complex, calcium, iron and sulphur, high protein, high dietary fibre and low glycemic index when compared to mainstream cereals like rice and wheat. They are known as both preventive and curative foods. They help to manage life style related health issues like diabetes, hypertension, cardiovascular diseases and obesity. They are also safe source of food as no or meagre farm chemicals are used for their cultivation. They are part of the diverse cropping systems with many healthy associated crops like horsegram, niger, cowpea, etc. and many uncultivated greens.

Fig. 1: Major small millet crops in India

Besides nutritious food, they also offer nutritious fodder. Small millets are climate resilient crops as they have the ability to adapt to a wider range of growing environments, withstand difficult climatic situations, and require less water and few external inputs. Despite these advantages, cultivation and consumption of small millets have declined in India. The area under cultivation declined from 7.26 million ha to 1.98 million ha (a decline of 56.4% in finger millet and 82.5% for the other small millets) between 1965-66 and 2011-12 (Government of India 2014). Drudgery of women in primary processing is a major reason for

decline in consumption of 'small millets with husk' namely kodo, little, foxtail, proso, barnyard and browntop millets in the production regions across India.[1]

Primary processing of small millets

'Small millets with husk' are well protected in glume encasements, which are not human edible, hence in need of dehusking/hulling (see Figure 2). It is a vital process for obtaining grain-rice and for further processing of grains for consumption. Primary processing of 'small millets with husk' essentially means a few iterations of cleaning, grading and dehusking. The major challenges in processing small millets are:

1. The small size of the grains
2. Variations in the raw materials due to variation in varieties, cultivation practices and microclimate across production regions and across the years, and variations across the crops
3. Low shelf life of the processed small millet rice and grits due to pest infestation and rancidity

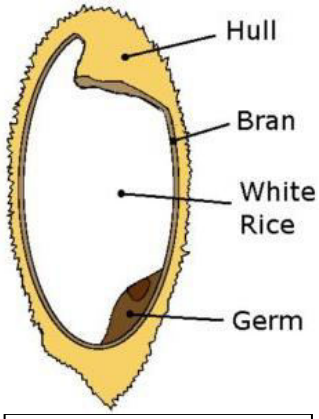


Fig. 2: Cereal grain structure

Traditionally, small millets were hulled manually by women in the production regions using pestle and mortar and/or wooden/stone grinders. Women in the small millet farming household in general spend about three to four hours to process 5-8 kg of grains of these small millet crops. This process involves considerable drudgery and physical efforts. Given these issues in manual processing, decentralized mechanized processing of small millets is the way forward.


Fig. 3: Cleaning of little millet using a pan


Fig. 4: Manual processing of little millet by women

Establishing small scale or Community scale Small Millet Processing (CSMP) units with appropriate equipment and tools can benefit rural communities in many ways. With increasing availability of nutritious small millet rice and other food products from CSMPs, rural families can enhance their food and nutrition security and improve their health. Furthermore, it can offer business opportunities to budding small rural entrepreneurs who can meet the rising demand for staple and value added small millet based food products in their region. These developments in the food systems will in turn help in reviving and

[1] While sorghum, pearl millet and finger millet are naked grains without husk, other six millets namely kodo, little, foxtail, proso, barnyard and browntop have husk layer in the outer part of the grain.

increasing area under these ecologically suitable crops. The cultivation of small millets in the farms as part of biodiverse cropping systems will improve the condition of the soil and reduce dependence on chemical fertilizers, pesticides, etc. Development of decentralized processing is also critical for meeting the rising demand for small millets in the non-production areas, both as bulk and value added products. Given the rising life style related diseases, value chain development of small millets will go a long way in improving the health and nutrition of the wider society.

Using available machines, small millets can be processed with minimal drudgery to good quality staple products (i.e.) small millet rice, grits and flour. However, in order to make best use of machines, operators and supervisors need to be trained on how to use these machines to process the grains and on related aspects of material quality assessment, machine maintenance and pest management. Given the huge degree of variability in the grain characteristics of small millet crops (in terms of i) the size of the grain, ii) density/specific gravity, iii) hardness, iv) elastic modulus, v) husk-grain bonding, vii) bran layer thickness & composition, etc.), the ability of the operators to assess the raw materials and accordingly fine tune the operations of the processing equipment plays a major role in optimising the quantity and quality of the outputs from the CSMP. Large number of community level processing units supported by Government schemes and NGOs have become defunct due to inadequate capacity of the operator. Even the ones that are functioning are incurring high production cost per kg of rice due to their inadequate ability to ensure optimum rice recovery and quality of output. They face difficulty in removing extraneous matter, separating hulled and unhulled grains and removing mud particles of same size and weight from small millet rice and grits. Poor quality of small millet rice sold in the market with unhulled grains and mud particles acts as a dampening factor in the development of market for small millets. These aspects have serious implications given that the small millets as a 'food category' is in the early stage of market development. Therefore, it is essential to build the capacity of the entrepreneurs, operators and farmers organisations involved in CSMP.

About the training manual

This training manual is developed by Small Millet Foundation (SMF), a division of DHAN Foundation, for the above-mentioned purpose. DHAN Foundation has been engaged in development of improved small millet processing equipment and their wider adoption across India since 2011. In this endeavor, it has been collaborating with research institutions, processing equipment manufacturers and processors of various scales. This manual is offered as part of its effort to scale up decentralized processing of small millets to support existing processors and new entrants. It is intended to be a quick primer for operators, entrepreneurs, supervisors and community leaders on what goes into converting small millets to their edible forms and the aspects to be given attention to run the Small Millet Processing Unit (SMPU) effectively. It is expected that this manual will serve as a resource material to new entrants to the small millet processing sector and for the various Millet Missions of state and central Governments and for the NGOs involved in promoting consumption of small millets as part of their food and nutrition security interventions. The following sections cover various aspects of Community scale Small Millet Processing as part of eight chapters given below and ends with a summary and conclusion.

Chapter 2: Assessing Quality of Small Millet Grains

Chapter 3: Steps involved in CSMP

Chapter 4: Machines and Tools used in CSMP

Chapter 5: Pre-hulling Cleaning and Grading in CSMP

Chapter 6: Hulling and Post-hulling Operations in CSMP

Chapter 7: Products of CSMP

Chapter 8: Pest Management and Quality Control in CSMP

Chapter 9: Maintenance and Basic Repair of CSMP Machines

A complementary audio-visual training manual covering major part of the above-mentioned content is available in English and Hindi. Going through both the written and audio-visual training manuals will help in better understanding of various aspects of CSMP.

Chapter 2: Assessing Quality of Small Millet Grains

The quality of the grains of various small millet crops used as input for processing will strongly influence the quality of the output. It is extremely important to ensure that the input millet grains are of good quality. There are five main parameters to be considered in this assessment, namely,

a) Moisture level
b) Average grain size and hardness
c) Uniformity of grain sizes
d) Nature and share of Materials Other Than Grains (MOTGs) and
e) Presence and nature of mud balls

The following section describes how each parameter influences processing and simple techniques to measure some of them to assess the quality of a particular grain sample.

a. Moisture level

When the grains have too much moisture, storage losses due to fungal growth and heating of the grains increases dramatically. Pest infestation probability also increases significantly. Most importantly, the hulling efficiency drops dramatically as the moisture levels in the millet grains increase. Therefore, ***it is better to avoid procurement of grains with excess moisture.***

Fig. 5: Checking for excess moisture before storage

All procured grains need to be ***checked for excess moisture before storage***. A simple way to check the moisture level of grains in a sack is to put one's hands deep in the middle of the sack (see Figure 5). The temperature of the grains at different depth is about the same if the moisture is low. When moisture is high, the temperature increases as the hand goes deeper and deeper into the sack. Grains procured with excess moisture need to be dried for reducing the moisture level to the acceptable levels (12 %). Another way to check the moisture level of grains in the drying yard is to pick up a fistful of millet grains in one hand and hold it in the clenched fist for say 15 seconds (see Figure 6). If the grains are dry, the temperature will drop gradually. If the grains are still high on moisture, the temperature will drop fast and the grains will feel cool. Such batches need to be again dried and to be tested after a few more hours of drying.

Fig. 6: Checking moisture of grain

b. Average grain size and hardiness

The size of the small millet rice kernal increases with the size of the grain. Therefore, rice recovery would be better if larger grains are used for processing. Therefore, ***it is better to procure grains with larger size***. However, it is also important that the kernel is hard and cracks when bitten or crushed. An irrigated crop will have higher average grain size when compared to rainfed crop, but will not have the same grain hardness. Grain hardness will reflect on the millet cooking quality, aroma and nutritional composition. Rainfed grains are better than irrigated

Fig. 7: Checking average size of grains with magnifying glass

grains on these three parameters. Therefore, if there is choice, it is better to procure rainfed grains. The simple way to determine, especially close to the farm gate, if the crop was cultivated in rainfed conditions or was irrigated is by checking the grain hardness by biting a few grains. The simplest way to check the size of grains of various small millet crops is to use a magnifying glass and visually inspect multiple samples (see Figure 7).

c. Uniformity of grain sizes

Uniform sized grains are easier to hull than grains of varied sizes. A few really large grains with a lot of small grains would not be a desirable grain size distribution. The grains should be as uniform as possible with large proportion of bigger sized grains and less share of extra large and small grains. ***Attention should be given during procurement to buy grain lots with almost uniform sized grains.***

Fig. 8: Test sieves for checking grain size

Test sieves set can be used to identify the size distribution of the grains as follows: Select about 200 gms of grain as a sample and sieve the grains through successively finer sieves (using sieves with larger size perforations first followed by sieves with lower size perforations). The size of the sieve on which maximum quantity of grains remain (at least 50% by weight of the sample) is taken as the grain size of the majority of grains in the lot.

d. Nature and share of Materials Other Than Grains (MOTGs)

Ideally MOTGs should be zero, but in reality it is rare. There will always be some MOTGs in the material that is brought in for processing. Presence of MOTGs such as sand, large pebbles, stones and straw dramatically increase the cost of processing (see Figure 9). So, ***efforts need to be taken to procure grains with meagre presence of MOTGs.***

Fig. 9: Materials other than grains (MOTGs)

The MOTGs present in the grains can be removed by standard processing techniques as they typically have a different size and density compared to the grain. If the presence of MOTGs like twigs, fine sand, stones and, other grains of different size and structure are high, then pre-cleaning with portable manual grader will help in reducing the time of cleaning. Weed seeds, especially those that have similar size and densities as that of grains, pose quite a challenge. It is better to understand the level of presence and nature of MOTGs in the grain lot before processing the same, as it will help in planning pre-cleaning. To know the level of presence of MOTGs, take a reasonably large sample, say 10 kg of the grain, and subject the same to pre-cleaning operations. Weed seeds and other MOTGs need to be inspected visually.

e. Presence and nature of mud balls

The presence of mud balls, one of the MOTGs, is a major concern in processing. In particular, the mud balls coming from grains cultivated in clay rich black soils (see Figure 10), as they erode and reshape while rubbing with the metal surfaces and the grains during the processing. These mud balls are about as dense as the grains and so are extremely difficult to remove by the usual techniques of grain cleaning. This increases the cost of processing and hence it is better to identify these at the point of procurement

itself. One would need to do a similar test as that used for MOTGs and look for these mud balls in the grain sample to check if the quality of the material meets the required standards.

