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A Village-level Pigeonpea Processing Machine for Sri Lanka

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ABSTRACT

Vegetable proteins occupy an important place innutritional securityin rural Sri Lanka; and theseprimarily come from different pulses and vegetables. Annual production of the traditionallygrown pulsesin the island falls shortof demand andto offsetthis deficit, a new pulse pigeonpea (*Cajanus cajan*), was introduced from India. This pulse found good adaptation in the Dry and Intermediate rainfall zones of the country. Since pigeonpea grains need dehulling and splitting before consumption, it was found necessary to develop a processing machine so that the farmers´produce could be converted into *dal* (decorticated splits) for domestic consumption and local marketing. Hence, a small-scale pigeonpea processing machine was designed and fabricated bythe Department of Agriculture, using locally available resources. This machine is simple, compact, and easy to transport and operate using domestic power supply. Besides pigeonpea, it can also process other pulses such as cowpea, green gram, and black gram. The present paper describes key features of the machine in relation to its design, fabrication, operation, and maintenance.

Keywords: Abrasion, Attrition, Dehulling, Design, Milling, Splitting

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INTRODUCTION

In Sri Lanka, the staple food is rice and pulses provide the cheap source of protein. Traditionally, such pulses as green gram (*Vigna radiata*), black gram (*Vigna mungo*), and cowpea (*Vigna unguiculata*) are cultivated in the country. But interestingly, lentil (*Lens culinaris*), which is not cultivated in the country, is the most popular cuisine amongst the people of all classes. To meet this requirement the entire lentil (about 50,000 t annually) is imported, and this drains out a reasonable proportion of foreign currency (Saxena, 1999).

Under this scenario, the Department of Agriculture was on the lookout for a substitute which could be grown locally; and this search ended with pigeonpea (*Cajanus cajan*) because of its multiple uses (Saxena *et al.*, 2021) and adaptation to marginal growing conditions of the island. Unfortunately, unlike other pulses, the pigeonpea grains cannot be cooked and consumed directly because of their tannin-rich hard seed coat; and these need to be removedformarketing and consumption. According to Swamy *et al.* (1991) the adherence of husk to the cotyledons is strong and it is due to the presence of arabinogalactan type polysaccharide, which is gummy and hygroscopic in nature. Therefore, as a first step in milling loosening of seed coat is carried out either by soaking the grains in water, treating the grains withwater and oil, or using $NaHCO_3$ solution. This is followed by dehulling and splitting of grains through mechanical means. In India, which accounts for >85% of global produce, the conversion of grains into *dal*at village level it is done by using stone mills (*chakki*), which operate at low pressure to split the grain (Kurien and Parapia, 1968). At commercial level, pigeonpea grain processing is undertaken by over 10,000 medium- to large-scalemilling units in the major pigeonpea growing states (Kulkarni, 1989).

To provide relief to the rural folks, who cannot easily transport their produce to the commercial mills, various Agricultural Universities and research organizations from time to time developed small village level pigeonpea processing machines (Anonymous, 2013). Notable among them were IARI de-husking CUIITT splitting machine, CIAE de-husking and splitting machine, PKV mini dal mill, CFTRI hand operated pulse de-husking machine, CFTRI mini dal mill, Pantnagar manually operated dal mill, Pantnagar mini dal mill, and IIPR mini dal mill. Also, several private entrepreneurs and State Agro-industries developed small-scale pigeonpea processors in Maharashtra, Gujarat, and Rajasthan (Vikaspedia, 2022). Since no such facility wasavailablein Sri Lanka, from the outset the pigeonpea grain processing was given high prioritywhile introducing the crop in the island country. Accordingly, theFarm Mechanization Research Centreof the Department designed and developed a versatile small-scalepigeonpea processing machine. This paper, besides describing its design and other technical details, also highlights its operational and maintenance procedures.

MATERIAL AND METHODS

Obligatory parameters: Since this was a multi-locational small farmer-oriented project, it was found necessary that the targeted processing machine is light weight, compact, can operate on domestic power with minimum wear and tear, andhigh operational safety standards. Besides, it should yield high quality dehulled splitswith acceptable recovery ratesin different grain size grades.

