International Journal of Academic and Applied Research (IJAAR)
ISSN: 2000-005X
Vol. 3 Issue 3, March – 2019, Pages: 12-18

Effect of Far Infra-Red Radiation on Paddy Parboiling and Milling Qualities

A.M.M.Irfeey[1], A.B.F. Husna[2], A.L.M. Rifky[1]

[1] Department of Biosystems Technology, Faculty of Technology, Eastern University, Vantharumoolai, Chenkallady, Sri Lanka.
[2] Zahira college, Anuradhapura, Sri Lanka.

Abstract: *Paddy parboiling is a hydrothermal process applied as a treatment to rough rice, prior to normal milling stage. The parboiling process consists of three separate operations as; soaking, steaming and drying. The traditional parboiling soaking process needs high water consumption, causes high water pollution, air pollution and high energy consumption than using far –infrared (FIR) method. This study was conducted to use the FIR on parboiling process and to test quality of milled rice. The paddy sample BG358 (1kg) was selected and measured its initial moisture content and different soaking moisture contents from the sample were prepared as: 22%, 25%, 28% and 31% respectively for parboiling. Parboiling process was done at 175 ^{0}C for 20s by using FIR in 3 different distances as: 20cm, 30cm, 40cm and 3 replicates for each samples and rice cooker (100 ^{0}C, 25 min) used as control method. Milling qualities of par boiled rice were tested. The white belly rice percentage and broken rice yield percentage were significantly low in samples soaked up to 28% and the total rice yield and head rice yield were not significantly difference with control samples. The selected qualities were not influenced by various radiation intensities while the white belly rice only showed significantly less yield in 30 cm distance. The energy consumption of FIR was 0.005445kWh while the energy consumption was 0.416 kWh from traditional method. Moisture content of soaked paddy was identified as main cause for broken paddies.*

Keywords*;* Par boiling, milling, soaking, steaming, drying, far-infrared (FIR)

1. Introduction

Parboiling is an old method of rice processing, widely used in most of the developing countries. The process of parboiling are three-stages: soaking, gelatinization and drying (Das *et al*., 2004). Treatment of parboiling: gelatinizes the rice starch, improves the hardness of the rice upon drying and minimizes the breakage losses and thus increases the milling yield (Poritosh Roy *et al*., 2011). The starch gelatinization brings about changes in the physicochemical properties of the rice (Bualuang *et al.,* 2012). Parboiling prolongs storage life, allows easier hulling of the grains, makes the grain harder, produces less broken during milling ,reduces breakage and also facilitates the breakdown of protein bodies as well as adding a characteristic colour (Imonigie *et al.,* 2017), reduces insect attack on the grain and increases vitamin B content of grain (Toktok, 2003). Parboiled rice has lower nutrient loss during milling and cooking corresponding to percentage of ash enrichment and high content of mineral and nutrient matter compared with the milled rice (Bualuang *et al.,* 2012). Texture and flavour to the rice also increase the nutritive value during parboiling. It also increases the market value (Imonigie *et al*., 2017), and is preferred by some people for its taste (Toktok, 2003) and paddy with a high initial moisture content >22% wb is found to be suited for parboiling by this technique (Das *et al.*, 2004).

One of the consequences of this pre-treatment is an increase of moisture content to 35% (wb). Hence it is essential to reduce the moisture to 14% (wb) prior to further processing (Das *et al.*, 2004). Parboiling prolongs storage life, allows easier hulling of the grains, makes the grain harder, produces less broken during milling, reduces breakage and also facilitates the breakdown of protein bodies as well as adding a characteristic colour (Imonigie *et al.,* 2017), reduces insect attack on the grain and increases vitamin B content of grain (Toktok 2003). Parboiled rice has lower nutrient loss during milling and cooking corresponding to percentage of ash enrichment and high content of mineral and nutrient matter compared with the milled rice (Bualuang *et al*., 2012).

