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Optimization of crop-machine parameter on the performance of *Kodo* pearler

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■ **ABSTRACT :** *Kodo* millet (*Paspalum scrobiculatum* L) is a stable food of some tribal's of India especially in the states of Chhattisgarh and Madhya Pradesh. Traditionally, de-husking was done by hand pounding using stone mortar and wooden pestle with metal ring on the tip or by the use of *Kodo* pearler. The performance was optimize and evaluated at different treatments of *Kodo* grins and cylinder speeds with factorial SPD. It was observed that cylinder speed and treatment have a significant effect on the performance indices. The results show that the milling recovery and capacity of machine increased as the cylinder speed increase. The milling recovery and capacity of machine was highest (62.62 %) and (17.65 kg-h^{-1}) for 24 h soaked grins at 22.83 m-s^{-1} cylinder speed. The head rice per cent was found to be highest (93 %) for 24 h soaked grins at cylinder speed 11.57 m-s^{-1}. The percentage of broken rice decreased with the increase soaking time and decrease cylinder speed.

■ **KEY WORDS :** *Kodo* pearler, Optimization, Treatments, Cylinder speed, Milling recovery

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Araka or *Kodo* millet (*Paspalum scrobiculatum* L.) was domesticated in India almost 3000 years ago. It is found across the old world in humid habitats of tropics and subtropics. It is a minor grain crop in India, and an important crop in the Deccan plateau. Its cultivation in India is generally confined to Gujarat, Karnataka, Chhattisgarh, Eastern Madhya Pradesh Uttar Pradesh, Bihar Maharashtra and parts of Tamil Nadu, but also in the Philippines, Indonesia, Vietnam, Thailand, and in West Africa where it originated (Malleshi and Desikachar, 1985)

Traditionally processing of small millet in tribal region of Baster and the basic problem in *Kodo* millet was the milling for the grains, milling drudgery associated with upper husk sticking endosperm tightly which reduces the efficiency of grain recovery from each spikelet (Pradhan *et al.*, 2010). In the absence of suitable processing equipment the tribal farmers growing this valuable crop are facing severe problem for the processing, which directly indicates the reduction in cultivated area under this crop. However, the need of the day is to exploit the possibilities of identifying processing method and suitable machines for processing of *Kodo* millet.

■ METHODOLOGY

The experiment was conducted in KVK, Kanker and raw material was procured from S.G. College of Agriculture and Research Station, Jagdalpur (C.G.) for

the present investigation. *Kodo* grains obtained were cleaned properly with the help of an aspirator to remove light weight impurities and graded to have a uniform sample. They were further cleaned manually to remove foreign matters and other impurities like stones. The initial moisture content of the sample was determined by hot air oven method (Ranganna, 1995).

Description of *Kodo* pearler machine :

Fig.1 shows the three dimensional view of *Kodo* pearler machine. It consists of basic units as frame, pearling unit, separating unit, driving mechanism and power unit. Overall dimension of the machine is 1400 mm x 990 mm x 1880 mm (LxBxH). The pearling unit consists of the hopper, housing and emery pearler. The hopper retains the *Kodo* grain before it is introduced into the milling chamber. The housing is horizontal conical cylinder in shape. The housing is also consists of 1 mm sieve size and the separating unit consist of aspirator, blower and duct. The aspirator will separate husk from grain. The machine is powered by 3 phase electric motor having 3.7 kW rated power and 1440 rpm was used.

Description of different components :

The *Kodo* pearler machine consisted of various components such as hopper, milling chamber, husk aspirator, blower, cyclone separator, drive and driven assembly and power unit and the descriptions of each component are illustrated.

Hopper :

This is square in shape which is made up of mild steel. Its upper diameters are 420 mm x 420 mm x100 mm, respectively. The flow of *Kodo* down the hopper is by influence of gravity. It has shutter at the bottom to regulate the flow of *Kodo* in to the milling chamber.

Milling chamber :

The milling chamber consists of a milling cylinder (emery pearler) which is enclosed within a half cylindrical casing and sets of screen at the lower side. Power to the milling cylinder rotates at 11.57-22.83 m-s^{-1}. The rotating cylinder rubs the kernels of *Kodo* against themselves and screen in order to remove the husk and dust.

Husk aspirator :

This is made up of a suction fan enclosed in a circular casing. The suction fan draws air through the grain and separates husk, dust and light impurities. The suction fan however, pulls the husks down the screen into the fan where it is discharged through its outlet.

Blower :

The blower is made up of a fan enclosed in a circular casing fixed to one end of the milling cylinder shaft. It produces air stream that blows away the remaining husk, dust and light impurities as milled *Kodo* fall down from the milling chamber spout into the collecting pan.

