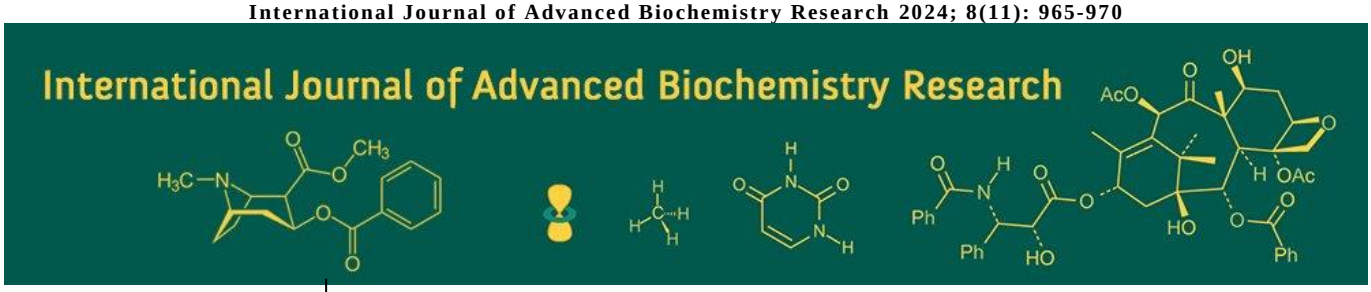

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Study of milling and nutritional characteristics of brown rice obtain from power operated pounding machine

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Abstract
The performance evaluation of power operated pounding machine was carried at three speed levels 65.18 rpm, 88.88 rpm, 112.58 rpm by three belt and pulley arrangement respectively. Three moisture content levels were maintained as 8%, 12%, and 16% for 10 minute of time span. Values for milling characteristic such as milling recovery, head rice recovery, broken rice recovery, husk percentage and milling loss were observed as 50.60%, 14.30%, 36.30%, 23.5% and 1.00% respectively at three speeds i.e., 65.18 rpm, 88.88 rpm, and 112.58 rpm. The observations it can be concluded that the milling characteristics were highest at 8% m.c. at 112.58 rpm. Head rice recovery was highest at 8% moisture content and 65.18 rpm. i.e., up to 17.96%. Nutritional properties at three moisture content levels were maintained as 8%, 12%, and 16% for 10 minute of time span. Values for nutritional characteristic such as crude protein, crude fat, crude fibre , carbohydrates were measured. as moisture content increased from 8% to 16%. Similarly fat content gets decreased from 2.69 to 1.11% with respect to increase in moisture content. Fiber content also decreased from 3.51 to 1.23% as moisture content increased from 8% to 16%. Ash content also decreased from 2.41 to 1.09%. In case of carbohydrate as percentage of moisture was increased from 8% to 16% the percentage of carbohydrates get increased. Thus, it can be concluded that as moisture content increases the milling efficiency get decreases. Head rice recovery becomes maximum at low moisture content with low rpm and machine requires 10 minutes time span to achieve more than 50% milling efficiency In case of nutritional properties, ash content, fat, fiber, protein was inversely varying with moisture content while percentage of carbohydrate directly vary with moisture content.

Keywords: Impact force, pounding machine, milling characteristics, performance evaluation

Introduction
For centuries, rice (*Oryza sativa* L.), one of the most well-known cereal foods, has been a primary food for many people around the world and is known to feed half of the population. Globally, India becomes first in paddy cultivation and second in paddy production, after China. It contributes 21.5% percent of global paddy production. More than 50% of the world's population feed on rice.

White rice is polished rice more popular for consume than brown rice beacouse of tits cooking quality and water absorption. Brown rice is a rich source of various bioactive compounds, such as γ-oryzanol, tocopherol, tocotrienol, amino acids, dietary fibres and minerals and the palatability quality of brown rice is inferior to white rice. (Ravichanthiran *et al.*, 2018) [11].