Texture and flavour to the rice also increase the nutritive value during parboiling. It also increases the market value (Imonigie et al. 2017), and is preferred by some people for its taste (Toktok 2003). Demand for brown rice and parboiled rice are increasing because of their reputation for nutritional excellence and health claims associated with eating this type of rice (Parnsakhorn & Noomhorm 2008). It is special one in health food and green organic products. But, it requires more energy and time for cooking of parboiled rice (Poritosh Roy *et al*., 2003). Parboiled rice has been produced by both traditional and modern methods. Modern methods are energy and capital intensive, and are not suitable for small scale operation at the village level (Poritosh Roy *et al.*, 2003).

The traditional method is time consuming and often laborious, and the end products are always below the required quality desired by the consumers. The traditional parboiled rice still doesn't meet the required standard of storage (Imonigie *et al*. 2017).

In the process, the paddy is soaked, steamed and re-dried before milling. This process greatly affects the milling, storage, cooking and eating qualities of rice. Parboiling can be mechanized or carried out in simple traditional forms (Toktok 2003). Infra-red radiation heating operation is relevant to many industrial heating and drying process because, it can achieve rapid and contactless heating. Specific advantages of IR heating compared with conduction and convection heating are reduced heating time, uniform heating, reduced quality losses, absence of solute migration in material, versatility, simplicity, compact equipment and energy saving (Zhongli Pan and Griffiths Gregory Atungulu, 2010).

Infrared (IR) is used for heating of food stuffs for different purposes like drying, cooking, baking, roasting and blanching. IR heating technique to be fit for drying of heat-sensitive products like rice (Dariush Zare *et al.*, 2015.). Its ability to reduce the drying time has been reported by several researchers who dried a variety of food products such as rice, potato, barley, welsh onion, banana and citrus press-cakes (Nathakaranakule *et al*., 2010). Combining FIR with some other drying processes could also improve the quality of dried products, i.e. head rice yield of paddy , hardness of dried banana slices and fresh condition of onion (Nathakaranakule *et al.*, 2010).

2. Materials and methodologies

Paddy sample (variety BG 358) was cleaned and separated from immature, undersize and oversize, stones, dust and chaff by using paddy cleaner device and prepared. Initial moisture content of paddy sample was measured by using oven dry method (Gravimetric method). Then, soaked into 4 different volumes of water samples to create different moisture contents. 1kg of paddy sample was filled in each bottles and air tied and shacked in regular interval for 21days and moisture contents of the 4 volumetric water filled samples were calculated and mean time traditional soaking method also done. Samples were processed for parboiling by using FIR machines and traditional method sample was processed to parboil by using rice cooker.

In FIR parboiling method, three radiation intensities (three 15 cm x 5 cm ceramic electric IR modules (660 W each) mounted at the top of the apparatus) of FIR machine with three different distances (20cm, 30cm and 40cm) were tested for parboiling. Then final moisture content of the parboiled rice sample were measured by using moisture meter and after allowed to reach room temperature by spreading in the large pan.

The moisture content of dried parboiled rice is determined as 14 ± 0.3% (wet basis) and the dried parboiled paddy from each samples were sent to determine the milling quality of rice. Sample of 250g is weighed to the nearest 0.1g and de-husking was carried out by using laboratory husker. The whitening of brown rice is carried out to a bran removal of 7.0 ± 0.5% by using laboratory polishing machine.

2.1. Testing of milling quality of rice

The milling quality of the dried parboiled paddy was calculated using following equation (Sahay and Singh 2006).

$$TMY = \left(W_{MR} / W_P \right) \times 100$$

TMY = Total milling yield
W_{MR} = Total weight of milled rice
W_P = Paddy weight

2.2. Head rice yield

The head rice yield of dried parboiled paddy was calculated using following equation (Sahay and Singh 2006).

$$HRY = \left(W_{HR} / W_{MR} \right) \times 100$$

HRY = Head rice yield
W_{HR} = Weight of head rice
W_{MR} = Weight of milled rice

2.3. The percentage of broken

The selection of broken rice percentage was done manually based on broken grains, which were less than ½ broken of rice kernels. Then the broken percentage was expressed as a percentage of milled rice weight. The percentage of broken of milled rice was calculated using following equation (Sahay and Singh 2006).

