

## Testing and evaluation of CFTRI Dal mill for pigeonpea (UPAS 120)

VIJAY K SINGH

Department of Processing & Food Engineering, College of Agricultural Engineering and Technology, CCS Haryana Agricultural University, Hisar 125004, Haryana, India; E-mail: vijurss@gmail.com

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### ABSTRACT

This study covers the performance study of CFTRI dal mill using UPAS 120 variety of pigeonpea as untreated and treated grains. The machine performance was carried out in term of maximum grain input and output capacity, degree of dehusking, milling efficiency, dal recovery and quality index. In dry milling method, it was found that the maximum grain input and output capacity were 83.77 kg/h and 54.85 kg/h, respectively. For milling of untreated grains the mill performances, viz., degree of dehusking, milling efficiency, dal recovery and quality index, were 99.97%, 89.32%, 71.04% and 89.34%, respectively, while the pearled grains, broken, powder, dal with husk and unhusked grains were 4.35%, 2.71%, 5.68%, 16.20% and 0.02%, respectively. The power consumption at no load and load conditions, with untreated and treated grains, were 0.90, 1.19 and 1.03 kW/h, respectively. Similarly, in milling of water treated grains, the maximum grain input and output capacity were 93.21 kg/h and 63.79 kg/h, respectively. Degree of dehusking, milling efficiency, dal recovery and quality index for treated grains were 99.90%, 92.83%, 75.21%, and 92.93%, respectively from the mill. The pearled grains, broken, powder, dal with husk and unhusked grains obtained from treated grains were 2.62%, 2.90%, 3.01%, 16.23 and 0.10% respectively. The power consumption at load with treated grains was 1.03 kw/h.

**Key words:** Dry milling, dal recovery, pigeonpea, quality index, wet milling

Pulses can be described as most valuable of the naturally occurring protein. Protein present in pulses is complementary to the proteins of cereals. Daily diets, including combination of cereals and pulses provide wide range of essential amino acids to predominantly vegetarian population of the country and for those who cannot afford expensive animal protein. Pulses are therefore, often regarded as poor men's meat (Mangaraj *et al.* 2013). It also provides energy, essential minerals, vitamins and several compounds considered beneficial for good health (Sadan *et al.* 2008). India is the largest producer (18.5 million tons) and processor of pulses in the world and also imports around 3.5 million tons annually to meet ever increasing domestic requirements of around 22.0 million tons (Patel 2015). In the country pulses are consumed mostly in the form of dal, dehusked and split kernel. Nearly 75% of the total legumes production is converted into the dal, which makes pulse milling as third largest food processing industry after wheat and rice (Garg and Agarwal 2005). Milling of edible pulses for production of dal is an age-old

process. Large quantity of pulses are milled at cottage and domestic level, where milling losses are about 10-15% (Lal and Verma, 2007). Milling procedures vary for pulse to pulse and from place to place. Thus, recovery of dal varies from 60-75% depending upon the type of pulses, techniques and mills adopted by the millers. Variety, agronomic conditions, size, maturity and uniformity are few factors which influence the milling outturn. Apart from these factors, conditioning of pulses, and machine parameters can cause lower recovery of dal by 10-20% (Vadivambal *et al.* 2007).

CFTRI pulse mill consists of vertical cone emery coated roller as milling unit, which rotates inside conical sieve. Reported milling efficiency of the mill is 78-80% by weight using standard recommended procedure giving broken 3-5%, and capacity of the mill is 100kg/h. CFTRI dal mill operates at speed 110 and 450 rpm. The objective of the present investigation was to test and evaluate recovery of dal, broken, powder, pearled grain, unhusked dal and unhusked grain in the output. It also aims to determine the power consumption, speed of milling unit, type and dimensions of belt and pulley, specification as well as any other marked audio-visual observation.

### MATERIALS AND METHODS

Pigeonpea variety UPAS 120 available at IIPR, Kanpur was used for testing and evaluation in the CFTRI mill. The grain was cleaned and graded. The oversize and undersize grains were rejected and intermediate size grains were used for conducting pulse milling.