In case of nutritional quality, it was observed that red rice has a higher amount of iron (13.45 mg/g), magnesium (192.27 mg/g), calcium (8.71 mg/g), and zinc (1.91 mg/g) content than white rice. Regarding other nutrients it revealed that red rice had a higher crude protein (10.49%), crude fiber (2.71%) and (1.81%) of fat as compared to white rice. (Raghuvanshi *et al.*, 2017) [10].

In ancient time hand pounding method most predominantly used in rural areas of Konkan region of Maharashtra for paddy milling to dehusked the brown rice but it is drudgereous and time consuming method. Brown rice is less desirable due to its poor cooking and eating qualities (Das *et al.*, 2008) [5]. The nutritional properties of rice gradually changes during increase or decrease of moisture content rice after few months.

This phenomenon of change in cooking and eating properties of rice. During a period numerous changes in the chemical and physical properties of rice (Patindol *et al.*, 2005) [9] and (Sowbhagya *et al.*, 2001) [12].

For a stable supply, and to minimise qualitative and quantitative grain losses of brown rice losses. (Genkawa *et al*, 2008) [8]. This give wide scope to study the milling characteristics and nutritional properties of brown rice obtained from power operated pounding machine based on traditional mechansism but modern construction.

Material and Methodology

Study of the laboratory and field experiments of power operated pounding machine method have been conducted at College of Agricultural Engineering and Technology, Dapoli. The paddy was procured from Department of Agronomy, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. Ratnagiri-7 variety of paddy isused for study of Power operated pounding. Equipment's used during sample preparation of paddy for milling, proximate analysis of sample obtains by using pounding machine, sieve, weighing balance, muffle furnace, soxhalet apparatus, oven, distilled water, chemicals such as NaOH, $CuSO_4$, sulphuric acid, catalyst K_2SO_4, petroleum ether, beaker etc.

Milling characterictics of brown rice obtained by pounding machine

Performance evaluation of the power operated pounding machine was done by considering following parameters. Following parameters were evaluated which are described below. (Das *et al.*, 2016) [6]

Milling recovery

Take 1000 gm sample of rough paddy having moisture content level 8%, 12% and 16%. Allow milling of paddy in developed pounding machine up to 10 min time span. After 10 minutes stop pounding. Remove husk by manually winnowing or aspirator. Weight milled rice and find out milling recovery by following formula.

$$\text{Milling Recovery (\%)} = \frac{\text{Weight of milled rice}}{\text{Weight of rough rice}} \times 100$$

Percentage head rice

Take 1000 gm sample of rough paddy having moisture content level 8%, 12% and 16%. Allow milling of paddy in developed pounding machine up to 10 min time span. After 10 minutes min stop pounding. Remove husk by manually winnowing or aspirator. Milled rice allows to pass through grader which separate brokens and whole head rice. Weight head rice and milled rice and find out percentage of head rice by using following formula.

$$\text{Percentage of Head Rice (\%)} = \frac{\text{Weight of Head rice}}{\text{Weight of Milled rice}} \times 100$$

Percentage broken rice

Take 1000 gm sample of rough paddy having moisture content level 8%, 12% and 16%. Allow milling of paddy in developed pounding machine up to 10 min time span. After 10 minutes min stop pounding. Remove husk by manually winnowing or aspirator. Milled rice allows to pass through grader which separate brokens and head rice. Weight broken rice and milled rice and find out percentage of broken rice by using following formula.

$$\text{Percentage of Broken Rice (\%)} = \frac{\text{Weight of Broken rice}}{\text{Weight of Milled rice}} \times 100$$

Percentage of husk

Take 1000 gm sample of paddy having moisture content level 8%, 12% and 16%. Allow milling of paddy in developed pounding machine up to 10 minutes time span. After 10 minutes stop pounding, remove husk by manually winnowing or aspirator. Take weight of husk removed from milled rice and weight of milled rice and find out percentage of husk by using following formula.

$$\text{Percentage of Husk (\%)} = \frac{\text{Weight of Husk}}{\text{Weight of Rough rice}} \times 100$$