Materials: To provide stability during its operation and ease in transportation, the machine frame was constructed using

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rigid 5-cm angle iron. To develop the milling unit, the abrasive carborundum of No. 16 grit paste was used. To avoid damage to the grains during milling 9-mm thick cushioning rubber sheet was acquired. For grain cleaning and grading three types of metal sieves were obtained. These included (i) 25 x 20 cm size sieve with 2.5 mm diameter round holes, (ii) 25 x 20 cm sieve with 4 mm round holes, and (iii) 60 x 20 cm sieve with 3.2 mm oblong holes. To collect the graded materials one hoper for each sieve was arranged. Besides these, a blower and a flexible hose were also obtained. For operating the machine, a 1-hp single phase electric motor was used.

Methods: This pigeonpea processing machine was designed and fabricated by Farm Mechanization Research Centre, Department of Agriculture, MahaIlluppallamma, Sri Lanka. The prime emphasis in this endeavour was to use the locally available construction materials and human resource.

As a first step, the cleaned and graded grain lotwas passed through the milling unit for initial pitting or scratching the husk to facilitate oil absorption. The pitted grains were thoroughly mixed with 1% oil and spread in open yard for sun drying for a couple of days. Each night the lot was heaped and covered to conserve heat. About 2-3% of water was added to thegrains before milling.

Once completed, the machine was put to rigorous testing at the Institute´s workshopusing the pre-treated grains. This was followed by on-farm testing and training of the potential village-level operators in different areas ofthe Dry and Intermediate zones.

RESULTS AND DISCUSSION

Salient Features of the Machine

The machine is 150 cm in height, 180 cm in length, and 95 cm in width (Fig. 1) and its gross weight is 130 kg. This pulse processor elegantly integrates three operating assemblies – milling, air respiration, and cleaning plus grading (Fig. 2). These units are mounted on a 5-cm angle iron frame andall the units are simultaneously driven by 1-hp single phase four-pole electric motor. It can process about 40 kg grain in one hour with 70-74% dal recovery.

Fig. 1: The milling machine

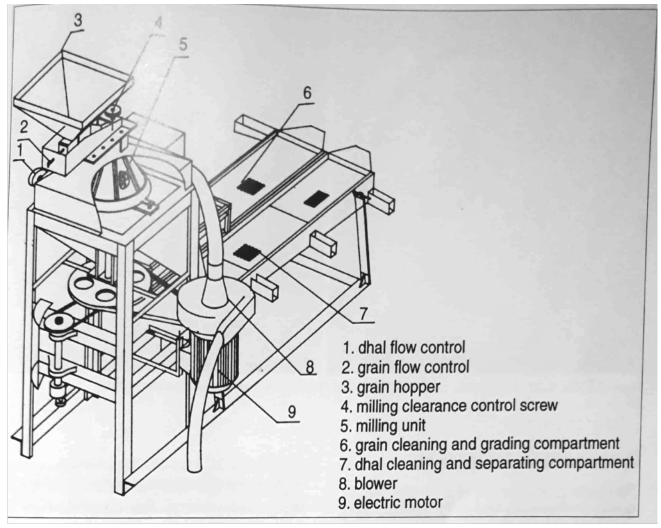

Fig. 2: Schematic diagram of dal mill

Milling assembly: The milling assembly consists of a feeding hopper, a dehulling unit, and a collection hopper. A grain flow control gate is located below the feeding hopper. This unit consists of a rotary inner abrasive cone, an outer hollow cone, metal base plate, and a mount. The rotary inner cone (13.2 cm in height with 25.7 cm base diameter) is attached to the upper end of the drive shaft that runs on a sealed ball bearings housed in a bearing bracket (Fig 3). The shaft is driven @ 300 rpm. The rotary inner cone has a rigid outer lining made of No. 16 grit carborundum. The outer cone has two types of lining on the inside surface. The upper portioned is lined with 9-mm thick rubber sheet, while the lower portion (3.8 cm high band) is lined with abrasive carborundum grit. The combined attrition-abrasion forces ensured good dehulling and splitting operations.