**CFTRI Dal mill:** CFTRI dal mill is designed and developed by Central Food Technology Research Institute, Mysore and manufactured by A.M.I Engineering, Patna, Bihar. It is a semi-automatic composite unit consisting of a dehusking unit, aspirator assembly and reciprocating sieve arrangement, all combined in a manner that the entire system operates by 1hp electric motor. Pulses dehusking system consists of a vertical emery cone fixed to the shaft which can be lowered or raised by clearance adjustment screw with a chucknut and a wheel. The - emery cone is enclosed in a steel wire mesh cone fixed on the main frame of the machine, concentric to the emery cone. A hopper provided at the top gravity feeds the grains into the conical milling assembly for smooth in-flow of pulses. Wire mesh cone is covered by mild steel sheet to prevent escape of dust outside. A suitable steel ladder is provided so that the

operator may conveniently pour grains into the hopper. Just below the milling assembly, another inverted conical cavity is provided which collects the milled output. The discharge outlet at the bottom is



Fig. 1: CFTRI Dal Mill

connected to the aspirator assembly to collect powder and husk mixture in jute or cloth bags. Milled fractions, viz., dal with and without husk, whole and dehusked grains and broken are separated using reciprocating sieves. These fractions are collected in containers placed at the outlet for each fraction. All these operations in CFTRI dal mill are performed continuously.

**Milling Procedure:** As per recommendation of CFTRI Mysore, raw grains of pigeonpea were cleaned and graded, by CFTRI grader using 3.0 x 19 mm and 6.0 mm sieves. The uniform graded uniform sized grains were used for milling under untreated and water treated conditions. In treated milling method, whole grains were soaked in tap water for 1 h. After soaking, excess water was drained off and heaped for 3 hours. Grains were sun dried up to moisture content 10% (w.b.). Then the material was passed through CFTRI mill to carry out dehusking and splitting operations. Materials received at outlet, i.e., processed material was separated into various fractions using 2.5mm and 3.0 x 19.5mm sieve combination. The over flow grains contained whole unhusked and dehusked grain which were separated manually (Fig.1).

**Pretest operations:** Testing of dal mill was followed by some pretest operations under which raw pigeonpea were cleaned, graded, scratched and then conditioning of grain was performed. Just before commencement of test, machine was checked and gap between emery cone and conical sieve was adjusted according to grain size. Following pretest operations were performed;

**Cleaning and grading of grain:** Cleaning was carried out by CIAE air screen cleaner to remove light particles like

chaff, dirt, etc. Then, grading was done by CFTRI grader. The grains passed through 6.0 mm and retained over 3.0 x 19 mm sieve were used for milling. Grading was done to obtain uniform grain of pigeon pea.

**Pre-milling treatment:** In conditioning, whole pigeonpea grains were soaked in a tap water for 60 minutes. After soaking, excess water was drained off and grains were heaped for 3 hours followed by sun drying of grains up to 10.1 (% (w.b.) moisture content. Then the milling was carried out in CFTRI dal mill to performed dehusking and splitting.

**Testing steps and procedures:** The testing of CFTRI pulse mill using piogeanpea grains was performed mainly in three phases, namely, general testing, test at no load and test at load.

**General testing:** In this testing, the machine specifications like, overall dimension, power unit, milling unit, sieve unit, feeding unit, power transmission system and material of construction etc. were measured.

**Test at no load:** Under test at no load, the mill was run without giving any input for half an hour at the specified speed of different components. During this period the shaft speed, energy consumption and audio-visual observations were taken. Calculations related to these observations were performed.

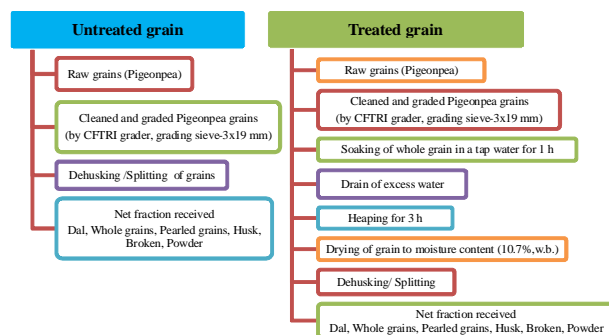


Fig. 2. Process flow chart for milling of untreated and treated grains

**Test at load:** In test at load conditions, 5 kg of untreated and treated pigeonpea grains (UPAS-120) were milled and observations were recorded for power consumption, input-output capacity and milling performance.

