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To cite this article: J.O Ojediran *et al* 2021 *IOP Conf. Ser.: Mater. Sci. Eng.* **1107** 012044

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Evaluating the Drying Characteristics of Paddy Rice Using Superheated Steam Dryer

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Abstract

It has been recorded in literature that superheated steam has the ability to combine the parboiling operation (steaming and drying) of paddy (*Oryza sativa* - UPL1) rice into a single unit. According to literature, this process has not been fully explored and implemented in rice processing. In this research work, superheated steam dryer was used to parboil (steam and dry) paddy rice. Soaking time and temperature used was 12 hours at 60°C, with steaming time ranging from 10 to 24 mins, while the drying conditions used were; temperature (160, 170 and 180°C), bed depth (1, 3 and 5 cm) and tempering time (20 and 40 minutes). In addition, paddy rice was dried from initial moisture content ranging from 26-43% (d.b) to a final moisture content of 2 – 8% (d.b). It was observed that the milled rice yield ranged from 71.32 to 94.5%, head rice yield ranged from 70.5 and 90.6%, broken rice ranged from 3.2 to 7.7%, chalkiness ranged from 3.4 to 10.6% and drying capacity ranged from 0.1 to 0.36 kg/h. The results obtained shows that drying with superheated steam can be used to improve rice quality.

Keywords: Superheated steam, (*Oryza sativa* - UPL1) rice, Milling rice yield and Head rice yield.

1. Introduction

Parboiling, a hydrothermal treatment given to rice involves; steeping/soaking, steaming and drying rice prior to milling. About 90-95% of paddy harvested in Nigeria is parboiled before milling [1]. The quality of grain is a complex feature which is determined in terms of milling recovery, sensory, and nutritional qualities [2]. Quality of rice is an important factor that can influence its rate of consumption, thus improving its production [3]. According to Miah *et al.*, [4], parboiling has been indicated to improve the yield of head rice and the overall value of rice as it seals the empty spaces and fortifies the cracks within the endosperm, making the grain harder thereby abating internal crack formation and breakage during milling. Higher milling yields, resistance to spoilage caused by insects and molds, and a higher nutritional value are the main reasons for parboiling rice, during the parboiling process (soaking and steaming) nutrients are moved from the external bran layer to the interior of rice kernels. [5]. Endosperm (chalkiness) remained one of the key determinants in the market value of rice grain under the grain quality characteristics. Chalkiness is a vital quality attribute for rice, it shows poor paddy characteristic and affects the cooking and sensory quality of paddy rice [3]. It takes place during the parboiling cycle when paddy rice is not fully gelatinised. [6].



In recent years, increased attention has been paid to the usage of superheated steam (SS) in thermal food treatments. Teachepajaroj [7] reported that it has the potential to combine the parboiling process (steaming and drying) of paddy. SS is known as dry steam, similar to a gas that doesn't contain water or exist in contact with it [8]. It has been stated that the use of SS doesn't result in the enzymatic browning reactions of food products due to the lack of oxygen and that rice dried with SS has a higher yield of head rice compared to that dried with hot air [7, 9, 10].

Consequently, this project was conducted to evaluate the drying performance of paddy rice using a superheated steam dryer.

2. Experimental Methods

2.1 Sample Preparation: UPL 1 paddy variety was used in this research and it was sourced from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria on November 2019. Paddy samples were weighed and washed with water to remove impurities and empty hulls. It was steeped in water at a temperature of 60°C (and allowed to come to ambient temperature) for 12 hours to achieve the desired moisture content of 26-43% dry basis (d.b.). After soaking, paddy was sieved and was spread on a flat surface to temper for an hour to ensure equilibration at ambient conditions. Moisture content was then estimated by dehydrating already soaked sample in a fixed air-oven at 105°C for 24 h and calculating the moisture content using the formula stated by ASAE standard (1997). Different combinations of drying temperatures (160, 170 and 180°C, bed depths (1, 3 and 5cm) and tempering time (20 and 40 minutes) in between drying were selected to carry out this experiment;

For each experimental run, the dryer was allowed 30min to stabilize the drying conditions. The initial moisture content of each sample was noted and the sample was weighed before placing it in the dryer.