Fig. 10: Presence of mud balls

Using these measures and tests, one can improve the quality of the raw material in terms of i) keeping the moisture close to 12%, and ii) selecting material that has larger average grain size, more uniform grain size distribution and minimum of MOTGs, including mud balls. With such a selected batch of grains, the processor has better chances of getting good quality small millet rice without incurring too high a cost in processing.

Chapter 3: Steps involved in CSMP

The principles involved in optimising quantity and quality of outputs in processing small millets include,

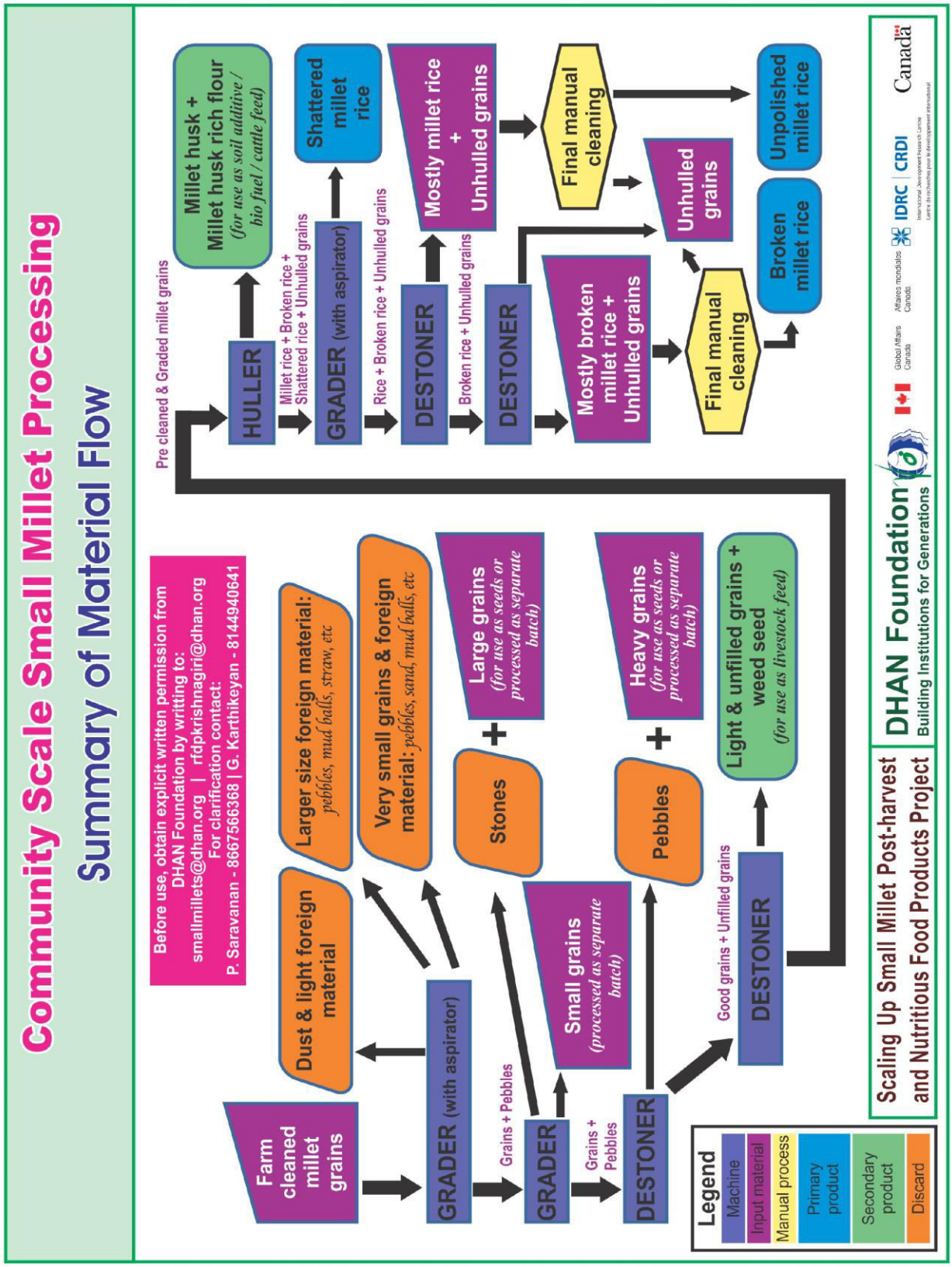
1. The quality of i) cleaning (to remove MOTGs), ii) grading and iii) removal of lighter and unfilled grains in the pre-hulling stage, will decide how well, and with how much effort, the different hulled fractions can be separated and made usable in the post-hulling stage.
2. Grains with uniform size and weight are easier to hull than grains of varied sizes and weights. This is especially so when impact hullers are used, as the force with which a grain would impact on the surface is determined by the weight of the grain.
3. The viability of processing small millets can be significantly improved if greater fraction of the raw material processed can be recovered as output and if a) half broken rice kernals, b) shattered millet rice kernals, c) husk with millet flour and d) light and unfilled grains can be used effectively, besides the main product (i.e.) unpolished whole grain small millet rice.
4. The nutritious bran layer needs to be retained as much as possible.
5. The damage to the bran layer needs to be minimized as much as possible to lessen rancidity.
6. It is to be ensured that small millet rice, grits and flour has very little exposure to situations where pests could infect them.

The process flow chart in the end of this chapter share the different steps to be followed in community or small scale small millet processing to practice the above mentioned principles. The summary of processing steps depicted in the process flow chart is listed below:

1. Removal of comparatively lighter MOTGs like straw and dust using an aspirator or air classifier.
2. Removal of larger size foreign material (pebbles, mud balls, small sticks, etc.), and very small grains and foreign materials (pebbles, sand, mud) from the grains using a pre-cleaning grader with aspirator.
3. Grading of the cleaned grains into average size, very large and very small ones using a two or three deck grader.[2]
4. Removal of stones and pebbles from each of the one or two main grades of grains using a destoner.
5. Removal of the light and immature grains from each of the one or two main grades of grains using a destoner.[3]
6. Hulling / dehusking of each grade of the cleaned and graded small millet grains separately using a huller.

[2] If the batch is sufficiently large, it can be segregated into multiple grades, which will be hulled in separate batches for improving the efficiency of hulling and post-hulling processing.

[3] The efficiency of the destoning / density grading is maximized when uniform sized grains are put into it. i.e. material is already been graded such that it is predominantly of one size. **So, it would be better if the step of destoning comes after grading and not the other way around. So the material flow suggested would be aspirator – grader – destoner.**


Community Scale Small Millet Processing
Summary of Material Flow
Before use, obtain explicit written permission from DHAN Foundation by writing to:
smallmillets@dhan.org | rfdpkrishnagiri@dhan.org
For clarification contact:
P. Saravanan - 8667566368 | G. Karthikeyan - 8144940641
Farm cleaned millet grains
GRADER (with aspirator)
Dust & light foreign material
Larger size foreign material: pebbles, mud balls, straw, etc
Very small grains & foreign material: pebbles, sand, mud balls, etc
Grains + Pebbles
GRADER
Stones
Small grains (processed as separate batch)
Grains + Pebbles
DESTONER
Pebbles
Large grains (for use as seeds or processed as separate batch)
Heavy grains (for use as seeds or processed as separate batch)
Good grains + Unfilled grains
DESTONER
Light & unfilled grains + weed seed (for use as livestock feed)
Pre cleaned & Graded millet grains
HULLER
Millet husk + Millet husk rich flour (for use as soil additive / bio fuel / cattle feed)
Millet rice + Broken rice + Shattered rice + Unhulled grains
GRADER (with aspirator)
Shattered millet rice
Rice + Broken rice + Unhulled grains
DESTONER
Mostly millet rice + Unhulled grains
Broken rice + Unhulled grains
DESTONER
Final manual cleaning
Unhulled grains
Unpolished millet rice
Mostly broken millet rice + Unhulled grains
Final manual cleaning
Broken millet rice
Legend
Machine
Input material
Manual process
Primary product
Secondary product
Discard
Scaling Up Small Millet Post-harvest and Nutritious Food Products Project
DHAN Foundation
Building Institutions for Generations
Global Affairs Canada
Affaires mondiales Canada
IDRC | CRDI
Canada