Cyclone separator :

In a cyclone separator, a particle is acted upon by two forces, *i.e.* the centrifugal force and the gravitational force. Centrifugal force helps in separating out air borne materials *i.e.* lighter products at top of cyclone from heavier particles which are discharged at the bottom of the cyclone.

Drive and driven assembly :

This consists of an electric motor of 5hp with its pulley and the milling cylinder shaft pulley as well as the aspirators pulley. The motor, the milling cylinder shaft and aspirator are connected by v-belts. Machine frame: the machine frame is made up of angle iron. It holds the machine, drive and driven assemblies in position and provide point of attachment to the floor and stabilizes the system during operation.

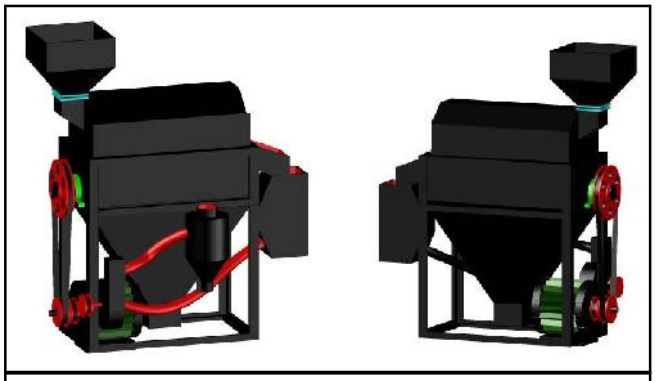

Fig. A : Three dimensional (3D) view of *Kodo* pearler machine

Evaluation procedure :

The performance tests of the *Kodo* pearler machine were conducted at different three level of cylinder speed and six level of moisture content by using split plot design (SPD) of 3x6 experiments with three replications in each

treatment. The cylinder speeds: 11.57, 15.68 and 22.83 m-s^{-1} were considered for the experiment. Preliminary milling trials were conducted on raw *Kodo* samples moisture content 12.71per cent (db), then further milling trials were conducted with different treatments (Table A). The weights obtained were recorded after each operation. The weights were used to determine the milling characteristics such as milling recovery, head rice percentage, broken percentage, co-efficient of hulling and co-efficient of wholeness of the various samples (Sharma and Mandhyan, 1992). The above procedure was adopted for all the samples and then estimation of various milling properties for each sample was done.

Table A : Different treatment of *Kodo* grains

Treatments	Moisture content, (% db)
Control	12.77
10 min roasting at 60ºC temp.	9.63
20 min roasting at 60ºC temp.	8.19
18 h soaking in normal water	8.22
24 h soaking in normal water	8.26
30 h soaking in normal water	9.20

RESULTS AND DISCUSSION

The result of applying SPD to the means of interaction between moisture content and cylinder speed is presented in Table 1. These results showed that interaction between moisture content and cylinder speed statistically affected all the performance indicators at 5 per cent level of significance.

Capacity of the machine :

The capacity of *Kodo* pealer was found significantly different for each different moisture content and three different cylinder speed. It was observed that the capacity of machine increased with increased cylinder speed at a given moisture content. This was perhaps due to the fact that the duration of milling process was very short.

The capacity increased from 7.38 to 7.92 kg-h^{-1}, 11.25 to 12.00 kg-h^{-1} and 15.27 to 17.65 kg-h^{-1} at cylinder speed 11.57, 15.68 and 22.83 m-s^{-1}, respectively. It was statistically observed that the capacity of machine was significantly higher at 5% level (7.63 kg-h^{-1}) for 24 h soaked grains at 11.57 m-s^{-1} cylinder speed.

Milling recovery :

Milling recovery depends upon feed rate, cylinder speed and holding time. It was observed that there was significant difference in the milling recovery. The milling recoveries varied from 9.00 to 12.47, 36.44 to 43.04 % and 57.30 to 60.11 % at cylinder speed 11.57, 15.68 and 22.83 m-s^{-1}, respectively. It was statically observed that the milling recovery of machine was average significantly lowest at 5% level 10.52 % in case of 11.57 m-s^{-1} cylinder speed where as it is average significantly higher at 5% level 59.52 % at cylinder speed 22.83 m-s^{-1}, respectively.

Head rice percentage :

The head rice recovery depends upon the different cylinder speed and moisture content. It was observed that there was significantly difference in the head rice recovery. The cylinder speed decreased from 22.83 to 11.57 m-s^{-1} the head rice recovery of the machine increase. The average head rice recovery at different cylinder speed *i.e.* 11.57, 15.68 and 22.83 m-s^{-1} varied from 84.00 to 93.00 %, 85.00 to 90.33 % and 78.33 to 87.00 %, respectively.