2.2 Evaluating Drying Characteristics of Paddy Rice

- Milled rice yield: - Milling of paddy took place at the Food Processing Laboratory, Landmark University, Omu-Aran, Nigeria. The milling process involved dehusking. Dried parboiled samples were first weighed before loading into the hopper of the departments' fabricated rice dehusking machine to produce brown rice. Milled yield is the mass percentage of rough rice remaining as milled rice; it is also known as the "total" yield. Milled rice yield can be calculated using the formular as given by Ghasi *et al.*, [11] as:

$$MRY = \frac{\text{Milled rice mass}}{\text{rough rice mass}} \times 100 \quad (1)$$

- Head rice yield: - Head rice yield serves as a commercial indicator of rice quality. They consists of milled rice kernels at least three-fourths of the kernel's original length; sometimes it is referred to as "full" kernels. Head rice yield (HRY) which is the mass percentage of rough rice remaining as head rice is calculated as:

$$H_R = \frac{M_H}{M_R} \quad (2)$$

Where, M_H = Mass of head rice, M_R = Total mass of milled rice, H_R = Head rice (milled rice with length greater or equal to three quarters of the average length of the whole kernel).

- Broken rice yield: -Broken rice yield (BRY) is calculated using the formular as stated by Sarker *et al.*, [12] as;

$$\text{BRY} = \text{MRY} - \text{HRY} \quad (3)$$

- Chalkiness: - it is determined by the visual assessment of the chalky proportion and is calculated using the formula as stated by IRRI [13];

$$\% \text{Chalkiness} = \frac{\text{weight of chalky grains}}{\text{weight of milled grains}} \times 100 \quad (4)$$

Calculation is based on the standard evaluation system scale presented below;

Table 1: standard evaluation system (IRRI, 2002)

SCALE	%AREA OF CHALKINESS
1	Less than 10
5	10-20
9	More than 20

3. Results and Discussion

3.1 Milled Rice Yield

As shown in figure 1 the milled rice yield ranged from 71.32 to 94.5%, it decreased with increasing temperature but increased with bed depth and tempering time. This result is higher than that obtained by Sarkar *et al.*, [12] who recorded a milled rice yield of 64%. The decrease in milled rice yield with a rise in temperature occurs because superheated steam at high temperature causes paddy to become rigid and tough thereby causing it to resist milling [6].

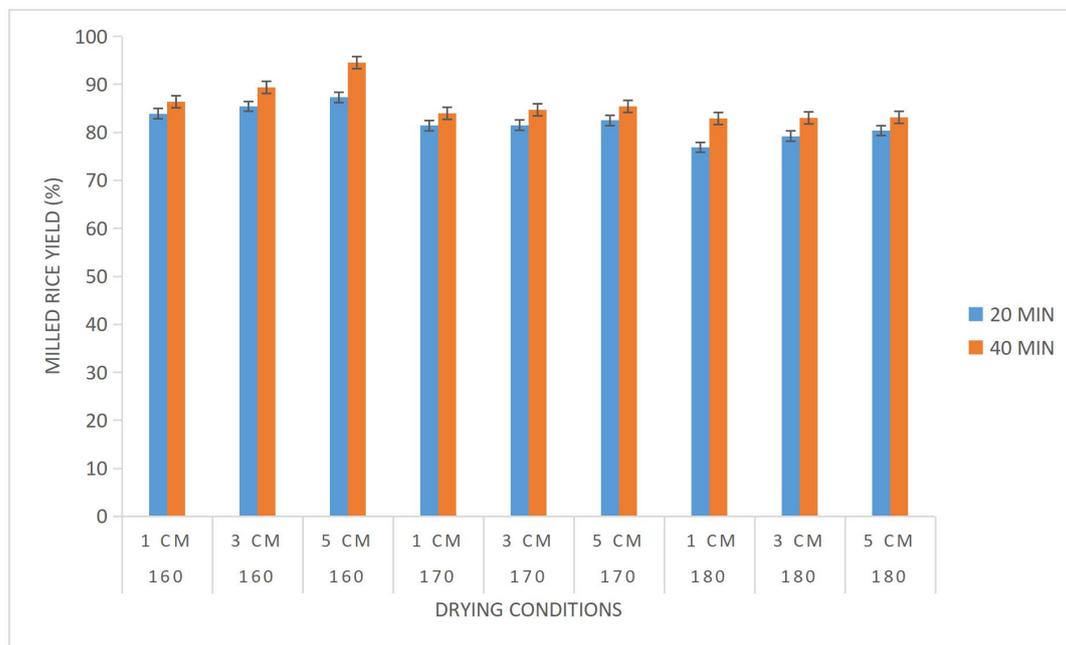


Fig 1: Percentage milled rice yield

3.2 Head Rice Yield

As shown in figure 2, the head rice yield of paddy rice was between 70.5 and 90.6%. The maximum HRY (90.6%) was obtained at drying condition 180,1cm and 20 mins tempering time. Teachapajaroj *et al.*, [7] dried paddy rice with SHS and obtained a maximum head rice

