

Feasibility study of wet grinding of rice and black gram by bullock operated rotary transmission system in rural areas

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■ **ABSTRACT** : A wet grinder was attached to the rotary transmission system operated by a medium pair of bullocks having a pair weight of 610 kg. The combination of the bevel and spur gears in the system could produce a rotation ratio of 1:29 in the out put shaft. Further, flat and V pulleys were arranged to get the required rpm of 450 for operation of the wet grinder. Rice samples were soaked for 6h at room temperature before grinding. Black gram samples were soaked only for 3h. The ingredients were passed through the hopper with different ratio of rice and black gram as 1:0, 1:4, 1:1, 4:1, 0:1, respectfully. Water was added at the rate of 300 ml per kilogram of mixture. The draft requirement during the operation varied from 30 kg in the beginning to 24 kg at the end, the mean being 27 kg which was 4.43 % of the bodyweight of the bullocks. The physiological responses of the bullocks like heart rate, respiration rate and body temperature increased upto 66 beats/min, 22 blows/min and 38.2°C, respectively after one hour of operation. The fatigue score of the bullocks was observed to be 14, well within safe limit of 20. The particle size of the batter came out was in between 200 µm to 300 µm. More was the quantity of black gram in the mixture more was the fine particles in batter. The average batter output over one hour of operation was 9 kg /h. Grinding efficiency of wet rice and black gram at different ratio varied from 81 to 86 %.

■ **KEY WORDS** : Batter, Wet grinding, Rice, Black gram, Fatigue score

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Generally cereal and legumes form an important part of the human diet in south-east Asia, Middle East and Africa. Wet grinding is a critical step in the preparation of batter based traditional food products like idli, dosa and vada. It involves both physical and chemical changes of the ingredients. In wet grinding of cereals, the protein matrix holding the starch granules is destroyed, releasing the starch granules from the protein network (Kent and Evers, 1994). In rural areas, wet grinding is mostly performed by traditional manual methods which are energy intensive processes. India has

about 65 million draught animal population mainly bullocks and buffaloes used for tillage, threshing and transportation (Singh, 1992 and Kurup, 2003). The annual utilization of bullocks in Odisha was found to be less than 200 hrs which makes them economically liable to the farmer (Behera *et al.*, 2006). Hence, to make them economically viable, the annual utilization hour of the bullocks can be increased by using bullocks in rotary mode of operation for running of small agro processing units in rural areas where electricity is not available (Swain *et al.*, 2015). In this experiment the feasibility of

wet grinding for rice - black gram for batter preparation was studied in bullock operated rotary transmission system.

■ METHODOLOGY

The study was conducted in the College of Agricultural Engineering and Technology, OUAT, Bhubaneswar. The combination of the bevel and spur gears in the bullock operated rotary transmission system could produce a rotation ratio of 1:29 in the out put shaft. Further, flat and V pulleys with belts were arranged to get the required rpm of 450 for operation of the Kalsi make wet grinder procured from the local market. One pair of medium sized bullocks having a pair weight of 610 kg was used to rotate the rotary gear unit. The rpm of the grinder at no load and loaded condition was measured by using a tachometer.



Fig. A : Inside and outside view of Gear box of the rotary transmission system

The rice and black gram samples were soaked in water for 6 and 3 hours, respectively at room temperature before taking them for grinding (Solanki *et al.*, 2005). Preliminary testing was conducted to optimize the rice to water ratio to get the desired consistency and particle size. Accordingly, rice (as is basis) to water (addition including water absorbed during soaking) ratio was maintained as 1:1.1 (w/w) for raw rice. A flour/water ratio of 1/1 for batter preparation was suggested by Hui-Huang Chen *et al.* (2008). The ingredients were passed through the hopper with different ratio of rice and black gram as 1:0, 1:4, 1:1, 4:1, 0:1, respectfully. For every ratio two passes were taken to get good quality batter. Water was added at the rate of 300 ml per kilogram of mixture. The experiment was conducted for one hour and the observations were taken at 15 min interval. Mainly two forces, crushing and shearing were acting in screw and serrated plates of wet grinder for grinding and mixing. The ingredients were passed through

the screw first then through the serrated plates. After coming out of the batter or paste of the ingredients, different samples were taken and dried in hot air oven dryer for two hours. Then the material was ground by hand and particle size was measured by sieve analysis



