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Original Research Article

Study of Some Operational Parameters in Microwave Heating for Parboiling of Paddy

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A B S T R A C T

Rice (*Oryza sativa*) is the staple food of half of the world population. But it is necessary to reduce the losses in the post harvest processing of rice for completing its demand. To reduce these losses, there is a very important process of parboiling which is done before the rice milling, parboiling of paddy is also known as pre milling treatment of paddy. For the effect of MW heating on moisture absorption during hot soaking of paddy for parboiling, at lower power levels of 320 W the moisture absorption (47%) was better for supplying the same heat energy (120 KJ) as compared to other power levels. The higher moisture level (47%) attained in time 375 sec of lower power (320 W) facilitated the gelatinization of the starch which resulted in hardening of rice, ultimately provided better head rice yield. Using CRD statistical design we analyzed the moisture absorption in paddy during hot soaking of paddy in MW oven. The maximum moisture was attained at lower power level (320 W), maximum exposure time (375 sec) and energy level (120 KJ). This combination also resulted in maximum HRY (%) (66.08%).

Keywords

Parboiled, Moisture content, Microwave etc

Introduction

Paddy is normally harvested at a high moisture content of about 20% to 24% (wb). After harvesting to prevent deterioration, the paddy should be dried down to a safe moisture content of about 12-14% (wb), which is considered safe for storage, milling and further storage as milled rice (Bonazzil *et al.*, (1997). Most rice varieties are composed of roughly 20% rice hull or husk, 11% bran layers, and 69% starchy endosperm, also referred to as the total milled rice. In an ideal milling process this will result in the following fractions: 20% husk, 8−12% bran depending on the milling degree and 68−72% milled rice or white rice depending on the variety. Total milled rice contains whole grains or head rice, and broken. The by-products in rice milling are rice hull, rice germ and bran layers, and fine broken (IRRI, 2013).

Parboiling is a hydrothermal process in which paddy is deliberately allowed to absorb water and later steamed to gelatinize the starch in

the endosperm before drying and milling. The process of parboiling seals internal fissures in the rice grain resulting in higher HRY during milling (Manful *et al.*, 2009). About one-fifth of world's rice harvest is parboiled. The process changes the starch structure from amorphous form and hardens the endosperm, making it translucent. The hardening process makes the grain tough and increases its resistance to breakage during milling operation, resulting in improved head rice yield. It also increase grain resistance to insect attack and improve its nutritional quality.

There are great overall advantages of parboiling, due to hardening of the grain, insects find it more difficult to infect. Total yield after milling increases by 3-4% when compared to regular rice as the breakage reduces. Parboiled rice is rich in minerals as it contains 3% of calcium, potassium, zinc, iron, and magnesium which if consumed on a daily basis is very beneficial for the body. It loses less starch during cooking. Once cooked, it stands for long times and stays fluffy. High blood sugar levels of body are well-managed because of sufficient carbohydrate presence. Being rich in vitamin B and niacin, it helps in producing neutron transmitters and helps our body metabolize food into energy. This rice is heavier for diabetics as it has low glycemic index meaning the food gets converted to sugar very slowly thereby keeping the sugar level low. Cooking quality differs from normal rice as it is non-glutinous and non-sticky.

Microwave heating refers to use of electromagnetic waves of certain frequencies to generate heat in a material and is mainly used for defrosting and low pressure drying. Microwave processing uses two frequencies of 2450 MHz and 915 MHz. For home ovens 2450 MHz is used and in industries both frequencies are employed (Pare and Madhyan (2011). The microwave heating mechanism is based on the interaction between water dipolar molecules and the electromagnetic field. Thus, the higher moisture content part of a product can absorb more energy which results in faster drying. The whole study was undertaken for optimization of operational parameters in microwave heating for parboiling of paddy.

Materials and Methods

This study was conducted for evaluation of the effect of microwave heating on moisture absorption during hot soaking of paddy for parboiling and to study its effect on milling quality of parboiled paddy. The research work was undertaken at the department of Post-Harvest Process and Food Engineering, College of Agricultural Engineering and Department of Food Science and Technology, JNKVV, Jabalpur (M.P).