yield of 70% with drying conditions of 160°C and 10cm bed depth. The result obtained is higher than that recorded by Sarker *et al.*, [14] who recorded a highest head rice yield of 53% using hot air in drying paddy rice and also Ghiasi *et al.*, [11] who had a head rice yield of 59%. The higher yield of head rice is due to the fact that swelling caused by the superheated steam which occurs during gelatinization allows the starch granules to move together and are therefore resistant to deformation by enhancing the binding forces intra-molecularly [15]. Although tempering has been known to increase HRY during hot air drying, it is not the case when drying with SHS, it was observed during the research that a rise in tempering time resulted in a decrease in HRY, this could be due to the interference in the gelatinization of paddy during drying and can also be due to the variety of paddy used for the research [16].

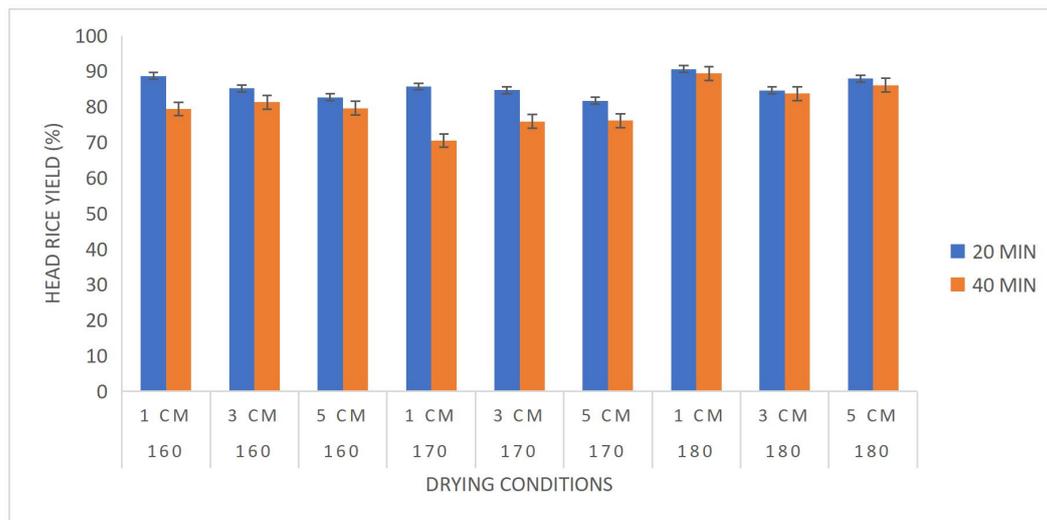


Fig 2: Percentage head rice yield

3.3 Broken Grains Yield

Figure 3 represents the percentage of broken grains yield obtained at the various drying condition with 7.7% as the highest recorded which occurred at drying temperature of 160°C, tempering time of 40min and bed depth of 5cm. The highest percentage of broken rice recorded is acceptable as it does not exceed the benchmark of 30%. Sahari *et al.*, [17] stated that paddy parboiling that produces a broken rice percentage of higher than 30% is a failure. High percentage of broken grains is a major problem in the rice industry as it is a determinant of the appearance quality of rice [3].