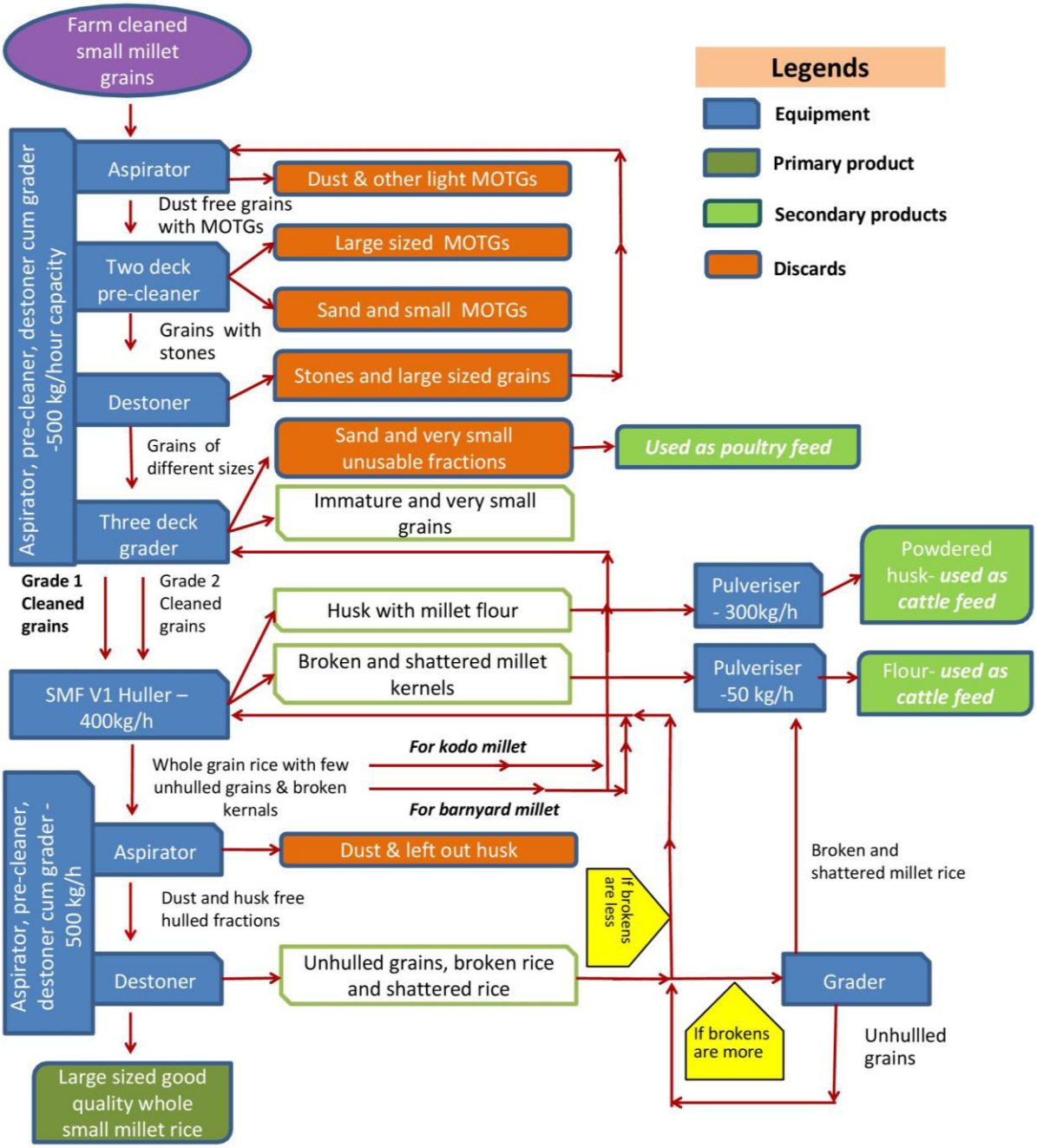
7. Separate the ‘husk, unhulled grains and shattered small millet rice’ from the ‘whole sized rice and bigger sized rice grits’ using a grader with aspirator.
8. Separate the ‘whole grain small millet rice’ from ‘unhulled grains and bigger sized rice grits’ using a destoner.[4]
9. Separate the ‘unhulled grains’ from bigger sized rice grits’ using a destoner.
10. Manual cleaning of each grade of the unpolished whole grain small millet rice.
11. Manual cleaning of the broken kernals. It can be graded into different *rava* (grits) grades to ensure uniform output quality based on need.
12. Manual cleaning of shattered rice kernals for ensuring their utilization for human use.
13. Packing of different grades of primary products namely i) whole grain small millet rice, ii) broken rice (*rava*) and iii) shattered rice kernals separately and keeping them away from the processing equipment to avoid pest infestation.
14. Collection of each of the secondary products (light and unfilled grains and millet husk plus millet husk rich flour), separately and utilizing them in an economically viable way.
15. Collection of each of the byproducts (MOTGs of different sizes) and utilizing them in an economically viable way.

A new entrant to small millet processing can start with the process flow described here. With gaining of experience, she/he can improvise the same to optimize the quantity and quality of output with the available equipment, manpower and other resources. An example of optimized process flow developed by Mr. Janagan, based on his numerous iterations is shared in the next page. A picture showing the arrangement of different processing equipment in his unit can be seen in the front cover back page.

[4] The ease with which the hulled and unhulled grains are separated in the post-hulling stage depends on how well grains are graded in the pre-hulling phase.

Process flow followed in Millet Processing unit by Mr. Janagan, Rasipuram

As on 27/11/2019



Notes

1. During post-hulling phase, only aspirator and destoner component of the 'Aspirator, pre-cleaner, destoner and grader equipment' is used.
2. Based on the need, cleaning and segregation of the hulled fractions is done once or twice.
3. Processing assembly output: With three manpower, 1500 kg of pre-cleaning and hulling and 500 kg of final products accomplished per shift; can double the output of final products with the addition of another post-hulling cleaning machine and a manpower.

Chapter 4: Machines and Tools used in a CSMP

A minimum of three machines and a few tools are needed to reduce drudgery and improve the quantity and quality of the output in a Community scale Small Millet Processing unit as they can help in processing small millets more efficiently and in larger quantities. This section familiarises each of these machines and the important tools.

Machines used in CSMP

The following equipment are needed for processing small millets:

1. Aspirator with Grader / Mechanized Sieve / Shaker
2. Destoner / density grader
3. Dehusking / hulling machine

Fig. 11: Aspirator attached to grader

Aspirator

This machine is also called air classifier and it is in general attached with the grader, destoner and huller (see Figure 11). It is used to remove dust and light MOTGs. Use of this simple machine results in two outputs namely i) usable material and ii) dust collected in a cyclone or a dust collection sack. The airflow entering the aspirator can be controlled by adjusting the dampener.

Grader

Grader separates the input material based on the size of the fractions. This is a simple machine utilizing less energy and can speed up the cleaning and segregation operations significantly with the use of right sized sieves.

Fig. 12: Grader with aspirator

The graders in use for small millets are flat screen type graders designed for paddy (see Figure 12). It has a sieve box which swings freely, with the help of a flywheel, and a built-in motor. Sieves are fastened to the sieve box. Products to be graded are deposited from the feed hopper on the top of the upper-most screen. In operation, the screens move forward and backward. All screens in a single block move simultaneously in the same direction. This motion causes the products to move down the inclined screens toward the discharge spouts. Product larger than the hole-openings in any particular screen remain on top of the screen and are discharged at the end of the screen (see Figure 13). Product smaller than the openings, because of gravitational force, drop through and are deposited on the top of the next lower screen in the machine. This screening action continues until the products are appropriately sized and discharged according to screen types and sizes in the machine (Source: file:///C:/Users/Administrator/Downloads/Unit-8.pdf). As the material gets sieved through the lower deck, three size-separated fractions of the input material - large, medium and small- are obtained. If there is a third sieve under the second one (with a hole size smaller than the second one), i.e. if it is a 3 deck grader, four size separated fractions will be obtained. The size range within each of the fractions depends on the hole sizes of the sieves used. There are three kinds of sieves frequently used in processing small millets viz. wire mesh, punched sheet with round holes and punched sheet with slots

(see Figure 14). Currently two deck and three deck graders are available in the market. Frame size of graders currently available in the market are i) 3'×1.5', ii) 4'×1.5', iii) 4'×2' and iv) 6'×2.5'. Three versions are available: 1) Just grader, 2) Grader with aspirator and 3) Grader with destoner and aspirator.

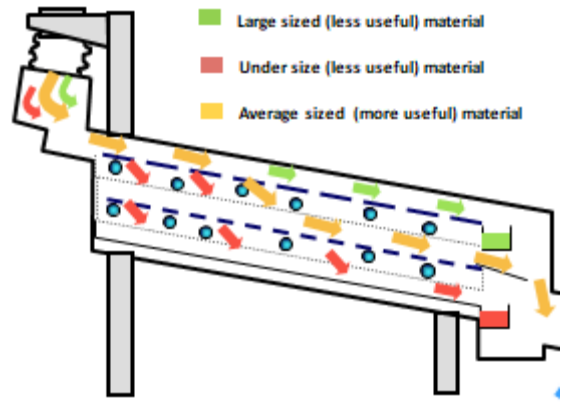


Fig. 13: Operating principle of flat screen

Functions of grader with aspirator in processing small millets are given below,

During pre-hulling

1. Removing light MOTGs like dust and straw, large MOTGs like pebbles, mud balls, sticks, etc. and fine sand from the millet grains.
2. Separating very large and very small grains from the average sized grains in a batch.

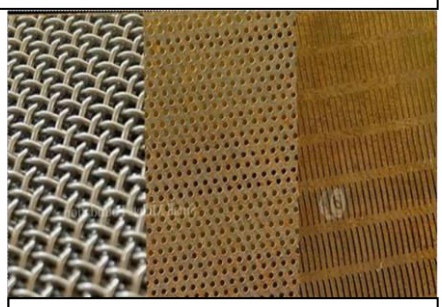


Fig.14: Types of sieves

During post-hulling

3. Separating millet husk, husk rich flour and unhulled grains from hulled fractions.
4. Separating shattered rice kernels and broken kernels of different sizes from rice.

The control parameters that determine the effectiveness of segregation by grader are, i) rate of feed or input flow rate, ii) hole size of sieves, iii) angle of screen and iv) frequency and stroke of oscillation. As the angle of screen and frequency and stroke of oscillation are not changed often, other two parameters are critical to control the operation of the grader. The frequency and stroke of oscillation can be changed using Variable Frequency Drive (VFD).