Table 1. Specification of machine

Machine parameter			
Sr. No.	Pullies	Diameter, cm	RPM
1	Motor pullies	11.5	1425
2	Emery pulley	30	100
3	Grader pulley	30	398
4	Blower pulley	5	2930
Grading Unit			
1	I screen	Size = 47x24.3 cm <sup>2</sup> Circular holes/cm <sup>2</sup> =6	
2	II screen	Size = 47x24.3 cm <sup>2</sup> Circular holes/cm <sup>2</sup> =2	
3	Strokes	No. of strokes/min.	98
4	Screen slope (θ)	$\cos \theta = \frac{\text{Projected length of sieve at ground}}{\text{Inclined length of sieve}} = \frac{112.1}{112.23} = 2.76^\circ$	

**Analysis of response parameters:** The following milling parameters were recorded during the experiment conducted in the IIPR (Indian Institute of Pulse Research) lab:

## RESULTS AND DISCUSSION

**General Testing:** In general testing, specifications, material of construction, visual observation and provision for various adjustments of the mill were checked and measured. The length, width and height of CFTRI dal mill were 1720 mm, 840 mm and 2025 mm, respectively. A 1 hp single phase induction motor was used as power unit. Milling unit consists of vertical emery cone rotating inside conical spring wire mesh sieve. The emery cone has overall dimensions of base diameter 31.0 cm and height 18.0 cm. Milling clearance at inlet was 11 mm while at outlet it was observed to be 5mm. Milling unit is rotated by a shaft of diameter 3.54 cm. The diameter of pulley attached to motor was 11cm. The sieving unit consists of two rectangular sieves each having overall size of 47 x 24.3 cm. For grading of pigeonpea dal, combination of circular sieve of 2.5mm diameter, 6 numbers of hole per cm<sup>2</sup> and rectangular sieve with 19x3mm size and 2 numbers of hole per cm<sup>2</sup> were found most effective. Sieving system of milled dal is attached to milling unit and supported on frame at a slope of 2.75°. The speed of milling unit was fixed at 100 rpm.

Grain is fed through feeding hopper having size 43x43cm at the upper end and 8x8 cm at the lower end. The

hopper is located at a height of 266 cm above the ground level to gravity feed the grains into the mill. Components of the machine were constructed of different material. Frame is made of mild steel while feeding trough is made of mild steel sheet. Milling unit, i.e., cylinder is made of carborandum and is coated over emery base. Main shaft is made of high carbon steel and pulley is made of cast iron. B-Belts made of rubber are used for power transmission. Sieve is constructed by perforated sheet metal. The machine provides easy replacement and cleaning of sieve. Belt tightening is possible by adjusting motor position. Milling clearance can be adjusted according to crop and grain size. Feed rate can be controlled by adjusting the opening of inlet. Milling shaft can be adjusted for two rotational speeds. Sieve slope is fixed but sieve combinations can be varied as per crop requirement.

**Test at no load:** During test at no load the machine was run for 30 minutes and readings of energy meter were taken after each 5minute. The power consumption in 30 minutes was noted to be 0.45 kWh. Finally, the power consumption at no-load was found 0.90 kWh. There was no marked oscillation/vibration, undue knocking or rattling sound, unusual wear or slackness in any component. The shafts were running properly/smoothly in their respective bearings, there was no marked rise in temperature of the bearings and belts were functioning properly.

**Table 2. Milling parameters**

S. No.	Parameters	Formula	
1	Dal recovery (%)	$\frac{\text{Weight of dal after milling}}{\text{Weight of whole grains before milling}} \times 100$	
2	Pearled grain (%)	$\frac{\text{Weight of pearled grain after milling}}{\text{Weight of whole grains before milling}} \times 100$	
3	Broken (%)	$\frac{\text{Weight of broken after milling}}{\text{Weight of whole grains before milling}} \times 100$	
4	Powder (%)	$\frac{\text{Weight of powder after milling}}{\text{Weight of whole grains before milling}} \times 100$	
5	Husk (Dal with husk) (%)	$\frac{\text{Weight of husk after milling}}{\text{Weight of whole grains before milling}} \times 100$	
6	Unhusked grain (%)	$\frac{\text{Weight of unhusk after milling}}{\text{Weight of whole grains before milling}} \times 100$	
7	Degree of Dehusking (%)	$DD = \frac{\text{Total input weight, g} - \text{Weight of whole unhusked grain, g}}{\text{Weight of whole unhusked grain, g}} \times 100$	
8	Quality Index (QI)	$QI = \frac{F_w}{F_w + B_w + P_w} \times 100$ $F_w = \text{Finished product weight (Dehusked split \& full grains)}$ $B_w = \text{Broken weight, } P_w = \text{Power weight}$	
9	Milling efficiency (%)	$ME = \frac{DD \times QI}{100}$ $DD = \text{Degree of Dehusking}$ $QI = \text{Quality Index}$	
10	Maximum input capacity (MIC)	$MIC = \frac{\text{Quantity of whole grains fed in inlet of milling unit}}{\text{Time}}$	kg/h
11	Dal output capacity (DOC)	$DOC = \frac{\text{Dal received at the end of process}}{\text{Time}}$	kg/h
12	Power consumption	Energy meter was used	kWh