$$BP = \left(W_{BR} / W_{MR} \right) \times 100$$

BP = Broken percentage
W_{BR} = Weight of broken rice
W_{MR} = Weight of milled rice

2.4. The percentage of white belly

The percentage of white belly of milled rice was calculated using following equation (Sahay and Singh 2006).

$$WBP = \left(W_{WB} / W_{MR} \right) \times 100$$

WBP = Percentage of white belly
W_{WB} = Weight of white belly
W_{MR} = Weight of milled rice

2.5. The percentage of discolored grains

The percentage of discoloured grains of milled rice was calculated using following equation (Sahay and Singh 2006).

$$DGP = \left(W_{DG} / W_{MR} \right) \times 100$$

DGP = Discoloured grain percentage
W_{DG} = Weight of white belly
W_{MR} = Weight of milled

2.6. Energy estimation

Measured energy consumption of rice cooker (1000W) and FIR heater (1980W). (Fernando 2015),
$E = P \times T$
E- Energy (kWh)
P- Power (w)
T- Time (h)

Results and Discussion

4.1 White belly percentages

4.1.1 White belly percentage with moisture changes

There was a significant relationship between moisture level and the white belly percentage. Moisture with 28% was the low percentage value of white belly rice and moisture with 36.7% was the high percentage value of white belly rice ***(Figure 1).***

4.1.2 White belly percentage with radiation distance

There was a significant relationship between radiation intensities and white belly percentage. Radiation intensity of 30cm distance was low in percentage and 40cm distance was high in percentage ***(Figure 2)***.

4.2 Broken rice percentage

4.2.1 Broken rice percentage with moisture changes

We have determined the broken rice % changes with moisture contents of soaked paddy. There is a significant change between the broken rice % and moisture changes of soaked paddy. The moisture content of 28% is showing least broken rice %. The moisture levels (25%, 28%, 31%) are showing significant different in broken rice % with control level and 22% moisture content ***(Figure 3).***

4.2.2 Broken rice percentage with radiation distance

We have measured broken rice % with radiation intensity using FIR machines. It is showing a significant change between broken rice % and radiation intensities. The intensity 30 cm is having less broken rice % but other intensities (20 cm, 40 cm) are having high broken rice %. Although mean value is not showing a significant change with

International Journal of Academic and Applied Research (IJAAR)
ISSN: 2000-005X
Vol. 3 Issue 3, March – 2019, Pages: 12-18

