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Modification of hand operated octagonal maize sheller

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ABSTRACT

Maize shelling is one of the tedious and time-consuming agricultural operations. Shelling is the important post-harvest activity in maize crop. The present study was undertaken to modify the existing manual octagonal maize sheller (OMS) to increase its output capacity. The existing octagonal maize sheller was modified and provided with a rotating handle and a clamp so that it can easily be clamped with table, wooden rack etc. The performance of the modified octagonal maize sheller was evaluated with manual octagonal maize shelling. There was an increase in the average heart rate, energy expenditure as well as oxygen consumption while shelling with the modified OMS, however, there was also an increase of output capacity by 32 per cent. The average output capacity of modified OMS was 18 kg/h as compared to 13.9 kg/h with the existing octagonal maize sheller.

Keywords: Maize sheller, tubular, hand operated, maize, traditional shelling

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INTRODUCTION

In India, maize (*Zea mays* L.) is the third most important cereal crop after rice and wheat (Parihar *et al*.,2011). India contributes around 2% of this production chart with a quantum of 26 million MT in 2016-17 (In India maize is grown in all the seasons, i.e., kharif, rabi and summer. The Bihar government's report states that maize acreage was 7.21 lakh hectare in 2016–17 out of a gross sown area of 78.82 lakh hectare. Maize cultivation provides livelihood to 1.3 million farmers of Bihar, most of whom are small and marginal farmers. The demand for maize has been fueled mainly by animal feed industries, modified corn starch facilities, and exports to South East Asia and Latin America (Anonymous 2022). After harvesting maize with sickle and plucking of cob manually, de-husking of cob is carried out by hand to remove its outer sheath. Maize grains are obtained by shelling of the cob using traditional manual methods like beating the de-husked cobs with sticks, using fingers or sickle for shelling of individual cob etc. This activity is mostly done by farm women and output varies with individual skills. Several research workers (Singh *et al.* 2007; Singh and Gite, 2007) have used heart rate for assessment of the physiological workload of the workers

MATERIALS AND METHODS

The existing octagonal manual maize sheller was modified to increase its output capacity.

Octagonal Maize Sheller (OMS)

An OMS is a tool used to separate maize grains from de-husked cobs. The maize Sheller used for conducting the study was of octagonal shape. It had four mild steel fins tapered along their length with one of the edges of fin tapered (Fig. 1). Two holes are made on each fin for the purpose of riveting. In order to assemble the maize Sheller in an octagonal shape, each fin was bent at two places. Care was also taken for providing safety aspect by bending the fins, thereby avoiding injury during operation. The maize Sheller is generally made of sheet metal and in order to increase its working life and avoid corrosion, it is powder coated. The de-husked maize cob is held in the right hand and OMS in the left (Fig. 2). The cob is given clockwise and anti-clockwise movement by inserting the de-husked maize cob in the OMS leading to separation of grains from the cob. After removing the grains from one side of the cob, other side is inserted into the Sheller for complete removal of grains from the cob.

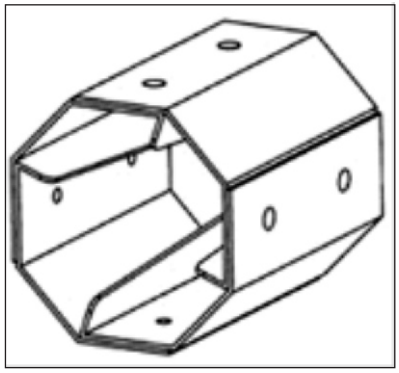

Fig. 1: Octagonal Maize Sheller (OMS)

Fig. 2: Shelling by OMS

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Modified Octagonal Maize Sheller

The existing octagonal maize sheller was modified and provided with a rotating handle and a clamp so that it can easily be clamped with table, wooden rack etc. (Fig. 3 &5). this will free one hand which will continuously rotate the maize sheller and other hand will be used to feed the maize cob. The OMS was welded with three-pronged rod each of length 120 mm (9 mm dia) and the end was welded to a washer (44 mm dia). The washer was connected to the hub (cycle) with the help of nut and a long bolt (9 mm dia) with grooves both ends (Fig. 4). One end of the bolt is attached with the L shaped handle. As the handle rotates, it rotates the OMS also. A square MS pipe (25×5 mm) was welded with the hub. At the end of the square pipe a clamping system is provided which can accommodate maximum thickness size of 40 mm. Tubular maize Sheller with handle is a small kind of machine for threshing maize, features on simple structure, high rate of threshing and easy to use and maintenance. It is reliable and safe because it is not controlled by the power so; it is more convenient in using. It is much suitable for the needs of small farmer's maize thresher.

