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Performance Evaluation of a Ricemill Developed in NCRI

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Abstract : ***Performance of a rice mill developed in National Cereals Research Institute, Badeggi was evaluated to determine the behavior of different grain (paddy) types at different feed rates and moisture contents. Three levels of feed rate (0.088, 0.033 and 0.014kg/s) and three levels of moisture content (15-16, 12-13 and 10-11%) were considered for the test. Percentages milling recovery, broken rice and machine capacity were measured as well as the examination of whiteness of rice in milling long, medium and short grain paddy varieties of faro 44, Babanyagi and Ndawodzufangi respectively. The effectiveness of the milling machine depends on the paddy varieties and size, paddy condition and operator's skill among other factors.. It was concluded that as the feed rate decreased, percentage broken rice as well as whiteness of rice increased. The capacity of the machine decreased with decreasing feed rate.***

Keywords: performance evaluation, rice mill, feed rate, grain type and moisture content.

Introduction

A rice milling machine was designed to dehusk paddy rice, separate the husk and polish the milled rice. Milling is a crucial step in post production of rice. The basic objective of a rice milling system is to remove the husk and the bran layers, produce an edible white rice kernel that is sufficiently milled, which is free of impurities and preserve most of the rice kernel in their approximate original shape.

Prior to the advent of modern mills several traditional methods were used to mill rice. These methods include: pounding in mortar with pestle, beating with clubs on the floor, beating gently with clubs in jute bags and threading under the feet of man or hooves of animals. These crude means are inefficient due to the fact that lots of damages are done on the rice which leads to rice wastage and labour lost. It also involved enormous human energy and time apart from the fact that these methods are not hygienic.

The available rice mills in most of the rice processing industries were imported with high cost of procurement, complex maintenance procedures and operation, inadequate spare parts and sometimes complicated mode of operation. Though these imported mills may be efficient and effective, they require some expertise skills for proper operation.

In order to meet up with the demand for high quality and well processed rice, there is need for locally – made mills that will produce quality rice at a cheaper price.

Nevertheless, the performance of a rice milling machine in terms of milled yield and head rice yield as well as milled quality depend on different factors such as the moisture content which has a marked influence on all aspect of paddy and rice quality and it is essential that the paddy be milled at the proper moisture content to obtain highest head rice. Paddy with high moisture contents are too soft to withstand hulling pressures which result in kernel breakage and possible pulverization of kernel. Paddy that is too dry becomes brittle and has greater breakage. Dilday (1987) found that the rice breakage during milling process decrease with increasing moisture content in the range of 12 – 16%

Moisture content and temperature during drying process are critical as it determines the introduction of fissures and/or full cracks into the grain structure. Peuty et al (1994) reported that paddy drying condition affected the rice breakage rapidly. It increased with increasing moisture content of paddy drying air.

In addition, a paddy dimension (length – width ratio) is a varietal property that influences milling yields. Long slender grains normally have greater breakage than short, bold grains and consequently have a lower milled rice recovery. Seguy (1994) established that long and tiny rice kernels were more susceptible to breakage during the milling process. Varietal purity is very essential as mixture of varieties causes difficulties at milling and more often results in reduced capacity, excessive breakage, lower milled rice recovery and reduce head rice.

Also the degree of milling (a measure of the percent bran removed from the brown rice kernel) affects milling recovery and influence consumers' acceptance. Apart from the amount of white rice recovered, milling degree influences the colour. Rahaman et al (1996) reported that milling degree should be restricted to 7 – 8% for maximum recovery.

Furthermore, parboiling treatment helps in retaining some of t[illegible]nts, reduce breakage loss during milling and increase [illegible]ice recovery. The parboiling treatment gelatinizes the rice starch improve the hardness of the rice upon drying, minimized the breakage loss and thus increases milling yield, Islam R. et. al (2002).

In a nutshell, rice researchers have already indentified many factors that affect milling quality. These factors were grouped into two major categories: engineering and variety factors. Engineering factors include harvesting, handling, drying, storage, transport and milling operations while variety factors include physical and mechanical properties of grain Firouzi, et al (2010).

The objective of this study is to evaluate the performance of a rice milling machine developed in N.C.R.I on different grain types at different moisture contents..