control levels ***(Figure 4).***

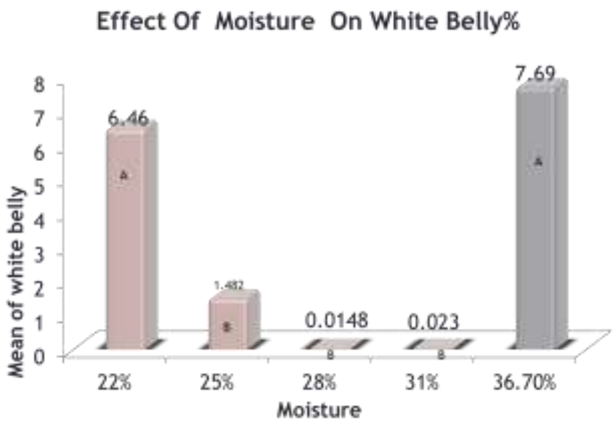

Figure 1. Effect of moisture on white belly percentage

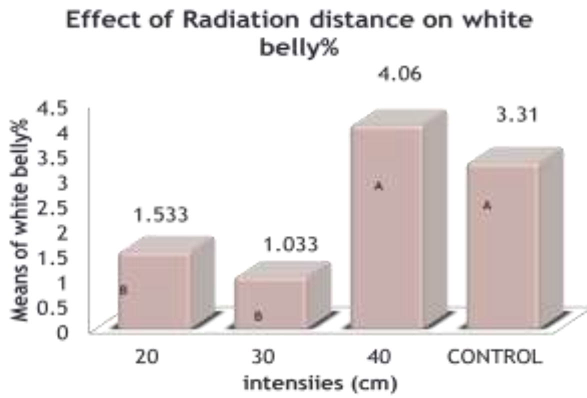

Figure 1. Effect of Moisture on White Belly %

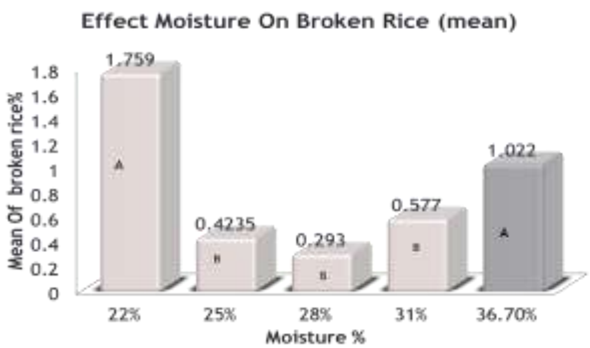

Figure 3. Effect moisture on broken rice (Mean)

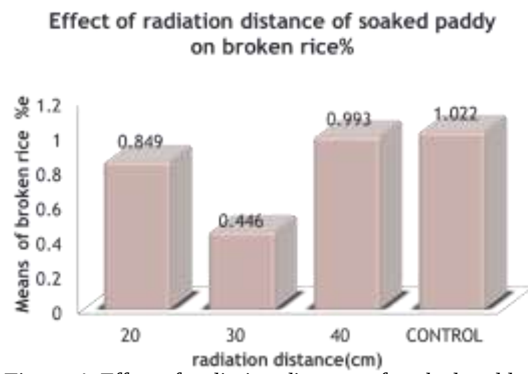

Figure 4. Effect of radiation distance of soaked paddy on broken rice %

4.3 Discolor percentage

4.3.1 Discolor grain percentage with moisture changes

We have measured Discolour grain % with moisture changes of soaked paddy. It is showing a significant difference between the Discolour grain % and moisture changes of soaked paddy. The moisture level 22% is having a high Discolour grain %. All other moisture levels are not showing significant difference with control level ***(Figure 5).***

4.3.2 Discolor grain percentage of radiation distance

We have measured Discolour grain % with radiation intensity of FIR machines. It is not showing a significant change between Discolour grain % and radiation intensities. The intensity 30 cm is having less Discolour grain % but other intensities (20 cm, 40 cm) are having high Discolour grain percentage. Although mean value is not showing a significant change with control level ***(Figure 6).***

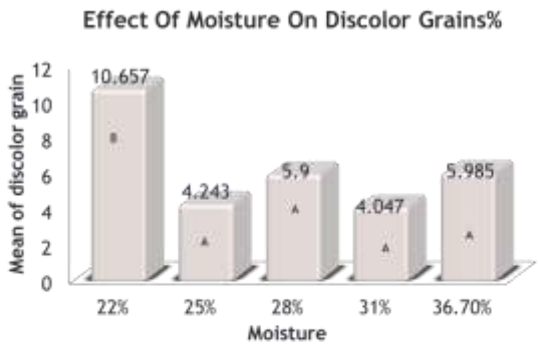

Figure 5. Effect of moisture on discolour grains %

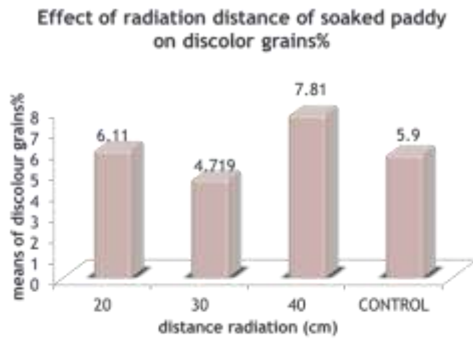

Figure 6. Effect of radiation distance of soaked paddy on discolour grains %

4.4.1 Head rice yield percentage with moisture changes

We have measured Head rice yield % with moisture changes of soaked paddy.it is not having a significant difference between the Head rice yield % and moisture changes of soaked paddy. The moisture level 28% is showing high Head rice yield % compared with other moisture levels ***(Figure 7).***

