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Optimization of speed for sorghum *Hurda* extraction machine

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Abstract
Sorghum (*Sorghum bicolor* L.) is an important cereal crop for food and fodder of Indian next to rice, wheat and maize. Sorghum has nutritional composition similar to or better than rice and wheat in some aspects. The grains contain high fiber and non-starchy polysaccharides and starch with some unique characteristics. Protein quality and essential amino acid profile of sorghum is better than many of the cereals and millets. Sorghum in general is rich source of fiber and B-complex vitamins (Chavan *et al.*, 2013). *Hurda* is the name given to tender *Jowar* - the main staple grain of rural Maharashtra, India. In early January, *jowar* grain is juicy and very tender. Just the right time to be eaten roasted. It is generally picked from fields and roasted there and then; this young *jowar* tastes awesome when roasted. The manual extraction that means removing grains with indigenous techniques is very time consuming process. The availability of suitable *hurda* machine for this crop would eliminate all drudgery and losses of the crops. Efforts were made to optimize the speed of developed hand operated sorghum *hurda* extraction machine for extraction sorghum *hurda* grains at Post Harvest Engineering & Technology, Dr. PDKV, Akola. Performance evaluation was carried out and different response parameters viz., extraction efficiency, percent grain loss and percent mechanical damage were studied. The developed machine is quite reliable and feasible for sorghum *hurda* extraction. The working capacity of the machine was found to be11.65 kg/h. The maximum extraction efficiency was found to be 85.5% for the speed at 75rpm and 16 kg/h feed rate. The total grain loss including mechanically damaged is 17.01% and the particular mechanically damaged grain loss is 1.3% at the 75 rpm and 16 kg/h feed rate.

Keywords: Optimization, *Hurda*, machine, sorghum

Introduction
Jowar is the Indian name for sorghum, a cereal grain. Also known as white millet, which can be roasted, steamed, boiled, added to soups and stews or can be ground to flour. Sorghum has nutritional composition similar to or better than rice and wheat in some aspects. The grains contain high fiber and non-starchy polysaccharides and starch with some unique characteristics. There is a considerable variation in sorghum for levels of proteins, lysine, lipids, carbohydrates, fiber, calcium, phosphorus, iron, thiamine and niacin. Protein quality and essential amino acid profile of sorghum is better than many of the cereals and millets. Sorghum in general is rich source of fiber and B-complex vitamins (Chavan *et al.*, 2013) [2].
Largest share of country's production is contributed by Maharashtra and Karnataka states. Due to its ability to grow in dry lands of tropical Africa, India and China it has become the staple diet of these countries also. Sorghum is the main staple food of Maharashtra, Karnataka, and is also an important food of Madhya Pradesh, Tamil Nadu and Andhra Pradesh (Chavan *et al.*, 2013) [2].
Hurda is the name given to tender *Jowar* - the main staple grain of rural Maharashtra, India. In early January, *jowar* grain is juicy and very tender. Just the right time to be eaten roasted. Generally farm party called *hurda* party is organized where the freshly plucked young tender *jowar* is roasted. It can be directly eaten after roasting when it is still hot and tender. To accompany they have jaggery (*gud)*, *shengdana-lassun chutney* (both red and green), dry *khobra chutney* (dry coconut), *wangabhaji* (Brinjal vegetable) and *taak* (butter milk). Hot and spicy *theecha* made of green chillies and garlic is also served (Anonymous, 2013) [1].

Without roasting With roasting

Plate 1: Manual *hurda* extraction process

There is a need to popularize sorghum foods as sorghum with its high mineral and fiber content and with low or slow starch digestibility makes an ideal food for diabetic and obese population in the urban as well as rural society. Nowadays agro-tourism business is increasing in the rural area and in that contest supplying sorghum *hurda* as a niche product get the more profit to the farmer/producer (Chavan *et al.*, 2013) [2]. The development of hand operated *hurda* extraction machine for sorghum crops has not received the attention proportional to its importance to the farmers in the country. The studies have been inadequate and incomplete for optimization of speed for extraction of sorghum *hurda* for cereals in general to sorghum.

