Cassava Flour Production
For Small-scale Farmers
Manufacturing Report

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Introduction

This report aims to explain how to manufacture human powered devices that will allow for the conversion of cassava root into cassava flour. The targeted end user of these products are small scale farmers. Universal applications (any variety of cassava) should be possible given the design parameters. Please refer to the main report for detailed explanation of the development of the process and devices.

Process

Figure 1 shows the process that has been developed for converting the cassava root into cassava flour. The complete report explains the reasoning behind the process and provides data proving its effectiveness.

![Figure 1. Cassava flour production process](image-url)
Some key points to keep in mind are as follows:

- Water waste from the process should not be consumed or used for ANYTHING
  - It is potentially high in cyanide
  - Water should be disposed of in a charcoal pit
- Steps in the process prior to milling should be completed in well ventilated or open areas
  - Depending on the temperature, the hydrogen cyanide that is released during processing could become gaseous
- Steps prior to milling should be completed in quick succession
  - Prevents deterioration of the root
  - Prevents mold growth because of moist product
- Sun drying should be done for one whole day of sunlight
  - Desired moisture content is 12%
    - Prevent mold and bacterial growth
    - Assures a high quality flour
    - Better removal of toxins

**Peeling**

Cassava root should be completely peeled before moving on to the next step. No skin should remain. A quick rinse / wash to remove dirt and any excess skin is required. This can be done with a brush.

**Grater**

**Supplies Need:**

1. Tape Measure
2. Hammer and 1 Nail (To be used as a punch)
3. Electric Drill or Screwdriver
4. 150x #8 ¾” (15.9mm) Construction Screws (Flat Head)
5. 4x 3” Construction Screws
6. 3 1.5” Construction Screws
7. Ball Bearings (Choose easiest bearing size to obtain)
8. 23” long steel shaft (Outer diameter of shaft should be the inner diameter of the bearing)
9. 2x 2x4 wood pieces cut to 6” lengths
10. PVC Pipe- 8” Diameter
11. ½” thick piece of wood, 2.5” diameter circle
12. Steel bike gear. (Any size diameter less than 4” is sufficient)

**GRATING DRUM**

1. Cut PVC pipe to length of 18”
2. Drill 1 hole in each of the 2x4 wood segments to the outside diameter of the bearings
   a. Round the edges of the 2x4 wood pieces to fit the inside diameter of PVC pipe
   b. Align edges of 2x4 wooden block with end of PVC pipe
   c. Fasten 2x4 wooden blocks to inside of PVC pipe with 3” construction screws
3. Create marks on the PVC surface with the hammer and nail in the arrangement shown in figure 2 below. Be sure to stagger the rows so that the entire length is covered. The rows should be 2 inches apart.

![Figure 1. Grating drum support](image)
4. Using the drill, place one screw in each of the punch marks on the PVC surface.
   a. See figure 3 below as a reference of finished PVC surface.

5. Cut a piece of $\frac{3}{8}$" thick wood into a circle of diameter 2.5 inches. Drill a hole through the center that is slightly larger than the steel shaft diameter.
6. Drill 3 holes through the bike gear and circular wooden piece equidistant from each other in a circular orientation. See figure 4 below for example.
7. Screw bike gear to the wooden circle as shown above using 3x 1.5” screws.
8. Finished grating drum pictured below.
1. Cut 2 x 4 into the lengths called out in figure 6 and figure 7, these will make up the main stand for the grater (quantity required is shown on the left side of the figure).

**Figure 6. Wood size callout for main grater stand**

**Figure 7. Grater tower angled supports**
2. Connect pieces as shown in figure 8
   a. The horizontal piece is 24 inches
   b. The vertical piece with the hole is the 40 inch piece
      i. The hole shown in the 40 inch section should be the diameter of the shaft that was used

![Figure 8. Not bike side grater tower construction schematic](attachment:image.png)

3. Connect pieces as shown in figure 9.
   a. The hole shown in the 40 inch section should be the diameter of the shaft that was used
   b. It is recommended to pre drill all holes to prevent splitting of the wood
   c. This grating tower should also get the two remaining grater tower angled supports (figure 7)
      i. Connected in the same manner as figure 8
4. Cut the grater tower cross beams shown in figure 10
   a. Two pieces
5. Connect the two grater towers with the cross beams from figure 10 as shown in figure 11
   
   a. The grating drum on its shaft should be inserted before screwing the two towers together
   
   b. Figure 12 shows a completed stand with grating drum
   
   c. The design shown in figure 12 includes spacers to prevent the grating drum from moving left to right on its shaft
      
      i. The size of these spacers can be variable
      
      ii. The shown design uses pvc pipe that is slightly larger than the shaft used and cut to the desired length