DESCRIPTION OF MACHINE

The rice mill developed in N.C.R.I is made up of the following components as shown in plate. 1:

Hopper: This is frustum in shape which is made up of mild steel. Its upper and lower diameters are 60cm and 10cm respectively. The flow of paddy down the hopper is by influence of gravity. It has shutter at the bottom to regulate the flow of paddy in to the milling chamber.

Milling Chamber: The milling chamber consists of a milling cylinder which is enclosed within a half cylindrical casing and sets of screen at the lower side. Power to the milling cylinder rotates at 650-750rpm. The rotating cylinder rubs the kernels of rice against themselves and screen in order to remove the husk and bran.

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, bran 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, bran and light impurities as milled rice fall down from the milling chamber spout into the collecting pan.

Drive and driven assembly: This consists of an electric motor of 15hp 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.

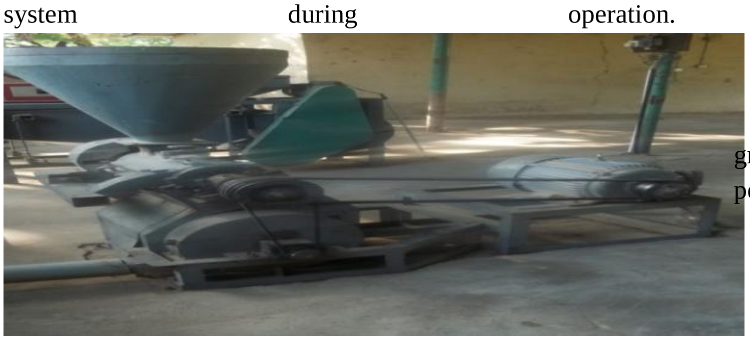


Plate.1: Rice Mill Developed In N.C.R.I

MATERIALS AND METHOD

The grain type used for the test were long (Faro 44), medium (Babanyagi) and short (Ndawodzufangi) varieties of rice sample. Each variety was soaked at 70-75^o for 6hrs after which they were steamed for 45 mins. The steamed paddy were dried to 15-16%. At this point each variety sample was divided into three portions. A portion from each variety was milled at different feed rates of 0.088kg/s, 0.014kg/s) and 0.033kg/s. The remaining portions were further dried until when their moisture contents were at 12-13% and 10-11%.They were also milled at the above stated feed rates.

Feed rates were determined by milling a weighed quantity of paddy rice at certain shutter opening. Shutter opening is directly proportional to the outlet pressure. The time taken was recorded using stopwatch.

Milling Procedure

Before each test run for a particular variety of paddy, there was a trial run carried out with the same lot of paddy that was to be put through the mill. This allowed setting of the units, filling of empty space of the milling chamber, flushing of the previous lots of rice and ascertains that the mill was in a fit condition to undertake the tests.

After the trial run, a weighed quantity of paddy from each test run was fed into the mill, all the mill products and by-products were recorded. Bran could not be weighed separately because the bran and husk were mixed and it was not possible to separate one from the other.

The percentage milling recovery, head rice recovery and broken as well as machine capacity were then obtained using the following formulae:

1) **Milling Recovery : This** is the quantity of milled rice obtained from a quantity of paddy. It is expressed as a percentage of milled rice including broken obtained from paddy as shown:

$$Mr = \frac{Wm}{Ws} X\ 100 \quad \text{———} (1)$$

Where *Mr* is milling recovery percentage,
Wm is the weight of milled rice,
Ws is the weight of sample used.

2) **Head Rice Recovery : This** is the wieght of head grains or whole kernels in the rice lot. It is computed in percentage as follows:

$$Mh= \frac{Ww}{Ws} X\ 100 \quad \text{———} (2)$$

Where *Mh* is the head rice recovery percentage,
Ww is the weight of the whole grains.

3) Broken Rice : This is a kernel or piece of kernel having less than seventy five percentage of the average length of the whole kernel.

$$Mb=\frac{Wb}{Ws}\ X\ 100 \qquad \text{———} \quad (3)$$

Where *Mb* is the percentage broken rice,

Wb is weight of broken rice.

4) Machine Capacity : This is the quantity of the paddy rice that passes through the machine per unit time. Mathematically expressed as

$$Mc=\frac{Ws}{tm} \qquad \text{———} \quad (4)$$

Where *Mc* is the capacity of machine,

tm is the milling time.