Fig. B : Operation of wet grinder in rotary transmission system using bullocks

■ RESULTS AND DISCUSSION

First, the grinder was operated in no-load condition by the bullocks. It was observed that the average draft requirement was 18 kg, which was 2.95 % of the bodyweight of the bullocks. The speed of operation of the bullocks varied between 2.12 to 1.83 km/h from 15 min to 1hour of operation. The mean pulse rate, respiration rate and body temperature were 58 beats/min, 20 blows/min and 38^o C, respectively. At loaded condition, the draft requirement for moving the rotary system varied from 30 kg in the beginning to 24 kg at the end, the mean being 27 kg which was 4.43 % of the body weight of the bullocks. Bullocks can exert a draft of 8 – 10 % of their body weight (Behera *et al.*, 2009). The physiological responses of the bullocks like heart rate, respiration rate and body temperature increased upto 66 beats/min, 22 blows/min and 38.2^oC, respectively after one hour of operation. The fatigue score of the bullocks was observed to be 12, well within safe limit of 20 and they could operate the wet grinder in rotary mode comfortably (Table 1).

The particle size of the batter came out was in between 200 µm to 300 µm. More was the quantity of black gram in the mixture, more was the fine particles

Table 1 : Performance of wet grinder in bullock operated rotary transmission system

Parameters	Initial	15 min	30 min	45 min	1 h
Pulse rate of bullocks, bpm	48	56	58	62	66
Respiration rate of bullocks, bpm	14	14	16	18	22
Body temp of bullocks, °C	37.8	37.9	38.0	38.1	38.2
Ambient temp., °C	26.0	26.3	26.6	27.0	27.3
Relative humidity (Rh), %	23	24	26	27	30
Draft, kg	-	27	26	26	27
Fatigue score of bullocks	-	8	8	10	12
RPM of bullocks	-	2.0	1.8	1.8	1.6
Speed of bullocks, km/h	-	2.5	2.41	2.41	2.29
Power output, kW/h	-	0.189	0.175	0.175	0.173
RPM of grinder	-	420	400	400	380
Grinder output (Batter), kg	-	2.0	4.0	7.0	9.0

Table 2 : Particle per cent analysis of batter using sieve shaker with different blends of rice : black gram

Rice : Black gram	212 µm (size)	212 µm (%)	150 µm (size)	150 µm (%)	75 µm (size)	75 µm (%)
1:0	15.04	86.74%	1.05	6.05%	1.25	7.20%
0:1	13.37	81.82%	0.93	5.7%	2.04	12.78%
1:1	11.90	86.29%	0.68	4.93%	1.21	8.77%
4:1	16.10	85.18%	1.00	5.29%	1.80	9.52%
1:4	15.16	86.03%	0.96	5.44%	1.50	8.51%

came out. The suitable ratio of rice - black gram in batter is 1:4 for *Dosa*, 1:1 for *Vada* and 4:1 for *Idili* which could be prepared by this grinder. The average batter output over one hour of operation was 9 kg/h. The average power output varied from 0.173 to 0.189 kW/h. Grinding efficiency of wet rice and black gram in the different ratio varied between 81 to 86 % (Table 2).

Conclusion:

The batter of rice and black gram having ratio of 1:4 for *Dosa* and 1:1 for *Vada* and 4:1 for *Idili* can be easily prepared by using the wet grinder in bullock operated rotary transmission system in rural areas where electricity is not available.

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