Percentage of milling loss

Take 1000 gm sample of rough paddy having moisture content level 8%, 12% and 16%. Allow milling of paddy in developed pounding machine up to 10 minutes time span. After 10 minutes stop pounding, remove husk by manually winnowing or aspirator. Take weight of straw, stones, dust from milled rice and weight of rough rice and find out percentage of milling loss by using following formula,

$$\text{Milling loss (\%)} = \frac{\text{Weight of unhusk rough rice + stone + dust}}{\text{Weight of Rough rice}} \times 100$$

Nutritional characteristics of brown rice obtained by pounding machine

Nutritional properties of brown rice obtained from pounding machine was determined by using proximate analysis of brown rice . detail methodology of proximate analysis . Proximate composition of brown rice was calculated by using standard method of analysis (AOAC, 2000) [3] for different milling methods such as protein content, fat content, fiber content, moisture content, carbohydrate content and ash content evaluated using standard methods. this method for proximate analysis was also referred by Bhattacharjee S., P. Das., (2020) [4].

Moisture content

Moisture content on weight basis will be calculated by using the following formula,

$$\text{Moisture content (\%)} = \frac{w_1 - w_2}{\text{wt.of sample}} \times 100$$

Where,
W_1 = Initial weight of crucible + Sample.
W_2 = Final weight of crucible + Sample.
W = Mass of container

Crude protein

The percent protein will be calculated by the using following formula,

$$\text{Protein (\%)} = \frac{(S-B) \times N \times 14.01 \times 100 \times 6.25}{W \times 1000}$$

Where,
S = Volume of standard acid (0.1 N HCl) used for titration (ml)
B = Volume of 0.1 N HCl used for blank (ml)
W = Weight of sample (g)
N = Normality of acid used for titration (0.1 N HCl)

Crude fat content

Crude fat was estimated by standard method (AOAC, 2000) [3] using Soxhlet extraction apparatus,

$$\% \text{ Crude fat} = (W_2\text{-}W_1) \times \frac{100}{s}$$

Where,
Weight of empty flask (g) = W_1
Weight of flask and extracted fat (g) = W_2
Weight of sample = S

Crude fibre

Crude fiber was estimated by the standard method of analysis (AOAC, 2000) [3].

$$\text{Crude Fibre } (\%) = \frac{W2-W3}{W1} \times 100$$

Where,
W_1 = Weight of sample, g
W_2 = Weight of insoluble matter (weight of crucible + insoluble matter-weight of crucible), g
W_3 = Weight of Ash (crucible + Ash-wt. of crucible), g

Ash content

Ash in the sample was estimated by employing the standard method of analysis (AOAC, 2000) [3]. 10 grams of dried sample was taken in a weighed crucible and ignited until no charred particles remained in the crucible and then the crucible was put in muffle furnace (550 °C) for 6 h or until a white Ash was obtained. Thereafter, the crucible was cooled in a desiccator and reweighed,

$$\text{Ash}\% = \frac{\text{Weight}}{\text{Sample Weight}} \times 100$$

Where,
W_1= Wt. of the crucible
W_2 = Wt. of crucible + Ash
W_2-W_1= Weight (g) of Ash = Wt. of crucible + Ash-wt. of crucible

Total carbohydrate content

Total carbohydrate of the rice samples was determined by subtracting protein, fibre, moisture, ash, fat from 100. The total percentage carbohydrate content in the rice sample was determined by the difference method .The total carbohydrate content was calculated by using formula,

% Carbohydrate =100 (% Moisture + % Fibre + % Protein + % Fat + % Ash)

Results

Milling characteristics of rice obtained from developed pounding machine

The effect of operational parameters on the performance of developed power operated pounding machine unit was studied at optimum values of operational parameters such as speed, moisture and has been discussed in following sections. The effects of these parameters on overall milling recovery, head rice recovery, broken rice recovery, husk percentage and milling loss. These parameters were measured at three speeds i.e. 65.18 rpm (S_1) 88.88 rpm (S_2) and 112.58 rpm (S_3). Shelling of Ratnagiri-7 paddy variety at 8% (M_1) 12% (M_2) and 16% (M_3) moisture content was done in single pass (P_1), with the three replications of each pass. By considering operational time as 10 minutes and same feeding quantity i.e. 1000g (T_1), respectively. The replications were taken in three different arrangement of belt and pulley drive. Following results were obtained when paddy was shelled for one time in three moisture content levels at three speeds with three passes.