Broken rice percentage :

During milling, a considerable number of broken rice depending on moisture content and cylinder speed. It was observed that broken rice decreased with the increasing soaking time. It was also observed that the broken rice per cent decreased with decreased cylinder speed from 22.83 to 11.57 m-s^{-1}, respectively. The data for broken rice percentage are presented in Table 1, *Kodo* broken rice was maximum 21.67 % and minimum 7.00 % at cylinder speed 22.83 m-s^{-1} and 11.57 m-s^{-1}. Data for broken *Kodo* rice was found to be significantly different at 5% level of significance.

Co-efficient of wholeness :

The co-efficient of wholeness was observed at different moisture content and different cylinder speed. The data for co-efficient of wholeness ranged from 0.34 to 0.42, 0.58 to 0.65 and 0.60 to 0.64 at different moisture content ranging from 8.19 to 12.71 per cent (db). It is clear that the varieties and level of moisture content had significant effect on co-efficient of wholeness at 5% confidence level. It was also observed that the maximum 0.62 and minimum 0.39 for *Kodo* grain at cylinder speed 22.83 m-s^{-1} and 11.57 m-s^{-1}, respectively.

Table 1: Results of milling/shelling test

Treatments	T_1	T_2	T_3	T_4	T_5	T_6
	11.57 m-s^{-1}					
Capacity (kg-h^{-1})	7.38	7.50	7.76	7.48	7.92*	7.74
Milling recovery (%)	9.00	9.86	11.47	9.36	12.47*	11.00
Head rice (%)	89.00	86.00	84.00	89.67	93.00**	90.00
Broken rice (%)	11.00	14.00	16.00	10.33	7.00*	10.00
Co-efficient of wholeness	0.34	0.36	0.42	0.36	0.45*	0.42
Co-efficient of hulling	0.27	0.28	0.28	0.27	0.28*	0.27
Electricity (kWh)	2.07	2.04	1.97	2.05	1.93**	1.98
	15.68 m-s^{-1}					
Capacity (kg-h^{-1})	11.25	11.59	12.00	11.69	12.33	11.79
Milling recovery (%)	36.44	39.36	41.33	38.69	43.04	40.73
Head rice (%)	88.33	86.00	85.00	87.00	90.33	88.00
Broken rice (%)	11.00	14.00	15.00	13.00	9.67	12.00
Co-efficient of wholeness	0.58	0.62	0.63	0.61	0.65**	0.63
Co-efficient of hulling	0.64	0.65	0.67	0.64	0.67	0.66
Electricity (kWh)	1.76	1.71	1.65	1.69	1.61	1.68
	22.83 m-s^{-1}					
Capacity (kg-h^{-1})	15.27	16.18	17.31	15.89	17.65**	16.37
Milling recovery (%)	57.30	58.58	60.16	58.38	62.62**	60.11
Head rice (%)	80.00	78.33	80.00	85.00	87.00*	85.33
Broken rice (%)	20.00	21.67	20.00	15.00	13.00**	14.67
Co-efficient of wholeness	0.60	0.61	0.63	0.61	0.64	0.63
Co-efficient of hulling	0.96	0.97	0.97	0.96	0.98**	0.97
Electricity (kWh)	1.59	1.50	1.37	1.53	1.37*	1.49

Note: * and ** indicate significance of values at P=0.01 and0.05, respectively

T_1-Control T_2- Roasted at 60ºC temp. for 10 min T_3- Roasted at 60ºC temp. for 20 min

T_4- Soaked in normal water for 18 h T_5- Soaked in normal water for 24 h T_6- Soaked in normal water for 30 h

Co-efficient of hulling :

The data for co-efficient of hulling of the *Kodo* pearler machine at different cylinder speed and different treatments are presented in Table 1. It was significantly lowest at 5% level (0.27) at cylinder speed 11.57 m-s^{-1} and significantly highest at 5% level (0.97) at cylinder speed 22.83 m-s^{-1}, respectively.

Conclusion :

In this study, the conclusion on the performance of *Kodo* pearler machine were observed significantly higher by their capacity, milling recovery, co-efficient of hulling and co-efficient of wholeness with, it was also observed that the lower energy consumption at cylinder speed 22.83 m-s^{-1}, respectively. The combination of 11.57 m-s^{-1} cylinder speed with 24 h soaked grain found optimum to yield high head rice percentage. It was also observed that broken rice percentage decreased with the decrease cylinder speed and increase soaking time.

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