Semi-dwarf variety of paddy (IR-36) was procured from the Department of Plant Breeding, College of Agriculture, JNKVV, Jabalpur. Paddy sample collected was cleaned and preliminarily open sun dried till moisture content of 13.6 % (db) was achieved. Each of sample (250 g) was carefully weighed and stored in microwaveable container and later subjected to different power and time combinations as per experimental plans discussed (Table 1). Four different power levels of microwave ranging from 320 W to 800 W were selected along with different time combinations.

In this research work, First of all moisture absorption during hot soaking was measured then milling qualities of parboiled paddy determined and compared with that of freshly harvested paddy sample (raw paddy) at 13.6 (%db) moisture content and at last optimization of process parameters for parboiling were calculated.

Plan of work

Experimental procedure

Moisture content calculation by hot air oven method

Temperature controller and hot air oven was used for gravimetric method of moisture content determination. The temperature and time combination of 130 degree Celsius and 16 hours was used to find the moisture content.

$$\text{Moisture content (w.b)} = \frac{\text{initial weight} - \text{final weight}}{\text{initial weight}} \times 100 \ldots (1)$$

$$\text{Moisture content (d.b)} = \frac{\text{initial weight} - \text{final weight}}{\text{final weight}} \times 100 \ldots (2)$$

Sample preparation

The initial moisture content of paddy (IR-36) was determined by hot air oven method. For determination of moisture content of paddy the hot air oven was set to a temperature of 130^{o} Celsius for 16 hours (AOAC standard). The initial moisture content obtained was 13.6 (%db.). 500 ml water was then gradually sprayed over the sample collected allowing sufficient time and temperature (70^{o} C) for its soaking.

Calibration of power level in the microwave oven

The power output by the microwave oven is displayed in the range of P1 i.e. 800, 640, 480 and 320 like this. The microwave exposure time was displayed within an interval of 10 sec. The power consumed by this microwave oven at different power levels were measured first by using watt-meter. Further, experiment was conducted to compare between the actual energy consumed by the material and the power level displayed in the oven. The calibration of the oven was carried out by boiling water method (Buffler, 1992). Measured amount of water was taken in a glass beaker and its initial temperature was recorded. Water was heated in the microwave oven and the time taken to initiate boiling was noted. The energy consumed by the water (Q) to boil was found out with equation (3) and the corresponding exposure time was calculated with equation (4). This t was compared to that of the displayed time in the oven.

$$Q = mCp(T-T1) \ldots (3)$$

$$P = Q / t \ldots (4)$$

Process of parboiling

The research work is fully based on microwave parboiling which is a hydrothermal treatment and has following steps:

Soaking

Draining

Heating

Drying

Process of milling

The procured paddy was converted into brown rice through a lab model Rice Miller at Department of Food Science, College of Agriculture, JNKVV, Jabalpur. Milling refers to the size reduction and separation operations used for processing of food grains into edible from by removing the milling process includes both de-husking and polishing simultaneously in a rice processing

lab McGill type rice miller which collectively operates both the operations of de-husking and polishing with a sample range up to 250 g.

The rice miller removes the husk of paddy grain with the help of two rubber rolls rotating in opposite direction at different speeds. The milling action of 28 treated samples and 1 controlled sample of 250 g each gave us following products of milling:

Husk

Head rice

Brokens

Unshelled paddy

Bran, with very little losses during operation.

Separation

The various components of milling obtained during milling were separated by Broken Rice Separator of various indent size(3.5, 4.2, 4.6 and 4.8 mm). These separated components were weighed using a weighing machine of least count 0.01 g.

Milling qualities of parboiled paddy

The qualities of parboiled paddy can be calculated by following formulas:

$$\text{Degree of milling} = \frac{\text{weight of milled rice}}{\text{total weight of sample regained after milling}} \times 100 \ldots (5)$$

$$\text{Degree of polishing} = \frac{\text{(weight of bran)}}{\text{weight of brown rice}} \times 100 \ldots (6)$$

$$\text{Head rice yield} = \frac{\text{weight of head rice}}{\text{total weight of sample regained after milling}} \times 100 \ldots (7)$$

$$\text{Broken percentage} = \frac{\text{weight of brokens}}{\text{weight of sample(brokens + Head rice) after milling}} \times 100 \ldots (8)$$

Results and Discussion

The results on various aspects of work have been presented and interpreted under suitable headings and sub headings. Inferences have been drawn from the results.