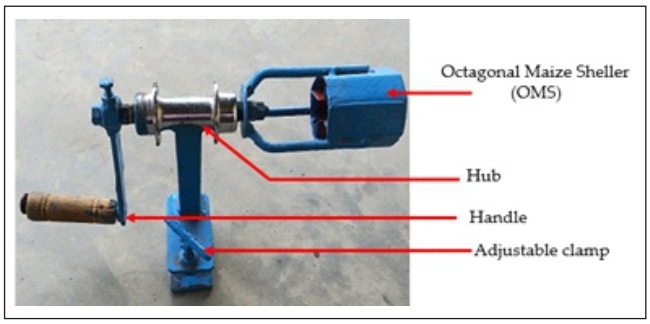

Fig. 3: Modified octagonal Maize Sheller

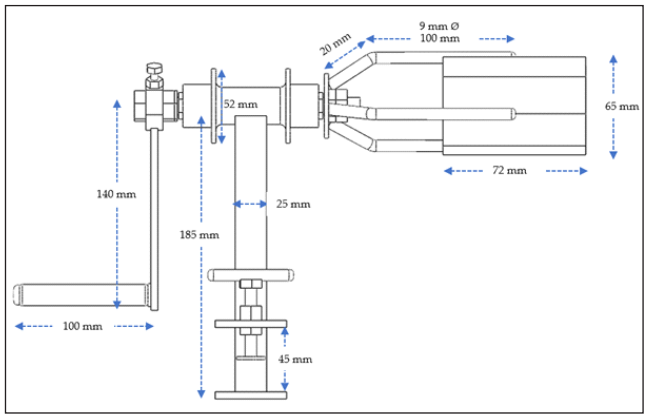

Fig. 4: Different dimensions of the modified OMS

Ergonomic evaluation

Ergonomic evaluation of maize shelling by octagonal maize shelling (OMS) and modified OMS was carried out with farm women at ICAR RCER, Patna during 7-15 July 2022. The maize cobs used for the study were harvested from institute farm. The cobs were allowed to dry for few days and at the time of experimentation the moisture content of the cobs was 12.65 per cent.

Selection of subjects

Five farm women with no history of acute or chronic illness or cardio vascular diseases were randomly selected for the experiment in which they had to wear a Watch (HR monitor) and perform maize shelling by OMS tool (Fig.1). The age of participating women ranged between 45-55 years and they had no physical disability. The shelling capacity of both the methods was calculated by noting the time required for shelling of 10 cobs. After shelling of cob by both the tools, a rest period of 5 minutes was allowed. The recover heart rate was also measured. The anthropometric rod and weighing balance were used to measure the physical characteristics like height and weight of the participating farm women. The health status of women was graded on the basis of Body Mass Index (BMI). Stop watch was used for recording the time while the heart rate was recorded using the polar heart rate monitor. During experimental period, the air temperature varied between 22-40°C with an average relative humidity of 48%. The shelling operations of OMS were done in sitting posture while modified OMS was attached on a wooden tool and was operated by women sitting on a chair.

Fig. 5: Shelling by modified OMS

Work output parameters

Generally, heart rate is used as an ergonomic measure to evaluate the physiological or functional demands of work on the individual workers (Hasalkar *et al.*, 2004). The heart rate is a better index of the overall physiological demand of work than energy expenditure and it has the additional advantage of being very easy to measure in the field. Several research workers have used heart rate for assessment of the physiological workload of the workers. Heart rate monitor watch was used for recording the heart rate of subjects and stopwatch was used for recording the time consumed.

Before starting the activity, women were given sufficient rest to determine the resting heart rate (HR rest). The resting data was noted for 15 min prior to any experiment.

The oxygen consumption rate (OCR) of subject on their measured heart rate was estimated based on general equation as given by Singh *et al.* (2008).