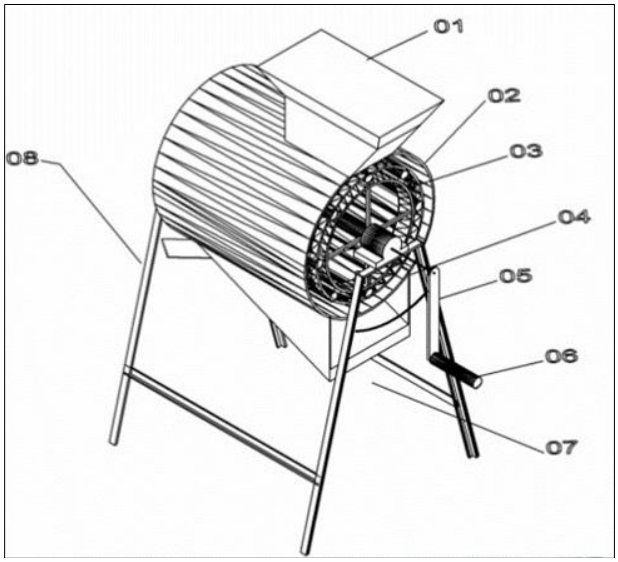
Keeping the above facts, this study was proposed for optimization of speed for hand operated sorghum *hurda* extraction machine. It was proposed with specific references to the crops and farmers of Maharashtra state.

Material and methods

Machine description

At present, the mechanism of green sorghum *hurda* extraction machine was developed at AICRP on PHT, Dr. PDKV, Akola. PKV- Ashwini variety was used for the performance of machine. The machine mainly consisted of three units viz., feeding unit, extraction unit and seperation unit. The feeding unit consisted of hopper fabricated by using 1.22 mm thick MS sheet. It had 150 mm length, 100 mm width at bottom, 145 mm front width, 285 mm length at upper edges. Extraction unit comprised of concentric perforated cylinder. The length of cylinder was kept 302 mm. It was fitted on ring made up of MS flat of size (25×4) mm mounted on the shaft of diameter (ϕ) 25 mm. The basic structure of perforated cylinder consisted of GI of 22 gauges having outer diameter of 250 mm. There was arrangement of bar of 8 mm in size and 10 cm in length given to the shaft assembly for supporting it for stability of rings fitted on both ends of shafts. Separation unit consists of two discharge units *i.e.* one for discharging straw and another for grains. A sieve of 5 mm round holes, was provided below the perforated cylinder. The inclination was given to the discharge units to both of the straw and grains *i.e.* 50° and 40° respectively. It was made up of aluminum sheet.

The fresh cleaned samples were used for further experimentation. PKV- Ashwini variety was used for extraction. Before start of actual experiments, preliminary trials were conducted. The engineering properties viz., size, surface area, sphericity, bulk density, true density, porosity, angle of repose of grains and panicles were determined. The weighed 5000 g sample was used for each experiment. The panicles were fed through the hopper manually. The experiment was conducted at three different feed rates viz., 14 kg/h, 16 kg /h, 18 kg/h with three different speed viz., 50 rpm, 75 rpm, 100 rpm. After completion of Extracting efficiency, damaged grains, unextracted panicles etc. were were measured critically as per standard procedures. (Gaikwad *et al.*, 2015) [3].



1. Feeding unit
2. Outer case
3. Extraction unit
4. Sieve
5. Driven assembly
6. Main Frame
7. Outlet for grains
8. Outlet for straw

Fig 1: Isometric view

Plate 2: *Hurda* extraction machine

Plate 3: *Hurda* extraction machine in operation

Results and discussion

Extraction efficiency

The results of extraction efficiency of the machine are presented in Table 1. Test results indicated that extraction efficiency was between 81.7 to 85.5% for the range of

variables studied. Extraction of sorghum *hurda* at 16 kg/h feed rate and speed of 75 rpm produced the highest efficiency of 85.5% and sorghum hurda 16 kg/h feed rate with the speed of 50 rpm produced the lowest threshing efficiency of 81.7% (Fig. 2).

Percent total grain loss

The quantity of unextracted grains, mechanically damaged grains and grains at straw outlet collected and recorded. Speed of cylinder found to be prominent influencing parameter for the grain loss and varies directly. The variation was observed to be to 17.01 to 21.5 % (Table 1). Grain loss vary significantly with cylinder speed. Graphical representation of variation of total grain loss with respect to feed rate and cylinder speed is shown in Fig.3. Similar results have been reported for threshing sunflower (Moussa and Mohamed, 2005) [4].

Mechanical grain damage percentage

The grains were damaged in the extraction also be determined during the evaluation. For speed of cylinder 50 rpm, 75 rpm and 100 rpm, the variation is significant and found to be 1.6, 1.4 and 2.2%, respectively. However, for higher feed rate, the mechanical grain damaged 1.9% was observed. Similar trend has been reported by Moussa and Mohamed (2005) [4]. It is presented in Table 1.It is shown in Fig.4.