![Figure 11. Grater tower and cross beam construction schematic](image-url)
6. Connected the pieces of the correct length from figure 6 as shown in figure 13. Two of these pieces will be required.

   a. These will be the stands on which the bike axle is mounted. The offset between the edge of the 8 inch piece and the edge of the 6 inch piece may vary depending on bike size (see figure 15 for an example)

      i. Pieces should butt up against the 60 inch piece (figure 17)
7. Create two mount plates for bicycle attachment (figure 14)
   a. These plates will hold a lot of weight and should be strong
      i. 0.060” Steel was used
   b. These plates will then be screwed into the previously created bike axle mount stands (figure 15)
8. The bike axle mounts should be connected to the 60 inch section of the grater stand towers using L brackets.

**BICYCLE ATTACHMENT**

1. Remove the tire and main rim from the back hub of the bicycle (figure 16)
   a. The goal is the keep the axle and sprocket hub but remove the outside.
   b. Tin snips or other methods can be used to cut the spokes and the excess can be slid out of the hub
2. Reattach the rimless hub to the bicycle and bolt it to the bike axle mounts (figure 17)
   a. Depending on the bicycle other pieces may be in the way
      i. For this particular bike the derailleur had to be removed
         * This led to chain shortening being required

Figure 16. Bike tire alterations

Figure 17. Bike mounted to stand (Note that this prototype did not include a 60 inch piece like the one that is being suggested in this report)
HOPPER

Materials Needed

1. 17”x12”x ⅛” sheet of aluminum, plexiglass, painted steel or other material
   a. Any type of sturdy material can be used, plywood could also be used
2. 17”x10” x ⅛” sheet of aluminum, plexiglass, painted steel or other material
   a. Any type of sturdy material can be used, plywood could also be used
3. 3x 1.5”x .5” thick pieces of wood cut to 18” in length
4. 1x 4” x .5” thick piece of wood cut to 18” in length
5. 18x 1.5” construction screws
6. 16x ½” Sheet metal screws
7. 4x 2x4 wooden pieces cut to 4” length
8. 2x ½” plywood cut to 1.5” x 10.5” dimensions
9. 2x ½” Plywood sections cut to the below figure dimensions

![Figure 18. hopper box side panel dimensions](image)

Instructions

1. Predrill Holes into plywood and 4x wooden cross pieces
   a. Space screws ½” from end of cross braces and 1” apart
   b. Insert screws into wooden cross braces and screw into plywood sections.

![Figure 19. hopper box spanner](image)

c. Place cross braces in locations shown below
2. Add pieces of sheet metal (or other material)
   a. Select larger sheet and align the end of the material with the edge of the wooden hopper without the 3”x3” square cut out
   b. Repeat above step with smaller sheet
   c. Secure in place with sheet metal screws (or equivalent) (see below image)
3. Final wooden hopper with sheet metal (or other materials) attached and secured with sheet metal screws. See below figure.

4. Take wooden hopper and attach 2 wood 2x4 with a 2x4 gap between each of the supports as shown in the below image
   a. Place hopper on gratter support stand and mark with a pencil location that 2x4 supports are to be located. You want to make sure that there is clearance for the rotating grating surface and that the gratter can spin freely.
   b. Make sure sheet metal is as close to grating surface as possible without causing interference.
   c. Attach 2x4 with 2 screws in each 2x4
d. Center 1.5”x10.5” wooden span on 2x4 supports and screw into place

e. Repeat above steps on opposite side of hopper box
5. Locking mechanism to prevent hopper from sliding off grater stand.
   a. Holes should be drilled through the hopper mount that were added in step 4 and into the main grater stand
      i. This prevents the hopper from sliding up during use
      ii. The hold should then have some sort of pin inserted into it to lock it in place
b. In this case ½” holes were drilled through the hopper mounts and into the main grater stand as shown in figure
c. Long lag bolts were inserted through the hole to hold the hopper in place (figure)

Figure 25. Hopper lock holes

Figure 26. Hopper lag bolts lock down

6. Cassava exit chute manufacture
   a. The exit chute was made out of sheet aluminum
      i. Any material that is food safe and not sensitive to excess water can be used
   b. Cut aluminum sheet to dimensions specified in the figure below
      i. Bend sheet on dashed line to dimensions shown at 90 angles
c. Attach exit chute to gratter stand using triangular wooden blocks shown below
   a. Angle is left blank to allow for accurate placement by the builder to achieve desired angle
   b. However, make sure grater has clearance in order to spin freely with no obstructions