To adjust the milling clearance, the outer cone can be moved upward or downward with the help of a spring-loaded bolt located at the top of the cone. As the inner cone rotates, the grains move from top to bottom in a spiral path around the cone, due to their weight and the friction forces exerted on them. The grains also tend to rotate as they move down, and the abrasive forces action helps remove the seed coat. The rotation of grains is an important event, and it is facilitated by

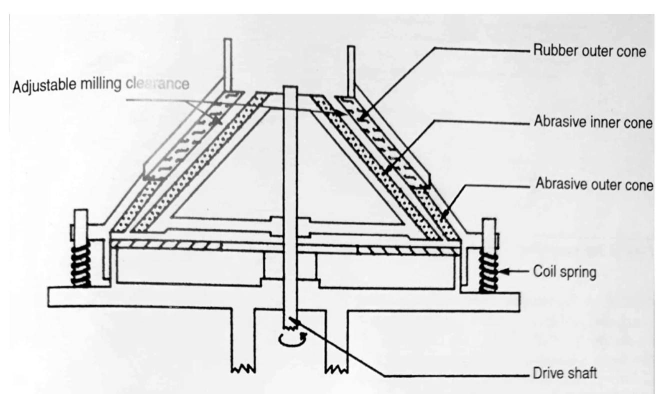

Fig. 3: The milling unit

the frictional forces exerted on them and the softness of the rubber lining. These frictional forces are less powerful than the shear strength of the gum layer bonding the two cotyledons of the grains. This results in the exertion of a force-couple on the grains that helps to rotate them and thereby facilitate their dehulling. The dehulled unsplit grains (called pearls) move further down into the space between the inner cone and the lower abrasive portion of the outer of the outer cone. At this point, the frictional forces exerted on the "pearls" exceed the shear strength of the gum layer between the two cotyledons, resulting in the pearls being split into two cotyledons (i.e. dal). The splits and husk drop directly into a hopper, placed below.

Air aspiration assembly: A blower, directly coupled to the drive motor, helps to remove the chaff and other light particles from the milled grains immediately after milling. A flexible hose connects the blower suction port to an air duct through which the milled grains are delivered to the cleaning and grading sieves after processing.

Cleaning and grading assembly: The cleaning and grading of grain and splits are carried out by using sieves of different sizesmounted on a single frame. This unit is divided into two compartments to receive whole grain and splits separately and it rests on four wooden arms to facilitate optimum oscillation with a backward angle of 9o. The compartments are slightly inclined (2o) towards the front. The unit oscillates at 5 cycles per second, with an amplitude of 12 mm. The top tier of the unit has a single 50 x 20 cm sieve with 7 mm diameter holes. The lower tier has two sieves -a 50 x 20 cm sieve with 3.5 mm oblong holes, and another 60 x 20 cm sieve with 5.5 mm diameter holes. The dal cleaning and grading compartment consists of a series of sieves. The first sieve (25 x 20 cm) has 2.5 mm diameter round holes; the second sieve (25 x 20 cm) has 4 mm round holes, and third sieve (60 x 20 cm) has 3.2 mm oblong holes. A separate hopper is attached to each sieve to collect the graded material that drops through the holes.

Maintenance and Repair

This pulse processor has been designed for trouble-free operation and minimum maintenance. Even though the machine has several vital moving parts, no pivot point uses self-lubricating polyethylene bushes that can be replaced easily without any special tool. Both the main drive shaft and the intermediate shafts are mounted on long- lasting self-lubricating sealed ball bearings. The most fragile components of the machine are the wooden swinging arms of the oscillating unit which can be damaged by inappropriate handling or transport. Therefore, it is advisable to keep one spare set of swinging arms while operating this machine in remote areas.no other parts are required for routine operationof the machine. Table 1 gives an outline of a typical maintenance schedule. The maintenance costs of operating this machine can easily be afforded by small-scale millers.

Table 1: Summary of routine maintenance of the processing machine

Interval of operation	Maintenance jobs
750 hours	Replace polyethylene bushes
5000 hours	Redress abrasive cone Replace rubber lining of outer cone
15000 hours	Replaster abrasive cone Replace ball bearings

Technical and Socio-economic Feasibility

Handling and operation: This machine isdriven by a 1-hp single phase electric motor and can therefore be operated on domestic supply. The machine is built on a rigid metal frame base and does not need to be fixed on the ground. It can be transported easily from one place to another. The versatility of the machine in processing different types of pulses has increases its utility. No specialized technical skill is required to operate this machine.