Destoner

Operations done using a winnowing pan in manual processing are achieved using a machine commonly referred to as a destoner. Using this machine drudgery is reduced and the quantity of material that can be processed in a given time is increased by many folds. Destoner utilizes the difference in density between different fractions- impurities, grains and hulled fractions like rice and broken kernels, for segregation under continuous vibration and airflow. The Destoners in use for small millets are pressure type destoners designed for paddy destoning but with smaller sieve/mesh holes. The destoner consists of a reciprocating perforated deck mounted at an angle. Requisite quantity of air is blown from below through the sieve. When small millet grains containing stone/ heavier impurity is fed at the top of the sieve, air coming through the sieve stratifies the materials according to their density. The heavier materials like

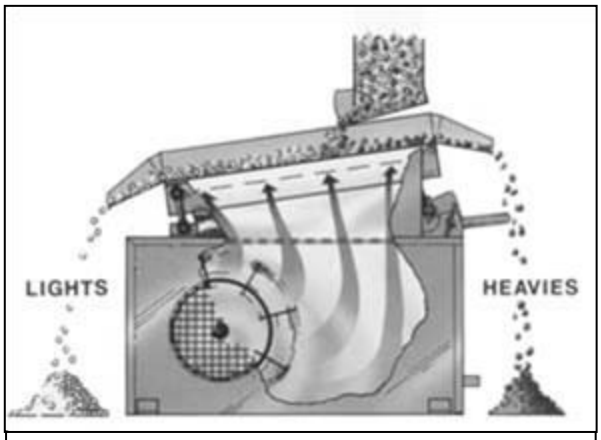


Fig. 15: Operating principle of destoner

stones and larger grains remain on the deck and are carried backward to the top end by the reciprocating motion of the deck and discharged (adopted from file:///C:/Users/Administrator/Downloads/Unit-10.pdf). Small millet grains remains floating and slides down the incline (see Figure 15). Currently three versions are available: 1) Just destoner, 2) Destoner with aspirator and 3) Destoner with grader and aspirator.

Functions of destoner in processing small millets are given below,

During pre-hulling

1. Removing stones and other heavier MOTGs from the small millet grains.
2. Separating lighter and unfilled grains from the good quality grains.

During post-hulling

3. Separating unhulled grains from hulled fractions.
4. Separating heavier and lighter hulled fractions.

Fig. 16: Input inflow control in destoner

Destoner aid in increasing the life of hullers by removing stones and particles that may damage huller's working surfaces like the rubber liners/ receiving plates and rotors.

The control parameters that determine the effectiveness of segregation by destoner are, i) rate of feed, ii) volume of air, iii) bed angle and iv) sieve/mesh hole size. Once a de-stoner is tuned for small millets, it can process any of the small millets. However, airflow needs to be changed for different grains (by trial and error) during each of the runs based on the quality of the output. This observation and feedback based fine-tuning of the setting is critical and the better the operator can do it, the better will be the quality of the processing output. The airflow is controlled using a shutter that can be slid to expose a controlled area of the inlet port of the aspirator fan within the destoner (see Figure 17 & 18).

Dehusker/huller

Fig. 17: Controlling airflow in destoner through fan box adjustment

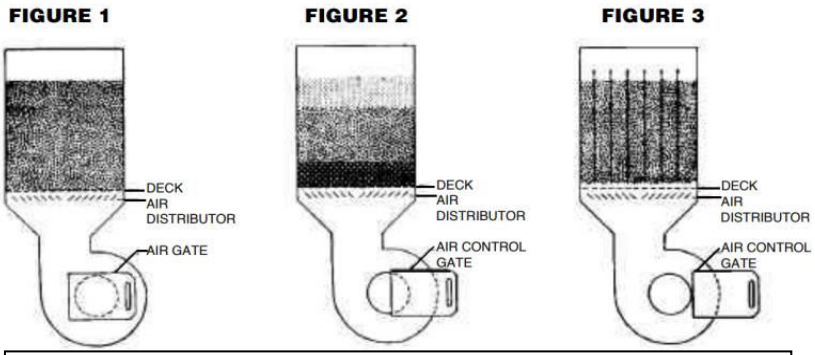


Fig. 18: Stratification of lighter and heavier fractions with different levels of airflow

Source: Stoner operating instructions manual, Oliver Manufacturing Co.

Currently three types of dehusking technologies are deployed for processing small millets namely
1. Emery mill working on abrasion principle, 2. Rubber roller mill working on compression and shearing principle and 3. Centrifugal type working on impact principle (see Figure 19).

Fig. 19: Different kinds of dehusking technologies used for processing small millets

Impact type hulling machines are most commonly used in processing small millets these days and so it is dealt in detail below. In an impact huller, grains are flung off a rotating component to hit a fixed surface a certain distance away with as uniform a force as possible. The receiving plate is lined with rubber in some models. The impact causes the husk to break open and separate from the millet rice kernel. The force with which a grain would impact the surface is determined by the weight of the grain. Therefore, it is important to take out the immature and light grains from the input material before putting it into an impact huller, as these grains will not be hulled properly and come out with the output. It is very difficult to mechanically separate them from the hulled whole grain millet rice kernals and so removing them later dramatically increase the processing cost. A built in aspirator pulls out the husk from the hulling chamber and the hulled grains, broken millet rice kernels, and un-hulled grains are discharged from the hulling chamber's primary output port. The advantages of impact hullers over the other type of hullers are, i) they can hull even small quantities of grains and ii) their working surfaces do not require frequent maintenance when properly designed. The following models of impact hullers are currently available in the market:
a) Single chamber huller, b) Double chamber huller, c) Portable huller and d) Tabletop huller (see picture above). The capacity of these hullers varies from 50 to 500 kg per hour (see Figure 20).

The control parameters that determine the effectiveness of dehusker/huller are, i) rate of feed, ii) speed of rotation of the impeller (rpm), iii) type of receiver plate where the grain is impacted, iv) airflow patterns inside the centrifugal chamber, v) throw angle of the impeller and vi) airflow in the aspirator. As the iii, iv and vth parameters are fixed for each huller, the control parameters available for the operator are i, ii and vi. The quantity of material flowing into the impact chamber is the primary control parameter, which needs to be used based on the inspection of the output. The rate of revolution per minute (RPM) is another important parameter of hulling operation. Based on the small millet crop, RPM can be varied to improve hulling efficiency. This can be done by changing the pulley sizes or using a Variable Frequency Drive (VFD). The degree of husk removal by the aspirator can be controlled by adjusting the dampener.

Double chamber impact huller

Portable impact huller SMF V2

Tabletop impact huller SMF

Fig. 20: Different kinds of small millet impact hullers

Tools used in CSMP

Other than grader with aspirator, destoner and huller, the following tools are needed to improve the utilization of the machines and to manage processing in a better way.

(i) Metal wire brushes

(ii) Air blower with speed control

(iii) Set of test sieves

(iv) Manual portable grader

(v) Weighing machine and

(vi) Volume measures

Metal wire brush and air blower

The wire brushes and the air blowers are essential accessories that help to maintain the grader sieves and the destoner bed sieve/mesh. They also help in cleaning and freeing blockages in the hard to reach places within machines.

Fig. 21: Metal wire brush

Fig. 22: Air blower

Set of test sieves

Fig. 21: For each of the grader sieve screens, there need to be a corresponding one in the test sieves set. This would help in identifying the most appropriate sieve size for top, middle and bottom sieves in a grader for a particular material. One uses the test sieves to select a sieve in which the holes are not getting clogged. If the holes in a particular sieve does get clogged, one would need to try a sieve with either one step larger hole size, or one step smaller hole size depending on which of the fractions is more important.

Fig. 23: Portable manual grader

Manual portable grader

This tool will help in effectively removing dust and large impurities like sticks, mud balls, stones, etc. during the pre-cleaning stage, thereby easing the cleaning operations with aspirator and grader.

The weighing machine and the volume measures

These are useful to grade the grains, as they are useful to get a better, more accurate idea of the grain fraction proportions and hence in better sieve selection.

Fig. 24: Volume measures

Using machines and proper tools, a significant positive difference can be achieved in the quantity and quality of the output. Some aids and accessories such as test sieves and volume measures are useful to understand the quality of the raw material and so aid planning the process steps. As one gains experience, these may be used only when one come across an exceptionally different batch of material.

More details on processing equipment needed for Small Millet Processing Unit (SMPU) at different scales and how to test them at fabricator's workshop and install them in processing unit is given in "Guidelines for Setting up a Small Millet Processing Unit".

Chapter 5: Pre-hulling Cleaning and Grading in CSMP

In order to get better quality output material, all MOTGs and immature grains have to be removed and the grains need to be segregated into different size grades before hulling. If the batch is sufficiently large, it can be segregated into multiple grades, which will be hulled in separate batches for improving the efficiency of hulling and post-hulling processing.

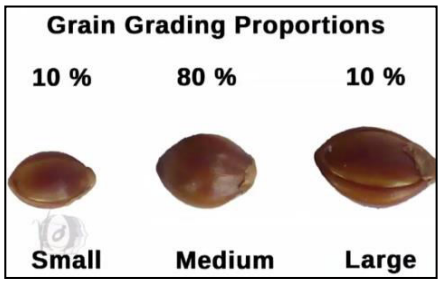
Cleaning

Cleaning the grains for removing all MOTGs is an essential step in CSMP that often does not get the attention it deserves. The differences in size and density between MOTGs and the grains are the primary properties used in cleaning the grains. As given in the process flow diagram, the following steps to be undertaken for removing all the MOTGs from the grains. i) The small millet grains are first passed through an aspirator to remove dust and light MOTGs. If portable manual grader is available, then the grains can be cleaned first with it and then can be passed through the aspirator. ii) The dust free grains are then passed through a 2 or 3 deck shaker / grader with the top sieve selected such that large foreign objects such as straw, twigs, mud balls, other large grains and stones are retained above the screen and almost all the small millet grains fall through the sieve. The bottom sieve is selected such that only sand and other extremely small and/or thin grains fall through, but no good quality small millet grains should fall through. Therefore, the output from between these two sieves is dust free and free of foreign objects of different sizes. However, these grains have some foreign objects, which are of the same size as that of small millet grains.