Figure 28. Exit chute mount blocks

c. Attach wooden blocks to frame as shown in the figure below
Figure 29. Exit chute mount blocks attached to stand

d. Attach exit chute to wooden blocks as shown with 2 sheet metal screws
   a. See finished attached exit chute shown below

Figure 30. Exit chute mounted to stand
SAFETY COVER

1. Cut aluminum sheet metal to the dimensions shown in the figure below
   a. Cut and remove 4”x4” square at the corners to allow metal to be bent to proper form

   ![Figure 31. Safety cover sheet metal layout](image)

b. Bend the sheet metal to 90 degree angles on the dashed line
   i. See figure below for completed shape

   ![Figure 32. Final safety cover](image)

c. Drill or punch 2 holes (diameter of sheet metal screw) into top corners of safety cover

d. Attach safety cover to grater stand as shown below in a location that is sure to cover the rotating grating surface
   a. See attached safety cover as shown below
Figure 33. Attached Safety Cover

Finished Cassava Grating machine

Figure 34. Finished Cassava grating machine
Dewatering Press

Squeezing the cassava between two parallel plates is the best method for reducing the moisture content of the cassava. This will expel a majority of the water and reduce the sun drying time required. This method is already being used in other regions and proves effective. It is also very cheap and easy to construct. Cassava at this stage should be in some form of porous bag at this point to assure water can be evacuated. Any evacuated water should be assumed to be unsafe for use in any manner (see table 1 from the formal report). Waste water should be disposed of in a charcoal pit. Pulling the two plates together (applying a force to the bag of cassava) can be done in a number of ways including the suggested threaded rod. Alternate methods include heavy stones or ratchet straps. The force should be maintained until water stops dripping from the cassava bag. Greater water removal at this stage assures that solar drying will reach the desired water content and even has the potential to reduce solar drying times.

Figure 1. Dewatering concept
Drying Table

Any table of suitable size depending on desired throughput can be used. We recommend having the layer of ground cassava being no more than an inch thick. Some breaking up of the cassava by hand may be required to achieve this. It is also recommend that the table has raised edges to both hold the product in and help prevent contamination. Clean polyethylene or tarpaulin sheets should be placed between the table and the cassava. The sheets will both absorb additional sheets and prevent mold and bacterial growth.

Figure 1. Cassava solar drying table concept
1. **Building the frame**

1.1. The frame can be made completely out of standard 2x4 pieces.

1.2. **FRONT OF MACHINE**

1.2.1. Cut the 2x4 boards to the following dimensions

1.2.1.1. A: 20 inches

1.2.1.2. B: 26 ½ inches

1.2.1.2.1. If desired, can cut off the overlap as shown in Figure 1.

1.2.1.2.2. A ⅝ inch hole should be drilled in the center for the shaft.

1.2.1.2.2.1. In the back of B, drill a 1 ½ inch hole to a depth of ½ an inch, concentric with the ¾ inch hole.

1.2.1.3. C: 16 inches

1.2.1.4. D: 16 inches

1.2.2. Arrange the pieces in the same orientation as Figure 1 and 2.

1.2.2.1. Figure 2 shows the angle at which C and D should be oriented behind A.

1.2.2.1.1. The corner of C and D should be 4.5 inches from each end of A.

1.2.2.1.2. Each are tilted 56 degrees from the base to support the bucket.

1.2.3. Use two screws per board to secure together A, C, and D.

1.2.4. When B is in the correct position, clamp it into place.
1.2.5. Drill a ½ inch hole through the indicated positions on each end of board B.

1.2.5.1. Use a ½ inch bolt and nut (along with a washer) in each hole to secure board B to C and D

Figure 2. Angle and mounting distance for front of machine.

1.3. BACK OF MACHINE

1.3.1. Cut the 2x4 boards to the following dimensions

1.3.1.1. E: 20 inches
1.3.1.2. F: 23 ¼ inches

Figure 3. Back of the frame
1.3.1.2.1. Similar to B, a \( \frac{3}{8} \) inch hole needs to be drilled through the center.

1.3.1.2.2. In the front of F, drill a 1 ½ inch hole to a depth of \( \frac{3}{4} \) inch, concentric with the \( \frac{3}{8} \) inch hole.