The effect of MW heating on moisture absorption during hot soaking of paddy for parboiling.

The moisture uptake by paddy during hot soaking by microwave parboiling at different exposure time and energy levels were discussed in the following section.

Moisture uptake by paddy during hot soaking by Microwave parboiling at different exposure time

The moisture absorption by paddy increases with the increased in the duration of exposure time for heating at various power levels (Fig. 1). It was observed that at lower power levels of 320 W the moisture absorption was less at same exposure time as compared to other power levels i.e. 480, 640 and 800 W at the same time. The higher power level at same exposure time, the moisture absorption was high as compare to other power levels. It was due to the reason that at higher power level the operating temperature was optimum for the moisture penetration to the paddy and then the rate of moisture absorption was higher (Table 2 and 3).

Table.1 The dependent and independent parameters used in the study

Sl. No.	Independent parameters	Levels	Dependent parameters
1	Microwave heating		• Moisture absorption during hot soaking of paddy. • Milling quality of parboiled paddy.
a.	Energy levels	7	
b.	Power levels	4	
c.	Exposure times	28	

Table.2 Operational independent parameters of MW heating for parboiling of paddy by hot soaking at initial moisture content of 13.6(%db).

Energy (KJ) / **Power (W)**	48	60	72	84	96	108	120
320	150	188	225	263	300	338	375
480	100	125	150	175	200	225	250
640	75	94	113	132	150	169	188
800	60	75	90	105	120	135	150
	Time of MW heating (sec.)						

Table.3 Comparison of factors of milling quality of parboiled paddy of suggested parboiling power, energy and time combinations with the control sample.

Sl no.	Energy (KJ)	Power levels (W)	Time (sec)	Degree of milling (%)	Degree of polishing (%)	Head rice yield (%)	Broken (%)
1	120	320	375	80.04	7.5	66.08	10.7027
2	120	480	250	80.01	8	64.61	9
3	120	640	188	80	8.25	63.16	10.24
4	120	800	150	80	8.5	62.8	10.4
Control sample				80	9.5	37.6	34.8

Fig.1 Effect of moisture content with time of microwave parboiling of paddy at different power levels

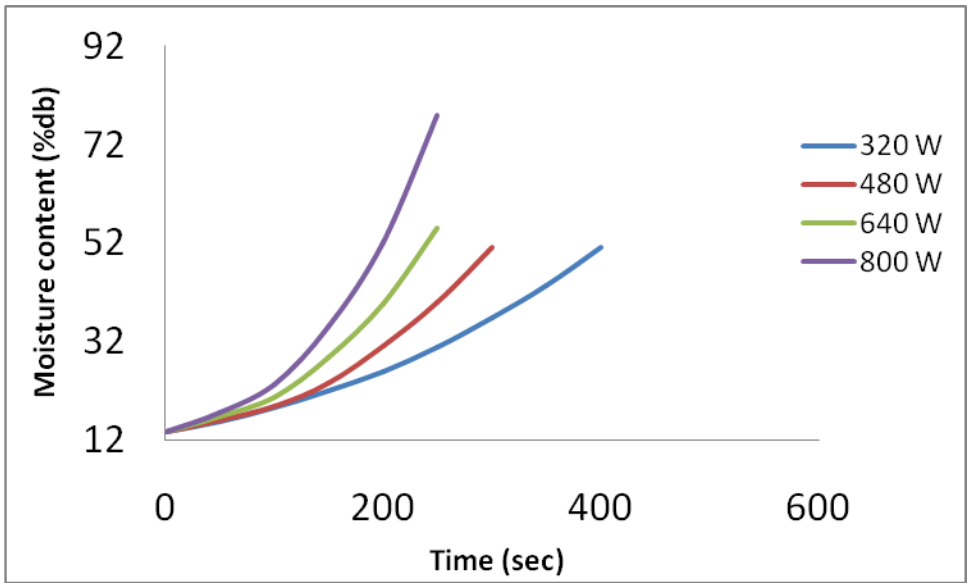


Fig.2 Effect of moisture content with energy of microwave parboiling of paddy at different power levels