**Table 3. Test data of untreated pigeonpea grains**

S. No.	Parameters	Sample I	Sample II	Sample III	Average values
1	Dal recovery (%)	72.86	72.50	67.76	71.04
2	Pearled grain (%)	4.76	4.46	3.82	4.35
3	Broken (%)	2.82	2.70	2.62	2.71
4	Powder (%)	3.35	4.29	9.39	5.68
5	Dal with husk (%)	16.20	16.03	16.36	16.20
6	Unhusked grain (%)	0.03	0.01	0.03	0.02
7	Degree of Dehusking (%)	99.97	99.98	99.97	99.97
8	Quality Index	92.60	89.79	85.62	89.34
9	Milling efficiency (%)	92.57	89.77	85.59	89.31
10	Maximum input capacity (kg/h)	95.54	76.42	79.36	83.77
11	Dal output capacity (kg/h)	66.03	51.05	47.49	54.86
12	Power consumption (kWh)				
	at no load	0.84	0.96	0.96	0.92
	at load	1.08	1.20	1.29	1.19

**Table 4. Test data of treated pigeonpea grains**

S. No.	Parameters	Sample I	Sample II	Sample III	Average values
1	Dal recovery (%)	77.84	74.40	73.39	75.21
2	Pearled grain (%)	3.84	2.54	1.47	2.62
3	Broken (%)	2.41	2.70	3.60	2.90
4	Powder (%)	3.66	4.08	4.58	4.11
5	Dal with husk (%)	16.24	16.10	16.36	16.23
6	Unhusked grain (%)	0.10	0.16	0.04	0.10
7	Degree of Dehusking (%)	98.90	98.83	98.96	98.90
8	Quality Index	96.67	91.89	90.22	92.93
9	Milling efficiency (%)	96.57	91.73	90.18	92.83
10	Maximum input capacity (kg/h)	94.63	87.71	97.29	93.21
11	Dal output capacity (kg/h)	66.97	59.46	64.94	63.79
12	Power consumption				
	at no load	0.84	0.96	0.96	0.92
	kWh at load	1.02	1.03	1.03	1.03

**Test at load:** The results of test at load are discussed for milling of untreated and water treated pigeonpea grains. The moisture content of untreated and treated pigeonpea grains were 8.9% (w.b.) and 10.1% (w.b.), respectively. Five kg sample was fed into the hopper and performance data were recorded. The experiments were conducted in triplicate and results were tabulated as below:

**Untreated grain:** Table 3 shows that the maximum grain input and output capacity are 83.77 kg/ha and 54.86 kg/h, respectively. The machine degree of dehusking, milling efficiency, dal recovery and quality index, are 99.97%, 89.31%, 71.04% and 89.34%, respectively while the pearled grains, broken, powder, dal with husk and unhusked grains are 4.35%, 2.90%, 5.68%, 16.20 and 0.02%, respectively. The power consumption at no load and load conditions are 0.92 and 1.19 kWh, respectively.

**Treated grains:** Table 4 shows that the maximum grains input and output capacity are 93.21 kg/hand 63.79 kg/h respectively. The machine degree of dehusking, milling efficiency, dal recovery, quality index, are 99.90%, 92.83%, 75.21% and 92.93%, respectively, while the pearled grains, broken, powder, dal with husk and unhusked grains are 2.62%, 2.90%, 4.11%, 16.23 and 0.10%, respectively. The power consumption at no load and load conditions are 0.92 and 1.03 kW/h respectively.

## CONCLUSION

CFTRI dal mill was evaluated for milling performance of pigeonpea variety UPAS-120. Dry and wet milling

methods, commonly adopted at small scale milling, were used in this study. The study revealed that throughput capacity of the mill increases by 8.94kg/h for water treated grains in comparison to dry grain milling. Similarly increase in other parameters, viz., degree of dehusking, milling efficiency, dal recovery and quality index were observed to be 0.07, 3.51, 4.17 and 3.59%, respectively. Water soaking followed by sun drying pretreatment also helps in saving the energy by 0.16 kWh. Performance evaluation of CFTRI dal mill for toughest-to-mill kind of pulse, i.e., pigeonpea, indicates suitability of the unit for different pulses.

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