Fig. 25: Presence of sand in small millet rice

The process of cleaning needs to be repeated based on an inspection of the output at each step. Typically, two passes are needed to get effective pre-cleaning of the small millet grains. If sand persists in the working material, it will contaminate the shattered millet rice kernel from the hulling operation, making it unusable for human consumption (see Figure 25). This would compromise the financials of the processing and leave the entire processing cost to be recovered from the primary product alone (i.e.) whole grain small millet rice. Hence, care should be exercised and a thorough job needs to be done during pre-hulling cleaning for removal of sand.

Grading



The dust, sand and large MOTGs free grains are next passed through a two deck grader / shaker with the top sieve selected such that large sized grains up to about 10 % of the total grain (by weight) are separated and collected off the top of upper deck sieve. The bottom deck sieve is chosen such that small grains up to about 10% of the grains put on to the grader are sieved through it. This will result in getting pre-cleaned and graded fraction of the grains close to average grain size approximately about 75% to 80% of the original quantity of grains. In a three-deck grader, this 75 to 80% would be obtained as two grades of good quality grains. For this to happen, sieve selection is very important. The sieves will be

chosen based on the input materials. Sieves with hole sizes in the range of 0.5mm to 3mm would be sufficient for processing all the millets, not just the small millets. Being rainfed crops, small millets exhibit a wide range of size distributions. Therefore, the more the number of sieve hole sizes available in the processing unit within this range, the better it would be. The grading fractions to be segregated are best considered relative to the size distribution for a particular material at hand. Size distribution is gauged by visual estimate to a large extent and if needed, test sieves can be used. While the bottom sieve hole size will be same for all small millet crops and their varieties, the hole sizes of other sieves will vary depending on the small millet crop and average grain size of the raw materials. The recommended sieve hole size for different small millet crops for pre hulling operations is shared below:

Recommended sieve hole size for pre-hulling operations with grader (in mm)			
Small millet	Top sieve	Middle sieve	Bottom sieve
Little millet	2.20-2.40	1.35-1.46	0.80-1.00
Foxtail millet	2.00-2.40	1.35-1.46	0.80-1.00
Barnyard millet	2.40-2.80	1.46-1.60	0.80-1.00
Proso millet	2.50-2.80	1.70-2.00	0.80-1.00
Browntop millet	2.40-2.80	1.70-1.90	0.80-1.00
Kodo millet	2.50-3.00	1.90-2.10	0.80-1.00

As there are wide variations in the raw materials of each small millet crop due to variation in varieties, cultivation practices and microclimate across production regions and across the years, the above given data can be used as a reference and decisions to be taken based on the actual inspection of the grain lot. Caution should be exercised that the sieve holes are not getting clogged. Clogged sieves lead to inefficient grading that would be leading to a dramatic increase in the cost of processing. If clogging is observed, a sieve with one size bigger or smaller shall need to be checked and used, instead of the initial choice of sieve. The process of grading needs to be repeated based on an inspection of the output. Typically, two passes are needed to get effective size grading of the small millet grains.

Fig. 26: Destoner with aspirator and grader

Destoning and removal of light and unfilled grains

Each of the three grades of small millet grains obtained through grading has small stones and pebbles of the same size as the grains, which need to be removed. Each of the size-graded fractions from the grader is passed through a destoner separately to remove stones and MOTGs denser than the grains. This process has to be repeated to ensure that the stones and other denser MOTGs are fully removed from the material. In the second iteration, least dense grains up to 10% (by weight) need to be separated using an appropriate setting of the airflow in the destoner, taking the useful grains towards the rear of the machine. Note that each operation would need more than one pass through the destoner. The output material from each pass for each of the two actions needs to be checked to see if the process is indeed complete or iteration would be needed.

So, once the cleaning and grading has been completed in the pre hulling phase, one or two grades of grains devoid of sand, mud balls, pebbles and other MOTGs and light/immature grains are made available, each falling within a small window of size and density. These good quality grains will be taken for further processing in the hulling and post-hulling operations phase.

Chapter 6: Hulling and Post-Hulling Operations in CSMP

Hulling

Most of the Community scale Small Millet Processing units use an impact huller and the operations descried here are for these machines. With minor modifications, the process can be adapted for emery mill dehusking machines too.

The important primary output of hulling operation is whole grain small millet rice. The only control that can be exercised on the hulling operation of the impact huller is the rate of feed, as the other parameters are set for a particular machine and operation. The relationship of rate of feed or flow rate with hulling efficiency, shattering of rice (due to breakage) and bran loss is shown in the picture below. As the flow rate increases, the hulling efficiency, shattering and bran loss comes down and vice versa. A sweet spot need to be identified where the hulling efficiency can be optimized with less shattering and bran loss, so that minimum numbers of unhulled grains and minimum number of broken rice kernels comes in the output from the hulling machine. The rate of feed is changed based on observation of the output to optimize for these two aspects. It has to be increased if the broken is more and vice versa.

Fig. 27: Adjusting dampener in aspirator attached

The built in aspirator removes most of the husk from hulling of grains. Output of the aspirator vent need to be checked to see whether whole, broken and shattered rice kernals are coming out along with husk. If so, the aspirator dampener opening need to be reduced (see Figure 27). A mixture consisting of mainly hulled unpolished whole grain small millet rice kernels, limited quantities of unhulled grains, broken millet rice kernels and shattered millet rice kernels, and some left over husk flow out of the output port of the hulling machine. If more husk come in the huller output port, the opening in the aspirator dampener need to be increased.

Flow Rate Control in Hulling Machine

- Hulling efficiency
  - Number of hulled grains as a percentage of total grains in the output
- Shattering loss
  - Number of grains that are broken as a percentage of total grains in the output
- Bran loss
  - Number of grains that are white as a percentage of total grains in the output

Flow Rate	Hulling efficiency	Shattering & bran loss
Too low	↑	↑
Too high	↓	↓

The grains of different small millet crop vary in terms of shape, nature of grain surface, hardness, husk-grain bonding, etc. (see the table below). Therefore, there is need for adjusting the huller process for effective dehusking of different small millet crops. For example, foxtail millet and little millet grains have shining surface (which aids them in flowing smoothly) and are dehusked with limited impact. However, kodo millet and barnyard millet grains have

Data on critical parameters related to processing of small millets			
Small millet	Hardness (N)	Force required (F) to split the husk	Terminal velocity m/s
Kodo millet	25.5	18.5	3.75
Barnyard millet	23.8	17.3	3.08
Little millet	22.8	16.4	2.73
Foxtail millet	21.5	16.0	2.94
Proso millet	18.5	14.3	2.45

many rough husk layers and need more impact than little and foxtail millets. So, the rate of feed for little and foxtail millets will be more than that of kodo and barnyard millets. While little, foxtail and proso millets are dehusked with one pass in the huller, kodo, barnyard and browntop millets need two to three passes. Similarly, RPM can be varied to for better hulling of different small millet crops. This can be done by changing the pulley sizes or using a Variable Frequency Drive (VFD).

Typically, the rice kernels would form about 50 to 60% (by weight) of the input material put into the huller and the broken and shattered rice kernels would constitute another 5 to 10%. About 5 to 10% would remain as unhulled grains and the remaining 20 to 30% of the input material would be removed as husk depending on the small millet crop being processed. With the improved hullers, the share of rice kernals can be increased up to 70% with reduction in the share of broken and shattered kernals and unhulled grains.

Expected rice recovery percentage for different small millets crops	
Small millet	Rice recovery (%)
Kodo millet	60-64
Barnyard millet	60-65
Little millet	70-75
Foxtail millet	70-75
Proso millet	70-75

Post-hulling operations

In the post-hulling operations, the same machines used in the pre hulling phase viz. aspirator, grader and destoner are used to get clean graded staple forms of small millets. When processing at a reasonable scale (say more than 500 kgs of finished products in a day), it is better to have separate machines for the pre-hulling operations and for the post-hulling operations. When the scale of operations is smaller, one can compromise to use the same machines though only after thorough cleaning of the machines between the two set of operations.

Left over husk in the output material is removed by passing it through the aspirator. Then the hulled fractions are passed through a two or three deck grader to segregate the components namely, the unhulled grains, the hulled unpolished whole grain small millet rice kernel, half-broken millet rice kernals and the shattered millet rice kernels. The first post-hulling grading sieve is selected such that most of the unpolished whole grain small millet rice kernels fall through the sieve (so that less than 5% of unpolished whole grain millet rice kernels are left over above the sieve), while as small a proportion as possible of the unhulled small millet grains are allowed to fall through the sieve. Typically, this sieve size would be one measure smaller than what was used for the top sieve when grains were graded during the pre-hulling phase. The hulled fractions falling through the top sieve during the first grading of the post-hulling output lands on the second sieve. This sieve is chosen such that most of the shattered rice kernel – i.e. those that have been broken to a 4th or 5th of the rice kernel size will pass through the sieve and very little of the whole rice or the half broken small millet rice kernels fall through the sieve. The recommended sieve hole size for different small millet crops for post-hulling operations is shared below:

Recommended sieve hole size for post-hulling operations with grader (in mm)			
Small millet	Top sieve	Middle sieve	Bottom sieve
Little millet	1.35-1.46	1.20-1.25	1.00
Foxtail millet	1.35-1.46	1.20-1.25	1.00
Barnyard millet	1.46-1.60	1.35-1.40	1.00
Proso millet	1.70-2.00	1.50-1.70	1.00
Browntop millet	1.70-1.90	1.46-1.60	1.00
Kodo millet	1.90-2.10	1.70-1.80	1.20

As there are wide variations in the raw materials of each small millet crop due to variation in varieties, cultivation practices and microclimate across production regions and across the years, the above given data can be used as a reference and decisions to be taken based on the actual inspection of the hulled output. Care should be taken that the bottom sieve hole size should be such that it is bigger than the hole size of the destoner mesh, to avoid falling of materials into the destoner bed chamber. Once the grader screens are selected, separating out the shattered millet grains is just a matter of iterating through the grader until the desired quality of separation is attained. Note that in the grading operations described thus far, the hulling output was graded to remove only these components – the husk, unhulled grains and the shattered rice kernels. The remaining hulled fractions have a combination of three different components in different proportions – unhulled grains of same size as that of whole rice, hulled rice kernels and broken rice kernels.