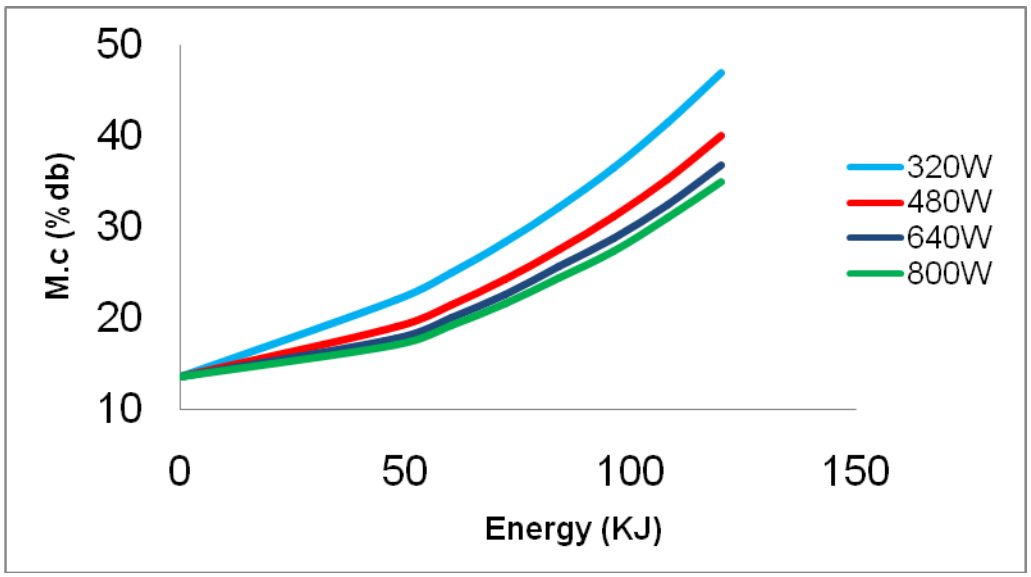


Fig.3 Effect of Head rice yield with time of microwave parboiling of paddy at different power levels

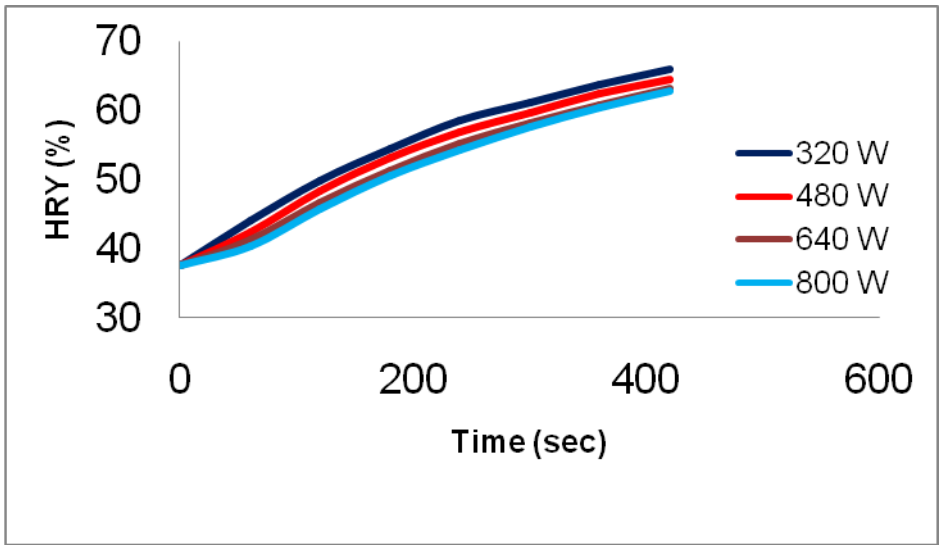


Fig.4 Effect of Head rice yield with time of microwave parboiling of paddy at different energy levels