Safety features: The processing machine has been designed for a high standard of safety with respect tonoise level, vibration, location of the movingparts and control devices, installation of electric equipment etc. the standard shock-proof electric equipment eliminates the risk of electrocution. All the moving parts of the machine are compact and enclosed. Once the machine is set in its optimum processing mode, the operator can move freely around it without any risk of accident.

Setting the machine for processing

Before processing any material, three critical adjustments are made to the machine to optimize the output capacity, recovery, and quality.

Grain flow control: The rate of grain flow into the milling chamber is important determines the dehulling quality. High grain flow reduces the quality and increases losses due to breakage. Sometimes, the machine can be overloaded by an excessive flow of grain. On the other hand, reduced grain flow will lower the output of the machine. The grain flow into the milling chamber can be controlled by adjusting the sliding plate located at the bottom of the grain hopper.

Milling clearance: This is most critical adjustment of the machine. The gap between the outer and inner cones can be

Table 2: A comparison of three mini dal mills for de-husking efficiency (%) and dal recovery (%) using various grain treatments

Treatment	Parameter	IIPR dal mill	CIAE dal mill	CFTRI dal mill	Sri Lanka dal mill
Raw grain	De-husking efficiency	49.53	40.35	45.35	-
	Dal recovery	42.60	38.00	40.60	-
Water soaked grains	De-husking efficiency	87.90	77.09	88.10	-
	Dal recovery	75.60	68.00	76.60	-
Oil + water Treatment	De-husking efficiency	98.90	79.86	98.20	98.30
	Dal recovery	77.20	51.40	75.80	70-74
$NaHCO_3$ Treatment	De-husking efficiency	95.20	85.48	94.75	-
	Dal recovery	75.38	50.70	72.20	-

Source: Vikaspedia. 2022. A portal Govt of India, Ministry of Electronics andInformation Technology, Govt. Centre for Development of Advanced Computing, Hyderabad.

controlled by turning a bolt located at the top of the milling unit. Tightening the bolt clockwise pushes the outer cone downward, reducing the gap between the cones. This gap must be re-adjusted for each grain lot.

***Dal* flow control:** The milling assembly has a plate with two ports through which the milled grains are dropped into the hopper below. One of these ports is always open, while the other, the *dal* flow control port, can be opened or closed by turning a screw that moves the sliding plate over the port. When processing large-seeded pulses, both ports are kept open. For such small grains as black gram, the adjustable flow control port is closed.

Milling efficiency: In a comparison of three small scale pigeonpea processing machines, the oil and water pre-treatment produced yielded over 98% de-husking efficiency and 75-77% dal recovery using IIPR and CFTRI dal mills (Vikaspedia, 2022). The results of Sri Lankan dal mill matched well with respect to these two parameters (**Table 2**).

CONCLUSION

Small-scale pigeonpea processing machine is simple, compact, and easy to transport and operate using domestic power supply. Besides pigeonpea, it can also process other pulses such as cowpea, green gram, and black gram.

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REFERENCES

Anonymous. 2013. CPE Chapter 6: Methods of milling. Short course on post-harvest processing and agro processing centers for value addition in rural areas. Post-Harvest Technology Scheme, University of Agriculture Sciences, Bangalore.

Kulkarni S D. 1989. Pulse processing machinery in India. *Agric. Mech. Asia Lat. Am.* **20**: 42-48

Kurien PP and Parpia H A B. 1968. Pulse milling in India. Processing and milling of tur (arhar). *Journal of Food Science and Technology* **5**: 203-207.

Saxena KB. 1999. Pigeonpea in Sri Lanka. Monograph. International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, A.P., India. Pp 99.

Saxena KB, Choudhary AK, Dalvi VA, Saxena RK, Ghosh J, Singh S, Verma P, and Kumar S. 2021. Pigeonpea is significantly more than just a delicious pulse. *Journal of AgriSearch* **8**: 177-187.

Swamy R N, Ramakrishnaiah N, Purine P P, and Salimath P V. 1991. Studies on carbohydrates of red gram in relation to milling. *Journal Science Food and Agriculture* **57**: 379-390.Vikaspedia 2022.

A portal of Government of India, Ministry of Electronics and Information Technology, Centre for Development of Advanced Computing, Hyderabad.

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