Table 1: Milling characteristics of sample obtained from power operated pounding machine for single pass with three replications.

Sr. No.	Treatment details	Milling Recovery (%)	Head Rice (%)	Broken Rice (%)	Husk Percentage (%)	Percent Milling Loss (%)
1	$S_1P_1M_1$	33.56	17.96	15.66	14.20	0.96
2	$S_2P_1M_1$	40.13	16.03	24.10	16.86	1.03
3	$S_3P_1M_1$	50.60	14.30	36.30	23.5	1.00
4	$S_1P_1M_2$	26.72	11.56	15.16	12.5	1.26
5	$S_2P_1M_2$	34.36	12.06	22.06	12.83	1.10
6	$S_3P_1M_2$	40.52	12.3	28.20	17.3	1.00
7	$S_1P_1M_3$	17.33	9.1	08.63	8.23	0.96
8	$S_2P_1M_3$	26.16	7.7	18.46	9.43	1.10
9	$S_3P_1M_3$	31.70	6.2	25.5	11.46	1.03

(Above results are given in average values)

From the above table 1, it was observed that at 8% moisture content milling recovery of rice, highest in third treatment i.e., at 112.58 rpm which was 50.60% in power operated hand pounding machine and head rice recovery was highest in the first treatment i.e. 17.9% at 65.18 rpm. Percent milling loss was found to be 0.96% which was less as compared to other treatments. Similarly, if consider 12% moisture content then milling recovery was highest at 112.58 rpm i.e. 40.52%. Head rice recovery was highest at third replication. i.e. 12.3% at 112.58 rpm and broken percentage also was highest at third replication at 112.58 rpm i.e., 28.20%. In case of 16% moisture content with respect to 65.18, 88.88, and 112.58 rpm then milling recovery was highest at 112.58 rpm i.e. 31.70%. Head rice recovery was highest at 65.18 rpm i.e., 9.1%. As speed increased up to 112.58 rpm then broken was to be increased up to 25.5%. If considered overall performance of power operated hand pounding machine. Then result shows that machine shows lowest milling recovery at 16% moisture content and 65.18 rpm while highest milling recovery was found to be at 8% moisture content and 112.58 rpm. While machine have highest head rice recovery at 8% moisture content with 88.88 rpm. The highest broken percentage was found to be at 8% moisture content at 112.58 rpm. Similar study of milling properties were studied by (Thapa *et al.*, 2013) [13]. They were milled bold varieties of rice in Satake Sheller and polished in Yamamoto polisher at different degree of polishing (0, 4, 8 and 12%). The mean milling recovery (73.4%), head rice (84.8%), broken rice (15.1%), protein (7.71%), ash (0.84%) and fat (1.34%) were recorded from the experiments. The statistical analysis shows that head rice recovery, broken rice recovery, husk obtain, unshelled paddy significantly varies with moisture content and rpm. Losses non significantly vary with moisture content as well as rpm.