RESULTS AND DISCUSION

The result of performance test is shown as follows:

Milling Recovery: At the feed rate of 0.088kg/s, from figs. 1,2 and 3, the percentage milling recovery was almost the same at higher moisture contents of 12-13% and 15-16% while from figure 3 it is indicated that short grain type has the highest percentage milling recovery of 71.43% at 10-11% moisture content and long grain has the lowest percentage milling recovery of 61.10% also at 10-11% moisture content. This shows that at 10-11% long grain is brittle and therefore could not withstand the pressure of the milling chamber and most of the broken rice might have escaped with the husk which could have accounted for the more quantity of husk and bran collected at this level .

At the feed rate of 0.033kg/s (fig 6), medium grain has the highest percentage milling recovery of 69.25% at 10-11% moisture content and short grain has the lowest percentage milling recovery of 57.66% at 12-13% moisture as indicated in fig.5. Here the medium grain type has more milling recovery which increased as the moisture contents dropped.

At the feed rate of 0.014kg/s, from figure 7, the medium grain has the highest percentage milling recovery of 67.54% at 15-16% moisture content and decreased slightly as the moisture content dropped while short grain type has the lowest percentage milling recovery also at 15-16% moisture content which increased slightly as the moisture content dropped.

Rice breakage: At the feed rate of 0.088kg/s, (fig 1), medium grain type has the highest Percentage breakage at 15-16% moisture content and the same medium grain type has the lowest percentage broken rice at 10-11% moisture content. This shows that medium grain type is too soft at higher moisture content and therefore pulverized when milled at such moisture content, short grain has almost the same percentage at all levels of moisture considered. This is because of its shape and less pressure in the milling chamber at this feed rate. Medium grain type has less percentage broken rice of7.13% at 12-13% moisture content at this feed rate.

At the feed rate of 0.033kg/s, from fig 4, medium grain type has highest percentage broken rice of 20.39% at 15-16% moisture content and decreased as the moisture content dropped. This further explains the softness nature of medium grain type. Short type has the lowest percentage broken rice of 3.21% at 15-16% moisture content and increased as the moisture content dropped which shows the brittleness of this grain type as can be seen in figure 4, 5 and 6. At this feed rate long grain has lowest percentage broken rice at 12-13% moisture content which is the optimum moisture content for this particular variety above and below which percent breakage increased..

At the feed rate of 0.014kg/s, from fig 7, medium grain type has highest percentage broken rice of 33.75% at 15-16% moisture content and decreased as the moisture content dropped which is attributed to its softness at higher moisture content. Short grain has the lowest percentage broken rice of 11.60% at 15-16% moisture content dropped. At this feed rate, the percentage broken rice was relatively high at all moisture contents and with different grain types considered. This is attributed 4 ore pressure in the milling house at this feed rate.

Machine capacity: The machine capacity at a particular feed rate is almost the same for different grain types at all level of moisture content considered, but varies significantly as the feed rate changes. From fig 10, the feed rate of 0.088kg/s has the highest input and output capacity of 9.5 and 6.5 ton/day respectively, while 0.014kg/s has the lowest input and output capacity of 2.2 and 1.2 ton/day respectively.

In a nutshell,, the percentage milling recovery decreased with decreasing feed rate while rice breakage increased with decreasing feed rate at all levels of moisture content with long and medium grain types, this is because paddy and brown rice in milling chamber have spiral movement round the milling cylinder and towards the outlet, thus with increasing feed rate, the kernels undergo several movement and subsequently the pressure inside milling chamber increases. This pressure on kernels inside milling chamber result in lower milling recovery percentage and more broken rice ratio.

In this performance test, it was observed that the appearance of milled rice, that is, whiteness of milled rice increased with decreasing feed rate at all levels of moisture content and grain types considered. This result can be related to more flow ability of kernels into milling chamber and consequently decreasing the pressure on the materials in the milling chamber. Hence, lower pressure result in lower whiteness. Fironzi et al (2004) indicated this trend that whiteness of output rice increased with increasing output pressure in a rice jet pearlier.