4.4.2 Head rice yield percentage of radiation distance

We have measured Head rice yield % with radiation intensity of FIR machines. It is not showing a significant change between Discolour grain % and radiation intensities. The intensity 30 cm is having high Discolour grain % than the other intensities (20 cm, 40 cm) ***(Figure 8).***

4.5.1 Total rice yield percentage with moisture changes

We have measured Total rice yield percentage with moisture changes of soaked paddy.it is not having a significant difference between the Total rice yield % and moisture changes of soaked paddy. Control level is showing high total rice yield, but the other levels of moisture showing lower total rice yields ***(Figure 9).***

4.5.2 Total rice yield percentage of radiation distance

We have measured Total rice yield % with radiation intensity of FIR machines, it is not showing a significant change between Total rice yield % and radiation intensities, control is showing the high total rice yield ***(Figure 10).***

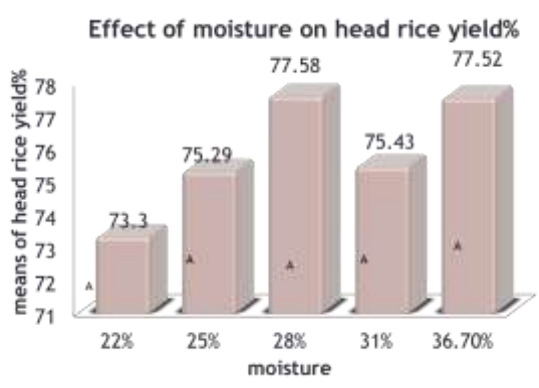

Figure 7. Effect of moisture on head rice yield %

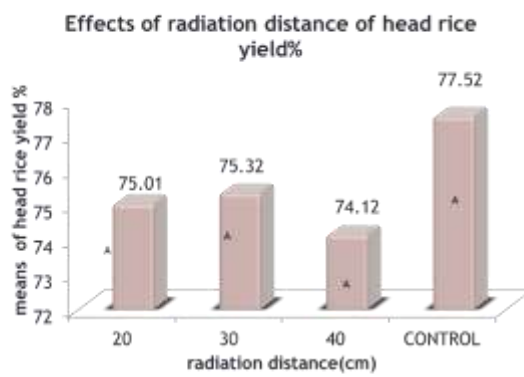

Figure 8. Effects of radiation distance of head rice yield %

International Journal of Academic and Applied Research (IJAAR)
ISSN: 2000-005X
Vol. 3 Issue 3, March – 2019, Pages: 12-18