The separation of these components is achieved using a destoner. Good quality whole grain rice is denser than unhulled grains as the lighter husk is removed. It is separated from other two components by setting the destoner such that the denser small millet rice kernels are moved out of the rear end of the destoner bed by operating the destoner for one or two times. Then by adjusting the airflow, unhulled grains and broken rice are segregated, by utilizing the differences in their densities. A similar process is implemented for the other grade size fractions.

The unhulled grains from the first pass through the huller of the different size grade fractions are subjected to another round of processing. The process of hulling and, then size grading and density grading of the huller output is repeated until the process is economically viable. On reaching that threshold, the remaining materials are discarded. The unpolished whole grain small millet rice kernels, half broken millet rice kernels and the shattered millet rice kernels are subjected to one final manual cleaning before they are packed as a finished product. Final manual cleaning of all the machine outputs like broken kernals, whole grain rice and shattered rice kernels, husk and flour helps in recovering a greater fraction of the material processed, thereby improving the overall financial proposition of small millet processing.

Again, it must be reiterated that all the different components of the output from the processing of small millets will be usable only when clean and well-graded grains are obtained in the pre-hulling stage. The quality of cleaning, grading, and the separation and removal of the lighter grains from the heavies in the pre-hulling stage will decide how well, and with how much effort, the different components of the post-hulling operations can be separated and cleaned. Only through this, the presence of unhulled grains in the small millet rice output, which is a major complaint from most retailers and customers, can be addressed. In general, up to 1% of unhulled grains in the whole grain millet rice is considered acceptable.

The operators, supervisors and entrepreneurs managing the SMPU need to learn through experience to optimise the output quantity of the processing assembly/unit without compromising on the quality of the outputs, by organising the utilization of the available processing equipment and manpower effectively, to reduce the cost of processing and to increase viability of the enterprise.

Processing small millets poses certain challenges given the size and diversity of the grains. Though the steps in processing are fairly straight forward, care needs to be taken to observe the output material at each stage of the processing before proceeding further. With adequate efforts by the operator to gain skills in using appropriate equipment and tools, Community scale Small Millet Processing units can optimize the quantity of output of process assembly/unit and produce good quality whole grain small millet rice, grits and flour.

Chapter 7: Products of CSMP

There are two types of outputs from a Community scale Small Millet Processing unit viz. (i) human consumable output and (ii) outputs used for other purposes (including cattle feed, soil additive, etc.). This chapter explains about different primary, secondary and other useful outputs from CSMP and their uses.

Primary products

1. Unpolished whole grain small millet rice

This is the most important **primary output** from small millet processing. This is expected to be anywhere from 50 to 70% (by weight) of the cleaned and graded grains put into the huller. The exact number will depend on the type of small millet crop, quality of the grains, condition of the machines, relative humidity on the day of the processing, level of proficiency of the operator, etc.

Fig. 28: Kodo millet whole grain rice

Fig. 29: Kodo millet half broken rice kernals

2. Half broken small millet rice kernels

This is the second most important primary output and it is expected to be around 5% of the cleaned and graded input grains. This output can either be used as it is for cooking or if so desired, can be passed through an abrasion mill or semolina making machine and sieved to give us *rava* of desirable size – coarse one for making *upma*, fine one for making *idli* and extra fine one for making sweet dishes. A byproduct of this further step in processing would be bran rich flour that can be packed and marketed for its high fibre, mineral and essential fatty acid content.

3. Shattered millet rice kernels

This component is expected to be around 3 to 5% of the cleaned and graded input grains. It can be used as an additive when preparing the particular small millet's flour. If it contains traces of sand or has too many shattered husk pieces, it can be used as cattle feed.

It would be pertinent to note here, again, that any shortcomings in the pre-hulling cleaning and grading would result in one or more of these output products to be discarded, which will threaten the economic viability of the processing itself.

Fig. 30: Kodo millet shattered millet rice kernals

Secondary products

1. Husk with millet flour

Fig. 31: Kodo millet husk with millet flour

It is the most important secondary product from small millet processing collected through the aspirator vent of the huller. It is the second largest output by weight and would be around 20 to 30% of the cleaned and graded input grains. This component as such can be used for different purposes. As it is high on cellulose and mineral content, it can be used as very effective soil additive / mulch for horticultural plants and trees. It can also be used as a biofuel in furnaces and energy plants. After grinding to a fine powder, it can be used as cattle feed. Subjecting this material to sieving and winnowing or passing through an appropriately tuned aspirator will remove the dust and retain just the husk. This is used as a therapeutic, light, biodegradable green alternative filling material for pillows, mattresses, cushions, beanbags, etc. Necessary arrangement should be made to collect and store this product in a clean chamber in the processing mill, instead of disposing outside the mill in a haphazard manner. Other commercial uses for this product need to be explored, as good quality material is more easily available now with increase in decentralized processing of small millets.

2. Light and unfilled grains

Fig. 32: Little millet- unfilled and good grains

The utility of the light grains separated from the grain lot need to be assessed based on the material. The light grains may be immature not properly formed rice or smaller grain with well-formed rice. When a grain is very light, it does not have a sufficiently well formed starch component in the endosperm, the heart of the grain. The quality of the oils –the fatty acids in the bran layer- is also very low, which means that the small millet rice from these grains will become rancid very quickly, even if the grains can be dehusked without damaging the millet rice kernel. The rice from such light small millet grains would also not taste good when eaten. Most importantly, the cooking quality of rice or *rava* deteriorates dramatically. Therefore, these light grains can be sold as poultry / bird / cattle feed or if the quality is not too bad, it can be dehusked and used as an additive when preparing the particular small millet flour.

Besides the above two secondary products, the large grains that are taken out from grading can be used as seeds.

Other byproducts

Other less useful outputs from the small millet processing unit are listed below along with their potential use.

1. Dust collected in the dust sacks and cyclones can be used as a nutrient enhancer in a compost pile (preferred) or can be added directly to the soil.

2. Mud balls, straws, sticks, pebbles and stones from cleaning of the grains can be used as a nutrient enhancer, either in a compost pile (preferably) or directly added to the farm or garden soil as mulch.

Therefore, all together, there will be three primary, two secondary and three other useful products from the processing of a batch of small millet grains. Each of these have a certain value that can be realized when the CSMP unit use appropriate machines and procedures to process the grains.

Chapter 8: Pest Management and Quality Control in CSMP

The most common reasons for rejecting small millet products or any cereal grain for that matter, from the most frequent to the least, are:

1. Pest infestations
2. Presence of foreign objects.
3. Rancidity of the whole grain

The foreign objects in the final product could be stones, pebbles or seeds of some weeds. They could even be grains, i.e. unhulled grains. The ways to handle them using grader and destoner were discussed in Chapters 5 and 6. The other two issues, pest management and addressing rancidity problem are covered in this chapter. It also covers how to test the degree of damage to bran layer.

Pest management

Small millets are extremely pest resistant as long as their husk layer is not disturbed. There is certain class of rodents that could eat the grains; but most insect pests do not eat the grains. It is primarily the rice kernels that the pests eat. So, once dehusked, the small millet rice kernels are highly attractive sources of nourishment for pests and a sample kept open is sure to get infested within a day. This is even more so given the retained bran layer in unpolished whole grain small millet rice. Pest infestation is the most common reason for rejecting small millet rices, grits and flour. So in order to reduce pest infestation probability to a minimum and to avoid using chemicals for pest management during processing and storage, it is extremely important to follow the three layers of pest management processes given below.

Fig. 33: Pest infestation in little millet rice

The first layer of pest management

The first layer includes different activities to be taken to ensure that small millet rice, grits and flour has very little exposure to situations where it could be infected. It must be kept in mind that the infestation will be known only when the eggs have hatched and the grubs are seen. This could be anywhere from 10 days to 3 months depending on the conditions in the sack/packet and the infestation would remain undetected until then. By that time, the products would most probably have left the processing facility and would be on a retailer's shelf or would have reached the home of the consumer. So, the hulled material must be protected from situations where pests can lay eggs in them. The interventions needed are,

<u>1. Removing adult moths</u>

The adult moths in the vicinity need to be removed when they are active using methods such as the electrical pest traps and ‘bats’ typically used to kill mosquitoes (see Figures 34 and 35). The adult moths are active during the evenings (and sometimes during the early morning hours) and are dormant during the rest of the day and night.

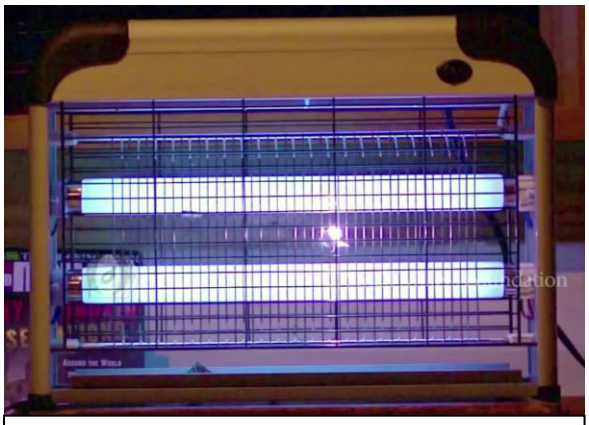


Fig. 34: Electrical pest trap

Fig. 35: Mosquito bat

2. Properly covering all the hulled materials

In order to minimize infestation probability in a CSMP unit, no hulled material should be kept exposed overnight within the processing unit. Even during the day, it is critical to keep the dehusked millet products properly covered. Sacks, bags or boxes that can be re-sealed and are tear/hole-free must be used. Once the processed products are ready, they need to packed and the bags must be stitched up, labeled appropriately and stored in a separate facility rather than keeping in the processing unit. Particular attention has to be given during the stitching of these bags. The stitches themselves must not damage the fabric enough to create needle holes that will allow the pests to access the grains. It is also advisable to keep the sack material folded up always during the stitching process so that there will be minimal chances of exposure of the grains.