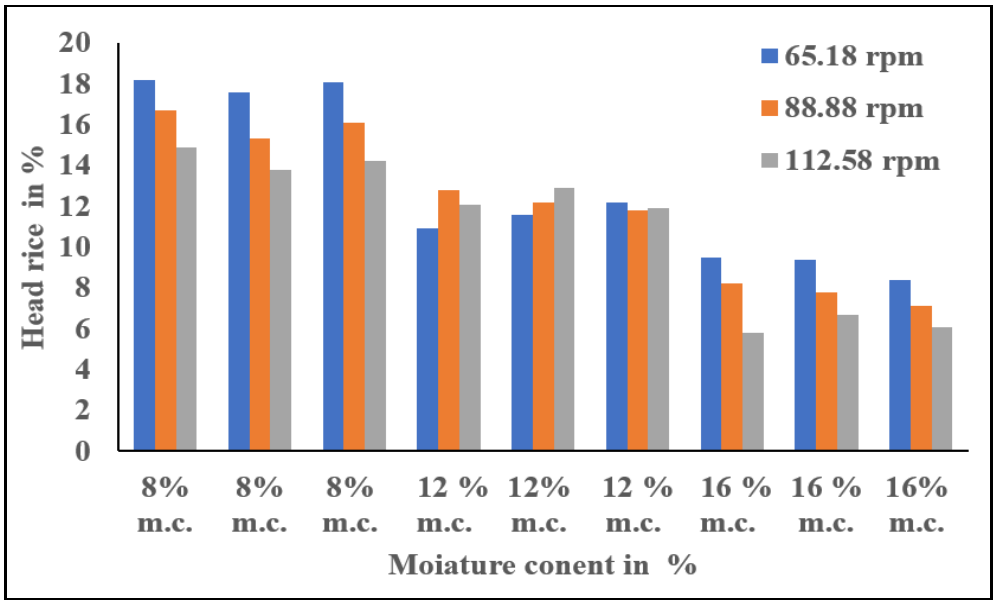

Fig 1: Head rice recovery from pounding machine

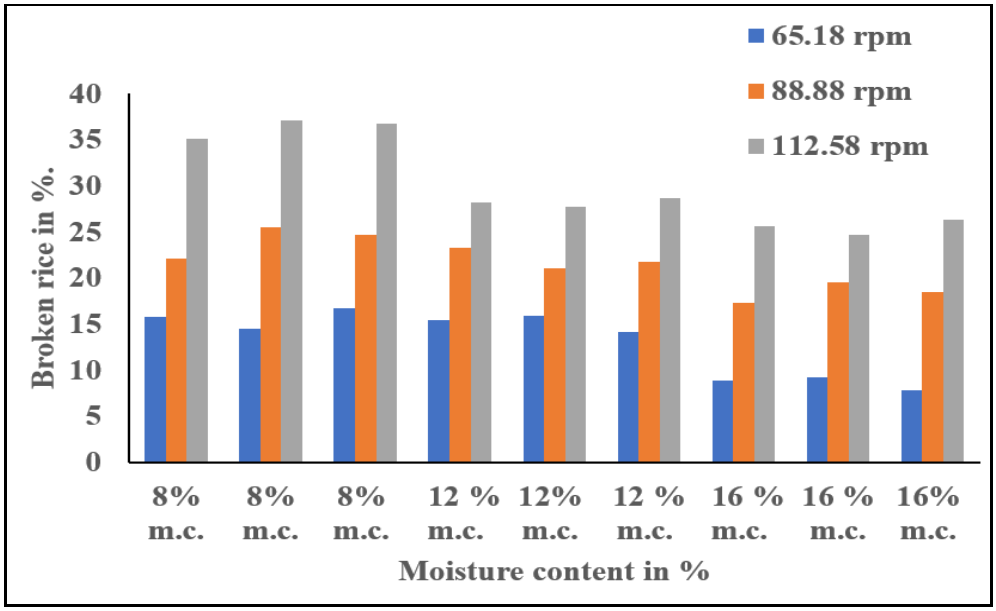

Fig 2: Broken rice recovery from pounding machine

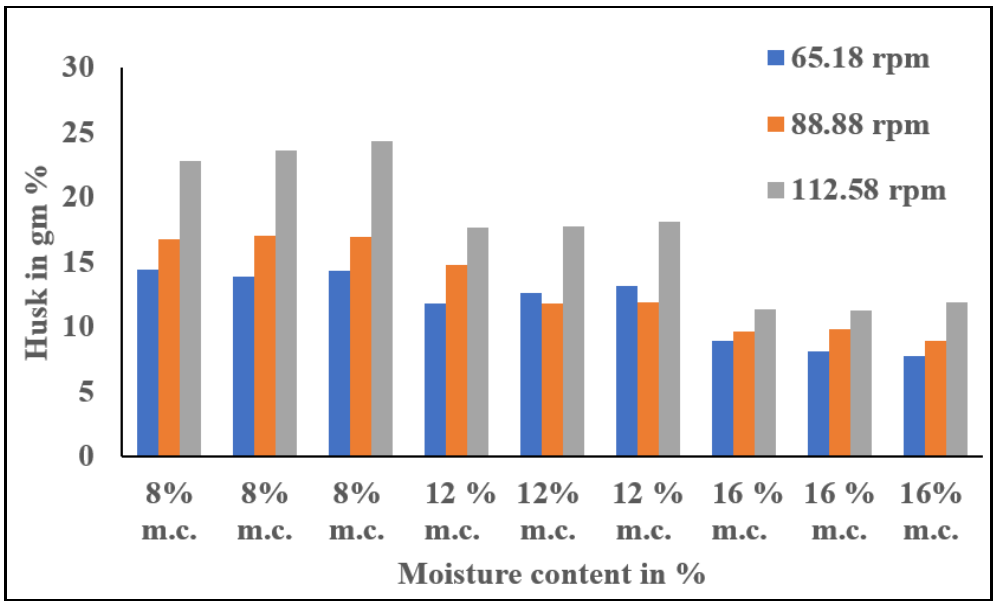

Fig 3: Husk recovery from pounding machine

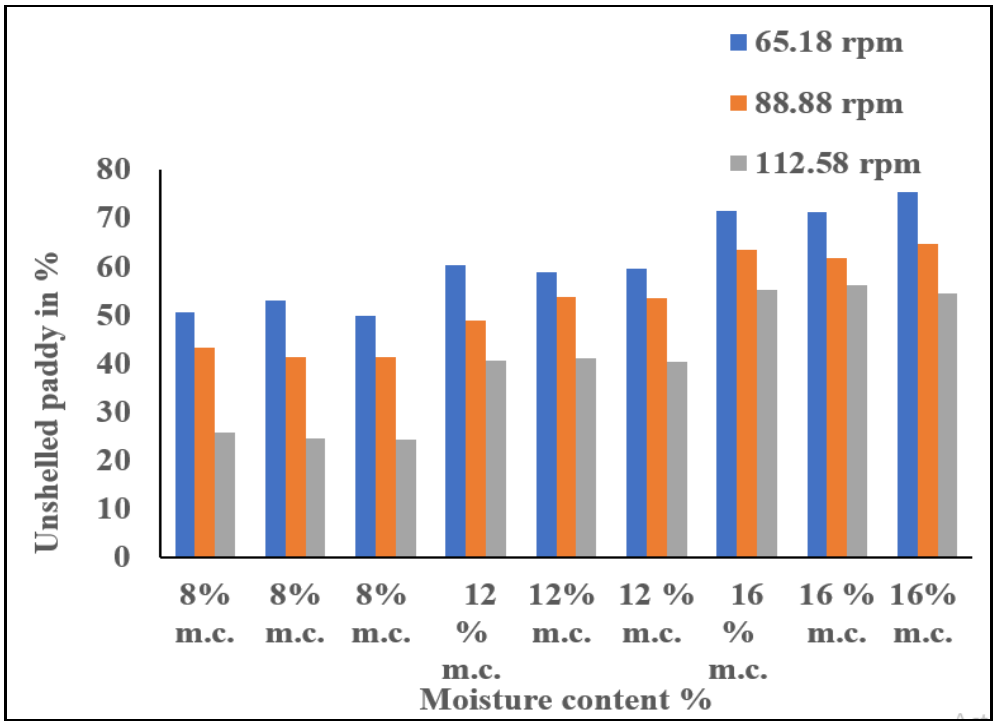

Fig 4: Unshelled paddy recovery from pounding machine

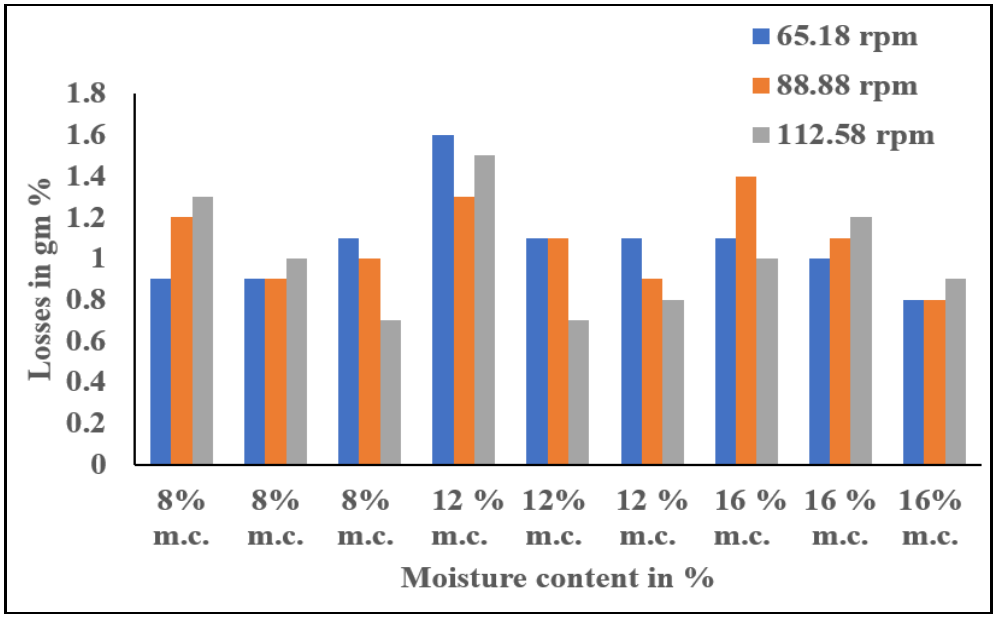

Fig 5: Losses in pounding machine

From below table 2 observed that protein percentage of rice obtain from power operated pounding machine was decreased from 9.67 to 6.32% as moisture content increased from 8% to 16%. Similarly fat content gets decreased from 2.69 to 1.11% with respect to increase in moisture content. Fiber content also decreases from 3.51 to 1.23% as moisture content increased from 8% to 16%. Ash content also