The performance test shows the significant effect on increasing feed rate on the machine capacity (input and output) of rice milled at all levels of moisture content and with different grain type. The input and output capacity of the machine decreased with decreasing feed rate. This is attributed to the freer flowing of rice kernels into milling chamber, because of more space opening of the shutter, hence, the highest input and output rates in the largest feed rate treatments could be logical..

The Effect of Feed Rate On The Percentage Milling Recovery, Head Rice Recovery And Broken Rice As Well As Machine Capacity At Different Moisture Contents With Different Grain Types

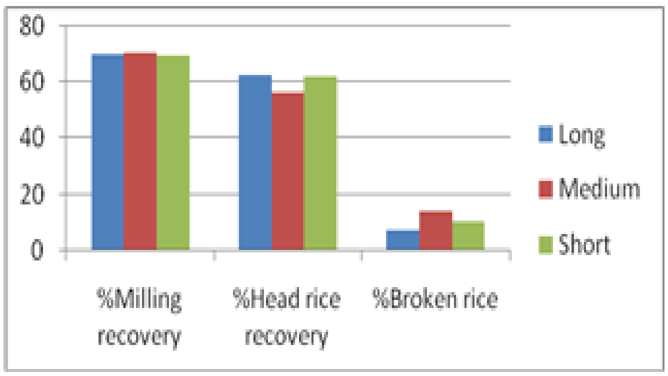
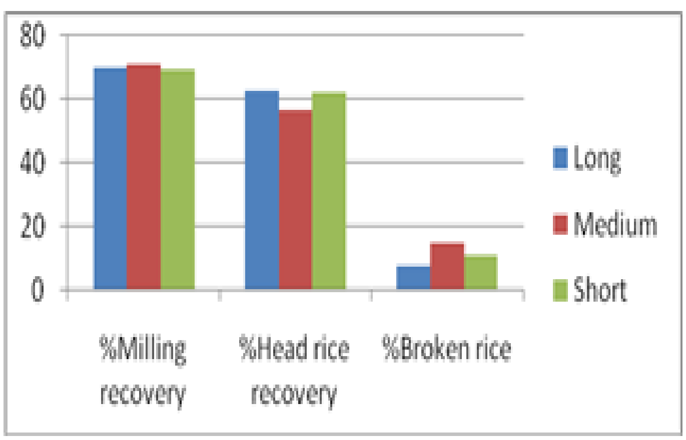