3. Planning the quantum of grains to be dehusked in a day/shift

More important than the above-mentioned two interventions, is the way the materials, especially the by-products are handled during the course of the processing and stored for aggregation. All hulling and post-hulling operations should be completed in a single shift. All the products, whether it is human edible products like small millet rice and grits or the secondary processing output products should be packed/moved away by the end of the shift. So, when identifying what quantity of material should be taken up for hulling and post-hulling operations in a batch, the demand for end product can decide the minimum and the processing capability of the SMPU can decide the maximum quantity. This is very important because many times the processors end up with left over material from one shift, which has a very high probability of being exposed to air and so to pest infestations. This situation leads to loss of significant quantum of output. Therefore, proper planning of hulling operations so that it can be completed within the day/shift can help in preventing pest infestation and improving the quality of output.

The second layer of pest management

The second layer includes different activities to be taken for cleaning the machines on a regular basis to ensure that the machines are not becoming a breeding ground for pests. Almost all conventional machines – grain elevators, graders, de-stoners, hullers, aspirators – have been designed taking into account that some chemicals will be used to save the processed material from pest infestations. If use of any pest repellent, pest suppressants or pesticide need to be avoided while processing or storing, then the machine design and how material is flowing through them (how much material, of what kind, and where does it get left over or left behind during processing) need to be relooked. It is to be ensured that any stagnation points are removed in the design or at least being cleaned at the end of every shift. The

infestation probability when the machines are running is very low. However, when the machines are not running and there is material on or in them, it is an open invitation to moths to lay eggs. Each machine needs to be cleaned at the end of each shift, i.e. removable components such as sieves should be taken out and any residual material within the machines needs to be removed. Easy cleaning provision should be given in all small millet processing equipment. If needed, necessary design modifications have to be done for this purpose. The portable (SMF V2) and tabletop (SMF V3) impact hullers developed by Small Millet Foundation has provisions for cleaning most of the machine components with ease.

Fig. 36: Areas where it is hard to clean

Of the three main equipment used in CSMP unit, the grader can be cleaned easily. It has a big tub/body in which the grains flow over sieve screens. The nooks and corners of the sieve screen should be kept grain free, and the inside of the bin cleaned out. Clogged material should be removed. After every batch of processing, the grader needs to be cleaned with the help of steel wire brush and air blower (see Figure 37). It is slightly more difficult to clean destoner. If the material landing on the bed of the destoner has components that are smaller than the size of screen used on the bed, it would fall through and accumulate within the body of the destoner (see Figure 38). This accumulated material act as a breeding ground for the pests. This is a critical issue because air from within the body of the destoner gets blown up through the bed and interacts with the material above. If there were infestation within the body of the de-stoner, there would be a finite probability of infestation of the material flowing on the bed, even though it does not come into direct contact with the material in the body. So, it is important that the sieve size of the destoner bed screen is chosen to be smaller than the sieve size of bottom sieve in the grader used in the post-hulling process. At the end of each shift, the enclosure needs to be opened and cleaned of any working material and dust that would have slipped through the destoner bed mesh. Considering the importance of this maintenance work, it is better to buy destoners that have provisions for removal of cover plates for easy cleaning of the bedchamber (see Figure 39). In addition, the bed sieve should be kept grain free. Metal wire brush and air blower need to be used for effective cleaning. In medium and large-scale processing units, it will be ideal to use separate destoners in the pre-hulling and post-hulling processes with different bed screens.


Fig. 37: Grains clogged in the sieve screen to be removed regularly

Fig. 38: Accumulation of processed fractions in the destoner bed chamber

Fig. 39: Provision of removable cover plates for ease of cleaning in destoner bed chamber

Fig. 40: Cleaning of aspirator fan box vanes

The huller with the attached aspirator is even more difficult machine when it comes to pest management. In it, shattered millet grain dust and millet bran dust are either released or pass through whenever the machine is in operation. These are the most sought after material by pests. The infestation probability also goes up if processing aims for whole grain small millet rice with bran layer. The bran layer is extremely attractive for the pests and so, the need for precautionary practices goes up. At the end of each shift, cleaning of huller need to be ensured. The removable parts like fan box plates have to be taken out and the accumulated shattered millet grain dust and millet bran dust are removed on a regular basis (see Figure 40). Air blower need to be used for effective cleaning of this machine. The dead zones in huller, where residual material can remain even after the machine has been shut down, need to be minimised with appropriate design modifications and process corrections.

The third layer of pest management

The third layer includes different activities to be taken in the premises of CSMP unit to reduce possibilities of pest infestation. Care should be taken that, residual material does not remain not just in the machines, but also on or around the machines. Inaccessible nooks and corners should be avoided and those present need to be identified and screened off when material is being processed. The layout of the machines and the mounting should be such that small millet grains do not drop through or slip into inaccessible points that cannot be cleaned daily. Following proper layout design during installation of machines in the CSMP unit to avoid any inaccessible places within the unit and allocation of spaces to ensure separation of hulled materials from unhulled ones is quite important. For more details on layout of CSMP unit, see Guidelines for Setting up a Small Millet Processing Unit.

Following all the three layers of pest management in CSMP unit shall help to avoid pest infestation to a great extent.

Addressing rancidity issue

The third important aspect affecting the quality of small millet outputs is rancidity. Rancidity is the oxidation of the fatty acids in the bran layer of the millet products. Therefore, more the surface area exposed, faster will be the rancidity process. Rancidity occurs in unpolished grains with an undisturbed

bran layer; but it is a slow process and allows anywhere from three months to a few years of shelf life depending on the millet, its variety and the conditions in which it was cultivated. Rancidity rates increase dramatically when the bran layer gets disturbed, scratched or is broken up during processing.

The bran is a thin outermost layer of hulled rice. Like pest infestation, the extent of bran damage is not identifiable for two months from processing. By then, the product would have surely left the processor's facility and most likely will be in a customer's cupboard. Whenever the grain rubs or hits against metal or hard surfaces, there will be scratches on the bran layer. Therefore, the following steps to be taken to reduce and/or avoid damage to the bran layer:

(i) Completing grading and cleaning as much as possible before the hulling operation when the grains still have their husk on, so that damage to bran layer can be avoided as much as possible.

(ii) Exercising caution when the grains are moved from one machine to another so as to minimize the friction and abrasion, and avoid impact as much as possible-*This factor need to be considered when selecting the tubs or bins used to collect the grains and/or where they are positioned; Simple steps like avoiding drop of the hulled grains from an higher elevation either on to a sieve or on to the bed of grader or collecting bin, etc. would help.*

(iii) Avoiding as much as possible putting already hulled grains into the hulling machine again. Usually second or repeat runs are done to improve rice recovery ratios. But, repeated hulling will not only lead to breakage of grains, it will also increase the damage to the bran layer and hence speed up onset of rancidity. Therefore, it is better to separate all the unhulled grains from the hulled fractions thoroughly and only subjecting the unhulled grains to a second round of hulling process.

The other way of minimizing rancidity is to store the processed products in airtight containers and using nitrogen filling for retail packing.

Testing the degree of damage to bran layer

The small millet rice output with almost intact bran layer is of higher quality than that of one with less bran layer. So, one of the important quality control aspect pertaining to small millet rice is identification of the extent of damage to the bran layer. One way to do it is checking the colour. Typically the polished or bran removed grain will be a shade lighter in colour and more shiny than the whole grains and if fully polished will appear almost white. Little and barnyard millets are generally off-white in colour, kodo millet has a darker brown colour, browntop has a greenish bran layer, and foxtail and proso millets are little yellowish. The last two millets might be difficult for colour check, because they will appear nearly the same colour even when the bran is removed. Another test for bran retention is to check how oily its surface is. Hold a fistful of the product (rice or *rava* or flour) in hand for say 15 seconds and then drop them. If the millet rice has retained its bran content through the processing, then the oil will remain on the part of the palm that was in contact with the millet rice. Just make sure to wipe the hand well before doing this test.
Another way to get an idea of bran retention is by taking a fistful of the material, dropping it from one hand to the other, and rubbing it between the two palms. If it is sticky and oily on the palms, the bran retention is good. If there is dust sticking to the palm, it shows that the bran has been eroded and the rice kernel has been scratched leaving behind a dusty top layer. These are qualitative tests and not quantitative, and does not give an exact measure of the actual bran content.

By following the interventions suggested to address pest infestation, rancidity and damage to bran layer, the quality of the CSMP output can be improved significantly. It is better to assess the quality of the CSMP outputs at every stage and take required measures of control rather than handling the problem at the end. Ensuring the material going out of CSMP unit is of good quality and pest free is critical to make the CSMP unit a community resource that gets used and is cared for by the local community. It is also critical for commercial promotion of small millets and establishing it as a commonly utilized 'food category'.

Chapter 9: Maintenance and Basic Repair of CSMP Machines

Each of the machines used in a CSMP unit - grader with aspirator, destoner and huller - requires regular maintenance and some degree of preparedness to reduce down time due to machine repair. The grader is a fairly simple machine, the destoner slightly more complex and the impact huller is a specialized machine with some special functions making it important from a preventive maintenance perspective.

In the **grader**, the sieve screens need regular inspection and maintenance. After every batch of processing, the grader sieves need to be cleaned with the help of steel wire brush and air blower. Any cracks or holes in the sieve need to be filled so that the sieving efficiency is not affected (see Figure 41). Gaps between screen and frame due to usage and material fatigue should be filled at the earliest. Weekly once oil need to be put in movable machine parts. Rust formation should be avoided in all sieves. At a slightly longer time scale, preventive maintenance work on the dynamic components of the machine needs to be undertaken. This will involve inspecting the drive belts, motor, the driving shaft, eccentric drive, pulleys, bearings and the struts on which the grader bin rocks back and forth for signs of fatigue and wear. If any of these seem to have deteriorated, they need to be replaced.