Table 1: Observations on performance of sorghum *hurda* extraction machine

Treatments	Extracted grains, g	Extraction efficiency,%	Total grain loss,%	Mechanically damaged grain loss,%
S1F1	3166.00	82.3	1.7	21.5
S1F2	3320.83	81.7	1.3	20.7
S1F3	3367.33	83.4	1.7	19.9
S2F1	3362.83	84.6	1.4	19.5
S2F2	3496.33	85.5	1.3	17.01
S2F3	3460.83	83.3	1.5	17.2
S3F1	3422.00	84.8	1.9	17.9
S3F2	3403.66	84.00	2.3	19.0
S3F3	3379.16	84.9	2.5	17.3
Mean	3375.44	83.83	1.73	19.8

Speed of cylinder, Feed rate
S1=50 rpm F1=14 kg /h
S2=75 rpm F2=16 kg/h
S3= 100 rpm F3 =18 kg/h
Replications= R1, R2, R3

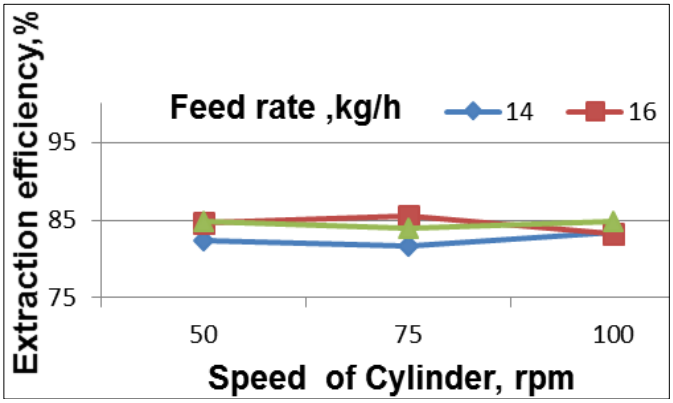


Fig 2: Effect of feed rate and speed of cylinder on extraction efficiency

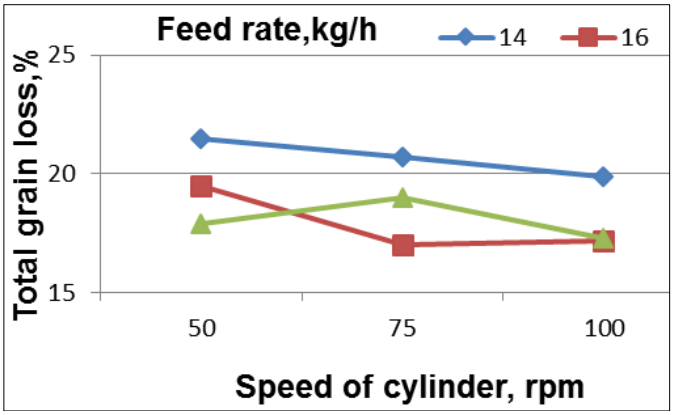


Fig 3: Effect of feed rate and speed of cylinder on total grain loss percentage

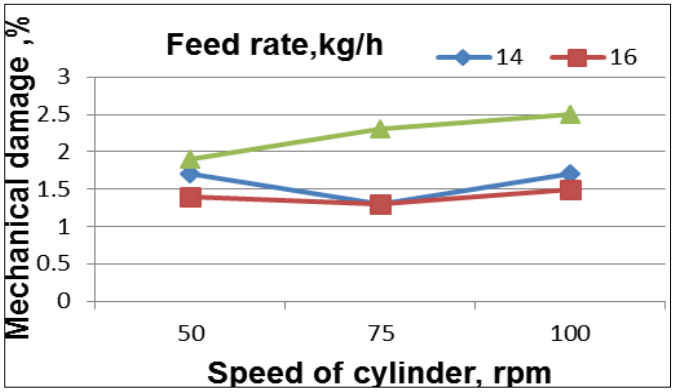


Fig 4: Effect of feed rate and speed of cylinder on mechanically damaged grain

Conclusion

To achieve maximum extraction efficiency, with minimum grain loss and mechanical grain damage, the operational parameters of sorghum *hurda* extraction machine could be decided by optimization of the analysis of variance. It has been observed that the optimum performance was found at speed of cylinder 75 rpm as the overall performance of speed of cylinder was superior to other cylinder speed in respect of total grain loss and working capacity. It can be concluded that the developed machine is quite reliable and feasible for sorghum *hurda* extraction with optimized parameters.

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