Table 1: Specifications of the shellers

Particulars	Octagonal Maize Sheller (OMS)	Modified OMS
Overall dimensions (L x W xH), mm	72×65	360x85x2 30
Shape	Octagonal	Tubular maize Sheller with handle
Weight (kg)	0.23	1.73
Unit cost (Rs)	100	500

$$OCR = 0.0114 \times X - 0.68 \quad (1)$$

where, X = heart rate

The increase in heart rate per kg of grain threshed (Δ HRKG) was determined by the following formula given by Solanki *et al*. (2006):

$$\Delta HRKG = [\Delta HR/C].60 \quad (2)$$

where, ΔHR = (Mean working HR – Resting HR), beats/min

C = Threshing capacity of the sheller, kg/h

The energy expenditure rate was measured by multiplying the OCR (l/min) with 20.93 kJ (1 litre = 20.93 kJ) (Singh *et al.* 2008).

$$EER = OCR \times 20.93 \quad (3)$$

The total cardiac cost of the work (TCCW) can be obtained by adding cardiac cost of work and cardiac cost of recovery. When this total cardiac cost of work is divided by duration for which this activity carried out, it gives physiological cost of work. Following formulae were used to calculate the total cardiac cost of work (TCCW) and physiological cost of work (PCW) (Singh *et al.* 2007).

$$CCW = \Delta HR \times t_a \quad (4)$$

$$CCR = (AHR\ recovery - AHR\ rest) \times t_r \quad (5)$$

where, CCW = Cardiac cost of work

ΔHR = Mean working heart rate – Mean resting heart rate,

t_a = duration of work activity,

CCR = cardiac cost of recovery

AHR recovery = Average recovery HR,

AHR rest= Average resting HR,

t_r = duration of recovery.

$$TCCW = CCW + CCR \quad (6)$$

RESULTS AND DISCUSSION

Randomly selected healthy women farm workers had age in the range of 45-55 years with an average age of 49.20 years (Table 2). The average height and weight of workers was 153.80 cm and 58.20 kg, respectively. The average BMI was found to be 24.62 which indicate that the farm workers involved in the experiment were fit and healthy. Physiological stress experienced while working on maize Sheller was determined on the basis of various parameters like average heart rate during work, rest and recovery, energy expenditure and physiological cost of work while shelling.

On an average shelling OMS tool required 4.06 minutes and modified OMS required only 3.18 minutes to shell 10 maize cobs (Table 3). The output capacity was 13.92 and 18.35 kg per hour for OMS and modified OMS respectively. So, there was an increase of 31.76 per cent in shelling by the modified OMS tool. However, the average heart rate during work was more for the modified OMS. Hence all other physiological parameters like oxygen consumption rate and energy expenditure rate were more for the modified OMS (Table 3).

Table 2: Physical characteristics of selected respondents (N=5)

Physical characteristics	Mean ± S.D .
Age (Years)	49.20±3.96
Height (cm)	153.80±8.20
Weight (kg)	58.20±9.44
BMI	24.62±4.05

Table 3: Comparison physiological parameters during maize helling (N=5)

Particulars	Octagonal Maize Sheller (OMS)	Modified OMS
Time spent to shell 10 cobs (min)	4.06±1.77	3.18±0.43
Average heart rate during rest (beats/min)	86.60±4.67	87.60±3.58
Average working heart rate (beats/min)	94.35±3.55	101.60±8.12
Average recovery heart rate (beats/min)	89±2.91	91.79±3.99
ΔHR (beats/min)	8.35±3.55	14.00±8.90
Output (kg/hr)	13.92±0.12	18.35±0.11
ΔHRKG (beats/kg)	35.97	45.78
Average OCR (l/min)	0.395	0.478
TCCW	48.89	65.46
Average Energy expenditure rate, KJ/Min	8.28	10.00

Table 4: Categorization of the agricultural work (Nag et al. 1980)

Variables	Light	Moderate	Heavy	Extremely heavy
OCR (l/min)	0-0.435	0.436-0.870	0.871-1.305	>1.306
EER (KJ/min)	<9.10	9.11-18.15	18.16-27.22	>27.23

As the average oxygen consumption rate of workers during shelling by octagonal maize sheller is 0.395 l/min, it came under light agricultural work (Table 4). However, the oxygen

consumption rate of workers during shelling by modified octagonal maize sheller is 0.478 l/min, it came under *moderate* category.

CONCLUSIONS

The modified octagonal maize sheller increased the shelling capacity by approximately 32 per cent but also increased the energy expenditure of the worker. But the work load was still under moderate category. So, the modified OMS tool can be suggested to be used by farm women for better output capacity.

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