Fig 2: At 12-13%m.c and 0.088kg/s f.r



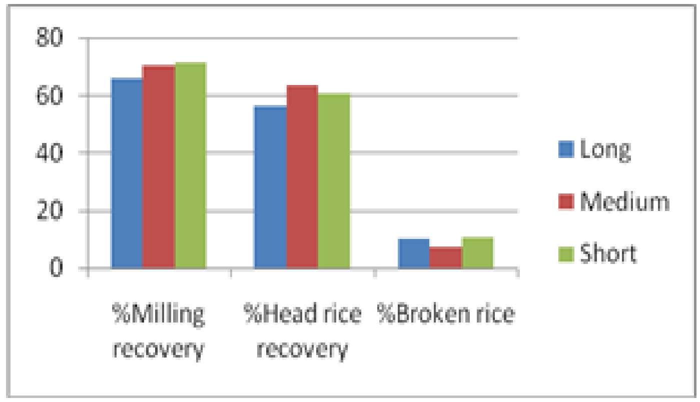
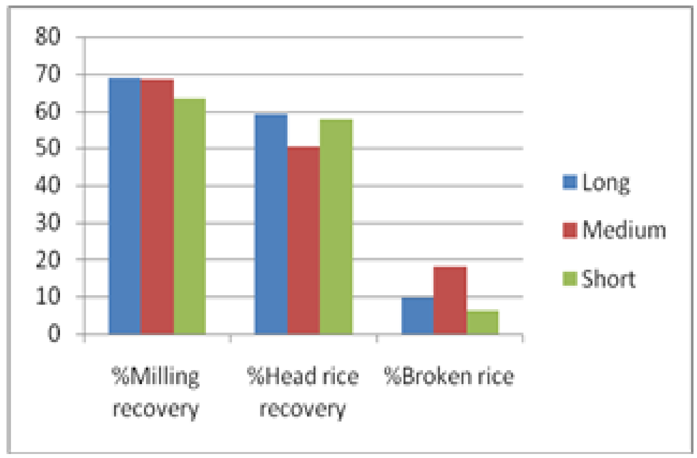
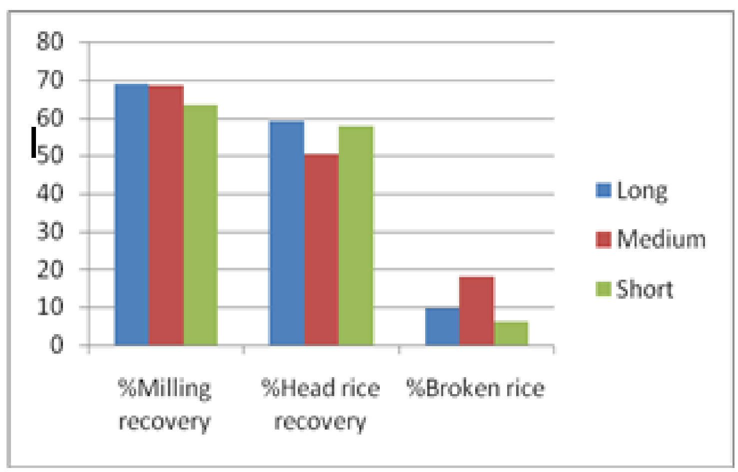
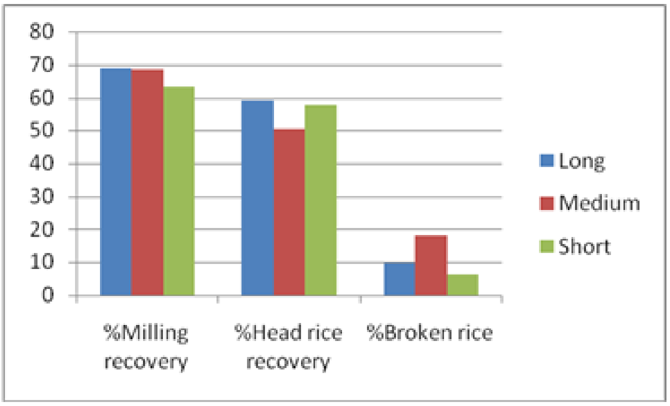