1.3.1.3. G: 16 inches

1.3.1.4. H: 16 inches

**Figure 4. Angle and mounting distance for back of machine**

1.3.2. Arrange the pieces as shown in Figure 3 and 4.

1.3.3. Use two screws per overlap to secure the boards to one another.

1.3.4. No bolts and nuts will be used at the back of the machine.

1.4. MILLING MACHINE STAND

1.4.1. Cut the 2x4 boards to the following dimensions

1.4.1.1. I: 2 boards each cut 15 inches

1.4.1.2. J: 4 boards each 16 inches

1.4.1.3. E: 2 boards each 24 inches

1.4.2. Each I board will connect the Front and Back sides together as shown in Figure 5.

1.4.2.1. Boards C & D and G & H will be facing inwards.

1.4.2.2. Use 2 screws per joint

1.4.2.3. Do this for both sides.

1.4.3. A J board will be placed in each inside corner, with the face of the board against the I boards, as is shown in Figure 5.

1.4.3.1. Each J board will overlap the I board by 2 inches.

1.4.3.2. Use 2 screws per joint

1.4.3.3. Do this for both sides

1.4.4. One K board will run along the ground and connect to the ends of the J boards as shown in Figure 5.
1.4.4.1. Use this opportunity to make sure that the machine is level.
1.4.4.2. Use 2 screws per joint.
1.4.4.3. Do this for both sides.

Figure 5. Side View of the Milling Machine Stand.

Figure 6: Finished milling machine frame painted black.

1.5. At this point, the Milling Machine frame is complete. It should look similar to Figure 6.

2. The Bucket

2.1. For this project, a Home Depot 5 gallon bucket (Figure 6) was used as a container for the flour to be milled.

2.2. The dimensions used:
2.2.1. Depth: 13 inches
2.2.2. Inner diameter: 12 inches
2.2.3. Height: 14 inches
2.2.4. Largest width: 13 inches

2.2.5. If a different size is used, some adjustments to the frame may need to be made.  

*Figure 6: Example of the bucket used for the design.*

2.3. A leak-proof lid (Figure 7) was used to cap the container.  

*Figure 7: Leak-proof lid used for the design*

2.4. A ¾ inch hole must be drilled through the center of the lid and the bottom-center of the bucket.

2.5. Test the fit of the capped bucket in the frame and mark what end will be used as the bottom of the milling machine.

2.6. Using a sharp knife, remove the excess plastic to leave a 3 inch gap up to, but not including, the lid. An example is shown in Figure 8.
2.7. Measure \( \frac{3}{8} \) inch from the lip of the lid, and drill a 1 ¾ inch hole in the side of the bucket. Shown in Figure 9.

**Figure 9: The whole for the filter drilled through the side of the bucket**

2.8. Filter attachment (shown in Figure 10).

2.8.1. Cut a 2x4 into a 2 ½ x 2 ½ inch square.

2.8.2. Drill a 1 ¾ inch hole in the center of the square of wood.
2.8.3. Cover the square in fine wire mesh and staple (or secure) the mesh to the wood.

![Figure 10. The filter attachment covered by the mesh.](image)

2.9. Once the filter attachment has been made, use 4 screws to attach the filter to the side of the bucket, as shown in Figure 11.

![Figure 11. The Filter attachment secured to the side of the bucket.](image)

2.9.1. By placing a bucket, bowl, or bag underneath the hole, the cassava flour will easily be output.

2.9.2. Another option is to add a 1 ½ inch pvc elbow to the 2x4 opening to allow the cassava to dispense out the front of the machine.

2.10. Cassava inlet
2.10.1. To secure the inlet tube, a 2 inch PVC Slip Joint adapter (Figure 12) was used.

![Figure 12. PVC Slip Joint adapter.](image)

2.10.2. Put the bucket into the frame, and make sure that the side with the filter attachment is pointed downwards.

2.10.2.1. Mark the space above Board F on the bucket where the top of the milling machine will be.

2.10.3. Drill in marked zone a hole to allow only the threaded portion of the adapter, shown in Figure 13.

![Figure 13. PVC adapter in end of bucket.](image)

2.10.4. Use PVC primer and glue to attach a PVC elbow, straight piece, and reduction coupler (as shown in Figure 14) to the protruding end of PVC.
2.10.4.1. Each piece should be same 2 inch diameter.

2.10.4.2. The PVC straight piece is 8 inch in length.

Figure 14. PVC elbow, straight piece, and reduction coupler attached together

2.11. Align the bucket so that the inlet and outlet are in their correct position in the frame
2.11.1. Put 2 screws through the back of the bucket to secure the bucket to Board F.