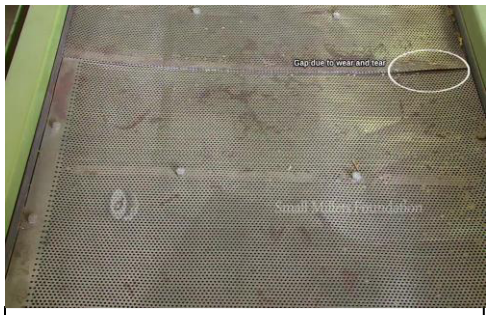


Fig. 41: Gaps in the sieve which to be addressed

The bran may accumulate on the exit side of the aspirator with use. Regular cleaning of the inside of the **aspirator** and exit vanes is necessary to prevent accumulation of bran and other highly decomposable materials inside the aspirator (see Figure 42).


Fig. 42: Accumulated bran on exit vane of aspirator fan box

The **destoner** is a slightly more complex machine, with a few more moving components when compared to the grader. The destoner bed mesh is a critical component and need to be inspected at regular intervals. Any holes or gaps in the mesh need to be filled to ensure that materials do not slip through the bed and into the machine enclosure (see Figure 43). At the end of each shift, the enclosure needs to be opened and cleaned of any working material and dust that would have slipped through the destoner bed mesh. Weekly once oil need to be put in movable machine parts. Rust formation to be avoided in the bed sieve. The vibrations and noise from the enclosure components need to be checked regularly. The inherent vibrations in the machine may lead to some bolts coming undone. The bolts holding down the destoner bed mesh to the frame of the bed needs to be inspected at regular intervals and tightened (see Figure 44). The moving components, i.e. the drive belts, pulleys, eccentric drive, shafts and fan would also need to be inspected at regular intervals for fatigue and signs of wear and tear. Specifications of the bearings and the primary shaft must be kept at hand for quick replacement in case of component failure.

Fig. 43: Gaps in bed mesh should be plugged

Fig. 44: Bolts on the bed mesh should be tightened in a periodic interval

The **centrifugal impact huller** is a slightly more complex machine, though somewhat comparable to a destoner in terms of the number of moving components. The primary concern in a centrifugal huller is of over tightening of the impeller shaft bearings causing increased friction, heating and eventually component failure. The high rotational speed of the impeller shaft necessitates frequent checks on its performance. Another component prone to heating effects is the pulley on the impeller shaft. This increased heat at the pulley if left unchecked can affect the impeller shaft. If there is high pulley size ratio across the drive belt, the probability of slip between the impeller pulley and the drive belt is fairly high (see Figure 45). The faceplate on the fan box of the aspirator will also need to be removed and the box cleaned regularly. Frequently, oil need to be applied in the impeller shaft bearing with help of grease gun to avoid friction between the bearing and the shaft. In some huller models like portable and tabletop impact hullers, greaseless heavy-duty bearings are used. In the medium time frame, the rubber liner will get eroded with the repeated impacting by the grains and has to be replaced. Similarly, in the medium to long time frame, the impeller will get eroded with the repeated impacting by the grains and has to be replaced. It is better to keep spares for these components to reduce down time.

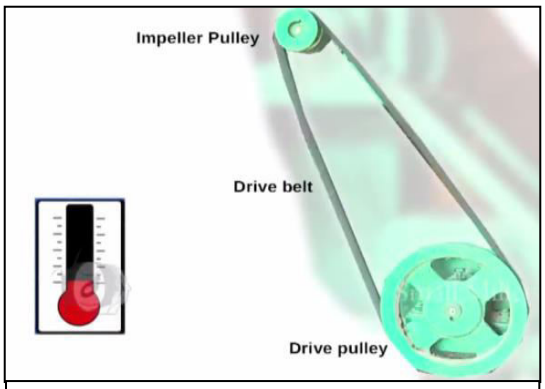


Fig. 45: Heating due to slip of pulley belt

Maintenance and upkeep of machines and tools is an important aspect to be given attention to ensure that the CSMP unit serves its purpose. Regular maintenance and reduced down time for repair work will improve the reliability of the CSMP unit and enable it to function as a community resource that it is intended to be.

Chapter 10: Summary and Conclusion

Community scale Small Millet Processing unit is an important resource needed to improve the farming community's access to edible forms of small millet grains (rice, grits and flour) that they themselves are growing. This manual is intended to serve as an introduction and primer to processing small millets at a community or small scale. Hopefully it shall provide community leaders, entrepreneurs and operators a good idea of the different steps in processing small millets, the machines that can be used, and the operation and maintenance of the machines. The overview of quality assessment of input material and the output products will aid them to better identify the material on hand and plan the process steps accordingly. Increased familiarity and training in selecting appropriate tools and pest management can help in improving management of processing units. This manual also helps to aids the new and existing processors to best utilize the available technology and current know how about grain processing for optimising quantity and quality of output.

Small Millet Foundation (SMF) hopes that this manual will encourage setting up of enterprises involved in primary processing and value addition of small millets by the entrepreneurs, community organisations and other agencies in the rural areas. SMF welcomes feedback, comments, suggestions, and questions. Please get in touch with SMF through email or phone given in the back cover.

Also see other publications of DHAN Foundation on small millets

Increasing production of small millet based cropping systems

1. ஜவ்வாதுமலையில் சிறுதானிய உற்பத்தியை முன்னேற்ற கடைபிடிக்க வேண்டிய உத்திகள்
2. Sustainable Agriculture Practices for enhancing small millets production in Jawadhu Hills
3. Integrating Conservation, Varietal Improvement and Seed Systems in Small Millets
4. A Manual on Participatory Varietal Selection (PVS)
5. விவசாயிகள் பங்கேற்புடனான இரகத் தேர்வு கள ஆராய்ச்சியாளர்களுக்கான கையேடு
6. Characterization of Land Races and Local Varieties of Finger Millet and Other Small Millets
7. Uncultivated Edible Greens (UCG) - A less explored aspect of Contribution of Small Millet Cropping Systems (SMCS) for Nutrition of Poor Rural Families in India
   - *These can be accessed at* https://www.dhan.org/smallmilletfoundation/production.php

Scaling up decentralised processing of small millets

1. Assessment of Existing Small Millet processing Equipment in India
2. Guidelines for Setting up a Small Millet Processing Unit
3. Audio-visual Training Manual on Community Scale Small Millet Processing
   - *These can be accessed at* https://www.dhan.org/smallmilletfoundation/decentralised-processing.php

Nutritional benefits and food products of small millets

1. Multi millet based instant Therapeutic foods
2. Multi small millets based food products- A Technical Manual
3. Value added products from small millets
4. Video on Modern millet based recipes
   - *These can be accessed at* https://www.dhan.org/smallmilletfoundation/nutritional-benefits.php

Promotion of household consumption of small millets

1. Film on cooking show covering 28 small millet recipes in Tamil, Telugu, Hindi and Odiya
2. **Nam Unave Nam Marabu**- A small millet recipe book on small millets
3. Awareness posters on small millets
4. Small Millet Music Treat- A music album in Tamil
5. Puthayal (Treasure) – An effort to revive lost food habits – Ten episodes of radio programme
6. Educational materials on small millets
7. பல்லுயிர் ஓம்புவோம்-ஊட்டத்துடன்கூடிய உணவுப் பாதுகாப்பில் சீர்மிகு சிறுதானியங்கள்
   - *These can be accessed at* https://www.dhan.org/smallmilletfoundation/consumption-smallmillet.php

Policy advocacy for mainstreaming small millets

1. Proceedings of National Policy Workshop on Mainstreaming Small Millets in Our Diets
2. Small Millet, In Mainstream Diets: *Promoting Decentralized processing Infrastructure*- A Policy Paper
3. Small Millets, Big Potential: Diverse, Nutritious and Climate Smart-A Policy Brief
4. Supporting Millets in India: Policy Review and Suggestions for Action- A scoping study

- *These papers can be accessed at* https://www.dhan.org/smallmilletfoundation/policy-action.php

About Small Millet Foundation, A division of DHAN Foundation

Realizing the importance of small millets for addressing triple burden of malnutrition and the prevalence of non-communicable diseases such as diabetes, and for ensuring health of the economy and the planet, DHAN Foundation has been working on small millets since 2011. It has led two South Asian consortium research projects on small millets in India, Nepal and Sri Lanka, supported by IDRC and Global Affairs Canada under Canadian International Food Security Research Fund (CIFSRF). These projects resulted in a set of technologies and working models developed on production, processing, value chain development and consumption of small millets. There is considerable need and scope for scaling up the learning across India. Towards this, DHAN Foundation has initiated an exclusive organisation, Small Millet Foundation (SMF) by 2018. Small Millet Foundation is engaged with 6000 farmers in Tamil Nadu, Odisha and Jharkhand. It supplies quality seeds of various small millet crops and improved processing equipment to the interested agencies. It also offers training on small millet cultivation, setting up and operating small millet processing mills, value added food products and promoting consumption. More details on the activities, training manuals and publications of SMF can be seen at https://www.dhan.org/smallmilletfoundation/

For further details contact

Regional Office

Small Millet Foundation,
1/31-33, 2nd cross, 6th Street, Rajaji Nagar,
Krishnagiri 635001. Tamil Nadu, INDIA
Tel: +91 4343 226568
Email: karthikeyanrfd@gmail.com, rfdpkrishnagiri@dhan.org
Website: https://www.dhan.org/smallmilletfoundation/

Central Office

Small Millet Foundation,
DHAN Foundation,
1A, Vaidyanathapuram East, Kennet Cross Road, Madurai 625 016. Tamil Nadu, INDIA
Tel: +91 452 2302560
Email: dhanfoundation@dhan.org