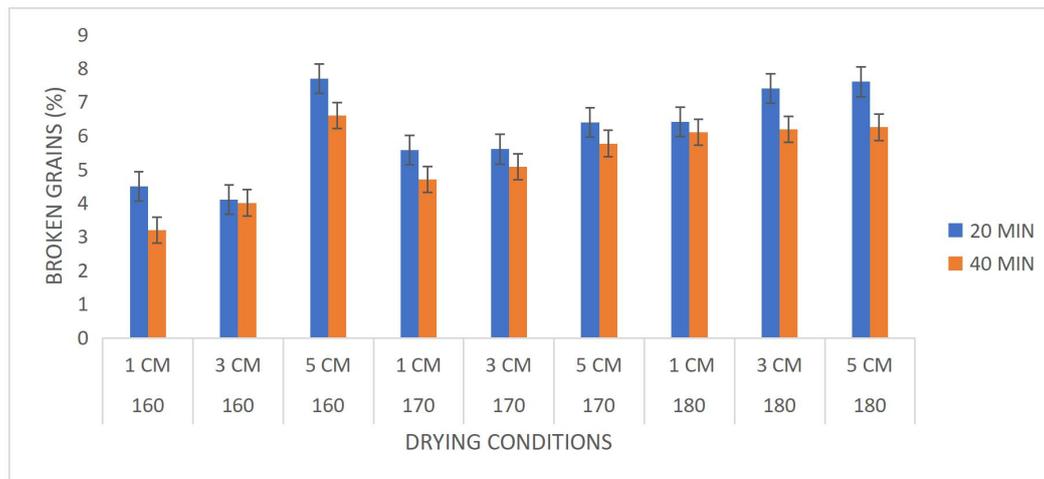


Fig 3: Percentage broken grains

3.4 Chalkiness

It was observed as shown in figure 4 that chalkiness reduced with an increase in temperature but increased with a rise in tempering time and bed depth. The lowest percentage of chalkiness was obtained at a temperature of 180°C with bed depth of 1cm and tempering time of 20 min. Based on table 1, the percentage of chalkiness was medium at the drying condition of 160°C, 5cm and 10 min tempering time and low at other drying conditions. Soponronnarit *et al.*, [6] recorded their highest percentage of chalkiness of 85% at drying conditions of 140°C and 10cm bed depth while Taechapairoj *et al.*, [7] recorded their highest at a percentage of 4% with drying conditions of 160°C and 10cm bed depth, they reported that the percentage of chalky grains reduced with a rise in drying temperature. There was also a reduction with decrease in moisture content and increase in drying time. The gelatinization process requires that grains be exposed to steam long enough to ensure complete gelatinization through the endosperm of the kernel [18].

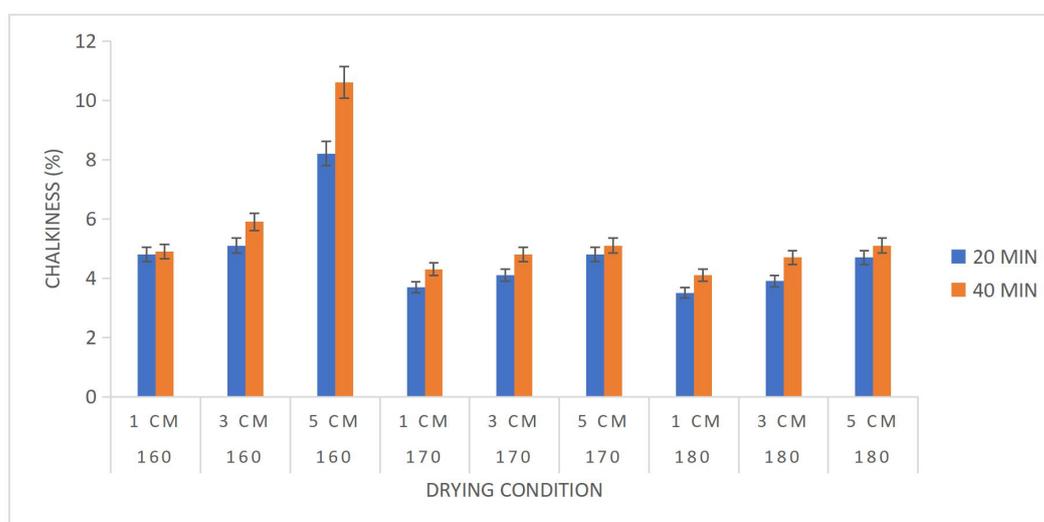


Fig 4: Percentage Chalkiness

4. Conclusion

In this research, the drying conditions used has proven to produce higher head rice yield and milling yield; as a rise in tempering time resulted in an increase in milling yield and chalkiness and also led to a reduction in head rice yield. It was also detected that bed depth had a noticeable influence on grain chalkiness as an increase in bed depth led to an increase in grain chalkiness. This research shows that drying with superheated steam can be better used in improving the quality of rice when compared to hot air drying. The drying conditions used also gave better dryer performance as compared to other superheated steam drying conditions, used in the drying of paddy rice. Further research should be carried out into the use of superheated steam in boosting the quality of rice.

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