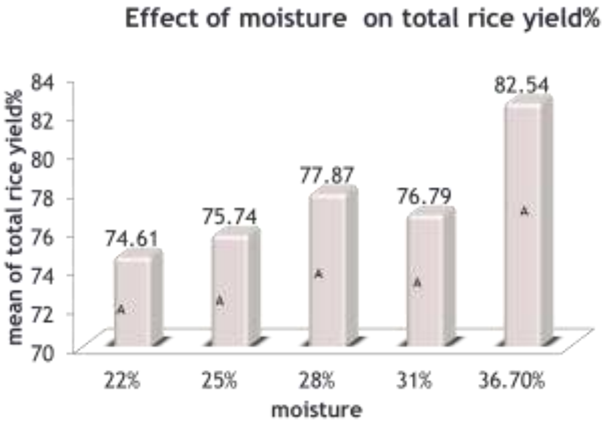

Figure 9. Effect of moisture on total rice yield %

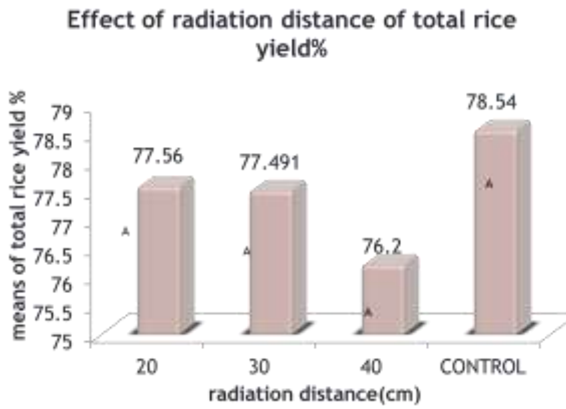

Figure 10. Effect of radiation distance of total rice yield %

Table 1. Effect of radiation distance of total rice yield %

Moisture%	White belly%	Discolour grain%	Broken rice%	Head rice yield%	Total rice yield%
22%	6.46±4.38	16.65±1.657	1.759±2.744	73.3±3.00	74.61±2.88
25%	1.48±1.971	4.24±1.368	0.423±5.158	75.29±5.49	75.74±5.26
28%	0.04±0.534	5.90±1.528	0.293±4.748	77.58±4.95	77.87±4.75
31%	0.02±1.55	4.04±1.704	0.577±4.33	75.43±3.26	76.79±4.34
36.7%	7.69±5.04	5.98±2.04	1.022±2.285	77.52±1.83	82.54±1.58

Table 2. Mean value of Radiation intensities and milling qualities

Intensity (cm)]	White belly%	Discolour grain%	Broken rice%	Head rice yield%	Total rice yield%
20	1.533±2.851	6.11±3.88	0.84±0.601	75.01±3.63	77.56±2.58
30	1.033±1.875	4.71±3.146	0.446±0.593	75.32±2.34	77.49±2.18
40	3.42±4.60	7.81±3.54	0.993±1.31	74.12±5.82	76.2±5.8
Control	7.69±5.04	5.98±2.04	1.022±2.285	77.52±1.83	82.54±1.58

Conclusion

According to this research study, the moisture content significantly changed with white belly%, discolour grain%, broken rice%. Total rice yield and head rice yield % were not significantly changed with moisture contents. White belly % and broken rice % were significantly changed with radiation distance but all other properties as discolour grain%, broken rice yield%, total rice yield% and head rice yield% were not expressed any significant changes with radiation distance. Far infra-red radiation method is an effective method considering energy consumption.

References

Bualuang, O., Tirawanichakul, Y. Tirawanichakul, S., (2012). "Comparative study between hot air and infrared drying of parboiled rice : kinetics and qualities aspects." *International Journal of Food Processing and Preservation.* 37(6). pp.1–14.

Das, I., Das, S.K. Bal, S., 2004. "Specific energy and quality aspects of infrared (IR) dried parboiled rice." *Journal of Food Engineering*, 62(1), pp.129-133.

Imonigie, P.S., Yusuf, K.A. & Atanda, E.O., 2017. "Development of a Temperature-Controlled Paddy Rice Parboiler." *American Journal of Mechanical and Material Engineering*, 1(1), pp.5–9.

Nathakaranakule, A., Jaiboon, P. & Soponronnarit, S., 2010. Far-infrared radiation assisted drying of longan fruit. *Journal of Food Engineering*, 100(4), pp.662–668.

Poritosh Roy, Takahiro Orikasa, Hiroshi Okadome, Nobutaka Nakamura, Takeo Shiina. (2011). "Processing Conditions, Rice Properties, Health and Environment (Review)." *International Journal of Environmental Research and Public Health*, 8, pp. 1957-1976.

Poritosh Roy, Naoto Shimizu, Singo Furuichi, Toshinori Kimura (2003). "Improvement of traditional parboiling process." *Journal of the Japanese Society of Agricultural Machinery* 65 (I). pp. 159-166.

Parnsakhorn, S., Noomhorn, A. (2008). "Changes in physicochemical properties of parboiled brown rice during heat treatment." *Agricultural Engineering International*. 5 (10), FP 008– 009 pp 1- 20.

Dariush Zare, Hossein Naderi, Mohsen Ranjbaran (2015). Energy and Quality Attributes of Combined Hot-Air or Infrared Drying of Paddy. *An International Journal of Rying Technoloy*. 33(5). pp.37–41.

Toktok, N., 2003. "Parboiling of Paddy Rice". National Agricultural Research Institute Wet Lowlands Mainland Programme PO Box:1639, LAE 411.

Zhongli Pan, Griffiths Gregory Atungulu. (2010). "Infrared heating for food and agricultural process. *Boca Raton: CRC Press*.