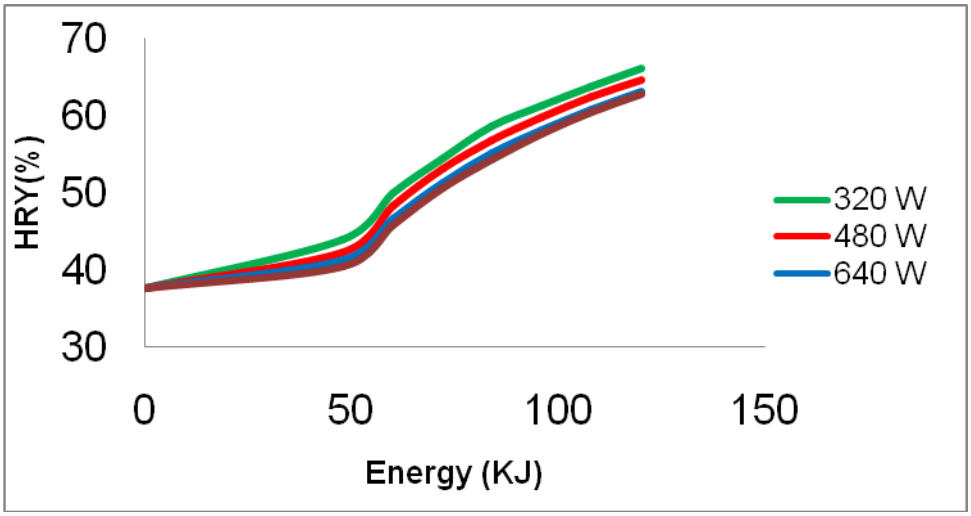


Fig.5 Effect of Brokens (%) with time of microwave parboiling of paddy at different exposure time

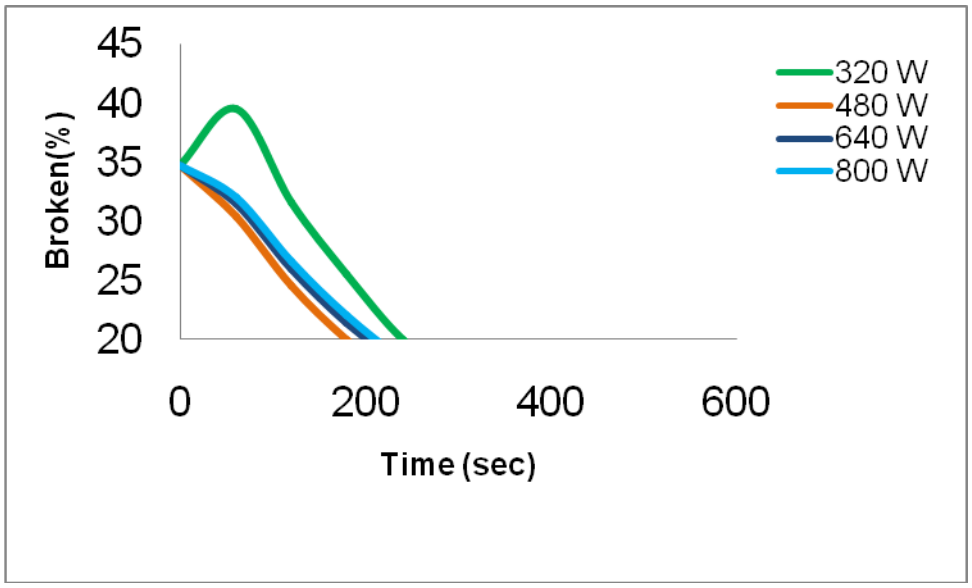
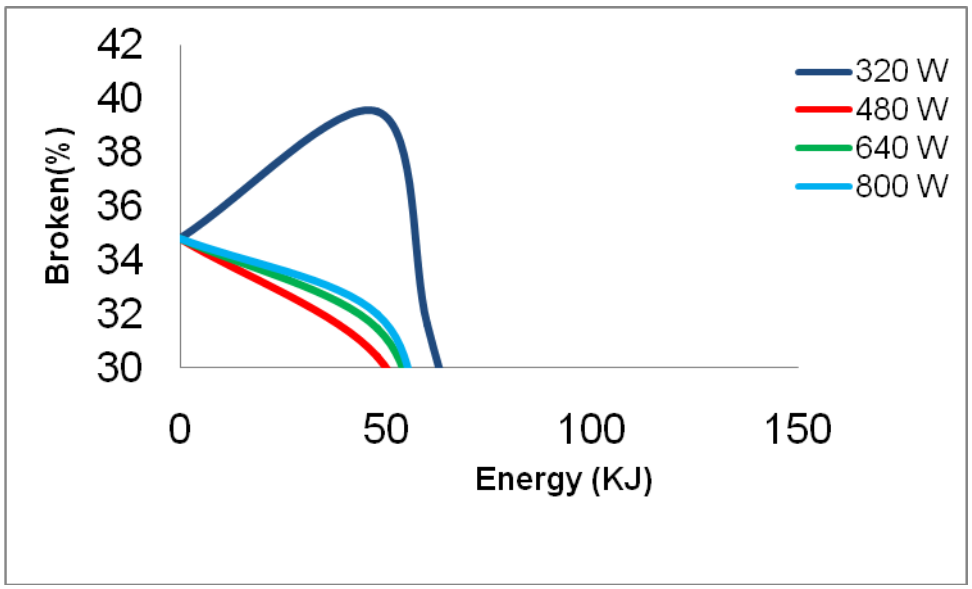