Fig 3: At 11-10%m.c and 0.088kg/s. f.r







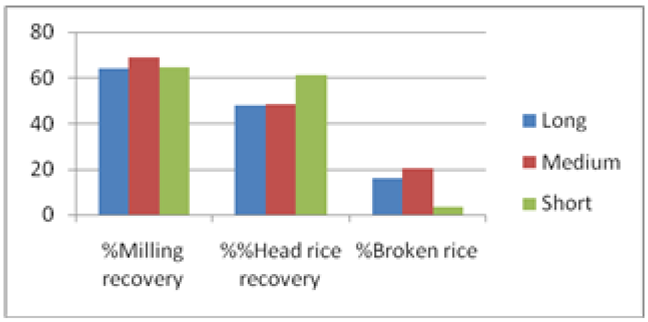


Fig 4: At 15-16%m.c and 0.033kg/s f.r

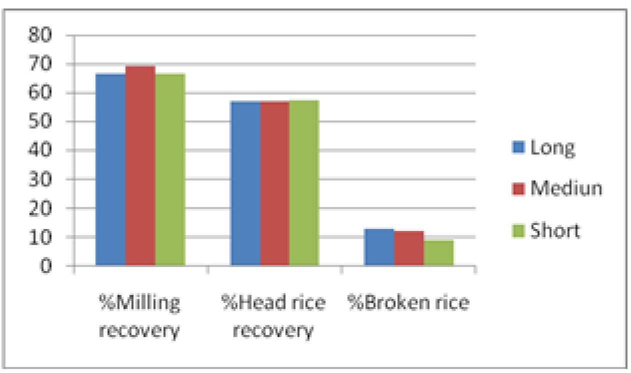


Fig 6: At 10-11%m.c and 0.033kg/s f.r

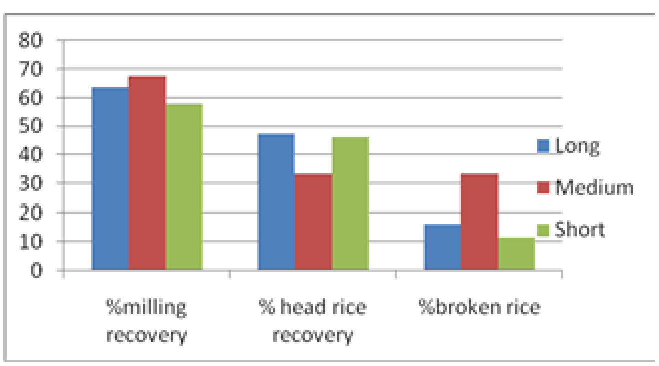


Fig 7: At 15-16% m.c and 0.014kg/s f.r.

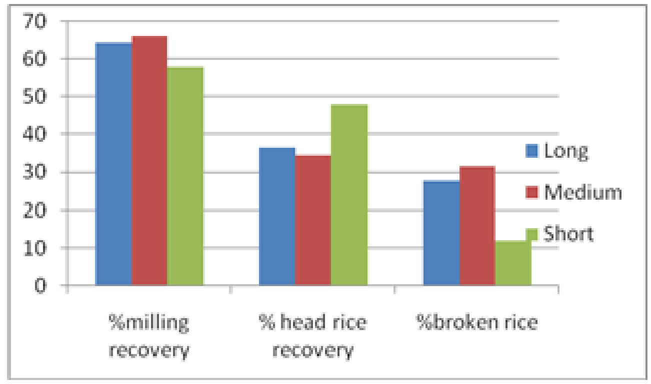


Fig 8: At 12-13%m.c and 0.014kg/s f.r.

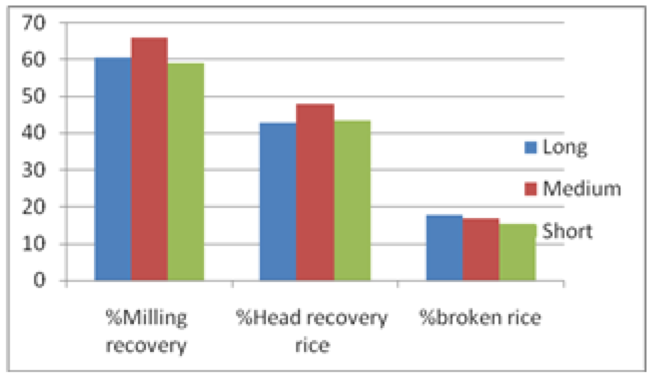


Fig 9: At 10-11%m.c and 0.014kg/s f.r.

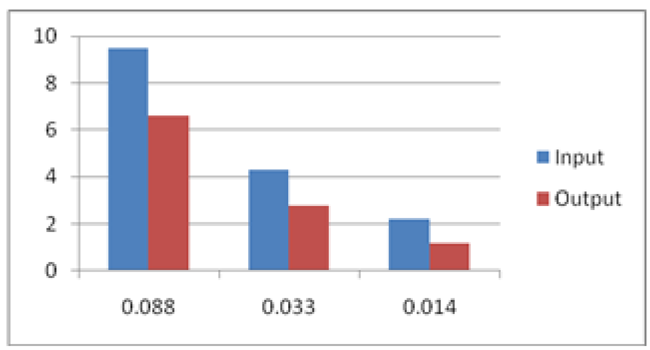


Fig 10: Machine capacity at different feed rate

CONCLUSION

The machine performed well at all levels of moisture contents,but much better at lower moisture contents of 12-13% and 10-11% with all grain types except with the medium grain type which breaks more at lowest moisture content of 10-11%.Therefore 12-13% moisture content is a condition for optimal performance of this machine with all grain types.

It performed much better at the feed rate of 0.033kg/s, because at higher feed rate of 0.088kg/s the milled rice obtained were not sufficiently polished and at lower feed rate of 0.014kg/s the broken percentage was high, therefore, 0.033kg/s is recommended for optimal performance of this machine.

Also, whiteness of rice milled in this machine increased with decreasing feed rates at all levels of moisture contents considered; while input and output rate varied inversely.Finally,the operational mode of this machine is simple with higher input and output rate when compare to the imported rubber roller milling machine.

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