3. The Mixer
3.1. THE SHAFT
3.1.1. The shaft is made with a steel tube, ⅝ inch diameter, and 22 inches in length.
3.1.2. At the back end of the machine is attached a bike chain gear. Shown in Figure 15.
3.1.2.1. The most secure way of attaching the gear is to butt the gear against the pipe and weld the two together.
3.1.2.2. Be careful to align the center of the shaft with the center of the gear.
3.1.3. 3 inches from the end of the pipe with the gear, drill a hole to feed through a bolt and nut to keep the shaft from moving laterally (shown in Figure 15).
3.1.3.1. On the other end, an inch from the end of the pipe, drill another hole for a second bolt and nut (shown in Figure 16).
3.1.4. After the bolt and nut next to the gear, push on a 1 ½ inch rolling bearing, with a ¾ inner diameter, with ½ inch thickness. The bearing will go into the 1 ½ hole on Board F.
3.1.5. On the front, the bearing will be on the backside of Board B
3.1.6. Three more holes need to be drilled to match the center holes in Figure 18.

3.1.6.1. More information on this step is found in the next section.
Figure 15 (left) Showing the geared end in the back and Figure 16 (right) showing the front end bolt and nut placement.

3.2. THE MILLING PLATE (shown in Figure 17)

3.2.1. The milling plate is made of a sheet of aluminum 1/16 inch thick.

3.2.1.1. The dimensions are 9 ¾ x 13 inches

3.2.1.2. Down the middle of the plate are three holes. Two holes 2 inches from each edge, and one in the center. (Shown on Figure 18)

3.2.1.3. First, drill the plate holes, then clamp the plate to the shaft inside the bucket.

3.2.1.3.1. Make sure that the shaft will rotate with the plate without contacting the sides or the ends of the bucket.

3.2.1.3.2. Use the holes in the plate to mark the holes on the shaft.

3.2.1.3.3. Drill the holes in the shaft and attach with bolts and nuts.

3.2.2. Attached to the milling plate are two stainless steel bars ¼ inch thick

3.2.2.1. The dimensions of the bars are ¾ x 12 ½ inch

3.2.2.2. The two bars are on opposite sides and edges.

3.2.2.3. Attach the bars to the plate by drilling holes as shown in Figure 18 and securing with 4 bolts and nuts.

3.2.3. Between the steel bars and the milling plate are pieces of heavy chicken wire.
3.2.3.1. The dimensions of the chicken wire are 2 x 12.5 inch
3.2.3.2. Align the chicken wire with the bolt holes to keep the chicken wire secure.

Figure 18. Diagram showing the distances between bolt holes for the milling plate.
3.2.3.3. The wire may need to be bent in the opposite direction the plate will be spun if it is coming into contact too strongly with the sides, as is shown in Figure 19.

Figure 19. Showing how the wire may need to be bent to accompany the sides of the bucket

3.2.3.4. Be sure that the wire reaches the filter, so that the cassava flour does not get clogged at the outlet.

4. PUTTING TOGETHER THE PIECES
4.1. Make sure the frame is weighted down, with weight or sand bags on the legs of the frame.
4.2. With the bucket already securely in the frame, put a bearing on the shaft and feed the shaft through the back of the bucket.
4.3. Push the bearing in the hole in Board F and insert the bolt and nut to stop lateral motion.
4.4. With the milling plate bars and wire already attached, put the plate inside the bucket and feed the center bolts through the shaft and secure tightly with nuts.
4.5. Feed the shaft through the hole in the lid and put the lid on the bucket tightly.
4.6. Put the second bearing on the shaft and secure it in the back of Board B.
4.7. Use the bolts and nuts to lock Board B onto the frame.
4.8. Feed bolt and nut through end of shaft to further restrict lateral movement of the shaft.
4.9. Attach the chain, previously used for the Cassava grater to the gear on the Milling Machine, being sure the chain is tight.
4.10. Feed Cassava and pedal the bicycle.
Parts Needed for Milling Machine

- 2x4 – 24 feet
- Screws
- Bolts
- Nuts
- 2 – Rolling Element Bearings, 1 ½ inch OD, 5/8 inch ID, ½ thickness
- 5 gallon Bucket and Lid
- Fine wire mesh
- Heavy chicken wire
- 5/8 inch and 22 inch length steel tube
- 2 inch PVC Slip Joint Adapter
- 2 inch PVC 90- elbow
- 8 inch straight PVC pipe
- 2 inch PVC reduction coupler
- PVC Primer and Glue
- Bicycle gear
- 9 ¾ x 13 inch Aluminum plate, 1/16 inch thick
- 2- ¾ x 12 ½ inch stainless steel bars, 1/8 inch thick
- Sand Bags

Storage

Cassava flour should be stored in clean and dry polypropylene bags or a similar containment unit. Cassava flour should not be stored in jerry cans or on bare floor. The important thing is that the storage device is dry and keeps moisture out.