Fig.6 Effect of Brokens (%) with time of microwave parboiling of paddy at different energy levels



Moisture uptake by paddy during hot soaking by Microwave parboiling at different energy levels

The moisture absorption by paddy increased with the increase in energy supplied for heating at various power levels (Fig. 2). It was observed that at lower power level of 320 W the moisture absorption was better for supplying the same heat energy as compared to other power levels.

It was due to the reason that at lower power level the time required was higher to deliver

the same energy content and thus gave more time for hot soaking of paddy.

The effect of microwave heating on milling quality of parboiled paddy

The effect of microwave heating on milling quality of parboiled paddy at different exposure time and energy levels were discussed in the following section.

Head rice yield, % (HRY) for parboiled paddy at different exposure time of microwave heating

The moisture absorption by paddy increased with the increase in time for heating at various power levels (Fig. 3). As the moisture absorption at lower power levels of 320 W was better than other power levels (480, 640, and 800 W) for hot soaking in MW oven at higher exposure time (375 sec) and also at higher power level 800 W provides better HRY (%) in less time (150 sec).

The higher moisture level facilitated the gelatinization of the starch which resulted in hardening of rice which ultimately provided better head rice yield.

Head rice yield, % (HRY) for parboiled paddy at different energy levels of microwave heating

The moisture absorption by paddy increased with the increase in energy supply for heating at various power levels (Fig. 4). As the moisture absorption at lower power levels of 320 W was better than other power levels for the same amount of energy supplied for hot soaking in MW oven.

The higher moisture level facilitated the gelatinization of the starch which resulted in hardening of rice which ultimately provided better head rice yield.

Broken (%) for parboiled paddy at different exposure time of microwave heating

Fig. 5 shows that the broken (%) was found to be highest at treatment combination of 320 W and 150 sec. the percentage of broken was found to decrease with increase in time of exposure. The lower power level at 375 sec provided 10.7 % brokens. The power level 480 W, we found only 9 % brokens in 250 sec were at 640 and 800 W we were found 10.24 and 10.4 % brokens. The lower power level Longer exposure time allowed higher moisture absorption which resulted in complete gelatinization of starch and lower brittleness.

Broken per-cent for parboiled paddy at different energy levels of microwave heating

Fig. 6 shows that the highest broken (%) was found in the treatment combination of 320 W and 48 KJ energy. The amount of broken was found to reduce as the energy increased. For a given power higher energy level is attained at more exposure time. More exposure time allowed better moisture absorption and proper gelatinization of starch, this resulted in decrease of brittleness ultimately affecting the breakage.

Comparison with the control sample

When milled samples of the control were compared with the milled samples of parboiled paddy at suggested time of treatment the following results were found:

The heat treatments during parboiling have increased the head rice yield (i.e. from 37.6 % to 66.08 %) and broken(%) were found to decreased from 34.8 % to 9 %. The degree of milling and degree of polishing have no major effect.

The moisture absorption by paddy increased with the increase in energy supply for heating at various power levels. As the concept of parboiling of paddy in MW ovens is limited to the laboratory, it requires sincere efforts to optimize the process and conditions in order to produce parboiled rice from paddy in industry.

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