decreases from 2.41 to 1.09%. In case of carbohydrate as percentage of moisture was increased from 8% to 16% the percentage of carbohydrates get decreases. From above table it was concluded that ash content, fat, fiber, protein was inversely varying with moisture content and percentage of carbohydrate directly vary with moisture content. From table no. 1 and table no. 2 it was observed that milling characteristics and nutritional values retained in rice obtain by pounding machine was high due to less impact force absorption and proper circulation of feed paddy material from bottom to top and top to bottom.

Table 2: Nutritional composition of Ratnagiri-7 rice obtained by power operated pounding method.

Sr. No	Milling Method	Moisture content (%)	Protein content (%)	Fat content (%)	Fibre content (%)	Ash content (%)	Carbohydrate content (%)
1	Pounding machine	8	9.67	2.69	3.51	2.41	73.72
2	Pounding machine	12	8.14	2.07	2.26	1.51	74.01
3	Pounding machine	16	6.32	1.11	1.23	1.09	74.25

(Above results are given in average values)

Conclusion

The milling of 1 kg of paddy sample by power operated pounding machine required 10 minutes lower than traditional hand pounding. The high milling recovery was obtained at 8% moisture content and 112.58 rpm. The head rice recovery was found to be highest at 8% moisture content with 65.18 rpm and it was get decreased as moisture content and speed get increased from 8% to 12% and 65.18 rpm to 112.58 rpm. Nutrient recovery such as protein, fat, fibre was found to be high i.e. 9.67%, 2.69%, 3.51% respectively in rice obtained by milling of paddy from power operated pounding machine.

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